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Invited feature

Fishery maps contain approximate but useful information for inferring the distribution of marine habitats of conservation interest

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ABSTRACT

Mapping marine coastal habitats provides an important aid to the long-term sustainability of urban development and the conservation of marine biodiversity. Historical maps, when available, may represent effective tools to evaluate quali-quantitative changes over time and to fix reference conditions. Scientific mapping of marine habitats is relatively recent, but the existence of fishery maps could compensate, after a critical evaluation, for the lack of more rigorous historical data. Coralligenous reefs are among the most important marine coastal habitats in the Mediterranean Sea, whose conservation requires, as a first step suggested by the recent European Directives, updated and detailed cartographies. This paper compares the recent cartographies (i.e. 2006 and 2009) on coralligenous reefs distribution in Liguria (NW Mediterranean Sea) with two historical fishery maps (i.e. dating back to the second half of the last century), on a GIS platform. Application of the Reliability Index (RI) showed that both historical sources can be trusted, with some caution. Fishery maps report few quantitative data (e.g. extent in hectares of coralligenous reefs) that are in little agreement with recent cartographies, mainly due to errors in positioning. In contrast, qualitative data (i.e. presence/absence in a specific site) represent the main information found in these maps and agree much more with the recent ones. It is more than likely that many of the rocky bottoms reported only in the fishery maps may host coralligenous reefs, which are apparently unknown in the recent cartographies. Latent information provided by this kind of historical maps may thus be useful for planning new surveys to sea-truthing on sites where no recent information is available and to promote the ecological studies required for their conservation.

1. Introduction

Seafloor mapping has become an effective tool to analyse the spatial aspects of the marine environment and to define the exact collocation of marine coastal habitats (Young and Carr, 2015). Combined with bio-ecological data and information on human pressures, detailed maps allow for marine spatial planning (Crowder and Norse, 2008; Parravicini et al., 2012) and efficient coastal zone management (Wätzold et al., 2006; Bianchi et al., 2012). Ecological mapping of marine habitats is relatively recent (Bianchi et al., 2004), because of the reluctance to consider the sea as a 'territory' and the evident operational difficulties involved in underwater surveys (Rovere et al., 2010, 2011). This hampers the needs for management and conservation (Galparsoro et al., 2012; Vacchi et al., 2013). Many recent international agreements underline the necessity of mapping marine habitats for their management: the European Marine Strategy Framework Directive (MSFD), for instance, requires seabed maps to monitor the extent to which the Good Environmental Status (GES) for the European marine waters is achieved by 2020 (Katsanevakis et al., 2011) and to maintain (or recover) the 'seafloor integrity' (Rice et al., 2012). Maps can be used to identify habitats of conservation interest (Bock et al., 2005), commercially important demersal fish concentrations (Corsi et al., 1998), biodiversity 'hotspots' (Levin et al., 2014), areas mainly affected by human activities (Holon et al., 2015), as well as to evaluate changes over time (Barsanti et al., 2007; Montefalcone et al., 2013): they constitute the basis for marine spatial management (Salomidi et al., 2012; Giakoumi et al., 2013).

Historical maps (i.e. dating back to the last century) can be

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effectively used to evaluate quali-quantitative changes and temporal dynamics of coastal ecosystems and to fix the reference conditions (i.e. the baselines) for marine habitats. However, historical maps are relatively few and, in most cases, their reliability should be determined before comparison (Leriche et al., 2004). Although not specifically designed for seabed mapping, historical fishery maps include valuable implicit information about the distribution of marine habitats and can therefore compensate, after their critical evaluation, for the lack of available historical data (Ardizzone et al., 2006).

Coralligenous reefs represent an important benthic habitat of the Mediterranean Sea, with unique three-dimensional complexity, biomass, production and richness that involve more species than any other Mediterranean community (Ballesteros, 2006). It constitutes a seascape resulting from the building activities of algal and animal constructors, counterbalanced by physical, as well as biological, eroding processes. Mechanical disturbance and destruction (mainly due to fishing activities), sedimentation, pollution, increased turbidity, and also thermal anomalies are the greatest pressures affecting coralligenous reefs (Barbera et al., 2003) and appropriate management measures are thus required to guarantee their conservation (UNEP-MAP-RAC/SPA, 2008). Even if, together with *Posidonia oceanica* meadows, coralligenous reefs represent the major source of Mediterranean biodiversity, the need to acquire an inclusive knowledge to manage this habitat of high conservation interest has been fully recognised only recently (Gatti et al., 2012).

Coralligenous reefs occurring in the north-western Mediterranean Sea are better known than those in the southern and in the eastern parts of the basin, thanks to a greater number of studies since the 19th and 20th centuries (Marion, 1883; Laubier, 1966) and to recent updates (Agnesi et al., 2009; Martin et al., 2014). Despite this, the knowledge on the distribution of coralligenous reefs along the coast of Liguria (Italy, NW Mediterranean), is still incomplete (Cánovas Molina et al., 2013, 2014, 2016b). In this paper, we explore the possibility to improve the existing cartographic information on the distribution of coralligenous reefs in Liguria thanks to the data provided by fishery maps dating back to the second half of the last century.

Many studies used historical maps to evaluate change over time in both terrestrial (Sprague et al., 2007; Frajer and Geletič, 2011) and marine environments (Leriche et al., 2004; Bakran-Petricioli et al., 2006). All of them underlined the necessity to assess the reliability and comparability of cartographies done in different periods with different technologies. Frajer and Geletič (2011) focussed on positional accuracy, while Leriche et al. (2004) have been the only ones to propose a formal method to assign historical maps with a measure of confidence that takes into account, in addition to positioning, the acquisition method, the scale and the year of publication. These parameters have been ranked, scored and combined in a single number that Leriche et al. (2004) named the Reliability Index (RI) and applied to seagrass maps. The RI was then successfully applied by Montefalcone et al. (2013), again to compare seagrass maps produced in different periods. The present study represents the first attempt at testing the effectiveness of the RI for a different habitat.

2. Materials and methods

2.1. Study area

Liguria is an administrative region of NW Italy, facing most of the Ligurian Sea (Fig. 1). With its 330 km of coastline, most of which is rocky, the Ligurian seafloor provides favourable environments for the development of coralligenous reefs (Cattaneo-Vietti et al., 2010).

2.2. Recent cartographies and historical maps

The Atlas of Marine Habitats (Diviacco and Coppo, 2006), resulting from surveys done with Side Scan Sonar (SSS), Remote Operated Vehicle (ROV), aerial and satellite imageries and underwater sea-truthing by scuba diving, and its updated digital version in 2009 (www.cartografia.regione.liguria.it) that has been implemented with multibeam surveys (Table 1), represent the two most recent available cartographies reporting coralligenous reefs distribution in Liguria (hereafter named ‘recent’). Coralligenous reefs are represented on these maps as a distinct layer in red colour (see Fig. 2 D, E for examples). When available, but only for specific areas, another cartographical source was considered (Tunesi et al., 2002) (see examples in Fig. 2 C), although most information provided by this source had already been included in the Atlas of Marine Habitat (Diviacco and Coppo, 2006).

Historical information on the distribution of coralligenous reefs in Liguria was inferred from 37 fishery maps published in the second half of the 20th century (hereafter named ‘historical’): 34 by Santi (1965) (Appendices 1–34 in the Supplementary Material) and 3 by Fusco (1967, 1968, 1972) (Appendices 35–37 in the Supplementary Material). Both authors described, more or less accurately, the seafloor typology and the coastline morphology together with target species of different fishery methods (Table 1, and see Fig. 2 A, B for examples). The seafloor typology shown on these maps could be indirectly related to the occurrence of coralligenous reefs: although these maps were produced to locate areas abounding in fish, they also report the occurrence of rocky bottoms that, at depths between 20 and 120 m, are expected to host coralligenous reefs (Pérès and Picard, 1964; Martin et al., 2014). Fusco's maps cover the whole Ligurian coastline, while Santi's maps have several gaps and cover specific sites only. Apparently, Fusco (1967, 1968, 1972) did not consider the existence of the older fishery maps of Santi (1965).

2.3. Data acquisition on the GIS

Fusco's and Santi's fishery maps were scanned respectively at 150 and 600 dpi, to make them available to the Esri 10.3 ArcGIS platform as raster data. All the rasters were edited to delete non-relevant information from the maps and to make information on bottom typology more visible (see examples in Fig. 2 and Appendices 1–37 in the Supplementary Material). The georeference tool was applied to these digitalized non-metrical maps in the geo-workspace using the TPS (Thin Plate Spline) transformation algorithm to point off the non-metrical map with known or given coordinates, called ground control points (Favretto, 2012). This interpolation method introduces only punctual deformations and results particularly effective with images of low quality (Hutchinson, 1998). Using the nearest neighbour sampling method (Chang, 2013), interpolation is fast but a little bit inaccurate at the borders; in our case, this problem could be neglected because of the overlaps between maps. Georeferencing accuracy has been tested, and case-by-case adjusted, using easily recognizable coastal features (e.g. harbours, piers, rocky headlands) from the online cartographic records of the Ligurian Region (available at http://www.cartografia.regione.liguria.it). The result of this transformation is that all the other points of the non-metrical map got coordinates that are ‘predicted’ (through linear interpolation function) from the known or given coordinates of the ground control points.

The projection system used for cartographic representation in the target map (i.e. the final map where all the concordance analyses were done) is Gauss-Boaga, the Italian National System centred in Monte Mario (EPSG: 3003). On this map, all points and areas