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ARE MEDITERRANEAN MPAs PROTECTING MARINE FORESTS?

Abstract *In the Mediterranean Sea, Marine Protected Areas (MPAs) are nearly 700, covering approximately 5% of the sea surface, but merely 0.1% of the Mediterranean's total surface is included in no-take zones. Mediterranean MPAs are often established according to political or socio-economic criteria more than nature conservation aspects, and only less than half of them have a management plan or have evaluated the status and the distribution of marine habitats. Results from our literature-based research highlight that scientific studies are abundant only in few Mediterranean MPAs, generally the biggest and the long-established ones. Usually, it is often the case that on land the vegetation has a primary role in establishing protected areas. By contrast, in marine systems, the vegetation has a secondary role or in some cases is absent in the establishment of protected areas. Furthermore, in the most studied Mediterranean MPAs, there have been limited scientific research on the status of large brown algae (i.e. *Cystoseira* and *Sargassum*) forests. As a result of this lack of information, marine forests are generally not included in Mediterranean MPA management plans, making it difficult to assess their evolution and understand the potential role of MPAs in the conservation of marine forests. With this contribution, we would like to remark the importance of conducting research on marine forests of *Fucales* in MPAs that may represent priority sites for the conservation of healthy forests and for the recovery of degraded ones.*

Key-words: *Cystoseira*, marine protected areas, marine forests, algae, Mediterranean Sea

Introduction

Since many centuries Mediterranean populations have exploited coastal ecosystems for their development. In the last decades this phenomenon intensified with increased pollution, fishing, tourism and an uncontrolled coastal urbanisation (Caddy, 1993; Airoidi, 2003; Ludwig *et al.*, 2009), so that important changes have occurred on coastal ecosystems (Airoidi & Beck, 2007) but, unluckily, they are difficult to quantify due to the lack of historical data. As a result, a set of conservation measures have been conceived at the regional, national or international level to protect this biodiversity (for a review see Micheli *et al.*, 2013). Nowadays, nearly 700 Marine Protected Areas (MPAs) have been established in the Mediterranean Sea, covering nearly 5% of its surface (including the Pelagos Sanctuary, representing alone 4% of the surface), while merely 0.1% of the Mediterranean total surface is included in no-take zones. Such percentages are even smaller if we consider only the 161 MPAs of national status that cover 0.73% of the Mediterranean Sea (Gabrié *et al.*, 2012). The 33 SPAMIs (SPA/BD Protocol) usually overlap with national MPAs and therefore in the following text, we include them in the general term MPAs. However, MPAs are often established more according to political or socio-economic choices than conservation aspects (Leenhardt *et al.*, 2013), and only less than half of them have a management plan or have evaluated the status and the distribution of marine habitats, among which algal forests. Indeed, contrarily to what generally happens on land, where vegetation has a priority role in the establishment of protected areas (e.g. many forest-reserves were established in the

world to reduce deforestation), marine forests are not considered in the creation of MPAs and they are generally not targeted in monitoring programs or in the evaluation of MPA efficacy. An exception is the CARLIT index, applied in the North-Western Mediterranean and in the Adriatic Seas in the framework of the Water Directive 2000/60/EU (Ballesteros *et al.*, 2007; Mangialajo *et al.*, 2008), that use the distribution of very shallow *Cystoseira* forests to assess the ecological status of coastal shallow waters. It is now widely accepted that marine forests of large brown seaweeds (represented by the genus *Cystoseira* and *Sargassum* in the Mediterranean Sea) are some of the most important marine habitats, forming extended canopies comparable to land forests and providing refuge and subsistence for many organisms, including fish (Jones *et al.*, 1994; Ballesteros *et al.*, 1998). However, many large brown forests are considered threatened worldwide and several studies described the loss of *Cystoseira* forests in the Mediterranean Sea (for a review see Airolidi *et al.*, same issue). Only few events of natural recovery have been reported at present, and especially in MPAs (Bonaviri *et al.*, 2009; Hereu & Quintana, 2012; author's personal data). MPAs could have a strong potential for conservation of large brown algae forests because they may guarantee protection from several kinds of direct (i.e. coastal development and destructive fishing) and indirect (cascade effects of overfishing) human impacts that are the major causes of loss of these forests (Gianni *et al.*, 2013).

The aim of this work was to quantify the contribution of scientific research to the study of large brown algae forests in the Mediterranean MPAs in order to estimate the degree of knowledge of this habitat compared to other major habitats and/or species.

Materials and methods

We identified Mediterranean MPAs using the MedPAN list (see Gabrié *et al.*, 2012). In our work we considered only 113 national MPAs out of 161, because we excluded coastal protected areas mainly characterised by wetlands or land, with no evidences for a real protection of the marine environment. We also considered 32 SPAMIs out of 33: we excluded the Pelagos Sanctuary because it is mostly characterized by pelagic waters. Natura 2000 sites were not considered in this work because most of them are still in the establishment process or lack a management plan, including a specific regulation for tourism or marine resources exploitation. We searched ISI Web of Science in order to quantify the number of international scientific papers produced on each MPAs. In this way we can obtain replicable results, although, unfortunately, grey literature or national papers are not considered. Papers were found searching the crossed topics:

- "name of the MPA" and
- "* protected area*" or "park" or "marine reserve*" or "nat* reserve*" or "monument" or "Mediterranean".

We selected all studies performed in the MPAs focused on the marine environment, whether or not the authors considered the protection of the site as mandatory for their study. In addition, we evaluated the number of papers on algae, on Fucales, on seagrasses and on fish combining to the previous search the following topics, respectively:

- "*alga*" or "seeweed"
- "Fucales" or "furoids" or "*Cystoseira*" or "*Sargassum*"
- "seagrass" or "*Posidonia*" or "*Cymodocea*" or "*Zostera*"
- "fish*"

In this study, we considered papers with algae, seagrasses or fish as main subject, but also papers focused on other topics and reporting some analyses or observations on algae, seagrasses or fish. All our searches are updated to July 2014. For the entire dataset and for each MPA, we identified the papers considering the protection as mandatory for the study (hereafter MPA papers) in contrast to the general studies not considering the protection (hereafter General papers) and we calculated the relative proportions of studies on algae, Fucales, seagrasses and fish.

Results

In total, 1500 studies were carried out in the 113 MPAs (512 of which in the 32 SPAMIs), but merely 38% of them were specifically performed in those sites because they were protected (MPA papers). Studies on marine vegetation (algae and seagrasses) represented 15% of all studies and 26% of MPA papers. Papers on algae represented 9% of all studies and 14% of MPA papers (40% of which centred on Fucales). Studies on seagrasses represented about 6% of all studies (mostly on *Posidonia oceanica*) and 12% of MPA papers. Studies on fish assemblages represented 22% of all studies and 36% of MPA papers. Such percentages were coherent with the ones calculated only on SPAMIs. Only 20 out of the 113 Mediterranean MPAs with national status had at least 10 MPA papers published in international journals (henceforth it will be mentioned as Highly studied MPAs), 12 of which are also SPAMIs. In Fig. 1 the amount of MPA and General papers are reported for the Highly studied Mediterranean MPAs. The totality of studies performed at Miramare and Cerbère-Banyuls MPAs were focused around the protection effect (MPA papers). A great percentage of MPA papers (> 70%) was also found for Tabarca, Tavolara-Punta Coda Cavallo, Torre Guaceto, Asinara, Port-Cros and Scandola MPAs. On the contrary, in Zakynthos, Cap de Creus, Palma Bay and Columbretes islands only 30% of studies was performed there because of the protected status of the site. The relative proportion of papers on algae (excluding Fucales), on Fucales, seagrasses and fish respect to the number of MPA papers carried out at the highly studied MPAs is reported in Fig. 2.

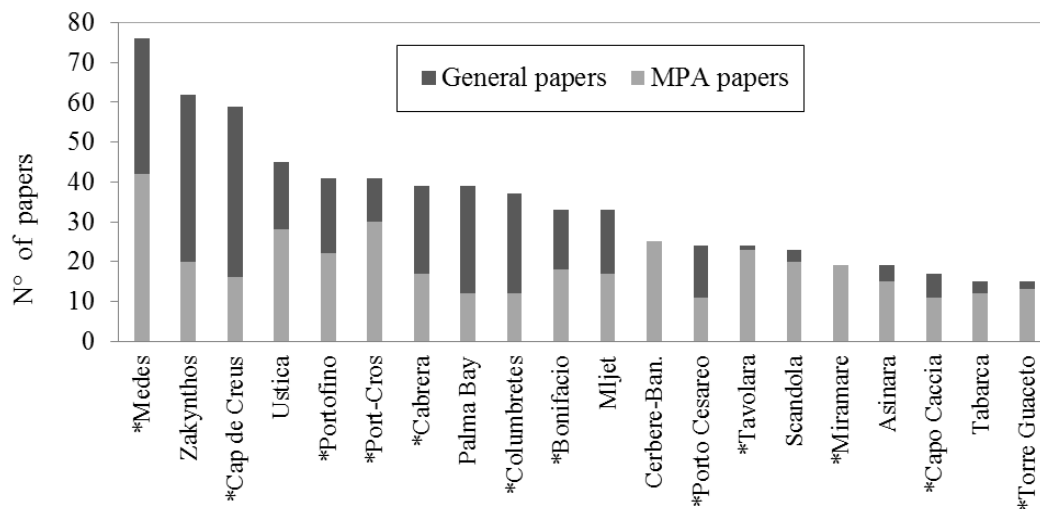


Figure 1. Amount of papers considering the protection as mandatory for the study (MPA papers) and of papers not considering the protection as mandatory (General papers) in highly studied (at least 10 MPA papers) MPAs. MPAs with an asterisk are also SPAMIs.

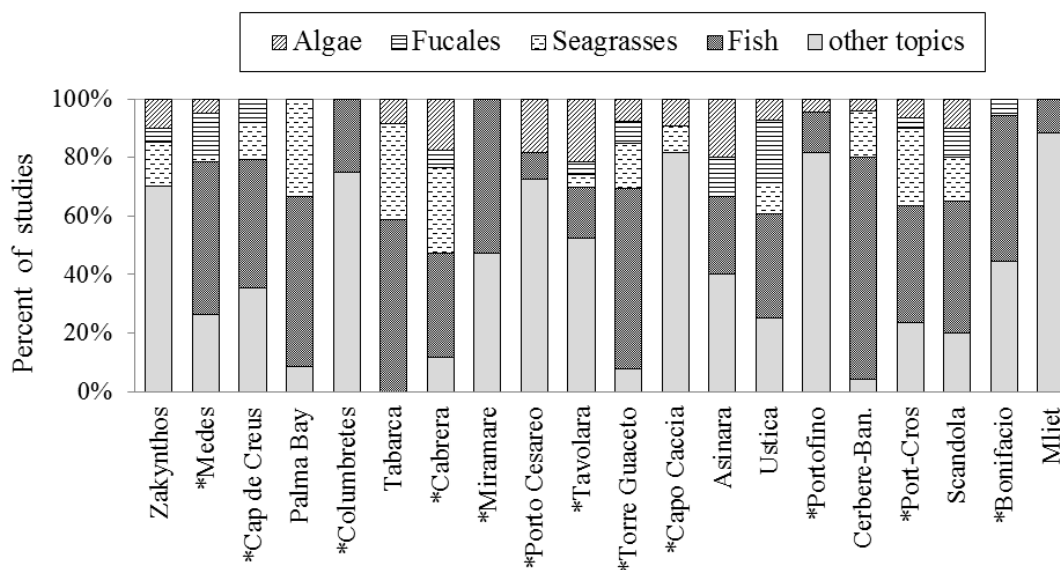


Figure 2. Percentages of studies on algae (excluding Fucales), Fucales, seagrasses, fish and “other topics” in MPA papers (considering the protection as mandatory for the study) for highly studied MPAs (at least 10 MPA papers). MPAs with an asterisk are also SPAMIs.

The highest percentage of studies on algae, including also Fucales, was done in the protected areas of Ustica, Asinara and Tavolara (30-40%). In almost all other MPAs, papers considering algae represented less than 20%. The percentage of studies on Fucales was also lower in all MPAs (< 15%), except for Ustica (21%). Papers on seagrasses were mostly carried out in Palma Bay, Tabarca island, Cabrera archipelago and Port-Cros, where they represented nearly 30% of MPA papers. In our search we did not find any study on marine vegetation of the protected areas of Columbretes, Miramare and Mljet. In contrast, the percentages of papers on fish were almost always greater than the ones on marine vegetation (> 30%). Torre Guaceto and Cerbère-Banyuls were the MPAs with the highest percentage of studies on fish (> 60%).

Discussion

According to the Convention of Biological Diversity (reviewed in 2010), by 2020 10% of the Mediterranean Sea’s surface should be protected. In order for this to be a reality, more MPAs have to be established. However, as we showed in this work, in many national MPAs a big amount of research did not consider the protection as mandatory (General papers). This is partially due to the fact that data previous MPA establishment are lacking, so it is often difficult to assess the effect of protection on some habitats (i.e. marine vegetation). Only 20 out of 113 MPAs can be considered as highly studied MPAs. Such MPAs include the biggest and/or the long-established ones and most of them belong to France, Italy and Spain, the Mediterranean countries where most of marine research published on international journals is carried out. For instance, many North-African and Middle-East MPAs were established more than 30 years ago, but few international studies are available. Information on marine forests potentially exists in these MPAs, but it is hardly accessible, consisting in grey literature or being written in other languages than English. The highest percentage of studies carried out in Mediterranean MPAs is focused on fish assemblages, the compartment usually more facilitated by the protection (generally fishery limitations). Seagrasses, and in particular

Posidonia oceanica meadows, were object of several studies in different MPAs, since their ecological role is widely recognised (Personnic *et al.*, 2014). The amount of studies on *P. oceanica* was comparable to the amount of studies on all algae. Indeed, we found a low percentage of studies focused on *Cystoseira* and *Sargassum* and they were astonishingly almost absent in many well-managed MPAs where it is still possible to find dense marine forests (e.g. Tavolara-Punta Coda Cavallo, Columbretes). Ustica MPA had the higher number of papers on *Cystoseira* forests, because many studies investigated the cascade effects of sea urchins proliferations on benthos and highlighted the loss and then a gradual recovery of macroalgal assemblages (among others: Gianguzza *et al.*, 2006; Bonaviri *et al.*, 2009).

Although *Cystoseira* species are listed in the annexes of some European Conventions (Barcelona Convention, 1976 and Bern Convention, 1979), they are still unprotected and little studied. In order to ameliorate the conservation of marine forests in the Mediterranean Sea, the implementation process of MPAs has to be improved and the management has to be planned on the base of a complete and detailed habitat mapping of marine vegetation. The establishment of Natura 2000 marine sites is often accompanied by the cartography of habitats (e.g. in France), following the Habitat Directive annexes (Directive 92/43 EEC). *Posidonia oceanica*, priority species for this Directive, is therefore well documented in Natura 2000 sites and we have now good information on its health and evolution. Unluckily, large brown seaweeds (i.e. *Cystoseira* species), although mentioned in the previous Conventions, are not included in the Habitat Directive, so that the cartography done in the Natura 2000 sites usually reports merely “photophilous algae on rocky bottom”, without any specification if macroalgal communities are deserts of encrusting corallinales, filamentous algae, shrubs of photophilous algae or forests of large brown algae. In conclusion, results of our work highlighted a lack of information on marine forests in Mediterranean MPAs, especially compared to other communities (i.e. fish assemblages or *P. oceanica* meadows). Although grey literature and old papers were excluded by our search, we are confident that the results would have been comparable to the ones obtained with the search on ISI Web of Science.

MPAs can theoretically have an important role for marine forests conservation. Unluckily, the current state of knowledge does not allow assessing if present regulations in MPAs are protecting healthy marine forests and/or enhancing natural recovery of the degraded ones (Sala *et al.*, 2012). Protection of Mediterranean coastal ecosystems should be evaluated with a constant monitoring of the distribution and status of marine forests and we suggest that future research priority should be the assessment of the conservation status of Fucales in particular in the MPAs, in order to better understand the real role of present protection rules in the conservation of healthy forests and, potentially, in the restoration of damaged ones.

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