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SETTING CONSERVATION PRIORITIES FOR THE CONSERVATION OF CRITICAL HABITATS IN THE MEDITERRANEAN SEA USING CONSERVATION PLANNING TOOLS

SELEZIONE DI SITI PRIORITARI PER LA CONSERVAZIONE DEI PRINCIPALI HABITAT DEL MAR MEDITERRANEO UTILIZZANDO STRUMENTI DI PIANIFICAZIONE SPAZIALE

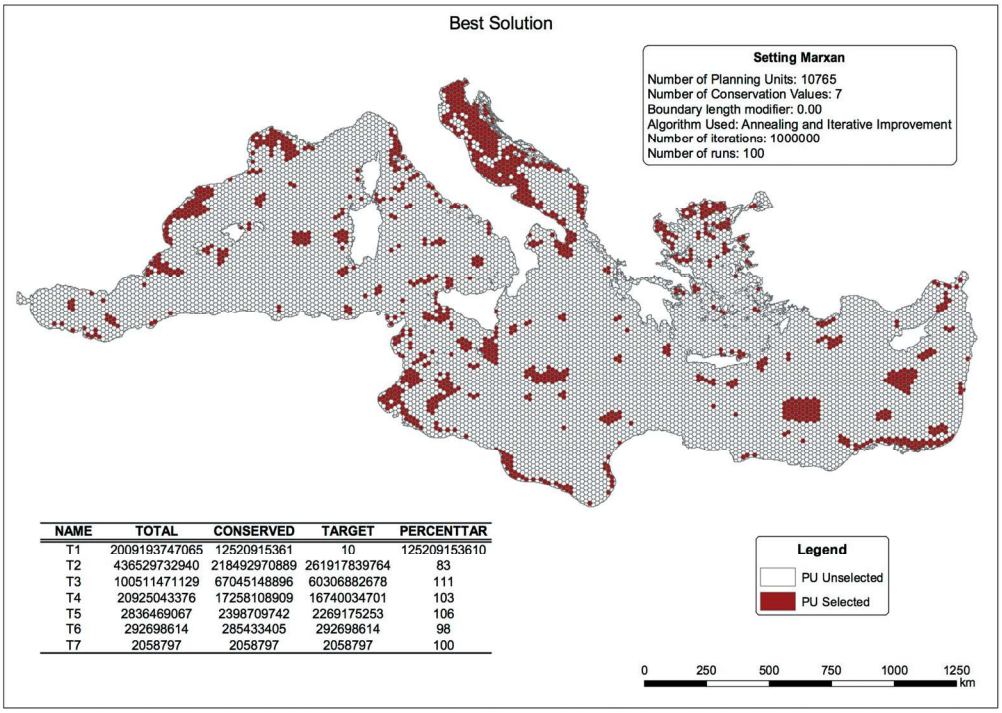
Abstract *- The Mediterranean Sea is a hot spot of biodiversity. Current protection measures are still poorly designed. The Aichi target requires the inclusion of at least 10% of the sea surface under some form of protection by 2020, while currently the MPA encompass approximately the 4% of the Mediterranean Sea, and this percentage drops to 0.4% if the Pelagos Sanctuary is not taken into account. Here, spatial priorities for the conservation of key Mediterranean habitats were identified through a systematic planning approach using a collection of georeferenced fine scale data of priority habitats (*Posidonia *meadows, coralligenous outcrops) and essential fish habitats (i.e. nurseries, spawning grounds) analyzed with the software Marxan. Our best protection scenario based on habitat distributions data covers the 13% of the basin and expands present conservation plans to areas that are generally neglected (deep-sea, eastern basin). The percentage of overlap between the current conservation measures and the Marxan scenario produced in this study are about the 50% of the priority areas identified.*

Key-words: *benthic communities, nursery ground, spawning ground, conservation, Mediterranean Sea.*

Introduction - In the last two decades, multiple spatial conservation plans have been developed in the Mediterranean Sea (e.g. present MPAs, EU CDDA, SPAMI, Natura2000, Ramsar sites, ACCOBAMS, EBSAs, Oceana). A recent analysis shows significant differences in the identification of priority conservation areas (Micheli *et al*., 2013), resulting from differences in the objectives, criteria and data used by the different initiatives. In addition, systematic approaches for spatial optimization available for the Mediterranean basin (Giakoumi *et al*., 2013; Mazor *et al*., 2013) show that conservation planners routinely conduct prioritizations without direct data on variables such as habitat condition or protection/management cost. The arbitrary use of surrogates may give untrusted results (Game *et al*., 2013). Here, the motivating idea is to identify priority areas using a systematic conservation planning approach within the software MARXAN, based on the most complete data-set to date on the distribution of benthic vulnerable habitats and essential fish habitats in the Mediterranean Sea. The aims are: 1- to build upon current protection/management initiatives in those areas that are presently less represented within the different conservation initiatives (e.g. the high seas and the eastern Mediterranean Sea); and 2- to compare our results with current conservation/management efforts.

Materials and methods - The MEDISEH project (http://mareaproject.net) provided an unprecedented opportunity to bring together the most complete data set to date, including georeferenced data on *Posidonia* meadows (model output), coralligenous formations (model output, see also Martin *et al.*, 2014), habitat of fish and shellfish nurseries (model output) for *Parapenaeus longirostris*, *Sardina pilchardus*, *Trachurus mediterraneus*, *Trachurus trachurus*, *Engraulis encrasicolus* and spawning grounds of *Mullus barbatus* and *Parapenaeus longirostris*. In addition, to the MEDISEH data layer, deep-sea habitats (e.g. canyons, banks, sea mounts) were also included (OCEANA MedNet, 2012). For coralligenous formations and fish habitats, the parts of the model output predicting the highest probability of habitat presence were used. The software Marxan (http://www.uq.edu.au/marxan/) was used to identify priority areas for conservation. Optimization algorithms implemented by the software (simulated annealing, iterative improvement) are proposed to solve the issue of minimal representation, protecting the greater biodiversity (here expressed in terms of habitat heterogeneity) minimizing the area selected. To decrease the costs associated to protection initiatives Marxan is a decision support tool for systemic conservation planning that implements a minimum set approach (Ball *et al.*, 2009). The conservation initiatives considered in this study are the Marine Protected Areas already established in the Mediterranean Sea, the Natura 2000 sites, together with all areas where bottom, pelagic trawls and purse seines limitation are present. There is some overlap between the Natura 2000 dataset and the MPA dataset so that the percentage of the Mediterranean Sea under protection regime here reported can suffer from a light overestimation. All data were standardized into a single layer using Arc-GIS "identity" tool. The highest number of overlapping features in a single area was seven. We grouped all areas into seven categories according to the number of the overlapping habitats. These categories were used as input features for the analysis. Conservation targets were set according to the habitat heterogeneity. The study area was divided into 10764 hexagonal planning units (PUs, side of the hexagon: of 10 km). Costs were set for all PU as the area of one PU and the Boundary Length Modifier was set at zero. All PUs were considered available, none has been blocked or excluded *a priori*.

Results - In the Best Scenario produced by the analysis (Fig. 1), conservation targets are met for all features. The Adriatic Sea is considered as one of the most relevant priority areas with most PUs coming from this area of the Mediterranean. Large portions of the deep sea were selected through the analysis, largely driven by the Oceana dataset, with several selected areas falling in the eastern basin of the Mediterranean driven by the distribution of fish and deep sea habitats. The analysis of the overlap between the output generated by Marxan and the distribution of the habitats included in the analysis shows that the habitat mostly excluded from this scenario is the *Posidonia* meadows, with only the 30% of its actual extension under some form of protection measure. The most represented habitat is the nursery grounds of *Parapenaeus longirostris* with 72% of its distribution included in the areas selected by MARXAN. The total area selected by MARXAN is 312,665 km^2, about 13% of the surface of the Mediterranean, in agreement with the target of protection recently suggested for the Mediterranean Sea (CBD's Aichi target 11 http://www.cbd.int/sp/targets/rationale/target-11/). Surprisingly conservation/management measures, although featured by different aims, when are combined they cover about 80% of the whole basin. The percentage of overlap between the current conservation measures and the Marxan scenario produced in this study are about the 50% of the priority areas identified, in other words, only approximately 50% of Best Scenario, individuate by Marxan based on habitat distributions data is currently under some form of protection measures.



NAME	TOTAL	CONSERVED	TARGET	PERCENTTAR
T1	2009193747065	12520915361	10	125209153610
T2	436529732940	218492970889	261917839764	83
T3	100511471129	67045148896	60306882678	111
T4	20925043376	17258108909	16740034701	103
T5	2836469067	2398709742	2269175253	106
T6	292698614	285433405	292698614	98
T7	2058797	2058797	2058797	100

Fig. 1 - Map of priority conservation areas, elaborated using software Marxan. Red polygons correspond to areas with higher selection frequency and therefore constitute spatial priorities.

Mappa delle aree prioritarie per la conservazione, ottenuta con l'utilizzo del software Marxan. I poligoni rossi corrispondono ad aree con una maggiore frequenza di selezione, pertanto, costituiscono le priorità spaziali per interventi di conservazione.

Conclusions - This attempt to use spatial optimization tool including georeferenced, fine-scale information on a suite of priority habitats and nursery areas at basin scale significantly expands present conservation plans to areas that are generally neglected with a special focus on essential fish habitats like nurseries and spawning grounds. The total area of the scenario covers the 13% of the whole basin, in agreement with the future targets of protection set for the basin (AICHI Target 11). In addition, the use of this spatial optimization tool would allow reaching conservation targets that are generally higher than those suggested by the literature (Harborne, 2009), with the exception of bioconstructors and *Posidonia* meadows, reaching conservation targets lower than those suggested by the EU (60% for the seagrass). Not considering the distribution of threats and the potential socio-economical constrains of the basin surely sets critical limits in the potential future application of this output. However, our intention was to identify highly heterogeneous areas in terms of habitats, to guide future conservation initiatives across the Mediterranean Sea, capitalizing on this fine-scale habitat mapping. Balancing nature conservation with the human use will be the step forward. The most important observation coming out from this work is that 85% of the basin is formally under some form of protection/management measure, however, using as leading criteria quantitative information of the distribution of habitats and their pattern of heterogeneity, the 45% of the habitats used in this

analyses is presently not included in any of the protection measures considered. This supports the consideration that, at least on paper, and with very different aims, conservation/management initiatives are quite widespread in the Mediterranean but they have been possibly decided ignoring the distribution of critical habitats. This result confirms the importance of using spatial prioritization tools. However, an important issue is represented by the quality of the information used that is seldom accurate and complete e.g. the spatial distribution of certain habitats could be underestimated or model output could be biased. Moreover, adding information on the spatial distribution of fishing effort along could also be part of the next step. Our conclusion is that the use of spatial prioritization tools can be very promising when combined with a rigorous knowledge of the distribution of biodiversity of the systems. The challenge, now, is a careful consideration of the social, cultural and political complexity of the basin that can largely refine our protection scenarios together with a concrete application of regulations that are currently already in place across the basin.

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