EUSeaMap

Technical Report No. X

Substrate data and thresholds

Contents

1 Introduction

The task for producing a unified substrate map for the Baltic, North Sea, Celtic and the Mediterranean seas was not easy. Maps has to be compiled and integrated together where each individual map has its own classification standard and was presented in a particular format which need not to be the same as the others. Some maps are quite old and on paper which need digitization and georefrencing, other do not have metadata with which makes the judgment of its accuracy very difficult. Due to the low resolution background maps and the existence of gaps at many areas, the final product is not homogeneous in accuracy. Some parts are highly accurate with high confidence scores while others lack information and hence accuracy. Expert judgment was used in areas where there is little or no information.

2 Data layer preparation

Two main substrate maps were produced in the EUSeaMap project; one for the Baltic, North and Celtic Seas and the other for the Western Mediterranean Sea. The former required 200 maps to compile while the latter was produced from enormous amount of source maps and information as well as a lot of expert judgment and interpolation.

Folk classification system was adopted for the sediment classification, but it was modified according to the required outcome of the project which is the habitat map. The two modified Folk systems were not similar but follow the special characteristics of the two geographic regions.

2.1 Baltic, North and Celtic Seas

2.1.1 EMODNET sediment map

The first draft of EMODNET sediment map was delivered to EUSeaMap by June 2010. The map was a result of integration and harmonisation of data from 17 organisations from all partner's countries (Fig. 1). Each partner submitted a substrate map of their national waters including the EEZ. The submitted shape file contains attribute table containing information about the metadata.

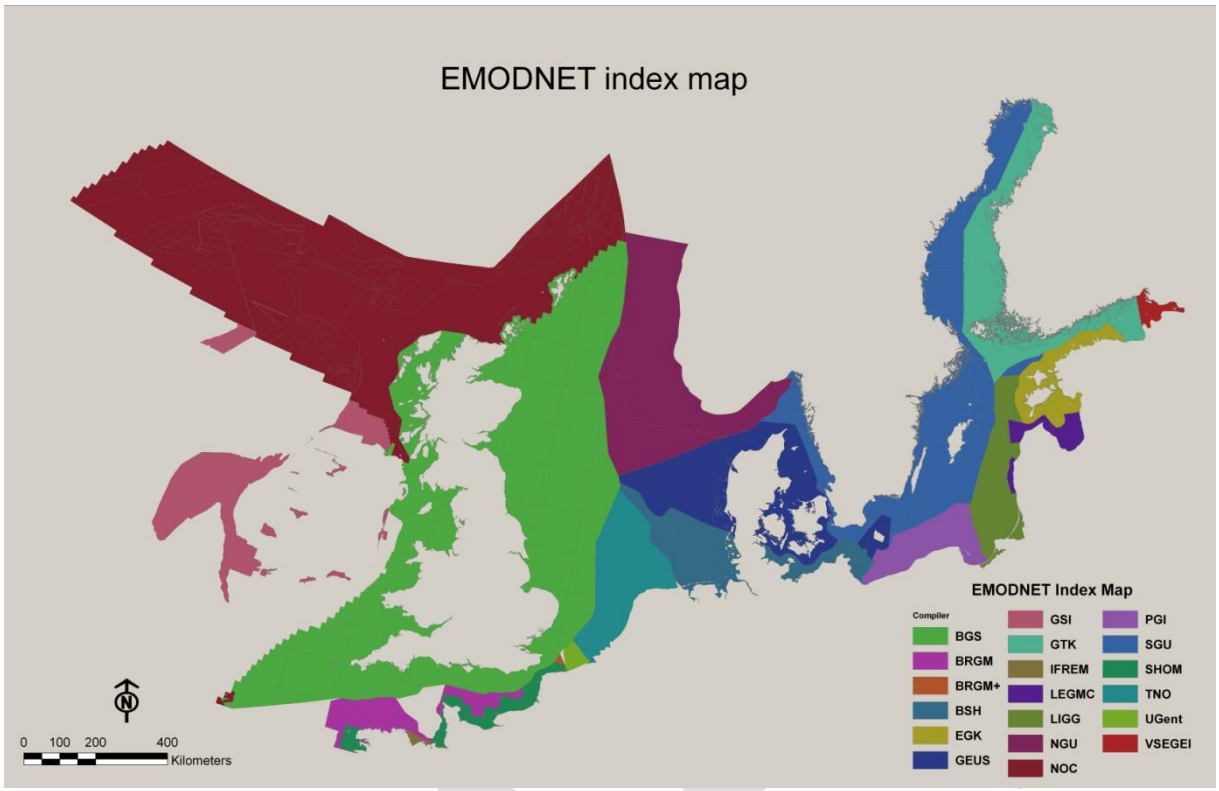

Figure 1 EMODNET index map

More than 200 maps were harmonised to a one continuous map. Methodologies used for producing these maps divers enormously, remote sensing method can varies from poor to full coverage and positioning systems ranges from advanced systems with 0-5m accuracy to Nautical Charts with over 100m accuracy. Gaps were found in few areas such as the Channel and the Celtic Sea.

One of the aims of the EMODNET - Geology project is to highlight data gaps and deficiencies, for example the low - resolution data on which many of the national geological interpretations are based. The attribute table was created in order to stress the importance of the metadata; even though the resulting substrate map would look continuous, the datasets behind include variable methodologies, sediment classification and confidence. The confidence of the map is not uniform and so areas are not always comparable. This information is necessary for users and decision - makers to allow them to realize the limitations of the maps.

Harmonisation

Each partner harmonised their available sea - bed substrate data. Like the index shape file, the sea - bed substrate shape file includes an attribute table that contains information related to the reclassification.

The current sea - bed substrate map was produced on the basis of EUSeaMap requirements. Due to the challenging timeline, the substrate reclassification scheme is simplified and provides an estimate of the substrate from the uppermost 30 cm of the sediment column. The BALANCE approach was adapted to reclassification due to its simplicity and transparency (Al - Hamdani et al. 2007). The approach is based on surface material (that is sometimes predicted). At the kick - off meeting in

Edinburgh it was decided to include 4 substrate classes on the basis of the modified Folk triangle (mud to sandy mud; sand to muddy sand; coarse sediment; mixed sediment) and take into account 3 additional classes (boulder, till/diamicton, bedrock) (Figure 2). The aim was to compile one sea‐bed substrate map that includes all seven classes. Only two boulder fields were defined from the study area. Due to their small coverage and feedback from the EUSeaMap project, boulders were merged with bedrock.

The numerous European national and international sediment datasets are very diverse. Traditionally, European countries have conducted their marine geological surveys according to their own national survey and interpretation standards.

Substrate classifications also vary as different nations have interpreted their data according to national classification schemes. The seabed surface sediment maps that were not originally in the Folk classification system were reclassified. The first step in the reclassification was to analyze the surface material. In ideal cases the substrate content was examined from the actual surface samples and grain‐size analysis. If this was not possible, an expert‐based prediction of the surface sediments was made.

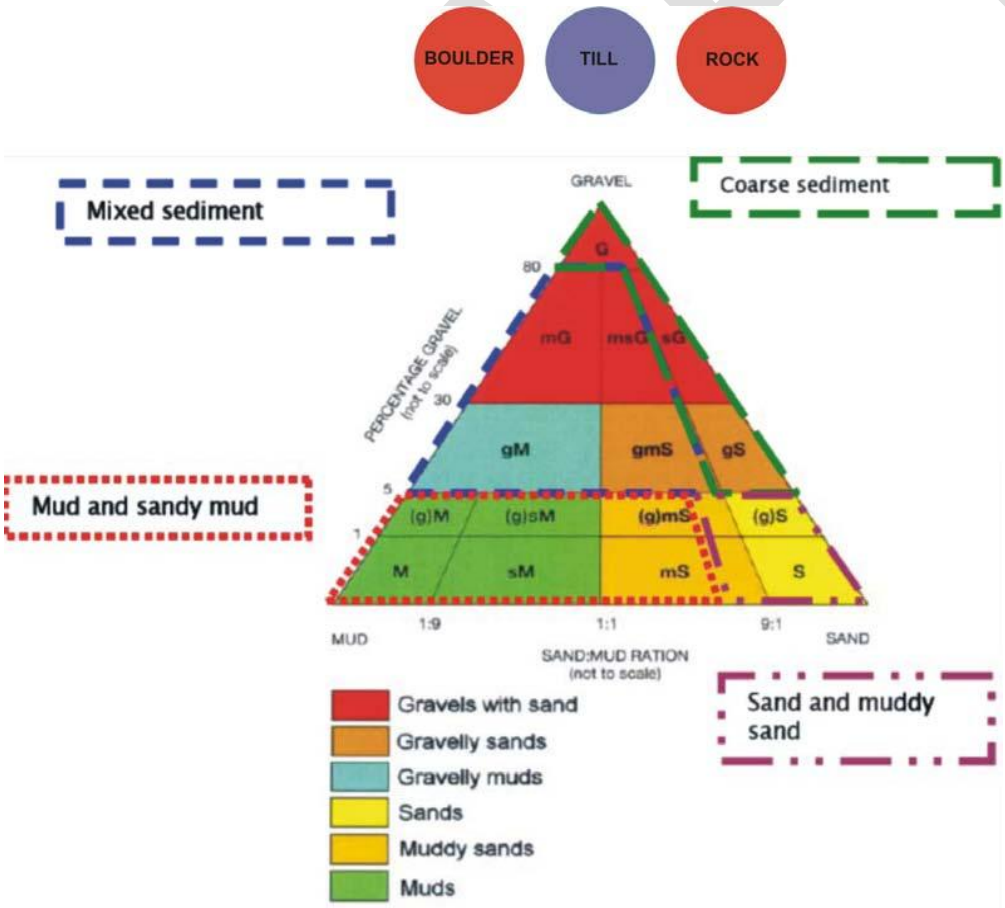

Figure 2 The modified Folk classification system.

The predicted surface sediments were then compared with the modified Folk classification system to find the best fit. In addition, differences in national grain-size classification schemes were identified.

Harmonization of national categories into one classification scheme is essential for interoperability. Unfortunately, the substrate reclassification is not unambiguous in every case. In particular, the definition of the mixed sediment class turned out to be somewhat "fuzzy". During the project meeting in Rovaniemi it was found that the term ”mixed sediment” had been interpreted different by the partners during the harmonizing process. For example, the following seafloor types and sediments have been identified as "mixed sediment": patchy seafloor; glacial clay; bimodal grain size distribution.

The seabed substrate attribute table shows that large portion of the maps is reclassified to the modified Folk system based on expert-based prediction, especially in the Baltic Sea area.

Generalisation

The EMODNET Geology project provides data at 1:1 million scale. If not originally compiled at this scale, more detailed maps were generalized. The EMODNET project followed the cartographic principles established in MESH project (Foster ‑ Smith, R. & al., 2007). Accordingly the smallest cartographic unit (polygon) on a map of the scale 1:1 million is about 4 km^2. Thus all sediment polygons less than 4 km^2 were eliminated.

The generalization procedure was implemented in ArcGIS environment and followed GTK's guidelines (Väänänen et al., 2007). This method raises the issue of the deletion of important information. It is important to be aware of these issues to try to improve the generalization methodology in future projects. For example, partners could generalize their data individually or could be separate layers that show heterogeneity and special features.

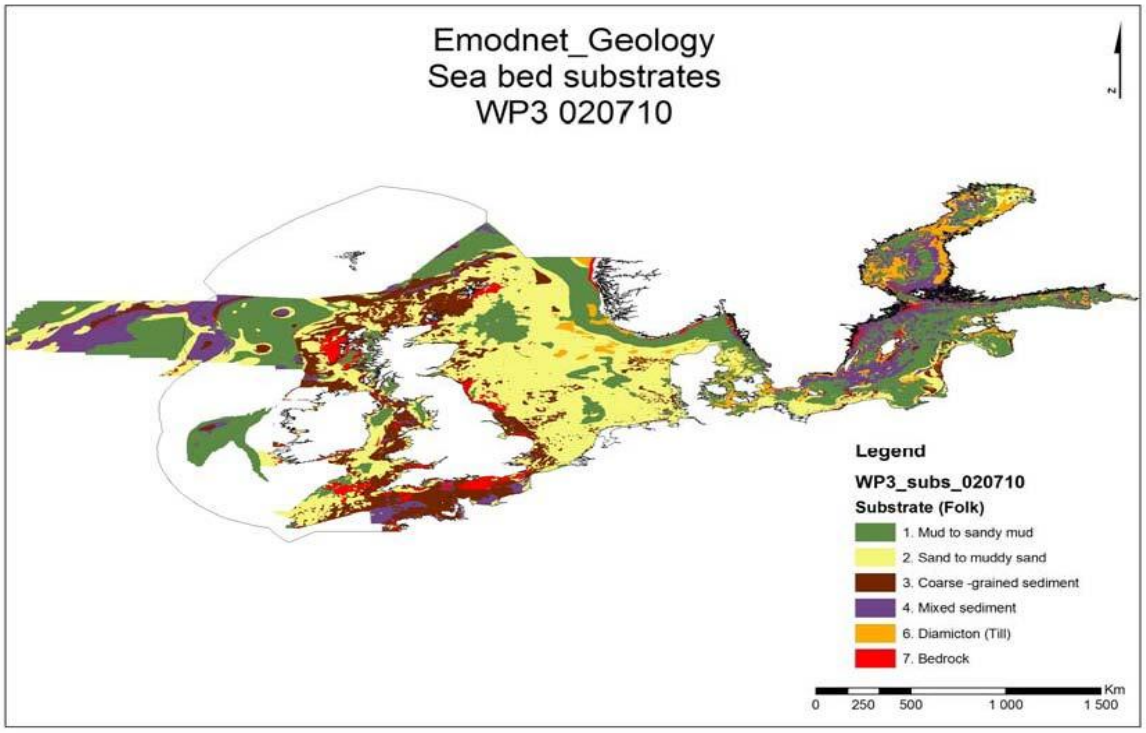

Figure 3 Sea-bed substrate map of the EMODNET geology study area.

2.2 Western Mediterranean Sea

EMODNET map was not extended to the Western Mediterranean basin; therefore the substrate map for the Mediterranean Basin was compiled separately. The only available map of the seabed substrate that covered the Mediterranean basin was the sediments map of the International Bathymetric Chart of the Mediterranean (IBCM) of the Intergovernmental Oceanographic Commission (IOC), but its scale was (1: 5000.000) and precision was not appropriate for the requirements of the EUSeaMap project.

In order to obtain substrate maps for the Mediterranean basin at a resolution appropriate to the grid analysis defined by the project (cells of 0,0027 degrees); it was necessary to carry out compilation, analysis and harmonization of different types and sources of information on seabed substrate of each country (geologic, bionomic and substrate maps or other documents or data)..

The seabed substrate map obtained for the Mediterranean Basin contains information on the superficial sediments, seagrass meadows and hard substrata. It has been prepared by EUSeaMap project directly using different cartographic sources derived by previous works compiled by all partners. Therefore, it must be kept in mind that, this represents an assemblage of different information collected at different scales and/or projections, with different methodologies, for different objectives and was available in different formats (shape files, images or printed maps).

Therefore much effort was put in standardizing the different sediment classifications used in the various maps, documents and projects.

Compilation and harmonization of the sub-bottom substrate information

The construction of the seabed substrate map went through the following stages:

1. Compilation of substrata, bionomic maps and other documents at national level.

2. Adoption of standards and common classification protocols for the substrate map.

3. Harmonization of the substrate maps to national level and generation of a unique map for the country.

4. Realization and evaluation of the first version of the harmonized map of the Mediterranean basin.

5. Gaps elimination and completion of information

6. Final seabed substrate map in vector and raster formats.

1. Compilation of substrata, bionomic maps and other documents at national level.

There is a lot of information on the Mediterranean bottom substrate, but it is multi-source, not systematic, without standards and at the same time there are wide areas without information.

Each partner carried out an inventory and compilation of information on the seabed substrate to national level, finding information that was at different scales and/or projections, classifications and formats.

The sources (original projects) used for the collection of the original data have showed that the cartographic projects identified had a quite local character and they were not harmonized. The bionomic maps have variable scales, ranging from 1:1.000.000 at 1:5.000.

For the French and the Italian substrate maps, the number information sources were few and quite homogeneous (they mainly were cartographic projects), but Spanish sources were much more numerous and complex of harmonizing.

For the areas outside of the EEZ of these countries it decided to use the sediments map of IBCM and to complete the information with documents compiled by the IEO as they are the available sources for completing the map of the seabed substrate.

2. Adoption of standards and common classification protocols for the substrate map.

The existing national and international substrate maps are numerous, but substrate classifications vary as different projects have interpreted their own data according to different objectives, local names and standards. For this reason it was essential to adopt a common classification that leads to the harmonization of different categories into one classification scheme. This is important for obtaining a unified substrate map that can be integrated with the biological, oceanographic and bathymetric datasets and modelled with GIS tools.

In Madrid meeting, November 2009, this issue was discussed keeping in mind the characteristics of main habitats substrate, results and experience of BALANCE, MESH and EMODNET geology projects. In the same way, it was considered that due to the variable and irregular boundaries and the variations of the different substratum classes, as well as the scale of the maps and the difficulty that it causes for the application of the EUNIS classification, that finished basic substrate map should be compiled, without reference samples in many cases and with a variable degree of accuracy. The reclassification of the substrates should be simple and comparable to the results obtained in the above mentioned projects.

Due to the important climatic, litological and geologic differences among the Northwester European Atlantic and the Western Mediterranean, it was not possible to use the same classification for the substrate, because till and boulders are associated mainly with periglacial sedimentation zones, and are not present in Western Mediterranean.

On the other hand, the posidonia oceanica and cymodocea represent a very significant habitat in Mediterranean basin and although they cover many zones, they don't form very extensive meadows and if they are not kept in mind, they can disappear of the final map of habitats.

For this reason there was the agreement to considerer posidonia oceanica and cymodocea as substrate classes. It was also agreed to do a unique class with all sediments bigger than sand size, since it adapted better to the characteristics of the Mediterranean substrate and habitats. The coarse and mixed sediment is a class that includes all sediment sizes larger than 2 mm (very coarse sand in Udden Wenthworth classification).

Finally a "Modified Folk" classification which is similar to the NW Atlantic was adopted, but with some changes due to the Mediterranean characteristics. Then 5 substrate classes were suggested based on the modified Folk triangle (mud, sandy mud, muddy sand, sand and mixed sediment) and 3 additional classes (rock, posidonia oceanica and cymodocea) (Fig 4). The aim was to compile one sea-bed substrate map that includes all these eight classes.

The final substrate map was produced in ESRI shape file format showing polygon features, with the highest possible resolution and using the WGS84 geographical coordinate system (Lat/Lon).

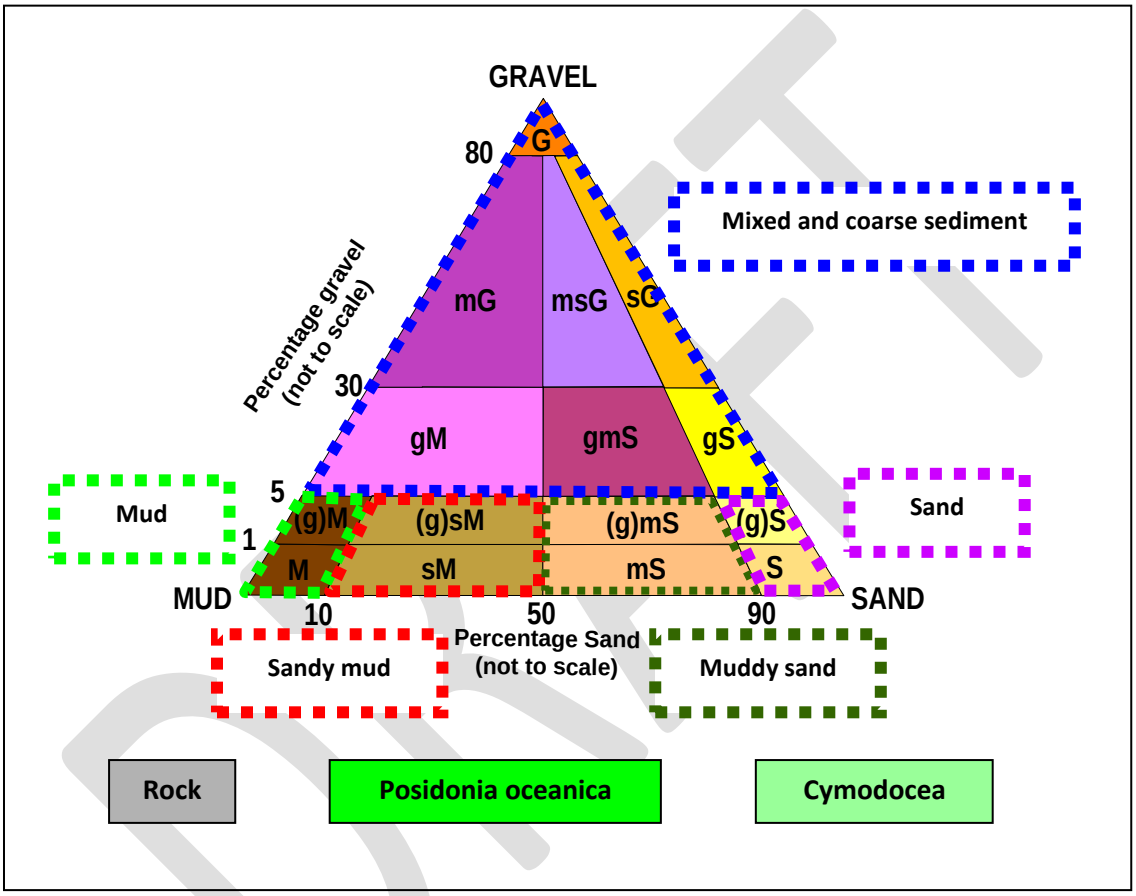

Figure 4. Mediterranean modified Folk classification system.

3. Map harmonization to national level

National substrate maps of each country were synthesis and harmonization at national level following the approved standards.

The maps were re-interpreted with the following criteria:

- On the basis of possible equivalence between grain size or class of old and new classification, grouping and renaming the old classes into new classes

- In case of prediction (interpolation or extrapolation) the modified Folk classification should be considered.

- The reclassification of the sediment map should be according to surface material correlation.

- Sediments maps of IBCM were used to fill blank zones outside national information of the EEZ. This information was adapted and reclassified by the IEO for making the map of the Mediterranean seabed substrate. The equivalence used is in Table 1.

IBCM classification	**Modified Folk classification**
Muddy sand	Muddy sand
Sandy mud	Sandy mud
Mud	Mud
Clayey sand	Muddy sand
Sandy clay	Sandy mud
Clay	Mud

Table 1. Equivalence between IBCM classes and Modified Folk System to Western Mediterranean.

- National maps ArcGIS polygon shape file was prepared with attributes shown in Table2.

Field name	**Format**	**Description**
FID	Short integer	Sequential ID provided by the software
Shape	Text	Description of the geometry
Area	Long integer	Area of the polygon (square meters)
Field 1	Text	Source
Field 2	Text	Classification of the polygon according to the EuSeaMap

Table 2. Main attributes considered in the national shape file of substrata layer.

An inventory was made with the main information about each source (Name, owner, year of the data, original projection, original scale, original Sediment Classification and other comments). This dataset was used later to make the confidence maps.

The gaps in the maps were filled by IEO with new information or by interpreting other data.

4. Realization of a harmonized map of the Mediterranean basin.

The national substrate harmonized and generalized maps were provided to IEO by partners in ArcGIS polygon shape file format. These files were unified by IEO, harmonizing inconsistencies encountered between maps, and fixing errors of topology, overlapping, etc. This was performed by contacting the map providers or by interpreting these areas with the following criteria:

- In boundary zones among different sources the most precise source in the original maps was considered and the boundaries were reshaped to become coherent with the geomorphologic characteristic.

- The geometry of boundaries between different substrata polygons should be coherent with geomorphology.

- The areas where rock sub-outcropping has been integrated in the rock category.

Most of the Mediterranean deep basin (continental slope and abyssal area) was compiled with sediment data of IBCM map.

In the continental shelf where more variety of habitats exists, but it is quite narrow in the Mediterranean basin and it is difficult to represent the variety of substrata and habitats, in consequence it has been necessary to look for maps of high resolution.

In the first version of substrate map (July 2010) was not complete and lacks information on the fanerogams meadows and it had incoherencies in some datasets boundaries.

Also there were four important gaps (figure 5), in the Algerian continental shelf, a great zone on the Italian shelf, western margin of Sardinia and Corsica and French margin.

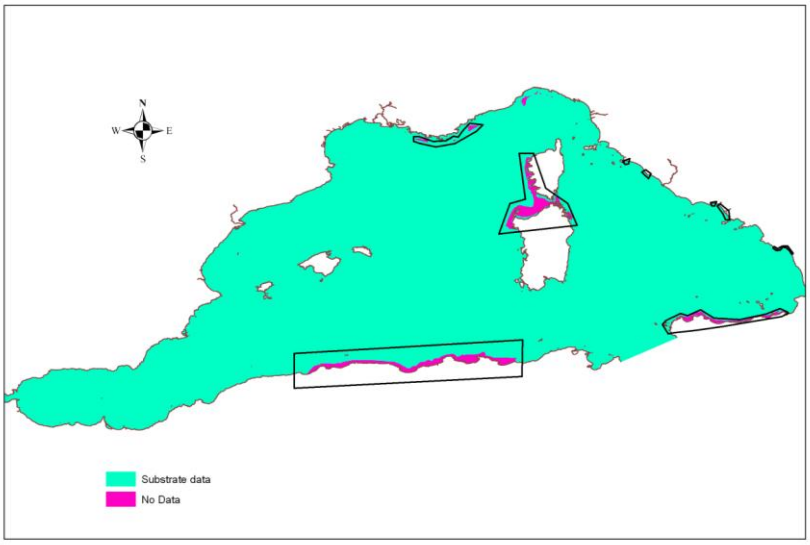

Figure 5. Gaps situation in the first map version (July2010). .

5. Gaps elimination and completed of the information

For gaps elimination, some substrate classes were extrapolated and/or polygons were expanded , keeping in mind that the areas of capes and abrupt coasts reflect certain continuation of shallow bottom due to the rocky outcropping. Likewise, the areas around the rocks and where the slope is high polygons of coarse sediment can be expanded.

The Algerian continental shelf:

The gap of substrate has been filled considering that it is possible to make a valid interpretation and model to wide scale using procedure given by Domzig et al. (2009), the geologic characteristics of the coastal area, as well as the following interpretation criteria:

- The areas where the coast is irregular and abrupt correspond to hard rock zones (this is supported in the geologic maps of the emerged zone) and therefore the adjacent seabed substrate should be constitutes of outcropping rocks.

- The main features of substrate should be very similar to those of the adjacent continental shelves surrounding the substrate.

Italian continental shelf:

- Since the available information was only on fanerogams meadows, the substrate information was completed with the data of ICBM.

Margin of Corsica and Sardinia:

- Geomorphologic characteristics of Corsica and Sardinia margin are very similar as well as the original data of internal shelf. Therefore the margin of Sardinia was assumed to have a similar evolution of that for Corsica, where there is very high resolution information. The geometry of substrate distribution in the continental shelf and upper part of slope of Corsica can be partially extrapolated from Corsica to Sardinia.

For this reason it has been considered that the gaps can be filled carrying out an interpretation (prediction) following a similar model using same geologic and geomorphologic criteria that exist for the nearest areas.

- In the continental slope of Corsica the turbidity activity has filled the canyons with sand and coarse sediments in the central part and base of slope; therefore, in the same zones, polygons with this type of sediments have been prolonged until the abyssal area using the geological information of the area. This has improved and completed the information of the western part of the islands and it has modified the data of ICBM.

The new interpretation of the nature of the substrate is based in Kenyon et al. (2002) and Mas et al. (2010), who extend the Var lobe to West of Corsica.

Kenyon et al. (2002) studied with high resolution geophysical techniques as well as cores samples the western margin of Corsica. They found that this margin is dissected by deep and straight canyons

that have steep axial gradients and that extend from land to deep sea. The axes have scour holes and trains of gravel or pebble waves.

In the lower part of canyons there were r five separate depositional lobes extending beyond the canyon mouths. The lobes are constituted of stacked sedimentary sheets, whose core contain coarse to medium sand beds with some mud clasts in the middle. The sand bodies sampled are found where backscatter is relatively weak

- On the other hand, the data of the west margin of Corsica seems to support the hypothesis that all canyons of the east and west margins of Corsica and Sardinia present a similar structure and sedimentary distribution which exists in the west margin and upper part superior of the slope.

French continental margin:

New information from IFREMER (French Research Institute for Exploration of the Sea) was used to fill same small gaps and also to solve incoherencies in the information of the French margin and in that between Italy and France.

The deep area in front of Nice was mapped after modifying the data of GEBCO according to data on the evolution Var lobe presented in recent papers of Mas V. (2009) and Mas et al. (2010).

The zones where the data were modified or changed in last version are shown in figure 6.

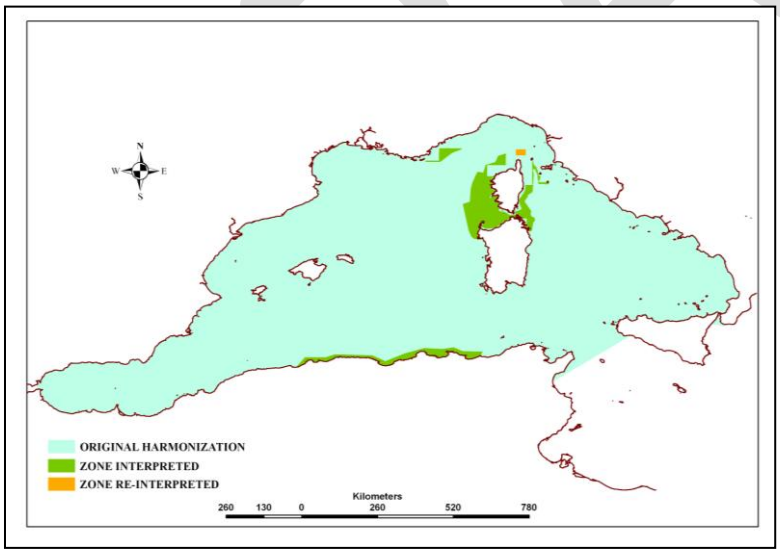

Figure 6 The modified Zones.

It has been very interesting, from habitats point of view, to discover that there are recent papers that show the existence of sands and coarse sediments in abyssal zones. It is possible that at west and east of Corsica Sardinia block new studies find more deposits with similar characteristics.

6. Final seabed substrate map in vector and raster formats.

As result of these processes a final substrate map was produced, unified and harmonized in an ArcGIS polygon shape file (Figure 7) as well as in raster format with a cell size of 0, 0027 degrees (about 250 m)..

The substrate map of western Mediterranean is quite accurate in continental shelf and slope, but it is less accurate at deeper zone due to lack of information.

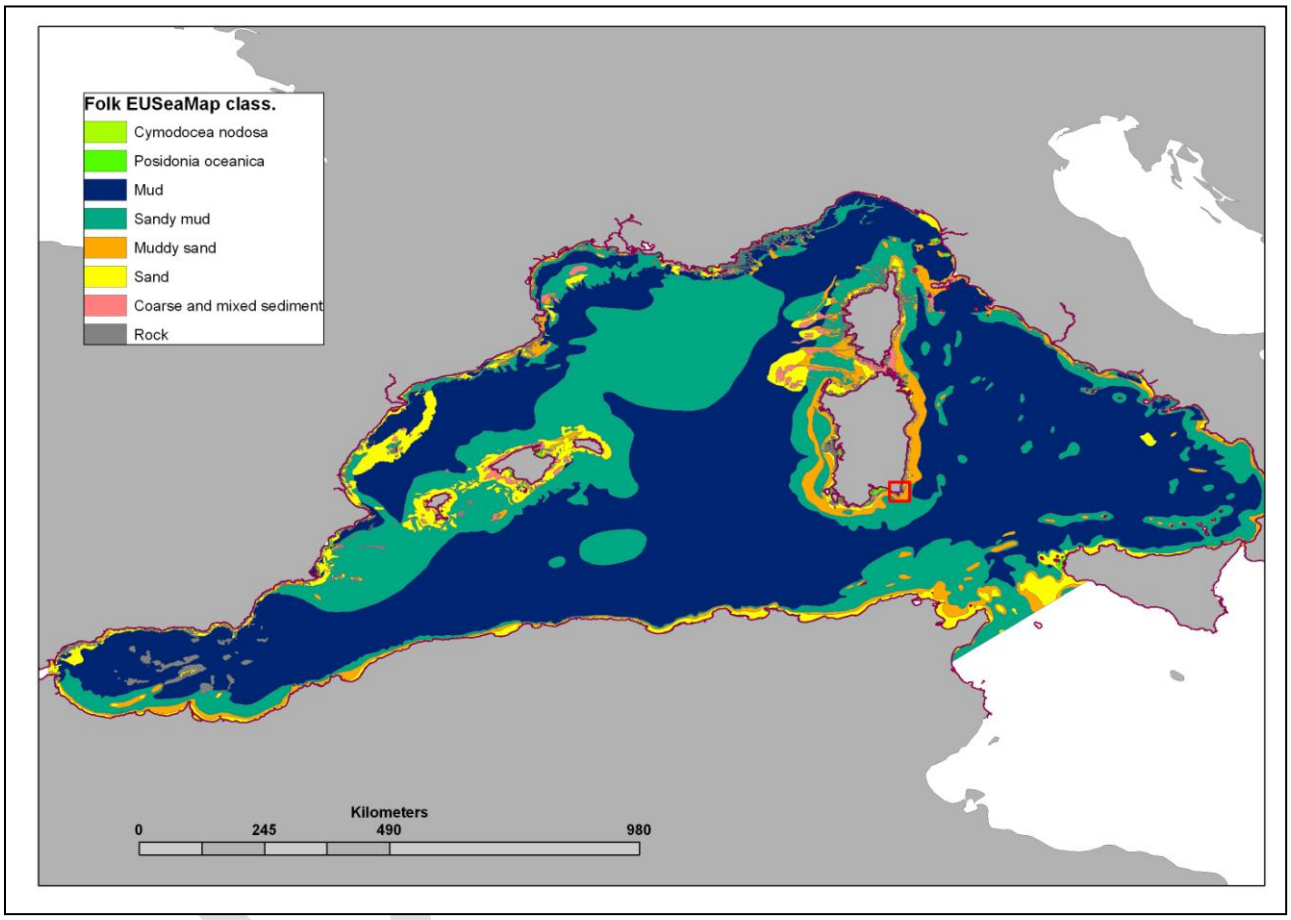

Figure 7. Final substrate map to Mediterranean basin

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