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DATA FROM MULTIBEAM SURVEYS AND 3-D SEAFLOOR IMAGES OF ANCONA HARBOUR

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ABSTRACT

The present study was conducted in order to chart the bathymetric of all the Ancona harbour with EM3000 multibeam echosounder. It was the first time that a so far-reaching work was performed for one of the most important Italian harbours in the Adriatic sea. It represents a basic starting point for further studies such as the description of sea morphology just near the docks to assess the load draught for the docking, the investigation of current condition of each dock board wall, or also the precise volume calculation of mud to be dredged in an area. Furthermore, it enabled to try out EM-3000 obtaining the most detailed and more systematic information on last generation geophysical techniques.

INTRODUCTION

Ancona, a relevant seaport of the Marche Region, is situated on the NE coast of Italy. To the East of the town is the harbour (Fig. 1), now an oval basin of 990 by 880 yards, one of the most important and well equipped harbours on the SW coast of the Adriatic sea, if not of Italy.

It was originally protected only by the promontory of Conero on the north, from the elbow-like shape of which the ancient town, founded by Syracusan refugees about 390 b.C., took the name which it still holds. Probably before the Greek Syracusan colony, this natural bay performed an important military and trade function. In 1904, the port of Ancona was already entered by 869 steamships and 600 sailing vessels, with a total tonnage of 961,612 tons. The main imports were coal, timber, metals, jute. The main exports were asphalt and calcium carbide.

Nowadays, the water sheet has an extension of 700,000 m^2 and docks for 5,400 m. It has become a traditional port of call for travellers and has a great impact on the economy and the quality of life of the city and the adjacent populations to harbour, representing one of the primary source that feeds the Italian region, the main nucleus of East-Mediterranean countries' cruise ships and of imports and exports of all type of loads, from containers until loads of liquid and solid bulks. Every year more than one million passengers call at this port, which is well equipped to welcome such a great number of people. The deep sea, the safe landing places and the quays allowing even the largest ships to draw alongside are all features that make this port suitable - even for cruisers.

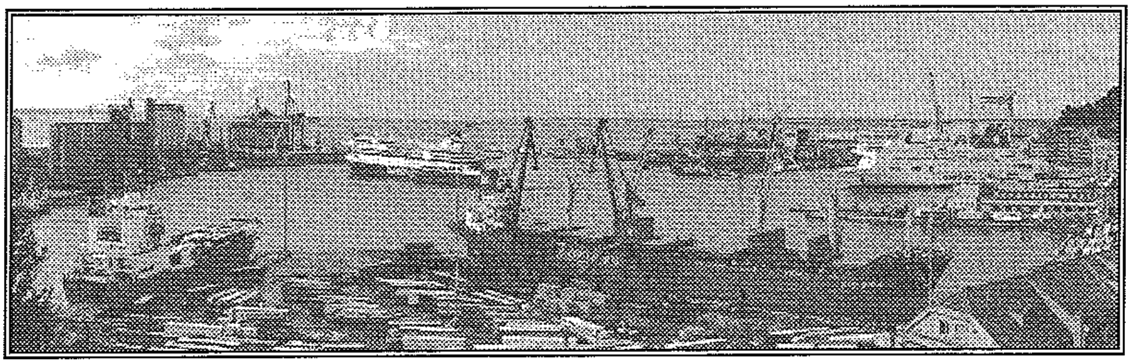


Figure 1 – Ancona harbour.

The Port Authority of Ancona tries to maintain and to enlarge this modal point, requiring sometimes particular services or systematic surveys to assess the harbour conditions. In November 2002 they instructed ISMAR–CNR of Ancona to conduct the first acoustic survey of the entire port area in order to map seabed relating to the sheets of water, thereby investigating the morphological features of sea bottom. Figure 2 schematizes the harbour with its 25 docks and 3 dock heads.

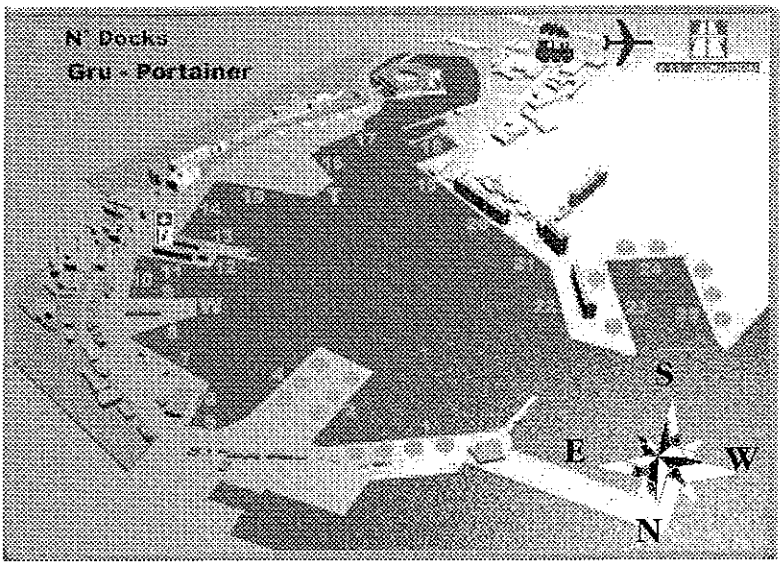


Figure 2 – Ancona harbour' scheme showing its 25 docks and three dock heads.

It was the first time that a so far-reaching work was performed for one of the most important Italian harbours on the Adriatic sea. It represents a basic starting point for further studies such as the description of sea morphology just near the docks to assess the load draught for the docking, the investigation of current condition of each dock's board wall, or also the precise volume calculation of mud to be dredged in an area.

MATERIALS AND METHODS

Kongsberg Simrad EM-3000, the last generation multibeam echosounder with double transducer, operates at a frequency of 300 kHz and allows for considerable accuracy to carry out a great variety of works like a volumetric control of a channel, or harbour's main entrance, a precise calculation of an area to be dredge or a dredged area, a monitoring of pipelines, and emissaries, a study of bottom quality and biomass, a tracking of the docks of a port, localization and pursuit of artificial reefs, etc. Base maps are fundamental tools for studying not just offshore hazards but also natural resources and the offshore environment (USGS, 2000). They provide a context for recording and interpreting scientific data.

To perform the mapping of the Ancona harbour, the bathymetric system was configured with double sonar head but always meeting all standards suggested by International Hydrographic Organization (IHO Standards for Hydrographic Surveys, 1998). It consisted of three parts (Fig. 3):

1. a workstation;

2. a processing unit that directed the sonar head arrays to form the transmitting and receiving beams, identified the sea bottom and handled the interface with the DGPS, the gyrocompass and the MRU for the correction of pitch and roll;

3. two sonar heads (transducers), each of them with two different arrays, one for the transmission and the other for the reception of signals. This system is called "dual-head" system.

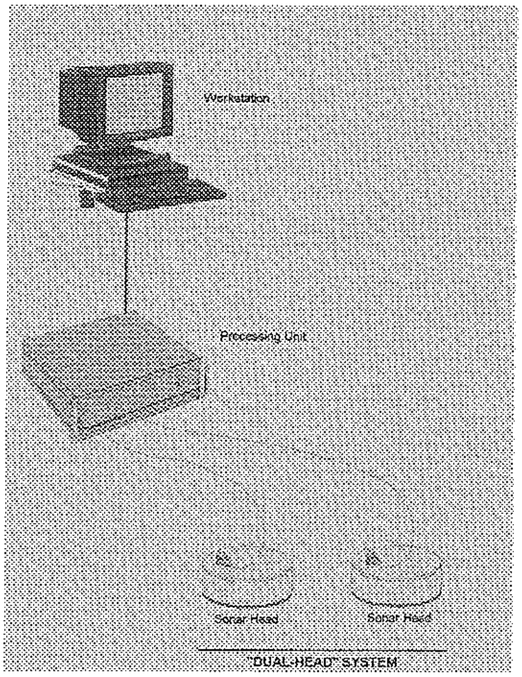


Figure 3 – Scheme of Multibeam echosounder EM3000 with double sonar head.

The "dual-head" system was installed on the vessel M/N "Tecnopesca II" belonging to ISMAR-CNR of Ancona (Fig. 4), through a vertical pole fixed to the bow of the vessel (Fig. 5). In such an installation the mounting structure was sufficiently rigid that the line of sight from the sonar heads to the bottom was not blocked, and that aerated water was kept away from the sonar heads faces.

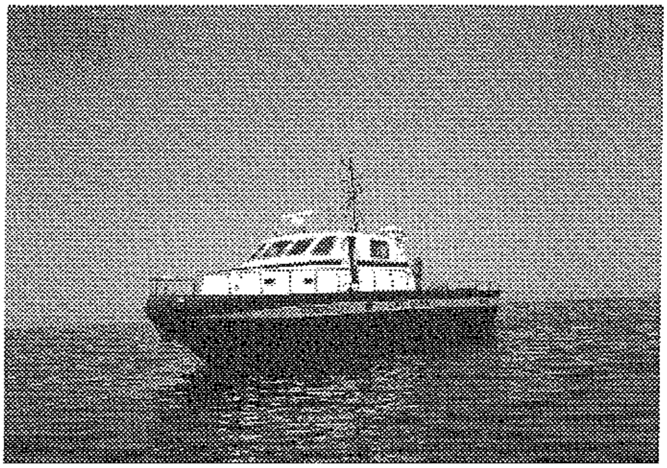
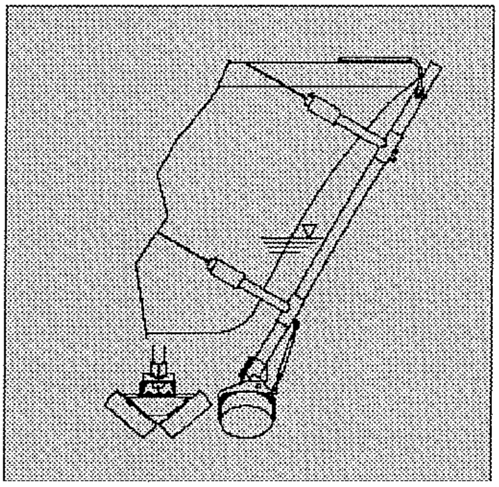


Figure 4 – Research vessel M/N "Tecnopesca II".

The two sonar heads were mounted with an angle of 45 degrees to the vertical pole (Fig. 5). Considering that one sonar head fans out up to 127 acoustic beams at a maximum ping rate of 25 Hz and at an angle of 120° (1.5° x 1.5° beams are spaced 0.9° apart), the "dual-head" system was capable to increment the beams up to 220 and the total incidence beam till about 230°, enabling the sea bottom coverage up to ten times.



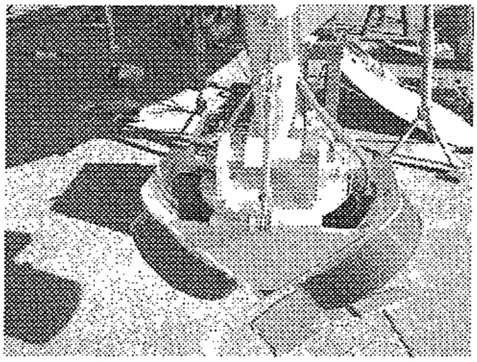


Figure 5 – The two sonar heads mounted with an angle of 45 degrees to the vertical pole.

At normal survey speeds of 3–12 knots, the sonar can capture data at depths as great as 100 meters, with data gridded at spacings of 0.25–25 meters (Wright et al., 2002). Also using double head system it was possible to follow this data collection scheme, but with extremely reduced work time.

To ensure the accuracy of depth soundings across the full cross-track width of the swath, the EM-3000 combined them with critical information on both the attitude and position of the survey boat. Attitude was obtained with a motion reference unit (MRU) from which adjustments were made for the heave, roll, pitch, and heading of the boat. The position of the boat was obtained via 24-hour, differential global positioning system (DGPS) navigation connected to a geostationary satellite, an Anshutz Standard 20 gyrocompass and a sound velocimeter. The last one enabled to obtain the sound velocity profile according to the local temperature and salinity of the water (and corrections had to be made for the resulting refraction of acoustic beams). With differential GPS, the system was capable of cm resolution with a depth accuracy of 10-15 cm RMS and a horizontal positional accuracy of less than 1 m.

Before carrying out any survey, the sound velocity profile along the water column was recorded to obtain an accurate distance between the sea bottom and the sonar heads. Due to the variability of water density during the day, such recording was conducted more than one time. The vessel sailed at a speed lower than 5 knots, following prearranged survey lines as much parallel as possible to guarantee a complete coverage. One survey per dock was carried out.

Recorded data were processed using Simrad Neptune and Roxar C-Floor software. The first one allows to apply the post-processing steps: the "cleaning" of the navigation and the tidal corrections applied to the depth soundings using verified downloaded tide data available for the study area from the National Hydrographic and Mareographic Institute of Rome. This last step allows to apply statistical filters to the bathymetric measures. Processed depth soundings from the EM-3000 system were available as ASCII xyz files. The C-Floor software allows to perform a further data processing in order to modify the map scale and the bathymetric range in regard to the bathymetric charts of the Ancona harbour and to obtain detailed three-dimensional representations of sea bottom morphology.

RESULTS AND DISCUSSION

Maps created with data from Kongsberg-Simrad multibeam system were of excellent quality in terms of the morphological features detailed in them. The processing of the xyz data obtained from Neptune software enabled to create the bathymetric charts. To describe the depth contour of a whole monitored area, a chart with a scale of 1:2000 and a bathymetric range of 50 cm was created, reproducing it also as a coloured chart. For a more detailed picture, the area was divided in six blocks and for each of these blocks a chart with a scale of 1:1000 and a bathymetric range of 25 cm was created (Fig. 6).

Bathymetry of whole monitored area turned out to range between 3.0 m, near an extraordinary pentagonal building called Mole Vanvitelliana built on the sea in a peripheral area of the port, and 17.6 m, about 100 metres away from dock n° 20 towards NE.

The six detailed charts with a scale of 1:1000 and a bathymetric range of 25 cm highlighted the morphology and the quality of seabed near a particular dock allowing the load draught assessing for the docking.

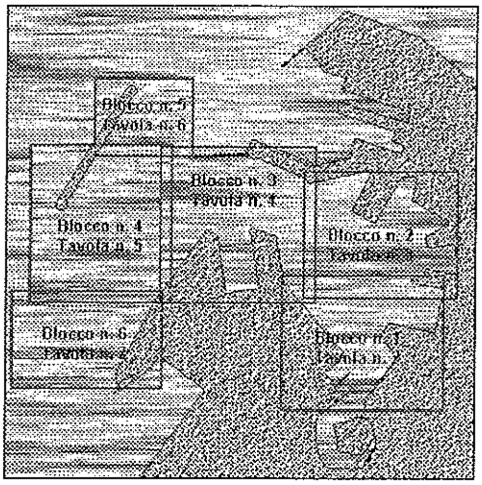


Figure 6 – The whole harbour area was divided in six blocks for more detailed study

For each chart a very detailed description of the bathimetric trend was given: whether the bathymetry had a parallel trend just near the docks, such as along docks n° 19-20-21; or whether there was a very sinuous area with a significant variability of the depth, like that one recorded about 10 m away from these dock board walls; or even if there were some depression areas or morphological rises. It was very useful to identify the latter, even those with very small extension and identified as spikes. Dock n° 25 is an example. Just near the dock the depth ranged between 11.0 m and 11.5 m. Data relating this dock showed two significant morphological spikes till 10.75 m about 10 m from the board wall (Fig. 7). Dock n° 25 is used above all for the docking of cargo vessels, so it was very important to localize these two critical points to assess the precise lading of the ships or to plan a dredging work.

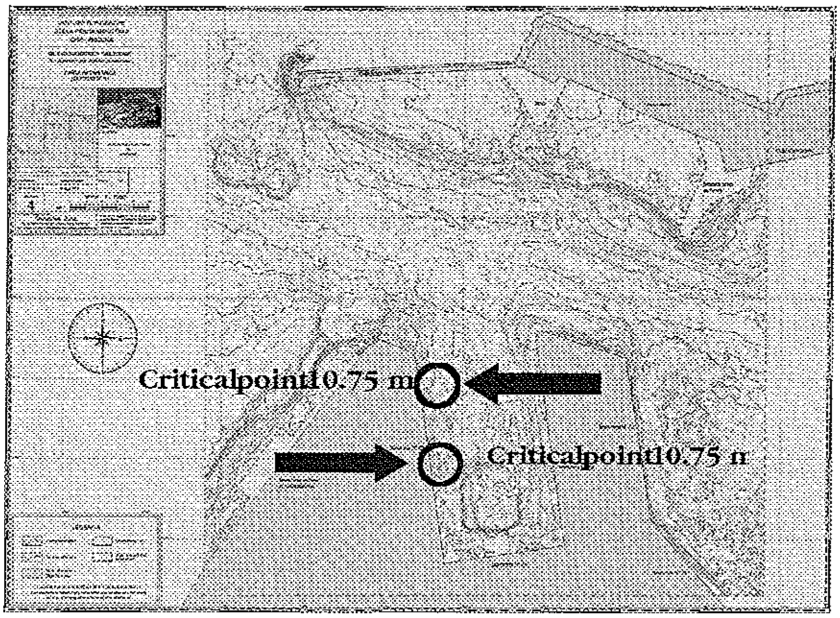


Figure 7 – Bathymetry chart concerning dock n° 25. The two morphological rises about 10 m from the dock board wall represent critical points for vessel docking.

Very important was also to mark the presence of deeps that could be probably caused by the docking of the vessels, and that could determine dock instability after a further excavation, just like near dock n° 14 where a deep till 12.75 m was spotted.

Connected to certain docks, small areas without data were present in some of these six charts. These "gaps" were due to the docking of a particular vessel that could not be moved, or some buoys that barred the recording of data.

A further processing of the xyz data allowed to obtain with unprecedented accuracy 3D visualization of seabed providing information that would assist the careful management of the harbour. The following images are 3D representations of the Ancona harbour as a whole (Fig. 8) and some particular areas of it (Fig. 9) obtained by C-Floor, where it is possible to appreciate sea bottom morphology.

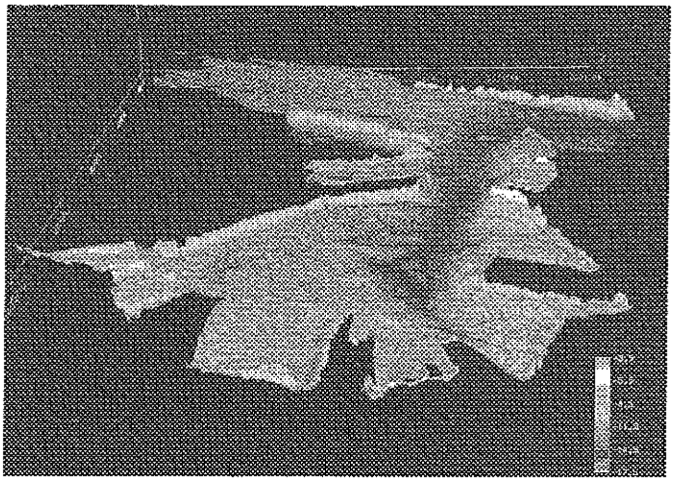


Figure 8 – 3D image of whole Ancona harbour obtained by C-Floor.

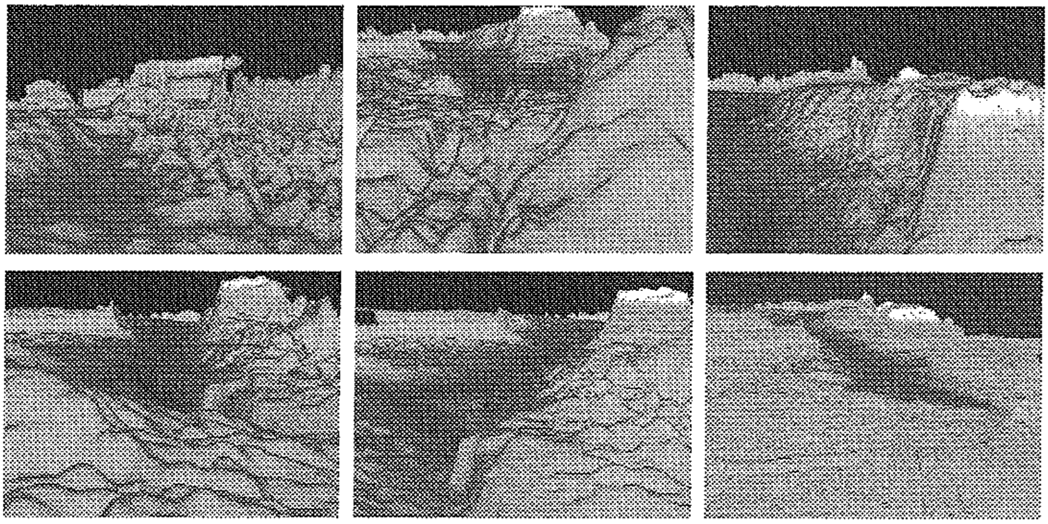


Figure 9 – 3D detailed images of Ancona harbour obtained by C-Floor.

CONCLUSIONS

Surveys with a multibeam bathymetric mapping system provided complete coverage of the entire Ancona harbour, meeting the requirements of Ancona Port Authority and, on the other hand, showing how it is essential to any geoscientific activity.

It was the first time that a so far-reaching work was performed for one of the most important Italian harbours on the Adriatic sea, enabling to try out EM-3000 and obtaining the most detailed and more systematic information on last generation geophysical techniques. It turned out an extremely accurate system to carry out studies on bathymetry, morphology, quality of a harbour sea bottom.

The collected and processed data were of excellent quality to obtain a realistic view of the underwater morphology of the landmass. The detailed bathymetric charts permitted to appreciate accurately the depth near each dock allowing the load draught assessing for the docking. This work represents a basic starting point to perform successively works with a further data processing such as the investigation of current condition of each dock board wall, the racking of the docks of a port, the precise calculation of an area to be dredge or a dredged area, the volumetric control of a channel, etc.

It is clear that the information contained in multibeam survey maps is of a quality that now approaches that of aerial photographs and is increasingly being requested for many types of activities. Precise morphological underwater maps are valuable instruments not only for scientists (geology, biology, engineering, etc...) but also to regional planners, environmentalists, sports people, fisherman and tourists.

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