Multidimensional analysis of data from Bari Harbour: a GIS based tool for the characterization and management of bottom sediments.

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Abstract
Mediterranean harbours are today experiencing criticalities on the management of bottom sediment. Bari harbour among them is one of the most important in southern Italy, in terms of both commercial and touristic activities. Surveys dealing with the geophysical and sedimentological characterization of harbour sediments were performed during the period 2009-2011. The aim was: 1) a volume estimation of the sediments; 2) a granulometric characterization for the classification of sediment quality. The bathymetric and geophysical survey allowed a detailed estimation of the total sediment volume. The grain–size characterization consisted in the analysis of sediment samples collected at different depths in the harbour area. A combined elaboration of results lead to a multidimensional representation of the physical characteristic of sediments by means of a GIS platform.

Keywords: harbour sediments, geophysics, granulometry, harbour management.

1. Introduction

Bari harbour is located along the Southern Adriatic sea and is a multipurpose harbour (both commercial and passenger traffic). It is among the main Italian harbours, considering that it deals with a yearly commercial displacement of about 5 million tons (mainly dry generic goods) and about 2 million passenger transits (of which 600000 cruisers). The Harbour Authority of Levante, constituted according to the Italian law 84/1994, is in charge of port management. The hydrodynamic characteristics of the harbour and the geologic nature of its bottom substrate lead to a sediment circulation that provokes thickening of sediment near the entrance and docks. These sediment accumulations do not allow an optimum exploitation of the harbour operational depths. For this reason, maintenance dredging is necessary. The new legislative framework requires complex procedures for the obtainment of environmental permits, which dramatically slows down harbour's maintenance. In order to organize maintenance activities, a detailed knowledge of the harbour bathymetry, sediment thickness and grain size is needed. It is to remember that sediment disposal is regulated by severe environmental laws, especially for the pelitic fraction (< 0.0064 mm) (ICRAM-APAT, 2007).

2. Materials and Methods

A stratigraphic and bathymetric survey, followed by a coring campaign and sediment sampling was performed in the Bari harbour in the period 2009-2011. The stratigraphic and bathymetric survey, completed in 2009, was carried out for determining the status of the seafloor. The survey was certified according to the IHO Special Order S-44. The navigation and geophysical data acquisition system consists of a central computer equipped with two specific softwares (Thales PDS 2000, Communication Technology SwanPro), both interfaced with the positioning system, the sound velocity profiler, the high-resolution multi beam echosounder transducer and the single-channel sub-bottom profiler. Raw bathymetric data were processed by CARIS HIPS 7.0 sw, which allows the creation of a weighted grid surface (BASE, Bathymetry Associated with Statistical Error), reduced to the mean sea level as vertical datum reference. The stratigraphic survey was executed using the high resolution seismic reflection methodology.

The probing campaign with sediment sampling was carried out in the period January-February 2011. Cores of 10 cm radius were extracted in the sectors where, by the data of the previous bathymetric survey, the depth of the sea bottom resulted lower than the operational depth of the commercial and touristic traffic. The cores were of a length between about 1 and 2.5 m. Sediment samples were extracted each 50 cm. Most of the cores refer to the inner harbour perimeter and docks. An area near the harbour entrance was also cored. On the sediment samples, grain-size analyses were carried out. The grain-size distributions were represented as relative frequency distribution of percent weight and cumulative distributions.

3. Results

With regard the stratigraphic survey, the collected data consist of n. 87 seismic profiles (fig. 1) showing the geometry generated by the major acoustic reflectors and related to the interfaces between different sedimentary layers. Seismic data were processed by TEI sw in order to reconstruct the thickness of the sediments layer deposited on the bedrock through the picking operation. The modelling of the surfaces of the seabed and limestone bedrock respectively, allows to estimate the amount of loose sediment to be dredged in 120,000 m^3, in relation to established minimum safety depth for movement and berthing port areas.

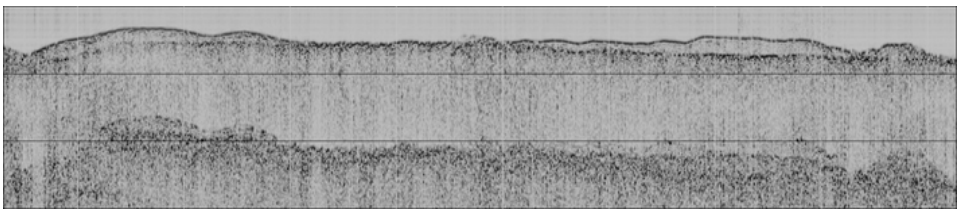

Figure 1: A seismic profile. The position of seismic reflectors allows locating the limit between the calcareous rock substrate with the overlying sediments.

The mosaic of the seismic profiles, performed by using GIS software platforms, allowed the 3d reconstruction of both the geometry of the rock substrate (fig 3a) and the sediment thickness (fig. 3b), allowing to highlight the main thickenings and accumulation of sediments near the harbour entrance and docks.

The grain-size spectrum from the sediment samples analysis covers a range between 2mm and 0.002mm, and is represented by means of the ϕ metric, where ϕ is = $-\log_2 d$, and d is particle diameter in mm. From the cumulative distribution the median size, Mdϕ (50^{th} percentile of the cumulative distribution) and sorting, σϕ (16^{th}-86^{th} percentile/2), which represent, respectively, a graphic approximation of the central tendency and of the dispersion of the distribution was calculated (fig.2).

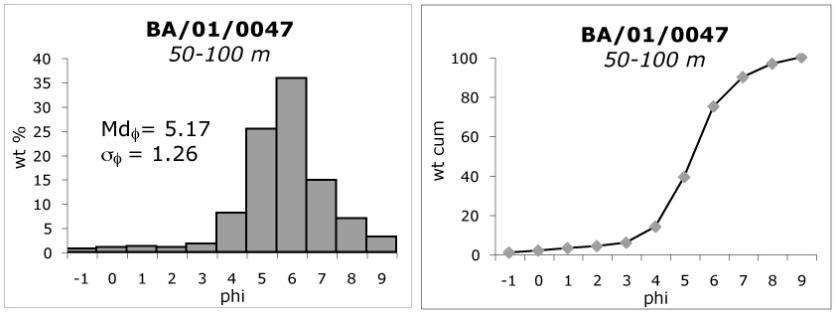

Figure 2: A sediments sample from the Bari harbour: an example of grain-size distribution histogram and cumulative distribution.

4. Concluding remarks

By combining data from the bathymetric investigation and from the granulometric characterization of sediments, it is possible to evaluate both the total volume of sediments inside the harbour and also the amount that needs to be dredged for the harbour maintenance. Furthermore, it is possible to highlight the relationship between sediment thickness and grain size, as shown on figure 3c. Data show a broad variability of grain size, both as a function of depth and location inside the harbour. These data are to be interpreted with reference both to the net sediment supply as due to the marine currents and also as a function of sediment recirculation, inside the harbour, as due to the ships movement. Sediment recirculation is favoured in the front of docks and much attenuated on the docks rear. In conclusion, starting from these data and by means of further investigation, it will be possible to implement sediment circulation models in the various sector of Bari harbour, and the relative sedimentation rate, with the aim of better designing the dimension and effectiveness of maintenance dredging according to the available rules and guide-lines (AA.VV., 1999; ICRAM-APAT, 2007). These results represent a good base for the purpose of future integrated management of the investigated harbour.

References

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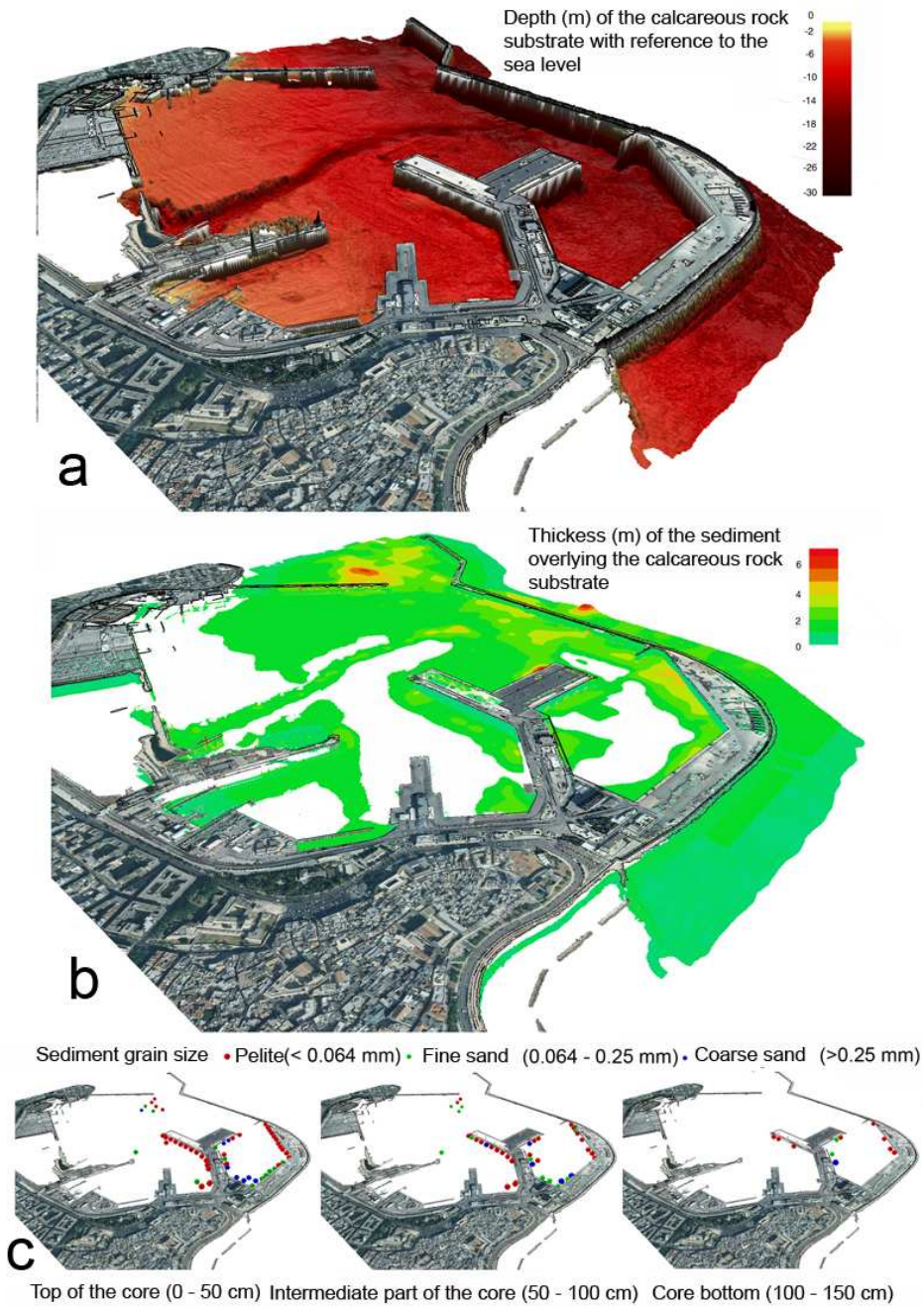

Figure 3: a = depth of the calcareous rock substrate. b = sediment thickness. c= sediment grain size.