The Use of Interferometric Sonars for Acoustic Seabed Classification *(Alexandru-Vlad Lazăr, Gheorghe-Viorel Ungureanu, Alexandru-Dan Ionescu, Andrei-Daniel Balahura, Robert Lazăr, Alexandru Magher)*	"Cercetări Marine" Issue no. 45 Pages 149-159	2015

THE USE OF INTERFEROMETRIC SONARS FOR ACOUSTIC SEABED CLASSIFICATION

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ABSTRACT

Seafloor mapping is of great importance for the management of marine resources. The past decades have seen the fast development of acoustic seabed mapping techniques. Of particular importance is the mapping of seafloor type. It has applications in marine geology and biology, environmental sciences, coastal engineering and fisheries. Traditional techniques relied on grab samples or scuba diving, so they were done only on spot observation and extrapolating the findings to the surrounding area. The use of marine acoustics helps in picturing the extents of various areas dominated by a specific bottom type.

The paper discusses the use of interferometric sonars for seabed classification and provides examples from the Romanian Black Sea coast, on a 42 hectares site offshore Mangalia. They are devices that acquire both bathymetry and side-scan imagery and combined they prove to be better that approaches based on only one of them. Interferometric sonars can be deployed as pole mounted devices or AUV mounted.

We have been able to discern between several acoustic facieses and correlate them to substrate type by grab samples and ROV inspections. The hard bottoms, such as rocky substrate appears as areas of high rugosity and are usually stand out from the surrounding landscape. The muddy and sandy areas show gentle sloping and a general featureless aspect.

Key-Words: *Acoustic seabed classification, Interferometric sonar, Mangalia*

AIMS AND BACKGROUND

The last decades have seen the birth and development of acoustic seafloor classification for environmental types. The acoustic seabed classification is the process of dividing the acoustic seabed image of the seafloor into individual classes based on acoustic properties. It can be done using various types of acoustic systems such as single beams, multibeams, side-scans, interferometers or sub-bottom profilers. Previous examples are widely found in literature, using side-scan (Atallah , 2002; Allen, 2005; Bartholoma, 2006, Cholwek, 2000), multiubeam (Bayer, 2007), combined multibeam and side-scan (Diesing and Schwartzer, 2006) and sub-bottom profiler (Garcia-Garcia et al, 2004) It is actively developing in field of marine geophysics - seabed classification for environmental management by mapping the extent of marine habitats.

On the European level, large scale habitat mapping projects such as MESH (seas around the United Kingdom), BALANCE (Baltic Sea) were carried out since 2004. They were followed by EUSeaMap and EMODnet Seabed habitats portal. Their aim was to extend the habitat mapping of European habitats on a broader scale and make the maps available to the general public.

On the Romanian coast, the National Institute for Marine Research and Development delivered habitat maps for the Natura 2000 marine sites in 2011 and 2012 based on the acoustic seabed classification and data provided by SC Marine Research SRL. The results of the seabed classification can be found in Lazar et al. (2013), Lazar et al. (2013), Ungureanu et al. (2015).

The purpose of this paper is to discuss the possibility of using interferometric sonars for acoustic seabed classification with examples from the Romanian coast based on our experience on a case study on an area of 42 hectares (Fig. 1).

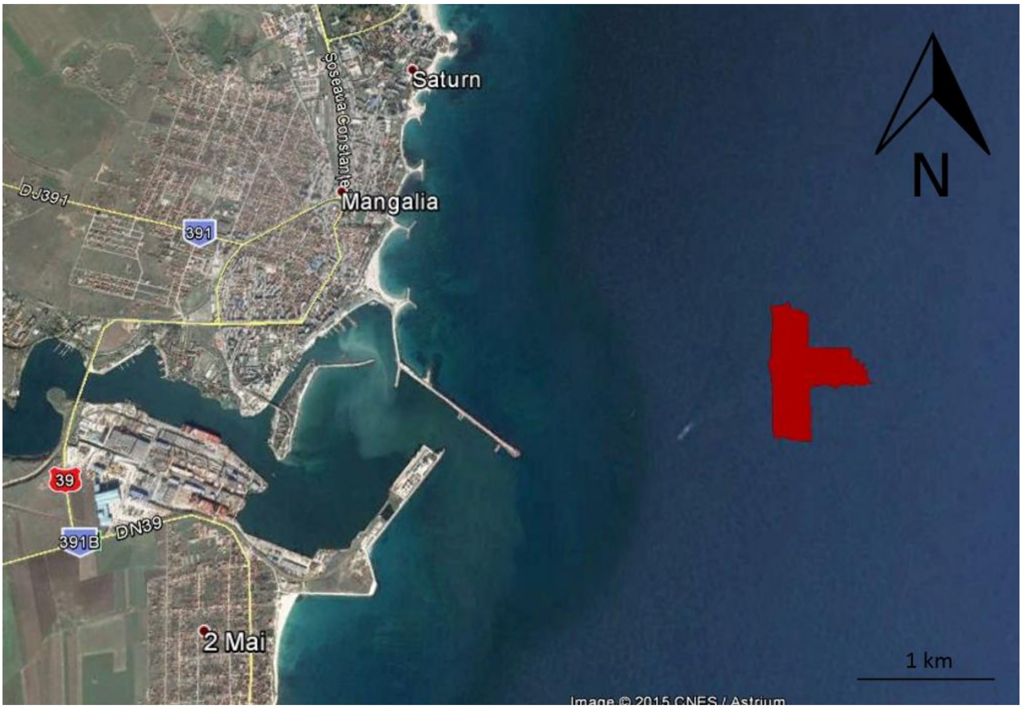

Fig. 1 Location of the study area (with red). Source Google Earth

METHODS

Interferometric sonars are a type of side-scan sonars that emit acoustic pulses laterally and analyze the phase difference of the returning signal on an array of a multiple antennas. By measuring the speed of sound, recording the two way time and determining the grazing angle, meaningful depth information can be derived.

The interferometric sonar have the advantage of providing both bathymetry and side-scan image. This is valuable information for discerning between different types of substrate and based on the aspect of the seafloor acoustic classes can be visually separated.

Ground truthing is necessary for correlating the substrate type to the acoustic facies. It can be done by grab sampling, or diving - scuba diving or ROV inspection. The grab samples were visually examined and the sediments finer than 2 mm were analyzed with by the help of a laser grain-sizer for discerning based on analytical methods between sediment types. The laser grain sizer provides histograms displaying the volume density on each class (size interval).

The ROV inspection has the important role of providing images of the seafloor, providing information regarding the type of substrate and also the relation between it with the living biota on the seabed. The ROVs have the advantage of being able to dive deeper that conventional scuba divers and operating them greatly reduces the risk of diving accidents.

For the present study, we have scanned the area with a Kongsberg GeoSwath Plus interferometer, operating on a frequency of 250 kHz. The positioning and inertial corrections were done using Applanix POS MV 320. Patch Test and GAMS calibrations were done prior to the actual site survey for assuring good corrections for the acquisition software. The software used for acquisition and processing was GS 4, software developed by Kongsberg Geo Acoustics for their interferometers.

The acquisition was done with real time coverage to assure full coverage of the site and the nadir blind zone. No filtering was applied to the data during acquisition. The positioning was aided by DGPS corrections received by satellite from the EGNOS network, which assured a 50 cm vertical precision, increased by the inertial processing of accelerations.

During the processing, the bathymetry data were filtered based on amplitude and range. There were supplementary filters that followed the seafloor, based on along track and across track continuity. The side scan was processed simultaneously by removing the water column area and applying gain corrections on the raw data. The filtered survey lines were merged into a grid/mosaic with 50 cm spacing between points.

The GS 4 software allows the superimposing of these two sets of data for better visualization (Fig. 2). The bathymetry grid and the mosaic were exported as GeoTif files. The GeoTif files were loaded in Global Mapper, a GIS application, together with the location of sampling and diving spots. Based on the acoustic data and ground information, the extent of seabed classes was drawn, resulting in a map of seabed types.

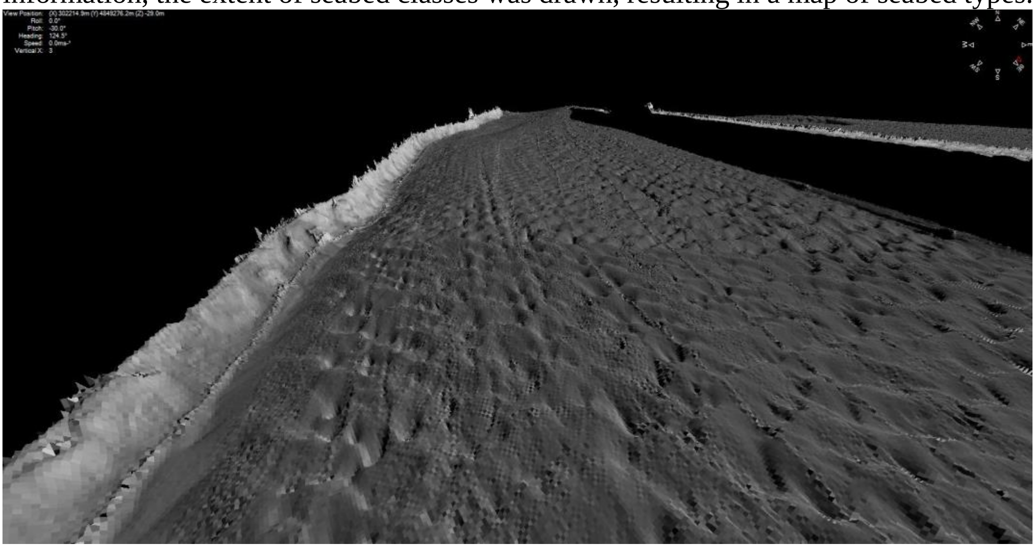

Fig. 2. 3D visualization of interferometric sonar measurements; side-scan mosaic overlapped on bathymetry - Danube river, near Corabia, Romania

RESULTS

A bathymetry map of the area (Fig. 3) and a side-scan mosaic (Fig. 4) were the first set of results following the data processing. These data could be visualized in 3D for a better understanding of the seafloor morphology (Fig. 7). Three seabed types were identified on the survey site, two hard bottoms and one of soft sediments. Their extent on the survey area can be seen in Fig. 8.

Seabed type 1 Limestone platform

The shores belonging to the Southern Dobrogea Geologic Provence have the following outcropping geology: Sarmatian limestone on the base, some Villafranchian shales in some areas, Pleistocene loess and Holocene littoral deposits. On the near shore area, the loess was washed by waves during the Holocene exposing the limestone underneath. The limestone platform can be followed down to approximately 15 to 20 meters, before giving place to soft sediments.

Seabed type 2 Rocks

The rocks are outcropping on the seabed at the edge of the limestone platform, separating it from the soft sediments. They represent the highest area of the site, topping up to 16 meters deep. Following our ROV inspection, we have seen that there are visible boulders covered with shells (Fig. 5), but we have no information regarding the lithology.

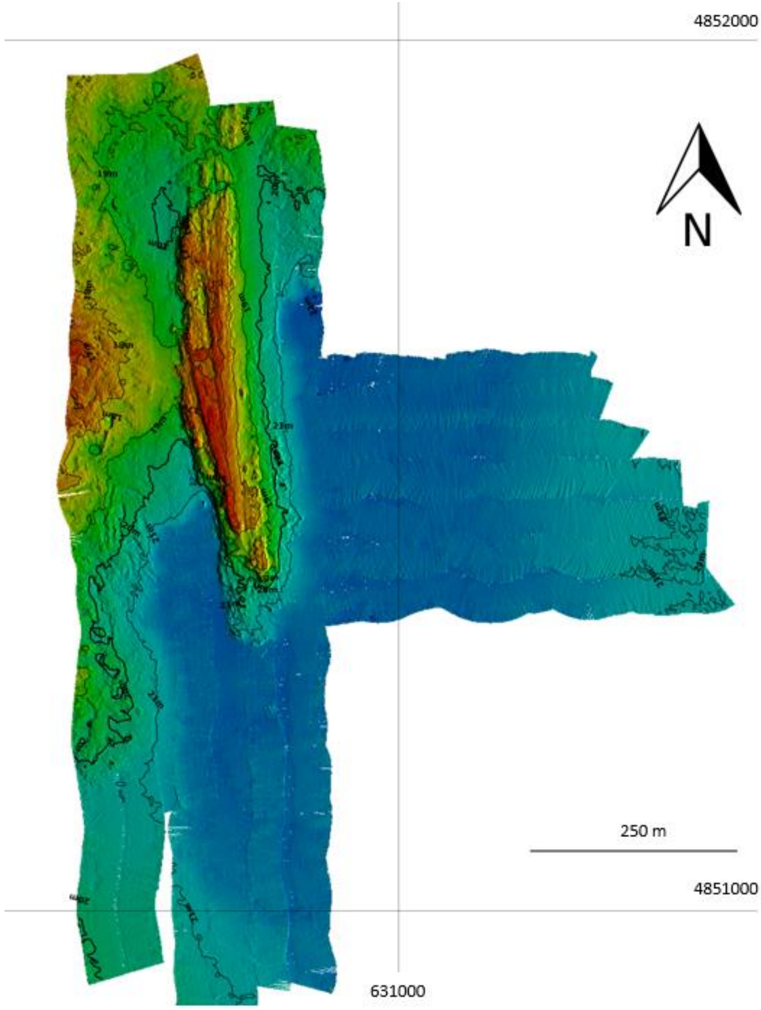

Fig. 3. Bathymetry map of the surveyed area. Coordinates UTM, zone 35 N, WGS84 ellipsoid

250

485

63100

Fig. 4. Side-scan mosaic. Coordinates UTM, zone 35 N, WGS84 ellipsoid

Fig. 5. ROV inspection - images of the rocks

Seabed type 3 Soft sediments

They are found an on the area deeper than 20 meters, west from the limestone platform and rocks. They show no surface sedimentary pattern, being below the depth at which the wave water motion may interact with the bottom sediments. Our grain-size analysis (Fig. 6) of the sediments shows that the samples have a bimodal distribution. The main mode is centered on 100 μm – fine sand. The second one is within the silt range.

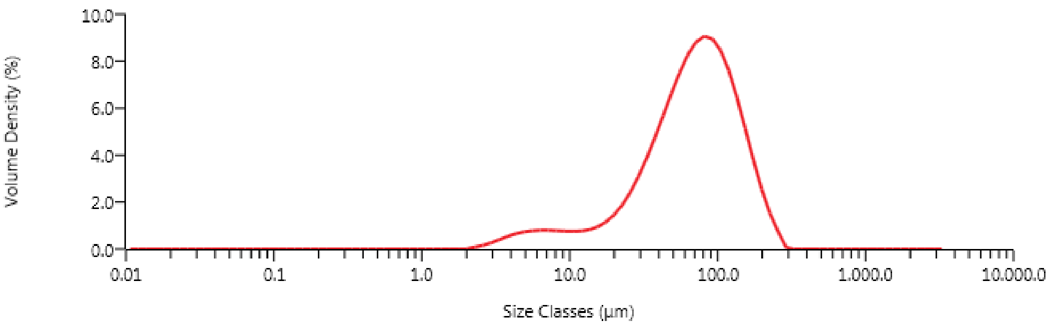

Fig. 6. Grain size histogram of a sediment sample form seabed type 3

Seabed type 4 Covered limestone platform

This seabed type is to be found at the transition between seabed type 2 - rocks and seabed type 3 - soft sediments. From the point of view of bathymetry it is a higher area and only the higher parts of the limestone tops out of the sediments. On the side-scan the backscatter intensity is lower than limestone platform and rocks, but higher than the soft sediments.

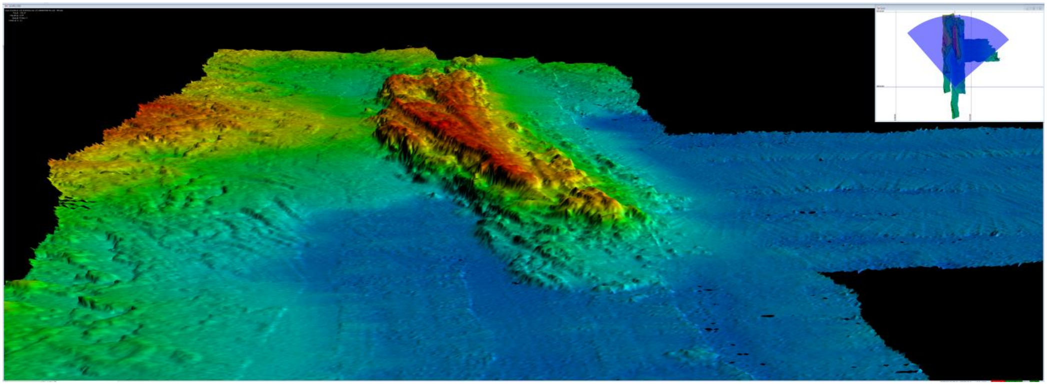

Fig. 7. Perspective view of the bathymetry grid. The upper right corner - positioning of the perspective view over the survey area

CONCLUSION

Based on this study, we can admit that interferometric sonars are a useful tool for acoustic seabed classification. The bathymetry DEMs and side-scan mosaics are an intuitive indication in determining the type of seabed, and the confidence in correlating them to substrate types increases when ground truthing is done.

ACKNOWLEDGMENT

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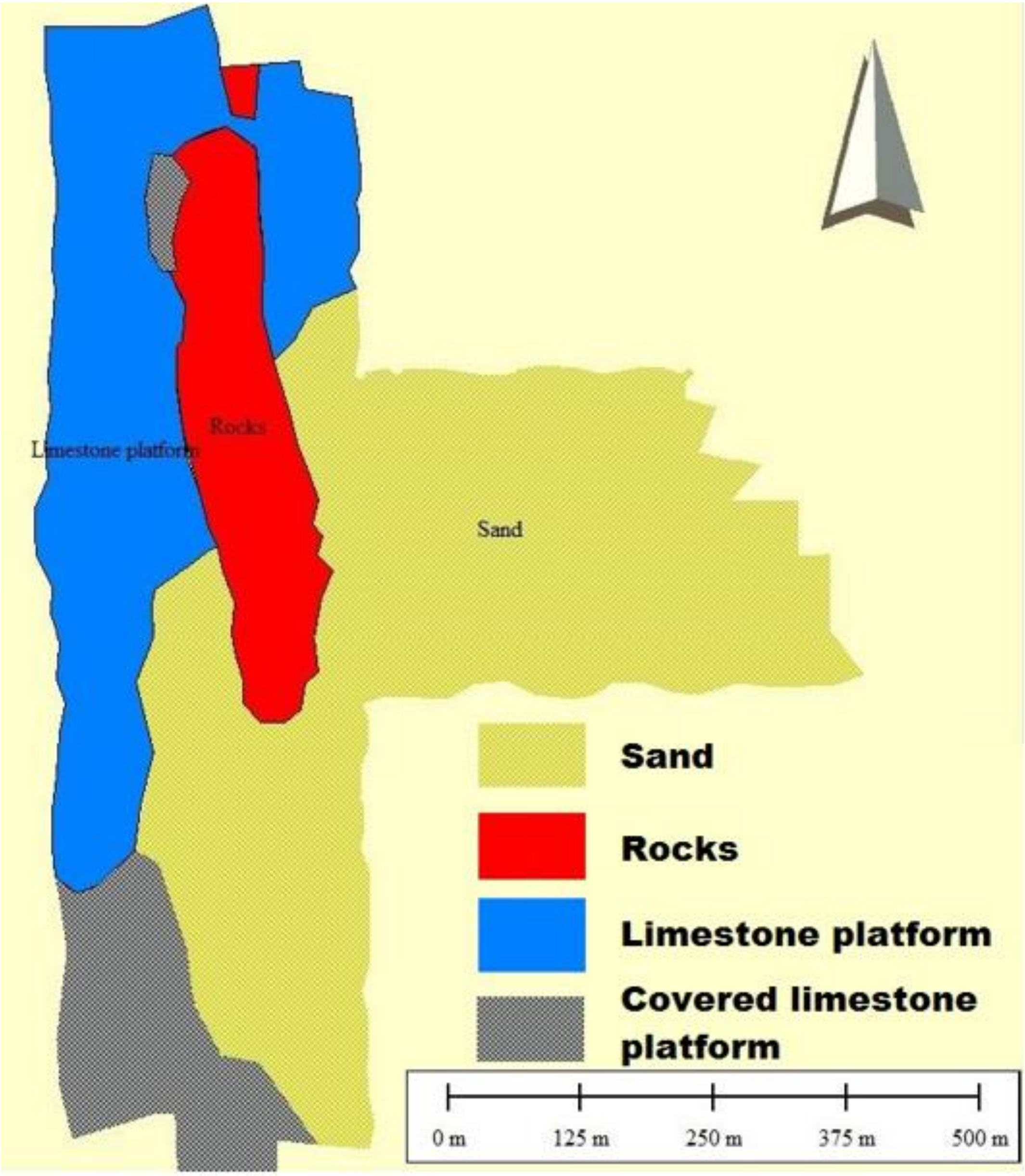

Fig. 8. Acoustic seabed classification of the study area

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