IMEKO International Conference on
Metrology for The Sea
Naples, Italy, October 11-13, 2017

Using Geomorphometric Techniques to Assess Spatial Distribution and Volume of Coralligenous Bioconstructions (Mediterranean Sea)

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***Abstract* – Within the framework of the BioMAP Project (BIOcostruzioni Marine in Puglia, - P.O. FESR 2007/2013), new acoustic data were acquired in order to identify and locate Coralligenous Habitats (CHs) along the Apulian continental shelf (South Adriatic Sea – Northern Ionian Sea). The analysis of the multibeam echosounder (MBES) dataset allowed us to identify different morphological expression of CHs. Geomorphometric techniques have been applied on the MBES data in order to (1) figure out relationships between the observed morphologies and the associated habitat distribution and (2) quantify the total volume of selected Coralligenous build-ups. Our results were obtained applying a quantitative analytical approach, focusing on the exploitation of the full potential of seafloor data sets in an objective manner. Our approach can be even used to monitor future changes, from anthropogenic impacts (e.g., bottom trawl damage) to the impacts of global change including ocean warming and acidification that can affect the structural complexity and total volume of carbonate deposits characterising the Mediterranean benthic environment.**

I. INTRODUCTION

Coralligenous Habitats (CHs) constitute the second most important ‘hot-spot’ of species diversity in the Mediterranean, after the *Posidonia oceanica* meadows [1], able to produce large deposits of biogenic calcium carbonate [2], becoming very sensitive to the ongoing global change [3], [2]. For this reason, a precise knowledge of Coralligenous (C) distribution is nowadays strongly important.

The BioMAP project (BIOcostruzioni Marine in Puglia, - P.O. FESR 2007/2013) promoted actions in order to map and monitor CHs along the Apulian shelf (southern Adriatic margin and northern Ionian margin – Mediterranean sea), collecting seafloor acoustic data (i.e.: multibeam bathymetric data and side-scan sonar mosaics) and videos.

In this work, multibeam data were analysed by means of geomorphometric techniques, in order to extrapolate quantitative information able to characterize the morphology and the volume of the observed carbonate bioconstructions. Our analysis was applied on three different groups of Digital Terrain Models (DTMs) collected in three selected CHs mapped in the project: (1) Mosaic of Coralligenous and Posidonia meadows (MCP), (2) Coralligenous Biocenosis (BC) and (3) Mosaic of Coralligenous and coastal Detritic (MCD).

II. MATERIALS AND METHODS

The acoustic dataset was obtained from several oceanographic research cruises, performed between March 2012 and May 2013 under the framework of the BIOMAP project. Two main research ship-based surveys, carried out using the R/V MINERVA UNO (BIOMAP I and BIOMAP II respectively on March and May 2012), explored the deepest areas, between 30m and 100m water depth, using the 50kHz Teledyne RESON 8160 MBES. Side scan sonar (SSS) data were obtained using two different models of dual frequency SSS: the 100/500 kHz Klein3000 system and the 100-400 kHz EdgeTech system.

Shallower sectors of the study area, located between 2 and 30 m below the sea level were surveyed during several small cruises carried out on board the CoNISMA research boat Calafuria ISSEL (from July 2012 until June 2013) using the Teledyne RESON SeaBat 8125 MBES.

The deepest areas, located between 30m and 100m of water depth (w.d.), were explored during two main ship-based surveys carried out on board the R/V MINERVA UNO (BIOMAP I and BIOMAP II respectively on March and May 2012), using the 50kHz Teledyne RESON 8160 MBES.

Teledyne PDS2000 Hydrographic suite was used for survey planning, MBES data acquisition and processing. SSS data were provided by a pole-mounted Klein3000 system.

MBES data where acquired and processed using Teledyne RESON PDS2000 software, the entire dataset did not cover all the investigated areas with 100% of coverage, but provided high-resolution bathymetry of the surveyed seafloor (i.e. from 0.3m cell size at 5m w.d. to 1 m cell size at 100 m w.d.). The DTMs, provided by the MBES survey, were used for the final georectification of the processed SSS mosaic obtained from the R/V MINERVA UNO surveys.

SSS operated at 200 m range setting and we reached 50% of overlap between adjacent lines. SSS data processing, performed using Triton ISIS (Triton Elics Information-TEI) suite software packages, produced geo-referenced gray-tone acoustic images of the seafloor at 0.5 m resolution. Only for SSS data acquired during the survey on the R/V Minerva 1, the track of the fish was computed using the position of the ship, the length of the tow cable, and the elevation of the fish above the sea floor. On the R/V ISSEL the SSS fish was fixed on a vertical pole, consequently a simple static offset (from the dGPS antenna position) was used to obtain georeferenced SSS images.

Groundtruthing were made by video inspections collected during all the oceanographic cruises. 3 ROV dives were performed using a Prometeo ROV (R/V MINERVA UNO) and more than 30 subaqueous transects were collected by the Quasi-Stellar© (Elettronica Enne) trawled camera (R/V Calafuria ISSEL).

III. GEOMORPHOMETRIC ANALYSIS

This first step started from a selection of testing areas (within the huge BioMAP dataset) able to represent each CHs (MCP, BC and MCD), matching two main criteria: (1) data resolution (0.30m for MCP and BC, 1m for MCD) and (2) the absence or significant artefacts. Three testing areas for each CHs were selected from the entire dataset.

The primary goal of the performed methodology was the detection of distinct C morphologies at the maximum resolution. Considering the three dimensional nature of C morphologies, that rise from the seafloor with steep and often sub-vertical flanks and sharp boundaries [4], we adopted an algorithm that allow to discriminate between CHs morphotypes [5] and the surrounding seafloor. The Topographic Position Index [6][7][8] tool of the SAGA software (System for System for Automated Geoscientific Analyses) [9], was then used to support the performed analysis. After several testing analysis that used different inner and outer radius, we recognised as the most efficient solution the selection of 1 cell for the inner radius and 10 cells for the outer radius. Then, using ArcGIS all the C structures were isolated and removed from the DTMs (Fig.1).

A "reference surface" without bioconstructions was created for each DTM through Golden Software Surfer®. The interpolation function, used for the creation of the reference surface, was the natural neighbour [10].

IV. VOLUME ANALYSIS

The last analytical step included the comparison of the analyzed DTMs, with their associated reference surface, in order to calculate the volume of those C bioconstructions selected from the analysis. ArcGIS™ provides a Cut/Fill tool that summarizes the areas and volumes of change from a cut-and-fill operation, i.e. by taking surfaces of a given location at two different time periods, the function will identify regions of surface material removal, surface material addition, and areas where the surface has not changed.

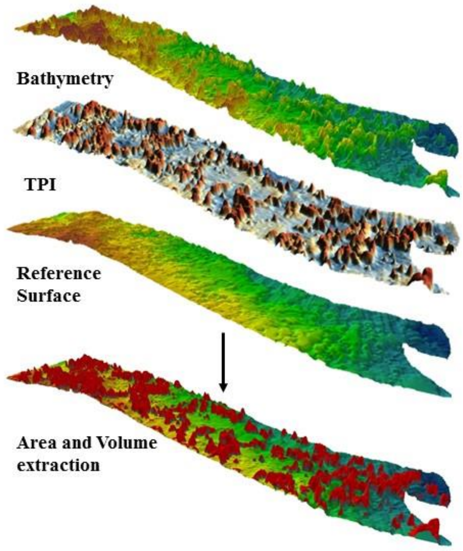

Fig. 1. Workflow for the area and volume analysis

V. RESULTS

Volume calculus performed through the above-mentioned analysis, provided quantitative results for each CH selected by the TPI algorithm. In order to relate this volume to all areas mapped by the BioMAP project, a ratio value between the total areas of CHs mapped by BioMAP project and by the one obtained from the method here presented, was calculated.

We therefore obtained for each analysed area the actual C coverage, and the corresponding percentage was calculated. The average percentage obtained from all the areas (for each habitat) was considered as representative of the real coverage provided by C bioconstructions in each habitat. Table 1 shows new area values and volume for all the CHs mapped by the BioMAP project, as estimated by the proposed analysis.

Table 1. Resulting Area and Volume of coralligenous bioconstructions, as derived from the proposed analysis.

Habitat Coverage	MCP	BC	MCD
BioMAP Project (Km^2)	103,8	185,6	101,9
New Methods (Km^2)	30.84	12.81	81.30
Volume (mln m^3)	80.94	55.40	200.89

VI. DISCUSSION

MCP polygons identified by our methodology show the highest difference between highness values. C bioconstructions within the MCP habitat show indeed a minor lateral continuity than the C bioconstructions included within the other CHs (CB and MCD) and are definitely more isolated within the entire habitat. They are more developed in the vertical direction than the horizontal one, forming isolated columns or field of columns, as described by Bracchi et al. (2014).

MCP build-ups are usually not as big as the ones representative of CB, since they likely lay in competition with *P. oceanica*.

Bioconstructions that typify the CB, even if not higher as the ones of MCP habitat, provide characteristic bank frameworks (sensu Ballesteros, 2006), with large and flat forms, laterally continuous and well developed in highness.

MCD represents the end-member of the series, showing very low difference in highness (indicative of more rounded morphologies).

The present results highlight how the different CHs are actually characterized by distinctive C morphologies, showing that C biocnstructions may have different morphological expression. The observed differences may be related to the different environmental condition in which C build-ups growth. For instance, from MCP through CB to the MCD there is a progressive increase of the depth, and consequently a decrease of light penetration. MCP is usually located in the shallowest zone, and develop where good conditions for seagrass growth are reported. CB develops in deeper bathymetric interval than MCP, where those typical dim light conditions, that favour the growth of those crustose coralline algae responsible of coralligenous formation, occur. MCD represents a CH that thrives in the deepest bathymetrical area of our dataset (maximum 100m w.d.). Very dim light condition characterize this zone, growth form are more rounded than the ones representative of the MCP habitat, but not well developed as in the BC habitat.

Other data are actually necessary to better outline the relationships between environmental conditions and growth forms in different CHs (i.e substrate, nutrient supply, current speed, ecc...), nevertheless the present work documented for the first time a quantitative relationships between C growth forms and the associated habitats in which they are distributed (that is in turn controlled by environmental conditions).

REFERENCES

[1] Boudouresque, C.F. “The erosion of Mediterranean biodiversity. In The Mediterranean Sea: An Overview of Its Present State and Plans for Future Protection.” Lectures from the 4th International Summer School on the Environment, C. Rodríguez-Prieto & G. Pardini (eds), Girona: Universitat de Girona, 53–112.

[2] Basso D. “Carbonate production by calcareous red algae and the global change”, in Basso D. & Granier B. (eds), Calcareous algae: from identification to quantification. Geodiversitas, 2012, 34 (1) : 5-11.

[3] Kuffner I.B., Andersson A.J., Jokiel P.L., Rodgers K.S., Mackenzie F.T. “Decreased abundance of crustose coralline algae due to ocean acidification.” Nature Geoscience, 2007, 1 : 114-117

[4] Bracchi V.A., Savini A., Marchese F., Palamara S., Basso D., Corselli C.: “Coralligenous habitat in the Mediterranean Sea: A geomorphological description from remote data.” Italian Journal of Geosciences 12/2014; 134(1). DOI:10.3301/IJG.2014.16

[5] Bracchi V.A., Basso D., Marchese F., Corselli C., Savini A.: “Coralligenous morphotypes on subhorizontal substrate: A new categorization.” Continental Shelf Research 144: 10-20, 10.1016/j.csr.2017.06.005.

[6] Guisan, A. & Zimmermann, N.E. “Predictive habitat distribution models in ecology.” Ecological Modelling, 2000, 135, 147-186.

[7] Weiss, A.D. “Topographic position and landforms analysis.” Poster Presentation, ESRI Users Conference, San Diego, CA, 2001.

[8] Gallant, J. C., and J. P. Wilson. “Primary Topographic Attributes.” In Terrain Analysis: Principles and Applications, J. P. Wilson and J. Gallant (eds.). New York: John Wiley & Sons Inc., 2000, pp. 51–85.

[9] Conrad, O., Bechtel, B., Bock, M., Dietrich, H., Fischer, E., Gerlitz, L., Wehberg, J., Wichmann, V., and Böhner, J.: System for Automated Geoscientific Analyses (SAGA) v. 2.1.4, Geosci. Model Dev., 8, 1991-2007, doi:10.5194/gmd-8-1991-2015.

[10] Sibson R, “A brief description of natural neighbour interpolation.” In V Barnett, editor, Interpreting Multivariate Data, 1981, pages 21–36. Wiley, New York,USA.