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CARTOGRAPHY OF MAIN COASTAL ECOSYSTEMS (CORALLIGNENOUS AND RHODOLITH BEDS) ALONG THE CORSICAN COASTS

Abstract
In the Mediterranean Sea, the improvement of knowledge on bio-concretion (bioconstructing) assemblages (coralligenous and rhodoliths beds) and particularly their distribution, is one of the priority actions identified in the Action Plan for the conservation of coralligenous and other bioconstructions in the Mediterranean. The various studies available show relatively recent and uneven knowledge across the basin regarding the distribution of coralligenous bioconstructions and very specific information about the distribution of rhodolith beds. In addition, while the methods for mapping infralittoral communities are now well mastered and standardized, methods and tools of investigation on settlements located at greater depths still require further development.
A mapping program of the main assemblages and bottom types between 0 and 100 m depth has been carried out since 2010 on part of the coast of Corsica (e.g. Cap Corse, Bouches de Bonifacio). The mapped areas cover a 780 km^2 area of Cap Corse and 387 km^2 area of Bouches de Bonifacio. The available results show the significant distribution of rhodolith beds and the frequency of hard substrates, hosting coralligenous bioconstructions in the area of Cap Corse. On the contrary the area of Bonifacio would appear to be characterized by great richness in coralligenous bioconstructions but over a smaller area with regard to the rhodolith beds surface area. These results represent a significant contribution to the knowledge of the distribution of these assemblages in relation to the extent of the area occupied by the rhodolith beds in particular, and showed the importance of these two areas for conservation.

Key-words: Mediterranean Sea, Cartography, Side scan sonar, Multibeam echosounder, Coralligenous, Rhodolith.

Introduction
In the Mediterranean, localization and mapping of the coralligenous and other calcareous bio-concretions are priority actions, identified in the Action Plan for the conservation of the coralligenous and other calcareous bio-concretions (bioconstructing) in the Mediterranean sea, (UNEP-MAP-RAC/SPA, 2008), adopted by the Contracting Parties of the Barcelona Convention.
These assemblages form the basis of the Mediterranean specific richness (Bellan-Santini *et al*., 1994; Relini, 2009) and are particularly important because of their extensive distribution, structural complexity, species diversity, role in energy flux and carbon cycle, and economic value (Bianchi & Morri, 2000; Ballesteros, 2006; Martin *et al.,* 2013b). The coralligenous assemblages create typical Mediterranean underwater seascapes, based on algal frameworks (Corallinaceae) that grow in dimly lit, relatively calm waters (Ballesteros, 2006). Mediterranean rhodoliths beds are constituted by free-living calcareous algae (Corallinaceae or Peyssonneliaceae), living on sedimentary bottoms (infralittoral and circalittoral); they are developed under dim light conditions and high level of current (UNEP-MAP-RAC/SPA, 2008).

Recent studies provide uneven information concerning the distribution of coralligenous and rhodolith beds. A preliminary study (UNEP-MAP-RAC/SPA, 2009) shows a substantial lack of relevant geospatial data with only fifty maps identified across the western basin. Most available data are based on a limited number of studies with scattered quantitative data, limited spatial range, on presence/absence data at a very low spatial resolution (Giakoumi *et al.,* 2013). Currently, there is only information on approximately 30 % of the Mediterranean coast. Data are unevenly distributed, essentially because the majority of systematic studies have taken place in the western Mediterranean (Martin *et al.,* 2014).
A mapping program of the main assemblages and bottom types, between 0 and 100 m depth and incursions to 150 m depth, has been carried out since 2010 on parts of the coast of Corsica (*e.g*. Cap Corse, Bouches de Bonifacio).

Materials and methods
Cap Corse, located in the north of Corsica (France, Mediterranean), corresponds to a relatively well-preserved coastline; Bouches de Bonifacio located in the south of Corsica corresponds to the area of the French-Italian Parc Marin International des Bouches de Bonifacio (International Marine Park). A small area called "Asinara" located to the southwest of the Marine Park has also been mapped.
The mapping of the main benthic assemblages and bottom-types between 0 and 150 m depth was carried out between July 2010 and May 2014.
In the Cap Corse area, the shallow waters (from 0 to -15 m) were mapped using complete photographic coverage (146 color aerial photographs at 1/5 000th, from the BD ORTHO® 2007 of National Geographic Institute) and with a resolution of 0.5 m. Image processing was applied to each photograph using Envi 4.4® software following the method of Pasqualini *et al.* (1998).
The deeper zone (-15 to -150 m) was mapped using exhaustive acoustic coverage (coupling a multibeam echosounder EM 1000™ and a side-scan sonar Klein 3000™). These data were acquired during three oceanographic cruises (Capcoral 1, Capcoral 2 and Coralcorse) during the summers of 2010, 2011 and 2013 and were processed with the Caraibes 3.8® software program. A digital Terrain Model (DTM) and a mosaic (resolution of 0.5 m) were developed.
More than 800 field data (bathyscope and scuba-diving observations, Remote Operated Vehicle images, grabs) provided a basis for validating the interpretation of aerial photographs and the mosaic of the sonograms.
All the data were gathered into a Geographic Information System (GIS; ArcGis 10®; projection Mercator-WGS84).
The identification of the main assemblages and bottom-types is based on work at Mediterranean level, on the basis of the classification of Péres & Picard (1964) and their description (Bellan-Santini *et al.,* 2002), following the typology of Michez *et al.* (2011).
If the treatment of aerial photographs and sonograms allows to obtain the production of a map of biocoenoses and associations, it is necessary to evaluate the reliability of these maps. It was assessed using different scales (Pasqualini, 1997; Pasqualini *et al.,* 1998; MESH, 2008).

Results

The mapped areas cover a 780 km^2 area of Cap Corse between 0 and 150 m depth (Fig.1) and a 387 km^2 area of Bouches de Bonifacio between 20 and 100 m depth (Fig. 2 and 3). The map of the main biocoenoses and associations of Cap Corse shows the importance of the association of rhodoliths (Fig. 1), which forms accumulations in the sandy depressions (9328 ha) or constitutes “carpets” (1660 ha), down to 90 m depth. The frequency of hard substrates, hosting coralligenous assemblages, is also observed (26 ha). In contrast, the area of Bouches de Bonifacio would appear to be characterized by great richness in hard substrates, hosting of coralligenous assemblages (Fig. 2 and 3; 181 ha) but over a smaller area with regard to the rhodolith beds surfaces areas (2013 ha). These rhodoliths are only observed down to maximum depths of 75 m and form accumulations in the sandy depressions.

It should be noted that, for both sites, the coralligenous areas are underestimated due to the method used (side scan sonar) which only takes into account horizontal or subhorizontal surfaces (3D assemblage).

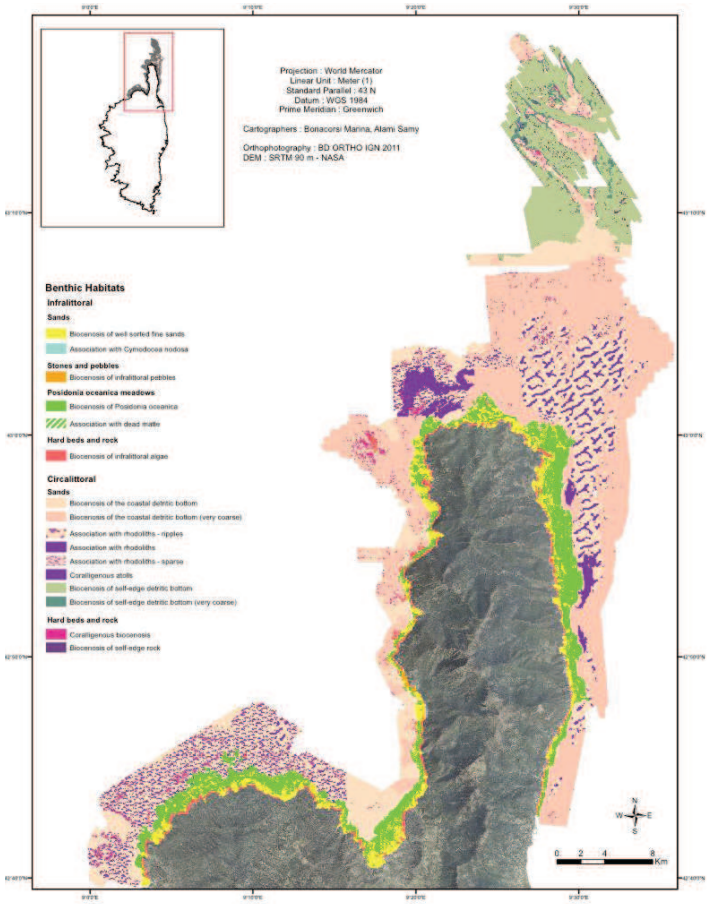

Fig. 1: Map of the main biocoenoses and associations of Cap Corse.

In addition in the northern part, new structures have been discovered. These structures, never previously identified in the Mediterranean Sea, are named "coralligenous atolls" because of their circular shape. They are formed of a massive central core constituted by a massive coralligenous structure, a halo of detritic bottom and a peripheral crown of free rhodoliths. The absence of coralligenous atolls must be emphasized, at the area of Bouches de Bonifacio, a site otherwise closely comparable to Cap Corse, despite the

presence of coralligenous assemblages. The reliability of the three maps is high. It is between 88% and 90% for Cap Corse and 91% and 90% for Bouches de Bonifacio according to the scale of Pasqualini *et al.,* (1998) and MESH (2008).

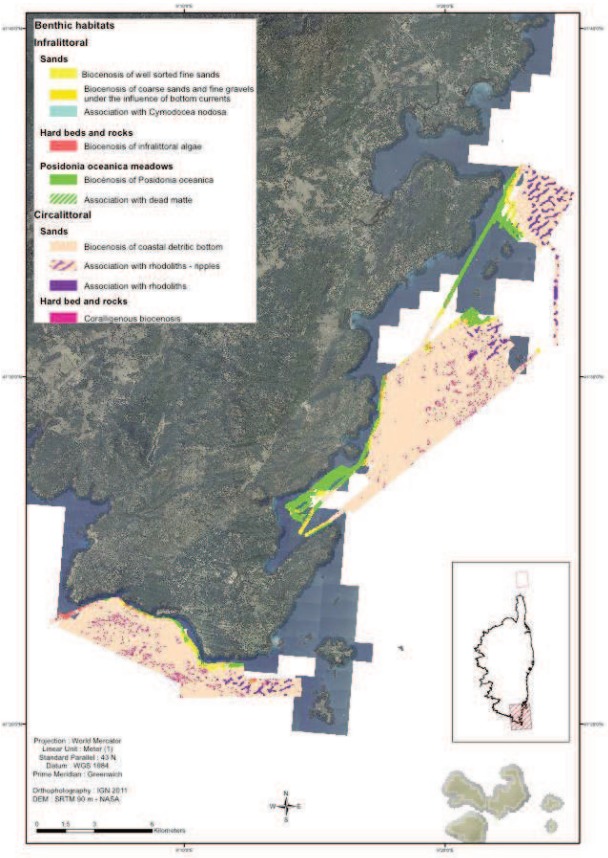

Fig. 2: Map of main biocoenoses and associations of Bouches de Bonifacio.

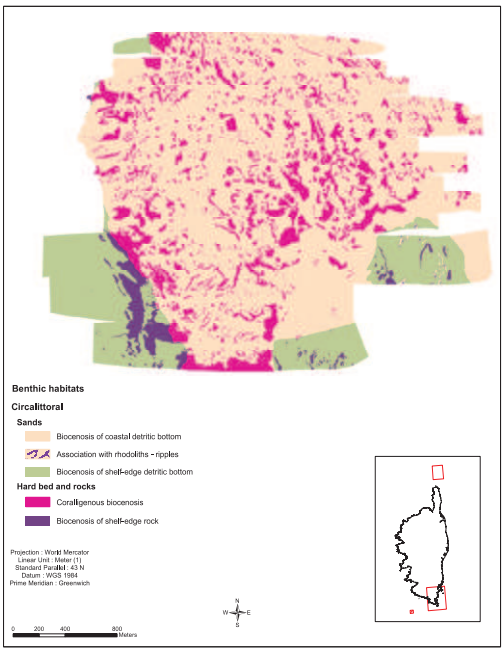

Fig.3: Map of main biocoenoses and associations of Asinara.

Discussion and conclusion

The maps produced constitute a significant contribution to knowledge of the distribution of the rhodolith beds and coralligenous assemblages, according to the existing data (UNEP-MAP-RAC/SPA 2009; Martin *et al.,* 2014) especially on rhodolith beds whose knowledge was limited, compared to what was available for coralligenous outcrops (Martin *et al.,* 2014). This study demonstrates the extent of the surface area occupied by the rhodolith beds in these Natura 2000 sites (8 % of the total mapped surface of the western Mediterranean basin (Martin *et al.,* 2014)).

Our results are in accordance with the existing data concerning the bathymetric distribution of coralligenous (Ballesteros, 2006) and rhodolith associations (Barbera *et al*., 2003; Georgiadis *et al.,* 2009) even if our observations are among the deepest recorded for the coralligenous in the western basin (down to -120 m; Bonacorsi *et al.,* 2012).

In addition to a heritage interest, these calcareous bio-concretions probably play a major role in the production of calcium carbonate and more generally in the biogeochemical cycles of carbon at regional level, but their role is still insufficiently studied (Martin *et al*., 2013a). Calcimetric analysis showed particularly high content in calcium carbonate of the biocoenosis of coastal detritic bottoms (90 %) as already reported for Balearic Islands (between -40 and -90 m; Fornos & Ahr, 1997), in the Gulf of Cagliari (-50 to -5 m;

Lecca *et al.*, 2005) and at the Pontine Islands (between -60 and -80 m; Brandano & Civitelli, 2007). It seems that these high levels are probably related not only to the nature and the topography of the bottom and/or bathymetry but also to the present benthic communities (Canals & Ballesteros, 1997). The values of calcium carbonate production of calcareous bio-concretions measured by Canals and Ballesteros (1997) and Martin *et al.* (2007) were applied to our surfaces. This production is then estimated respectively between 27 302 100 kg.an-1 and 63 275 867 kg.an^{-1} for rhodolith beds. Concerning coralligenous assemblages the values proposed by Canals & Ballesteros (1997) correspond to a production of 961 722 kg.an^{-1} for coralligenous assemblages. It confirms that coralligenous communities play a major role as carbon and carbonate producer in the Mediterranean Sea (Martin *et al*., 2013a).

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