MAPPING OF THE SUB-LITTORAL SUBSTRATES AS A BASIS FOR THE IDENTIFICATION OF NATURA 2000 HABITAT TYPES 1110 AND 1170 IN THE BULGARIAN BLACK SEA

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ABSTRACT. *The paper examines the levels of representativeness of the current NATURA 2000 network within the Bulgarian sector of the Black Sea regarding habitat types 1110 (sandbanks) and 1170 (reefs). The distribution of these habitats is directly linked to certain lithologic substrates, e.g. sandy sediments (sand banks) and rock substrates (reefs). Hence, the initial habitat assessment requires mapping of the associated seabed substrates. Results of the GIS analyses revealed that despite fulfilling the formal requirement at least 20 percent of the habitats' spatial extents to be included in the national network, there are several unacceptable omissions concerning potential sites of community importance. Therefore, these ecologically important sub-littoral areas are proposed for inclusion in the national NATURA 2000 network.*

Keywords: *lithologic seabed mapping, underwater coastal slope, area calculations, sandbanks, geogenic reefs, marine NATURA 2000 network*

INTRODUCTION

Being an EU Member State, the Republic of Bulgaria is committed to the creation of a coherent ecological network NATURA 2000, hosting the natural habitat types listed in Annex I and habitats of the species listed in Annex II of the Habitats Directive. Also, the country is obliged to enable the habitats concerned to be maintained or restored at a favorable conservation status [1].

The initial list of Sites of Community Importance (SCI) for the Black Sea biogeographical region was adopted with the Commission Decision of December 12th, 2008. This list was critically evaluated at the Marine Black Sea seminar in Brindisi (Italy) on June 15th, 2010, which was organized by the General Environment Directorate (DG Environment) of the European Commission with representatives of the European Topic centre on Biodiversity (ETC/BD), the Bulgarian Ministry of Environment and Waters (MOEW), non-governmental organizations (NGOs) and independent experts. As a result of the discussions held, ETC/BD concluded that there was a minimum to moderate insufficiency of the Bulgarian marine NATURA 2000 network concerning the natural habitat types 1110 **(sandbanks which are slightly covered by seawater all the time)** and 1170 **(reefs)**. Following the seminar conclusions, the DG Environment required actions for additional sites designation and/or revision of the boundaries/extension to current SCI's in the Bulgarian Black Sea [1].

As a result of MOEW initiative a research project was funded by the Enterprise for Management of Environmental Protection Activities (EMEPA) and executed under the coordination of the Institute of Oceanology – Bulgarian Academy of Sciences. The project aimed at mapping the distribution and quality of the habitats concerned using historical and newly generated field data and thus provided the scientific basis for the marine NATURA 2000 extension in Bulgaria [1].

The habitats of Community importance 1110 and 1170 are directly linked to certain lithologic substrate types. For instance, sandy sediments represent the most important physical characteristic of the habitat type "**Sandbanks which are slightly covered by seawater all the time".**

Furthermore, rock substrates correspond to **reefs** of geogenic origin. Although the variation of biological communities may be great depending on other important marine environmental factors (e.g. light, depth, wave exposure, salinity, currents etc.), still the lithological mapping represents the basis for habitat mapping, providing a canvas on which to superimpose the biological features [2]. The current work presents the results of the lithological mapping carried out.

DATA AND METHODS

Archive lithological data of Department "Coastal zone dynamics" at the Institute of Oceanology were processed in Arc GIS environment for the needs of the present study. Following the data integration procedures, a series of maps of the sub-littoral substrates found in the Bulgarian Black Sea coastal zone were compiled at scale 1:10 000. This scale was sufficient to define areas with physically distinct benthic conditions. Thus, the compiled maps were useful to predict the spatial patterns of the expected biological communities.

The existing lithologic types within 5 regions and 17 sub-regions along the Bulgarian Black Sea coastal zone were determined on the basis of long-term field surveys which were initiated in 1971 and finalized in the early 1990's *(Figure 1)*. Furthermore, in the period 1991-2010 additional mapping activities were carried out with regard to various national and international projects, municipal and governmental orders.

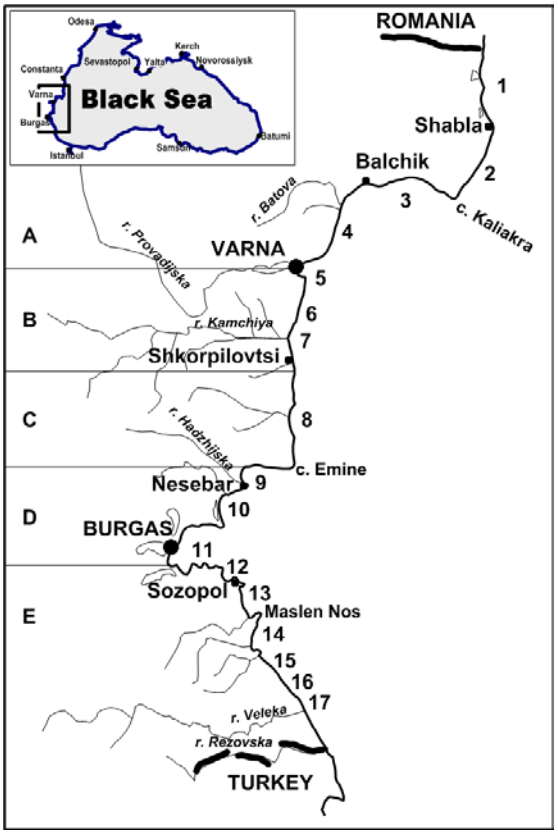

Fig.1. Schematic map of the regions and sub-regions covered by the long-term field studies initiated in the 1970's and finished in the 1990's

Field activities. A total of 627 echo-sounding profilings were performed in the period 1971-1990, covering the Bulgarian Black Sea coastal zone from cape Sivriburun on the north to cape Sinemorets on the south. The number of lithologic samples collected during the above-mentioned period from both terrestrial and underwater sectors of the coastal zone is 5135.

The initial stage of the field activities was creation of a geodetic network for the aims of the surveys. Distance between benchmarks was 500 m for erosive types of coast, and 300-400 m for accumulative types of coast. Further terrain mapping activities included:

- Topography and bathymetry along cross-shore profiles starting from the benchmarks. The average length of each transect was 2000-2500 m off the shoreline for the northern sector of the Bulgarian Black Sea coastal zone, 3500-7000 m for Nessebar bay and 4000 m for the coastal region stretching from Pomorie to Burgas. The maximum depths studied were 20 m for the Northern Bulgarian Black Sea, 30 m for the underwater coastal slope of Emine Mountain, 35 m for Burgas bay and 40 m for the underwater coastal slope of Strandzha Mountain
- Samples collection from investigated areas;
- Scientific diving for determination of the sediment layer thickness.

Laboratory tests. Laboratory analyses of the collected samples included determination of sediment grain sizes using 17 sieves, areometric analyses of silts and clays, as well as

determination of the CaCO3 content. Classification of the sediments was done in accordance with the Bulgarian National Standard (BNS) 676-75.

Desk-based studies of collected data. Over the years, a series of hard-copy maps were compiled on the basis of field-collected data, including the following types:

- Bathymetric maps at scales ranging from 1:1000 to 1:25 000;
- Geologic, lithologic and morpho-litho-stratigraphic maps, maps of the sediment layers thicknesses at scales ranging from 1:1000 to 1:25 000;
- Distribution of CaCO3 in surface sediments at scales ranging from 1:1000 to 1:25 000;
- Geomorphological, morphodynamic and geodynamic maps as well as schematic maps at various scales.

Subsequently, a heads-up digitizing campaign was carried out at Department "Coastal zone dynamics" of the Institute of Oceanology starting in the mid-1990's. Digital layers on loose and solid sea bed lithology were created and maintained in a GS SURFER environment.

In 2011, these graphic files were imported in Arc GIS 9.3.1 and missing attribute data were added. Also, the topology of the layers was corrected. *Figures 2 and 3* describe the process of lithological data integration into Arc GIS 9.3.1.

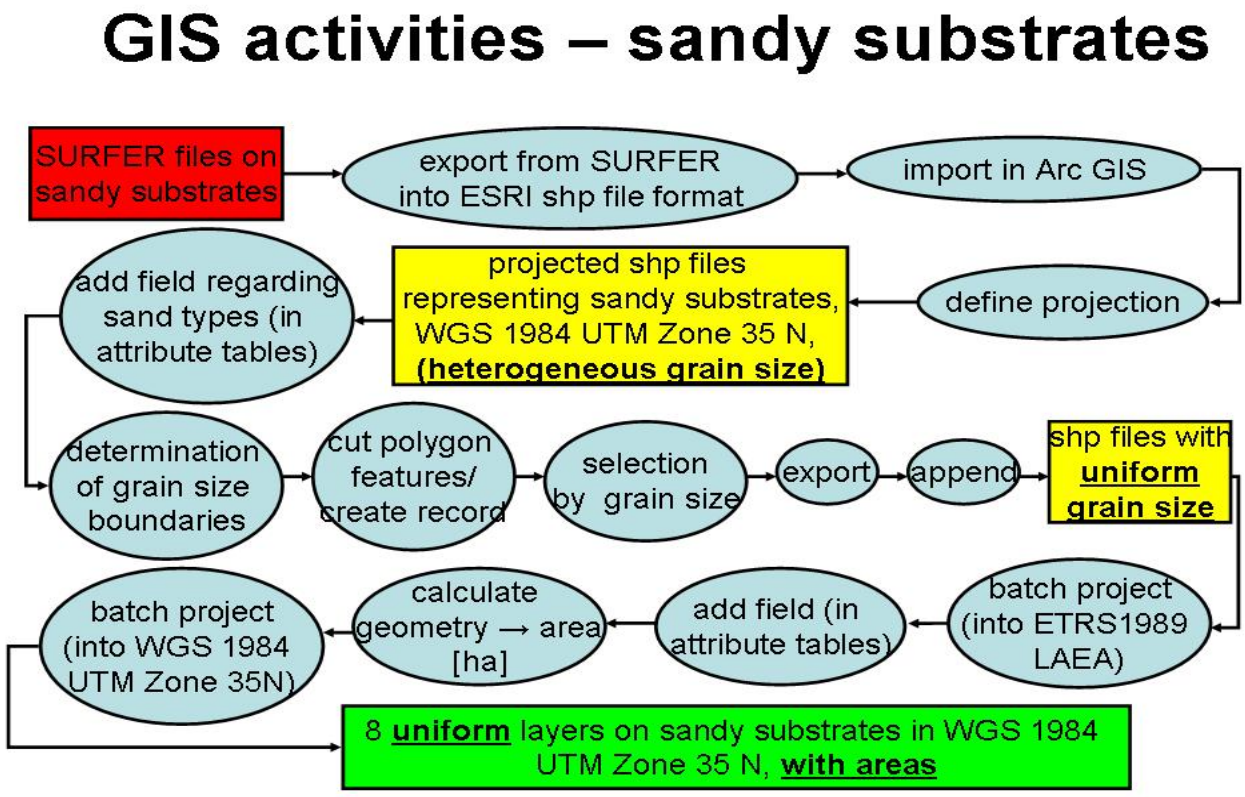

Fig. 2. Illustration of the process of data integration on sandy sediments into Arc GIS 9.3.1

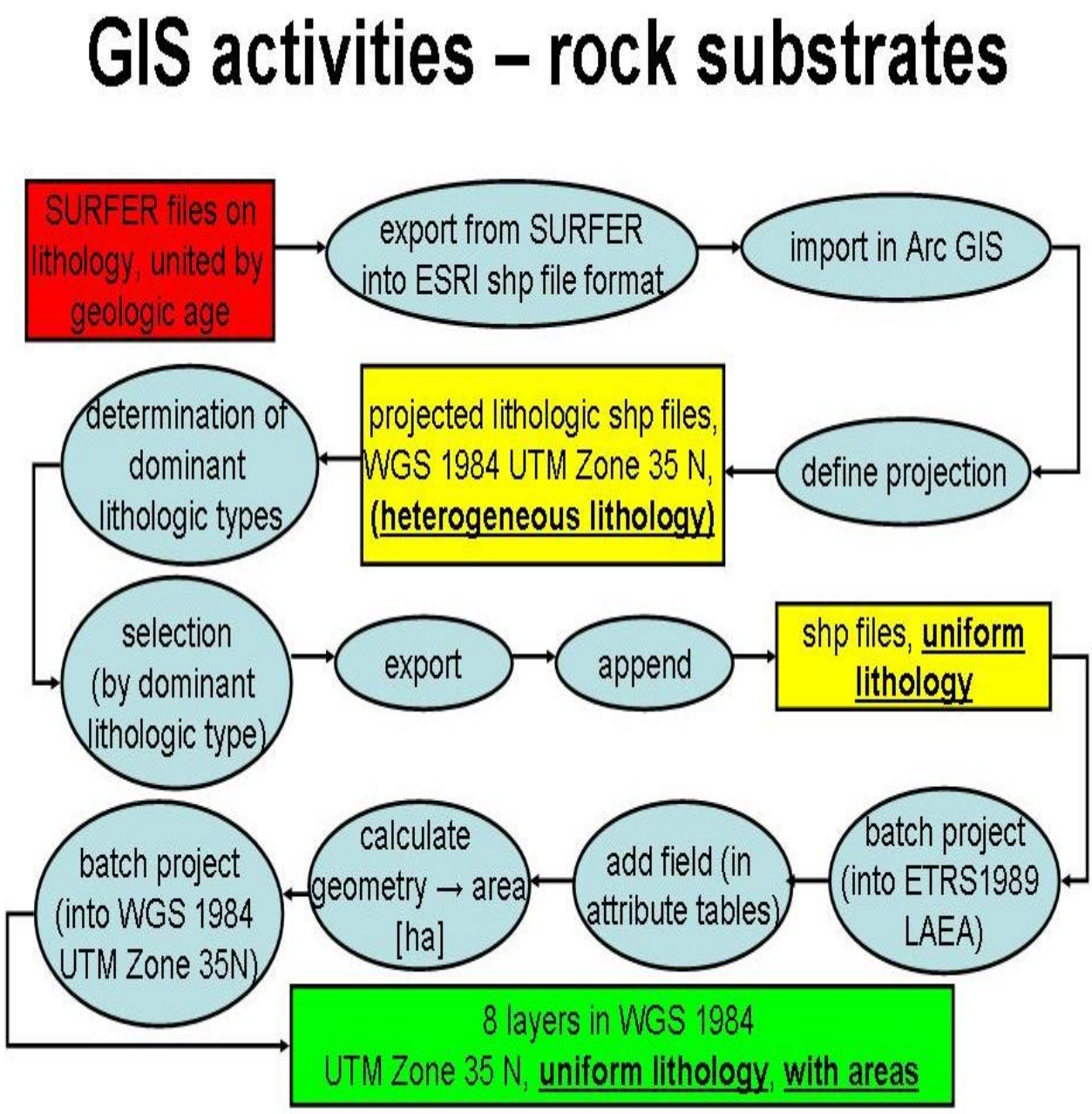

Fig. 3. Illustration of the process of data integration on rock substrates into Arc GIS 9.3.1

Following the Arc GIS integration procedures, the lithologic varieties were united into three main categories – sand, rocks and silt. Finally, these were clipped to the current extent of the national marine NATURA 2000 network. This procedure was executed by using the official shape files representing the boundaries of the protected sites established in accordance with the Habitats Directive so far [3]. The clipped areas of the simplified lithologic varieties falling within areas of NATURA 2000 sites were re-calculated in Lambert Azimuthal Equal-Area projection with datum ETRS 1989 (ETRS 1989 LAEA). Executing such calculations in an equal-area projection is described by several authors as a proper method for achieving spatially correct results [4], [5], [6], [7].

RESULTS

There are five loose and six solid dominant seafloor substrates found within the study area. These are illustrated on *Figure 4.*

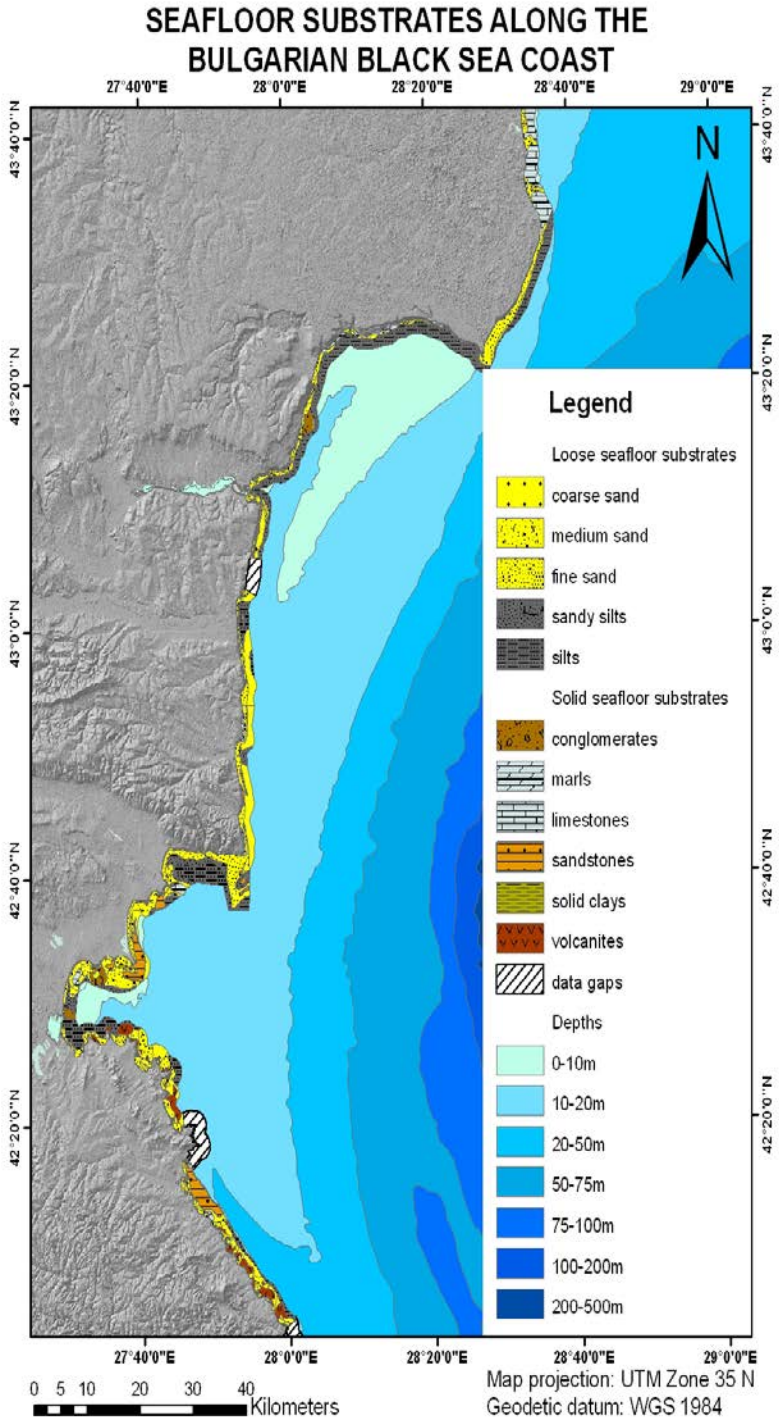

Fig. 4. Spatial distribution of the dominant seafloor substrates along the Bulgarian Black Sea coast

All sand types found within the Bulgarian Black Sea underwater coastal slope and thereby representing the physical habitat 1110 **(sandbanks)** cover an area of 33072.97 ha. The total area of all rock types corresponding to the physical habitat 1170 **(reefs)** is 16917.57 ha. Nevertheless, there are some 6404.70 ha of the Bulgarian Black Sea underwater coastal slope which remain uninvestigated concerning their lithology (*Table 1*).

Table 1. Areas occupied by the dominant sea floor lithologic types along the Bulgarian Black Sea coast

Lithologic variety	Area [ha]
coarse sand	8788.28
medium sand	10000.98
fine sand	14143.2
sandy silt	5717.44
silt	19058.71
conglomerates	1450.62
marls	1277.81
limestones	5389.90
sandstones	5506.73
solid clays	126.90
volcanites	1940.86
total sand	**33072.97**
total rocks	**16917.57**
areas with data gaps	**6404.70**

Equal-area calculations performed in Arc GIS 9.3.1 revealed that approximately 39% (12 898.5 ha) of the known national sandy sea bed and 20% (3383.5 ha) of the known national rocky sea are included in the initial list of SCI's adopted with the Commission Decision of December 12th, 2008 *(Figure 5)*. However, certain morphologic features and the associated biotopes, particularly representative of the habitat types 1110 and 1170, remain outside any of the nearby-located NATURA 2000 protected sites, the most outstanding examples being Aladzha bank, Kiten reef and Cockatrice sandbank *(Figures 6-8)*.

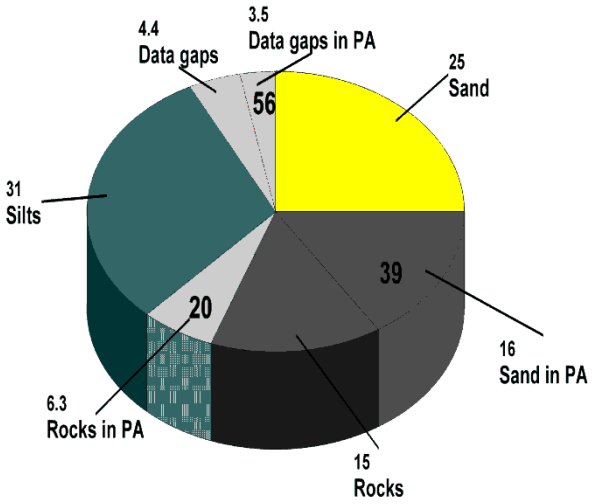

Fig. 5. Relative distribution of the sea bed substrates along the Bulgarian Black Sea coast (in % of total) and in the current marine NATURA 2000 sites (PA).

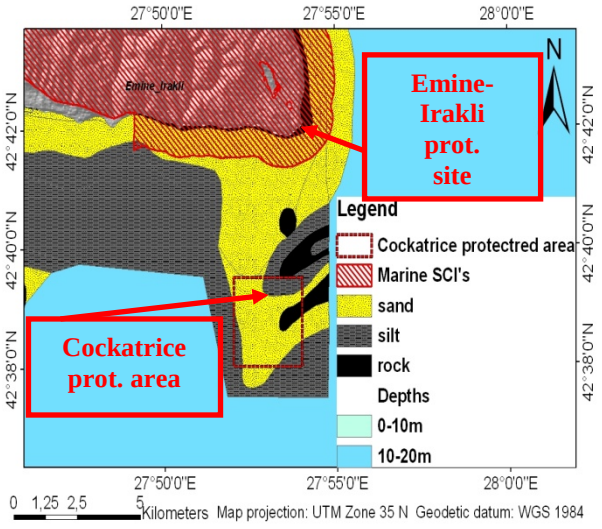

Fig. 6. Current extents of Cockatrice protected area and of Emine-Irakli NATURA 2000 protected site

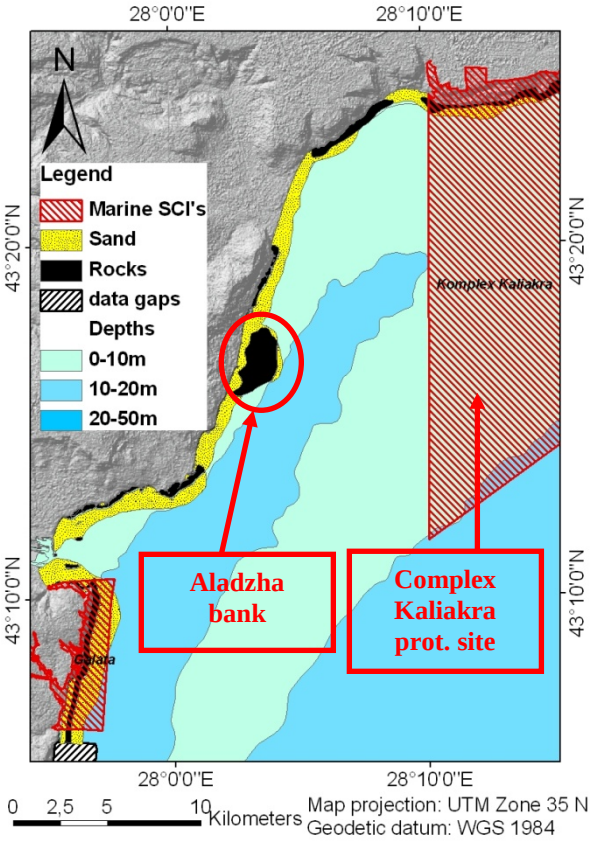

Fig. 7. Location of Aladzha bank and current extent of Complex Kaliakra NATURA 2000 protected site

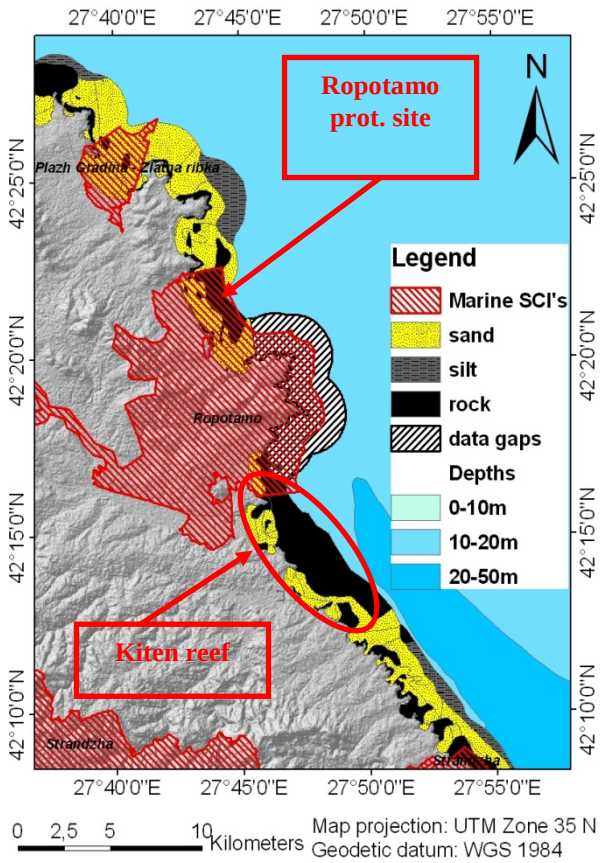

Fig. 8. Location of Kiten reef and current extent of Ropotamo NATURA 2000 protected site

DISCUSSION

The lithological mapping was useful in determining the national area of the habitat types 1110 (sandbanks) and 1170 (geogenic reefs) and the proportion of habitat area within NATURA 2000 network at the national scale. The proportion of habitat area is one of the most important criteria to assess representation of habitats. Arbitrary sufficiency levels 20-60% for non-priority habitats are suggested in the 'Criteria for assessing national lists of pSCI's at the biogeographical level' [2]. Habitat types for which the whole of the proposed sites hosts between 20% and 60% of the total habitat area are submitted to an individual analysis, which involves the distribution patterns, the ecological variation and the conservation status. Additional criteria to assess the importance of sites are "uniqueness", "high quality", "high biodiversity" and "network coherence".

The lithological mapping revealed that the proportions of the national areas of 1110 and 1170 included in NATURA 2000 at the national level fall between 20%-60%.

Further analyses of the biological communities variability, habitat quality, biodiversity and the conservation status carried out in the project suggested that the above mentioned morphologic features Aladzha bank, Kiten reef and Cockatrice sandbank are representative examples of the habitat types 1170 and 1110 and deserve inclusion in the NATURA 2000 network [1].

Cockatrice sandbank with an approximate area of 1500 ha is the largest structure of sand accumulation and the most representative sandbank in the Bulgarian Black Sea. Cockatrice is an outstanding example for high biodiversity of zoobenthos and feeding grounds for demersal fishes [8], therefore it has high national conservation value. A portion of it has already been declared a protected area in accordance with the Protected Areas Act of Republic of Bulgaria [9], [10]. Such nature conservation sites are included *in their own right* in NATURA 2000.

Aladzha bank with its area of 522 ha is one of the largest rocky reefs in the Bulgarian Black Sea. It is a representative example of **the biotope "Infra- and circalittoral rock overgrown by blue mussels *Mytilus galloprovincialis* and *Mytilaster lineatus*" – a subtype of the habitat 1170** [1]**.** It is important for the geographic coherence and connectivity between the northern and southern reefs in the Bulgarian coastal area.

Kiten reef with an area of 1739 ha is the largest rocky reef in the Bulgarian Black Sea. The reef hosts an unique biotope for the Black Sea biogeographic region classified as **"Lower infralittoral with sciaphic association of *Phyllophora crispa*"** [1]. High biodiversity of flora and fauna, high quality and wide spread of *Phyllophora* beds determine the conservation value of the site.

CONCLUSIONS

Lithological mapping was an important first step of habitat mapping within the Bulgarian Black Sea coastal zone, providing reliable data on the distribution of the sub-littoral substrates that directly link to NATURA 2000 habitat types 1110 **(sandbanks)** and 1170 **(reefs).** Thus, the elaborated GIS layers on sea bed substrates proved to be useful in the process of defining areas with physically distinct benthic conditions and therefore to predict the spatial patterns of the expected biological communities, which were further validated by biological sampling and scientific diving.

The national area of the sub-littoral habitats concerned and the percentage of the already included areas were calculated using GIS tools. Certain morphologic features that are currently omitted from the national marine NATURA 2000 network, e.g. sandbank Cockatrice, Kiten reef and Aladzha bank, being representative examples of the habitat types

1110 and 1170 because of hosting diverse biological communities, are to be proposed for inclusion in the national marine NATURA 2000 network.

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REFERENCES

[1]. Todorova V. et al., 2012. Project Report "Extension of the ecological network NATURA 2000 in the Bulgarian Black Sea", Contract 7976/04.04.2011 between EMEPA and IO-BAS. Scientific fund of the Institute of Oceanology - Bulgarian Academy of Sciences, Varna, Bulgaria *(in Bulgarian).*

[2]. Criteria for assessing national lists of pSCIs at the biogeographical level (Hab. 97/2 rev. 4 18/11/97) (available at http://bd.eionet.europa.eu, accessed on July 30th, 2012).

[3]. www.natura2000bg.org (accessed on July 30th, 2012).

[4]. Robinson, A. H., Morrison, J. L., Muehrcke, Ph. C., Kimerling, A. J. & Guptill, S. C. Commonly used map projections. In: Elements of cartography. John Wiley and Sons Inc., Danvers, Massachusetts (USA), 1995, pp. 74-84.

[5]. Snyder, J. P. Lambert Azimuthal Equal Area projection. In: Map projections – a working manual,. US Geological survey professional paper 1395. United States Government printing office, Washington (USA), 1987, pp. 182-187.

[6]. Longley, P. A., Goodchild, M. F., Maguire, D J. & Rhind, D. W. Projections and coordinates. In: Geographic information systems and science. John Wiley and Sons Ltd., Grafos S. A., Barcelona (Spain) 2005, pp. 117-122.

[7]. Yildirim, F. & Kaya, A. Selecting map projections in minimizing area distortions in GIS applications. Journal „Sensors",Vol. 8, 2008, pp. 7809-78017.

[8]. Konsulova T., Trayanova A., Todorova V. Sand bank Kockatrice – a Case Study on the Effect of Marine Protected Area Designation as a Key Approach to Black Sea Biodiversity and Habitats Conservation. Acta Zool. Bulg. Vol. 62 (1), 2010, pp.89-97.

[9]. Protected Territories Act of Republic of Bulgaria, Section VI "Protected areas" (available at www.lex.bg, accessed on July 30th, 2012) *(in Bulgarian).*

[10]. Georgiev, B. Black Sea biogeographic region. In: National parks, nature parks and reserves in Bulgaria. Publishing house Gea Libris, Sofia, Bulgaria, 2004, pp.217-271 *(in Bulgarian).*