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Measuring growth structure of reef frameworks in Mediterranean deep-water coral-topped mounds

Alessandra Savini[1], Marco Taviani[2], Fabio Marchese[1], Agostina Vertino[1,3], Cesare Corselli[1], Marie-Claire Fabri[4], Andrè Freiwald[5], Jozée Sarrazin[6]

[1] *Dept. of Earth and environmental Sciences, University of Milano Bicocca, 20126 Milan, Italy, alessandra.savini@unimib.it, fabio.marchese1@unimib.it, cesare.corselli@unimib.it*
[2] *CNR, ISMAR, Bologna, Italy, marco.taviani@bo.ismar.cnr.it*
[3] *Ghent University, Department of Geology, Renard Centre of Marine Geology, 9000 Gent, Belgium, agostina.vertino@unimib.it*
[4] *IFREMER, Département Océanographie et Dynamique des Ecosystèmes, La Seyne sur Mer, France, Marie.Claire.Fabri@ifremer.fr*
[5] *Forschungsinstitut Senckenberg, Department of Marine Science, Wilhelmshaven, Germany, Andre.Freiwald@senckenberg.de*
[6] *IFREMER, Département Etude Des Ecosystemes Profonds, Plouzané, France, Jozee.Sarrazin@ifremer.fr*

***Abstract* – Framework building scleractinian Cold-Water Corals (CWC) are able to form biogenic reefs in a number of geomorphic setting on continental margins, seamounts and oceanic banks. In this study we show the results obtained from a variety of mapping approaches (used at a range of scales) to map the distribution of CWC habitats in the northern Ionian Sea. A special focus is given to the analysis of ROV-based micro-bathymetry, that was pivotal for measuring, at metric resolution, the reef growth structure of a single, representative coral-topped mound of the region.**

I. INTRODUCTION

Multi-Beam Echo-Sounders (MBES) represent the most effective acoustic device able to provide a detailed representation of seabed geomorphology, defining the physical boundaries of those benthic habitats whose distribution in the vast deep sea is strictly associated with typical seabed geomorphologies [1, 2].

Seafloor geomorphologies are indeed increasingly used as proxies to predict the associated community of species, often representing *surrogates* for biodiversity in the deep sea [1, 3].

Our study shows the results obtained from a variety of mapping approaches to map the distribution of habitats of the Santa Maria di Leuca CWC province in the northern Ionian Sea [1, 4, 5, 6, 7] at various spatial scales. Here CWC growth contributed to a spectacular landscape dotted by more than 1000 sub-conical and elongated coral-topped mounds, located in water depths of 500-900 meters [1, 2]. The integrated analysis of acoustic data collected at multiple spatial scales, associated geoscientific information, and benthos data (i.e. seabed samples and video inspections) were used to decipher the control that geomorphic processes have had, from the late Pleistocene to the present time, in determine the general distribution of coral-topped mounds in the surveyed area. In addition, we described the fine-scale morphology of the reef framework that shapes the summit and the north-eastern flank of a single coral-topped mound, using a bathymetry data set obtained at metric resolution (i.e. microbathymetry).

II. MATERIALS AND METHODS

The present work made use of a consistent acoustic dataset acquired through a number of European oceanographic expeditions (see [1] for details). The survey area crosses roughly 2000 km^2 between 80 m and 1400 m of water depth, off the south-eastern coast of Apulia. A geomorphological characterization of the whole area was provided by previous studies through the analysis and integration of multibeam bathymetry, Side-Scan Sonar (SSS) mosaics collected at 4 sites, Sub-Bottom Profiles [1, 2, 6], results from sediment samples analysis [4, 5, 8] and video footage obtained from ROV dives (i.e.: QUEST4000, [9]) and from the GAS-SCIPACK module (equipped with cameras, see [10]), for a total of 10 sites visually investigated (namely MS01, MS02, MS03, MS03bis, MS04, MS04bis, MS05, MS06, MS07, MS08, ReefABC, Gallipoli-escarpment). Videos were analysed in order to identify coral-dominated macro-habitats, as described in [1].

Discrete forms or areas shaped by a dominant process (i.e.: *geomorphic units*) were systematically mapped and results were integrated to the present-day knowledge on the distribution of different CWC habitats. At a finer

scale, a single coral-topped mound [2] was surveyed by means of a work-class ROV (Victor6000) equipped with a ResonSeabat 7125 and deployed from the R/V Pourquoi Pas? during the 2007 MEDECO Expedition (October 2007). A DTM at a 1 x 1 m grid cell size was analysed, using basic geomorphometric techniques, including the Topographic Position Index (TPI), in order to emphasize how coral growth modified the original elevation and the morphology of the whole mound.

III. DISTRIBUTION OF CORAL-TOPPED MOUNDS

As documented by previous studies and further supported by the geomorphological mapping provided by the present study, CWC bioconstructions are more abundant in association with sediment blocks originated by late Pleistocene mass-transport events. Sediment blocks form sub-circular to elongated mounds, 200m wide in average and from few meters to 25m high [2], and likely offered widespread suitable substrate for coral colonization during last deglacial time (i.e.: 13.4–11.4 cal kyr BP, according to the oldest dated coral fragment reported in [8 and 11]).

Slide deposits typified by sediment blocks, occur exposed on the seafloor or partially/totally buried by recent sediments. When partially exposed (according to interpretation from high resolution seismic data), the slide deposits does not show a significant present-day (i.e. Holocene) sedimentary drape over the slide deposit, especially over those sediment blocks that rise from few meters to around 20 m from the surrounding seafloor.

As documented by the occurrence of sediment drifting [4,6], bottom currents also impact the study area. A core of cold (= 12.92uC), less saline (38.64%), and oxygenated water of Adriatic origin flows in particular from the Otranto Channel (i.e. from NE) and moves in geostrophic balance along isobaths of 500–1,000 m in depth [12, 13], sweeping the seafloor and preventing sedimentation especially at the top of sediment blocks (that representing obstacles to bottom currents, constrict and accelerate the water flow). Present-day oceanographic conditions [12, 13], coupled with an on-going uplift [14] of the margin (which reduced the accommodation space promoting low sedimentation rate) represent thus the most important geo-environmental controls that allow scleractinian corals to thrive on the upper and north-eastern slopes of a huge number of sediment blocks belonging to entirely and partially exposed slide deposits [1, 2, 5, 7].

IV. MORPHOLOGY OF REEF FRAMEWORK

The micro-bathymetric grid (that includes the extension of a single coral-topped mound – Fig. 1) revealed two well-delineated zones composing the single surveyed mound, each one characterized by a distinctive morphology. The most striking zone is the north-eastern sector, that is distinctly marked at the summit by a rough surface that becomes gradually smoother at the mound base, toward the north-east (Fig. 1). As well documented in previous works, by video observations [2, 7], the rough seafloor is produced by a live biogenic reef framework; distinct coral-dominated macro-habitats were also mapped on high frequency side scan sonar data in [7].

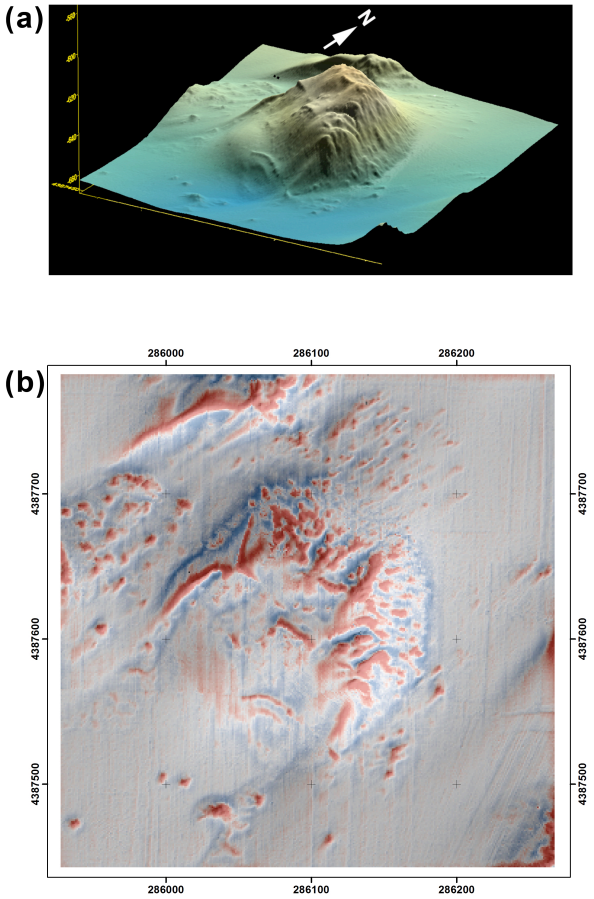

Fig. 1. (a) 3D view of the single coral-topped mound surveyed by means of a work-class ROV (Victor6000). The 3D view was obtained from the DTM produced by the ROV-based multibeam data collected during the MEDECO expedition, carried out on-board the R/V Pourquoi Pas? (October 2007). (b) The Topographic Positioning Index computed for the DTM shwon in (a): elevated areas are shown in red, whereas depressed areas are shown in blue. Inner radius:1 and outer radius:7.

The rough surface produced by the coral framework is just apparently randomly articulated. The morphometric analysis showed a repetitive pattern, which consists in small scale ridges and troughs, elongated from the top to the mound base along a downslope direction (Fig. 1b). In addition, at the north-eastern mound base, single seafloor features can be distinguished and associated to coral colonies. From each of them and toward the top of the

mound, small-scale elongated and linear sedimentary reliefs (less than 1 m high and wide and few metres long) run parallel to each other and die out in few metres, forming sedimentary tails deposited immediately downstream of an obstacle, where the single coral colony represents the obstacle.

V. CONCLUSION

The geomorphological mapping obtained at the mesoscale for the whole surveyed area, combined with the fine-scale dataset that illustrates the sedimentary setting of a single coral-topped mound in the northern Ionian Sea, gives new insights in the combined action of different geomorphic processes in providing suitable locations for coral growth. Results sheds in particular more light on the interaction between hydrodynamics, sedimentation and erosion, and on the importance of inherited morphologies (i.e.: Pleistocene sediment blocks) for coral growth in the region.

VI. CITATIONS AND REFERENCES

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