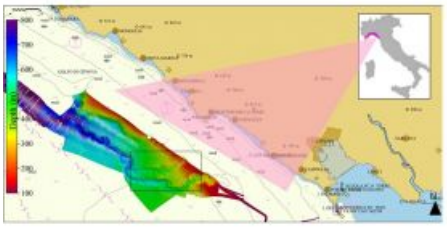
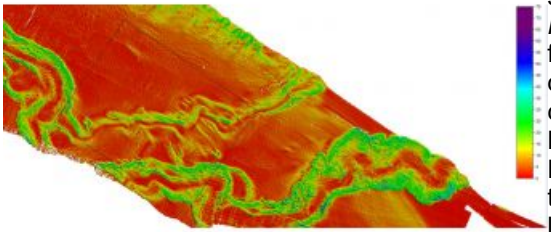
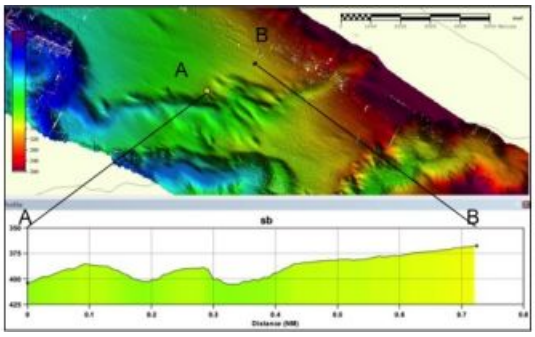
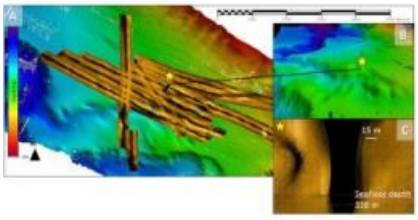
DUAL USE HYDROGRAPHIC SURVEYS FOR SEABED NATURE AND MORPHOLOGICAL RESEARCH

Integrated Mapping of Seabed Features









The Italian Navy, using survey vessel *Ammiraglio Magnaghi* and personnel from the "Istituto Idrografico della Marina" (IIM), in cooperation with ENEA Marine Environment Research Centre, surveyed the Levante Canyon system, located in the offshore area of "Cinque Terre", eastern Ligurian Sea, NW Mediterranean.

The purpose of the operation in the area depicted in figure 1 was on the one hand to collect the data necessary for the updating of nautical documentation and on the other hand to carry out scientific research on the seabed nature and specifically on deep coral banks.

Italian Navy Ships are equipped with state-of-the-art equipment and designed to be "dual use" in terms of enhanced logistic autonomy, support and service flexibility. Furthermore, Italian Navy personnel is highly trained and its expertise can be made available for civilian purposes. The Italian Navy shares its resources with many Italian Research Institutes and Universities carrying out joint survey activities while performing its institutional tasks, with no additional costs.

Through data integration and the use of seabed-mapping technologies it is possible to obtain a high-resolution (HR) study of seabed morphology and nature, discriminating ecological features and habitats at different spatial scales. The methods used for this hydrographic research are based upon data integration and multiple focusing approaches to identify areas to be investigated with different resolution systems in order to perform data exploitation and multiple usages of available resources.

This particular approach and scientific results obtained prove the power of "dual use" purposes in order to make HR maps that can be used by different stakeholders with different aims but only one standard.

Mapping Data

The Levante Canyon was investigated in autumn 2013 using high resolution multibeam echosounder (MBES) SeaBeam 1050, side scan sonar (SSS) Klein3000. The MBES (50kHz) survey was conducted upon a 183 km^2 area covering the main part of the canyon system (from 150m to 800m depth).

Through digital processing techniques, seabed morphology maps, based shaded-relief bathymetries, were obtained. Echo-strength data (reflectance) can be extracted and presented as seabed *backscatter* maps that display not only information on sediment types, but also seabed morphodynamics and habitat.

MBES data show that the Levante Canyon is a peculiar meandering submarine valley, extending SE-NW (coast direction), strongly structurally controlled, characterised by a main valley with channels and drainage structures that determine fine sediments deposition (low energy hydrodynamic processes). These geometries are typical of a valley with a complex origin, referring to different tectonics and hydrodynamics processes clearly shown by slope maps (Figure 2). In fact, from a combination of both shaded-relief bathymetries, slope analysis and backscatter maps, the seabed can be interpreted in terms of both relict and recent processes (erosive-depositional).

Swath systems (such as SSS) are most likely to provide the best HR maps made out of pictures, particularly over wide areas, as the Levante Canyon (Figure 3). They provide information on sediment texture and bedform structure and allow for dynamic processes (e.g. sediment transport) to be deduced.

For broad-scale mapping of aggregate habitat (>1 km^2), SSS and MBES are considered to be the most cost-effective means of discriminating different sediment types and dynamic processes. For small-scale habitat classification (<1km^2), high-resolution SSS, associated with ROV underwater cameras allow for the ground-truthing of the surveyed area.

It is clear that the different level of HR spatial analysis is just limited by the instruments and choice approach made during the advancement of the survey. However the system selection will depend on survey objectives and scale of the area to be mapped. For baseline broad-scale mapping of the continental shelf, where geological features, such as sand valley, channels, gullies, sediment waves and reefs are of interest, the quantitative data offered by MBES in conjunction with object detection in the order of tens of meters (at 200m depth) is often the preferred choice. However, for inshore areas and depths <50m where identification of small (<10m) habitat features may be required, a combination of MBES and SSS ensures that both quantitative bathymetric data (0,3m - 1m resolution) and qualitative, high-resolution habitat relief data (10cm resolution) are obtained.

In conclusion, Morphodynamics can be shown integrating morphology (bathymetry) and SSS backscatter map. Slope is the most variable element and through its analysis, at a regional scale, it is possible to display high/medium sedimentation rate in low gradient sectors (bottom channel). Moreover, at a local scale, it shows hard bottom covered by fine deposits with benthonic features/deep corals.".

Multiple Focusing

A multiple scale methodology approach was chosen in accordance with instruments and software available on board the Italian Navy Ship. MBES data acquired were processed by CARIS HIPS&SIPS software and compared with the IIM database. At first a seabed map of the area with high detail of the seafloor shapes was obtained, and used for other similar sectors of the canyon catchment area. The canyon is characterized by a gully network with a diverging pattern.

At a metric scale (medium scale), acoustic backscatter analysis permits to accurately describe drainage canyon system (with variable slope up to 30% in the channel sectors) and its geomorphic variability in relation with seabed nature. HR maps permit the identification of sites of interest for substrate dislocation and benthic features. These were investigated at a larger scale (sub-metric) by SSS Klein 3000, 100-500kHz (Figure 3). SSS operation was planned in accordance with seafloor canyon morphology and optimising recording data operations on board. In fact SSS lines were recorded in a selected area from 510 to 370m depth (Figure 4), where the seafloor morphology showed variable and interesting features characterised by different size, shape and slope.

Operating with MBES and SSS integrated data, morpho-bathymetric analysis and acoustic characterisation of the sub bottom allowed to determinate a large-scale area to be calibrated by ground - truthing. Figure 5 shows the section, chosen for its morphology, and used for higher resolution analysis with SSS. The presence of round structures (mound) of multi-metric dimensions inside the drainage system must be remarked. The highest values of slope (17%) can be found in the steep canyon heads and flanks. Slope values up to 10% can be seen depicting seabed mounds on the northernmost and central interchannel system. MBES and SSS data show higher acoustic backscatter in the deepest sections of the canyon than in the channels and the changes in the seabed nature on the mounds are highlighted as areas of variable intensity characterized by high level of reflectance typical of substrate. Besides that, SSS images show flat heterogeneous seabed with signs of trawling fishing (Figure 5).

In conclusion, the direct sampling bottom data collected on the mounds displayed the presence of biological communities, mainly typical of deep muddy bottom and small cold water coral colonies, possibly identified as *Madrepora oculata*. The hard bottom, probably constituted of buried coral banks, is also present.

Concluding Remarks

The sharing of knowledge and instruments is the basis of this integrated work focused on the study of seafloor features with particular reference to morphology of the proximal area of the Levante Canyon system.

Maps revealing the geophysical characteristics of the seabed represent an essential tool for the effective management of the

marine environment, because they allow for the wide-scale geology and present-day (Holocene) sedimentary processes to be determined and understood. Furthermore, the integration of different maps, resulting from the use of different equipment and data processing methods, allowed for the research to focus on the best possible area.

Operating with SeaBeam 1050 and Klein 3000, seabed morphological characterization, sediment type discrimination and processes dynamic description, on broad-scale (>1km^2) were carried out. Besides that small-scale habitat classification (<1km^2 up to centimetre) was achieved thanks to SSS images analysis integrated with direct sampling methods such as grab sampler or underwater camera.

During the real time survey processing, the establishment of a confidence level to each feature of interest, at the different scales, justified the multiple focusing and HR investigation of the seabed variability and nature with different instruments.

Finally, it is highly recommended that appropriate biological ground-truthing is under- taken where remote-sensing technologies are to be used for habitat-mapping purposes. In fact the ground truth confirmed the area ecological interest. Thanks to Italian Navy resources, the survey provided not only a detailed mapping of the variable morphology of the proximal area of the Levante Canyon at different scales, but it also investigated the seabed nature and the biological communities in the canyon system for the assessment of a potential Site of Community Importance under the European Commission Habitats Directive (92/43/EEC).

Further Reading

Delbono, I., Ivaldi, R., Pratellesi, M., Fanelli, E., Peirano, A., Cocito, S., Dialti, L., Delfanti, R., 2014. Seafloor morphology: nature of the seabed and the cold water corals of the Levante Canyon (eastern Ligurian Sea, NW Mediterranean). Geophysical Research Abstracts 16, EGU2014-14732.

Kenny, A. J., Cato, I., Desprez, M. Fader, G., Schuttenhelm, R.T.E., Side J., 2003. An overview of seabed-mapping technologies in the context of marine habitat classification. ICES Journal of Marine Science 60, 411–418.

Kostylev, V.E., 2012. Benthic habitat mapping from seabed acoustic surveys: do implicit assumptions hold? In: Sediments, Morphology and sedimentary Processes on Continental Shelves, Li, M.Z., Sherwood, C.R., Hill, P.R. [eds.]; Wiley Blackwell, IAS Spec. Pub., 44, pp 405-416.

Marta Pratellesi is an Italian Navy Lieutenant and Hydrographer Chief of the oceanographic department on board survey vessel *Ammiraglio Magnaghi*. She attended the Naval Academy from 2003 to 2008 getting a bachelor degree in Maritime and Naval Science. She took part in several military operations as telecommunication officer. In 2011 she obtained the M.Sc. degree in Marine Geomatics (University of Genoa and *Istituto Idrografico della Marina*). In 2014, she obtained FIG/IHO/ICA Category A Level Hydrographic Surveyor certification.

Roberta Ivaldi, Ph.D. degree in Environmental Science, Sea Science, (Trieste University, 1997) and M.Sc. degree in Geological Science (Genoa University, 1993), has been Associate Professor in Marine Geology at the *Istituto Idrografico della Marina* since 2008. Her research focuses on high resolution seismic stratigraphy, seabed mapping, physical mechanical properties and microstructures of sediments.

Ivana Delbono has been a researcher at ENEA Marine Environment Research Centre, La Spezia (Italy) since 2003. M. Sc. degree in Marine Environmental Science, Genoa University (1998) and Ph.D. in Environmental Science (Physical, Marine and Coastal Environment), Trieste University (2007). Her research field is Marine Geology and Radioecology.