EMODnet Thematic Lot n° 3

Seabed Habitats

EMODnet Phase 2 – Final report

Reporting Period: 27/08/2013 – 30/09/2016

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Table of contents

List of abbreviations and acronyms

BOLAM	Bologna Area Model, limited area model used in operational meteorological forecasts
Biozone	Also called “Depth zone”, is a area of seabed vertically homogeneous in terms of its oceanographic descriptors
BSSHM	Broad-scale seabed habitat maps
CBD	Convention on Biological Diversity
DELFT3D	3D modeling suite used to investigate hydrodynamics, sediment transport and morphology and water quality for fluvial, estuarine and coastal environments
DCE	Danish Centre For Environment And Energy
DTM	Digital Terrain Model
EASME	European Agency for Small and Medium Enterprise
EBSA	Ecological and Biological Significant Marine Areas
ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environment Agency
ETC / BD	European Topic Center on biodiversity
ETC /ICM	European Topic Center on inland and coastal marine waters
EU	European Union
EUNIS	European Nature Information System. eunis.eea.europa.eu
EurOBIS	European Ocean Biogeographic Information System (www.eurobis.org)
FP7	7 th Framework Program for Research and Technological Development
GEBCO	General Bathymetric Chart of the Oceans. www.gebco.net
GeoEcoMar	National Institute of Marine Geology and Geoecology of Romania
GIS	Geographic Information System
HCMR	Hellenic Centre for Marine Research. Greek Project partner.
HELCOM	Baltic Marine Environment Protection Commission - Helsinki Commission
IBCM	International Bathymetric Chart of the Mediterranean. www.ngdc.noaa.gov/mgg/ibcm/
ICES	International Council for the Exploration of the Sea
IEO	Spanish institute of oceanography. Project partner.
Ifremer	French Research Institute for Exploitation of the Sea. Project coordinator.
INSPIRE	Infrastructure for Spatial Information in the European Community
INTERREG	"An initiative that aims to stimulate cooperation between regions in the European Union."
ISPRA	Italian Institute for Environmental Protection and Research. Project partner.
JNCC	Joint Nature Conservation Committee – UK Project partner.
JRC	Joint Research Centre of the European Commission
KDPAR	Diffuse attenuation coefficient of the photosynthetically available radiation

LAMMA	Consortium- Environmental Modelling and Monitoring Laboratory for Sustainable Development, Italy
Mc-WAF	Mediterranean-Coastal WAve Forecasting
MESH	Mapping European Seabed Habitats
MeshAtlantic	Interreg Project 2010-2013
MODEG	Marine Observation and Data Expert Group of European Commission
MFS	Mediterranean Forecasting System
MPA	Marine protected area
MSFD	Marine Strategy Framework Directive (2008/56/EC)
NETCDF	Format for description of scientific data such as wind, current, temperature
NIVA	Norwegian Institute for Water research. Project partner.
OWF	Offshore windfarm
OSPAR	Oslo-Paris Convention for the Atlantic
QA/QC	Quality Assurance/Quality Control.
RAC/SPA	Regional Activity Centre for Specially Protected Areas
RSC	Regional Sea Convention
ROMS	Regional Ocean Modeling System, numerical model for oceanographic simulations
WFD	Water Framework Directive
WGMHM	ICES Working Group on Marine Habitat Mapping
WP	Work Package

Executive summary

In order to most benefit from the potential offered by the European marine basins in terms of growth and employment (Blue Growth), and to protect the marine environment, we need to know more about the seafloor. European Directives, such as the MSFD, but also the Horizon 2020 roadmap explicitly called for a multi-resolution full coverage of all European seas including bathymetry, geology and habitats.

The present work, following on a suite of past initiatives, has made a big step forward in this direction. It has first boosted the collation of existing maps from surveys by setting up a framework and a procedure to encourage people to submit their maps and data. This resulted in a more attractive EMODnet seabed habitat portal and a snowball effect with more and more people willing to join. However, collation will eventually come to an end and as new creations of seabed habitat maps are so complex and time-consuming, a cost-efficient way to meet the need for a full-coverage habitat map was found to be low-resolution maps and models to predict seafloor habitat types.

The broad-scale map referred to as EUSeaMap has been created by this project and after the first two phases it now covers all European basins from the Barents Sea to Macaronesia and to the Black Sea. By harmonising mapping procedures - based on the EUNIS classification - and fostering a common understanding among seabed mappers in Europe, EUSeaMap provides today the community with a comprehensive, free and ready-to-use map that can find applications at regional scale for management and conservation issues. Tables and maps for all basins can be found in Appendix 6 of this report.

The project has played a key role in giving feedback to other EMODnet communities dealing with bathymetry, geology and biology, all essential data sources for the broad-scale map. It has also improved the understanding of the EUNIS habitat classification - with a focus on the Adriatic and the Black Sea - by better specifying transitions between classes based on benthic ground-truth data. It has fostered the development of oceanographic variables such as light, waves and currents that have a strong bearing on habitats. Finally it has also been instrumental in developing map confidence assessment methods that account for the broad spatial variation in data sources quality and for uncertain boundaries between habitat classes.

The EUSeaMap methods are repeatable and ensure that the predictive maps can continue to be improved in the future, as a result either of EUNIS enhancements or increase in resolution. From today’s 250m resolution is it likely that new deliveries of enhanced source layers due to steady progress in oceanography and geophysics will enable constant refinement of the maps over time.

1. Introduction

Phase 2 of the Seabed Habitat lots has been a follow-up on the initial delivery in phase 1 of the first homogeneous European seabed habitats. The 2012 version (urEMODnet) was limited to the Atlantic, Baltic and western Mediterranean Seas. Following up on the Interreg MeshAtlantic Project that had completed the Iberian Peninsula and parts of Macaronesia over the 2010-2012 period, the main innovation at that time had been the coverage of the western Mediterranean Sea, the result of a very fruitful collaboration between Italy, Spain and France. The creation of a comprehensive map in a totally new basin with no history of broad-scale seabed habitat maps, in contrast with the Atlantic, had been a real breakthrough overcoming many difficulties.

In Phase 2 the community has even strengthened with the addition of partners from the Central and Eastern Mediterranean as well as the Black Sea. Challenges were still present, and even more acute, essentially with regards to classifications: what habitat classes was the broad-scale map going to show? While this issue was pretty straightforward in the Atlantic where EUNIS has long been established, in the Mediterranean there were still some loose ends in the crosswalk between EUNIS and Barcelona Convention habitats that appeared during the Project. In the Black Sea, we had to start from scratch as no official list of habitats was to be found there. This led to many discussions on the relationships between communities and edaphic/environmental factors influencing the seabed, and only recently was an agreement reached for a final list. This is described in section 3.1 of this report.

The consortium worked well together and also tried to reach further out to third party countries. This was mainly true for the Black Sea where the EU is only represented by two countries (Romania and Bulgaria) covering a small share of the marine basin. Along with METU from Turkey as a sub-contractor this Black Sea group was able to liaise with some Ukrainian and Russian colleagues and some data was made available from there. The consortium also worked actively with the other EMODnet lots, more specifically Bathymetry and Geology as the seabed habitat product is directly dependent on their outputs (see action 3.2). This collaboration was made easier by the fact that some of the partners are common between these lots.

On top of the broad-scale map as core product of this Project (its making is described in section 3.5 and the maps are displayed in Appendix 6), the group had committed to make habitats maps and data in general more easily available to the broader community. Several types of data were concerned: (i) habitat maps from surveys (both EUNIS and non-EUNIS, e.g. Natura 2000), (ii) modelled maps of individual habitats (e.g. kelp or maerl), (iii) habitat sample data. The Project managed to collate some of these but a lot remains to be done (section 3.6). There were several issues and constraints that limited success in this area, which are listed in the section on challenges below (section 4). However the seabed webGIS has been enriched with data sets from more varied sources as previously and hopefully this trend is going to take momentum over the next few years thanks to its arousing a spirit of competition among Member States.

2. Highlights of the Project

When thinking about Project's highlights, three major achievements appear right away. The first two result directly from the core work of the Project, i.e. the creation of a European broad-scale habitat map and confidence maps. However producing a confidence map was not regarded as certain even six months before the end of the Project and our warmest thanks go to the Bathymetry and Geology lots for their willingness to help us in providing confidence for their own data. The third highlight is about appreciating the efforts made by the partnership to significantly improve the resolution of physical oceanographic model outputs in the Mediterranean, efforts which we can only hope will be continued in future.

2.1 A pan-European broad-scale habitat map

The first highlight of this Project is no doubt the production of a pan-European seabed habitat map available at each location within EU marine basins extending as much as possible into adjacent third party countries waters. This achievement is a major one for several reasons:

- It proves people from various horizons, profiles and cultures can share a common understanding of a complex product involving a fair amount of research;
- The use of generic data layers delivered in due time by other lots (namely Bathymetry and Geology) gave evidence of EMODnet being a highly collaborative community;
- Making this map available and publicised through web channels generated quite a lot of uptake from a great variety of users essentially from research and academia, but also from the management sphere, who actively used it for MSFD or MPA design or assessment. However the needs of the industry and service companies will not be satisfied unless a way is found to increase the resolution;
- Increasing the resolution is one side of things, enriching the map in terms of its biological content is another one. So the collation, let alone the collection of more biological data and smart methods to integrate these into the maps is probably where progress lies;
- The associated confidence map gives users an account of the great variation in quality across the map and provide them with a warning about places where the map should be used with caution.

2.2 Confidence assessment of marine data

The second highlight is probably the progress boosted by the seabed habitat group in the area of confidence assessment, a tender requirement. This finds its origin with the initial collation of habitat maps from surveys with largely variable quality, from legacy maps made from samples to recent maps using full deployment of acoustic tools and methods. It was deemed essential to provide users with a map confidence assessment because low quality maps can still look good and be misleading. This need is even more acute when using a broad-scale map made with data from many sources with highly varying quality.

Since the inception of the EMODnet phases, the seabed habitat group has permanently been championing this idea, not only within the group but also towards its providers, namely the Bathymetry and Geology lots. Along with a more formal way of assessing confidence spatially (i.e. at all locations within the seabed habitat map), the Project has managed to prompt the other two lots to compute a spatial confidence index along with their depth or substrate maps and these were delivered on time for this Project to fully benefit from them in producing an integrated confidence assessment for the broad-scale map.

Beyond giving the user a warning when they use the maps, an additional advantage of the confidence map is to provide a valuable tool to orientate and optimise future habitat data collection in the EU by informing gaps and heterogeneity in seabed portrayal.

It is expected that confidence assessment of marine data will progressively become the norm in the research and surveying community, while recognising it remains a very slow process that may take another decade.

2.3 Improving the status of marine physical data

Two strands of work were given a particular thrust during the Project.

Regarding light levels in the water column, the variable used to define the photic zone, significant progress was made to retrieve light attenuation data from Meris (Medium Resolution Imaging Spectrometer Instrument) satellite imagery at full 250m resolution. By the end of 2015, the Project delivered full EU coverage of light attenuation obtained with the most up-to-date atmospheric corrections software version. This unique data set will not only be made available as a secondary layer on the seabed habitat webGIS but also on EMODnet Physics web site.

Regarding hydrodynamics, the Project triggered significant improvements to fill the gap between the resolution required to map habitats and the current resolution of available meteorological and oceanographic products available from numerical models and remote sensing. A viable strategy to bridge this gap, provided adequate numerical resources are available, is to operate with multiple scale analysis. To provide salinity, energy at the sea bottom and temperature, we recently used regional scale models nested in the global models in order to have simulations of waves and currents at 1-2 km resolution. In particular we worked at less than 2.5 km resolution for energy waves on the whole Mediterranean Sea and less than 1 km for the Adriatic Sea and the eastern Mediterranean. Confidence will increase with the extension of the temporal period considered. The important thing is that the method allows to keep a strong connection with the global models in order to ensure the complete compatibility of the coastal and regional scale climate with the global climate. The results will further improve when we use more accurate and resolved information on substrate and bathymetry.

3. Description of the work done

3.1 Classification review

3.1.1 Biological zones

In order to address habitat classification issues necessary to model broad-scale habitats across the European seas, efforts were placed in agreeing on the biozones (biological zones) that are known to be present in each European sea and on the environmental parameters that can be used to define them. The extent of each biological zone is generally driven by a specific environmental variable that is recognized as having overarching influence on the distribution of the habitats contained within the biological zone. The biological benthic zones which can be adequately portrayed in the EUSeaMap broad-scale map and which are recognized as being shared commonly amongst European seas are four and defined as follows: infralittoral, circalittoral, bathyal and abyssal[1]. Efforts were placed to define the parameters that are known to influence biological zone repartitioning across European seas and which could be used to define the biological zone boundaries in the modeled broad scale map. In some basins it was acknowledged that clear subzones exist within biozones and that these can be univocally defined on the basis of prevailing environmental parameters which can be used to model the boundaries (see Appendix 1). Efforts to use spatial data related to such parameters, or alternative proxies, and the identification of the threshold values used to model the biological zone/subzone boundaries are described in section 3.4 further on.

In the Baltic and newly modelled Mediterranean basins (Adriatic and central eastern Mediterranean sea) the biological zones (and the associated environmental parameters proposed to define their boundaries) are the same as those of Ur-EMODnet. The only exception is the Mediterranean circalittoral zone where it was recognized that, while decreasing light conditions influence the zonation of several “sciaphilic” assemblages of the shallow circalittoral, there is no environmental parameter that can be used to univocally model circalittoral habitats in two distinct subzones. Due to this reason in EMODnet phase 2 no Mediterranean circalittoral subzones were identified.

In the Atlantic region the biozones were modeled in a very similar way to that explained in the phase 1 approach with the exception of the bathyal and abyssal zones where three different subzones (upper, mid and lower) are modeled. More specifically the distinction between these

[1] It is important to note that this biological zone repartition is not completely coincident with the EUNIS (version 2007; http://www.eea.europa.eu/themes/biodiversity/eunis/eunis-habitat-classification) level 2 marine benthic habitat classification structure which considers the infralittoral and circalittoral soft bottoms as belonging to the single EUNIS category “A5 – sublittoral sediment” and the bathyal and abyssal zones as belonging to the single EUNIS category “A6 – deep sea”. The EUNIS marine habitat classification is currently under revision. In the proposed revised EUNIS version the four above mentioned biological zones are described in level 2 though the circalittoral and bathyal zones will be subdivided into subzones.

zones is recognized as being present and determined by a combination of depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux ranges (Bett and Jones, in prep). The biological relevance of these divisions have been found for some parts of the Atlantic (Parry et al, 2015) and further research is necessary to confirm it throughout the wider subregion however it is believed that there is sufficient scientific insight to extend the concept of subzonation within the frame work of the Atlantic region broad-scale habitat modelling.

The Black Sea was a novel region in which EUSeaMap broad scale habitats were modeled based on their distribution across the four above mentioned biological zones. In this basin a boundary between the shallow and deeper circalittoral zones is recognized based on the different temperature regimes that are found associated to each subzone (Table 3.1).

3.1.2 River plume areas

The identification of the infralittoral/circalittoral boundary based on the estimated percentage of light reaching the sea bottom does not work as appropriately in areas which are under the influence of high fine sediment riverine input. In fact, in these areas combined fine sediment and fresh water apposition interferes with the standard substrate and benthic zonation pattern observed in coastal areas with little or no coastal riverine input. For this reason, such areas, hereafter referred to as river plume areas were delimited using abiotic parameters or simply manually drawn, where abiotic parameter data did not allow to define their extent. In these plume areas the parameters considered to define the infra-circa boundary are linked to sediment nature and other parameters which will be explained in section 4 on thresholds.

In the western Adriatic Sea the area influenced by the Po river plume (and other smaller adjacent rivers) was delimited by considering the average surface salinity values observed in the northern part of the basin (37.93 PSU), since this variable is strongly correlated to freshwater input. Wave energy at the seabed (468 N/m2 average energy value observed in correspondence to the maximum depth known to be affected by energy) was also used since fine sediments lying in shallow water are also influenced by kinetic energy.

In the Black sea two distinct areas were identified where high riverine input due to the Danube and Dnieper-Bug rivers create a substantial riverine input of muddy sediment which interferes with the basic biological zonation schemes. These areas are located respectively off of the northwester Ukrainian and Romanian coasts. Initial attempts to define the plume boundary extent were based on the intersection of the 15 PSU isohaline and muddy sediments distribution. However attempts to compare the ground truth data of the coastal terrigenous muds and the hypothesized plume-influenced area did not prove successful. The extent of these areas was therefore manually drawn based on the presence points of engineering assemblages that define the specific terrigenous habitats in this area like: *Melinna palmata* - *Mya arenaria* - *Anadara kagoshimensis* and *Alitta succinea*. The characteristic community has been identified based on most abundant and high biomass contributing species and their ecological traits (preference for rich nutrient areas and muddy sediments, tolerance to hypoxia), for example abundance of bivalves higher than 25 ind.m^{-2} and of polychaetes higher than 400 ind.m^{-2}.

In some closed bays and very sheltered waters subject to riverine input contributing to coastal fine sediment deposition (i.e. Thessaloniki gulf and bay, Maliakos gulf, Geras gulf etc.) there appears to be high deposition of terrigenous muds in relatively shallow waters that would be classified as infralittoral zone if energy on the seabottom were to be used to define the infra/circalittoral boundary. In such areas manual delimitation of the river influenced plume areas was carried out on the basis of ground truth data indicating the extent in the shallow coastal waters of the circalittoral terrigenous mud communities.

3.1.3 Broad scale habitats

Broad scale habitats to be modeled in the Baltic, Atlantic (intended as North, Celtic, Macaronesia and Arctic) and Mediterranean Sea are the same as those modeled for the same regions in ur-EMODnet. The only exception to this is in the Atlantic region where the upper, mid and lower bathyal and abyssal subzones can potentially include broad scale habitats that can modeled based on the intersection of the Folk 7 sediment classes and specific biogeographic water masses known to influence each of the following hypothesized subzones (Bett and Jones, in prep) namely:

- Atlantic, Atlanto-Arctic upper bathyal
- Atlantic, Arctic, and Atlanto-Mediterranean mid bathyal
- Atlantic and Arctic lower bathyal
- Arctic upper abyssal
- Atlantic upper, mid and lower abyssal

In the Black Sea noticeable efforts were placed in compounding all available literature on the distribution of benthic habitats and their relative relationship with abiotic parameters. It is to be noted that at a basin wide level there is no concerted agreement over a univocal list of known benthic assemblages nor any hierarchical classification scheme according to which these assemblages are sorted out. In the Black Sea this work remained to be undertaken because there has never been a task force capable of exhaustively tackling this issue, and some current Black Sea habitats listed in EUNIS are mostly adaptations of Mediterranean types using modifiers. Effort was placed in defining a pan Black Sea list of assemblages that could be portrayed at a broad scale and identifying the environmental variables that are likely to influence their distribution. This was done by checking literature and ground truth data for all identified assemblages and associated environmental parameters. A broad-scale Black Sea habitat list containing the known benthic assemblages occurring throughout the basin and the abiotic variables known to influence them is provided in Table 3.1 below. In this basin broad scale habitats are modelled based on the intersection of biological zone, combination of substrate classes, bathymetry and oxygen saturation associated to the seabottom.

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 a 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.

Note that while we placed in appendix the table describing biozones and their thresholds for the various basins, we decided to keep Table 3.1 as part of the core description of work because the Black Sea is an area where EUNIS, our seabed habitat classification system, required complete revision. We therefore regard this contribution as a key block of the very scientific substance of this phase of work, which demanded significant efforts from the participants and hopefully will be of relevance to the current elaborations of the ETC/BD group for the Black Sea.

Table 3.1: List of expected modeled Black Sea broad scale habitats, respective environmental variables necessary for their modeling and included assemblages

<table>
<tr><th>Broad scale habitat name</th><th>Biological Zone</th><th>Substrate</th><th>Temperature</th><th>Bathymetry</th><th>Density (sigma-theta)</th><th>Contains indicator association</th></tr>
<tr><td>Infralittoral sand (Plume)</td><td>INFRA</td><td>SAND</td><td colspan="3" rowspan="4">Biological zones are defined based on the type of substrate
IF SAND or MUDDY SAND -> INFRA
ELSE -> CIRCA</td><td>Fine sand with Lentidium mediterraneum</td></tr>
<tr><td>Infralittoral muddy sand (Plume)</td><td>INFRA</td><td>MUDDY SAND</td><td>Cerastoderma glaucum, Mya arenaria, Anadara kagoshimensis</td></tr>
<tr><td>Circalittoral coarse and mixed sediment (Plume)</td><td>CIRCA</td><td>MIXED/COARSE</td><td>Diverse faunal assamblages due to hetergenous substrate dominated by bivalves Mytilus galloprovincialis, Spisula subtruncata, Acanthocardia paucicostata and polichaetes Nephtys hombergii</td></tr>
<tr><td>Circalittoral terrigenous muds (Plume)</td><td>CIRCA</td><td>MUD/ SANDY MUD</td><td>Danube and Dnieper plume areas (Mud with Melinna palmata, Mya arenaria, Alitta succinea, Nephtys hombergii)</td></tr>
<tr><td>Infralittoral rocks with photophilic algae</td><td>INFRA</td><td>ROCK</td><td></td><td><14m</td><td></td><td>Cystoseira barbata + Ulva rigida+ Polysiphonia subulifera Cladophora spp. - Ulva rigida - Ulva intestinalis - Gelidium spp.</td></tr>
<tr><td>Infralittoral Coarse and Mixed Sediment</td><td>INFRA</td><td>COARSE; MIXED</td><td></td><td><19m</td><td></td><td>Infralittoral shelly gravel and sand with Chamelea gallina and Mytilus galloprovincialis</td></tr>
<tr><td>Infralittoral sand and muddy sand</td><td>INFRA</td><td>SAND; MUDDY SAND</td><td></td><td><19m</td><td></td><td>Shallow fine sands with Lentidium mediterraneum, Tellina tenuis
Medium to coarse sands with Donax trunculus
Infralittoral sand with Chamelea gallina (with Cerastoderma glaucum, Lucinella divaricata, Gouldia minima) (depends of region)
Muddy sand with burrowing thalassinid Upogebia pusilla/Pestarella candida</td></tr>
</table>

Infralittoral mud and sandy mud	INFRA	MUD; SANDY MUD;		<19m		Mud and sandy mud with *Upogebia pusilla* Sandy mud and mud with seagrass meadows
Circalittoral rock	CIRCA	ROCK		>14m		Sciaphilic algae *(Phyllophora* spp. + *Polysiphonia* spp. + Apoglosium + *Zanardinia* spp.+ *Gelidium* spp.), sponges and hydroids
Shallow circalittoral shelly organogenic sand (clean shelly debris without mud)	CIRCA	SAND; COARSE (shelly with no mud)	>9.7°C	>19m		*Mytilus galloprovincialis* biogenic reefs *Coccotylus truncatus & Phyllophora crispa* on shelly organogenic sand
Shallow circalittoral mud and organogenic sandy mud/muddy sand	CIRCA	MUD; SANDY MUD; MUDDY SAND; MIXED	>9.7°C	>19m		Muds with *Abra nitida - Pitar rudis - Spisula subtruncata, Acanthocardia paucicostata* and *Nephtys hombergii* Muddy sand with *Dipolydora quadrilobata* meadows and *Mytilus galloprovincialis* biogenic reefs
Deep circalittoral coarse mixed sediments	DEEP CIRCA	COARSE; MIXED; MUDDY SAND	<9.7°C	>19m	<15.4kg/m^3	Shelly muds with *Modiolula phaseolina*
Deep circalittoral sand and sandy mud	DEEP CIRCA	SAND; SANDY MUD	<9.7°C	>19m	<15.4 kg/m^3	Sand and sandy mud with tunicates
Deep circalittoral mud	DEEP CIRCA	MUD	<9.7°C	>19m	<15.4 kg/m^3	Mud with *Terebellides stroemii, Pachycerianthus solitarius, Amphiura stepanovi*
Deep circalittoral suboxic calcareous muds	DEEP CIRCA	MUD	<9.7°C	>19m	>15.4 kg/m^3 <16.2 kg/m^3	White muds with *Bougainvillia muscus (ramosa)* and nematode communities (RO)
Deep circalittoral anoxic muds	DEEP CIRCA	MUD	<9.7°C	>19m	>16.2 kg/m^3	Anoxic muds
Bathyal anoxic muds	BATHYAL	MUD	The upper boundary is a break of slope manually defined			Bathyal anoxic muds
Abyssal seabed	ABYSSAL	ANY	The upper boundary is a break of slope manually defined			

3.2 Data preparation

This work package (WP2) was aiming at the collation of primary data and the preparation of various data layers as inputs to the model. In principal we have been using three main types of data: Digital Terrain Model (DTM) of the seabed (Bathymetry), seabed substrate (Geology) and oceanographic data, plus marginally some chemical data (Black Sea).

Bathymetric and geological data were received regularly during the course of the project by the EMODnet Bathymetry and Geology Lots whenever they were releasing their updated products. Therefore their secondary elaboration and processing was rather limited with the exception of the Black Sea. Oceanographic data (light, energy, salinity) needed more preparation because they are used as climates and as such underwent statistical computations leading to secondary layers appropriate to go into the model.

3.2.1 Bathymetry

In general the bathymetric data used for all the European Seas were provided by the Bathymetry Lot as a 250m (roughly 1/8th minute) resolution Digital terrain model (DTM) published in Sept. 2015. All the digital bathymetry tiles were downloaded from the EMODnet Bathymetry portal (http://www.emodnet-hydrography.eu/) and were provided to the project team after a limited elaboration and processing, in the appropriate format for the needs of the model.

For the central and eastern Mediterranean (Fig. 3.2.1) and the Black Sea in particular, the Bathymetry Lot provided us with the latest, significantly improved DTM version already in early summer 2016. These areas were crucial for the final run of the habitat model. Especially for the Black Sea some additional depth data (mainly in the form of bathymetric contours or point data) were provided by Romanian, Bulgarian and Turkish partners of the Projects and were to improve the bathymetry of areas which are still essentially based on GEBCO.

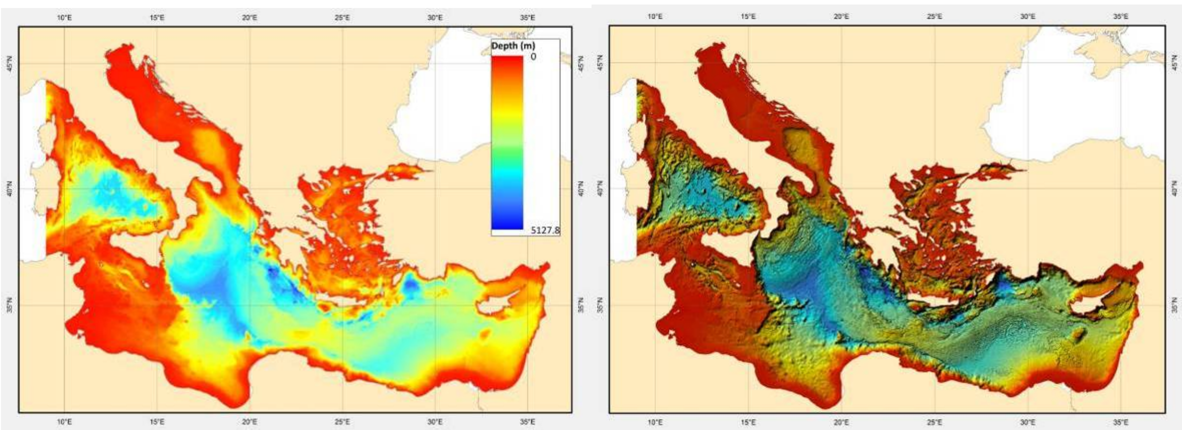


Figure 3.2.1 - Central and Eastern Mediterranean Sea DTM last updated version (Bathymetry Lot, June 2016).

For the processing of these additional Black Sea data we followed the procedure which is used by the Bathymetry Lot. The first step was to create a single DTM for each one of the provided datasets in the same resolution and extent compatible with the Bathymetry Lot DTM. Figure 3.2.2 shows the datasets and the corresponding grids for each one of them according to their origin.

The resulted grid was merged with the grids produced at the first step and then the filling of the remaining gaps with GEBCO 2015 (resampled at 1/8 arc minute) grid followed the processing. Finally a smoothing factor was applied around the edges (Figure 3.2.3).

In summary, the data sources of the bathymetric data used for the final habitat model are the Bathymetry Lot's DTMs produced in June 2016 for the Central and Eastern Mediterranean, the isobaths and the point depths provided by Romanian, Bulgarian and Turkish partners in combination with the EMODnet DTM of June 2016 for the Black Sea and the EMODnet DTM of September 2015 for the rest of the European Seas.

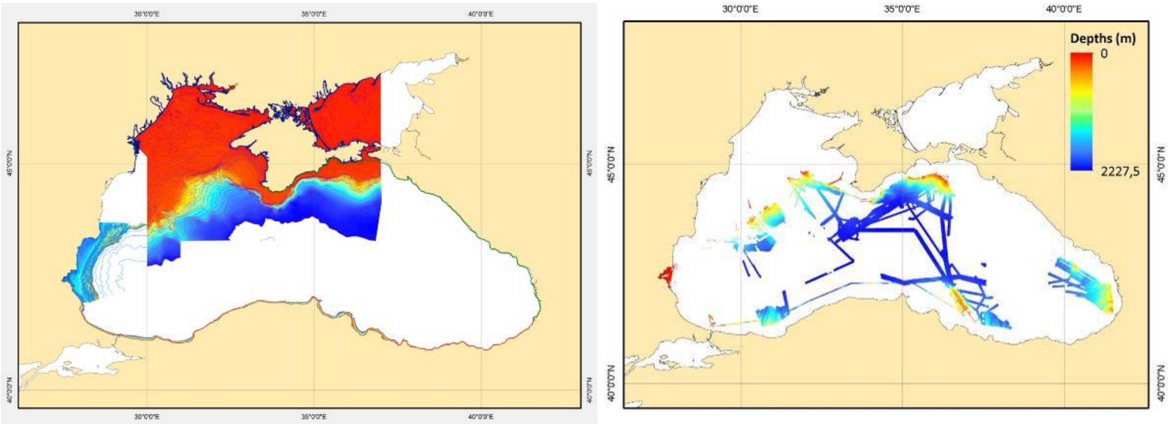


Figure 3.2.2 - Left: Bathymetric data have been derived through digitization by the Romanian, Bulgarian and Turkish partners. Right: Black Sea surveys DTM (Bathymetry Lot, June 2016).

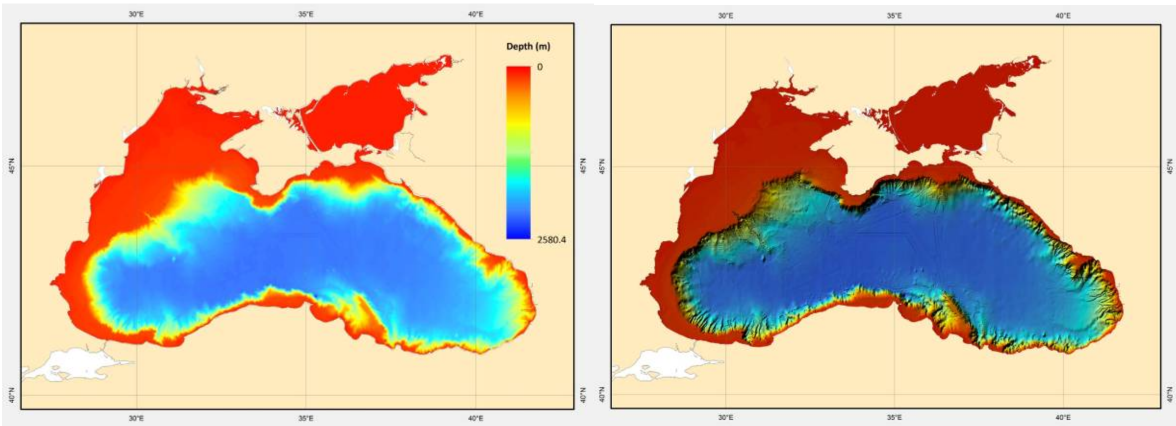


Figure 3.2.3 - Black Sea final DTM for EUSeaMap needs.

3.2.2 Seabed Substrate

The most up-to-date version of seabed substrate was received from the Geology lot firstly in July 2016 and after some necessary corrections in August 2016. It was organized in a geodatabase format as feature datasets in two different scales according to their origin. All the substrate data received from the partners of the Geology lot at scale 1:250000 were included in the first dataset which is of limited extent for European seas, while the full coverage is available at scale 1:1M (Figure 3.2.4). Data were combined from the following datasets:

- Broad scale (scale not better than 1:250000) data received from the partners;
- 1:250 000 data that were generalized into 1:1M;

- UrEMODnet data (1:1M);
- Unconsolidated Bottom Surface Sediments of the Mediterranean and Black Seas (IBCM-Sed) (Emelyanov, E.M., Shimkus, K.M, Kuprin, P.N., 1996. Intergovernmental Oceanographic Commission (UNESCO).

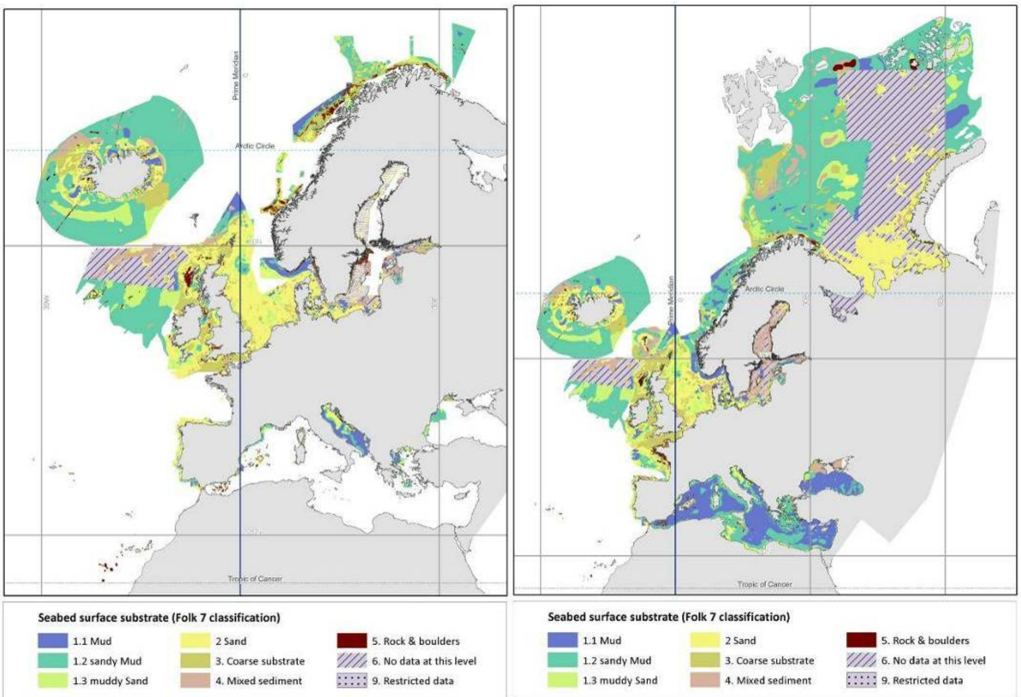


Figure 3.2.4 – Left, seabed surface substrate coverage at scale 1:250 000. (EMODnet Geology Lot July 2016); Right, Seabed surface substrate according to Folk 7 classification. Coverage of scale 1:1 000 000. (EMODnet Geology Lot August 2016)

In order to include the highest resolution of the substrate data as well as optimum coverage of the European seas, we produced a composite seabed substrate map by using the two different data scale maps provided by the Geology Lot. The 1:1M scale dataset includes a generalized (simplified) version of the 1:250000 data. In the 1:1M scale dataset we replaced the 1:250000 generalized data with the original data at 1:250000 resolution and used this composite map for our models. In the attribute table of the resulting composite feature dataset we added a new field, called "OriginLayer" in order to describe the source of the features.

The EMODNET substrate layer used to model seabed habitats in the Mediterranean sea was integrated with specific cartographic maps and point data referring to *Posidonia oceanica* meadows, *Cymodocea nodosa* beds and hard bottoms. The polygon layer was integrated in the final modelled map whereas the point layer was superimposed into the model in order to visualise the presence of these geomorphological features of conservation interest in cases where the broad scale nature of the model would not have otherwise allowed their representation. Polygon data referring to the above mentioned habitats were rasterized into the 250m pixel resolution whenever the polygon size covered the majority of the pixel area. Original habitat polygons that did not have a sufficient surface area to allow their inclusion in the rasterization process were treated as follows: all the polygon features lying farther than 1 km from the rasterized additional substate layer were selected, centroids of these polygons were extracted and only points distant from more than 100 meters from each other were retained. Georeferenced point data obtained from scientific and grey literature indicating the presence of *Posidonia oceanica* in a specific region were also integrated into the point data layer. Appendix 2 contains both the table summarising the different cartographic data sources and bibliographic data that were considered to construct the integrative substrate layers into the modelled map.

Finally, in the attribute table of the substrate layer, we created the relevant, new field, called "SubstratePlus" to include a description of the meadows and the integrated hard bottoms and also the substrate characterization according to 5-classes Folk where 7-classes Folk were not available (Fig. 3.2.5).

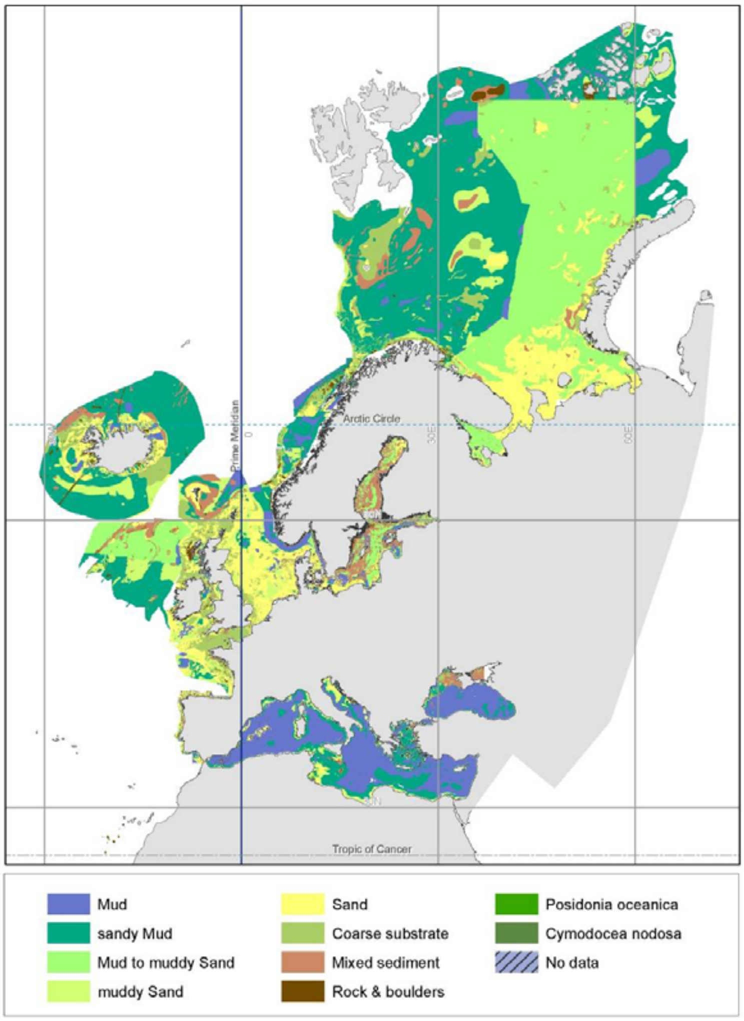


Figure 3.2.5. Seabed surface substrate in Folk 7 classes, completed in parts by Folk 5 classes and including seabed meadows.

3.2.3 Light levels at the seabed

Water transparency data received a lot of attention over the first two phases of the EMODnet Seabed habitats as they enable the identification of the infralittoral biozone. In urEMODnet the

Project had contracted work to process satellite imagery from the ESA MERIS satellite in its full resolution mode (~250m). Five years of overpasses were compiled so as to make sure a sufficient number of images was available at any given location to retrieve a reliable climatology. In phase 2, after receiving the delivery of the additional subareas completing the full EU coverage, we became aware of discrepancies in the KdPAR coverage between western and eastern Mediterranean respectively delivered in 2010 and 2013. An investigation led to identifying this as a consequence of the atmospheric correction algorithm – an essential step in ocean colour imagery processing – having undergone an update between the two dates. We then had to rerun all the original subareas in 2015 by using the same algorithm for the sake of consistency.

In addition, we requested from the contractor to provide us not only with the KdPAR (attenuation coefficient integrated over the whole visible spectrum) but also the real amount of light received by the seabed measured in mol.photons per square metre per time unit. This model uses a sun irradiance model for the Earth along with the cloud cover and the water transparency retrieved from the imagery for each pixel. The advantage of this is the provision of an intrinsic measure, the absolute quantity of light reaching the seabed, instead of the previously used relative amount of "percentage of surface light reaching the seabed". These images were delivered along with a grid file containing the number of images used for each pixel, which was subsequently used in WP5 to assess confidence in light data. The coverage of these data is shown in Fig. 3.2.6. This layer, having other potential uses than just habitats, has been handed out to the Physics lots for dissemination within their portal.

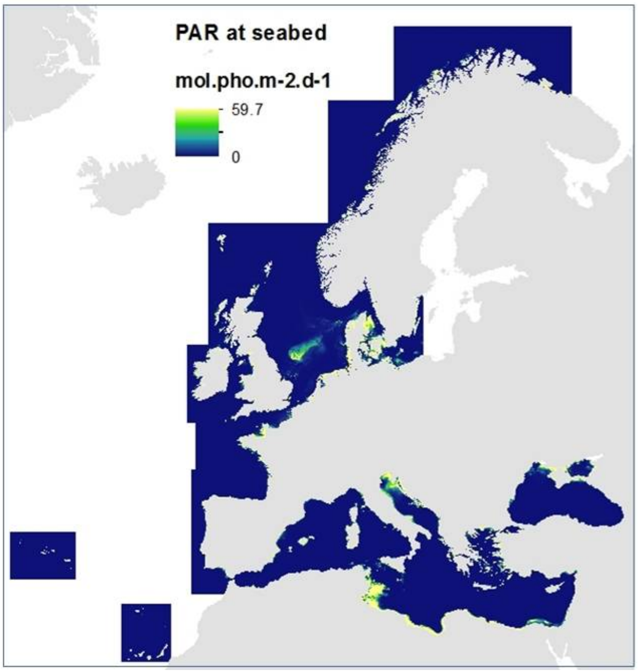


Fig. 3.2.6: Photosynthetically active radiation at seabed (in mole.photons per sq. m. per day)

3.2.4 Energy levels at the seabed in the Mediterranean and Black Sea

An effort to provide a state of the art evaluation of the energy levels at the sea bottom due to the action of the ocean currents and wind waves has been made by collecting the most resolved spatial information made available by operational models in the Mediterranean and Black Sea. In the Mediterranean Sea, basic oceanographic information (currents, temperature, salinity) has been extracted from the available dataset of the MyOcean Project (now Copernicus Marine environmental monitoring service) at about 7 km resolution. In addition, the Adriatic Sea datasets of oceanographic products have been extracted from the TESSA Project at about 2.2 km deg. resolution (Oddo et al., 2006; Guarnieri et al., 2008). A specific dataset of energy due to currents at 250m resolution have been prepared close to the Elba Island based on ad hoc numerical hydrological simulation. The oceanographic data, at the level closer to the bottom, has been post-processed in order to provide 90-percentile sea-bottom fields over the available time periods. The evaluation of wind waves contribution to the sea bottom energy has been based on the available data of the Mc-waf operational forecasting system (Inghilesi et al. 2016) at the Mediterranean scale (about 3.3 km resolutioàn) regional (1.7 km res.), and coastal scale (400 m res.). The regional areas for which wave datasets have been prepared are the Adriatic Sea, the northern Tyrrhenian and Ligurian Sea, and the eastern Mediterranean Sea. Very high resolution datasets have been provided in coastal areas around Cyprus Island (800 m res.), Elba Island (200 m res.) and in the Northern Adriatic Sea (400 m res.). The energy at the sea bottom due to the action of surface wind waves was evaluated using the Soulsby and Smallman method (Soulsby, 2006) using the significant wave height, the mean period of the waves and the bathymetry (Fig. 3.2.7). In the Black Sea both basic oceanographic and wave information have been extracted from the Kassandra Project (Ferrarin et al., 2013, Demyshev, 2012).

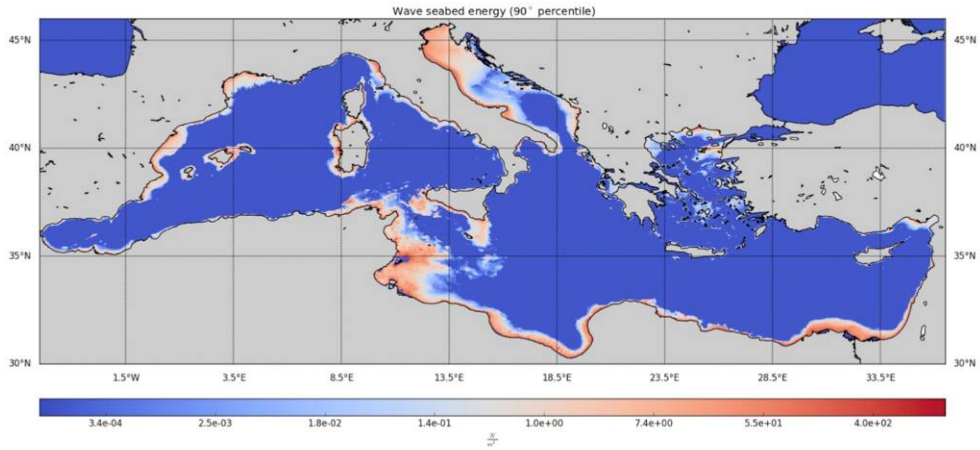


Fig. 3.2.7: Distribution of 90-percentile wave energy at the bottom in the Mediterranean Sea

Given the importance of resolution for habitat mapping, the different sources have been kept separated in order to provide the maximum accuracy at the regional and coastal scales. This decision reflects also the fact that the different sources of data covers different time periods, so that the evaluation of the 90th percentile fields had to be made separately on the original datasets for all the available data. The heterogeneity of the data collections has been taken into account in two ways: in the first place a quality assessment of the datasets was made based on the resolution of the original data used in the estimates. The Adriatic Sea regional scale data have been used in the identification of the Po plume area and in the evaluation of the threshold between infralittoral and circalittoral within this area. The issue of determining which should be the minimal resolution required to provide sufficient spatial variability for the habitat mapping at 250 m in the Mediterranean Sea has been considered in two case studies, at the Elba island in the northern Tyrrhenian Sea and near Cyprus in the eastern Mediterranean Sea. The results of the comparative studies, in terms of the correlation between seabed energy and the presence of offshore Rhodolith beds, indicate that the wave energy at the high resolution is strongly correlated with the presence of specific marine habitats. Even though the preliminary analysis of the wave and the current energy distributions at the sea bottom starts to reveal a significant spatial variability at the regional scale, the best results are obtained at very high resolution, i.e. below 400 m (Fig. 3.2.8). The framework of different datasets here provided can then be seen as a basis for the introduction of seabed energy thresholds in the future implementations of the habitat mapping model in the Mediterranean and Black Sea areas.

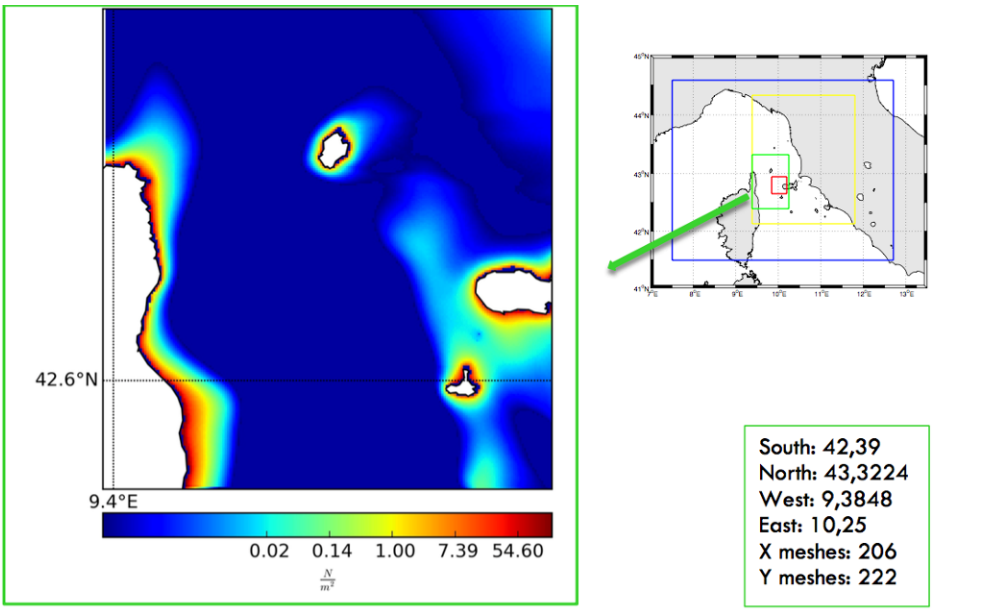


Fig 3.2.8: Elba Island domain: 90-percentile of sea-bottom wave energy at very high resolution

3.2.5 Collation of habitat maps from surveys

As well as the collation of data for use in the efforts of creating the broad-scale maps, a large effort was made to collate datasets representing habitat extents that were created as part of specific surveys or studies by organisations in EU member states.

The first task was to 'decompile' the habitat map holdings of the MESH and MeshAtlantic projects. The maps had been held in a composite dataset, with overlapping areas removed, but due to a new 'archive' style of data holdings developed as part of WP6, the original maps were re-sourced and made available as individual datasets. Further efforts in habitat map collation resulted in large ingestion of maps from across EU waters including, importantly, from regions such as the Mediterranean not previously covered by the above-mentioned projects.

JNCC led the final collation efforts and delivery of the maps via the web portal through WP6, but a great effort was made by partners in the initial collection and standardisation of maps within their own areas of interest. Effort was made to receive datasets with unrestricted conditions of use and access, and the vast majority of datasets currently available on the portal are accessible as such. However, where full unrestricted access was not possible, data were still collated and disseminated on a 'View only' basis, as it is still preferable to not inform the public of the dataset existence. In such a situation, users are invited to contact the data owner identified in the metadata to enquire about full access.

Towards the end of the project, new maps were identified and sourced concerning habitats identified within Annex I of the Habitats Directive and these were delivered in a new data standard created as part of WP6 (Fig. 3.2.9).

The final numbers (as of the writing of this report) of habitat maps collated are presented in the indicators section of this report. This work represents the beginning of a central habitat data holding for EU waters, where all data products are interoperable and presented in a standard format compatible with the relevant INSPIRE data specifications. This is a key requirement for any ongoing pan-european analysis concerning benthic habitats.

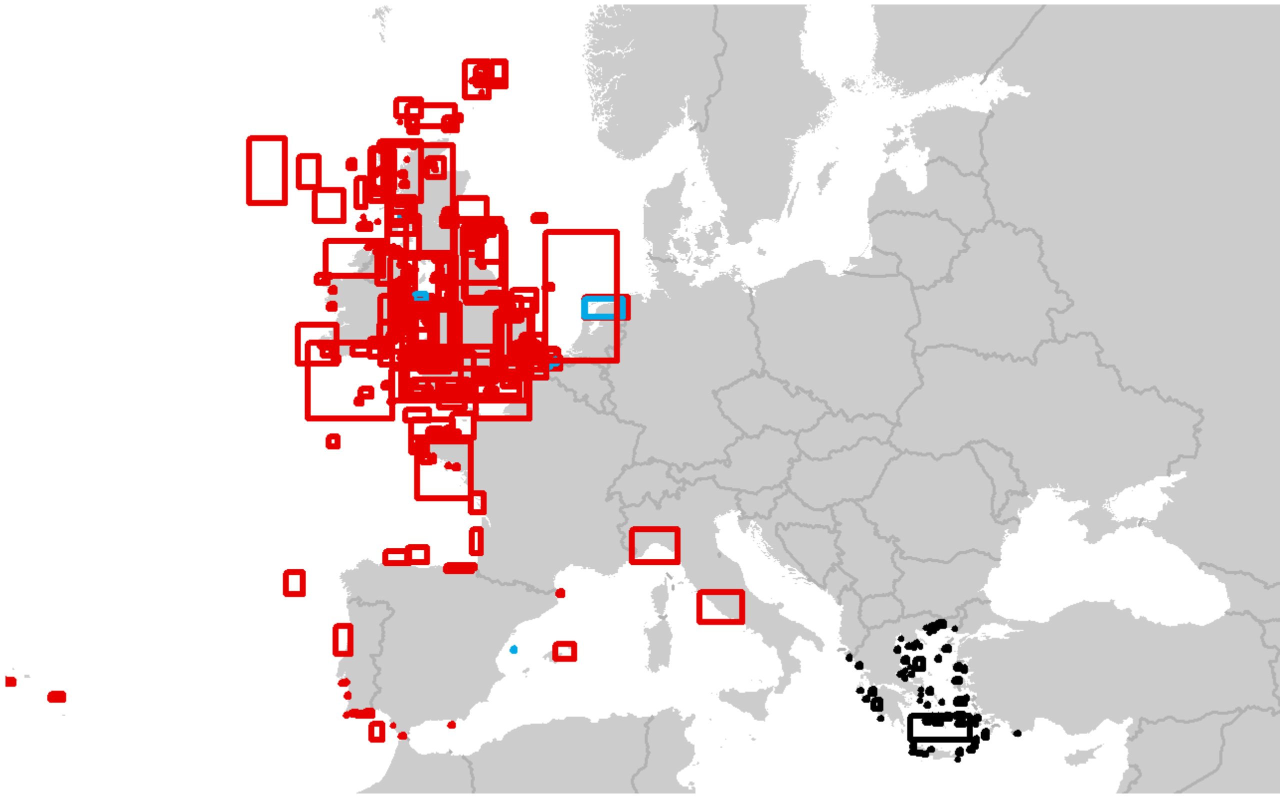


Fig. 3.2.9: Extent of habitat maps from survey in EUNIS (red), Habitats Directive Annex I (black) and other (blue) classifications.

In addition to the habitat extent maps collated above, probability distribution datasets of specific habitats were collated for display on the portal. These were sourced from the MEDISEH project and from work predicting the distribution of Kelp habitats in key areas along the Norwegian coast (not shown in Fig. above, see http://www.emodnet-seabedhabitats.eu/default.aspx?page=1974).

3.3 Habitat samples data

Over the entire project period, large sets of benthic ground-truth data have been gathered which helped out the finalization of habitat maps of all basins. Two types of data were collated: firstly a database made of more than 18,000 ground truth data (sampling points and polygons) covering the Black Sea, Mediterranean, Norwegian Sea, North and Celtic Seas, and North Atlantic coast (Ireland and UK coast) was created. These consist in biological samples of the seabed collected either with grabs or trawls but also in observations from video tows on hard susbtrate. Basically these samples were fed into statiscal analyses with a view to find the most relevant thresholds between either biozones (e.g. transition between infra- and circalittoral) or cut-offs between categories of physical parameters (e.g. energy, light or oxygen content) as decribed in section 4. The second type of ground-truth data is represented by the presence of seagrass beds - either of Posidonia or Cymodocea - mapped from surveys in the Mediterranean. As mentioned in section 2 above, these beds are considered as a substrate type in its own right and therefore, where available, they are integrated into the substrate map (Fig. 3.2.5) and then simply coded with their EUNIS name in the habitat model.

A good success has also been achieved in identifying, sourcing and collating individual survey or site-level habitat maps from organisations within EU Member States.

3.3.1 - Black Sea

A total of 5,063 macrozoobenthos sampling point data were collated for validation of habitat map modeling of the Black Sea. The highest percentage of data covered the northwestern (Romania, Ukraine – about 56%, 2,857 point data) and the western (Bulgaria – about 18%, 890 point data) shelf, while a serious gap was recorded for the eastern and southern part (about 17%), including Russia (586 samples), Georgia (261 samples) and Turkey (23 samples), see Appendix 2. Other 446 point data were used for the manual delineation of the plume areas in Romania and Ukraine.

In total (without plume area), 1,086 and 3,531 data points respectively belonging to infralittoral and circalittoral were used to define the indicator macrobenthic communities for these two biozones. Precisely, the purpose of the collation was to statistically work out the depth thresholds for the infra-circa boundary, both for hard and soft bottoms. The limit between shallow and deep circalittoral was also statistically fitted with the use of indicator macrobenthic presence/absence occurrences. Thus, 2,853 point data referring to eurythermic communities (for the shallow circalittoral) and 1,764 point data standing for the stenotherm ones (for the deep circalittoral) were used for this purpose. The deep circa is subsequently split in three subzones based on the oxygen regime. The oxic/suboxic circalittoral threshold of 15.6 $kg.m^{-3}$ representing the isopycnic value used as proxy for oxygen regime was validated by the presence of macrobenthic communities within the oxic zone and of their almost absence and presence instead of meiobenthic ones within the suboxic one. Within this scope, 17 sampling points of macrobenthic and meiobenthos were plotted. The lower limit of suboxic circalittoral and the upper one of anoxic circalittoral delineated by the isopicnic value of 16.2 $kg.m^{-3}$ was also validated by the presence (in suboxic)/absence (in anoxic) of the meiobenthic communities.

No biological data has been drawn out for bathyal or abyssal zones since very scarce existing information report a predominantly microbial activity (Fig. 3.3.1).

Almost 75% of the data were provided by GeoEcoMar and the international database EurOBIS. Almost all datasets supplied by GeoEcoMar coming from the national monitoring activities or international projects were submitted to the quality control protocol recommended by the BSIMAP (Black Sea Integrated Monitoring and Assessment Program, 2002).

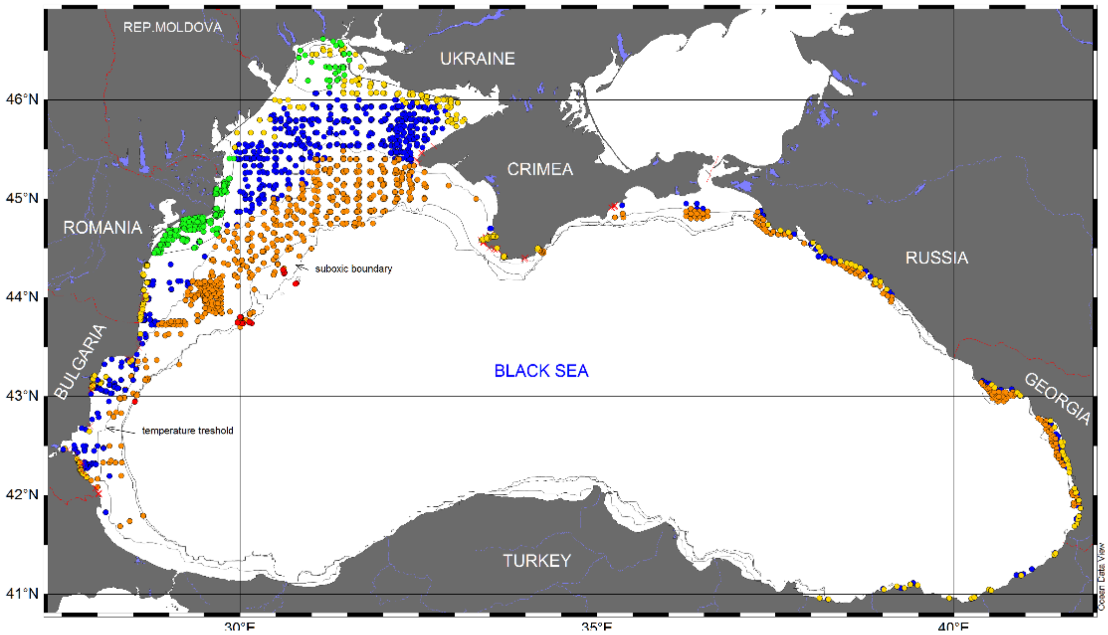


Fig. 3.3.1 - Black Sea: location of sample points indicator of habitats. Yellow dots: infralittoral soft bottom; red cross: infralittoral hard bottom with photophilic algae; green dots: Danube and Dnieper plume area; blue dots: shallow circalittoral soft bottoms; orange dots: deep circalittoral soft bottoms; red dots: suboxic deep circalittoral.

3.3.2 - Mediterranean, Adriatic, Aegean, Levantine and Ionian Seas

A database made of 76 point data of *Posidonia oceanica* meadows covering both the northwestern (Slovenia, Italy, Croatia, Greece and Cyprus, Malta) and southern coast of the Mediterranean (Tunisia and Lybia) served at the identification of the light threshold for the infralittoral lower limit. Figure 3.3.2 reports the locations of some of the point data. A large quantity of the above mentioned point data, indicating the meadows in good health, were used to select the meadow polygon data (when available) used in the light threshold computation (see section 3.4.2). ISPRA collected data from all around the Mediterranean, according to the following protocol:

- Project partners searched in-house and in national research networks for available *P. oceanica* cartographic data;
- All Barcelona Convention National Focal Points for the SPA/BIO protocol were contacted to make a census of the available mapping data and national contacts known to have been involved in monitoring Posidonia lower limits for the WFD.
- A literature review of UNEP-RAC/SPA technical documents and proceedings of the five Mediterranean Workshops on Marine Vegetation was conducted so as to identify potential scientific data owners with cartographic data and information on Posidonia meadows that met the selection criteria described above.
- Requests were sent to all identified data owners so as to collect cartographies and georeferenced information on *P. oceanica* lower limit characteristics. Advice was sought

directly with national experts and data owners so as to discuss appropriateness of data collected with respect to the above mentioned selection procedure.

- A challenging task was to obtain Posidonia data from North Africa where Posidonia maps and studies on the meadow lower limit are not abundant. In spite of difficulties, ISPRA managed to obtain mapping information from Tunisia and Libya through the UNEP/MAP RAC/SPA secretariat of the Barcelona Convention.

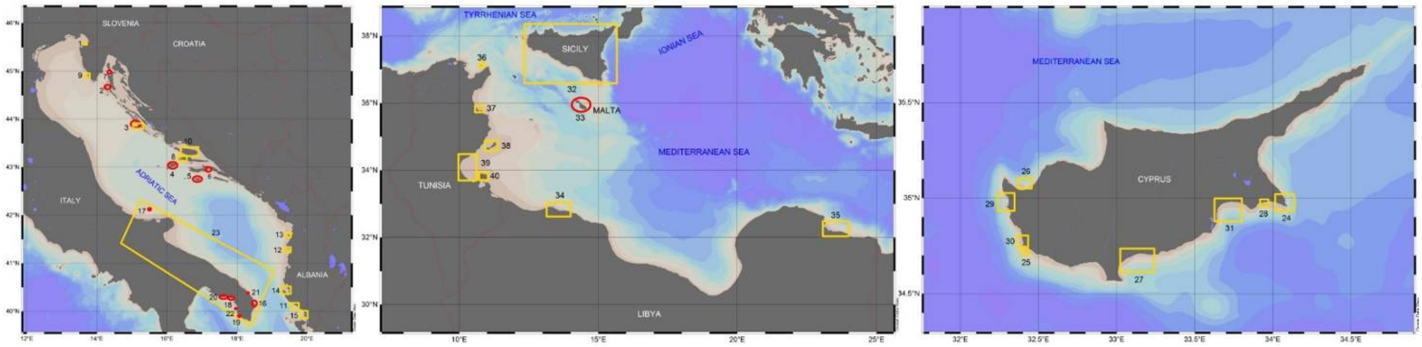


Fig. 3.3.2 - Locations of sampling points (red dots) and polygons (yellow rectangles) in Adriatic Sea, in Sicily (whole coast coverage), Cyprus, Tunisia, Libya and Malta. Numbers are given in Appendix 3.

3.3.3 - Aegean and Ionian Seas

The data on the *Posidonia oceanica* meadows distribution for the Mediterranean sub-basins (Aegean and Ionian Seas) came from the Natura 2000 national monitoring program network conducted by HCMR with support from the Ministry of Environment of Greece. There were 13 out of 76 point data used to determine the deepest point where *Posidonia* occurs bearing out the assumption of infralittoral lower limit light threshold. However, it is appreciated that no more than 20% of the total area could have been covered.

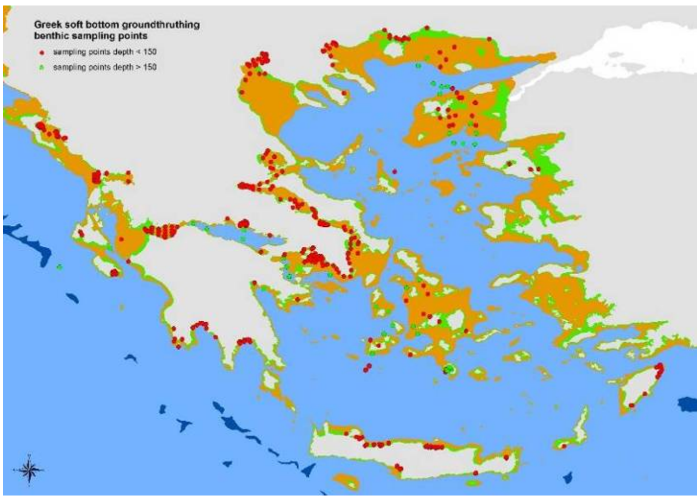


Fig. 3.3.3 - Aegean and Ionian Seas soft bottom benthic ground truth points (red dots: <150m depth, green dots: >150m depth)

Besides, a total of 436 sampling points (Appendix 2) covering 15 EUNIS soft bottom Mediterranean habitats types of Ionian and Aegean Seas were collected for validation the suitability of the modelled habitats of different biological zones. Three infralittoral habitats amounted to 43% of samples (Mediterranean biocoenosis of coastal terrigenous muds A.539, Mediterranean biocoenosis of coastal detritic bottoms A5.46, and infralittoral muds). There were 57 samples collected in order to draw the contours of the plume delineating the unexpected infralittoral muds, according to model outputs. The least number of point data (3) were confined to Mediterranean biocoenosis of fine sands in very shallow waters (A 5.235). For the first time, there were reported 37 biological point samples collected from the Mediterranean biocoenosis of 3 bathyal muds (A 6.51) (Fig. 3.3.3).

3.3.4 - Atlantic Ocean

For the coasts of UK and Ireland data from the UK Marine Recorder database have been acquired by JNCC on two purposes:

- Determination of Infralittoral lower limit light threshold
- Energy threshold analysis

Thus, 3,471 and 3,886 point data samples respectively from rocky infralittoral and circalittoral, have been used to discriminate the infralittoral lower limit light threshold. For the analysis of high/moderate energy infralittoral/circalittoral rock threshold, 611 (high energy) and 777 (moderate energy) point data, respectively were collected. Moderate/low energy threshold was drawn based on 450 (indicating moderate energy) and 274 points (for low energy), respectively.

In Norway data on kelp distribution (presence/absence data) in infralittoral of the Norwegian coast were collected by NIVA. More than 3,000 presence points and almost 400 absence points were recorded. The data were compiled from NIVA's projects, but mainly from the National program for Mapping for Diversity – Coast. These have been collected in order to model the kelp forest distribution in relation to wave energy index and light threshold for infralittoral delineation.

A total of 18,520 ground truth data were collated for habitat mapping of the Mediterranean (512 point data), Black Sea (5,063 point data), North Sea (Norway coast - 3,476 point data) and Atlantic Ocean (Ireland and UK coasts – 9,469 point data).

However, the heterogeneous spatial coverage of biological ground truth data at the level of bionomic zones within each basin is quite noteworthy. Most of the data are concentrated in infra (9,496 point data) and circalittoral (8,484 point data) zones, a hiatus being observed for the bathyal (37 point data) and abyssal ones.

3.4 Thresholds

3.4.1 Rationale

Before the creation of the broad-scale maps in a GIS software, it is necessary to define thresholds for likely changes in habitats: in each input layer these are used to define the boundaries between classes, where the change in the physical conditions reaches a critical point that defines an expected change in habitat type (at the map-scale adopted in EUSeaMap, 250mx250m blocks). For example in the Black Sea the boundary between the shallow circalittoral and the deep circalittoral biological zones is where the change in temperature condition reaches such a point that associations of mud with Abra prismatica, Pitar rudis, Spisula subtruncata, Acanthocardia paucicostata and Nephtys hombergii give way to associations of mud with Modiolula phaseolina. The expected threshold value corresponds to that critical value of temperature.

In order to get threshold values that best fit observations in the field, the thresholds are derived from statistical analyses of field-observation sample data. Where sample data is available for the two adjacent classes (in the aforementioned example sample data of Abra prismatica for the class "shallow circalittoral", and of Modiolula phaseolina for the class "deep circalittoral"), the receiver operating characteristic (ROC) curve is used (Fig. 3.4.1). This tool is commonly used for the determination of the optimal threshold value for any variable having a high discriminatory capacity to differentiate one class from another. Together with the ROC analysis, Generalised Linear Models (GLM) are fitted. GLMs provide an equation that can link any continuous value (in the aforementioned example temperature) to a predicted probability of being in a particular class. Those equations are later used for making maps of the confidence in classification of habitat descriptors (see section Modeling and confidence).

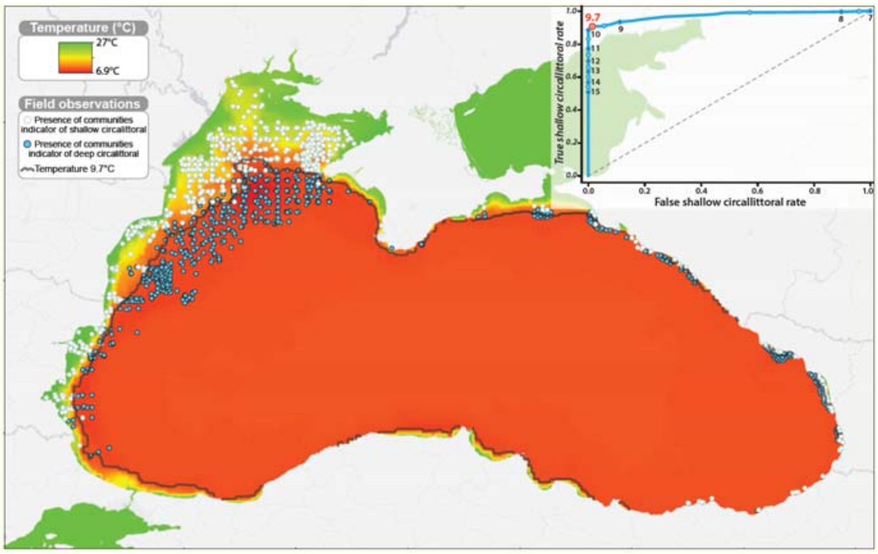


Fig. 3.4.1: Example of threshold identification: the temperature threshold used to separate between the shallow circalittoral and the deep circalittoral in the Black Sea. Map: full-coverage temperature layer and sample points used to construct the ROC analysis; top-right: ROC curve (along which temperature values are displayed), which led to a decision threshold value of 9.7°C. The 9.7°C isoline separating the shallow circalittoral (white dots) and the deep circalittoral (blue dots) is also shown.

3.4.1 Black Sea

An analysis was attempted to find the threshold value of wave energy to use for the **infralittoral/circalittoral** biozone boundary on **soft bottoms**. A wave-induced energy layer was produced from the archives of the Kassandra forecast system. Sample point data specific to infralittoral and circalittoral was collated. The analysis was not successful because the Kassandra model is too coarse for the map-scale adopted in EUSeaMap. Therefore we used the depth as a proxy and performed an analysis to find the depth value.

Similarly we tried to find the threshold value of light at the seabed to use for the **infralittoral/circalittoral biozone** boundary **on hard bottoms**. We tried to use the point occurrences of photophilic species collated by WP1, but we had to exclude many of them because their positional accuracy was deemed inadequate considering the map-scale adopted in EUSeaMap. There were too few points with appropriate positional accuracy to perform a ROC/GLM analysis. With those points we performed a simple histogram analysis of depth values and worked out a threshold value of depth.

The threshold value of temperature used to draw the **shallow circalittoral/deep circalittoral** biozone boundary was defined using a generalised linear model (GLM) together with a ROC analysis.

The shelf edge, which is the slope change that was chosen as the boundary between the deep circalittoral and the bathyal, was manually drawn by HCMR. So was the slope change that was chosen as the boundary between the **bathyal and the abyssal.**

For the **oxic/suboxic/anoxic** classes we chose to use as a proxy the intersection of individual isopicnic surfaces with the seabed. We computed from myOcean archives several polylines corresponding to different isopicnic values. We plotted all polylines together with sample points of species indicator of the suboxic area and kept the 2 polylines that best fitted the point observations, i.e. for **oxic/suboxic** the polyline corresponding to the intersection of 15.6 $kg.m^{-3}$ isopicnic surfaces with the seabed, and for **suboxic/anoxic** the polyline corresponding to the intersection of 16.4 $kg.m^{-3}$ isopicnic surfaces with the seabed.

3.4.2 Mediterranean Sea

The Posidonia oceanica meadows whose lower limit is limited *by light at the seabed* are selected (75 polygons) to estimate the **infralittoral/circalittoral** boundary. The minimum light value of each polygon were extracted using the zonal statistic tool. As the frequency distribution of the data was log-normal, the statistical parameter selected for the identification of the threshold was the geometric mean. This value ± ½ standard error of the geometric mean was used for the identification of the fuzzy interval.

In the Po river plume area the **infralittoral/circalittoral** boundary was detected by running a GAM analysis. The *sediment* datasets were used to define the response variable, sand and *muddy sand for the distribution of the infralittoral zone and sandy mud and mud for the circalittoral zone. The abiotic variables considered as predictors were: wave energy at sea bottom (log10 kinetic wave energy), depth and geographic position (latitude and longitude).*

For the **circalittoral/bathyal** boundary as well as for the **bathyal/abyssal** boundary we chose to use *slope changes*. The lines that correspond to those breaks of slope were manually drawn in the framework of EMODnet Seabed habitat phase 2 for the eastern part of the basin. For the western part we used the boundaries that were drawn in phase 1.

3.4.3 Norway, Celtic Seas and Greater North Sea

For the Celtic Seas and Greater North Sea we reviewed all of the thresholds that were defined in the framework of phase 1. For Norway, we determined biologically-relevant thresholds for the first time.

The threshold value of *light at the seabed* used to draw the **infralittoral/circalittoral biozone** boundary was defined using a generalised linear model (GLM). The input data was a combination of kelp presence and pseudo-absence data from the UK Marine Recorder database[2] and kelp presence and pseudo-absence data generated from data on the lower growth limit of kelp in Norway.

A similar analysis was also attempted to find the threshold value of *wave length/depth* to use for the **shallow/deep circalittoral biozone** boundary in the Celtic Seas and Greater North Sea; however, a lack of data related to this boundary and a lack of a clear indicator species or community meant that we continued to use the same threshold as in phase 1. In Norway, we had a slightly different variable – a fetch-dependent *wave exposure index* – therefore to produce a continuous boundary in Norway we identified a wave exposure threshold that spatially coincided with the boundary caused by the chosen wave length/depth threshold in the Greater North Sea.

A threshold value of *depth to the seabed* was used to draw the **deep circalittoral/upper bathyal biozone** boundary. This was based on the depth of the shelf break in the Celtic Seas. In Norway, the shelf break is much deeper; however, through consultation with deep sea experts, it was decided to continue the 200 m depth-based threshold up through Norway.

In the deep sea we used the latest research of Bett and Jones (in prep) of the National Oceanography Centre Southampton (NOCS), which determined "potential biogeographic zones" at the seabed using k-means clustering, using using multiple variables: depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux. The result was a consistent map of deep sea biozones across a huge area. The Bett and Jones model has a coarser resolution than EUSeaMap (0.25 degrees); this meant in some steeply sloping areas that zones were skipped. Acknowledging that the most influential variable was depth to the seabed, and that we had access to a higher resolution depth to the seabed layer, we determined depth proxies that best matched the zones determined by the Bett and Jones model. These were then used to draw the boundaries between all deep sea biozones **(upper, mid, lower bathyal and upper, mid lower abyssal).**

For the **high/moderate/low energy classes** (due to currents), we used the same threshold values of *kinetic energy at the seabed due to currents* in the Celtic Seas and Greater North Sea in phase 2 as in phase 1, except we excluded the top 10 % of values. This was to account for extreme events which were deemed unlikely to have lasting effects on the habitat type. No new analysis took please due to a lack of clear indicator species. In Norway there was no data on energy due to currents.

For the **high/moderate/low energy** classes (due to waves), we carried out a GLM using sample point data provided the UK Marine Recorder database to find threshold values of *kinetic energy at the seabed due to waves* in the Celtic Seas and Greater North Sea. As with currents, we excluded the top 10 % of values to account for extreme events which were deemed unlikely to have lasting

[2] UK Marine Recorder database: http://jncc.defra.gov.uk/marinerecorder

effects on the habitat type. As with the shallow/ deep circalittoral biozones, the equivalent classes in Norway were based on the *fetch-dependent wave exposure index* and to produce a continuous boundary we identified a wave exposure threshold that spatially coincided with the boundary caused by the chosen energy-based thresholds in the Greater North Sea.

3.4.4 Bay of Biscay, Iberian Peninsula, Azores, Canary Islands

The thresholds that were previously identified within the framework of the MeshAtlantic project were largely reused. However,

- The threshold values identified in the studies carried out in EMODnet phase 2 for Norway, Celtic Seas and Greater North Sea (see above section *Norway, Celtic Seas and Greater North Sea*) were used instead of MeshAtlantic's ones for the **infralittoral/circalittoral** boundary and for **deep sea biozones (upper, mid, lower bathyal and upper, mid lower abyssal).**
- The **shallow circalittoral/deep circalittoral** boundary threshold was recalculated for the Bay of Biscay in order to take into account inputs from a new high resolution wave model.
- Similarly new fine-scale inputs for wave- and current-induced energy for the bay of Biscay led to define new thresholds for the classification into **high/moderate/low** energy EUNIS categories.

3.5 Modelling and confidence

Under this work package (WP5) we designed and ran a model to produce broad-scale habitat maps (the product we call "EUSeaMap") and maps showing confidence in these predictions. The work was led by JNCC and the models were developed and run by GEUS (Baltic), Ifremer (Mediterranean and Black Sea) and JNCC (Atlantic and Arctic). At the end of year 2 (Sept. 2015) we extended the coverage of EUSeaMap to include all European Seas and released these as draft interim products. For the first time there was a broad-scale habitat map for Central and Eastern Mediterranean, Black Sea and Norway. Furthermore, draft updates were made to the existing maps, i.e. Baltic Sea, Greater North Sea, Celtic Seas, Iberia, Biscay, Atlantic High Seas and Azores. In the final year, we have made further updates to input datasets and methods which has led to the release of updated official top copies of the maps for all European Seas, with associated confidence maps (see 3.5.1 for timeline).

3.5.1 Running the models – full coverage matching EMODnet Bathymetry resolution

The models created to produce the habitat maps were designed and run in ArcGIS ModelBuilder. They work by taking the input continuous physical variables (e.g. wave energy and current energy) collated in WP2 and classifying them into habitat descriptors (e.g. energy; high, moderate, or low) based on biologically-relevant thresholds determined in WP4. The spatial location of different combinations of classified habitat descriptors led to a prediction of a habitat type, which was matched up to an existing code in the EUNIS habitat classification system, wherever possible.

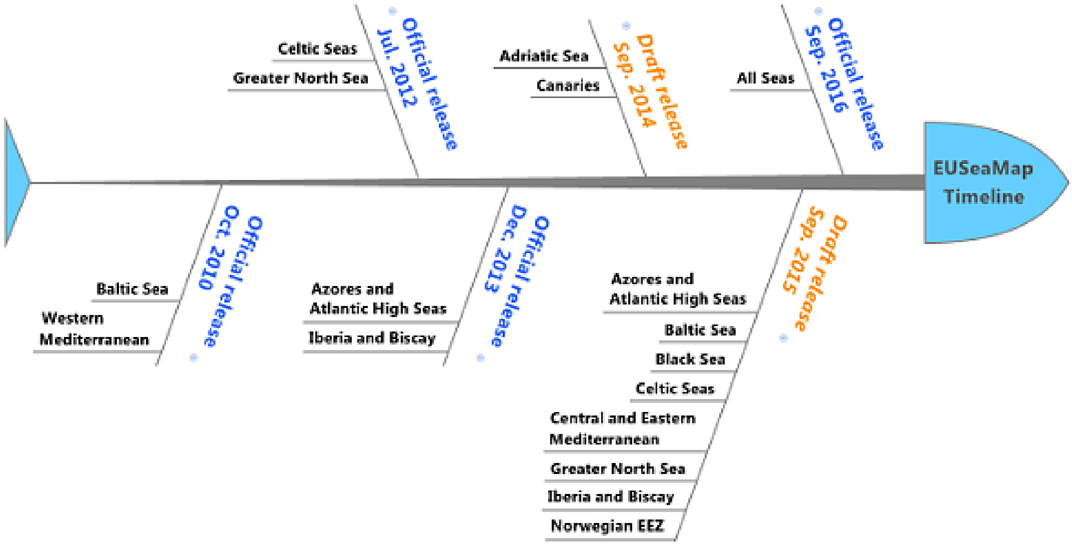


Figure 3.5.1 - Release timeline for broad-scale habitat maps in Europe.

Different input datasets and therefore different habitat descriptors are used in different basins (Table 3.5.1). The specific input datasets and habitat descriptors used were chosen to be ecologically relevant to their associated basins. All input data layers were converted to raster format where necessary and all rasters were regridded and resampled to match the grid and cell size of the EMODnet Bathymetry layer.

Table 3.5.1: Summary of habitat descriptors used in each region. The usage of each of these depended on (a) biological relevance and (b) data availability.

Habitat descriptor	Arctic Seas	Atlantic Seas	Baltic Sea	Black Sea	Mediterranean Sea
Biozone					
Substrate type					
Energy class					
Plume area					
Oxygen regime					
Salinity regime					

Every boundary in the broad-scale habitat map apart from those drawn by hand (mainly substrate), have been represented by both a "hard threshold" (a line) and a "soft threshold", i.e. a gradual transition, represented by a value between 0 and 1, indicating the degree of membership of each class (see Figure 3.5.2 and described further in WP4). The latter were usually defined using a range of uncertainty around the hard threshold value, e.g. 200 m +/- 20 m. However, in phase 2 we have also used GLMs to find the optimum hard threshold for several boundaries (e.g. the boundary between infralittoral and circalittoral biozones in the Atlantic). As well as offering a hard threshold value, the GLMs also gave us an equation that can link any continuous value to a predicted probability of being in a particular class. Therefore the model had to be updated to facilitate the use of GLM-derived predicted probabilities.

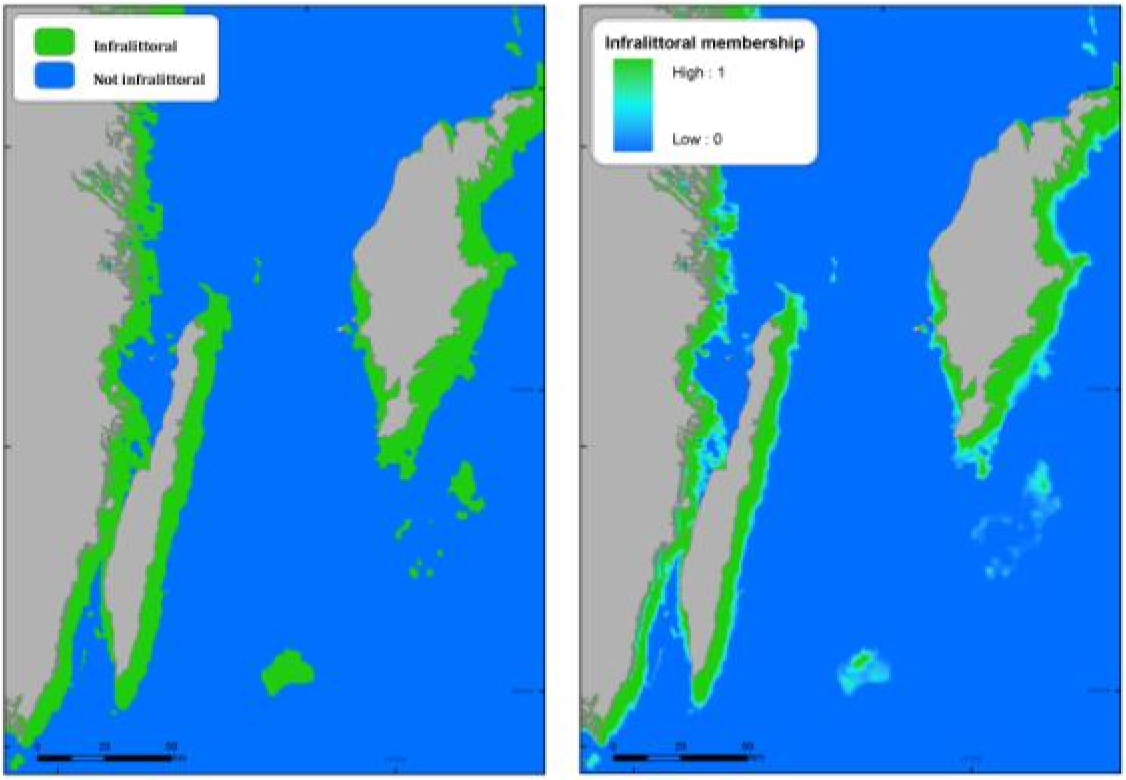


Figure 3.5.2 - Example of a hard (left panel) and soft classification (right panel) of the infralittoral zone around Gotland and Öland in the Baltic Sea using depth : secchi depth quotient. The differences can be observed in the boundary zones of the habitat, where the soft classification results in a gradient of membership to the biological zone, itself a measure of confidence related to the threshold used (from Cameron and Askew, 2012). Once the habitat descriptors were all calculated they were combined and used to predict the final habitat. For example, a pixel with the following habitat descriptors; Energy = high, biozone = infralittoral, and substrate = rock, would be assigned the habitat "A3.1 high energy infralittoral rock".

Habitats are given at the most detailed level of the EUNIS hierarchy possible, based on the available habitat descriptor information. A target of EUNIS level 3 was aimed for and was exceeded in some instances where a level of 4 or 5 was achieved. However, on occasions where a sufficient habitat descriptor information was missing (usually due to missing substrate data), it was not possible to assign a EUNIS habitat so only the available information is provided. For example "low energy circalittoral seabed" would be assigned to an area where energy and biozone information is available, but no substrate data has been collected.

Outputs from model were reviewed and any obvious errors, due to problems in source data or predicted habitats considered to be highly unlikely were corrected.

3.5.2 Running the models – Higher resolution case studies

The high resolution case studies were designed to give prospective guidance for phase three in two ways: i) assessing the present state of the art of data coverage to take the broad-scale resolution from 250 to 100m (the latter being a phase 3 requirement), ii) producing 100m resolution examples on a regional basis, iii) assessing very high resolution (VHR at 50 and even 25m) to show their particular value on local examples, as an incentive to target future efforts.

Gap analysis for a future 100m resolution broad-scale map

The analysis was carried out for the whole of Europe based on the best data sets currently available for bathymetry, seabed substrate, light energy and exposure at the seabed, these being the main inputs to the model. The various steps of this study are detailed in Appendix 4.

In a first approximation, due to still limited oceanographic data sets compatible with 100m resolution, we limited the feasibility to combining the two variables "depth" and "substrate" as shown in Fig. 3.5.3. The most striking gaps are the Baltic Sea and Denmark, most of Italy and Greece, where the limitations comes from bathymetry (known to be "restricted" in the Baltic Sea) and parts of France and Spain in the Bay of Biscaye, where the limitation rather comes from substrate. This gap analysis would need to be discussed with both the Bathymetry and Geology lots to examine in phase 3 how this could be tackled.

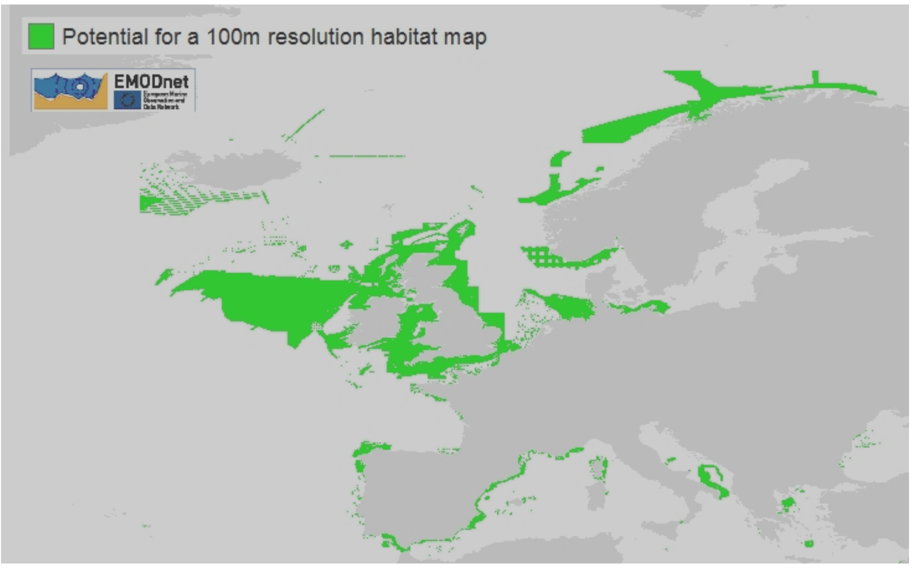


Figure 3.5.3: Combination of depth and seabed substrate suitable for a 100m model.

100m model for the UK continental shelf, Greater North Sea and Celtic Seas

For the extent of the UK continental shelf, we were able to replace two of the input data layers with data layers of a higher resolution:

- Seabed substrate: knowing that the seabed substrate data in the EMODnet Geology output is at a resolution closer to 100 m than the 250 m required by the project; we regridded this layer with a cell size of 100 m in order to make best use of the existing resolution.
- Depth to seabed: JNCC has access to a national DEM covering the UK continental shelf at a resolution of 1 arcsecond (roughly 30 x 90 m), much higher than the resolution of the EMODnet Bathymetry DEM.

The model was run according to the same rules as for the broad-scale map in the Greater North Sea and Celtic Seas, but using a grid resolution of 100 m. For the other input layers, this meant regridding them to a finer resolution than their information should permit; however, the result is a habitat map that makes the best use of the available depth and substrate data.

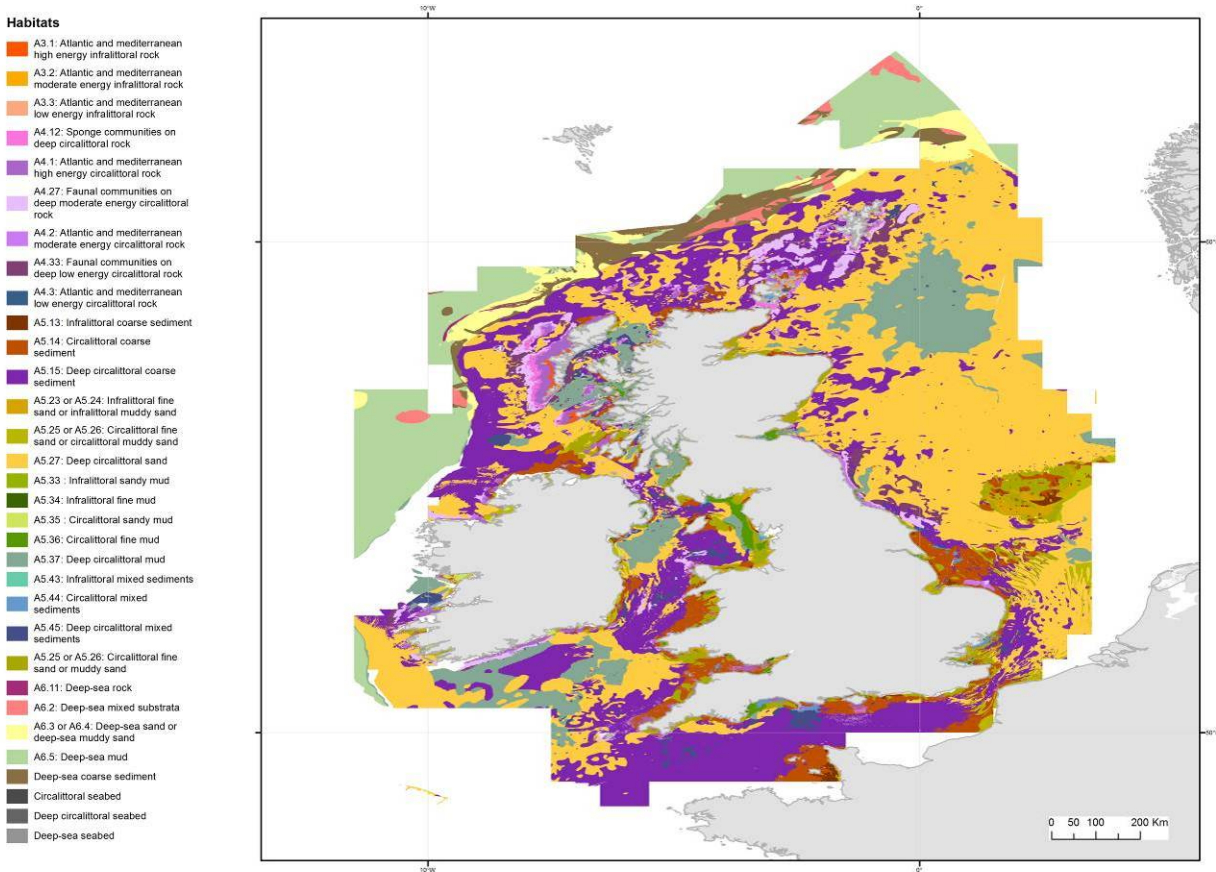


Figure 3.5.4 - Predictive habitat map of North and Celtic Seas at a resolution of 100m. The extent of the habitat map is restricted to areas where high resolution bathymetry data is available.

100m resolution model for the coast of France

In France, the 100m was orgininally run in 2010 in a contract for the AMP Agency using best depth and substrate data available at that time. The resolution of energy data (around 2km) was then far from meeting the requirements, so the results for hard bottom had to be used with caution. Since then improvements came from better oceanographic models: the computation of waves underwent great progress over the period, leading to a 300m resolution climatology. For currents, owing to resources from this Project, the climatology was taken from the former 2km to a resolution of 500m. Therefore these two new data sets could now suitably be input to a 100m model. However for the sake of homogeneity we thought we would rather leave this work for the third phase when other partners will be able to come up with enhanced oceanographic models and the 100m model will be more of a joint achievement.

VHR case study on the East of Scotland, Greater North Sea

For an area to the east of Scotland, we collaborated with EMODnet Geology to produce a habitat map in the same area as they conducted a case study to use statistical modelling to predict sediment types as opposed to the manual delineation common in the majority of the EMODnet Geology substrate product (Diesing, 2015). In this area the following input datasets were used:

- Seabed substrate: EMODnet Geology provided the map of predicted seabed sediments at a resolution of 50 m. We used the outputs of a recent rock-mapping exercise in the North Sea (Downie et al, 2016) to supplement the sediment map.
- Depth to Seabed: the same bathymetry dataset as used by the EMODnet Geology case study (at a resolution of 50 m) was also provided by Cefas for the same area as the substrate dataset.

The model was run according to the same rules as for the broad-scale map in the Greater North Sea, but using a grid resolution of 50 m. For the other layers, this meant regridding them to a finer resolution than their information should permit; however, the result is a habitat map that makes the best use of the available depth and substrate data in this area.

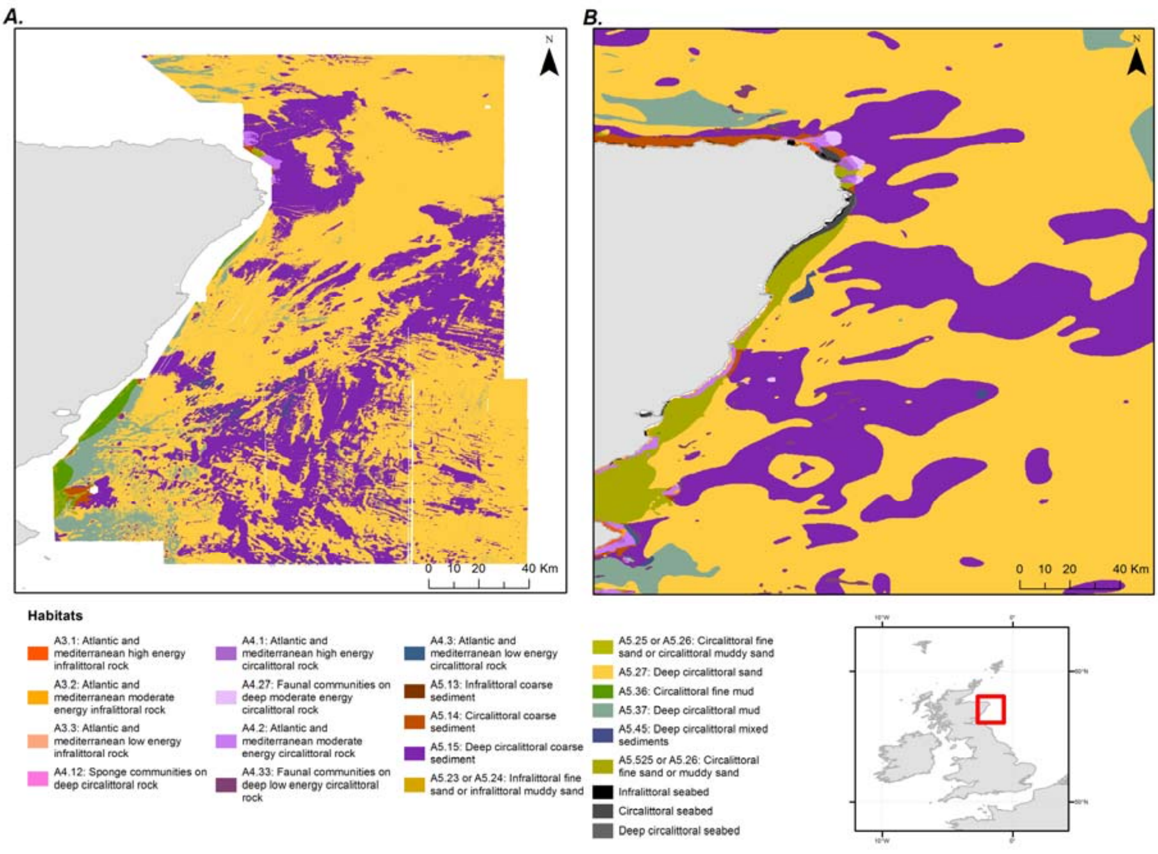


Figure 3.5.5: Side by side comparison of the VHR case study in the East of Scotland (A) and the EMODnet broad-scale map of Atlantic Seabed habitats (B).

VHR case study on Pontine Islands, Western Mediterranean

The availability of high resolution substratum data allows in specific and spatially reduced areas to test the improvement of seabed habitat modelling with respect to the entire broad scale habitat map produced by this project. In this exercise the number of modelled habitats is the same as that of the broad scale map in the Western Mediterranean. Three different high resolution models were tested: 25, 50 and 100m.

The Pontine Islands are a Tyrrhenian Sea archipelago located in front of the Gaeta Gulf (distance about 50 km). The archipelago is the result of volcanic activity and consists of 6 islands.

High resolution models in this test site were carried out using the following layers:

- Substrate: CARG map 1:50000 converted into 25-50-100 and 250m grid resolution;
- Bathymetry: mosaic of the 25 m resolution layer derived from the hydrographic service and 5 m resolution layer derived from multibeam survey converted into 25-50 and 100m resolution layers;
- Percentage of light reaching the seabottom calculated using the KdPAR layer available for the broad-scale model and the bathymetric layer at the resolution requested by the case study;
- Posidonia meadows collected cartographies.

The comparison between the resulting modelled maps at different scales with the broad scale habitat map obtained using the Geology lot delivery highlights different issues (Fig. 3.5.6). The most important aspect is the possibility to model habitat of conservation interest but characterised by small areas of hard bottom. Other aspects are more strictly linked to accuracy of high resolution input data which allow to better identify the boundaries between biozones and/or habitats. Finally, this exercise highlights the importance to simply convert the original map into a raster (i.e. by applying automatic GIS rules such as the maximum combined area within each pixel) instead of deleting features not mappable at that theoretical scale.

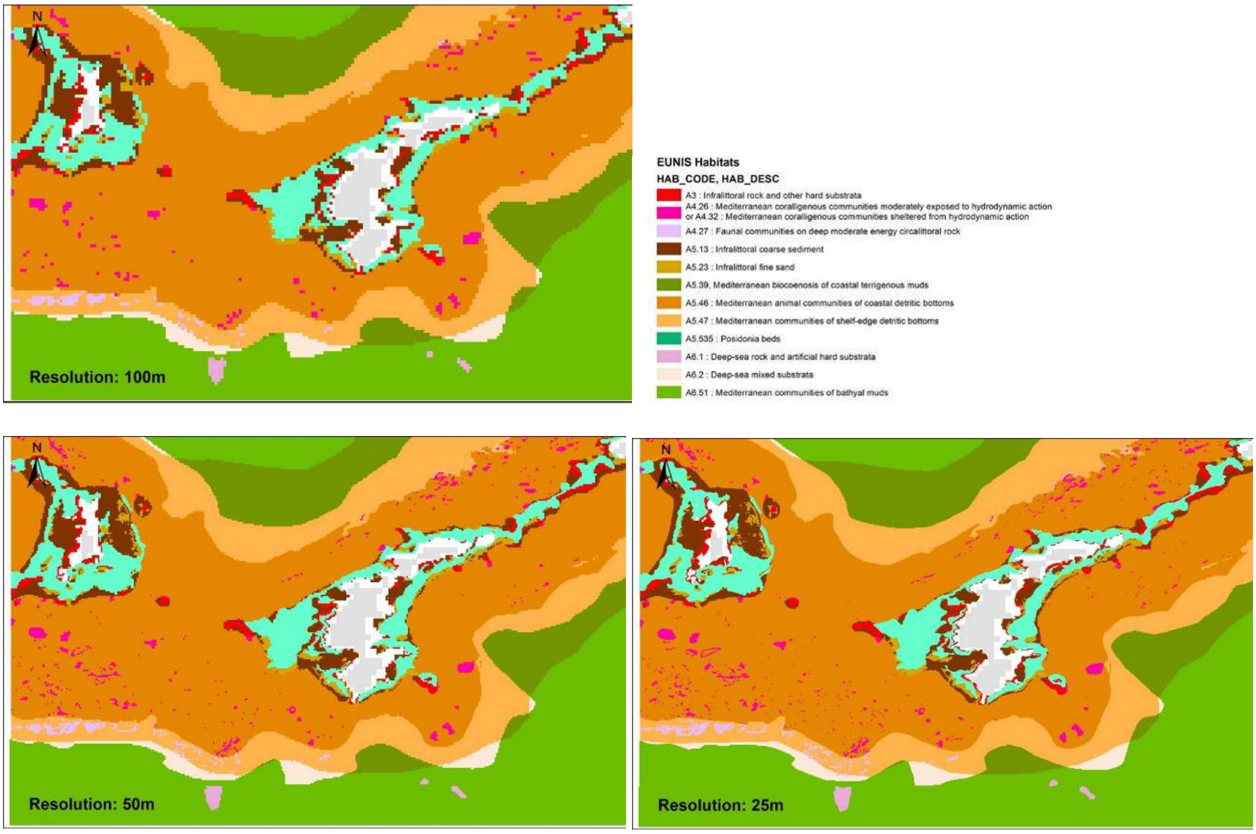


Fig. 3.5.6: High resolution model at resolution 100m (top), 50m (bottom left) and 25m (bottom right).

3.5.3 Confidence assessment

In year 3 of the project we have developed a confidence assessment method that follows a consistent structure and method for all regions, despite the multitude of different data types and methods. This will ensure that a user can easily understand the sources of uncertainty in the habitat map in any location. The method is briefly described below, with more detail given in the forthcoming technical report to be delivered by end Nov. 2016. The simple confidence assessment method resulted in a hierarchy of confidence assessments, related to the three levels of information associated with the habitat map (Fig. 3.5.7).

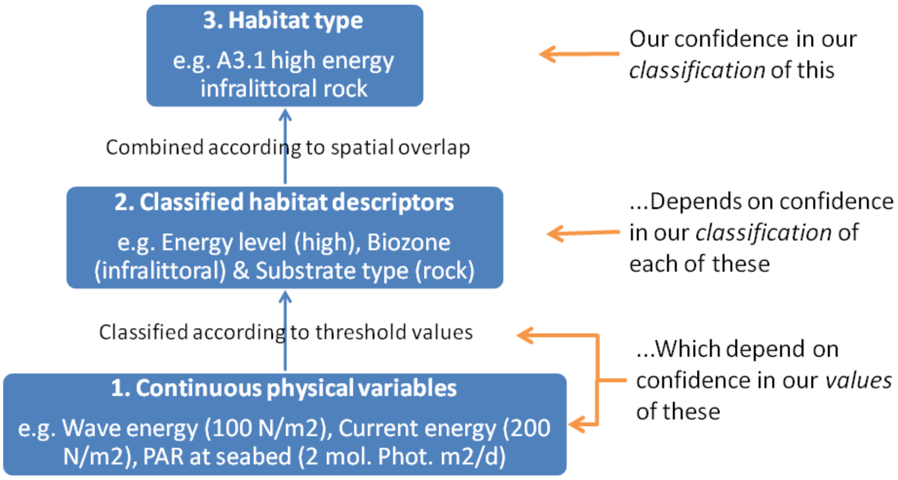


Figure 3.5.7 - Diagram summarising the three levels of data involved in building EUSeaMap, and how confidence in each layer relates to the confidence of the others.

The principles behind the method at each of the three levels (described below) were:

- Each assessment should be simple to describe and apply, so that users can understand what they mean.
- Each assessment should result in a rating of high (H), moderate (M) or low (L) confidence. This ensures consistency across data types and regions, and reflects the lack of detail available to produce a more detailed assessment in most cases.
- Confidence in the classification of the habitat type should be derived from the confidence in the relevant habitat descriptors that were overlaid to determine that habitat type.
- Confidence in the classification of habitat descriptors should be derived from the confidence in the relevant continuous physical variables and threshold values. If this is not possible (e.g. manually classified substrate type) then confidence in the classification of habitat descriptor should be calculated be other means.

Confidence in values of continuous physical variables

Assessment at this level asks: "how confident can we be that the value correctly describes the conditions of a variable that influences seabed habitats"? This considered factors such as:

- Quality of training data and methods used to construct the model.
- Temporal resolution.

- Spatial resolution

Using a combination of available data and expert judgement, a confidence assessment at this level was carried out for each input data layer. For example confidence was assigned to the amount of light at the seabed based on a combination of the number of satellite images taken in order to acquire light at the surface and light attenuation data, and the bathymetry quality index from EMODnet Bathymetry. A full description of each method is given in the scientific report due for delivery on 30 Nov.

Confidence in classification of habitat descriptors

Habitat descriptors form the component parts of the names of habitat types, e.g. the habitat "high energy infralittoral rock" is composed of three habitat descriptors: energy class (high energy), biozone (infralittoral) and substrate type (rock). Classified habitat descriptors (Table 3.5.1) are predominantly created through the classification of the continuous physical variables according to biologically-relevant thresholds (as described in WP4, above).

Assessment at this level asks: "how confident can we be that the habitat descriptor class is correct, considering the confidence in the (a) values and (b) threshold values of the continuous physical variables (or some other method for manual delineations)"?

To assess the confidence in the classification of the habitat descriptors per cell, the Confidence in values of continuous physical variables was combined with the information on the uncertainty of the threshold values determined in WP4; these two things were combined according to the following steps.

- Step 1: Create layers of confidence in classification of habitat descriptors based only on threshold uncertainty

Using the boundaries and uncertainties determined using the methods described in WP4, the following methods were used to produce a layer corresponding to each class boundary, classified according to three categories: high, moderate and low.

For boundaries based on a single threshold value with a range of uncertainty, the 0-1 membership values determined in WP4 were categorised according to Table 3.5.2. (see Figure 3.5.8 for example output).

Table 3.5.2: criteria used for categorising confidence in classification of habitat descriptors based on uncertainty in the hard threshold value.

Confidence per cell	Criteria
High	0.8 ≤ membership ≤ 1.0
Moderate	0.6 ≤ membership < 0.8
Low	0.5 ≤ membership < 0.6

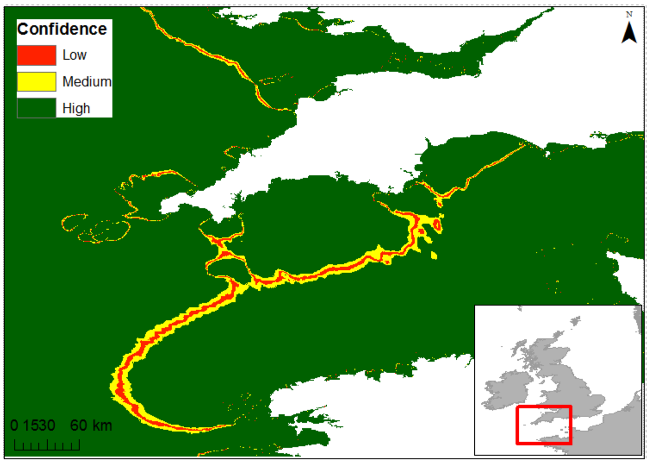


Figure 3.5.8 - Example map of confidence in classification of current energy class based only on threshold uncertainty.

For manually-drawn boundaries, two horizontal buffers were applied to each boundary – a narrower buffer corresponding to the boundary between low and moderate confidence and a wider buffer corresponding to the boundary between moderate and high confidence. This applies to just two sets of boundaries: circalittoral/bathyal/abyssal biozone boundaries in the Mediterranean Sea and oxic/suboxic/anoxic oxygen regime boundaries in the Black Sea.

- Step 2: Combine layers from step 1 with confidence in values of continuous physical variables to create a single confidence layer related to each habitat descriptor boundary.

At this stage each grid cell had a high/moderate/low score relating to confidence in the values of the continuous physical variable(s) (e.g. salinity at the seabed) and in the classification of the habitat descriptor boundary based only on threshold uncertainty. The next step was to combine these scores into a single high/moderate/low score per grid cell. The principles for this combination (Table 3.5.3) were based on the assumption that the main cause of uncertainty in the classification was the uncertainty in the threshold value (and proximity to that boundary).

Table 3.5.3: Logic used for combining confidence scores.

		Confidence in values of continuous physical variables		
		H	M	L
Confidence in classification based on threshold values	H	H	H	M
	M	M	M	L
	L	L	L	L

Finally, these boundary-specific confidence layers were combined to create a single confidence layer per habitat descriptor. Because of the different ways data were used to create the different habitat descriptor layers, slightly different approaches were taken to complete this step. The details for each habitat descriptor will be provided in the scientific report.

- Special case: Substrate type

Substrate type is the only habitat descriptor that was pre-classified before inputting into the model; I.e. there are no continuous physical variables involved. As a result, an alternative approach was followed to produce a confidence assessment at this level for substrate type. The EMODnet Geology project, which produced the seabed substrate type layer also produced a confidence assessment ([reference]). The assessment is qualitative, based on acoustic coverage, ground-truthing density and ease of detection of boundaries. The result is a score between 0 and 4, which we converted into high (3 or 4), moderate (1 or 2) and low (0 or no information) categories.

Combination of class confidence to get habitat type confidence

Assessment at this level asks: "How confident can we be that the habitat type is correct, considering the confidence in the habitat descriptor classes"?

To obtain a single confidence layer for the final habitat type, the confidence in the classification of the relevant habitat descriptors were combined. For each grid cell, the confidence in final habitat class was the minimum of all relevant habitat descriptor confidence scores. For example, a cell of A3.1 high energy infralittoral rock with 'low' energy class confidence, 'moderate' biozone confidence and 'high' substrate type confidence would have an overall 'low' confidence (Fig. 3.5.9).

It is important to note that a habitat type confidence score is only relevant to that particular level of the classification system. Using the example above, going up from EUNIS level three (A3.1) to EUNIS level two (A3 – Infralittoral rock) removes the energy class; therefore the confidence of the EUNIS level two habitat type would only consider the 'moderate' biozone confidence and 'high' substrate type confidence, resulting in an overall 'moderate' confidence.

Publication of data products

All of the confidence assessments have been published on the web portal. Whenever a user clicks on the habitat map, the pop-up information box will tell them (a) the confidence in the habitat type and (b) the confidence in each of the habitat descriptors (Fig). In addition, when a user requests to download any of the broad-scale habitat maps, they will also receive the confidence layers by default.

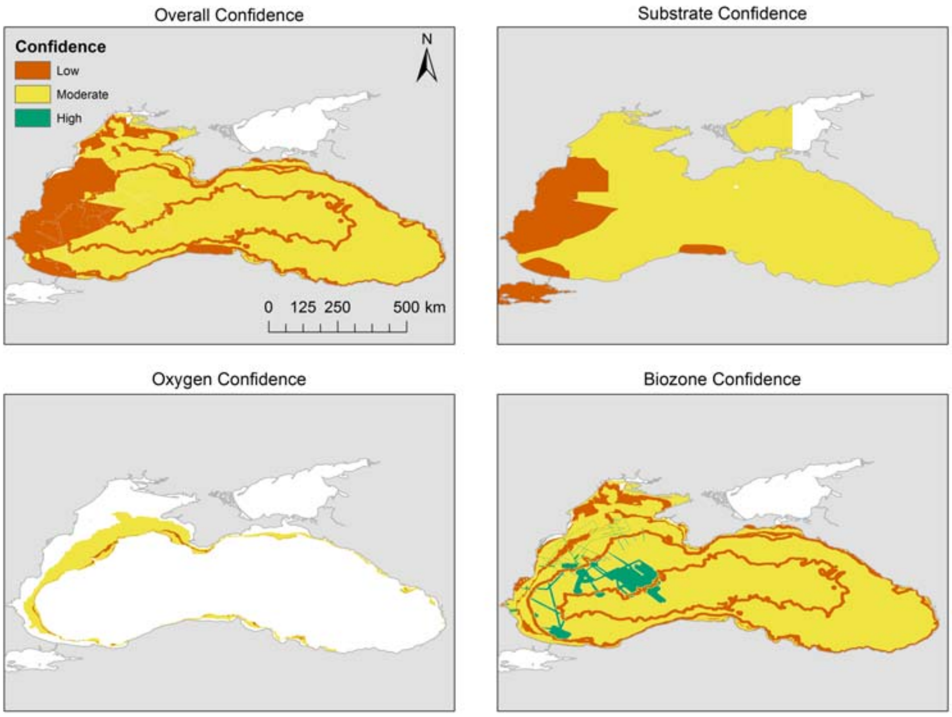


Figure 3.5.9 - Demonstration of how a an overall habitat confidence map is created by using the lowest confidence of the three habitat descriptors (Substrate, oxygen density at the seabed, and biozone) used in the Black Sea. Note that confidence in oxygen density at the seabed is only used as a habitat descriptor in the deep circalittoral biozone, and so has been clipped to the relevant area.

3.6 Web portal

Under this work package (WP6) we created a web portal to enable a single point of access for data and information collated and created by the EMODnet Seabed Habitats lot, creating close links with WP3 and WP5. This comprised of information webpages regarding the project itself and its outputs and a "webGIS" aspect, containing an interactive map, data download page and metadata search function. JNCC led the work through both in-house development and, where necessary, through a sub-contract with exeGesIS SDM Ltd.

The initial build of the website and webGIS was derived from the existing EUSeaMap and MESH portals, which EMODnet Seabed Habitats superseded. This initial portal was then developed further towards the particular requirements of the current project identified by guidance from the EMODnet Secretariat, portal users and expertise within the project partners.

3.6.1 Interactive map

The interactive map was initially created via a merger of the MESH and EUSeaMap portal, both run by JNCC using the same underlying architecture.

Over the project, several improvements were made to the user interface of the interactive map. The UI was streamlined to improve user experience and aid viewing of the map on congested screens such as projections, with the ability to hide the side panel and move the toolbox away from the map view itself and the table of contents was rearranged following user feedback, providing more intuitive layer groupings to aid users in finding relevant datasets. The MESH branding was slowly phased out over the project.

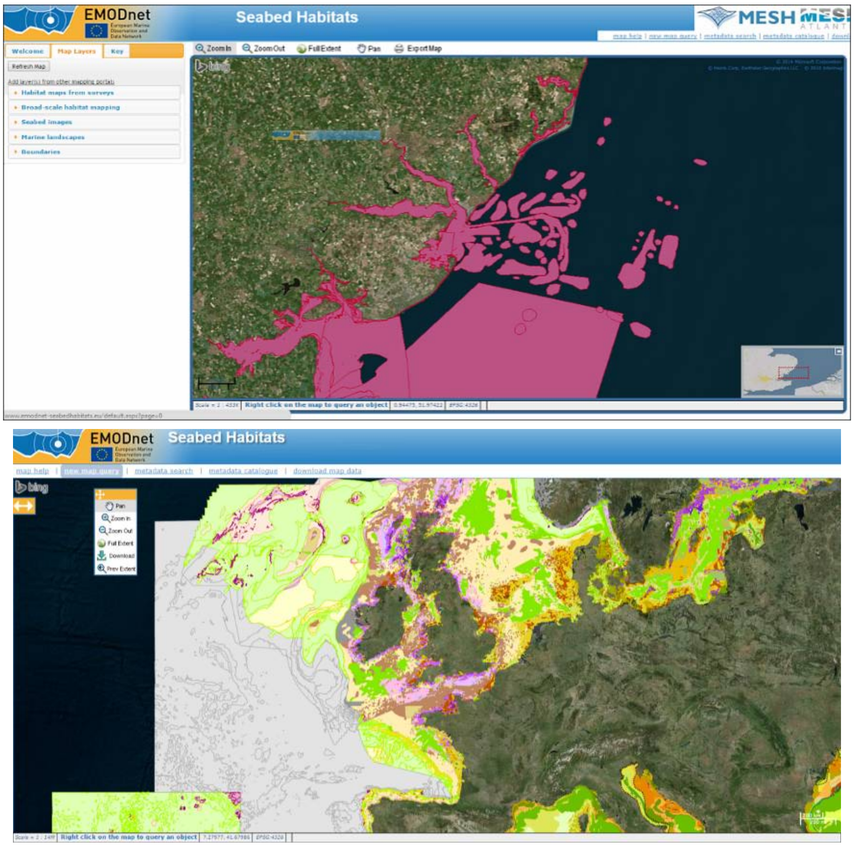


Figure 3.6.1: Comparison of interactive map original format (top), and new format (bottom) showing larger viewing extent and ability to hide the side panel.

We revised the original MESH system of storing and disseminating habitat maps from surveys as a single combined dataset with overlaps removed. Instead we held habitat maps collated through work package 3 as full individual datasets, displayed together using one of three rough scale groups (broad, medium or fine), but accessible as an individual dataset by the user when downloading the data packages or viewing the survey on the interactive map. This allows end-users to have control over how they use and combine the individual survey maps, and fills a requirement for a European storage location for habitat mapping data. The original MESH approach is still an option for the user; recombining the individual habitat maps by their confidence score will result in an equivalent product.

Through JNCC's close work with the OSPAR commission, the Seabed Habitats portal is currently the official location of the OSPAR database of threatened and/or declining habitats, and is referenced by OSPAR through their data access page and metadata. The dataset is available to view on the interactive map – filterable by OSPAR habitat through the Map Query page of the portal – and the full public dataset is available to download.

Following feedback from the steering committee review of the portal, we improved the links between the metadata search page and interactive map to allow the user to directly view only the survey map in question and improved the query page to add functionality to filter by OSPAR habitat, zoom to country EEZ and turn on relevant map layers when filtering by EUNIS habitat.

The download page features zipped packages of the available datasets, available freely and without login for ease of access, though retaining basic usage statistics. The original system of offering the large habitat maps from survey datasets as a single composite layer was first developed to offer the individual datasets as multi-dataset zip packages. We have now developed this even further to offer available maps as individual downloads should the user require this. This enables users to more precisely select the maps which they would like to download, decreasing wait time, server load and unwanted data for users.

In addition, following the request of the steering committee we developed the download page to allow users to arrive at the page with downloads preselected. This enables all downloads to be handled via the download page and links from layers in the interactive map to their respective downloads to be retained; a user can now easily follow a data layer on the interactive map right through to the final download outcome.

3.6.2 Data standards

Following on from the MESH project, the project has continued to lead in data standards for European habitat mapping. The MESH data exchange formats have been subsumed as the EMODnet Seabed Habitat Data Exchange Formats (DEFs) and updated through the project. Following efforts to collate data regarding habitats identified within Annex I of the EU's Habitats Directive, we created a new 'habitats directive' DEF. Links and compliance between the DEFs and the INSPIRE data specifications have been maintained through consulation with the INSPIRE team, resulting in the full INSPIRE compliance of the 'translated habitat' and 'habitats directive' DEFs.

Use of common data standards amongst datasets available through the portal has resulted in their increased ability for use in external projects requiring data collation and integration into composite products. Examples of project using EMODnet Seabed Habitats data in this way can be found in section 7 (User feedback).

3.6.3 Data contribution & guidance

A 'Contributing data' section was added to the portal to guide potential data suppliers in the preparation of standardised survey data. The development of this section resulted in a standard step-by-step process for potential suppliers to follow and the creation of ArcGIS/python tools to enable users to standardise and validate their own data.

3.7 Application of broad-scale maps

Our overarching objective has been to achieve a pan-European overview of the use of broad-scale seabed habitat maps (BSSHM) developed by UKSeaMap, BALANCE, MESH, MeshAtlantic and EUSeaMap with regard to the implementation of the EU Marine Strategy Framework Directive and also in regard to some related processes based on the Ecosystem Approach.

The MSFD aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. The Directive enshrines in a legislative framework the Ecosystem Approach to the management of all human activities having an impact on the marine environment, integrating the concepts of environmental protection and sustainable use. In order to achieve GES by 2020, each Member State is required to develop a strategy for its marine waters (or Marine Strategy) including an Initial Assessment as well as Programmes of Measures. In addition, because the Directive follows an adaptive management approach, Marine Strategies must be kept up-to-date and reviewed every 6 years. Given the legislative requirements, especially with regard to the contents of the Initial Assessment in combination with the Ecosystem Approach, Member States are in practice required not only to carry out comprehensive monitoring and assessment activities but also to include the best available knowledge, i.e. maps of broad-scale seabed habitats developed in parallel to MSFD implementation processes.

In order to describe and document the use of broad-scale seabed habitat maps developed by previous projects and now updated by EUSeaMap 2, work has focused on the following 2 key activities, as well as 2 lesser tasks in relation to an initial literature survey as well as a description of the history of broad-scale seabed habitat maps development in Europe:

3.7.1 Survey questionnaire

A survey based on a questionnaire has been carried out to gather information on the use of BSSHMs in assessment and reporting in Europe, in particular in work related to MSFD and Marine Protected Areas assessments. The questionnaire was divided into 4 parts dealing with the following aspects: Part 1: MSFD initial assessment (7 questions), Part 2: next MSFD assessment and MSFD indicators development (8 questions), Part 3: Marine Protected Area evaluations (11 questions) and Part 4: Profile of the respondent (3 questions). Respondents were given the option to omit answering a section (parts 1, 2 and 3 only) if they were not involved in that particular part of the work, by answering “no” to the first question at each section. Part 1 included 4 questions aimed at understanding whether a BSHM was available for the country (or part of the country) and used in the 2012 first EU member state MSFD assessment (as per Art. 8 of MSFD directive). The questionnaire allowed respondents to provide comments and specify which maps, if any, were used. In part 2 similar questions were asked about the likely use of BSHM for the next MSFD assessment, to be prepared for 2018. Two optional questions were included with the aim of gathering examples of use of BSSHM for the purpose of MSFD GES determination and monitoring, as some countries are in the process of developing indicators (as per art. 10 of MSFD directive). Part 3 focussed on the use of BSHMs for Marine protected areas (MPA), for site selection and in network assessments. Respondents were given the opportunity to provide further details on the BSHM used, the types of assessment carried out and the geographic scale of the analysis. The contact details of the respondent and the country assessed were collected in Part 4. Contact details were used if further clarification on answers was required. The questionnaire was sent to the members of the Marine Expert Group (established under the EU Nature Directives) and the Marine Strategy Co-ordination Group comprising 23 European Union Member States having jurisdiction over marine waters. Members of the group were given the option to forward the questionnaire to national experts where necessary. The survey was thus directed at a total of 141 experts, representing an average of 6.1 respondents per Member State. A notification email was sent to the contacts providing the online link to the questionnaire, explaining the reasons of the survey and defining the BSSHM concept. The survey was kept open for 4 weeks and a reminder was sent to non-respondents 10 days after the first email (See also 5.1.2 below).

3.7.2 MPA assessment within Regional Sea Conventions

The technical reports produced within the framework of RSCs were queried with an internet specific search, directed at RSC portals, so as to identify MPA related network assessments dealing with seabed habitats. These reports were screened so as to identify the MPA assessments which were carried out at a marine regional/sub-regional scale with the support of BSSHMs. A synthesis of each report was constructed containing information on: the year of assessment, the marine geographic region object of assessment, the name and typology of the broad scale habitat map considered, and a brief synthesis on the aspects for which the habitat map was used in the MPA assessment. The bibliography of each analysed RSC report on MPA network assessments was also screened in order to identify other existing regional/sub-regional/national assessments that may have used BSHMs within MPA related assessments. In such cases the reports of the national assessments were also analysed in the same manner as the RSC reports. Considerable resources have been spent on a synthesis of the results of the above described activities with the aim of submitting by the end of September 2016 the following manuscript to Frontiers in Marine Science's new Research Topic 'Horizon Scan 2017: Emerging Issues in Marine Science': "On the use of broad-scale seabed habitat maps in the context of ecosystem-based management".

Further, we are - as a spin out activity from EUSeaMap 2 - aiming to follow up on how key EUSeaMap 2 deliverables, i.e. the updated broad-scale seabed maps are being used by Regional Marine Conventions and by competent national authorities with regard to both regional marine quality status reporting and the upcoming MSFD Initial Assessment. A few uses of EUSeaMap 2 products have already now been identified, e.g. the second HELCOM Ecosystem Health Assessment, also known as HOLAS II (see also page 39).

4. Challenges encountered during the Project

- The main challenges identified along the course of the Project are listed in the table below.

Challenge	Description	Measures taken	Degree of success
Habitat classification	• EUNIS is still too little developed in Black Sea, with absence of concerted regional scientific documents attesting biozones and benthic bionomy, while some flaws still exist in Mediterranean. • A big unplanned challenge was how to deal with river plume areas where physical variables and habitats change dramatically. • EUNIS is not consistent in the way terms are applied, e.g. the sediment types and the biozones. This means that it is difficult to apply consistent approaches in all basins.	• Some of the partners took part in EUNIS upheaval • Introduce more modifiers in EUNIS for marine waters with river influence • Compromises were often taken that did not suit all regions equally. In other cases, we accepted the differences.	Good Good Average
Biological ground truth data collation	• There is still a shortage of habitat sample data in Eastern Med. and the Black Sea which jeopardized thresholds work.	• Proxies were adopted in some instances (e.g. depth contours)	Average
Habitat map collation	• Mediseh modelled maps were hard to secure and make available, in spite of this being a FP7 project. • Collating data from outside the partnership (e.g. Croatia) was not successful • Collating data from third party countries or regional organisations was partly successful because of inherent difficulties	• DG/MARE was activated. It should be made easier with the "Data Ingestion Facility". • Letters and requests. In future, include country in partnership. • Letters and requests. In future make more pressing lobbying.	Full Nil Low
Synchronisation between lots	• The 3 lots (SH, Bathymetry, Geology) started together, while SH rests on their deliveries (primary layers as well as confidence layers).	• Waiting for deliveries induced a bit of stress at times but Geology really did their best to satisfy our needs.	Moderate to good
Low resolution of oceanographic	• High coverage oceanographic data (currents, waves) are still currently in the multi-kilometric range, where an order of	• Bespoke models were run in Med., France and UK with higher resolution. Efforts to be	Good in absolute terms,

data	magnitude resolution improvement would be necessary. Energy at the seabed could not be used in Med.	continued in whole EU • Talks with EMODnet Physics	moderate in view of objectives
Gaps in primary layers	• Some areas still lacking seabed substrate data (e.g. Madeira, Canaries, Greece) • Some places only have Gebco depth data (e.g. Black Sea), which is not suitable to habitat mapping.	• More could be made of with the Geology lot in the next phase and local contacts taken (e.g. Madeira) • Reported at Steering Committee meeting. Improvements expected in future	Nil Nil

- The remaining challenges to be addressed in the next phase are listed below with a short description of how they could be tackled:

Challenge	**Expected improvements over next phase**
Biological data collation	The stronger links developed with the Biology lot will help provide them direction and focus to their species data collation. Their raising concern about habitat data (as opposed to species data only) and the perspective of an upcoming benthic survey to bridge critical gaps are a good omen that biological data will become more widely available in the third phase for enhanced mapping.
Habitat map collation	Stronger proactive involvement and lobbying in the collation of survey maps should be put forward for the next phase with the idea of stirring the spirit of competition between Member States. This can also be fostered by stronger dissemination policy and participation in more events and stakeholders platforms. While not in charge of seeking data, the Data Ingestion Project could help us finding incentives for providers.
Oceanographic data resolution	In this area progress is constant owing to a very active community of physicists and efficient dissemination tools (Copernicus marine services), however it remains slow due to inherent constraints and complexity and because of the size of EU marine basins. The wish of habitat mappers is for hectometric resolution for data describing temperature, salinity, water dynamics at seabed, water transparency or any other physical driver.
Confidence assessment	The confidence assessment scheme implemented by the Project is now fully operational. The scheme uses various entries, from confidence maps from other lots to fuzzy boundaries from biologically-inforemed thresholds and to arbitrary fuzzy limits when nothing else is available. Although this method can still be discussed and improved, we rather think improvements will come from the availability of more biological data and perhaps from confidence assessment made on physical data, something quite currently missing.
To show best available habitat information at any location	Various types of habitat maps exhibiting various geometric and semantic contents co-exist today: broad-scale EUNIS map, EUNIS maps from surveys, Annex 1 maps, individual habitat models, habitat samples. Whether they can be smartly assembled for optimum display of the most likely habitat present at each single location or whether this should be left to the user is an issue that needs to be looked at.

5. Analysis of performance and lessons learned

The Project tried to reach two categories of people, (i) mainly users to foster their uptake of seabed habitats products, (ii) but also providers whose data and information are needed to bridge gaps in European coverage of habitat maps and data.

Performance and lessons learnt are very closely linked. When performance is good, it may be difficult to analyse why, however when performance is not as good, one should learn from it and therefore provide suggestions for ways forward. In this section we first dwelled on user satisfaction, which is a token of quality of the products, then we looked at performance in terms of making providers adhere to the EMODnet setup and in a third part we analysed performance for each strand of work in the production process. Lessons are underlined in boxes better catching the eye.

5.1 Users' satisfaction

5.1.1 Downloads

Global performance is usually measured by usage and users' satisfaction. Usage is reflected by how often our products are effectively being used for various purposes. The primary evidence of usage is the number of downloads performed by users over the years and its evolution. In the period 2012-2013 when the first version of the broad-scale map only covered a few of the basins, downloads were of course limited. Since Sept. 2015 when the full map interim version was made available on the webGIS, downloads have picked up to higher numbers, which is an encouragement for the time being, but we can also expect the demand to fade away over time, hence a need to do some marketing of our products. Still, downloads are an encouraging indicator because it is likely users performed them in full knowledge of the map content, after they have had the opportunity to view the maps in full detail in the webGIS. So we are confident the number of downloads is a good reflection of people's interest.

However downloads may not mean effective use because after looking at the products in their own working environment some people may have found them unsuitable to their intended use, e.g. because of the low resolution of the maps when confronted with other data.

5.1.2 Users type

The type of users is also an interesting feature. Statistics show that users are mostly from the research and academic world, which is surprising at first glance because broad-scale maps are far from being raw data (which researchers like best) but rather elaborated products showing a strong simplification (both semantic and geometric) of reality. These maps are a final product suitable for management purposes and we could have expected a stronger uptake by the marine management community. As a matter of fact, this is something that has to be investigated and remedied by appropriate dissemination actions in the next phase.

Yet in an attempt to assess the use made by this latter community, the Project decided to launch a survey among two major groups of stakeholders a) those in charge of MSFD reporting, b) those in charge of MPA selection, an analysis forming a chapter of a paper submitted by the Project for publication in "Ocean Sciences". The outcomes of this analysis are summarised below.

		MSFD1	MSFD2	MPAs
1	Belgium	2	2	3
2	Bulgaria	2	1	2
3	Croatia	0	1	1
4	Cyprus	1	1	1
5	Denmark	0	2	2
6	Estonia	0	0	1
7	Finland	0	1	2
8	France	2	2	3
9	Germany	3	3	2
10	Greece	2	1	1
11	Ireland	1	1	1
12	Italy	1	0	1
13	Latvia	1	2	0
14	Lithuania	1	0	1
23	Malta	0	1	0
15	Netherlands	1	2	1
16	Poland	1	1	2
17	Portugal	1	2	3
18	Romania	1	1	2
19	Slovenia	1	0	1
20	Spain	2	3	2
21	Sweden	0	1	0
22	United Kingdom	1	4	3
	Number of respondents	24	32	34
	Number of countries	**17**	**18**	**20**

A total of 90 respondents representing 17 marine countries out of 22 answered the survey. Three distinct uses were identified in the poll: (i) effective use for the MSFD initial assessment, (ii) prospective use for the 2018 MSFD article 17 assessment, (III) MPA selection or management. The numbers of answers were respectively 24, 32 and 34 for the three categories, which shows an increasing interest in the broad-scale map between the two MSFD assessments. These are conservative numbers as a small number of respondents were still unsure of their involvement and 5 countries did not provide any elements. It should be noted that the proportion of answers from experts from countries within the OSPAR region was higher. This survey and its encouraging results satisfy a tender requirement expressed as: "The fitness for purpose of the data for measuring ecosystem health of the maritime basin and what might be done to overcome any shortcomings".

5.1.3 Geographic distribution of users

The geographic distribution of the webGIS respondents was quite illustrative with over 50 % of them being from the UK. Several reasons can explain this: (i) the UK is very active in the area of seabed mapping and marine activities in general, (ii) the webGIS is hosted by JNCC and highly publicized within the UK users community, (iii) the UK - mostly under the thrust of JNCC - has long had a strong tradition of seabed mapping, recently strengthened by a suite of projects starting in 2004 with the MESH Project that has really been instrumental in this domain. Some countries such as France and later on Spain and Portugal who were associated to this course of events, were able to collate maps from their own marine waters.

However a number of others basins as still lacking habitats maps in our webGIS in spite of our efforts. This is the case for the Baltic Sea, North Sea shores out of the UK as well as the French Mediterranean coast where targeted action is needed. Finally there are number of basins, most notably the eastern Mediterranean and the Black Sea which do not exhibit any maps at this stage, in spite of strong effort made over the course of the Project. We suspect though that at least some Natura 2000 maps were produced and it would be a case of making them visible and available.

It is difficult for the Project to give evidence of the efforts made in this area of map collation. The reasons for not being fully successful may be, among others:

- some institutions, in spite of being national do not have the power or remit to gather habitat maps from various national sources ;

- let alone for Member States not being represented in the partnership (the partnership involved nine marine MS out of 23), it was almost impossible to collate maps from them.

> Lesson n°1: Prompt Member States to contribute to the EMODnet seabed habitat repository by using appropriate incentives and technical assistance, in collaboration with the Data Ingestion Facility.

As a lesson from this situation these is a need to find incentives for more habitat mapping to be carried out in these places. This could be boosted through a variety of tools from research projects under commission funding or through regional initiatives using ERDF funding, e.g. the Mediseh or Coconet projects which resulted in the production of modeled maps of some threatened habitats for the whole Mediterranean basin. Although these is beyond the remit of this project and even EMODnet in general, these ideas could be promoted at regional platform meetings and workshops or at EMODnet stakeholders gathering such as the one that occurred in Ostende in 2015 or the forthcoming one in Brussels in Feb. 17.

> Lesson n°2: Prompt Member States to carry out more seabed habitat mapping by helping them leverage appropriate funding, either from EU DG/Research (H2020), environment (DG/ENV), regional (Interreg) or from national funds.

Regarding habitat sample data from Regional Convention, specific action has to be taken to make the Barcelone, Helcom and Bucaresti Conventions follow suit from Ospar by adopting the habitat portal as a potential “sister portal” to help further disseminate their data.

5.2 Reaching and guiding providers

Over the course of the Project, we managed to receive data from a number of high level suppliers, namely:

- Unesco IBCM map (International bathymetric chart of the Mediterranean)
- Croatia: State Institute for Nature Protection
- UNEP/MAP-RAC/SPA with data for Montenegro
- Albania: data submitted to CBD supporting a new EBSA for Albanian waters
- Institute of the Republic of Slovenia for Nature Conservation
- Institute of the Republic of Slovenia for Nature Conservation, Slovenia (government),
- University of Zagreb, Faculty of Science, Division of Biology
- Croatia Institute for oceanography and fisheries (Split)
- State Institute for Nature Protection, Croatia
- Agenzia Regionale per la Prevenzione e la Protezione dell'Ambiente, Puglia, Italy
- Department of Fisheries and Marine Research, Cyprus
- Malta Environment and Planning Authority, Malta
- Andromède Océanologie, France (SME)
- Barcelona Convention National Focal Points for the SPA/BIO

This is only a short list among a great many providers. Providers should be more systematically identified and linkages formally established for them to sign up to a mechanism of data ingestion into EMODnet. It should be rather easy to identify providers (although work from the industry or some consultants may have remained hidden) and some kind of systematic action could be launched among the actors of maritime economy having an interest in the seabed. This preliminary work rests with us, experts in seabed-related business, before it is handed out to the EMODnet Data Ingestion Project which could design incentives and ways of streamlining data to ease up its ingestion without burdening data owners (what is referred to as data “pathways”).

> Lesson n°3: Thoroughly identify seabed data providers throughout Europe and liaise with the Data Ingestion Project to design the best method for making providers adhere to the EMODnet pathways and central portal concept.

The performance of data submission was also increased by improving the “Contributing data” section. Users are now guided in contributing to the Project by submitting data (products). Options for contributors are provided via our “Contributing Data” group of pages, see: http://www.emodnet-seabedhabitats.eu/contributedata. This setup was tested by representatives of the partners committed to provide a copyright-free habitat map from their countries for testing the sequence of operations according to the technical guidance.

5.3 Performance of the EMODnet seabed habitat map dissemination set up

The performance of the whole process leading to the dissemination of seabed habitat maps across Europe was scrutinised for each of its components, namely: data collation, data processing, data dissemination and for each of them an analysis of performance and lessons learnt was made.

5.2.1 Performance in data collation

Challenges related to producing contiguous data over a maritime basin from fragmented, inhomogeneous data did not impinge too much on the seabed habitat group because they were mostly affecting upstream data layers produced by the other lots (Bathymetry and to a larger extent Geology). Liaison with these groups was permanent and effective, enabling the project to receive timely deliveries. Their products were obtained from the other lots partners themselves but not from the relevant EMODnet portals.

Regarding physical oceanography data, performance was high in the improvement of waves and currents models, but only on parts of the project area. This issue of hydrodynamic models producing gridded files at a variety of resolutions was technically easy to handle in the model with raster algebra, while it is reflecting in the final result by map confidence. Performance with the computation of water transparency was good, as mentioned in the “Highlights” section.

Performance in collating habitat maps from surveys was moderate. The UK was clearly leading on this with a model of data submission from providers implemented long ago by JNCC. Some progress was made by France, Spain and Italy over the three years. Norway provided some modelled maps. So there is ground for improvements on this topic by taking appropriate measures and incentives among Member States.

5.2.2 Performance in data modelling

The layers used to derive the classified map are referred to as secondary variables, the most salient example being the biozones which are a combination of base layers such as bathymetry, temperature, light penetration etc. These secondary layers directly feed into the habitat model. They are split into categories using thresholds based on biological data. Performance in thresholds assessment was high and a lot of work was produced to assess former thresholds from ur-EMODnet with new biological data sets (in North Sea, Norway, Mediterranean, Black Sea). Statistical methods used to assess these thresholds were also more robustly designed than previously.

The models were split per large region, namely Black Sea, Baltic Sea, the whole Mediterranean, the whole Atlantic including the North Sea. In each zone the model was unique, however it was deemed necessary to create masks in large river plume areas (namely the Po and Danube rivers). This was a painstaking work as it implied re-working thresholds within the plume areas. In future work this might have to be extended to smaller plume areas (e.g. Elbe, Rhône).

5.2.3 Performance in data dissemination and interoperability

Several requirements were expressed in the terms of reference of the Project. Four descriptors of performance are identified here: Compliance to standards, reliability, user friendliness and responsiveness.

Compliance of products to standards is ensured through the use of the EUNIS classification, the main standard for habitats, which is now a reality for the broad-scale map at the nominal resolution of 250m. Maps from surveys are also expressed in EUNIS, and should this not be the case for original maps, partners were requested to perform the translation from their native system. An aggregation to the Marine Strategy Framework Directive predominant habitat types is also available, following a request from DG/ENV.

Reliability is a difficult topic with products that are a strong simplification of reality, especially in the case of the broad-scale map. The main issue is, whatever the intrinsic quality of the map, the level of confidence with which it can be used, in other words the need to answer the following question: in this place, how close to reality is the information given by the map? The Project did not give a quantitative answer to this question but rather a qualitative one, either based on statistics (for the broad-scale map) or on metadata (for survey maps).

In terms of user-friendliness of our seabed habitats portal, an audit of the portals was commissioned by DG/MARE and corrective action was taken to improve it. The data querying function was improved mostly by making the list of products more user-friendly and by making the map delivery section highly visible and documented. The data submission section was made more visible and user-friendly.

As for portal response time it always remained high and generally users expressed their satisfaction in terms of visibility and availability. This was confirmed by some participants to the EMODnet Atlantic Checkpoint who in the preliminary identification of parameters needed for their challenges mentioned good suitability and availability of EMODnet seabed habitat maps.

6. Analysis of sustainability

6.1 Data policy

In our opinion there are several aspects to sustainability. The one coming to one's mind right away is the "political" one: who has the remit to sustain a marine information service? Up to now, the EMODnet Project has gone for about 7 years in two phases and a third phase is coming until 2020. These projects are being successful in collating blocks of data (if not all existing ones), set standards, test the tools and products, make the community aware of the existence of such a large and comprehensive repository. Efforts from the Secretariat will soon result in having a single portal, a great asset for users. However there will be a time soon when EMODnet will need to move from today's suite of time-limited projects towards a more permanent structure. The debate is open as to where and by whom this should be implemented. The answer does not lie with us but rather with Commission bodies and their experts such as those from the EEA, the JRC, perhaps also experts from ICES and other institutions with regional remit who all have a say in catering for marine data at regional level. Questions that need to be dealt with are the institutional setting and the required resources including costs.

However what we can do is give a few clues gathered from the experience built by working in EMODnet as regards two specific areas (i) data availability and quality and (ii) ease of use of data and interface user-friendliness.

6.2 Data quality: suitability and availability

These issues are those raised in EMODnet checkpoints: Are there data gaps? When data are present, are there suitable to users' intended uses? Finally, are there any constraints to data availability?

6.2.1 Data gaps

Some gaps are true geographic gaps, i.e. absence of data, such as gaps in the deep sea area or in the coastal well-known "white ribbon". Other lesser gaps (such as semantic gaps) depend on the intended uses: a gap for a given use (a local study needing a map from a survey) may not be one for another use, e.g. a regional assessment which may find a broad-scale map adapted to its problematic. Clearly if we had high resolution maps for all the marine basins of Europe, it would then be quite easy to generalise these maps into medium resolution ones.

Gaps also concern biological ground truth data, which are essential to improve broad-scale maps and give them more reliability. As has been mentioned above, gaps have to be bridged to the extent possible given the very high associated costs and a strategy is needed both at Member State and at EU level, should enhanced data acquisition be contemplated.

6.2.2 Data suitability

Various types of habitat maps exhibiting various geometric and semantic contents co-exist today: broad-scale EUNIS map, EUNIS maps from surveys, Annex 1 maps, individual habitat models, completed by habitat samples in highly variable density across space. Given the unlikelihood of having full coverage survey maps one day, a way to ease up users' queries and data selection would be to show best available habitat information everywhere. The challenge would then be to smartly assemble these various maps to provide optimum display of the most likely habitats present at each location. This is not a simple challenge in terms of boundary issues and it would certainly need to be trialled before its viability can be assessed.

As has been emphasised several times, the availability of a confidence map along with such a product would be of paramount importance because users tend to take for granted the overall quality of an assemblage even though it may have been made with quite disparate data sets.

6.2.3 Data availability

Data availability is a key factor of sustainability. Availability covers a number of aspects such as ease of access, policy, price, format, responsiveness. The user must be directed to data sets of interest using as few clicks as possible. This is primarily true for "discovery" where users must be given user-friendly tools to assess data suitability (mainly through comprehensive ISO-compliant metadata). Once they are willing to download data, the operation has to be simple, free and quick, possibly using format translators where needed. All this is readily available for seabed habitats today but should be seen jointly with other types of data in a broader perspective. The central portal concept of allowing users to select data using a tick-list and a "pastry-cutter" to crop any number of data sets is an ambitious one but certainly this is what would bring highest added-value to the EMODnet service.

6.3 Friendliness of user interface

The current Seabed Habitats portal, built on MapServer (v6.2) and Openlayers (v2) provides a large amount of the required functionalities including:

- Data displayed in a user-friendly manner allowing easy viewing access to the data layers on the interactive map;
- Data available for download without the need for sign-in through the download page, and download requests tracked for usage statistics;
- Guidance on how to use the portal, download pages and web services;
- Usage statistics (unique visits, time spent & site departures) of key web pages are collected with google analytics;
- Viewing of data values and quality (confidence) from the "Habitat maps from survey" datasets and 2016 EUSeaMap products.

In 2015 a steering committee review had stated that the cross-hyperlinking between the different services offered was considered smooth. In 2016 a large-scale overhaul of the website has been conducted, focused on the webGIS services and including:

- Improved 'clean' layout for low-resolution screens, providing a larger "map view";
- Improved map layer groupings on the table of contents guided by user expectations;
- Improved system of viewing "habitat maps from survey" based on rough scales.

Several points were improved, for example the "map search" page (http://www.emodnet-seabedhabitats.eu/search) with the "view on map" link now directing the user to the map itself, zoomed in to the map's extent and with the relevant habitat map layer showing. The layer is also filtered to only show the selected dataset. The "access data" page (http://www.emodnet-seabedhabitats.eu/webgis) has been improved to aid navigation by the user and to increase the visibility of the WMS service. The data download page (http://www.emodnet-seabedhabitats.eu/download) has been modified to place the "select layers" box at the top to aid user navigation.

Further improvement on interoperability can be achieved through the adoption or creation (if no option currently exists) of standards at all levels of the project's data framework. This incorporates standards in services, formats and schema that will provide an end user with a known expectation of what they will receive and how they will receive it, and a data provider or custodian of what they should provide and how they should provide it. The data may then be used seamlessly for whatever purpose is necessary.

The seabed habitats lot has had key successes in its interoperability. Firstly, its use of Open Geospatial Consortium webservices, an international standard for geographic data services, measn that the data viewable on its interactive map can also be viewed in a wide variety of popular GIS software packages. Use of open source solutions in the EMODnet project should be heavily promoted, enabling the smooth transition of infrastructure should the project custodians change.

The project has also developed and promoted a standard data schema in which to accept and disseminate habitat maps, and ensured that the schema are valid with the current INSPIRE data specifications. Use of data specifications (and therefore INSPIRE in Europe) is key to maintaining a long-lived, sustainable, and usable data holdings. Further integration with the project and INSPIRE should be sought to ensure that the similar goals of these two endeavours are acheived. A balance of functionality and simplicity/practicality must, however, be maintained to ensure that potential data providers and end-users are not dissuaded by imposingly technical solutions.

Finally, the distribution of data in a widely used format (currently Shapefiles) ensures that end-users in the first instance understand how they are receiving the data and how to use the data, and as a result are more likely to access the data holdings. Increased interoperability and sustainability may be achieved by offering data in a variety of formats to suit the end-user and maintaining a close eye on developments within the geospatial community in regards to the formats that users are commonly working with, especially in regards to open source solutions.

6.4 Towards a sustained infrastructure

How to enable a smooth transition to EASME (or a party designated by EASME):

- The portal is built using open source software including GIS tools used to prepare habitat maps for upload to the webGIS;
- Hosting would need to transfer to an organisation designated by EASME;
- Ensure that the IPR on any additional code/plugins behind the portal is transferrable

- Transfer of IPR: Service Contract states that foreground IPR generated during performance of contract is jointly owned by Partners and Commission, until transferred to the Commission in accordance with the Service Contract.

7. User Feedback

User feedback was voiced in a number of ways. There were direct email contacts or information received from communication broadcasts regarding either data needs or particular uses that were made of the products, contacts in events where the project took part, feedback from the Commission themselves and also from the Checkpoints, finally recent feedback by way of letters of support from the Regional Sea Conventions upon third phase submission.

7.1 From individual requests/comments

- In 2014 SLU Sweden requested the previous official 2011 version that includes the Kattegat, which was supplied by JNCC.
- The HOLAS II Project (Holistic Assessment of the Ecosystem Health Of the Baltic Sea) will give an update on the overall state of ecosystem health in the Baltic Sea. The assessment will follow up on the goals of the Baltic Sea Action Plan and will partly be based on the Baltic EUSeaMap. The results will support reporting under the EU Marine Strategy Framework Directive (MSFD). The first assessment results will be released by mid-2017 and will use the broad-scale map produced by EMODnet Seabed Habitats. The report will be finalized by mid-2018.
- GeoEcoMar was invited to an Emblas workshop as expert on macrozoobenthos monitoring. The Black Sea habitat map was presented and discussions were held regarding the way forward for the harmonization of habitats delineation and the classifying system according to EUNIS. Major data gaps were addressed and prospects of improvements of the actual habitat map within an MSFD-compatible monitoring programme were discussed.
- In May 2014 EMODnet Chemistry and Biology partners expressed the need of the broad-scale map for Marine Spatial Planning in the Adriatic and Ionian seas.
- Jul. 2014 the the French Office national de la mer et du littoral expressed its need for habitat statistics from the broad-scale (BS) map for French MSFD marine regions.
- Feedback was also received from the French MPA Agency regarding several types of use of the BS maps, mostly for the designation of “Parcs Naturels Marins” (Picardie, Corsica, Gulf of Saint-Malo, Bay of Biscaye) or Regional Strategic Anayses (Corsica), or local programmes (Capcoral, Coralcorse). It appears that the braod-scale Eunis map is quite often the only homogeneous document with continuous coverage, in spite of its reduced explicit biological content. So over the last few years the maps were used by several government authorities (préfecture, DDTM , CEREMA, DREAL Poitou-Charentes, DIRM Sud Atlantique), regional authorities (AGLIA, RaieBECA) or consultants (TBM and Créocéan, Biotope, Luxmarina) but also in the MPA Agency own mapping programme CARTHAM (2012). In the Channel an example can be found at:

(http://cartographie.aires-marines.fr/sites/all/modules/carto/pdf/MMN_PNMEPMO_PHY_geodiversite_201508_a4pa.pdf).

- We received feedback from Bernt Rane from Sweden who expressed his satisfaction that our webGIS supports webmercator (EPSG:3857) and recommended we also support EPSG:3034: ETRS-LCC and EPSG:3035: ETRS-LAEA, which are mandatory for INSPIRE services.
- ISPRA had talks with the RAC SPA director during a meeting in EEA (Copenhagen) in April 2016 where we expressed the concern of EMODnet seabed habitat portal possibly being the repository of habitats and species of conservation importance for Regional Sea Conventions, as is already the case for OSPAR. This type of cartographic information is displayed both as polygon and point data. Contact was then made with Atef Ouerghi from RAC/SPA to verify the feasibility of displaying their habitat data on the EMODnet seabed habitat portal (as biocenoses of conservation importance are listed on RAC/SPA webGIS legend).
- The Ostende Jamboree in oct. 2015 was an opportunity to collect expressions of interest. We got contacts from German, Swedish and British institutions willing to join a future initiative in phase 3, which showed seabed habitats are an appealing EMODnet strand. At the Geohab conference in Winchester, we were approached by several people wanting to also join us in the next phase: NOC Southampton, SYKE Finland, SGU Sweden, which all show a strong interest for theis pan-European endeavour.
- Consortium partner ISPRA is using the Emodnet seabed habitat cartographic layers within the framework of the EEA's ETC/ICM task on MPA network coherence scenario assessments across European seas.

7.2 From DG/MARE

Feedback was also received from DG/MARE upon an audit of the webGIS and more recently on two specific occasions:

- In 2014 DG/MARE launced an audit of the EMODnet Portal. Following this, corrective action was taken by the Project
- For the Safenet project in the Mediterranean, "Seabed habitat maps, available from the EMODnet web site (http://www.emodnet-seabedhabitats.eu), are currently being screened to determine how they can serve the identification of suitable habitats for the two sparid species in the study area." What they're doing is collecting info on the populations of certain commercial species in order to assess what sort of effect MPAs (as no-take zones) and displacement of fishing effort as a result of the MPAs, are having on these species.
- In 2015, DG/MARE was keen to get a idea of what the impact of closing 30% of each habitat to fishing would be. They needed to provide some feedback on the MSFD descriptors very urgently. A rough and ready analysis was conducted by JRC GIS experts using the 2015 model, even though it still featured some errors.

7.3 From the Checkpoints

As has been mentioned above in the analysis of performance, three of the EMODnet checkpoints whose data we had access to (Atlantic, Mediterranean, Black Sea) made good uptake of broad-scale seabed habitat maps in their literature review and specifically in the identification of characteristics (i.e. variables) needed in their challenges. This is going to be confirmed in a few months when they actually make their products using real data. The concerned challenges are those having to deal with the seabed, namely i) Winfarm siting, ii) MPA assessment, iii) Oil leak challenges, iv) Fisheries impacts. Upon preliminary receipt of their assessments of data availability for the first data adequacy report, there is evidence of good visibility, download capacity and performance of the EMODnet seabed habitats portal.

7.4 From the Regional Sea Conventions

There is a strong interest in EMODnet expressed by the RSCs regarding the fulfilment of MSFD obligations. The main three areas of interest are chemicals, biology and seabed habitats, which strogly reflect the ecological status. In addition to OSPAR, a body used to sitting in meetings with DG/MARE, the Bucharesti and Helcom conventions attended the last MSFD-EMODnet meeting convened in Brussels by both DG/MARE and DG/ENV and discussions were held on data relevance and future MSFD prospects enabled by EMODnet current progress.

In preparation for bidding for EMODnet phase 3, the new consortium received letters of support from each regional sea convention. In these letters were highlighted some of the ways they have used phase 1 and 2 outputs, as well as suggestions for future coordination. Some extracts are provided below.

7.4.1 Ospar

“There are already established links between OSPAR and EMODnet Seabed Habitats. The UK, through JNCC are the custodians of the OSPAR Threatened and/or Declining Habitats database, which is made available to the public via the EMODnet Seabed Habitats portal. In addition to this the OSPAR common indicator assessment of physical damage has been primarily constructed from data available from the EMODnet Seabed Habitats. We anticipate that the next phase of EMODnet and the greater engagement and dialogue that will be facilitated as a result of this proposal will realise further opportunities to work more closely together both in data sharing but also in product development” (Emily Corcoran, OSPAR Deputy Secretary, in Letter of Support for phase 3 bid, dated 3 August 2016).

7.4.2 Helcom

“The outcomes of the Seabed Habitats lot of the previous EMODnet phase have been welcomed by HLECOM as providing access to Baltic-wide habitat map products which were used e.g. in the analysis of ecological coherence of the network of HELCOM Marine Protected Areas. However, further development of the data products is needed in order to increase resolution and make sure that regionally specific features are taken into account in development of the habitat maps. ... HELCOM welcomes the possibility to give advice to the consortium on the scope and definition of products and also to monitor development of products and services that are planned to be in line and support both the regional and international data needs" (Monika Stankiewicz, HELCOM Executive Secretary in Letter of Support for phase 3 bid, dated 21 July 2016).

7.4.3 Barcelona

"With reference to the call for tenders 'Operation, development and maintenance of a European marine observation and data network: Lot 2 Seabed Habitats', RAC/SPA would like to support such initiative and moreover be part in the future implementation of the project. ... EMODnet will be useful in the implementation of [the] ecosystem approach with the [Mediterranean Action Plan] as ecological objective 1 deals with habitat distributional range. RAC/SPA could compliment the data gathered in other non-European countries.

"... RAC/SPA launched recently a call for tender to upgrade its online geographical information system (MedGIS) to a complete Spatial Data Infrastructure with a catalogue and geo-viewer. ... The two portals could be connected in an easy way and information shared for the benefit of the conservation of the Mediterranean." (Khalil Attia, RAC/SPA Director, in Letter of Support for phase 3 bid, dated 2 August 2016).

7.4.4 Bucharesti

"Needless to say that future EMODnet Seabed Habitats products might be used by Black Sea Commission and its scientific network, as well as contribute to ongoing relevant regional assessments. Keeping in mind the need to harmonize the approaches and use of data products on habitats in all the European regional seas and to ensure its relevant consideration in the Black Sea basin, we support the objectives of [the consortium] and hope that its successful implementation would considerably contribute to the improvement of the Black Sea marine environment" (Iryna Makerenko, PMA Officer, Black Sea Commission Permanent Secretary).

7.5 Feedback from the FP7 Pegaso project

Understanding where multiple pressures are occurring, their principal source and how they impact marine and coastal ecosystems is essential to support management strategies and is a requirement of the developing marine policies (Marine Strategy Framework Directive, EcAp MAP). At present, an integrated qualitative and quantitative understanding of the relationship between pressures and impacts in the marine environment is far from being achieved. In 2007, Halpern et al. provided a way to predict ecosystem response to pressures using expert knowledge. Using this methodology and its developments in more recent studies, a cumulative impact map was created by the Pegaso project for the Western Mediterranean (Spain, France, Italy, Morocco, and Algeria). Not only was this approach consistent and comparable across all marine regions and sub-regions, but it was also expected to enhance the cross-boundary cooperation between EU and non-EU countries assessing the availability of harmonized data for this area (which is a strong argument to extend and refine EUSeaMap at basin borders with adjacent countries where gaps are more salient).

The distribution of benthic habitat used in Pegaso was mainly based on the broad-scale EUSeaMap (Cameron, A. and Askew, N. 2011). Two other works on cumulative impacts had already been developed similar broad-scale maps (Korpinen et al, 2012; Andersen and Stock, 2012), respectively in the Baltic Sea and in the North Sea. The detailed list of habitats considered in this study is available in the table below.

Table 7.1 – Ecosystem component datasets used in the study (type, availability and origin)

Ecosystem component	Data origin/public availability (In blue when publicly available)	Type of data
Littoral		
Sandy beaches and dunes	Annexe 2	Analysis of Earth observation product (line with presence/absence)
Rocky shores	Annexe 2	Analysis of Earth observation product (line with presence/absence)
Coastal wetlands (Salt marches, Salines, Intertidal flats)	Annexe 2	Analysis of Earth observation product (presence/absence)
Estuaries	Annexe 2	Analysis of Earth observation product (line with presence/absence)
Coastal lagoons	Annexe 2	Analysis of Earth observation product (presence/absence)
Seagrass beds		
Posidonia Oceanica	EUSEAMAP/RACSPA Annexe 2	Compilation all the cartographic information available for this habitat type
Cymodocea nodosa	EUSEAMAP	Compilation all the cartographic information available for this habitat type
Specific deep water seabed ecosystems		
Canyons	Harris and Whiteway, 2012	Interpretation of the ETOPO1 bathymetric grid
Seamounts	RACSPA	
Broad-scale benthic habitats and their communities		
Infralittoral sand and coarse sediments	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters
Infralittoral mud and sandy mud	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters
Infralittoral rock and other hard substrata	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters
Coralligenous and shelf edge rock	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters
Mediterranean biocenosis of coastal detritic bottom	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters
Mediterranean communities of muddy and shelf edge detritic bottoms	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters
Mediterranean communities of coastal terrigenous muds	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters
Bathyal hard beds and rocks	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters
Abyssal and bathyal muds, sands and mixed substrata	EUSEAMAP	Modelisation based on physical and morphosedimentary parameters

8. Allocation of Project resources

In order to provide these figures, partners were requested to provide figures from their in-house time-card system, where at best they had a breakdown per work package. However work packages are not fully related to the breakdown requested here (left hand side column of the table below), so a gross estimate had to be made across the partnership.

Table: Resources breakdown per group of activities

Group of activities	Work packages	Resources	Comments
Collating, harmonising and giving access to data	• WP2, WP3 • Partly WP6	20%	This group includes data collation carried out in WP2 (data preparation) and WP3 (collation of biological data) and part of the WebGIS activity of WP6 related to harmonisation of data and metadata and dissemination of products
Creating data products	• WP1 • WP4 • WP5	52%	This is by far the larger group of activities as it is all about making the broad-scale map: WP1 for the identification of habitats to be modelled and classifications issues; WP4 for thresholds to classes; WP5 for running the models and confidence assessment
Developing and maintaining IT	• WP6	6%	This is strictly the development and maintenance of the WebGIS
Management and reporting	• WP8	10%	Management and reporting, steering committee meetings, projects progress meetings
Answering questions and other communication activities.	• WP6 • Partly WP7 • WP8	12%	This group represents communication with users but also with data providers about what becomes of their data. It includes work on and the production of, a paper on the use of BS maps as well as presentations in events, conference and at the Ostende Jamboree.

9. Outreach and communication activities

Four types of actions were taken by the Project to ensure strong outreach and dissemination: (i) Presentations at conferences and events, (ii) Reports and papers in scientific journals, (iii) Advisory actions, (iv) Dissemination material.

9.1 Presentations at conferences and events

Presentations were made at a number of events and conferences. They are listed in the table below with the five most relevant ones outlined in bold.

Date	Location	Topic	Short Description
Apr. 2014	Nantes, France	ValorIG workshop in (Ifremer)	Presentation of the various EMODnet lots and the links between them
Mar. 2014	Athens, Greece	MyOcean2 Project meeting (JNCC)	Presentation of the data needs of EUSeaMap at a MyOcean 2 workshop.
May 2014	San Sebastian, Spain	ICES Working Group on Marine Habitat Mapping (WGMHM) (Ifremer)	Presentation of EUSeaMap2 (objectives and description of work packages), and specific section in the ICES WGMHM annual report.
May 2014	Turkey	-EU Maritime Dialogue 2nd meeting (METU)	Presentation under agenda item “Involvement in seabed habitat mapping and marine data networking (EMODnet)” with a brief from DG-MARE representatives.
21 Jan. 2015	Brest, France	EMODnet information day (Ifremer, SHOM, CNRS, IRD)	• Presentation of EMODnet lots • Presentation of EU mechanisms dealing with oceanographic data: EMODnet, Seadatanet, Copernicus, DCF. • Perspectives
30 Apr. 2015	Edinburgh, UK	UK Seabed Mapping Working Group (JNCC)	Information day about Seabed Habitats and request for habitat maps contribution
May 2015	Reykjavik, Iceland	ICES WGMHM (JNCC)	Presentation of EMODnet Seabed Habitats (objectives and description of work

			packages), and specific section in the ICES WGMHM annual report.
21-25 Sep. 2015	Copenhagen, Denmark	**ICES Science Conference (Habitats Session)**	"The EMODnet Seabed Habitats initiative and examples of applications of the EUSeaMap broad-scale seabed habitat maps". (Ref: ICES-CM-2015/N:08)
21 Oct. 2015	Ostende, Belgium	**EMODnet Jamboree**	• Leaflets were made available • Two posters were displayed in the congress hall (Methodology and Pan-European map)
16-17 Nov. 2015	Rio de Janeiro, Brazil	**EU-Brazil high level meeting** (Ifremer)	Presentation of EMODnet with focus on Seabed Habitats
25 Nov. 2015	Italian Ministry of the Environment, Rome	EMODnet Information Day (organized by OGS, INGV, Cogea, ETT, ISPRA)	Presentation of EMODnet initiative, with a specific focus on the Seabed Habitats Lot by ISPRA
18 Nov. 2015	University of Sao Paulo, Brazil	Seabed habitat mapping (Ifremer)	Presentation of EMODnet Seabed Habitats to about 40 students and researchers
25 Nov. 2015	Brest, France	MeriGeo national conference on marine geographic information (Ifremer)	Presentation of EMODnet Seabed Habitats
30 Nov.-2 Dec. 2015	BfN, Isle of Vilm - Germany	Workshop on marine biotope mapping for conservation purposes (JNCC)	Presentation of the EMODnet Seabed Habitats portal as Europe's central access point for habitat maps.
24 Feb. 2016	Odessa Ecological University, Ukraine	Monitoring methods	Black Sea Biological Monitoring Methods to be used during EMBLAS National Pilot Monitoring Surveys and Joint Open Sea Surveys
19-22 April 2016	EGU, Vienna, Austria	**Session on data management. Presentation of MedSea and EMODnet**	• Mention of the European seabed habitat map (EUSeaMap) from EMODnet as a major block of information currently in use in the Medsea checkpoint.

3-6 May 2016	Winchester, UK	Geohab conference on Geological and **habitat mapping** **(Ifremer, JNCC)**	• Presentation on “Habitat map collation and data standardisation from a UK and European Perspective – JNCC's work within the UK and with EMODnet” (JNCC) • Presentation on “Using habitat maps to develop monitoring options for the deep-sea as part of the UK Marine Biodiversity Monitoring R&D Programme” (JNCC) • Posters: - Broad-scale map methodology - The pan-European Broad-scale map: EUSeaMap
May 2016	Winchester, UK	**ICES WGMHM** **(JNCC)**	Presentation of EUSeaMap2 (objectives and description of work packages), and specific section in the ICES WGMHM annual report.

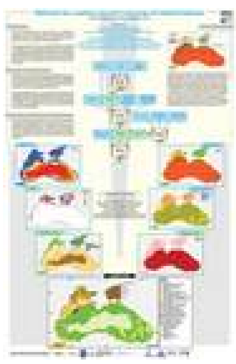
9.2 Reports, posters and papers in scientific journals

In 2014

- Extended abstract for the presentation given at the ICES Annual Science Conference 2015, Copenhagen, by EMODnet Seabed Habitats partners. “ The EMODnet Seabed Habitats initiative and examples of application of the EUSeaMap broad-scale seabed habitat maps”
- EMODnet Thematic Lot n° 3 - Seabed Habitats – Annual (interim) report. Reporting Period: Sept. 2013 to Aug. 2014

In 2015

- EMODnet Thematic Lot n° 3 - Seabed Habitats – Annual (interim) report. Reporting Period: Sept. 2014 to Aug. 2015
- Poster on the Methods for creating a broad-scale map of seabed habitats . Presented at the First EMODnet Open Conference, Oostende, 20th October 2015
- Poster on the 2015 EUSeaMap EUNIS broad scale habitat maps coverage. Presented at the First EMODnet Open Conference, Oostende, 20th October 2015



A couple of papers were also submitted to conferences or scientific journals:

- THE HCMR team presented a paper titled: “Bathymetric data and geologic elements analysis towards the assessment of coastal rocky bottoms” on behalf of EMODnet Seabed

Habitats in national conference "Hellenic Symposium on Oceanography & Fisheries" held in Lesbos FROM 13-17 May 2015.

- The Project team is preparing a paper titled "The use of broad-scale seabed habitat maps (BSSHM) in Europe in a management context" already submitted to the journal Frontiers in Marine Science's new Research Topic 'Horizon Scan 2017: Emerging Issues in Marine Science'. Part of this paper is based on a poll run in all marine European Union Member States on the use of broad-scale habitat maps (see section 5.1.2), specifically on three points (i) MSFD initial assessment, (ii) MSFD second assessment, (iii) the design of coherent MPA network. This latter aspect was also investigated through a bibliographic review of scientific and grey literature on the use of broad-scale habitat maps with respect to Regional Sea Convention initiatives on MPA design and assessment.

9.3 Advisory actions

On another line, project outputs helped provide advice to management entities.

- In the UK JNCC are keeping other government organisations informed of the Project progress through a national co-ordination group called the Seabed Mapping Working Group. At its last meeting in 2016 the broad-scale EUSeaMap was presented and a pledge was made for new habitat maps from survey.
- In the Baltic Sea HELCOM's Second Holistic Assessment of the Ecosystem Health Of the Baltic Sea (2014–2018) will partly be based on the Baltic EUSeaMap. The HOLAS II Project will give an update on the overall state of ecosystem health in the Baltic Sea. The assessment will follow up on the goals of the Baltic Sea Action Plan. The results will support reporting under the EU Marine Strategy Framework Directive (MSFD). The first assessment results will be released by mid-2017 and will use the broad-scale map produced by EMODnet Seabed Habitats. The report will be finalized by mid-2018.
- GeoEcoMar was invited to an Emblas workshop as expert on macrozoobenthos monitoring. The Black Sea habitat map was presented and discussions were held regarding the way forward for the harmonization of habitats delineation and the classifying system according to EUNIS. Major data gaps were addressed and prospects of improvements of the actual habitat map within an MSFD-compatible monitoring programme were discussed.

9.4 Dissemination material for wider public

Further than posters describing the methodology for map production and the final pan-European broad-scale map, a glossy brochure titled "EUSeaMap: A broad-scale physical habitat map for European Seas" to describe the achievements of EUSeaMap phase 1 and what to expect from phase 2 of the Project was produced and made available to the partners for dissemination.

See: http://www.emodnet-seabedhabitats.eu/outputs

On top of this, pdf and jpeg of a number of geographic subsets were created for more convenient use by partners and other users for specific needs. This includes three types of subsets: (i) basins subsets (e.g the North Sea), (ii) "regional subsets" such as the British Isles or the Iberian Peninsula, as well as some "national subsets" (e.g. France, Greece or Italy).

10. Evolution of Progress Indicators

Usage statistics for the period of 09/09/2013 to 15/08/2016

Indicator 1. Volume of data made available through the portal

The following 481 datasets are currently available through the portal:

- EUSeaMap 2012/2013 Top Copies:
  - Habitat map outputs **x8**
  - Input physical data **x16**
  - Confidence **x8**
- EUSeaMap 2105 Draft interim products
  - Habitat map outputs **x8**
- EUSeaMap 2016:
  - Input physical data **x5**
- Collated habitat maps from survey:
  - EUNIS maps **357** from x countries
  - Non-EUNIS maps **25**
- Official regional convention datasets:
  - OSPAR dataset of threatened and/or declining habitats
- Modelled maps of specific habitats:
  - MEDISEH habitat probability rasters **3**
  - Norwegian habitat probability rasters **17**

Indicator 2. Organisations supplying each type of data based on (formal) sharing agreements and broken down into country and organisation type (e.g. government, industry, science).

Further to the parner organisations providing data on which they had control, a few organisations responded favourably to our requests for data and we would like to acknowledge them here:

- Institute of the Republic of Slovenia for Nature Conservation, Slovenia (government)
- International Marine Centre in Oristano (science)
- University of Zagreb, Faculty of Science, Division of Biology, Croatia (science)
- Institute for oceanography and fisheries, Split, Croatia (government),
- State Institute for Nature Protection, Croatia, (government)
- International School for Scientific Diving, Lucca Italy (NGO)
- Agenzia Regionale per la Prevenzione e la Protezione dell'Ambiente, Puglia, Italy (government)

- Department of Fisheries and Marine Research, Cyprus (government)
- Malta Environment and Planning Authority, Malta (government)
- Andromède Océanologie, France (SME)
- EurOBIS (with help from the EMODnet Biology Lot)
- All Barcelona Convention National Focal Points for the SPA/BIO protocol were contacted for a census of their available cartographic data as well as all national contacts known to have been involved in the Water Framework Directive monitoring of Posidonia lower limits

Indicator 3. Organisations that have been approached to supply data with no result, including type of data sought and reason why it has not been supplied.

The FP7 Mediseh Project coordinator clearly indicated in an email to the Project coordinator and also to ISPRA that the geodatabase on samples of Posidonia meadows and other biocenotic data could not be made available to the consortium, as they were “background data” of their project and hence they had no permission to disseminate them. This entailed duplication of efforts on our part in making a census of Posidonia cartographies ex novo. As these data are “public data” from a number of Member States, we very much hope this kind of situation could improve in future, perhaps through a decision of the European Parliament.

Indicator 4. Volume of each type of data and of each data product downloaded from the portal

A total of 6,025 downloads were recorded throughout the course of the project; however, due to intermittent faults in the website's download log throughout year 2 (~40 days), the true value is likely to be higher.

	Downloads			
Layer	**Year 1: 09/09/13 to 05/08/14**	**Year 2: 06/08/14 to 06/09/15**	**Year 3: 07/09/15 to 15/08/16**	**Total**
EUNIS habitat maps from surveys	195	267	2	464
Habitat maps (various classifications) [3]		0	8	8
OSPAR threatened and/or declining habitats	3	187	301	491
MESH confidence assessments and study areas[3]	10	90	5	105
Predicted broad-scale EUNIS habitats - Atlantic area	111	169	239	519
Biological Zones - Atlantic area	0	108	157	265
Phase 1 Predicted habitats - North Sea and Celtic Sea	211	262	394	867
Phase 1 Predicted habitats - Baltic Sea	55	77	164	296
Phase 1 Predicted habitats - western Mediterranean	103	90	192	385

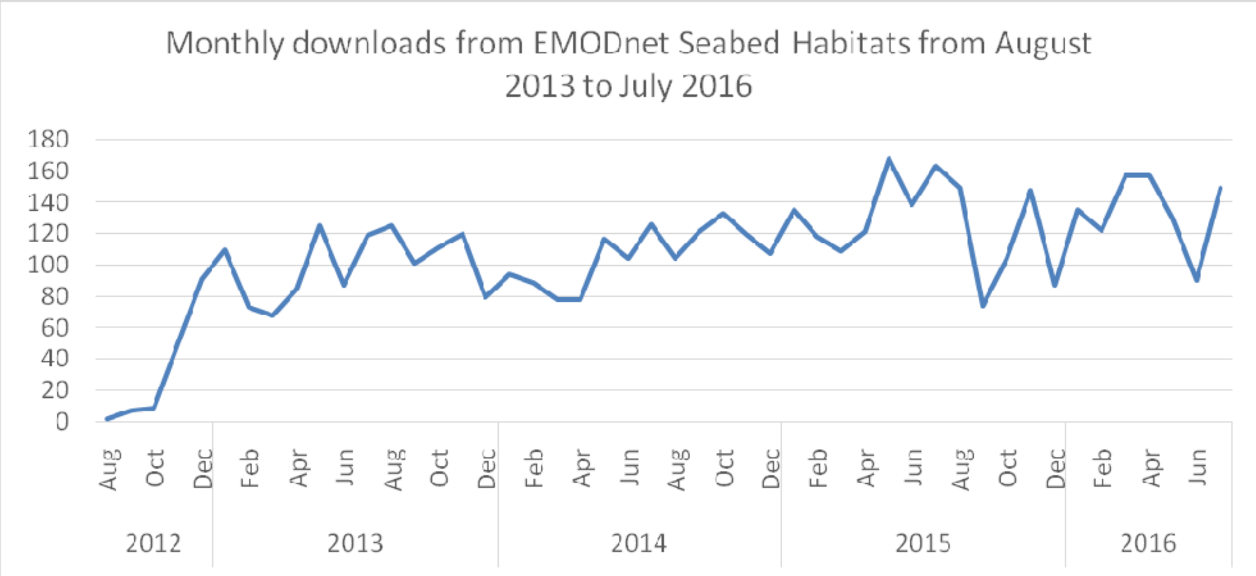
[3] Discontinued 09/09/2015 (replaced by Broad/Medium/Fine scale EUNIS datasets).

Sea				
Phase 1 Energy - North Sea and Celtic Sea	59	91	155	305
Phase 1 Energy/Wave Exposure - Baltic Sea	44	33	72	149
Phase 1 Seabed Substrata - western Mediterranean Sea	52	53	13	118
Phase 1 Halocline - Baltic Sea	22	32	66	120
Phase 1 Salinity - Baltic Sea	29	39	81	149
Phase 1 Fraction of light at the seabed - North Sea and Celtic Sea	47	77	128	252
National Marine Landscape Maps (published 2008)[4]	2	150	13	165
Broad scale EUNIS habitat maps from surveys[5]	0	0	295	295
Medium scale EUNIS habitat maps from surveys[5]	0	0	251	251
Fine scale EUNIS habitat maps from surveys[5]	0	0	375	375
Medium scale non-EUNIS habitat maps from surveys[5]	0	0	164	164
Fine scale non-EUNIS habitat maps from surveys[5]	0	0	205	205
EUSeaMap 2016 - Fraction of light reaching the seabed[6]	0	0	23	23
EUSeaMap 2016 - Photosynthetically Active Radiation at the seabed[6]	0	0	17	17
EUSeaMap 2016 - Photosynthetically Active Radiation at the surface[6]	0	0	14	14
EUSeaMap 2016 - Coefficient of light attenuation in water (KDPAR)[6]	0	0	14	14
EUSeaMap 2016 - Number of satellite images for each pixel of KDPAR[6]	0	0	9	9

[4] Discontinued 02/10/2015 (old dataset, no longer relevant).

[5] Made available 09/09/2015.

[6] Made available 24/05/2015.



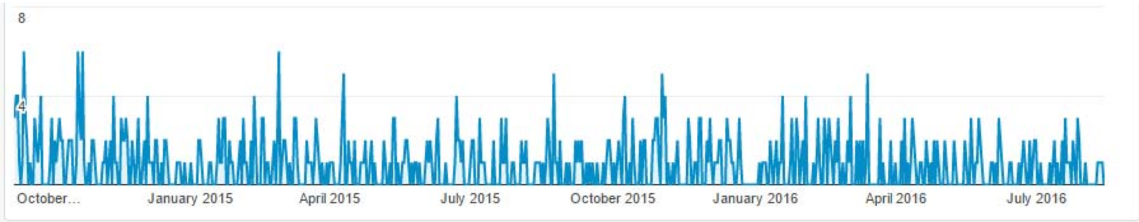
Indicator 5. Organisations that have downloaded each data type

The list of organisations can be seen in Appendix 5.

Indicator 6. Using user statistics to determine the main pages utilised and to identify preferred user navigations routes

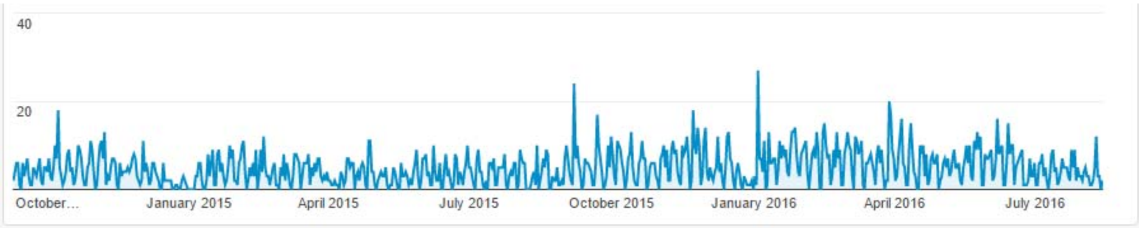
page description	page address	Number of unique visitors	How many users end their visit on this page	Average residence time (mm:ss)
Homepage	http://www.emodnet-seabedhabitats.eu	463	153	00:48
Interactive map	http://www.emodnet-seabedhabitats.eu/map	5858	5382	03:28
Downloads	http://www.emodnet-seabedhabitats.eu/download	2494	2536	02:05
Build custom map	http://www.emodnet-seabedhabitats.eu/custommap	1018	425	01:06
Search	hhttp://www.emodnet-seabedhabitats.eu/search	565	299	00:54

The following time series show unique user visits per day over the reporting period:

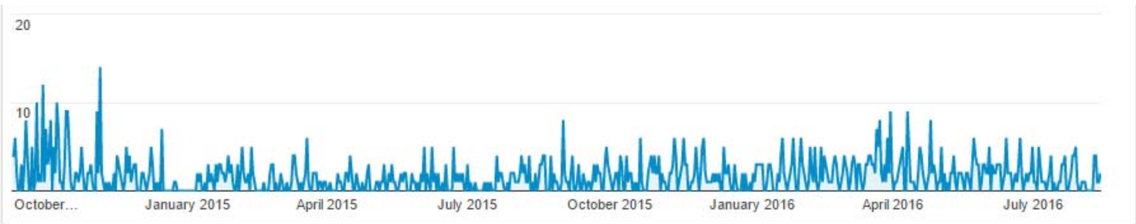


Visitors to EMODnet Seabed Habitats homepage from 09/09/2014 to 15/08/2016

Visitors to EMODnet Seabed Habitats interactive map page from 09/09/2014 to 15/08/2016



Visitors to EMODnet Seabed Habitats downloads page from 09/09/2014 to 15/08/2016

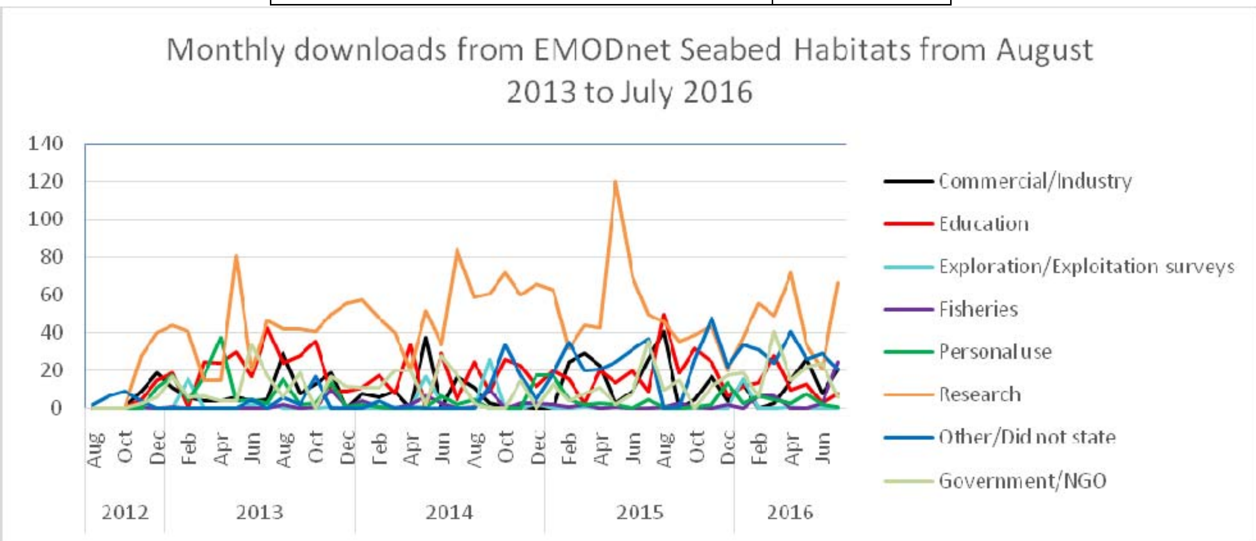


Visitors to EMODnet Seabed Habitats build custom map page from 09/09/2014 to 15/08/2016

Visitors to EMODnet Seabed Habitats search page from 09/09/2014 to 15/08/2016

Indicator 7. List of what the downloaded data has been used for (divided into categories e.g. Government planning, pollution assessment and (commercial) environmental assessment, etc.)

Reason	Percentage of total
Commercial/Industry	10 %
Education	16 %
Exploration/Exploitation surveys	2 %
Fisheries	2 %
Government/NGO	11 %
Other/Did not state	12 %
Personal use	5 %
Research	43 %



Indicator 8. List of web-services made available and user organisations connected through these web-services

A standard OGC-compliant WMS service (supplied by MapServer) of all map layers viewable on the interactive map is provided to clients through our Access Data page.

It is currently not possible to track organisations connecting through WMS services, as EMODnet Seabed Habitats does not require login for these services to aid ease of access.

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Appendix 1: Parameters known to be influencing biological zone and sub-zone boundaries in European seas

Biological zone boundary	Arctic, North, Celtic Seas, Macaronesia	Baltic Sea	Mediterranean Sea	Black Sea
Infralittoral / Circalittoral	**Rocky bottoms:** The limit of domination of photophilic macroalgae caused primarily by decreasing light availability. It is also associated with increasing stability in temperature, wave action and salinity. **Soft bottoms:** A less distinct boundary but generally associated with the same variables described for rocky bottoms. See Connor et al. (2004)	**Rocky bottoms:** The limit of domination of photophilic macroalgae caused primarily by decreasing light availability. It is also associated with increasing stability in temperature, wave action and salinity. **Soft bottoms:** A less distinct boundary but generally associated with the same variables described for rocky bottoms. Roughly equivalent to the photic/aphotic boundary in HELCOM Underwater Biotopes system (HELCOM, 2013), although the meaning of the terms photic/aphotic do not themselves correspond to this boundary as	**Rocky bottoms:** The limit of photophilic macroalgae caused by decreasing light availability. **Soft bottoms:** The limit of marine phanerogams associated to decreasing light availability. ***River plume area:*** The lowest depth limit of the muddy sand and sand bottoms influenced by the high riverine input	**Rocky bottoms:** The limit of domination of photophilic macroalgae caused primarily by decreasing light availability. **Soft bottoms:** Maximum depth at which seabed is affected by stormy waves (7-8 Beaufort) **River plume area:** *The lowest depth limit of the muddy sand and sand bottoms*

		some light penetrates the shallow circalittoral zone, allowing growth of sparse red algae.		
Shallow circalittoral / Deep (offshore) circalittoral	**Rocky bottoms:** The limit of all algae on rock caused primarily by decreasing light availability. It is also associated with further increasing stability in temperature, wave action and salinity. **Soft bottoms:** The limit of disturbance-tolerant species caused primarily by increasing stability in wave action and temperature. It is also associated with further increasing stability in salinity and decreasing light availability. See Connor et al. (2004)	Changes in dominant fauna based on haline stratification; this is associated with stability in salinity, wave action and temperature and can lead to reduced oxygen concentration. No equivalent in HELCOM Underwater Biotopes system (HELCOM, 2013)	n/a – no distinction made between shallow and deep circalittoral	Maximum depth at which seabed is affected by temperature seasonal variations
Circalittoral /Bathyal	Changes in dominant fauna based on water mass properties: many variables including depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux. Can be associated with the shelf edge delimited by the slope angle change of the continental platform.	n/a (seabed)	Shelf edge delimited by the slope angle change of the continental platform	Shelf edge delimited by the slope angle change of the continental platform
Upper bathyal / mid bathyal	Changes in dominant fauna based on water mass properties: many variables including depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux	n/a	n/a – no distinction made between upper/mid/lower bathyal	n/a – no distinction made between upper/mid/lower bathyal

	See Parry et al, 2015.			
Mid bathyal / lower bathyal	Changes in dominant fauna based on water mass properties: many variables including depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux See Parry et al, 2015	n/a	n/a – no distinction made between upper/mid/lower bathyal	n/a – no distinction made between upper/mid/lower bathyal
Bathyal / Abyssal	Changes in dominant fauna based on water mass properties: many variables including depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux. Can be associated with the lower limit of the continental slope delimited by the slope angle change of the continental platform. See Parry et al, 2015	n/a	Shelf slope break delimited by the slope angle change of the continental platform	Shelf slope break delimited by the slope angle change of the continental platform
Upper abyssal / mid abyssal	Changes in dominant fauna based on water mass properties: many variables including depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux See Parry et al, 2015	n/a	n/a – no distinction made between upper/mid/lower bathyal	n/a – no distinction made between upper/mid/lower bathyal
Mid abyssal / lower abyssal	Changes in dominant fauna based on water mass properties: many variables including depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux See Parry et al, 2015	n/a	n/a – no distinction made between upper/mid/lower bathyal	n/a – no distinction made between upper/mid/lower bathyal

Appendix 2: Sources and references of *Posidonia oceanica*, *Cymodocea nodosa* and hard bottoms data sets

Table 1. Sources of cartographic and georeferenced datasets used to integrate into the EMODNET substrate layer polygon and point data referring to *Posidonia oceanica*, *Cymodocea nodosa* and hard bottoms. Bibliographic references are indicated for documents that were made available for consultation.

Country	Direct cartographic data source	*Posidonia oceanica*	*Cymodocea nodosa*	Hard bottoms	Bibliographic reference codes
ALBANIA	International School for Scientific Diving, Lucca, Italy	•	•		1
CROATIA	International Marine Center, Oristano, Italy	•			
	University of Zagreb, Faculty of Science, Division of Biology , Croatia	•			
	Institute for oceanography and fisheries , Split, Croatia	•			
	State Institute for Nature Protection, Croatia	•			25, 27, 28, 29, 30, 31, 39, 54, 65,
CYPRUS	Department of Fisheries and Marine Research (DFMR), Cyprus	•			49
FRANCE	Ifremer, Bureau d'Etude Géologique - Brest	•	•		5
	Communauté d'Agglomération Nice Côte d'Azur, Conseil Général des Alpes-Maritimes, Région PACA, Agence de l'Eau Rhône Méditerranée & Corse, Andromède Environnement	•	•		24
	Ville de Cannes, Conseil Général des Alpes-Maritimes, Région PACA, Agence de l'Eau Rhône Méditerranée & Corse, Andromède Océanologie	•	•		22
	SIVOM du Littoral des Maures, Agence de l'Eau Rhône Méditerranée & Corse, SAFEGE CETIIS	•	•		15
	Parc national de Port-Cros, DIREN PACA, GIS Posidonie, Ifremer	•	•		56
	Parc national Port-Cros, DIREN PACA, Ifremer, Bureau d'étude géologique (Brest), Centre d'océanologie de Marseille	•	•		42
	Parc national de Port-Cros, DIREN PACA, GIS Posidonie, Ifremer	•	•		55
	Région PACA, Agence de l'Eau Rhône Méditerranée & Corse, Ifremer, GIS Posidonie	•	•		41
	Toulon Provence Métropole, Région PACA, DIREN PACA, Conseil Général du Var, Agence de l'Eau Rhône Méditerranée & Corse, GIS Posidonie, Ifremer	•	•		6
	Conseil général des Bouches du Rhône, Ifremer, GIS Posidonie, Philippe Clabaut Consultant	•	•		14

	Ville de Marseille, Agence de l'Eau Rhône Méditerranée & Corse, DIREN PACA, Conseil Régional PACA, Conseil Général des Bouches du Rhône, Marseille Provence Métropole, BCEOM	●	●		67
	Agence de l'Eau Rhône Méditerranée & Corse, Région PACA, DIREN PACA, Gis Posidonie, Ifremer, Centre d'Océanologie de Marseille, Parc Marin de la Côte Bleue	●	●		12
	Centre d'Océanologie de Marseille, CNEXO	●	●		8
	DIREN Languedoc-Roussillon, Andromede Environnnement	●	●		23
	ADENA, DIREN Languedoc-Roussillon, Agence de l'Eau Rhône Méditerranée & Corse, Conseil Régional du Languedoc-Roussillon, Université de Nice, CNRS-EPHE Université de Perpignan, GIS Posidonie, Ville d'Agde	●	●		18
	Réserve Naturelle Marine de Cerbère-Banyuls, GIS Posidonie, Ecole Pratique des Hautes Etudes, Observatoire océanologique de Banyuls, ADENA, Conseil Général des Pyrénées-Orientales, DIREN Languedoc-Roussillon	●	●		32
	Equipe Ecosystèmes Littoraux - Université de Corse	●	●		43
	Mairie de Sartène, GIS Posidonie, Université de Corse	●	●		20
	Equipe Ecosystèmes Littoraux - Université de Corse, IFREMER	●	●		47
	Office de l'Environnement de la Corse, GIS Posidonie, Equipe Ecosystèmes Littoraux - Université de Corse	●	●		66
	Office de l'Environnement de la Corse, GIS Posidonie, Equipe Ecosystèmes Littoraux - Université de Corse	●	●		44
	Equipe Ecosystèmes Littoraux - Université de Corse, Office de l'Environnement de la Corse	●	●		48
	Office de l'Environnement de la Corse, GIS Posidonie, Equipe Ecosystèmes Littoraux - Université de Corse	●	●		45
	Office de l'Environnement de la Corse, GIS Posidonie, Equipe Ecosystèmes Littoraux - Université de Corse	●	●		46
	Ifremer, reseau MEDBENTH		●		
GREECE	Greek Ministry of the Environment	●			37
	HCMR	●			
ITALY	see reference document	●	●	●	52
	see reference document	●	●		63
	Agenzia Regionale per la Prevenzione e la Protezione dell'Ambiente, Puglia, Italy	●	●	●	53
	see reference document		●	●	57
					16
	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale	●	●	●	

	see reference document	●	●		61
	see reference document	●	●	●	36
	see reference document	●	●	●	7
	see reference document		●	●	35
	see reference document			●	58
	Prof. Russo, Parthenope Un. of Naples			●	64
	see reference document	●		●	13
	see reference document			●	26
	see reference document	●		●	17
	Italian MSFD reporting on habitats			●	
	Italian MSFD reporting on habitats			●	
	see reference document	●		●	51
	Ente gestore Area Marina Protetta Secche di Tor Paterno	●		●	
	ISPRA, Chioggia			●	
LIBYA	UNEP/MAP - RAC/SPA, Tunis, Tunisia	●			62
MALTA	Malta Environment and Planning Authority, Malta	●	●		2,3,9,10,11, 21
SLOVENIA	Institute of the Republic of Slovenia for Nature Conservation, Slovenia	●	●		33
SPAIN	Instituto Español de Oceanografía (IEO) / Secretaría General de Pesca Marítima (MAPA)	●			59
	Dirección General de Costas. Ministerio de Obras Públicas	●			50
	Instituto Español de Oceanografía (IEO)	●			60
TUNISIA	Andromède Océanologie, France	●	●	●	4
	UNEP/MAP - RAC/SPA, Tunis, Tunisia	●			62
TURKEY	see reference document	●			19, 34, 38, 40

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Appendix 3: Seabed habitats ground-truth data (sampling points and polygons)

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
Black Sea									
BULGARIA	Whole coast (Kaliakra Cape, Varna Bay, Bourgas Bay-Tsarevo)	4,5,6	IO-BAS, GeoEcoMar	IO-BAS, GeoEcoMar & EurOBIS	point data	infralittoral soft bottom	112 (BG: 92 points)	infralittoral lower limit determination	IO_BAS monitoring data (unpubl.); UNDP/GEF BSERP (IO-BAS); BG national monitoring under WFD (IO-BAS), ; 7FP EC CoCoNet Project (IO-BAS); "State of the environment of the Stradza-Igneada MPA" (www.misisproject.eu) (GeoEcoMar); State of the Environment. Report of the Western Black Sea based on Joint MISIS Cruise" (GeoEcoMar)
BULGARIA	Bulgarian Black Sea		IO-BAS	Projects ISMEIMP, CoCoNet, Monitorng Data	Points	Infralittoral medium sand with *Donacilla*	3	Habitat Map	

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
BULGARIA	Bulgarian Black Sea		IO-BAS	Projects ISMEIMP, CoCoNet, Monitorng Data	Points	Infralittoral coarse and medium sand with *Upogebia, Chamelea*	97	Habitat Map	
BULGARIA	Bulgarian Black Sea		IO-BAS	Projects ISMEIMP, CoCoNet, Monitorng Data	Points	Infralittoral coarse sand with diverse fauna (none of the species is dominant, very limited distribution	2	Habitat Map	
BULGARIA	Bulgarian Black Sea		IO-BAS	Projects ISMEIMP, CoCoNet, Monitorng Data	Points	Infralittoral medium and fine sand with *Chamelea, Lentidium, Tellina*	145	Habitat Map	
BULGARIA	Bulgarian Black Sea		IO-BAS	Projects ISMEIMP, CoCoNet, Monitorng Data	Points	Infralittoral muddy sand and sandy mud with *Upogebia, Heteromastus, Nephthys, Aricidea*	18	Habitat Map	
BULGARIA	Bulgarian Black Sea		IO-BAS	Projects ISMEIMP, CoCoNet, Monitorng Data	Points	Upper infralittoral medium and fine sand with *Donax*	77	Habitat Map	

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
BULGARIA	Cape Atia, Sozopol, cape Agalina, cape Maslen Nos, Kiten, cape Emine, cape Sinemorets, Rodni Balkani, Ropotamo, Bolata, Kaliakra, Iailata, Zelenka, Tulenovo, Galata, Arapia, Veleka-Sinemoretz (Rezovo area)	52, 53, 54, 55, 56, 57	IBER, GeoEcoMar	IBER, GeoEcoMar	point data	infralittoral hard bottom (*Cystoseira barbata* presence)	32 (21 points - BG)	Infralittoral hard bottom lower limt (threshold 14 m isobath)	IBER monitoring data (unpubl.), MISIS project
BULGARIA	whole inner shelf	27	IO-BAS, GeoEcoMar	IO_BAS, GeoEcoMar & EurOBIS	point data	shallow circalittoral	217 (BG: 132 points)	shallow circalitoral delineation; temperature threshold	IO_BAS monitoring data (unpubl.); UNDP/GEF BSERP (IO-BAS); WFD monitoring program (IO-BAS), ; CoCoNet project (IO-BAS); UNDP/GEF BSERP project (GeoEcoMar), MISIS project (www.misisproject.eu) (GeoEcoMar)

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
Bulgaria	Bulgarian Black Sea		IO-BAS	Projects ISMEIMP, CoCoNet, Monitorng Data	Points	Circalittoral mud with *Nephthys, Arcidirea, Heteromastus, Abra, Pitar, Spisula*	43	Habitat Map	
Bulgaria	Bulgarian Black Sea		IO-BAS	Projects ISMEIMP, CoCoNet, Monitorng Data	Points	Circalittoral shelly sand and gravel with diverse fauna (none of the species is dominant)	49	Habitat Map	
BULGARIA	whole outer shelf	36	IO_BAS, GeoEcoMar	IO_BAS, GeoEcoMar & EurOBIS	point data	deep circalittoral	94 (BG: 38 points)	deep circa lower limit delineation;	IO_BAS monitoring data (unpubl.), GEF project, MISIS project (www.misisproject.eu)
BULGARIA	Varna outershelf	58	IO-BAS	IO-BAS	point data	suboxic deep circalittoral	1	suboxic deep circa; isopcnic values threshold	IO_BAS monitoring data (unpubl.)
GEORGIA	Gudaut, Sokhumi, Ochamchire - Batumi	19, 20, 21	GeoEcoMar	EurOBIS	point data	infralittoral soft bottom	41	infralittoral lower limit determinati on	www.eurobis.org

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
GEORGIA	Bichventa Bay - Sochumi, Ochamchire - Batumi Bay	31, 32	GeoEcoMar	GeoEcoMar & EurOBIS	point data	shallow circalittoral	67	shallow circalitoral delineation; temperature threshold	www.eurobis.org
GEORGIA	Pitsunda - Sokhumi, Kodori Bay-Kobuleti	41, 42	GeoEcoMar	GeoEcoMar & EurOBIS	point data	deep circalittoral	153	deep circa lower limit delineation;	www.eurobis.org
ROMANIA	Agigea-Vama Veche	51	GeoEcoMar	GeoEcoMar	point data	infralittoral hard bottom (*Cystoseira barbata* presence)	23	Infralittoral hard bottom lower limt (threshold 14 m isobath)	Environmental Baseline Survey Report, 2014
ROMANIA	whole inner shelf	25	GeoEcoMar	GeoEcoMar & EurOBIS	point data	shallow circalittoral	491	shallow circalitoral delineation; temperature threshold	Begun T., Teaca A., Gomoiu, M.T., Muresan M., 2010 - Present structure and distribution of macrobenthic populations in the North - Western Black Sea – Romanian Shelf. Rapp. Comm. Int. Mer Médit., 39, 443.

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
ROMANIA	whole outer shelf	35	GeoEcoMar	GeoEcoMar & EurOBIS	point data	deep circalittoral	736	deep circa lower limit delineation;	Begun T., Teaca A., Gomoiu M.-T., 2010 - Ecological state of macrobenthic populations within *Modiolus phaseolinus* biocoenosis from Romanian Black Sea Continental Shelf. Geo-Eco-Marina, 16: 5-18. Friedrich, J., Janssen, F., Aleynik, D., Bange, H. W., Boltacheva, N., Çagatay, M. N., Dale, A. W., Etiope, G., Erdem, Z., Geraga, M., Gilli, A., Gomoiu, M. T., Hall, P. O. J., Hansson, D., He, Y., Holtappels, M., Kirf, M. K., Kononets, M., Konovalov, S., Lichtschlag, A., Livingstone, D. M., Marinaro, G., Mazlumyan, S., Naeher, S., North, R. P., Papatheodorou, G., Pfannkuche, O., Prien, R., Rehder, G., Schubert, C. J., Soltwedel, T., Sommer, S., Stahl, H., Stanev, E. V., Teaca, A., Tengberg, A., Waldmann, C., Wehrli, B., and Wenzhöfer, F.:

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
									Investigating hypoxia in aquatic environments: diverse approaches to addressing a complex phenomenon, Biogeosciences, 11, 1215-1259, doi:10.5194/bg-11-1215-2014, 2014
ROMANIA	Sf. Gheorghe, Mangalia outershelf	44, 45	GeoEcoMar	GeoEcoMar & EurOBIS	point data	suboxic deep circalittoral	17	suboxic deep circa; isopcnic values threshold	Muresan M., 2014. Diversity and distribution of free-living nematodes within periazoic level on the Romanian shelf of the Black Sea, Geo-Eco-Marina 20, 19-28 pp
ROMANIA	Midia Cape, Constanta, Tuzla Cape	1, 2, 3	GeoEcoMar	GeoEcoMar & EurOBIS	point data	infralittoral soft bottom	56	infralittoral lower limit determination	BEGUN, T., TEACĂ, A., GOMOIU, M.-T. and PARASCHIV G. M., 2006 - Present state of the sandy invertebrate populations from two touristic beaches situated in the south sector of the Romanian Black Sea coast. GEO-ECO-MARINA, 12: 67-77. Teaca A., Begun T., Muresan M. - Chapter 7:

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
									Assessment of Soft-Bottom Communities and Ecological Quality Status Surrounding Constanta and Mangalia Ports (Black Sea), 67-74 pp., in Book: Stylios, C., Floqi, T., Marinski, J., Damiani, L., (eds.), 2015. Sustainable Development of Sea-Corridors and Coastal Waters, Springer International Publishing Switzerland 2015 DOI 10.1007/978-3-319-11385-2_1. http://www.springer.com/gp/book/9783319113845
ROMANIA + UKRAINA	Danube mouth	23	GeoEcoMar	GeoEcoMar & EurOBIS	point data	plume area	406	Danube and Dniepr plume area delineation; salinity threshold	GeoEcoMar monitoring data (unpubl.); Petrov, A, Milovidova, N. , Alyomov S., Shadrina L. - Initial data set (1982-1992) on abundance and biomass of soft-bottom macrozoobenthos , key abiotic variables in near-bottom layers of Sevastopol bay, SW Crimea, Ukraine. Institute

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
									of Biology of Southern Seas, Ukraine. www.eurobis.org; Petrov A., Povchun A.S., Zolotrev P.N. - Initial data set (1980-1989) on abundance and biomass of soft-bottom macrozoobenthos of Karkinitsky gulf, Western Crimea, Ukraine. Institute of Biology of Southern Seas, Ukraine. www.eurobis.org
RUSSIA	Kerch Strait offcoast, Anapa - Bolshoy Utrish, Gelendzhik - Shepsi	28, 29, 30	GeoEcoMar	GeoEcoMar & EurOBIS	point data	shallow circalittoral	141	shallow circalitoral delineation; temperature threshold	www.eurobis.org
RUSSIA	Anapa - Novorossiysk, Gelendzhik - Dzhankhot, Betta - Lermontov, Novomikhaylovskiy - Shepsi	15, 16, 17, 18	GeoEcoMar	EurOBIS	point data	infralittoral soft bottom	34	infralittoral lower limit determination	Petrov, A, Milovidova, N. , Alyomov S., Shadrina L. - Initial data set (1982-1992) on abundance and biomass of soft-bottom macrozoobenthos , key abiotic variables in near-bottom layers of Sevastopol bay, SW Crimea, Ukraine. Institute

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
									of Biology of Southern Seas, Ukraine. www.eurobis.org
RUSSIA	Anapa - Novorossiysk, Krinitsa - Shepsi outer shelf	39, 40	GeoEcoMar	GeoEcoMar & EurOBIS	point data	deep circalittoral	81	deep circa lower limit delineation;	www.eurobis.org
RUSSIA (CRIMEA)	Yalta (outer shelf)	38	GeoEcoMar	GeoEcoMar & EurOBIS	point data	deep circalittoral	40	deep circa lower limit delineation;	www.eurobis.org
RUSSIA (Crimeea)	Sevastopol, Fiolent Cape - Laspi Bay, Yalta	12, 13, 14	GeoEcoMar	EurOBIS	point data	infralittoral soft bottom	69	infralittoral lower limit determinati on	Petrov, A, Milovidova, N. , Alyomov S., Shadrina L. - Initial data set (1982-1992) on abundance and biomass of soft-bottom macrozoobenthos , key abiotic variables in near-bottom layers of Sevastopol bay, SW Crimea, Ukraine. Institute of Biology of Southern Seas, Ukraine. www.eurobis.org
RUSSIA (Crimeea)	Tarkhankut Peninsula, Sevastopol,	46, 47, 48, 49, 50	GeoEcoMar	EurOBIS	point data	Infralittoral hard bottom (*Cystoseira*	221	Infralittoral hard bottom lower limt	Milchakova N.A., Ryabogina V.G., Chernyshova E.B.

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
	Fiolent Cape-Laspi Bay, Simeiz, Kurortnoe-Planernyj Cape					*barbata* presence)		(threshold 14 m isobath)	Macroalgae of the Crimean coastal zone (the Black Sea, 1967-2007). Sevastopol, IBSS, 2011.
TURKEY	Pazar-Findikli, Besikduzu-Gorele	33, 34	GeoEcoMar	EurOBIS	point data	shallow circalittoral	15	shallow circalitoral delineation; temperature threshold	www.eurobis.org
TURKEY	Igneada outer shelf	43	GeoEcoMar	GeoEcoMar	point data	deep circalittoral	8	deep circa lower limit delineation;	MISIS project (www.misisproject.eu)
UKRAINA	Prymorske-Zatoka, Odessa sand bank, Tendrovskaya kosa, Karkinitsky Bay	8,9,10,11	GeoEcoMar	EurOBIS	point data	infralittoral soft bottom	156	infralittoral lower limit determinati on	TEACĂ, A., BEGUN, T., GOMOIU, M.-T., 2001 - The meio- and macrozoobenthos of limans and shallow marine waters of the Ukrainian Blak Sea littoral. An. Univ. “Al. J. Cuza” Iaşi: 203-213. Petrov A., Povchun A.S., Zolotrev P.N. - Initial data set (1980-1989) on abundance and biomass of soft-bottom macrozoobenthos of Karkinitsky gulf, Western Crimea, Ukraine. Institute

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
									of Biology of Southern Seas, Ukraine. www.eurobis.org
UKRAINA	Dnieper mouth	24	GeoEcoMar	EurOBIS	point data	plume area	40	Dniepr plume area delineation; salinity threshold	Petrov A., Povchun A.S., Zolotrev P.N. - Initial data set (1980-1989) on abundance and biomass of soft-bottom macrozoobenthos of Karkinitsky gulf, Western Crimea, Ukraine. Institute of Biology of Southern Seas, Ukraine. www.eurobis.org
UKRAINA	whole inner shelf	26	GeoEcoMar	GeoEcoMar & EurOBIS	point data	shallow circalittoral	800	shallow circalitoral delineation; temperature threshold	www.eurobis.org.
UKRAINA	whole NW outer shelf	37	GeoEcoMar		point data	deep circalittoral	578	deep circa lower limit delineation;	www.eurobis.org
Mediterranean Sea									
CROATIA	Uvala Planka, Strazika, Unije, Losinj	2	ISPRA	International Marine Center, Oristano	lower limit point data	Posidonia oceanica	11	infralittoral lower limit light	

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
								threshold determinati on	
CROATIA	Lojisce (Dug Otok), Rukavac (Vis), Saplun Island (Lastovo)	3, 4, 5	ISPRA	University of Zagreb, Faculty of Science, Division of Biology , Croatia	lower limit point data	Posidonia oceanica	3	infralittoral lower limit light threshold determinati on	
CROATIA	Kamenjak, Cres, Vis	6, 7, 4	ISPRA	Institute for oceanography and fisheries , Split, Croatia	lower limit point data	Posidonia oceanica	3	infralittoral lower limit light threshold determinati on	
CYPRUS	Nisia, Cavo Greko, Moulia, Polis, Limassol - Basilikos	24, 25, 26, 27, 28	ISPRA	Department of Fisheries and Marine Research (DFMR), Cyprus	lower limit point data and respective meadow polygon data	Posidonia oceanica	5	infralittoral lower limit light threshold determinati on	Petrou A., Patsalidou M., Chrysanthou K., 2013. Services for mapping the meadow of marine phanerogam *Posidonia oceanica* in coastal waters of Cyprus, within the operational programme for fisheries 2007-2013”. Final report, April 2013, 1-54pp.

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
GREECE	Aegean, Ionian and Levantine Sea		HCMR	Salomidi M. & V. Gerakaris, HCMR, unpubl data	lower limit point data and respective meadow polygon data	Posidonia oceanica	13	infralittoral lower limit light threshold determination	Monitoring of the Greek NATURA 2000 Network (work in progress, M. Salomidi chief scientist)
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.24 Infralittoral muddy sand	8	model ground truthing data	REFERENCES FOR ALL DATA: **Simboura, N. & A. Zenetos, 2002**. Benthic indicators to use in ecological quality classification of Mediterranean soft bottom marine ecosystems, including a new Biotic index. Mediterranean Marine Science, 3/2:77-111.49. **Simboura**, N., Kyriakidou, Ch., Drakopoulou, Salomidi, M., Sakellariou, D., 2015. Methodological approach for mapping the soft bottom zoobenthic habitats of Greece. Proceedings of the 11th Hellenic Symp. Ocenogr. & Fisher. 13-17 May 2015, Lesvos, pp. 501-504. 52.

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
									Simboura, N., M. Tsapakis, A. Pavlidou, G. Assimakopoulou, K. Pagou, H. Kontoyiannis, Ch. Zeri, E. Krasakopoulou, E. Rousselaki, N. Katsiaras, S. Diliberto, M. Naletaki, K. Tsiamis, V. Gerakaris, P. Drakopoulou, P. Panayotidis. 2015. Assessment of the environmental status in Hellenic coastal waters (Eastern Mediterranean): from the Water Framework Directive to the Marine Strategy Water Framework Directive. Mediterranean Marine Science. 16/1: 46-64.
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.13 Infralittoral coarse sediments	21	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.23 Infralittoral fine sands	35	model ground truthing data	

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.235 Mediterranean biocenosis of fine sands in very shallow waters	3	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.236 Mediterranean biocenosis of well sorted fine sands	12	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.24 Infralittoral muddy sands	19	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.28 Biocenosis of superficial muddy sands in sheltered waters	28	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	infralittoral muds	57	TO FLAG pareas	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.38 Mediterranean biocoenosis of muddy detritic bottoms	29	model ground truthing data	

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.39 Mediterranean biocoenosis of coastal terrigenous muds	73	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.43 Infralittoral mixed sediments	8	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.46 Mediterranean biocoenosis of coastal detritic bottoms	60	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.47 Mediterranean assemblages of shelf-edge detritic bottoms	30	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 5.51 Maerl beds (all Rhodolith beds)	16	model ground truthing data	
GREECE	Aegean and Ionian Seas		HCMR	HCMR benthic surveys. Data provider: N. Simboura	sampling points	A 6.51 Mediterranean biocenosis of bathyal muds	37	model ground truthing data	

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
ITALY	Puglia: Alimini-Otranto, Tremiti, P. Cesareo-T.Colimena, Ugento, T. Colimena-T.Ovo,	16, 17, 18, 19, 20	ISPRA	Agenzia Regionale per la Prevenzione e la Protezione dell'Ambiente, Puglia, Italy	lower limit point data and respective meadow polygon data	Posidonia oceanica	7	infralittoral lower limit light threshold determination	
ITALY	Puglia: Le Cesine, Ugento, Gallipoli	19, 21, 22	ISPRA	see reference document	lower limit point data and respective meadow polygon data	Posidonia oceanica	3	infralittoral lower limit light threshold determination	Regione Puglia e CRISMA (2004). Inventario e cartografia delle praterie di Posidonia nei compartimenti marittimi di Manfredonia, Molfetta, Bari, Brindisi, Gallipoli e Taranto. Relazione Generale. 105 pp.
ITALY	Sicily: meadow 17, 21, 22, 26,39,40, 41, 43	32	ISPRA	see reference document	lower limit point data and respective meadow polygon data	Posidonia oceanica	14	infralittoral lower limit light threshold determination	Ministero dell'Ambiente - Servizio Difesa del Mare. 2001. Mappatura delle praterie di *Posidonia oceanica* lungo le coste della Sicilia e delle isole minori circostanti. Relazione finale Fase 3 "Elaborazione dati e relazioni conclusive". Pp. 644.

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
MALTA	whole country	33	ISPRA	Malta Environment and Planning Authority, Malta	lower limit point data	Posidonia oceanica	17	infralittoral lower limit light threshold determination	
Atlantic Seas									
Norway	Norwegian coast		NIVA (Norwegian Institute for Water Research)	NIVA projects, but mainly the National program for Mapping for Diversity - Coast	points	Presence kelp or true absence of kelp due to light (Bare rocks or boulders)	3082 (kelp), 394 (absence kelp)	Mainly collected in order to model the kelp forest distribution. Good fitness for purpose for presence of kelp. Analysis would benefit from a larger number of absences	for more information on the mapping program (in Norwegian only): Mwww.miljødirektoratet.no/no/Tema/Miljoovervakning/Kartlegging-av-natur/Kartlegging-av-naturtyper/Marine-naturtyper/. Publications: eu.wiley.com/WileyCDA/WileyTitle/productCd-0470657561.html AND brage.bibsys.no/xmlui/bitstream/handle/11250/102389/G0711.pdf?sequence=1
UK and Ireland	UK and Ireland		Joint Nature Conservation Committee	Centre for Environmental Data and Recording (CEDaR, Northern Ireland) Data Archive for Seabed Species	points	Moderate Energy infralittoral/circalittoral rock and Low Energy infralittoral/circalittoral rock	450 (Moderate), 274 (Low)	Moderate Energy lower limit threshold	"Energy threshold extract from the Marine recorder snapshot V51 January 2015." Marine Recorder is the database application used by JNCC and other organizations in the UK to

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
				and Habitats (DASSH) Joint Nature Conservation Committee Natural England Natural Resources Wales (formerly Countryside Council for Wales and referred to as such or CCW in this version) Porcupine Marine Natural History Society Scottish Natural Heritage Seasearch (Marine Conservation Society) Shoresearch Kent Wildlife Trust					store marine benthic sample data such as species, physical attributes and biotopes. Biotopes are classified according to the biotope Marine classification for Britain and Ireland, which is compatible with EUNIS. Lack of clear definition in EUNIS of energy classes and confusing terminology for wave/tide swept biotopes makes it hard to relate biotopes to high/moderate and low energy classes. for more information on the full marine recorder snapshot visit http://jncc.defra.gov.uk/page-1538

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
UK and Ireland	UK and Ireland coastal waters		Joint Nature Conservatio n Committee	Centre for Environmental Data and Recording (CEDaR, Northern Ireland), Data Archive for Seabed Species and Habitats (DASSH), Joint Nature Conservation Committee, Natural England, Natural Resources Wales (formerly Countryside Council for Wales and referred to as such or CCW in this version), Porcupine Marine Natural History Society, Scottish Natural Heritage, Seasearch (Marine Conservation Society), Shoresearch Kent Wildlife Trust	points	infralittoral rock (IR) and circalittoral rock (CR),	3471 (IR), 3886 (CR)	Infralittoral lower limit light threshold	"Infralittoral and Circalittoral Rock from the Marine recorder snapshot V51 January 2015 for Light threshold analysis" Marine Recorder is the database application used by JNCC and other organisations in the UK to store marine benthic sample data such as species, physical attributes and biotopes. Biotopes are classified according to the biotope Marine classification for Britain and Ireland, which is compatible with EUNIS. Good fitness for purpose. For more information on the full marine recorder snapshot visit http://jncc.defra.gov.uk/page-1538

Country	Name of locations/code of the dataset	Locations' ID on the maps	Institution that acquired the data	Source of data	Type of data (sampling points, polygons, so on..)	Habitat name	Number of sample data per habitat	Fitness for purpose of data	Reference
UK and Ireland	UK and Ireland coastal waters		Joint Nature Conservation Committee	Centre for Environmental Data and Recording (CEDaR, Northern Ireland), Data Archive for Seabed Species and Habitats (DASSH), Joint Nature Conservation Committee, Natural England, Natural Resources Wales (formerly Countryside Council for Wales and referred to as such or CCW in this version), Porcupine Marine Natural History Society, Scottish Natural Heritage, Seasearch (Marine Conservation Society), Shoresearch Kent Wildlife Trust	points	High Energy infralittoral/circalittoral rock and Moderate Energy infralittoral/circalittoral rock	611 (High Energy), 777 (Moderate Energy)	High Energy lower limit threshold	"Energy threshold extract from the Marine recorder snapshot V51 January 2015." Marine Recorder is the database application used by JNCC and other organizations in the UK to store marine benthic sample data such as species, physical attributes and biotopes. Biotopes are classified according to the biotope Marine classification for Britain and Ireland, which is compatible with EUNIS. Lack of clear definition in EUNIS of energy classes and confusing terminology for wave/tide swept biotopes makes it hard to relate biotopes to high/moderate and low energy classes. for more information on the full marine recorder snapshot visit http://jncc.defra.gov.uk/page-1538

Appendix 4: Assessment of 100m model feasibility

The Bathymetry lot provided us with an overview of the data sources their current 250m DTM pixel values originate from. The depth value that is assigned to each pixel of that DTM has one of the following origins (Fig 1): i) averaged survey depth soundings, ii) composite DTM, iii) interpolation, or iv) GEBCO DTM.

The first category (blue-green in Fig. 1) contains pixels whose values are averaged survey depth soundings. These were considered as good candidates for 100m resolution if the number of soundings per pixel is at least 4. Composite DTMs having their own native resolution, so good candidates for the 100m model are those with a resolution around 100m. Regarding pixels derived from interpolation, in the EMODnet DTM the distance between those pixels and the measured values that were used for their interpolation is typically much higher than 100m. Therefore pixels coming either from GEBCO DTM or from an interpolation were considered as not eligible for a 100m resolution model. Finally, the 1km resolution of the GEBCO DTM is by definition much coarser than 100m, which makes it unsuitable.

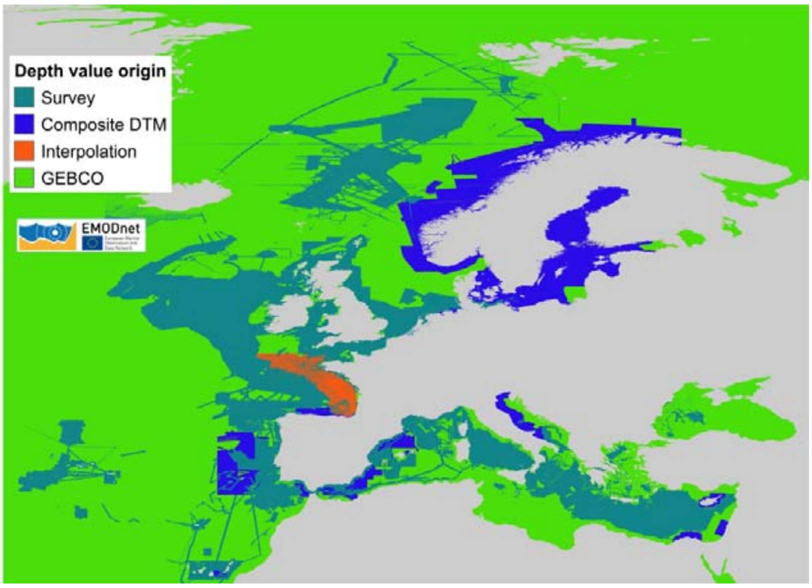


Figure 1: Origin of the EMODnet 250m DTM depth values

As a result, the coverage of a potential 100m model resulted from areas where the current EMODnet DTM 250m pixel values were calculated from at least 4 depth soundings along with the coverage of 100m resolution composite DTMs (Fig. 2).

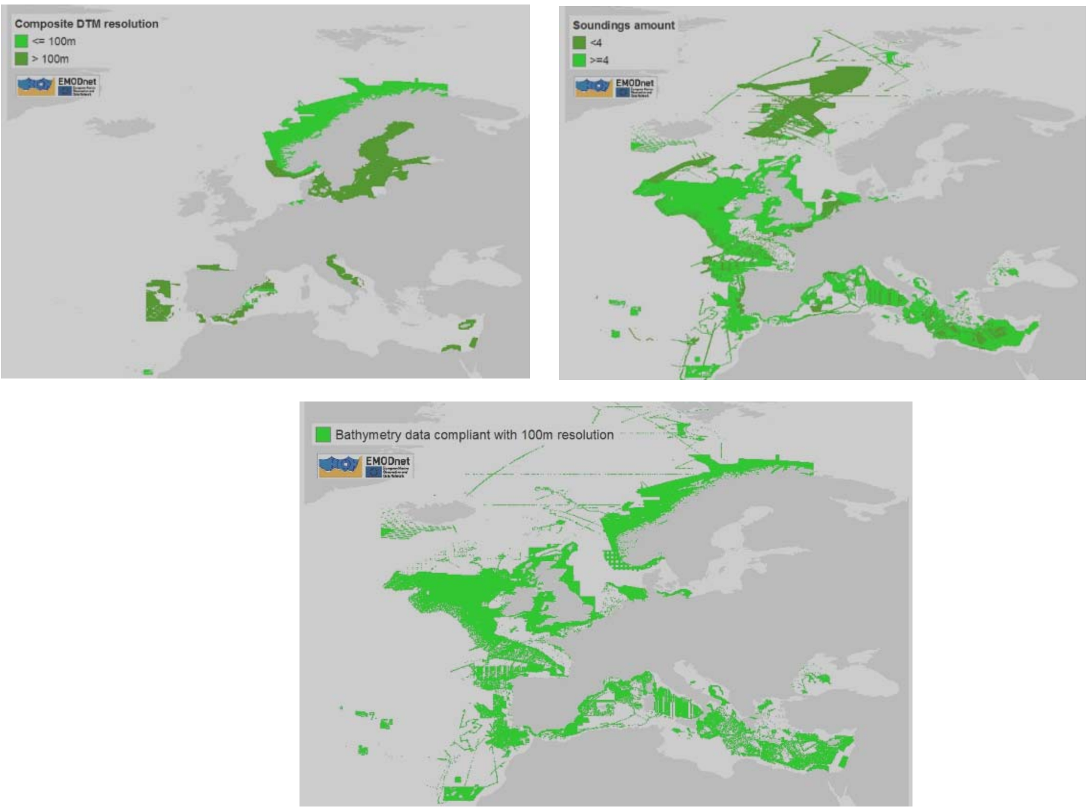


Fig. 2: Overview of: Top left, composite DTMs; To right, density of soundings; Bottom: Resultant coverage of potential 100m bathymetry DTM

As far as substrate is concerned, the Geology lot recently delivered a 1/250000 coverage for seabed sediment. This scale was deemed compatible with a resolution of 100m. Figure 3 shows this coverage throughout Europe.

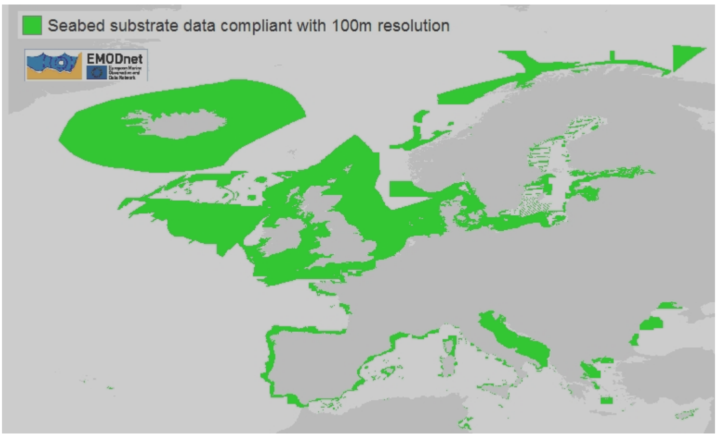


Figure 3: Coverage of seabed substrate suitable for a 100m model.

The resolution of light penetration data is 250m (from Meris pixels). Given the fact that water transparency values generally exhibits weak gradients, we deem this resolution to remain compatible with a 100m habitat model. Exposure at the seabed is more of an issue because, even though a lot of progress has been made (see Highlight and WP1 sections), only in the UK, France and possibly parts of Norway where a high resolution fetch model is available could the datasets meet the requirements of the 100m model. The rest of Europe, except for a very limited number of places (e.g. Italy), is not yet in a position to produce this high resolution model.

Appendix 5: List of organisations that have downloaded each data type

40South Energy	HKSTP	SAIC
Aarhus University	HR wallingford	School of fisiography
Aberystwyth university	HRI	Scottish Association for Marine Science
Åbo Akademi University	ICES	Scottish Government Marine Scotland
ABPmer	ICM	Scottish Natural heritage
Admistração do Porto de Lisboa	ICNF	Sea Fisheries Protection Authority
AECOM	IECS Univ Hull	Sea Mammal Research Unit, St Andrews
Agence des aires marines protégées (French Agency for MPA)	IFAPA, Junta de Andalucia	SEACAMS
Agri-Food and Biosciences Institute	Ifremer	Seafish Industry Authority
Aix Marseille Université	ign	SENRGY, Bangor University
Alcatel-Lucent	IH	Severn Estuary Partnership
Alderney Wildlife Trust	IHF	SGU - Geological Survey of Sweden
Alfred Wegener Institute for Marine and Polar Research	IHM	SHOM
Algarve University	IIMRO	sift-uk
Amec Foster Wheeler	Ile-de-france	SINTEF
APEM	ILVO	sLU
APL, S.A.	IMARES / Wageningen Marine Research	SMIAC
AquaBiota Water Research	Imperial College London	SOCIB ICTS
Aquafact Ltd	Inogs	Somerset Wildlife Trust
Aquatera Ltd	INPEX Corporation	Southampton University
Architectural Association School of Architecture	Institut de Ciencies del Mar	Spanish Oceanographic Institute
Ardboe Coldstore Ltd	Institut de géographie alpine Grenoble	SSE
Armada Española	Institut Mediterrani d'Estudis Avançats	Staatsbosbeheer
Arup	Institut océanographique Paul Ricard	Stanford University
Askham Bryan College	Institute for water of the RS	Station biologique de Roscoff
Associação para as Ciências do Mar	Institute of Hydrobiology	Stockholm Resilience Centre
Atkins Global	Institute of Marine Research	Stockholm University
Auditerg	Institutionen för geovetenskaper	Swansea University
Aveiro University	Instituto da Conservação da Natureza e das Florestas, IP	Swedish Agency for Water and Marine Management
AZTI	Instituto Español de Oceanografía	Swedish University of Agricultural Sciences

AZTI-Tecnalia	Instituto Geologico y Minero (IGME)	SYKE
Baltic University Programme	Intertek	Technische Universität Berlin
Bangor University	IOC.UNESCO	TEO
Basque Centre for Climate Change (BC3)	io-warnemuende	THA Aquatic
Belgian Navy	IPMA, Portugal	The Baltic Pavillion
BfN	ISMAR	The Crown Estate
Bioconsult	ISMAR-CNR	The GIS Institute
Bist Llc	ISPA	The Hebrew University of Jerusalem
BMT Cordah	isprambiente	The Marine Biological Association of the United Kingdom
BMT Cordah Ltd	IT Sligo, Eire. Thesis project.	The National academy of Sciences of Belarus
Bonn Agreement	Italian Navy	The Red Tentacle
BOREA Research Unit, University of Caen France	IUCN	Thomson Ecology
Bournemouth University	IUEM/CNRS/UBO	Thünen-Institut
BP	James Cook University	Tidal lagoon power
British Geological Survey	JNCC	TRAGSA - Ministry of Environment
BSH Startseite	Joint Research Centre -European Commission	Trinity College Dublin
BVG Associates	JRC-IES-H06 Unit (DERD)	U.S. Geological Survey
Ca' Foscari University of Venice	Jūros mokslų ir technologijų centras - Klaipėdos Universitetas	Ulster University
Cadcorp	kesti	UNEP-WCMC
Cagliari University	Khulani GeoEnviro Consultants	UNESCO
Cambridge University	Klaipeda University	UNESCO-IOC
Cantabria	Kretslopppsbolaget	UNIGIS
Cardiff University	Kuefog	Universidad Autónoma de Madrid
Cardno	KU-MARSTEC	Universidad de Cantabria
CAU	Laboratoire LEMAR	Universidad de Extremadura
CCMAR, University of the Algarve	Land Use Consultants	Universidad de Mañaga
CDPMEM29	Latvian Ornithological society	Universidad de Salamanca
Cedre	Leeds University	Universidade da Coruña
CEK	Leibniz Institute for Baltic Sea Research Warnemuende	Universidade de Aveiro
Cellule de Suivi du Littoral Normand	Leidos Health	Universidade de Coimbra
Center of Marine Sciences	Les éoliennes en mer	Universidade do Algarve
Centre for Environment, Fisheries and Aquaculture Science	Lisbon University	università degli studi di Firenze
CEPT University	Loudoun County High School	Università degli Studi di Genova
CESAM-UA	Loughborough University	Università di Bologna
CH2M HILL	LPDB	Università di Dine
CIBIO	LR Senergy	Université de Caen Normandie
Cibm	LUC	Universite de la Reunion
CIIMAR	Maich	Université de La Rochelle
Clearwater	Marine Biological Association	Université d'Orsay

CLS	Marine Ecological Surveys Ltd	Université du Havre
CMACS Ltd	Marine Institute, Ireland	Université du Littoral Côte d'Opale
CNR-IAMC Mazara del Vallo	Marine Institute, Plymouth University	Université Libre de Bruxelles
CNR-ISE	Marine Laboratory	Université Mohammed V de Rabat
CNR-ISMAR	Marine Management Organisation	University Antwerp
Cogea	Marine Mapping	University College Cork
Collecte Localisation Satellites	Marine Scotland	University College London
Comata	Marine Scotland Science	University Namur
Comité Régional des Pêches de Bretagne	Marine Systems Institute, Tallinn University of Technology	University of Aberdeen
Cooke Aquaculture Ltd	Marinespace	University of Aveiro
Cornwall Council	Maritime Institute in Gdańsk	University of Azores
Cornwall Wildlife Trust	MARUM Universitaet Bremen	University of Birmingham
County Administrative Board of Västra Götaland	mba	University of Bologna
COWI	md	University of Bradford
CREOCEAN	ME Certification Ltd	University of Brest
CRRU	MedPAN organisation	University of Bristol
CSIC	Michael Carder Ltd	university of Cagliari
Danmarks Fiskeriforening PO	Michigan State University	University of Cantabria
D'Appolonia	MMO	University of Cincinnati
DDTM 85	MMT	University of Coimbra
Defra	MOD	University of Colorado, Boulder
Deltares	MPI for Marine Microbiology	University of Copenhagen
DEME	MRAG	University of Exeter
Department of Art, Heritage, Region, Rurual and Gaeltacht Affairs	MSG Sustainable Strategies	University of Ghent
Dept of Environment Northern Ireland	Nass&Wind Offshore	University of Glasgow
Devon and Severn IFCA	National Biodiversity Data Centre	University of Greenwich
DGRM	National Museum of Natural History (France)	University of Hamburg
dmi	National Oceanography Centre	University of Helsinki
DNV GL	National Parks and Wildlife Service	University of Hull
DoE Marine Division, N. Ireland	Natural England	University of Kansas
Dokuz Eylul University	Natural Power	University of Kent
DTU Aqua	Natural Resources Wales	University of La Rochelle
Dublin	Naturebureau	University of Leiden
Earth Analytic, Inc	Navama - technology for nature	University of Liverpool
EASME	Navionics	University of Malaga
Eco Fish Consultants Ltd	New Economics Foundation	University of Málaga
Ecologic Institute	New University og Lisbon	University of Murcia
Edinburgh University	New Wave Foods	University of Pau (France)
EMODnet	Newcastle University	University of Pennsylvania
Engie Group	Nexen Petroleum UK LTD	University of Piraeus
EnQuest	NINA	University of Pisa
ENSM	NIOZ	University of Porto

ENVIRON UK Ltd	NIRAS	University of Sheffield
ENVIRONCORP	NIVA	University of South Wales
Environment Agency	NLWKN	University of Southampton
Environment Systems	NOAA, Southwest Fisheries Science Center	University of St. Andrews
Environmental Management Centre Vilnius	North West Wildlife Trusts	University of Stirling
Environmental Research Institute	NOVA SBE	University of Strathclyde
Environmental Research Institute, University of the Highlands and Islands	NTNU - Norwegian University of Science and Technology	University of the Azores
Environmental Resources Management Ltd.	NUI Galway	University of Thessaly
Envision Mapping Ltd	Ocean Ecology Ltd	University of Trieste
EPFL	Oceana	University of Vigo
ERM	OCEANSNELL	University of Viterbo
ETC/BD	oDTM	University of Western Australia
European Commission	OGS - Istituto Nazionale di Oceanografia e di Geofisica Sperimentale-Italy	University of Winchester
European Environment Agency	Orbis Energy Ltd	University of York
European Topic Centre on Biological Diversity	Orkney Sustainable Fisheries Ltd	University Pablo de Olavide
Faculdade de Ciências da Universidade de Lisboa	OSPAR Commission	University Pierre et Marie Curie, Banyuls Marine Observatory.
Fauna & Flora International	Ossian Resources Ltd	UPMC
Finnish Environment Institute	Oxford University Press	Uppsala University
FLPS	Periplus Consultancy	UPTC
Flyby S.r.l. Livorno Italy	Pinro	URS
France Energies Marines	Pisa University	USGS
Fugro EMU	Plymouth Marine Laboratory	UVIGO
Gardline Environmental Limited	Plymouth University	Van Hall Larestein University of Applied Sciences
General-Directorate for Natural Resources, Safety and Maritime Services	PML Applications	Vattenfall Wind Power Ltd
Genesis Oil and Gas Ltd	Politecnico di Milano	VHL University of Applied Science
GeoInterest	Portland State University	Victoria University of Wellington
Geological Survey of Spain IGME	Poseidon	Vilniaus Universitetas
Geo-Marine Technology	Project Development International	VisNed
Global Marine Systems Ltd	Proyectos Biológicos y Técnicos s.l.	VLIZ
GoBe	Queen's University, Belfast	Vrije Universiteit Amsterdam
Good Fish Foundation	Ramboll Environ	VUW
Göteborg University	Ramboll UK	Wageningen UR
GRID-Arendal	RES Offshore	WavEC
G-tec	Ricardo Energy and Environment	web
H+N+S Landscape architects	Rijksuniversteit Groningen	Wildfowl and Wetlands Trust
Hamburg	RIL	Woodside Energy
Hamburg University of Technology	Royal Belgian Institute of Natural Sciences	WWF

Hartley Anderson	Royal College of Art	Xodus Group Ltd
Havochvatten	Royal Haskoning DHV	xsXalence
Helcom	Royal Swedish Navy Mine Warfare Data Centre	Yildiz Technical University
Hellenic Center for Marine Research	RPS Group	Ymparisto
Helmholtz center for material and coastal research	RSK	Yorkshire Wildlife Trust
Heriot-Watt University	RSPB	

Appendix 6: Basin habitat tables and maps

Habitat types in the Black Sea which can be identified from the habitat descriptors seabed substrate, biological zone and, within the deep circalittoral, oxygen conditions. Grey cells are for those combinations that don't occur, pink cells are for those that are acknowledged, orange cells (and bold letters) are for those that are considered as uncertain (i.e. the habitat is not acknowledged but occurs in some places), and blue cells (and white letters) are for those that are unexpected (i.e. the combination requires further investigation where it occurs).

Biological zone	Oxygen conditions	Seabed substrate							
		Rock/Reef	Coarse sediment	Sand	Muddy Sand	Sandy Mud	Mud	Mixed sediment	No substrate
Infralittoral		Infralittoral rock	Infralittoral coarse and mixed sediment	Infralittoral sand and muddy sand	Infralittoral sand and muddy sand	**Infralittoral mud and sandy mud**	**Infralittoral mud and sandy mud**	Infralittoral coarse and mixed sediment	Infralittoral seabed
Circalittoral		Circalittoral rock	-	-	-	-	-	-	-
Shallow circalittoral		-	Shallow circalittoral shelly organogenic sand	Shallow circalittoral shelly organogenic sand	Shallow circalittoral mud and organogenic sandy mud/muddy sand	Shallow circalittoral mud and organogenic sandy mud/muddy sand	Shallow circalittoral mud and organogenic sandy mud/muddy sand	Shallow circalittoral mud and organogenic sandy mud/muddy sand	Shallow circalittoral seabed
Deep circalittoral	Oxic	-	Deep circalittoral mixed sediments	Deep circalittoral sand	Deep circalittoral mixed sediments	Deep circalittoral mixed sediments	Deep circalittoral mud	Deep circalittoral mixed sediments	Deep circalittoral seabed
Deep circalittoral	Suboxic	-	Deep circalittoral suboxic coarse sediment	Deep circalittoral suboxic sand	Deep circalittoral suboxic muddy sand	Deep circalittoral suboxic sandy mud	Deep circalittoral suboxic calcareous muds	Deep circalittoral suboxic mixed sediment	Deep circalittoral suboxic seabed
Deep circalittoral	Anoxic	-	Deep circalittoral anoxic coarse sediment	Deep circalittoral anoxic sand	Deep circalittoral anoxic muddy sand	Deep circalittoral anoxic sandy mud	Deep circalittoral anoxic muds	Deep circalittoral anoxic mixed sediment	Deep circalittoral anoxic seabed
Bathyal		-	Bathyal anoxic coarse sediment	Bathyal anoxic sand	Bathyal anoxic muddy sand	Bathyal anoxic sandy mud	Bathyal anoxic muds	Bathyal anoxic mixed sediment	Bathyal anoxic seabed
Abyssal		-	Abyssal seabed	Abyssal seabed	Abyssal seabed	Abyssal seabed	Abyssal seabed	Abyssal seabed	Abyssal seabed

Habitat types within the Danube and Dnieper plume areas. Those are identified from the habitat descriptors seabed substrate and biological zone. Grey cells are for those combinations that are irrelevant.

Biological zone	Seabed substrate							
	Rock/Reef	Coarse sediment	Sand	Muddy Sand	Sandy Mud	Mud	Mixed sediment	No substrate
Infralittoral	-	-	Infralittoral sand	Infralittoral muddy sand	-	-	-	-
Circalittoral	-	Circalittoral coarse and mixed Sediment	-	-	Circalittoral terrigenous muds	Circalittoral terrigenous muds	-	-

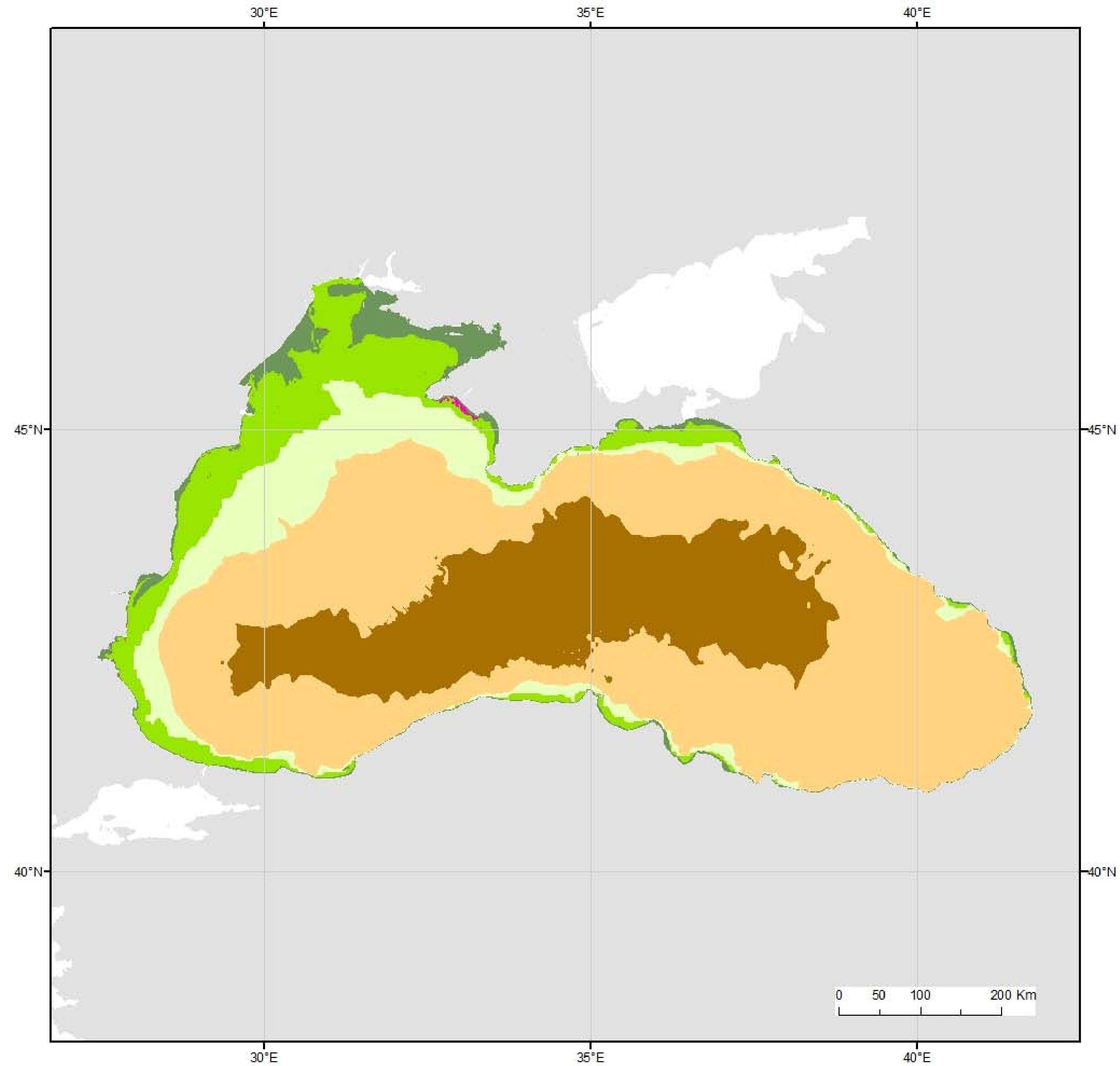
Overview of continuous physical variables and thresholds used to categorise the variables into habitat descriptor classes in the Black Sea

	EUSeaMap Phase 2		
Layer	Habitat desciptor class or ckass boundary	Variable(s)	Threshold
Biological zone	Infralittoral/ Circalittoral on rocks	Depth to the seabed	14 m
	Infralittoral/ Shallow Circalittoral (soft bottoms)	Depth to the seabed	19m
	Shallow Circalittoral/ Deep Circalittoral (soft bottoms)	MyOcean temperature data. Percentile 95th integrated over 2 summers (2013-2014)	9.7°C
	Circalittoral (rock) or deep Circalittoral (soft bottoms)/ Bathyal	Depth to the seabed	Shelf edge manually delimited from depth layer and slope
	Bathyal/ Abyssal	Depth to the seabed	2,100 m
Biological zone in plume areas	Infralittoral	Seabed substrate type	Presence of sand or muddy sand
	Circalittoral	Seabed substrate type	Presence of coarse sediment, sandy mud or mud
Oxic, suboxic and anoxic conditions	Oxic/ Suboxic	December 1993 MyOcean density sigma-theta values	Polyline corresponding to the intersection of the isopicnic 15.6 $kg.m^{-3}$ surface with the seabed
	Suboxic/ Anoxic	December 1993 MyOcean density sigma-theta values	Polyline corresponding to the intersection of the isopicnic 16.4 $kg.m^{-3}$ surface with the seabed
Substrate	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock
	Coarse sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	If sand:mud < 9:1 then %gravel = 80 %. If sand:mud > 9:1 then %gravel = 5 %
	Mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 9:1 and 5 % < %gravel < 80 %

	Fine mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 1:9 and %gravel < 5 %
	Sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:9 < sand:mud < 1:1 and %gravel < 5 %
	Muddy sand/Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:1 < sand:mud < 9:1 and %gravel < 5 %
	Sand/Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 9:1 and %gravel < 5 %

Biological zones

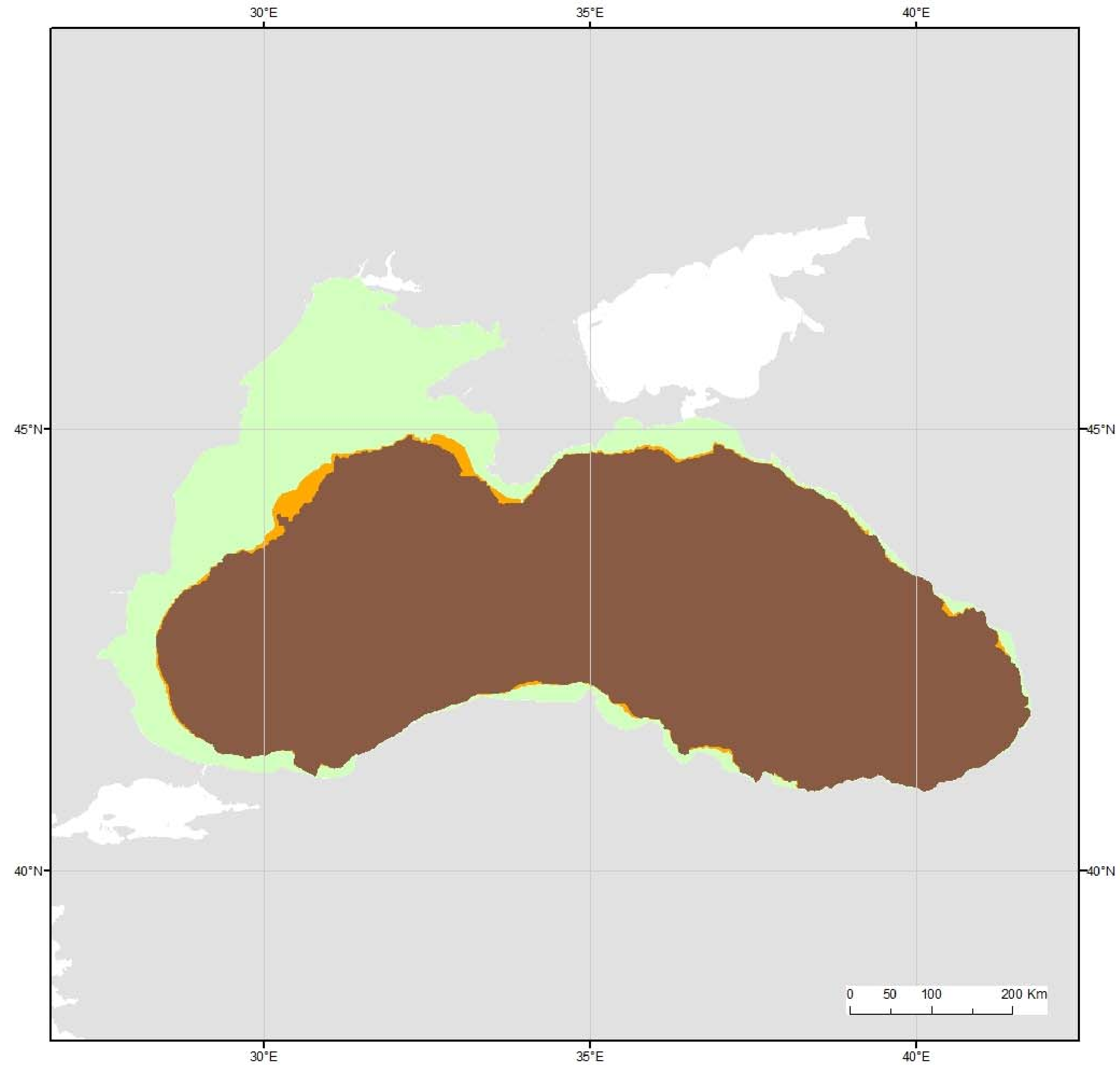
- Infralittoral
- Rocky circalittoral
- Soft bottom shallow circalittoral
- Soft bottom deep circalittoral
- Bathyal
- Abyssal



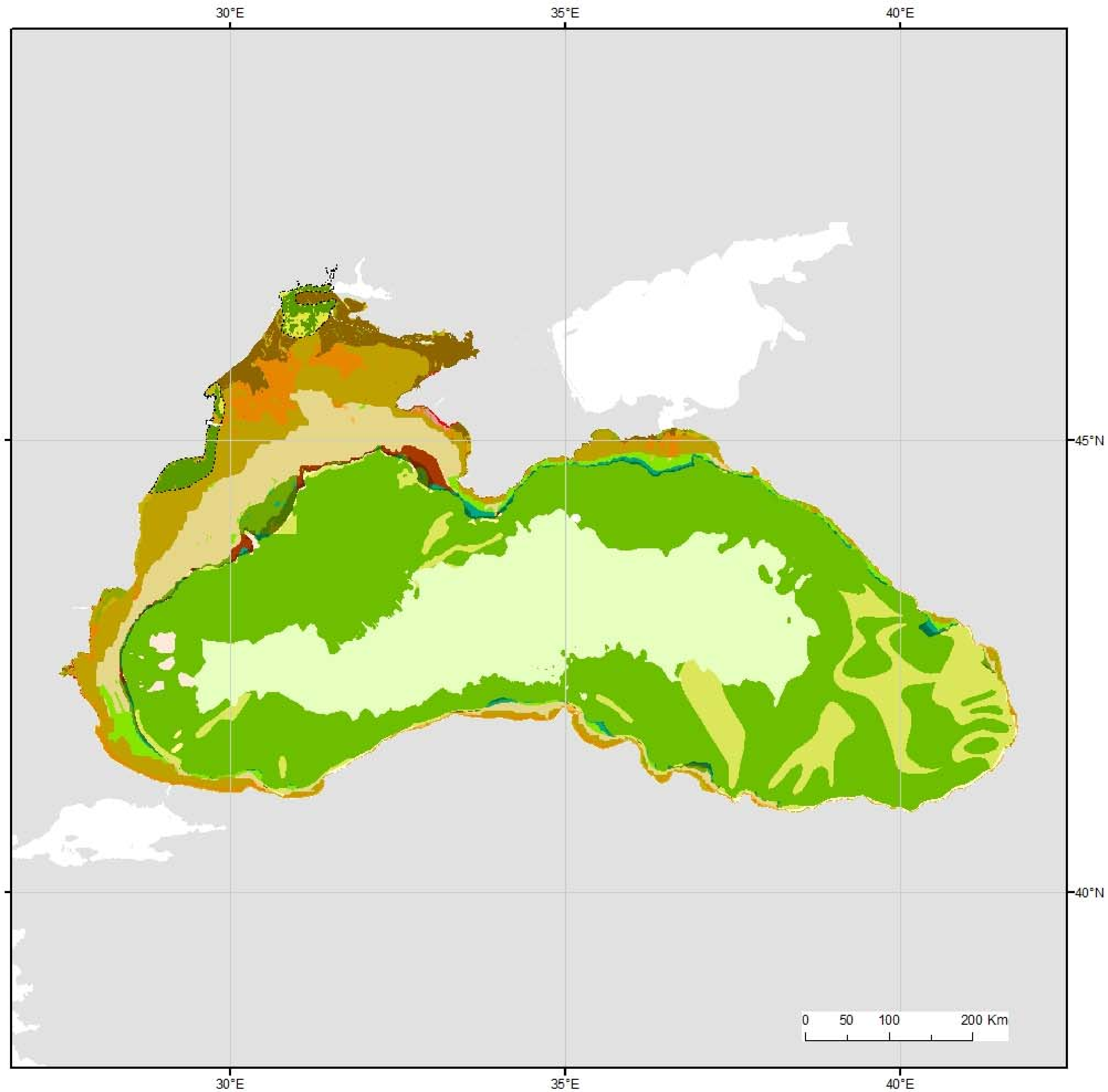
EMODnet Seabed Habitats
Final broad-scale map of Black Sea biological zones
(September 2016).
Mercator projection (standard parallel 44°N)

Oxygen vertical zonation

- Oxic
- Suboxic
- Anoxic



EMODnet Seabed Habitats
Final broad-scale map of Black Sea oxygen vertical zonation
(September 2016).
Mercator projection (standard parallel 44°N)



EMODnet Seabed Habitats
Final broad-scale map of Black Sea seabed habitats
(September 2016).
Mercator projection (standard parallel 44°N)

Habitat types in the Mediterranean Sea which can be identified from the habitat descriptors seabed substrate and biological zone. Orange cells (and bold letters) are for those that are considered as uncertain (i.e. the habitat is not acknowledged but occurs in some places). Fr means "Fraction of incident light reaching the seabed"

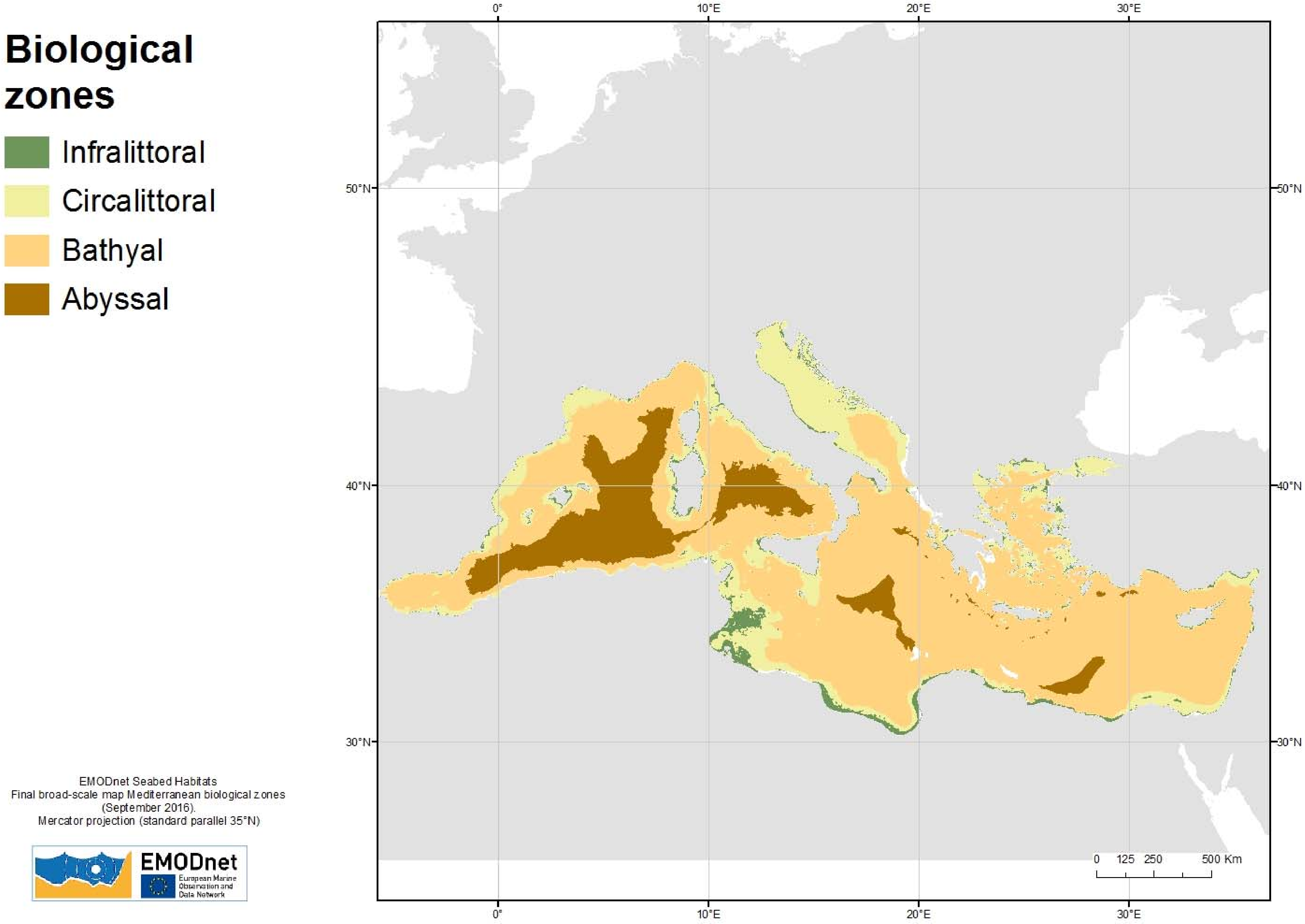
Biological zone	Seabed substrate						
	Rock/Reef	Coarse and mixed sediment	Sand	Muddy Sand	Sandy Mud	Mud	No substrate
Infralittoral	A3 Infralittoral rock and other hard substrata	A5.13 Infralittoral coarse sediment	A5.23 Infralittoral fine sand	A5.23 Infralittoral fine sand	**A5.33 Infralittoral sandy mud**	**A5.34 A5.34 : Infralittoral fine mud**	Infralittoral seabed
Circalittoral Fr > 0.0001	A4.26 Mediterranean coralligenous communities moderately exposed to hydrodynamic action or A4.32 Mediterranean coralligenous communities sheltered from hydrodynamic action	A5.46 Mediterranean animal communities of coastal detritic bottoms	A5.46 Mediterranean animal communities of coastal detritic bottoms	A5.46 Mediterranean animal communities of coastal detritic bottoms	A5.38 Mediterranean biocoenosis of muddy detritic bottoms	A5.39 Mediterranean biocoenosis of coastal terrigenous muds	Circalittoral seabed
Circalittoral Fr < 0.0001	A4.27 Faunal communities on deep moderate energy circalittoral rock	A5.47 Mediterranean communities of shelf-edge detritic bottoms	A5.47 Mediterranean communities of shelf-edge detritic bottoms	A5.47 Mediterranean communities of shelf-edge detritic bottoms	A5.47 Mediterranean communities of shelf-edge detritic bottoms	A5.39 Mediterranean biocoenosis of coastal terrigenous muds	Circalittoral seabed
Bathyal	A6.11 Deep-sea bedrock	A6.2 Deep-sea mixed substrata	A6.3 Deep-sea sand	A6.4 Deep-sea muddy sand	A6.511 Facies of sandy muds with Thenea muricata	A6.51 Mediterranean communities of bathyal muds	Bathyal seabed
Abyssal	A6.11 Deep-sea bedrock	A6.2 Deep-sea mixed substrata	A6.3 Deep-sea sand	A6.4 Deep-sea muddy sand	A6.52 Communities of abyssal muds	A6.52 Communities of abyssal muds	Abyssal seabed

EUNIS habitat types within river plumes identified from the data layers seabed substrate and biological zone. Grey cells are for combinations that do not occur in the Mediterranean Sea

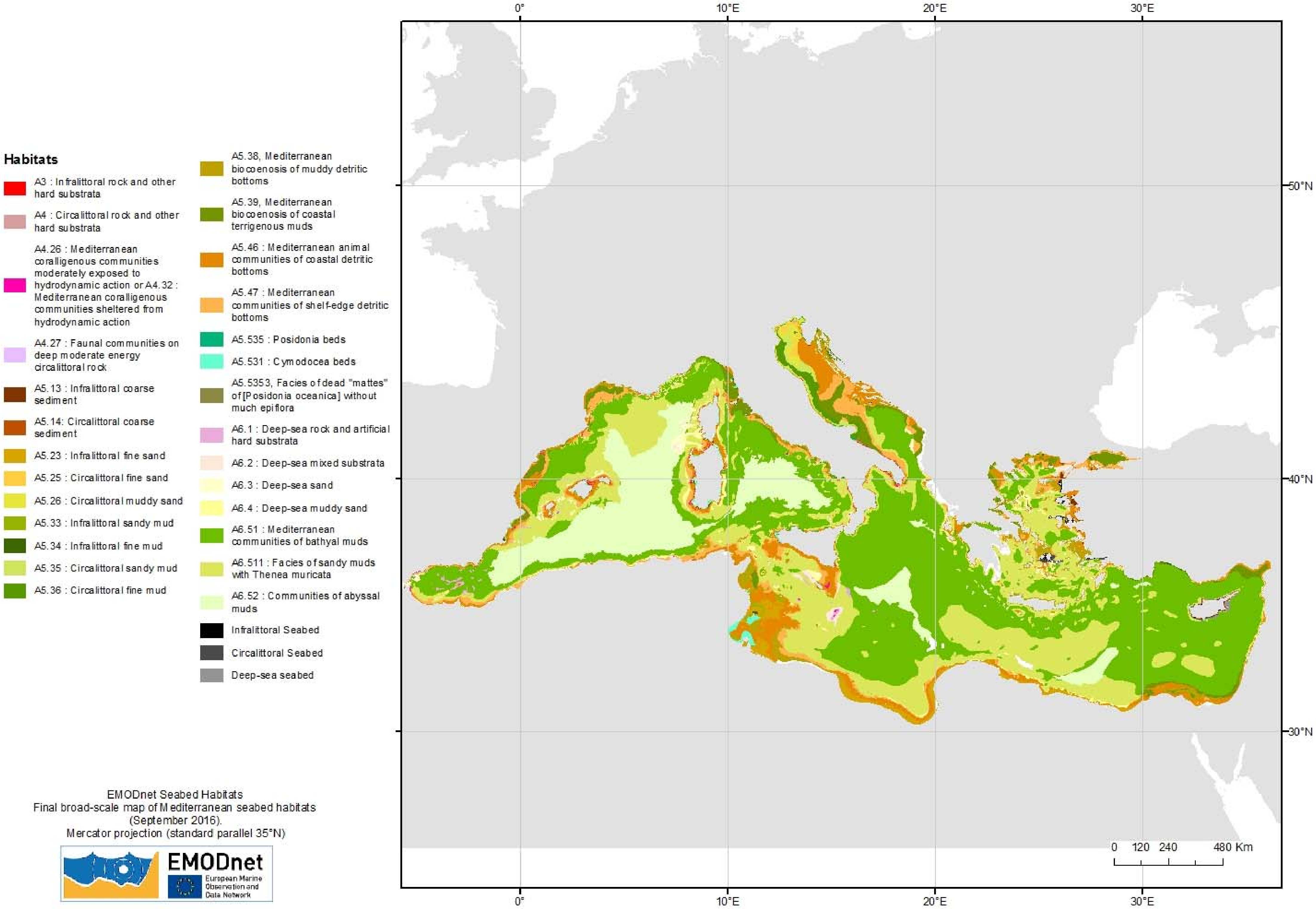
Biological zone	Seabed substrate						
	Rock/Reef	Coarse sediment	Sand	Muddy Sand	Sandy Mud	Mud	No substrate
Infralittoral	A3 Infralittoral rock and other hard substrata	A5.13 Infralittoral coarse sediment	A5.23 Infralittoral fine sand	A5.23 Infralittoral fine sand	-	-	Infralittoral seabed
Circalittoral	A4 Circalittoral rock and other hard substrata	A5.14 Circalittoral coarse sediment	A5.25 Circalittoral fine sand	A5.26 Circalittoral muddy sand	A5.35 Circalittoral sandy mud	A5.36 Circalittoral fine mud	Circalittoral seabed

Overview of continuous physical variables and thresholds used to categorise the variables into habitat descriptor classes in the Mediterrean basin

	EUSeaMap Phase 2		
Habitat desciptor	**Habitat desciptor class boundary**	**Variable(s)**	**Threshold**
Biological zone	Infralittoral/ Circalittoral	Photosynthetically available radiation (PAR) at the seabed, $I = I_0 e^{-d.Kd(PAR)}$ With I_0 = PAR at the surface, d = depth to the seabed, and K_d(PAR) = Light attenuation coefficient at depth d in relation to PAR (mean over five years)	1.82 mol. phot. m^2 d^{-1}
	Circalittoral/ Bathyal	Depth to the seabed	Shelf edge manually delimited from depth layer and slope
	Bathyal/ Abyssal	Depth to the seabed	Foot of slope manually delimited from depth layer and slope
Substrate	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock
	Coarse & mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	%gravel > 5 %.
	Fine mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 1:9 and %gravel < 5 %
	Sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:9 < sand:mud < 1:1 and %gravel < 5 %
	Muddy sand/Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:1 < sand:mud < 9:1 and %gravel < 5 %
	Sand/Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 9:1 and %gravel < 5 %



Biological zones
Infralittoral
Circalittoral
Bathyal
Abyssal
0°
10°E
20°E
30°E
50°N
40°N
30°N
0 125 250 500 Km
EMODnet Seabed Habitats
Final broad-scale map Mediterranean biological zones
(September 2016).
Mercator projection (standard parallel 35°N)
EMODnet
European Marine Observation and Data Network



EMODnet Seabed Habitats
Final broad-scale map of Mediterranean seabed habitats
(September 2016).
Mercator projection (standard parallel 35°N)

EMODnet
European Marine Observation and Data Network

EUNIS habitat types in the Atlantic and Arctic regions at Level 3 and 4 which can be identified from the habitat descriptors seabed substrate, biological zone and, for rock substrate, energy class. Grey cells are for combinations that do not have a EUNIS habitat equivalent.

Biological zone	Rock/Reef			Coarse Sediment	Sand	Muddy Sand OR Sandy Mud	Mud	Mixed Sediment
	Energy							
	High	Moderate	Low					
Infralittoral	A3.1 Atlantic and Mediterranean high energy infralittoral rock	A3.2 Atlantic and Mediterranean moderate energy infralittoral rock	A3.3 low energy infralittoral rock	A5.13 Infralittoral coarse sediment	A5.23 Infralittoral fine sand OR A5.24 Infralittoral muddy sand	A5.33 Infralittoral sandy mud	A5.34 Infralittoral fine mud	A5.43 Infralittoral mixed sediments
Shallow circalittoral	A4.1 Atlantic and Mediterranean high energy circalittoral rock	A4.2 moderate energy circalittoral rock	A4.3 low energy circalittoral rock	A5.14 Circalittoral coarse sediment	A5.25 Circalittoral fine sand or A5.26 Circalittoral fine sand	A5.35 Circalittoral sandy mud	A5.36 Circalittoral fine mud	A5.44 Circalittoral mixed sediments
Deep circalittoral	A4.12 Sponge communities on deep circalittoral rock	A4.27 Faunal communities on deep moderate energy circalittoral rock	A4.33 Faunal communities on deep low energy circalittoral rock	A5.15 Deep circalittoral coarse sediment	A5.27 Deep circalittoral sand	A5.37 Deep circalittoral mud	A5.37 Deep circalittoral fine mud	A5.45 Deep circalittoral mixed sediments
Deep Sea	A6.1 Deep-sea rock and artificial hard substrata	A6.1 Deep-sea rock and artificial hard substrata	A6.1 Deep-sea rock and artificial hard substrata	-	A6.3 Deep-sea sand OR A6.4 Deep-sea muddy sand	A6.5 Deep-sea mud	A6.5 Deep-sea mud	A6.2 Deep-sea mixed substrata

Extended version of Table A5.7 for the Atlantic region, with names given to the habitats in the deep sea that do not have a EUNIS code. Where the substrate type was unknown, the habitat name was given as "[biozone] seabed", e.g. Deep Circalittoral seabed.

Biological zone	Rock/Reef			Coarse sediment	Sand	Muddy sand OR Sandy mud	Mud	Mixed sediment
	Energy							
	High	Moderate	Low					
Infralittoral	A3.1 Atlantic and Mediterranean high energy infralittoral rock	A3.2 Atlantic and Mediterranean moderate energy infralittoral rock	A3.3 low energy infralittoral rock	A5.13 Infralittoral coarse sediment	A5.23 Infralittoral fine sand OR A5.24 Infralittoral muddy sand	A5.33 Infralittoral sandy mud	A5.34 Infralittoral fine mud	A5.43 Infralittoral mixed sediments
Shallow Circalittoral	A4.1 Atlantic and Mediterranean high energy circalittoral rock	A4.2 moderate energy circalittoral rock	A4.3 low energy circalittoral rock	A5.14 Circalittoral coarse sediment	A5.25 Circalittoral fine sand or A5.26 Circalittoral fine sand	A5.35 Circalittoral sandy mud	A5.36 Circalittoral fine mud	A5.44 Circalittoral mixed sediments
Deep Circalittoral	A4.12 Sponge communities on deep circalittoral rock	A4.27 Faunal communities on deep moderate energy circalittoral rock	A4.33 Faunal communities on deep low energy circalittoral rock	A5.15 Deep circalittoral coarse sediment	A5.27 Deep circalittoral sand	A5.37 Deep circalittoral mud	A5.37 Deep circalittoral fine mud	A5.45 Deep circalittoral mixed sediments
Atlantic Upper Bathyal	Atlantic upper bathyal rock or reef	Atlantic upper bathyal rock or reef	Atlantic upper bathyal rock or reef	Atlantic upper bathyal coarse sediment	*Atlantic upper bathyal sand or muddy sand*	*Atlantic upper bathyal sandy mud*	Atlantic upper bathyal mud	Atlantic upper bathyal mixed sediment
Atlantic Mid Bathyal	Atlantic mid bathyal rock or reef	Atlantic mid bathyal rock or reef	Atlantic mid bathyal rock or reef	Atlantic mid bathyal coarse sediment	Atlantic mid bathyal sand or muddy sand	Atlantic mid bathyal sandy mud	Atlantic mid bathyal mud	Atalntic mid bathyal mixed sediment
Atlanto-Mediterranean Mid Bathyal	Atlanto-Mediterranean mid bathyal rock or reef	Atlanto-Mediterranean mid bathyal rock or reef	Atlanto-Mediterranean mid bathyal rock or reef	Atlanto-Mediterranean mid bathyal coarse sediment	Atlanto-Mediterranean mid bathyal sand or muddy sand	Atlanto-Mediterranean mid bathyal sandy mud	Atlanto-Mediterranean mid bathyal mud	Atlanto-Mediterranean mid bathyal mixed sediment

Atlantic Lower Bathyal	Atlantic lower bathyal rock or reef	Atlantic lower bathyal rock or reef	Atlantic lower bathyal rock or reef	Atlantic lower bathyal coarse sediment	Atlantic lower bathyal sand or muddy sand	Atlantic lower bathyal sandy mud	Atlantic lower bathyal mud	Atlantic lower bathyal mixed sediment
Atlantic Upper Abyssal	Atlantic upper abyssal rock or reef	Atlantic upper abyssal rock or reef	Atlantic upper abyssal rock or reef	Atlantic upper abyssal coarse sediment	Atlantic upper abyssal sand or muddy sand	Atlantic upper abyssal sandy mud	Atlantic upper abyssal mud	Atlantic upper abyssal mixed sediment
Atlantic Mid Abyssal	Atlantic mid abyssal rock or reef	Atlantic mid abyssal rock or reef	Atlantic mid abyssal rock or reef	Atlantic mid abyssal coarse sediment	Atlantic mid abyssal sand or muddy sand	Atlantic mid abyssal sandy mud	Atlantic mid abyssal sandy mud	Atlantic mid abyssal mixed sediment
Atlantic Lower Abyssal	Atlantic lower abyssal rock or reef	Atlantic lower abyssal rock or reef	Atlantic lower abyssal rock or reef	Atlantic lower abyssal coarse sediment	Atlantic lower abyssal sand or muddy sand	Atlantic lower abyssal sandy mud	Atlantic lower abyssal sandy mud	Atlantic lower abyssal mixed sediment

Extended version of Table A5.7 for the Arctic region, with names given to the habitats in the deep sea that do not have a EUNIS code. Where the substrate type was unknown, the habitat name was given as "[biozone] seabed", e.g. Deep Circalittoral seabed.

Biological zone	**Rock/Reef**			**Coarse sediment**	**Sand**	**Muddy sand OR Sandy mud**	**Mud**	**Mixed sediment**
	Energy							
	High	Moderate	Low					
Infralittoral	A3.1 Atlantic and Mediterranean high energy infralittoral rock	A3.2 Atlantic and Mediterranean moderate energy infralittoral rock	A3.3 low energy infralittoral rock	A5.13 Infralittoral coarse sediment	A5.23 Infralittoral fine sand OR A5.24 Infralittoral muddy sand	A5.33 Infralittoral sandy mud	A5.34 Infralittoral fine mud	A5.43 Infralittoral mixed sediments
Shallow Circalittoral	A4.1 Atlantic and Mediterranean high energy circalittoral rock	A4.2 moderate energy circalittoral rock	A4.3 low energy circalittoral rock	A5.14 Circalittoral coarse sediment	A5.25 Circalittoral fine sand or A5.26 Circalittoral fine sand	A5.35 Circalittoral sandy mud	A5.36 Circalittoral fine mud	A5.44 Circalittoral mixed sediments
Deep Circalittoral	A4.12 Sponge communities on deep circalittoral rock	A4.27 Faunal communities on deep moderate energy circalittoral rock	A4.33 Faunal communities on deep low energy circalittoral rock	A5.15 Deep circalittoral coarse sediment	A5.27 Deep circalittoral sand	A5.37 Deep circalittoral mud	A5.37 Deep circalittoral fine mud	A5.45 Deep circalittoral mixed sediments
Atlantic Upper Bathyal	Atlantic upper bathyal rock or reef	Atlantic upper bathyal rock or reef	Atlantic upper bathyal rock or reef	Atlantic upper bathyal coarse sediment	Atlantic upper bathyal sand or muddy sand	Atlantic upper bathyal sandy mud	Atlantic upper bathyal mud	Atlantic upper bathyal mixed sediment
Atlanto-Arctic Upper bathyal	Atlanto-Arctic upper bathyal rock or reef	Atlanto-Arctic upper bathyal rock or reef	Atlanto-Arctic upper bathyal rock or reef	Atlanto-Arctic upper bathyal coarse sediment	Atlanto-Arctic upper bathyal sand or muddy sand	Atlanto-Arctic upper bathyal sandy mud	Atlanto-Arctic upper bathyal mud	Atlanto-Arctic upper bathyal mixed sediment
Arctic Mid Bathyal	Arctic mid bathyal rock or reef	Arctic mid bathyal rock or reef	Arctic mid bathyal rock or reef	Arctic mid bathyal coarse sediment	Arctic mid bathyal sand or muddy sand	Arctic mid bathyal sandy mud	Arctic mid bathyal mud	Arctic mid bathyal mixed sediment

Arctic Lower Bathyal	Arctic lower bathyal rock or reef	Arctic lower bathyal rock or reef	Arctic lower bathyal rock or reef	Arctic lower bathyal coarse sediment	Arctic lower bathyal sand or muddy sand	Arctic lower bathyal sandy mud	Arctic lower bathyal mud	Arctic lower bathyal mixed sediment
Arctic Upper Abyssal	Arctic upper abyssal rock or reef	Arctic upper abyssal rock or reef	Arctic upper abyssal rock or reef	Arctic upper abyssal coarse sediment	Arctic upper abyssal sand	Arctic upper abyssal sandy mud	Arctic upper abyssal mud	Arctic upper abyssal mixed sediment

Overview of continuous physical variables and thresholds used to categorise the variables into habitat descriptor classes in the Arctic region

Habitat desciptor	Habitat desciptor class boundary	Variable(s)	Threshold
Biological zone	Infralittoral/ Shallow Circalittoral	Photosynthetically available radiation (PAR) at the seabed, $I = I_0 e^{-d.Kd(PAR)}$ With I_0 = PAR at the surface, d = depth to the seabed, and K_d(PAR) = Light attenuation coefficient at depth d in relation to PAR (mean over 5 years)	0.7 mol. phot. $m^2 d^{-1}$
	Shallow Circalittoral/ Deep Circalittoral	Wave exposure index at the seabed, calculated from wind data (mean of annual 90^{th} percentile values)	10,000
	Deep Circalittoral/ Upper Bathyal	Depth to the seabed	200 m
	Arctic Upper Bathyal/ Atlanto-Arctic Upper Bathyal	Depth to the seabed	400 m
	Atlanto-Arctic Upper Bathyal/Arctic Mid Bathyal	Depth to the seabed	600 m
	Arctic Mid Bathyal/Arctic Lower Bathyal	Depth to the seabed	1,300 m
	Arctic Lower Bathyal/Arctic Upper Abyssal	Depth to the seabed	2,400 m
	Arctic Upper Abyssal/Arctic Mid Abyssal	Depth to the seabed	3,300 m
Energy	High/ Moderate Wave Energy	Wave exposure index at the seabed, calculated from wind data (mean of annual 90^{th} percentile values)	500,000
	Moderate/ Low Wave Energy	Wave exposure index at the seabed, calculated from wind data (mean of annual 90^{th} percentile values)	100,000
	High/ Moderate Current Energy	Kinetic energy at the seabed due to currents (mean of annual 90^{th} percentile values over six years)	1,160 N m^{-2}
	Moderate/ Low Current Energy	Kinetic energy at the seabed due to currents (mean of annual 90^{th} percentile values over six years)	130 N m^{-2}
Substrate	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock
	Coarse sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	If sand:mud < 9:1 then %gravel = 80 %. If sand:mud > 9:1 then %gravel = 5 %
	Mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 9:1 and 5 % < %gravel < 80 %
	Fine mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 1:9 and %gravel < 5 %
	Sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:9 < sand:mud < 9:1 and %gravel < 5 %
	Sand/Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 9:1 and %gravel < 5 %

Overview of the input data in the Greater North Sea and Celtic Seas region and comparison with previous version of the map

	EUSeaMap 2016			EUSeaMap 2012			
Habitat descriptor	**Habitat descriptor class boundary**	**Variable(s)**	**Threshold**	**Habitat descriptor class boundary**	**Variable(s)**	**Threshold**	**Comments**
Biological zone	Infralittoral/ Shallow Circalittoral	Photosynthetically available radiation (PAR) at the seabed, $I = I_0 e^{-d.Kd(PAR)}$ With I_0 = PAR at the surface, d = depth to the seabed, and K_d(PAR) = Light attenuation coefficient at depth d in relation to PAR (mean over five years)	0.7 mol. phot. $m^{-2} d^{-1}$	Infralittoral/ Shallow Circalittoral	Fraction of photosynthetically available radiation (PAR) at the seabed, $Fr = e^{-d.Kd(PAR)}$ With d = depth to the seabed, and K_d(PAR) = Light attenuation coefficient at depth d in relation to PAR (mean over five years)	4.3 %	The new I threshold corresponds to a Fr of about 0.024%, this makes the infralittoral areas smaller than in the previous version (when Fr was 4.3%). A new more accurate bathymetry has improved the Fr layer accuracy, and the introduction of I_0 should make latitude effects less significant at Atlantic scale.
	Shallow Circalittoral/ Deep Circalittoral	Wave base ratio calculated by dividing wave length (mean of annual 90th percentile values over six years) by Depth to the seabed	2	Shallow Circalittoral/ Deep Circalittoral	Wave base ratio calculated by dividing wave length (mean of annual maximum values over six years) by Depth to the seabed	2	Smaller wave lengths (for same water depth) produce a significantly smaller shallow circalittoral area and increase in deep circalittoral areas. The bathymetry layer has increased resolution, therefore also the wavebase layer resolution has improved
	Deep circalittoral/ Upper Bathyal	Depth to the seabed	200 m	Deep Circalittoral/ Upper slope	Depth to the seabed	200 m	Previously the thresholds were obtained following Howell et al., 2010. In this version the deep sea classification from the Marine habitat classification for Britain and Ireland described in Parry et al 2015, informed by new studies on deep sea biogeographic region modelling and analysis of deep sea assemblages. Upper slope renamed to upper bathyal. Bathyal zone divided into 3 classes following The abyssal zone is now divided into 3 zones The extent of abyssal areas has generally increased in this version of the map. The bathymetry layer increased resolution improved the deep sea boundary delineation. In this version patches of deep sea within the continental shelf have been manually reclassified as deep circalittoral, if they were not connected to the upper bathyal biological zone. For example all Scottish lochs deeper than 200m are disconnected from bathyal areas and are no longer classified as deep sea.
	Upper Bathyal/ Mid Bathyal	Depth to the seabed	600 m	Upper Slope/ Upper Bathyal	Depth to the seabed	750 m	
	Mid Bathyal/ Lower Bathyal	Depth to the seabed	1300 m	Upper Bathyal/ Mid Bathyal	Depth to the seabed	1100 m	
	Lower Bathyal/ Upper Abyssal	Depth to the seabed	2200 m	Mid Bathyal/ Lower Bathyal	Depth to the seabed	1800 m	
	Upper Abyssal/ Mid Abyssal	Depth to the seabed	3200 m	Lower Bathyal/ Abyssal	Depth to the seabed	2700 m	
	Mid Abyssal/ Lower Abyssal	Depth to the seabed	4300 m	N/A	N/A	N/A	
Energy	High/ Moderate Wave Energy	Kinetic energy at the seabed due to waves (mean of annual 90th percentile values over six years)	70.95 N m^{-2}	High/ Moderate Wave Energy	Kinetic energy at the seabed due to waves (mean of annual maximum values over six years)	1200 N m^{-2}	In this version the wave energy layer is characterised by smaller values of wave energy and reclassified using new thresholds. For the currents layer the old thresholds were used (as defined in EUNIS) but the current energy values are smaller because the 90th percentile statistics was used. The extent of moderate energy rock habitats (combined waves and currents) are generally reduced compared to EUSeaMap 1, and the extent of low energy rock has increased in some areas. This change is clear in the Outer Hebrides
	Moderate/ Low Wave Energy	Kinetic energy at the seabed due to waves (mean of annual 90th percentile values over six years)	11.41 N m^{-2}	Moderate/ Low Wave Energy	Kinetic energy at the seabed due to waves (mean of annual maximum values over six years)	210 N m^{-2}	
	High/ Moderate Current Energy	Kinetic energy at the seabed due to currents (mean of annual 90th percentile values over six years)	1160 N m^{-2}	High/ Moderate Current Energy	Kinetic energy at the seabed due to currents (mean of annual maximum values over six years)	1160N m^{-2}	

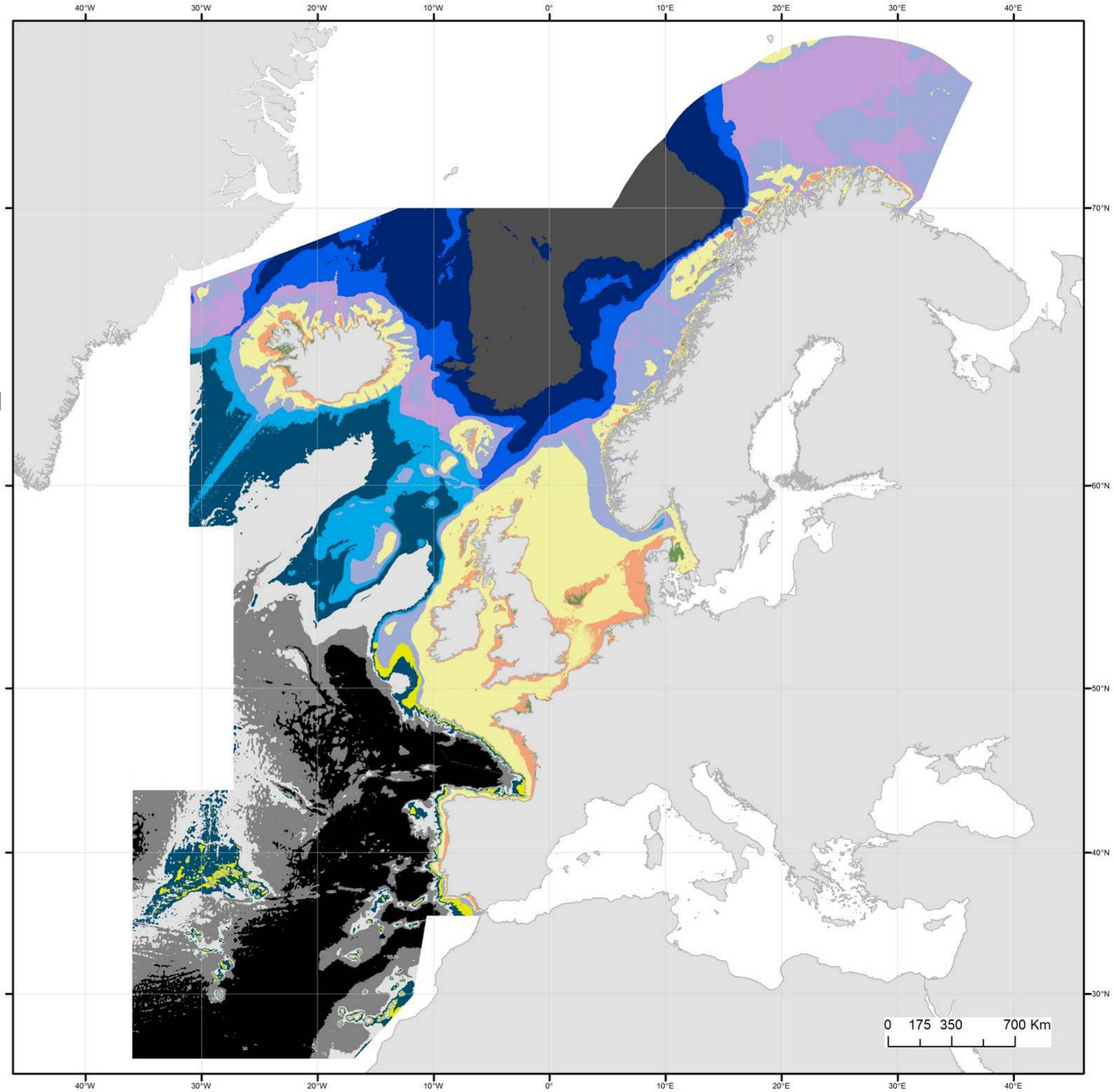
	EUSeaMap 2016			EUSeaMap 2012			
Habitat desciptor	**Habitat desciptor class boundary**	**Variable(s)**	**Threshold**	**Habitat desciptor class boundary**	**Variable(s)**	**Threshold**	**Comments**
	Moderate/ Low Current Energy	Kinetic energy at the seabed due to currents(mean of annual 90th percentile values over six years)	130 N m^{-2}	Moderate/ Low Current Energy	Kinetic energy at the seabed due to currents (mean of annual maximum values over six years)	130 N m^{-2}	and in the Western English Channel.
Substrate	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock	The BGS Hard substrate layer (used in this and in the previous version) tends to overestimate the amount of rock in UK waters. Different sand:mud ratio creates a reduction of areas of habitat classified as "Sand" or "Muddy sand", compared to EUSeaMap I.
	Coarse sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	If sand:mud < 9:1 then %gravel = 80 %. If sand:mud > 9:1 then %gravel = 5 %	Coarse sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	If sand:mud < 9:1 then %gravel = 80 %. If sand:mud > 9:1 then %gravel = 5 %	
	Mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 9:1 and 5 % < %gravel < 80 %	Mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 9:1 and 5 % < %gravel < 80 %	
	Fine mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 1:9 and %gravel < 5 %	Mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 4:1 and %gravel < 5 %	
	Sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:9 < sand:mud < 9:1 and %gravel < 5 %	As above	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	As above	
	Sand/Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 9:1 and %gravel < 5 %	Sand/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 4:1 and %gravel < 5 %	

Overview of the input data in the Bay of Biscay, Iberia and Azores, and comparison with previous versions of the map

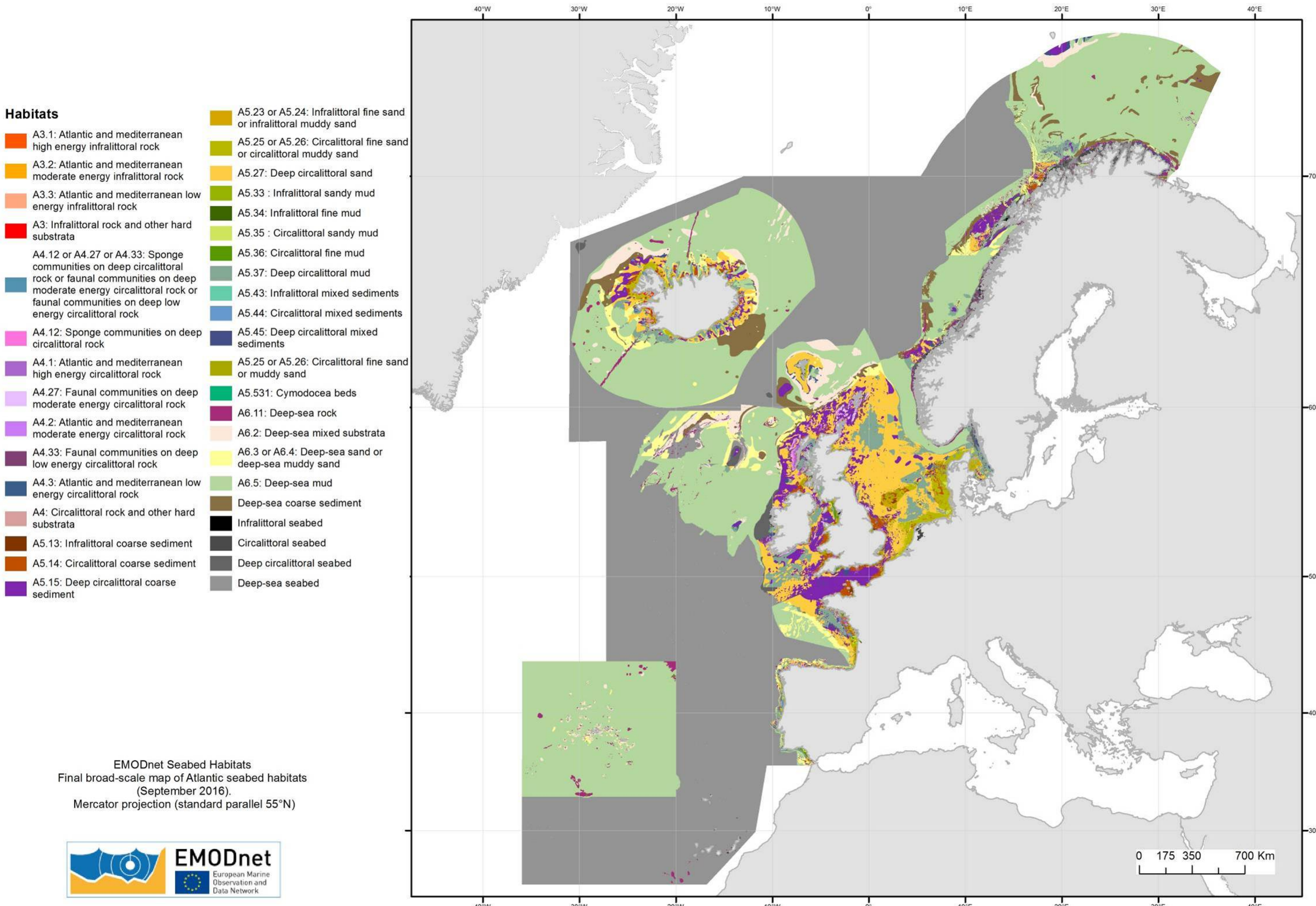
	EUSeaMap 2016			**MESH Atlantic 2013**			
Habitat descriptor	**Habitat descriptor class boundary**	**Variable(s)**	**Threshold**	**Habitat descriptor class boundary**	**Variable(s)**	**Threshold**	**Comments**
Biological zone	Infralittoral/ Shallow Circalittoral	Photosynthetically available radiation (PAR) at the seabed, $I = I_0 e^{-d.Kd(PAR)}$ With I_0 = PAR at the surface, d = depth to the seabed, and K_d(PAR) = Light attenuation coefficient at depth d in relation to PAR (mean over five years)	Azores = 0.3 mol. phot. m^2 d^{-1} Canaries = 0.4 mol. phot. m^2 d^{-1} Biscay and Ibera = 0.7 mol. phot. m^2 d^{-1}	Infralittoral/ Shallow Circalittoral	Fraction of photosynthetically available radiation (PAR) at the seabed, $Fr = e^{-d.Kd(PAR)}$ With d = depth to the seabed, and K_d(PAR) = Light attenuation coefficient at depth d in relation to PAR (mean over five years)	0.01	The new I thresholds of 0.7 mol. phot. m^2 d^{-1} corresponds to a Fr of about 0.024%, this makes the infralittoral areas smaller than in the previous version A new more accurate bathymetry has improved the Fr layer accuracy, and the introduction of I_0 should make latitude effects les significant at Atlantic scale.
	Shallow Circalittoral/ Deep Circalittoral	Wave base ratio calculated by dividing wave length (mean of annual 90th percentile values over six years) by Depth to the seabed Depth to seabed	Variable (depending on region) between 1.5 and 2.67 (see WP4) Depthto the seabed threshold = 80m	Shallow Circalittoral/ Deep Circalittoral	Wave base ratio calculated by dividing wave length (mean of annual maximum values over six years) by Depth to the seabed	2.53	Where no wave base data is available (e.g. the Azores) depth to seabed is used as the predictor variable In Bay of Biscay, by integrating recent wave data (Boudiere et al, 2013) the resolution of wave data has improved a lot. Elsewhere bathymetry layer has increased resolution, therefore also the wavebase layer resolution has improved.
	Deep circalittoral/ Upper Bathyal	Shelf edge, manually delineated	Edge of continental shelf	Deep Circalittoral/ Upper Slope	Shelf edge, manually delineated	Edge of continental shelf	Previously the thresholds were obtained following Howell et al., 2010. In this version the deep sea classification from the Marine habitat classification for Britain and Ireland described in in Parry et al 2015, informed by new studies on deep sea biogeographic region modelling and analysis of deep sea assemblages Upper slope renamed to upper bathyal. Bathyal zone divided into 3 classes following The abyssal zone is now divided into 3 zones The extent of abyssal areas has generally increased in this version of the map, for example Rockall trough is now abyssal , not longer lower bathyal. The area of Upper abyssal it is larger than before on the Mid Atlantic Ridge near the Azores, however along the shelf off France/Spain/Portugal it has decrease in extent.
	Upper Bathyal/ Mid Bathyal	Depth to the seabed	600 m	Upper Slope/ Upper Bathyal	Depth to the seabed	750 m	
	Mid Bathyal/ Lower Bathyal	Depth to the seabed	1300 m	Upper Bathyal/ Mid Bathyal	Depth to the seabed	1100 m	
	Lower Bathyal/ Upper Abyssal	Depth to the seabed	2200 m	Mid Bathyal/ Lower Bathyal	Depth to the seabed	1800 m	
	Upper Abyssal/ Mid Abyssal	Depth to the seabed	3200 m	Lower Bathyal/ Abyssal	Manually delineated from slope of the seabed	Edge of abyssal plain	
	Mid Abyssal/ Lower Abyssal	Depth to the seabed	4300 m	N/A	N/A	N/A	

	EUSeaMap 2016			MESH Atlantic 2013			
Habitat descriptor	**Habitat desciptor class boundary**	**Variable(s)**	**Threshold**	**Habitat desciptor class boundary**	**Variable(s)**	**Threshold**	**Comments**
							The bathymetry layer increased resolution improved the deep sea boundary delineation.
Energy	High/ Moderate Wave Energy	Kinetic energy at the seabed due to waves (mean of annual 90^{th} percentile values over 5 (Biscay) and 3 (Iberia, Azores) years)	Variable (depending on region) between 90 and 22 N m^{-2} (see WP4)	High/ Moderate Wave Energy	Kinetic energy at the seabed due to waves (mean of annual 90^{th} percentile values over 5 (Biscay) and 3 (Iberia, Azores) years)	Variable (depending on region)	Same thresholds (as defined in EUNIS) and datasets for the current induced energy layer. The wave energy thresholds and dataset (Boudiere et al, 2013) have been updated in French waters, but not elsewhere. This has resulted in a decrease in the extent of low energy rock and an increase in high and moderate energy rock habitats, in those regions.
	Moderate/ Low Wave Energy	Kinetic energy at the seabed due to waves (mean of annual 90^{th} percentile values over 5 (Biscay) and 3 (Iberia, Azores) years)	Variable (depending on region) between 3 and 60 N m^{-2} (see WP4)	Moderate/ Low Wave Energy	Kinetic energy at the seabed due to waves (mean of annual 90^{th} percentile values over 5 (Biscay) and 3 (Iberia, Azores) years)	Variable (depending on region)	
	High/ Moderate Current Energy	Kinetic energy at the seabed due to currents (mean of annual 90^{th} percentile values over 5 (Biscay) and 3 (Iberia, Azores) years)	1160 N m^{-2}	High/ Moderate Current Energy	Kinetic energy at the seabed due to currents (mean of annual 90^{th} percentile values over 5 (Biscay) and 3 (Iberia, Azores) years)	1160N m^{-2}	
	Moderate/ Low Current Energy	Kinetic energy at the seabed due to currents (mean of annual 90^{th} percentile values over 5 (Biscay) and 3 (Iberia, Azores) years)	130 N m^{-2}	Moderate/ Low Current Energy	Kinetic energy at the seabed due to currents (mean of annual 90^{th} percentile values over 5 (Biscay) and 3 (Iberia, Azores) years)	130 N m^{-2}	
Substrate	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock	A new update substrate layer was used. No changes in the rock , coarse, mixed sediment and fine mud habitats extent. The different sand:mud ratio used in this version results in changes to the Sandy mud and Sand habitat extent: the amount of muddy habitat has increased and the amount of sandy habitat has decreased
	Coarse sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	If sand:mud < 9:1 then %gravel = 80 %. If sand:mud > 9:1 then %gravel = 5 %	Coarse sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	If sand:mud < 9:1 then %gravel = 80 %. If sand:mud > 9:1 then %gravel = 5 %	
	Mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 9:1 and 5 % < %gravel < 80 %	Mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 9:1 and 5 % < %gravel < 80 %	

	EUSeaMap 2016			MESH Atlantic 2013			
Habitat desciptor	Habitat desciptor class boundary	Variable(s)	Threshold	Habitat desciptor class boundary	Variable(s)	Threshold	Comments
	Fine mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 1:9 and %gravel < 5 %	Mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 1:9 and %gravel < 5 %	
	Sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:9 < sand:mud < 9:1 and %gravel < 5 %	Sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:9<Sand:mud < 1:1 and %gravel < 5 %	
	Sand/Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 9:1 and %gravel < 5 %	Sand and muddy sands/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 1:1 and %gravel < 5 %	



EMODnet Seabed Habitats
Final broad-scale map of Atlantic biological zones
(September 2016).
Mercator projection (standard parallel 55°N)



EMODnet Seabed Habitats
Final broad-scale map of Atlantic seabed habitats
(September 2016).
Mercator projection (standard parallel 55°N)

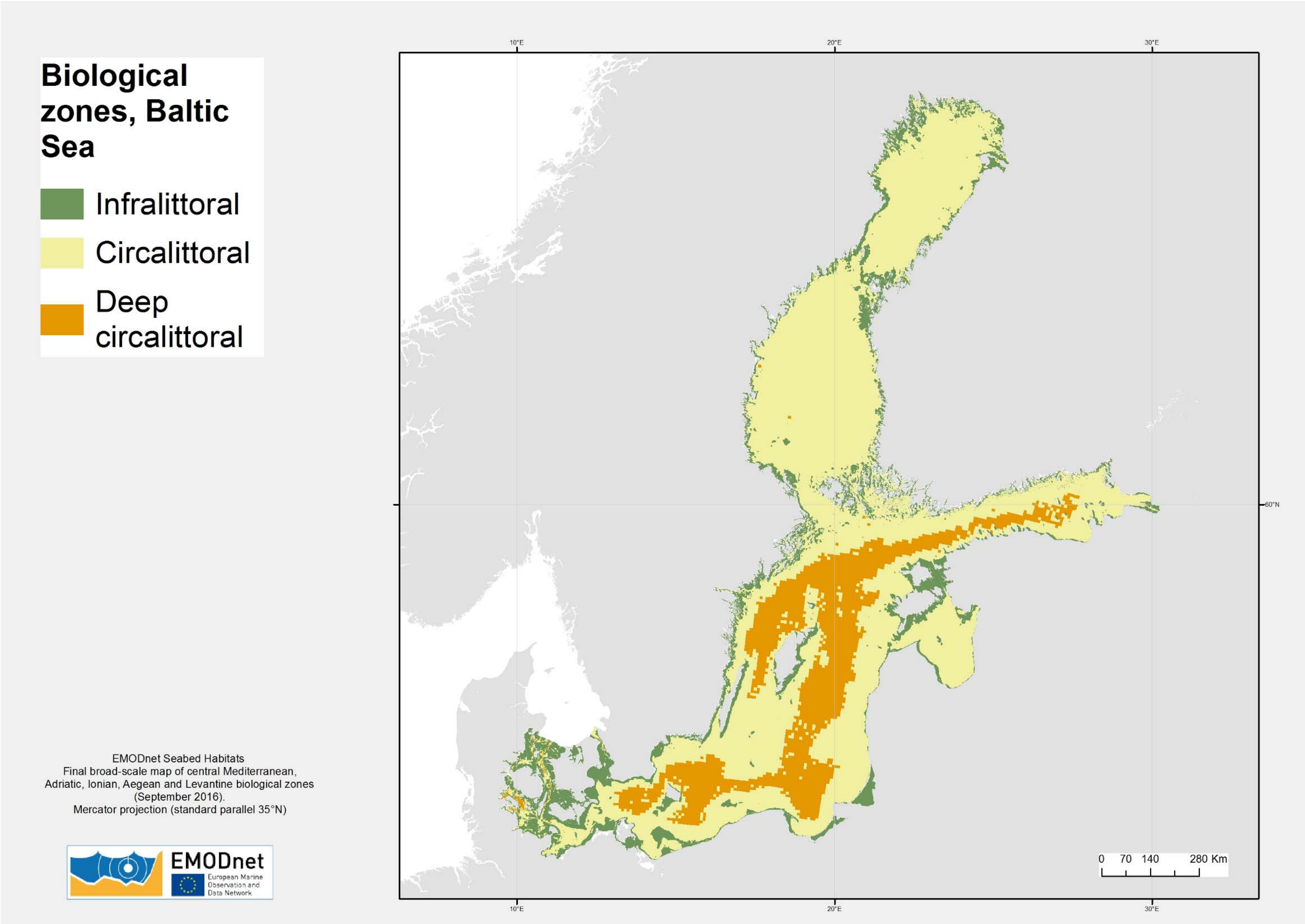
EUNIS habitat types in the Baltic Sea at Level 3 and 4 which can be identified from the habitat descriptors seabed substrate, biological zone and, for rock substrate, energy class. Grey cells are for tcombinations that do not have a EUNIS habitat equivalent.

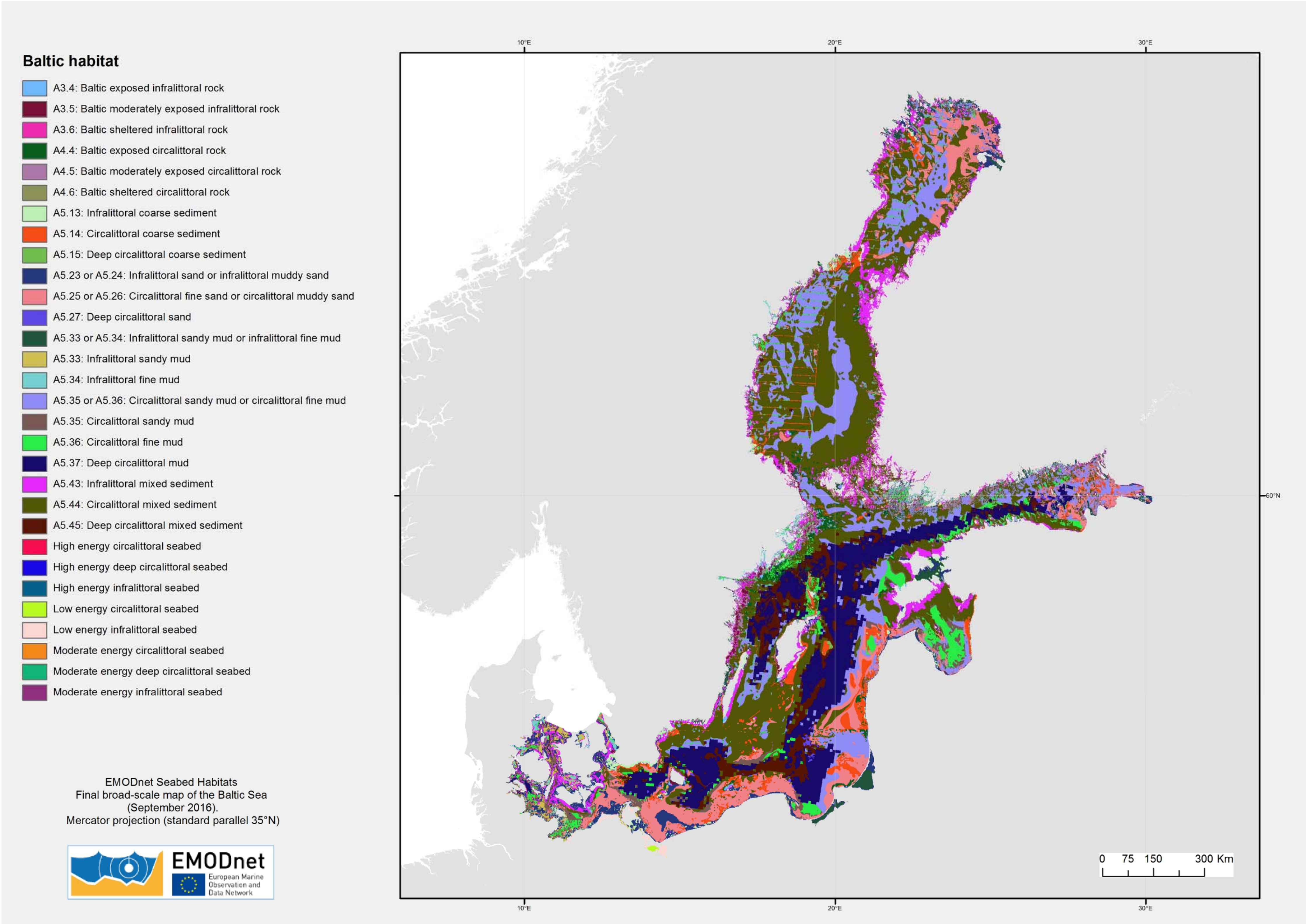
Biological zone	Rock			Coarse Sediment	Sand	Muddy Sand OR Sandy Mud	Mud	Mixed Sediment
	Energy							
	Exposed	Moderate	Sheltered					
Infralittoral	A3.4 Baltic exposed infralittoral rock	A3.5 Baltic moderately exposed infralittoral rock	A3.6 Baltic sheltered infralittoral rock	A5.13 Infralittoral coarse sediment	A5.23 Infralittoral fine sand OR A5.24 Infralittoral muddy sand	A5.33 Infralittoral sandy mud	A5.34 Infralittoral fine mud	A5.43 Infralittoral mixed sediments
Shallow circalittoral	A4.4 Baltic exposed circalittoral rock	A4.5 Baltic moderately exposed circalittoral rock	A4.6 Baltic sheltered circalittoral rock	A5.14 Circalittoral coarse sediment	A5.25 Circalittoral fine sand or A5.26 Circalittoral fine sand	A5.35 Circalittoral sandy mud	A5.36 Circalittoral fine mud	A5.44 Circalittoral mixed sediments
Deep circalittoral	-	-	-	A5.15 Deep circalittoral coarse sediment	A5.27 Deep circalittoral sand	A5.37 Deep circalittoral mud	A5.37 Deep circalittoral fine mud	A5.45 Deep circalittoral mixed sediments

Overview of the input data in the Baltic Sea and comparison with previous versions of the map

	EUSeaMap 2016			EUSeaMap 2012			
Habitat descriptor	Habitat descriptor class boundary	Variable(s)	Threshold	Habitat descriptor class boundary	Variable(s)	Threshold	Comments
Biological zone	Infralittoral/ Shallow Circalittoral	Depth to seabed divided by Secchi disk depth. Also Kdpar 1% light	1.6 in the Oligohaline 2.5 in the Mesohaline 1% of (Kdpar) light in Polyhaline.	Infralittoral/ Shallow Circalittoral	Depth to seabed divided by Secchi disk depth. Also Kdpar 1% light	1.6 in the Oligohaline 2.5 in the Mesohaline 1% of (Kdpar) light in Polyhaline.	No change to thresholds; updated Depth to seabed data.
	Shallow Circalittoral/ Deep Circalittoral	Probability of being below the deep halocline.	0.9 in the mesohaline. 0.01% of (Kdpar) light in Polyhaline	Shallow Circalittoral/ Deep Circalittoral	Probability of being below the deep halocline.	0.9 in the mesohaline. 0.01% of (Kdpar) light in Polyhaline	No change to thresholds; updated Depth to seabed data.
Energy	High/ Moderate Wave Energy	Wave exposure index at the surface, calculated from wind data (mean of annual 90th percentile values over 5 years)	600,000	High/ Moderate Wave Energy	Wave exposure index at the surface, calculated from wind data (mean of annual 90th percentile values over 5 years)	600,000	No change to thresholds
	Moderate/ Low Wave Energy	Wave exposure index at the surface, calculated from wind data (mean of annual 90th percentile values over 5 years)	60,000	Moderate/ Low Wave Energy	Wave exposure index at the surface, calculated from wind data (mean of annual 90th percentile values over 5 years)	60,000	No change to thresholds
Substrate	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock	Rock/ Sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Presence of rock	Updated seabed substrate data. In deep waters a thin covering of mud might be observed.
	Coarse sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	If sand:mud < 9:1 then %gravel = 80 %. If sand:mud > 9:1 then %gravel = 5 %	Coarse sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	If sand:mud < 9:1 then %gravel = 80 %. If sand:mud > 9:1 then %gravel = 5 %	Updated seabed substrate data.
	Mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 9:1 and 5 % < %gravel < 80 %	Mixed sediment/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 9:1 and 5 % < %gravel < 80 %	Updated seabed substrate data and new definition of mixed sediment that includes Till (Diamicton) and hard clay.
	N/A	N/A	N/A	Till (Diamicton)	Complex bottom, mud, sand, gravel, and boulders.	minimum 5% of three differnt material should exist plus boulders.	Updated seabed substrate data and new definition of mixed sediment that includes Till (Diamicton) and hard clay.
	Fine mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 1:9 and %gravel < 5 %	Mud and sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 4:1 and %gravel < 5 %	New EMODNet 1:250k substrate map.
	Sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	1:9 < sand:mud < 9:1 and %gravel < 5 %	Mud and sandy mud/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud < 4:1 and %gravel < 5 %	New EMODNet 1:250k substrate map.

	Sand/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 9:1 and %gravel < 5 %	Sand and muddy sand/ Other sediment	Relative proportions of gravel, sand and mud, or presence of rock (pre-classified)	Sand:mud > 4:1 and %gravel < 5 %	New EMODNet 1:250k substrate map. Muddy sand is a new class in the Folk 7 classification.
Salinity	Oligohaline/ Mesohaline 1	Salnity at the seabed	4.5 psu	Oligohaline/ Mesohaline 1	Salnity at the seabed	4.5 psu	No change in thresholds
	Mesohaline1/ Mesohaline2	Salnity at the seabed	7.5 psu	Mesohaline1/ Mesohaline2	Salnity at the seabed	7.5 psu	No change in thresholds
	Mesohaline2/ Mesohaline3	Salnity at the seabed	11 psu	Mesohaline2/ Mesohaline3	Salnity at the seabed	11 psu	No change in thresholds
	Mesohaline3/ Polyhaline	Salnity at the seabed	18 psu	Mesohaline3/ Polyhaline	Salnity at the seabed	18 psu	No change in thresholds
	Polyhaline/ Marine	Salnity at the seabed	30 psu	Polyhaline/ Marine	Salnity at the seabed	30 psu	No change in thresholds


Biological zones, Baltic Sea
Infralittoral
Circalittoral
Deep circalittoral
10°E
20°E
30°E
60°N
0 70 140 280 Km
EMODnet Seabed Habitats
Final broad-scale map of central Mediterranean,
Adriatic, Ionian, Aegean and Levantine biological zones
(September 2016).
Mercator projection (standard parallel 35°N)
EMODnet
European Marine Observation and Data Network



References used in the current appendix

- Boudiere Edwige, Maisondieu Christophe, Ardhuin Fabrice, Accensi Mickael, Pineau-Guillou Lucia, Lepesqueur Jeremy (2013). A suitable metocean hindcast database for the design of Marine energy converters. International Journal of Marine Energy, 3-4, e40-e52. Publisher's official version : http://dx.doi.org/10.1016/j.ijome.2013.11.010 , Open Access version : http://archimer.ifremer.fr/doc/00164/27524/