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USE OF ECHOSOUNDERS IN MARINE ARCHAEOLOGY: SURVEY OF HARBOUR IN SYRACUSE

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Abstract

Over the last ten years, the high-resolution marine geophysical survey field has witnessed significant advances in survey investigation equipment. New equipments are addressed towards the use of quantitative acoustic methods for the high-resolution mapping of the seafloor for archaeological heritage management. In particular, side-scan sonar and sub bottom profiler are been tested in Syracuse areas, especially in Porto Grande, about a project led under the supervision of the Sea Superintendence of Palermo and in collaboration with Aurora Trust, Malta and Pharos s.a.s., Milan.

Generally, this high-resolution equipments are becoming affordable for use on archeological projects thanks to the high accuracy of the measures, the high spatial resolution, the repeatability of the results and the possibility to integrate the data with other scientific ones. In addition of this, through the use of geographic information system (GIS), quantitative results are stored in digital format for post-survey processing.

Side-Scan Sonar system is applied to survey the morphology of the seafloor. This system identifies the different type of seafloor (such as sand, rocks, mud, posidonia, and so on) and objects eventually dispersed on the seafloor (such as wreck). The system is based on the different backscattering given by various material and lithotype and it records the backscattering data through a digital technology that gives back high-resolution images. Finally, the individual side-scan strips can be joined together to obtain a side-scan mosaic of the surveyed region through SonarWizMap software. Sub bottom profiler allows to identifying the litho-stratigrafic sequence of the seafloor and it is based on the different sound speed through the sediments. The penetration and the reflection of the backscattering depend from the physics characteristics of the material surveyed and from signal power and frequency. The backscattering impulses are recorded by the same echosounder that transmits the signal. The system uses the digital Chirp technology to create high-resolution images. On the surveyed area it's usually realized a mesh of strips, in relation to the accuracy required. The two systems (sub bottom profiler and side-scan sonar) can be used together to have an exact correlation of the areal and depth information.

Keywords: side scan sonar, sub bottom profiler, marine archaeological surveys.

SINGLEBEAM AND MULTIBEAM SYSTEMS

Acoustic mapping techniques have their origin in the methods developed for deep-ocean exploration. Multibeam sonar has led to new insights to the world's seafloor. Increasingly, this high-resolution equipment is becoming affordable for use on archaeological projects. Four important criteria are met with the new generation of tools: results are that are of high spatial resolution, results that are quantifiable and repeatable, positions of results which are measured accurately, and results that can be easily integrated with other scientific data. High spatial resolution and the recording of smaller features have been addressed by higher frequencies, swept frequencies and multi-frequency instrumentation. Quantitative results are stored in digital format for post-survey processing and the integration of results through the use of geographic information systems (GIS). Accurate position fixing, using DGPS, facilitates the use of the results for long-term monitoring of seafloor change.
While singlebeam system sends once echo impulse to the seafloor recording the exactly depth under the boat, the multibeam system records the backscattering data referred to the different angular directions of beams. So, the wide of the records seafloor's strip depends from instrument and depth characteristics. In addition to depth information, most modern day multibeam sonars can collect backscatter data, which is a measure of the amount of energy that returns to the sonar after scattering off the seafloor. The amount of backscattered energy is a function of many things, including the grazing angle, the surface roughness of the seafloor and the nature of the material type. The backscatter information is collected as a time series of echo amplitudes as the acoustic pulse for each beam moves through its particular footprint on the seafloor. Because the angular direction of each beam is known, the echo amplitude information for each beam can be correctly positioned relative to its neighbours within the swath and merged with the bathymetric and positioning data to generate an acoustic map of the seafloor. Thus these systems combine the ability to collect bathymetric data over a large area with the capacity to produce a co-registered sidescan-like sonar imagery of the surveyed region.

SIDE SCAN SONAR SYSTEM

The morphology of seafloor is surveyed by Side Scan Sonar (Fig. 1). This system identifies the different type of seafloor (such as sand, rocks, mud, posidonia, and so on) and objects eventually dispersed on the seafloor (such as wreck). The system is based on the different backscattering given by various material and lithotype and records the backscattering data through

Fig. 1: Side Scan Sonar

a digital technology that gives back high-resolution images.

The S.S.S. system is composed by two echosounders places on the two side of the Tow Fish, that's pulled along the boat on which is placed the hardware unit.

The applications of this technology is various: from characterizations of different type of seafloor to acoustic mapping of archaeological or environment site, to wrecks or other objects dispersed on the seafloor. The trace recorded could be wide until 500 m each side and the system works until 1500 m of depth. The SonarPro and ISIS software (Fig. 2) shown and processed the sidescan data to realize mosaics and map of the seafloors, putting together bathymetric and backscattering data with DelphMap. The datafile could be elaborated in XTF file (Extended Triton Format), TIFF file and GeoTIFF as GIS images.

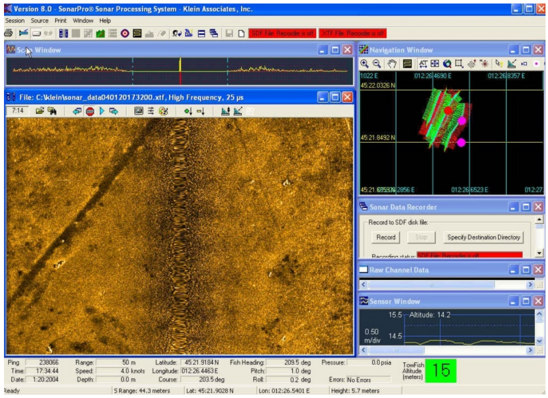

Fig. 2: ISIS software

Sidescan measurements are based on the collection of a time series of echo amplitudes as the acousticpulse for each beam moves through its particular footprint on the seafloor. This produces many more backscatter values than depth values because the time-series of echo amplitudes is sampled at a much finer interval than the beam spacing. The backscatter time-series data collected within each beam footprint are joined together across the swath width, creating a continuous time-series trace in the across-track direction, with a much finer resolution than that of the gridded sounding data. For an entire line, the continuous time-series data for each ping are combined together one after the other to produce a sidescan strip for the survey line. From there, a *sidescan mosaic* (Fig. 3) of the surveyed region is created that consists of all the individual sidescan strips joined together.

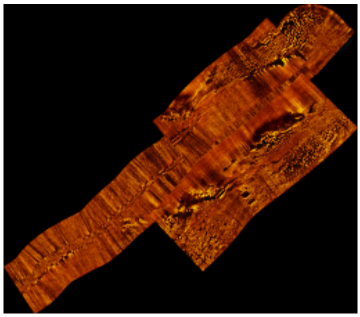

Fig. 3: Sidescan Mosaic

SUB BOTTOM PROFILER SYSTEM

The seafloor stratigraphy is studied through Sub Bottom Profiler (Fig. 4). This system allows to identify the litho-stratigrafic sequence of the seafloor and is based on the different sound speed through the sediments; higher is the speed, higher is the backscattering. The penetration end the reflection of the backscattering depend from the physic characteristics of the material

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surveyed and from signal power and frequency. The backscattering impulses are recorder by the same echosounder that transmit the signal. The system uses the digital Chirp technology to create high-resolution images. On the surveyed area it's usually realized a mesh of strips, in relation to the accuracy required. The S.B.P. is composed by: hardware on the boat, that records and processes the data; fish in water, fixed on the boat or pulled along. The recorded data are placed on maps on which are shown the thickness of the sediments.

Fig. 4: Sub Bottom Profiler

Sub Bottom Profiler applications: marine archaeological sites

The sub bottom profiler data can be processed with SonarWizMap. Through this software is possible identifying not only the seismic profiles but also the anomalies that could denote the presence of interesting archaeological heritage (Fig. 5).

Sub Bottom Profiler applications: not destructive analysis on parietal painting

The detachment areas of a parietal painting can be identifying through sub bottom profiler system (Fig. 6). As the instrument allow to read the stratification of the paint subsequent strata, is possible produce a map that show the different deterioration state of them.

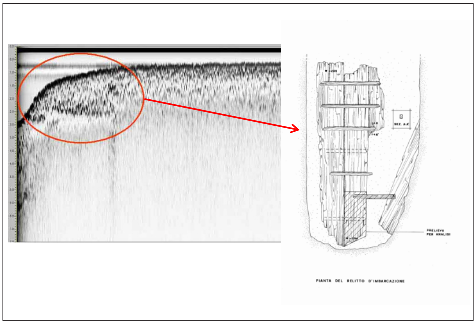

Fig. 5: Example of presence of archaeological items by using S.B.P.

Fig. 6: Application of S.B.P. for parietal painting

SUB BOTTOM PROFILER WITH SIDE SCAN SONAR

The system consists of a graphic recorder, a side-scan sonar, and a sub bottom profiler. Both the side-scan sonar and the sub bottom profiler were towed together (Fig. 7). The side-scan sonar and sub bottom profiler data were collected and displayed simultaneously to allow an exact correlation of the areal and depth information (Fig. 8).

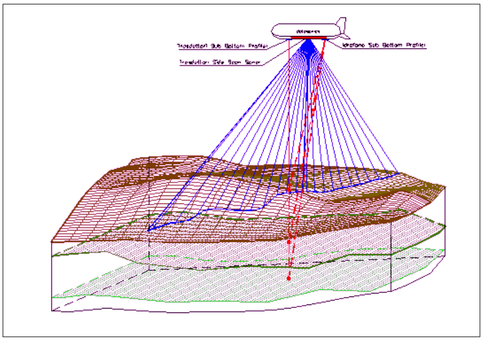

Fig. 7: Simultaneous use of S.B.P. and S.S.S.

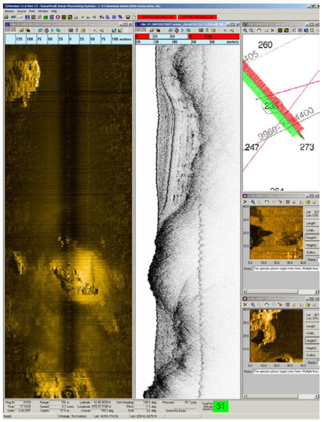

Fig. 8: Collected data

SURVEYING PORTO GRANDE IN SYRACUSE

The displayed area (Fig. 9) was been surveyed in this way: the meshed area through 5 meters lines with Elac sub bottom profiler and echosouder for bathymetry; the green area through 2 meters lines only with Elac sub bottom profiler.

About the project of the Porto Grande seafloor monitoring, under the supervision of the Sea Superintendence of Palermo, the Pharos s.a.s group have led a series of geo-archaeological surveys, through the displayed instrumentation.

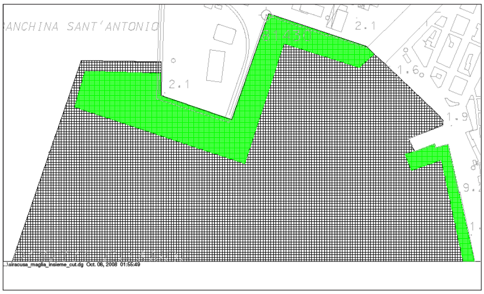

Fig. 9: Surveyed area in Porto Grande (Syracuse)

The Elac laz 72 echo sounders used for the research it's modified for low-sea. In the traditionally echosounders, sending the acoustic signal and receiving the backscattering ones, happens that the backscattering data is amplified because of the signal spread through the material crossed. Because of this interference aren't possible low-sea measurement. To overpass this problem are usually used two echosounds: one to send the acoustic signal and an other one to record the backscattering data. The modified Elac ecosounds allow to solve this problem thanks a interference blockage without data lousing.

FUTURE OF WORK IN PORTO GRANDE OF SYRACUSE

This is a work in progress. The data, actually processing by Pharos s.a.s., will be used by

Sopraintendenza del Mare to plan a marine archaeological excavation in Porto Grande. The results will be used to study the objects taked away from seafloors and to monitor the marine heritage of the area.

CONCLUSIONS: FUTURE FOR MARITIME ARCHAEOLOGICAL INVESTIGATIONS

High-resolution geophysics is finding increasing use in surveying for, and the management of, submerged archaeological heritage sites. In particular, modern techniques that yield quantitative, and thus repeatable, information mean that conditions on sites can be monitored and compared on a periodic basis. This is an important ability for the long-term management of sites that are currently known, and for the future assessment of sites that will no doubt continue to be found as climate changes and increased leisure activity puts pressure on the near-shore zone. The examples given here illustrate the use of techniques that do not penetrate the surface. However, in many sites, subsurface investigation tools are contributing significant additional information. The future of archaeological surveys, therefore, will contain a range of remote geophysical technologies to compliment the direct observation methods by diver and remotely operated vehicles.

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