



A regional network of sustainable managed areas as the way forward for the implementation of an Ecosystem-Based Fisheries Management in the Mediterranean

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ARTICLE INFO

Article history:

Available online 5 May 2012

ABSTRACT

In the Mediterranean there are a number of key issues that demand attention in relation to the application of Ecosystem-Based Fisheries Management. First, this region is considered a biodiversity hotspot where the pressures of human activities on ecosystems are predicted to increase. Second, fisheries in the Mediterranean, despite its significant impact, have not adopted the widely advocated ecosystem-based management. And third, the complex political situation in the Mediterranean, with many countries involved and a large fraction of international waters obstructs the adoption of a common management strategy. The way forward for ecosystem protection requires an enhancement of marine spatial planning, throughout the establishment of a network of sustainable managed areas. This network should be implemented at the Mediterranean regional scale, improving and integrating the best available knowledge to inform decision making and develop regional-based strategies. A regional management body should assume the coordination to ensure the success of a common strategy and safeguard the correct functioning of an ecosystem-based management. But first Mediterranean countries need to overcome their lack of cooperation and adopt a trans-boundary strategy.

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1. Introduction

Global marine biodiversity underpins the provision of essential goods and services for mankind and consequently the loss of the diversity of species and habitats has become a major concern (Costanza et al., 1997; Levin et al., 2009). One of the most widely acknowledged tools to preserve biodiversity against mounting anthropogenic pressures has been the establishment of areas restricted to certain activities and management of these areas through spatial planning (Douvere, 2008). Since the beginning of the 1990s the Convention on Biological Diversity (CBD) of the United Nations has been a core driver of attempts to prevent or

mitigate biodiversity loss worldwide. The Strategic Plan for Biodiversity 2011–2020 of the CBD states: “By 2020, at least 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are protected through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based protection measures”. This target was even more ambitious for the European Union that was committed to “halt the loss of biodiversity” and to reach Good Environmental Status by 2020 under the Marine Strategy Framework Directive (MSFD, Council Directive 2008/56/EC). However, these targets are unlikely to be achieved in the near future and presently more than a third of the world's oceans are heavily impacted by human activities (Halpern et al., 2008; Coll et al., 2010).

In the Mediterranean Sea context, the halt of biodiversity loss is important as this region is considered a biodiversity hotspot (Coll et al., 2010; Bianchi and Morri, 2000) and the ecosystem effects of human activities are predicted to increase. Progress has been

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made to reduce some pressures through specific legislation on atmospheric emissions, freshwater quality and waste water treatment (e.g. EU Water Framework Directive, 2000/60/EC), but fisheries remain a problematic sector that needs wider recognition of sustainability issues. Most fisheries in the Mediterranean, if at all actively managed, have taken a single species approach (Cacaud, 2005). The implementation of an Ecosystem-Based Fisheries Management (EBFM) (Pikitch et al., 2004) in the Mediterranean has in part been hampered by lack of a good understanding of the ecological role of species affected by fishing activities, as well as knowledge about their distribution and their corresponding habitats overlapped with the distribution of fishing activities. Moreover, the complexity of the Mediterranean from both geophysical and political perspectives makes the adoption of management actions at the regional scale difficult (Cacaud, 2005; Suárez de Vivero et al., 2009).

In the present work we discuss the existing problems regarding the protection of ecosystems from fishing activities in the Mediterranean and how these could be addressed regarding scientific management, international cooperation and the establishment of a regional management plan. An essential component of this management plan should be the establishment of a network of sustainable managed areas under the framework of an EBFM. We argue different aspects important for the implementation of an EBFM at the Mediterranean scale: 1) the lack of a systematic collection of data regarding the spatial distribution of biological communities and fishing activities that hampers the implementation of spatial planning in the framework of an EBFM; 2) the complex geopolitical context in which both the protection of marine ecosystems and fisheries management has to be implemented, and 3) the consequent failure of the existing ecosystem protection measures in areas associated to fishing grounds; finally 4) we discuss the implementation of a network of sustainable managed areas at a regional scale.

2. Towards the adoption of an Ecosystem-Based Fisheries Management in the Mediterranean: spatial distribution of sensitive habitats and fishing activities to identify hotspots for protection

Considering its small dimensions (1% of the global oceans' surface) the Mediterranean is one of the world's priority conservation areas as the region harbours approximately 17,000 marine species (see (Coll et al., 2010) for a recent review). Habitat diversity is also high with several habitats included in the European Commission Habitats Directive (Council Directive 92/43/EEC). Some of these habitats increase the structural complexity of soft bottoms, supply shelter for particular species, and represent an oasis of high production that counteracts the oligotrophic conditions of the Mediterranean (Ordines and Massutí, 2009; Colloca et al., 2004): *Posidonia oceanica* meadows, maërl (*Lithothamnium coralloides* and *Phymatolithum calcareum*), beds of the Anthozoa *Isidella elongata* and *Funiculina quadrangularis* and the Crinoidea *Leptomitra phalangium* and deep-water corals (*Lophelia pertusa* and *Madrepora oculata*). The deep sea, although generally poor in species richness, harbours several diversity hotspots (Danovaro et al., 2010), e.g. seamounts, cold water corals, submarine canyons (de Juan and Leonart, 2010). Despite these records, many habitats have been poorly sampled, particularly in deep seas, and several species-rich taxonomic groups, especially of the smaller organisms, remain poorly studied (Coll et al., 2010). This problem is even more critical for the functional diversity because little information exists about the functions many species fulfils within the Mediterranean ecosystems. One reason for this shortage of data is a low financial support for large scientific programs, and also a difficulty to explore

the deep seas that are a large fraction of the Mediterranean basin (57.8% of the basin is deeper than 1000 m). Data exist about the spatial distribution of key species at a local or meso-scale in the Mediterranean (e.g. (Abella et al., 2005; Gouraguine et al., 2011; Tserpes et al., 2008)) and some localized efforts have also been made for mapping sensitive and essential fish habitats that are important for the management of fishery resources (e.g. (de Juan and Leonart, 2010; Georgiadis et al., 2009; Peña and Barbara, 2008; Sciberras et al., 2009; Barberá et al., 2012; Ardizzone, 2006)). A large quantity of the existing scientific data, including results from marine biodiversity surveys, are very fragmented and scattered, and frequently they are available only on paper or in old electronic format. Increasing our spatial knowledge is essential in order to form a more complete picture of the currently patchy and disperse local information, but a systematic mapping of habitats and communities on a regional scale is still missing. Scientific and technical efforts are increasing in Mediterranean countries to gather information on the distribution of habitats, e.g. the European Nature Information System (EUNIS), MarBEF EU Network of Excellence and European Register of Marine Species, NATURA 2000 framework, and relevant international conventions as Barcelona Convention. But yet many developing countries in the Mediterranean cannot afford to implement comprehensive research on all marine habitats and species within their national jurisdiction.

The basic point for an adequate regional EBFM is to provide maps of vulnerable ecosystems overlapped with fishing activities. This objective is now hampered by lack of adequate data and problems for accessing to certain data sets, such as Vessel Monitoring Systems (VMS) that constitute basic information to estimate fishing effort distribution, as responsible national institutions are often reluctant to make this information public. Moreover, only vessels larger than 15 m are included in the current EU VMS (only compulsory for EU countries), while many vessels operating in the Mediterranean tend to be smaller. For example for Spanish fleet only 18% of fishing vessels were included in the VMS data in 2010. Among the wide variety of fishing techniques currently practised in the Mediterranean (more than 40 types of fishing gears have been described), bottom trawling has been identified as the fishing activity with the greatest environmental impact (de Juan et al., 2007). However, the pelagic purse seine, trolling and long-lining also have important ecosystem impacts, especially around spawning and migratory routes of large pelagic species (e.g. cetaceans and tuna fish in the Alboran Sea and Strait of Gibraltar) (de Juan and Leonart, 2010; Carreras, 2004). The artisanal fisheries, despite being coastal and generally considered sustainable, target some rare species and important top predators (Tudela, 2004). In addition to the commercial fishing sector, recreational fishing is particularly important in the Mediterranean, representing more than 10% of total fisheries production in the area (Morales-Nin et al., 2005). Available statistics of total landings in the Mediterranean show an increasing trend until the mid-1990's and stable yields, around 1,000,000 tons/years, in recent years (FAO FishStat, 2010; www.fao.org). This stable trend has to be viewed against the backdrop of an overall increasing mortality (Leonart, 2005) despite efforts of the EU in promoting the reduction of the fleet capacity over the past decade (Pascoe and Grêboval, 2003). Generally the economic importance of the fishing industry has decreased (e.g. in Spain the fishing sector corresponds to 0.1% of the GNP while tourism generates around 10%). However, the fishing sector has a strong influence on political decision making and together with subsidies has allowed Gross Tonnage of the fishing vessels to increase keeping catches stable while stocks of many target species are in decline (Leonart, 2005). This is a global problem, as subsidies allow the reduction of economic losses while maintaining the overexploitation of ecosystems (Norse et al., 2012).

Despite mounting evidence demonstrating the overexploitation of ecosystems in the Mediterranean (FAO General Fisheries Commission for the Mediterranean, 2010a), the EBFM is far from being implemented and actual fisheries management tends to be restricted to technical measures like establishing maximum horse power of fishing vessels or minimum mesh sizes for certain fishing gear types (Suuronen and Sarda, 2007). Currently only the tuna fisheries is actively managed and controlled by Total Allowable Catch (Oshima et al., 2010). In this context, an ocean zoning system is necessary to ensure the wide range of marine activities is sustainable (Douve, 2008; Crowder and Norse, 2008). It can encompass several types of subareas e.g. no-take sites for the highly vulnerable habitats, sites restricted for the operation of only the most damaging activities i.e. bottom trawling for vulnerable benthic habitats or pelagic gears for important migratory routes of large pelagic species, limiting fishing effort through access, i.e. permit schemes or restricting effort temporally to protect vulnerable phases of certain species 'life cycles'. Managers must establish clear goals and priorities and, therefore, should first analyse the degree of restriction that every site requires (Douve, 2008). The restriction of fishing activities must be accompanied by enforcement and control of the existing technical measures and by improving other measures like the selectivity of fishing gears in terms of species and/or sizes. These actions should be carried out through the coordination of regional fisheries management as the protection of different ecosystems across various territorial and international waters will only be achievable by strong between-countries collaboration.

One important component of the EBFM is the implementation of areas restricted to fishing activities or sustainable managed areas (Douve, 2008; Pikitch et al., 2004), but to ensure the success of this strategy the Mediterranean countries would need to adopt a common approach. To date there are around 110 Marine Protected Areas (MPAs) in 22 countries, which account for 9 million ha (ca. 4% of the Mediterranean surface). If only no-take MPAs are considered the percentage of protected area decreases to 0.1% and 92% of these cover less than 30 km² (Fig. 1; Table 1). But most of the existing MPAs have five common characteristics (Francour et al., 2001; Abdulla et al., 2008): i) they are coastal, ii) they are within territorial

waters, iii) they are mainly in the northern basin, iv) generally they do not match critical areas for ecosystem protection from fishery activities, and v), many of them exist only on paper and the protection has never been enforced. Moreover, most of these areas are too small and often ineffective, partially due to lack of monitoring and enforcement of measures (Badalamenti et al., 2000). Specifically, open-sea and deep-sea sites have little progress in protection. For example, the Sanctuary of Cetaceans "Pelagos" in the Ligurian Sea was the first protected area established in the high seas and this site was designated under a trilateral agreement between France, Italy and Monaco in 2002 (Fig. 2) (Notarbartolo-di-Sciara et al., 2008). It covers around 8 million ha (i.e. 90% of the total surface area of MPAs in the Mediterranean); however, its management has proven difficult (Notarbartolo-di-Sciara et al., 2008). The existing Fishery Restricted Areas (FRAs) implemented by the General Fisheries Commission of the Mediterranean (GFCM) are also located in the high seas (the Nile hydrothermal vents, Santa Maria di Leuca cold water corals and Erathostenes Seamount) but in these highly sensitive habitats only towed gears are prohibited (Fig. 2) (de Juan and Leonart, 2010). Another protection regulation referring to the high seas is the prohibition of using towed gears beyond 1000 m depth (Recommendation GFCM/2005/1), but it only bans bottom trawling in an area where historically fishing has not taken place.

3. Legal framework for the management of fisheries and protection of marine ecosystems in the Mediterranean: a complex geopolitical context

The current trend in Europe for conserving marine ecosystems is to use area-based measures. Clear examples are the creation of MPAs to protect species and habitats through the Barcelona Convention and the EU Nature 2000 Network under the Habitat Directive (Council Directive 92/43/EEC) and the Bird Directive (Directive 2009/147/EC) and the promotion of MPAs to protect species and habitats through the MSFD. The declaration of areas protected from fisheries through the MSFD and the EU Mediterranean Regulation (Council Regulation EC1967/2006) are initial efforts to introduce a spatial component in the reform of the

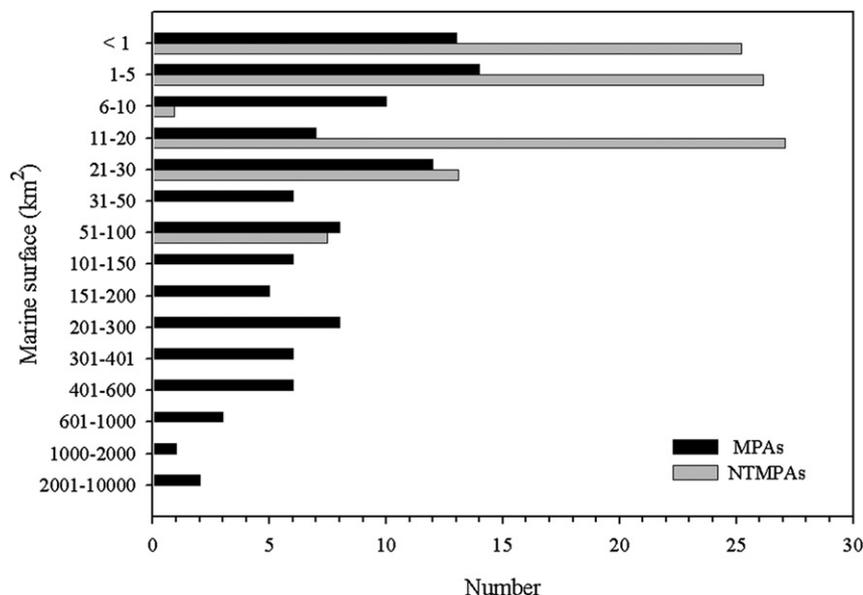


Fig. 1. Number of Marine Protected Areas (MPAs) and No-Take Marine Protected Areas (NTMPAs) in the Mediterranean Sea according to the marine surface covered. The Sanctuary of Cetaceans in the Ligurian Sea, between France, Monaco and Italy which covers around 8 million ha and represents 90% of MPAs surface is not included.

Table 1
List of Mediterranean countries indicating the kilometres of coastline, the number and the total surface of the Marine Protected Areas (MPAs) and No-Take Marine Protected Areas (NTMPAs) surface. This information has been obtained from the projects MedPAN (www.medpan.org), Global MPA (www.mpaglobal.org) and Abdulla et al. (2008).

Country	Mediterranean coastline (km)	Number of MPAs	Marine surface (km ²)	No-take surface (km ²)	NTMPA/MPA (%)
Albania	418	1	–	–	–
Algiers	1200	1	27.0	0.0	0.0
Bosnia Herzegovina	23	0	0.0	0.0	0.0
Croatia	5835	8	837.2 ^c	17 ^c	2.0
Cyprus	782	1	5.5	–	–
Egypt	955	0	0.0	0.0	0.0
France	1703	7	923.2 ^c	17.2 ^c	1.6
Greece	15021	5	2174.2 ^c	0.0 ^c	0.0
Israel	179	5	18.0	0.0	0.0
Italy	7375	28	2995.6	124.4 ^c	4.2
Lebanon	225	1	4.2	0.5	11.9
Libya	1770	0	0.0	0.0	0.0
Malta	180	2	11.6	0.0	0.0
Monaco	4	2	0.5	0.02	4
Montenegro	394	0	0.0	0.0	0.0
Morocco	512	2	196.0 ^c	94.0 ^c	48.0
Slovenia	47	3	1.6	0.2	12.5
Spain	3562	22	1060.2	93.4	8.8
Syria	183	3	50.0	0.0 ^c	0.0
Tunisia	1298	2	51.5	4.0	7.8
Turkey	5191	12	1973.4	0.0 ^c	0.0
UK (Gibraltar)	12	1	0.4	0.0	0.0
International ^a		1	87500.0	0.0	0.0
Deep-sea FRA ^b		4	17555.0	0.0	0.0
Total	46869	111	115383.1	356.2	0.3

Note: The GFCM established a protection for deep sea (Recommendation GFCM/2005/1: "The Members of the GFCM shall prohibit the use of towed dredges and trawl nets fisheries at depths beyond 1000 m of depth"). This corresponds to a sea surface of approx. 1,459,000 km², equivalent to 57.8% of the Mediterranean.

^a Pelagos Sanctuary between France, Italy and Monaco.

^b Deep-sea Fisheries Restricted Areas according to the General Fishery Commission for the Mediterranean (GFCM) concerning the "Establishment of fisheries restricted areas in order to protect the deep sea sensitive habitats" (Recommendation GFCM/30/2006/3). The Gulf of Lions slope (Recommendation GFCM/33/2009/1) is provisional for 2009.

^c Underestimated values due to no information for some MPAs have been reported in the different sources consulted.

Common Fishery Policy of the EU (COM, 2009). The MSFD constitutes the central component of the Union's future maritime policy, but generally initiatives are limited in what they can achieve as they tend to be adopted only by signatory nations. The principal goal of the MSFD is to achieve a Good Environmental Status at a regional level by 2020, and this role requires that fishing effects on target stocks and ecosystem components must be sustainable (Jennings and Rice, 2011). These principles urge the states to adopt regional

programs in order to protect the resources in which marine-related economic and social activities depend. Each Member State – cooperating with other Member States and non-EU countries within a marine region – are required to develop strategies for their marine waters. These actions should be implemented at three regional levels: Baltic Sea, Northeast Atlantic and Mediterranean, within the OSPAR, Helsinki and Barcelona Conventions. In 1975, the Mediterranean states adopted the Mediterranean Action Plan in the

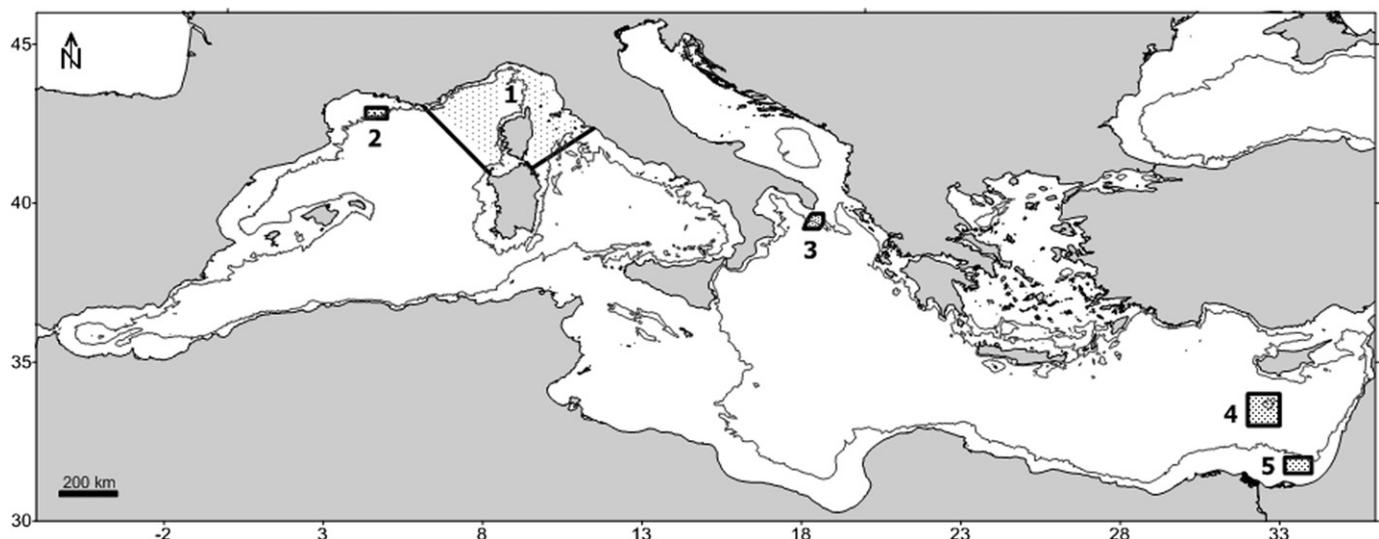


Fig. 2. Map of the Mediterranean Sea including the Pelagos sanctuary of cetaceans (1), the existing large GFCM FRAs (2: the Gulf of Lions slope, 3: St. Maria di Leuca cold coral reefs, 4: Erathostenes seamount and 5: Nile cold seeps) and the prohibition to trawl deeper than 1000 m established by GFCM (bathymetry corresponds to 1000 m, obtained from GEBCO). The coastal and national MPAs (Table 1) are not included in this figure.

framework of the United Nations Environmental Program (UNEP), which main objective was to establish a framework convention for the protection of the environment: the Barcelona Convention. Within this framework, the “Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean Sea” was adopted, which came into force in December 1999. Specially Protected Areas of Mediterranean Importance (SPAMI) are sites “of importance for conserving the components of biological diversity in the Mediterranean” (UNEP-MAP-RAC/SPA, 2010). This protocol promotes the creation of protected areas to conserve the biodiversity both in national and international waters, which implementation is undertaken with consensus of the involved countries (e. g. Pelagos Sanctuary of Cetaceans, Fig. 2).

While the political arena has now recognized the need for a more sustainable approach to fisheries management, a coordinated advance in this direction is still far from being implemented. The main potential fissure for the adoption of a regional EBFM in the Mediterranean is the complex political and geographical situation with a large number of countries with coastal areas (22) over the two shores of the sea (i.e. European Union member states vs. Middle-eastern and African countries) (Table 1). Most countries have ratified the United Nations Convention on the Law of the Sea (non-parties are Israel, Libya, Syria and Turkey) and states have established territorial waters within 12 nautical miles from the baseline (6 nm Greece and Turkey). Fourteen states have proclaimed or designated new maritime zones beyond their territorial seas in which they claim sovereign rights over the marine living resources occurring therein: Exclusive Economic Zone, others to an Ecological Protection Zone or a Fisheries Protection Zone. But these are not always accepted by all countries as most states want to preserve freedom of navigation, naval mobility and access to fisheries, causing the existence of political problems of delimitation (Cacaud, 2005). These areas represent two-thirds of the Mediterranean, turning this Sea into a harlequin’s coat composed of pieces of different fabrics. A detailed analysis of jurisdictional and legal issues in the Mediterranean and Black Sea can be found in Suárez de Vivero et al. (2010). The EU regulation framework has a key role in the protection of species and habitats in the northern coasts of the Mediterranean, but the high seas or international waters remain difficult to control. The existence of a large area of international waters requires an extraordinary level of cooperation between coastal states to ensure the sustainable management of ecosystems and the complex jurisdictional situation is the base of a general lack of willingness to establish collaborations between countries.

Few countries have developed assessment procedures to protect ecosystems beyond national jurisdiction (Abdulla et al., 2008; Ardrón et al., 2008) and, in this context, trans-boundary collaboration between states and institutions and coordination through a competent organization becomes particularly important for the adoption of an EBFM. Other initiatives that involve trans-national agreements are the trilateral cooperation for the protection of the Wadden Sea. This cooperation is a good example of how such a coordinated approach could work, however, it mainly considers an area under ultimately the same jurisdiction i.e. EU countries (Enemark, 2005). The Coral Triangle Initiative in the Pacific Ocean is another example. Here several countries collaboratively develop biological surveys, restrict fishing effort and enforce surveillance, among other coordinated measures (Fidelman and Ekstrom, 2012). The Commission for the Conservation of Antarctic Marine Living Resources is also an international organisation developing EBFM, but the need of an external international scientific body has been recognised for the achievement of ecosystem protection goals (Constable, 2011). Although these examples are not directly comparable to the Mediterranean scenario, they evidence that

cooperation across political borders to develop an independence regional management agency in the Mediterranean could be achieved.

4. Ecosystem protection strategies fall short to achieve Ecosystem-Based Fisheries Management goals

The General Fisheries Commission of the Mediterranean and the International Commission for the Conservation of Atlantic Tunas (ICCAT) are the regional organizations responsible for managing fisheries in the Mediterranean. The purpose of the GFCM is to manage fishery resources in the Mediterranean, the Black Sea and connecting waters, both in areas under national jurisdiction and on the high seas. GFCM endorses the ICCAT recommendations regarding the management of large pelagic resources. GFCM recommendations are binding for the signatory members and all Mediterranean countries, with the addition of Japan, are members of GFCM. The purpose of the Commission shall be to promote the development, conservation, rational management and best utilization of living marine resources, as well as the sustainable development of aquaculture in the Region. The mandate of these regional bodies is fisheries management, but the Ecosystem Approach to Fisheries (term adopted by GFCM to enclose EBFM objectives) has been recognized as a necessary tool to achieve the mandate (FAO General Fisheries Commission for the Mediterranean, 2010b). Otherwise, United Nations Environmental Program-Regional Activity Centre for Specially Protected Areas (UNEP-RAC/SPA) has as main mission the protection of biodiversity. The GFCM as well as UNEP-RAC/SPA have developed different approaches and implementations of areas protected from fishing activities (see Pelagos SPAMI and GFCM FRAs in Fig. 2), but the involvement of stakeholders is difficult as a Mediterranean Regional Advisory Council has not yet been developed. The European Commission identified the lack of stakeholder involvement as one of the major weaknesses of the Common Fisheries Policy, therefore, their early involvement in each consultation process will be extremely important for the success of management interventions (Pita et al., 2010) and a formalized process to implicate stakeholders in the Mediterranean is thus far not in place.

Regional disparities in governance, institutional structures, wealth distribution, social capital, and availability of ecological data are responsible for discrepancies in the establishment and effectiveness of protected areas in the Mediterranean region (Abdulla et al., 2008) (Table 1). Furthermore, the large area of international waters does not facilitate regional agreements. The Alboran and Ionian Seas have limited protection measures; there are no MPAs in the Tunisian/Gulf of Sidra region (Abdulla et al., 2008); and some countries have not yet established a single MPA (e.g. Egypt, Bosnia Herzegovina, Lybia, Montenegro). Yet there has been a rush to establish MPAs by some Mediterranean countries in the last decades and if current trends continue, 20% of the whole area could be protected by 2019. However, considering no-take MPAs i.e. where extraction of renewable resources is prohibited, this prediction could be extended until 2049 (Fig. 3), far away of the World Parks Congress recommendation, which explicitly calls for strictly protected marine reserves covering 20–30% of habitats by 2012 (Balmford et al., 2004). Despite these conflicts, the implementation of FRAs by GFCM is a good example of the EBFM progress. But the opposition to these management tools is still very influential and not all countries accept the existence of these areas. For example, the proposal for the protection of the continental slope in the Gulf of Lions, being an important spawning area for hake, was accepted but the neighbouring countries, Spain and

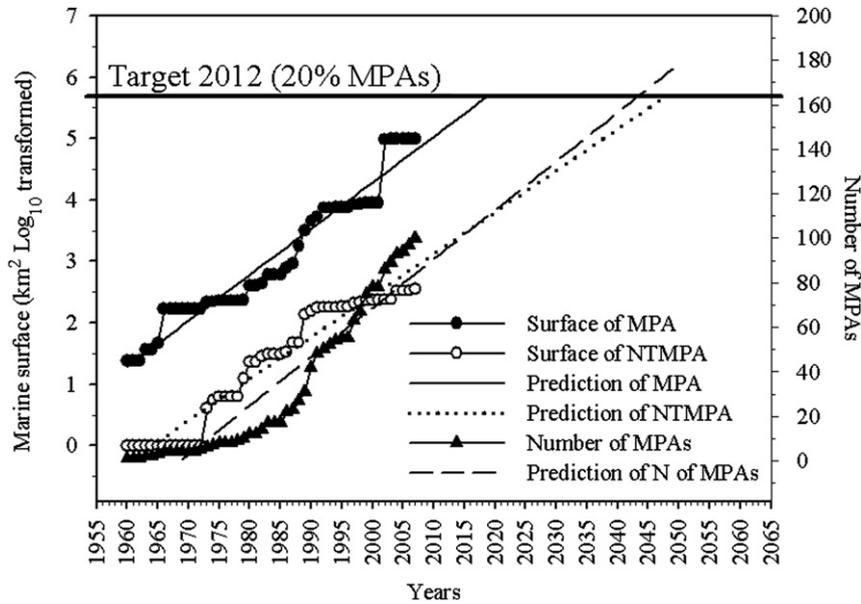


Fig. 3. Tendency of increasing the number and surface of Marine Protected Areas (MPAs) and No-Take Marine Protected Areas (NTMPAs) in the Mediterranean Sea indicating the target of covering 20% of the region by 2012 (Balmford et al., 2004).

France, only agreed to maintain the *status quo* of the fishing effort in 2008.

5. A framework for establishing a regional Ecosystem-Based Fisheries Management strategy for the Mediterranean Sea

There is no shortage of international and regional commitments, agreements, laws and scientific advice declaring the need for the protection of the Mediterranean marine habitats. However, the steps taken to date fall far short of what is needed. A regional operational strategy is imperative for preserving ecologically important habitats from the impact of fishing activities. Currently, there is poor information flow between scientists and decision-makers and there is an urgent need to organise science to

adequately inform managers that need to implement measures to achieve EBFM goals (Levin et al., 2009; Jennings and Rice, 2011). Moreover, there is a general absence of coordinated and cross-border scientific research that leads to a lack of regional-based information on the distribution of vulnerable habitats. But this should not be an excuse to postpone the protection of marine ecosystems in the current context of biodiversity loss. The first attempts to identify the priority sites for conservation in the Mediterranean have been done by different management bodies and non-governmental organizations (e.g. UNEP-RAC/SPA, (UNEP-MAP RAC/SPA, 2010); UICN, (UICN, 2010)). Based on these and other recent studies (Coll et al., 2010; de Juan and Leonart, 2010; Abdulla et al., 2008) we made a map with the priority sites for protection from fisheries (Fig. 4). These are not meant to be

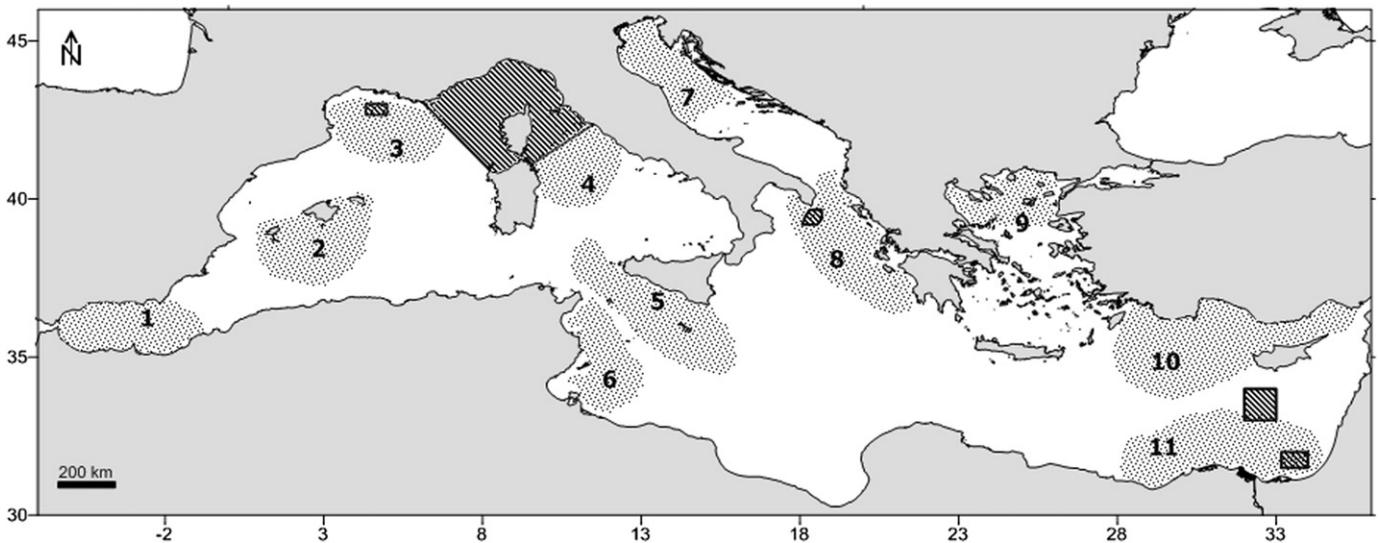


Fig. 4. Map of the Mediterranean Sea including the priority sites for protection: 1, Alboran Sea; 2, South of Balearic Islands; 3, Gulf of Lions slope; 4, central Tyrrhenian Sea; 5, Sicily strait; 6, Tunisian plateau; 7, north-central Adriatic Sea; 8, north-central Ionic Sea; 9, north Aegean Sea; 10, north Levantine Sea; 11, Nile hydrothermal area (after (Coll et al., 2010; de Juan and Leonart, 2010; Abdulla et al., 2008; UNEP-MAP RAC/SPA, 2010; UICN, 2010)). The existing GFCM FRAs and the Pelagos sanctuary of cetaceans are delimited by the black-slash polygons.

a comprehensive representation of diversity but should be the way forward to the establishment of a network of sustainable managed areas in the Mediterranean. These sites are known to harbour important habitats for many species of interest and have been identified as biodiversity hotspots. For example, the Alboran Sea and the Sicily strait are important migratory routes for large pelagic species (including the highly endangered bluefin tuna, *Thunnus thynnus*). The South of the Balearic Islands is an important area for cetaceans and a spawning area for bluefin tuna. Numerous seamounts and cold seeps can be found in the Alboran Sea, the Tyrrhenian Sea and the area off the Nile Delta; and the North-central Ionian Sea harbours the massive cold water corals at Santa Maria di Leuca. Important spawning and nursery areas for demersal species can be found at the Adventure and Malta banks in the Sicily Strait, in the Gulf of Lions, central Adriatic Sea (specially at the Jabuka Pit) and north Aegean. This network of priority areas address the need for representation of all eco-regions and, despite the complex political situation, efforts should aim to include the currently underrepresented southern shore and eastern basin.

We propose an ocean zoning system at the Mediterranean scale as a tool for an EBFM. This would be facilitated by the identification of the priority sites for conservation (Fig. 4). These priority sites should be protected under the framework of the Barcelona Convention and MSFD and managed at the Mediterranean regional scale. Currently, the only organizations that have the capacity to monitor and regulate fishing activities across borders in the Mediterranean are GFCM, ICCAT and the EU for the participant countries, and these should assume the responsibility of the adoption of regional strategies. Additionally, an independent Mediterranean Regional Advisory Council should be developed to ensure the enforcement of cross-country scientific advice and adoption of management measures. Moreover, each individual nation needs to control the activity of their fleets and ensure the eradication of illegal fishing activities through the implementation of VMS and surveillance for the smaller vessels. The present situation is still far from reaching the agreement between countries that would allow an undisputed coordination by a regional organisation. This lack of agreement when it comes to define the priority sites for conservation, to promote common management measures and to ensure the eradication of illegal fishing is still the greatest obstacle for the implementation of a regional operational strategy. A feasible option is starting by strengthening existing collaborations and urging the countries to sign and accept the agreements (e.g. Pelagos sanctuary of cetaceans), enhancing the establishment of GFCM FRAs (e.g. fishery restriction in the Gulf of Lions) and supporting the SPAMI initiatives by UNEP-RAC/SPA (UNEP-MAP RAC/SPA, 2010).

6. Conclusions

The legal status for the protection of Mediterranean marine biodiversity is relatively complex as it requires taking into account different geopolitical and economic factors. The disparities in regional governance and institutional structures, as well as the discrepancy in protection between European and non-European countries evidences the difficulties for adopting coordinate measures in the framework of EBFM. This paper also provides evidences of the difficulties that scientist and managers face to protect ecosystems, and how this could be dealt with a trans-boundary scientific management setup. The Mediterranean Sea harbours several biodiversity hotspots that are not sufficiently managed to guarantee their protection and therefore are open to deterioration by damaging fishing activities. This urges the adoption of a regional operation strategy for biodiversity conservation by restricting fishing activities in areas of ecological importance. On

the last years the GFCM has adopted actions towards the implementation of an EBFM and declared several Fishery Restricted Areas; however these actions are not yet accepted by all countries and up to date there has been a lack of will to adopt the necessary arrangements and implement a common strategy. The current European directives and Council Regulations in the Mediterranean Sea could play an important role in driving coordinated management strategy and scientific programs as basic steps to achieve EBFM goals. But the way forward for the protection of marine ecosystems in the Mediterranean requires an enhancement of marine spatial planning, integrating the best available information and implementing a regional-based coordination across the basin. This implies the existence of an effective regional management body and, although the existing regional agencies could assume this role, the involved countries must be willing to cooperate and strengthen collaboration.

Acknowledgements

The authors would like to acknowledge A. Cañadas, F. Maynou, X. Pastor, S. Requena, A. Tejedor and S. Tudela for their valuable and helpful inputs, and three anonymous reviewers for comments that greatly improved the manuscript. S.J. was funded by COMSOM project (CTM2008-04617/MAR). J.M. was supported by a José Castillejo grant (JC2008-00263) from the Spanish Ministry of Science and Innovation and is indebted to Prof M. Kaiser and the staff at School of Ocean Sciences (Bangor University) for their support and advice on the early manuscript preparation.

References

- Abdulla, A., Gomei, M., Hyrenbach, D., Notarbartolo-di-Sciara, G., 2008. Challenges facing a network of representative marine protected areas in the Mediterranean: prioritizing the protection of underrepresented habitats. *ICES Journal of Marine Science* 66, 22–28.
- Abella, A., Serena, F., Ria, M., 2005. Distributional response to variations in abundance over spatial and temporal scales for juveniles of European hake (*Merluccius merluccius*) in the Western Mediterranean Sea. *Fisheries Research* 71, 295–310.
- Ardizzone, G.D., 2006. An Introduction to Sensitive and Essential Fish Habitats Identification and Protection in the Mediterranean Sea. STECF, Rome, p. 60.
- Ardrón, J., Gjerde, K., Pullen, S., Tilot, V., 2008. Marine spatial planning in the high seas. *Marine Policy* 32, 832–839.
- Badalamenti, F., Ramos, A.A., Voultziadou, E., Lizaso, J.L.S., D'Anna, G., Pipitone, C., et al., 2000. Cultural and socio-economic impacts of Mediterranean Marine Protected Areas. *Environmental Conservation* 27, 110–125.
- Balmford, A., Gravestock, P., Hockley, N., McClean, C.J., Roberts, C.M., 2004. The worldwide costs of marine protected areas. *Proceedings of the National Academy of Sciences of the United States of America* 101, 9694–9697.
- Barberá, C., Moranta, J., Ordines, F., Ramón, M., Mesa, A., Díaz-Valdés, M., et al., 2012. Biodiversity and habitat mapping of Menorca Channel (western Mediterranean): implications for conservation. *Biodiversity and Conservation* 21, 701–728.
- Bianchi, C., Morri, C., 2000. Marine biodiversity of the Mediterranean Sea: situation, problems and prospects for future research. *Marine Pollution Bulletin* 40, 367–376.
- Cacaud, P., 2005. Fisheries Laws and Regulations in the Mediterranean: A Comparative Study. Studies and Reviews, General Fisheries Commission for the Mediterranean. FAO.
- Carreras, C., 2004. Incidental catch of the loggerhead turtle *Caretta caretta* off the Balearic Islands (western Mediterranean). *Biological Conservation* 117, 321–329.
- Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Ben Rais Lasram, F., Aguzzi, J., et al., 2010. The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. *PLoS ONE* 5, e11842.
- Colloca, F., Carpentieri, P., Balestri, E., Ardizzone, G.D., 2004. A critical habitat for Mediterranean fish resources: shelf-break areas with *Leptometra phalangium* (Echinodermata: Crinoidea). *Marine Biology* 145, 1129–1142.
- COM. Reform of the Common Fisheries Policy. 163 Final Green Paper. EU. 2009, p. 27.
- Constable, A.J., 2011. Lessons from CCAMLR on the implementation of the ecosystem approach to managing fisheries. *Fish and Fisheries* 12, 138–151.
- Costanza, R., D'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., et al., 1997. The value of the world's ecosystem services and natural capital. *Nature* 387, 253–260.

- Crowder, L., Norse, E.A., 2008. Essential ecological insights for marine ecosystem-based management and marine spatial planning. *Marine Policy* 32, 772–778.
- Danovaro, R., Company, J.B., Corinaldesi, C., D'Onghia, G., Galil, B., Gambi, C., et al., 2010. Deep-Sea biodiversity in the Mediterranean Sea: the known, the unknown, and the unknowable. *PLoS ONE* 5, e11832.
- de Juan, S., Leonart, J., 2010. A conceptual framework for the protection of vulnerable habitats impacted by fishing activities in the Mediterranean high seas. *Ocean & Coastal Management* 53, 717–723.
- de Juan, S., Thrush, S.F., Demestre, M., 2007. Functional changes as indicators of trawling disturbance on a benthic community located in a fishing ground (NW Mediterranean Sea). *Marine Ecology Progress Series* 334, 117–129.
- Douvere, F., 2008. The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy* 32, 762–771.
- Enemark, J., 2005. The Wadden Sea protection and management scheme - towards an integrated coastal management approach? *Ocean & Coastal Management* 48, 996–1015.
- FAO FishStat, 2010. Food and Agriculture Organization of the United Nations (FAO), FishStat Plus, 2010; www.fao.org/fishery/statistics/en.
- FAO General Fisheries Commission for the Mediterranean, 2010a. Report of the Thirty-fourth Session. Athens, Greece, 12–17 April 2010. GFCM Report. No. 34. FAO, Rome, p. 98.
- FAO General Fisheries Commission for the Mediterranean, 2010b. Report of the twelve session of the Scientific Advisory Committee. Budva, Montenegro, 25–29 January 2010. FAO Fisheries and Aquaculture Report, No. 936. FAO, Rome, p. 167.
- Fidelman, P., Ekstrom, J.A., 2012. Mapping seascapes of international environmental arrangements in the Coral Triangle. *Marine Policy* 36, 993–1004.
- Francour, P., Harmelin, J.-G., Pollard, D., Sartoretto, S., 2001. A review of marine protected areas in the northwestern Mediterranean region: siting, usage, zonation and management. *Aquatic Conservation: Marine and Freshwater Ecosystems* 11, 155–188.
- Georgiadis, M., Papatheodorou, G., Tzanos, E., Geraga, M., Ramfos, A., Koutsikopoulos, C., et al., 2009. Coralligène formations in the eastern Mediterranean Sea: morphology, distribution, mapping and relation to fisheries in the southern Aegean Sea (Greece) based on high-resolution acoustics. *Journal of Experimental Marine Biology and Ecology* 368, 44–58.
- Gouraguine, A., Hidalgo, M., Moranta, J., Bailey, D., Ordines, F., Guijarro, B., et al., 2011. Elasmobranch spatial segregation in the western Mediterranean. *Scientia Marina* 75, 653–664.
- Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., et al., 2008. A global map of human impact on marine ecosystems. *Science* 319, 948–952.
- Jennings, S., Rice, J., 2011. Towards an ecosystem approach to fisheries in Europe: a perspective on existing progress and future directions. *Fish and Fisheries* 12, 125–137.
- Levin, P.S., Fogarty, M.J., Murawski, S.A., Fluharty, D., 2009. Integrated ecosystem assessments: developing the scientific basis for ecosystem-based management of the ocean. *PLoS Biology* 7, e14.
- Leonart, J., 2005. B5 – Mediterranean and Black Sea, FAO statistical area 37 (table D5). In: FAO Marine Resources Service, Fishery Resources Division, Review of the State of the World Marine Fishery Resources. FAO Rome, pp. 49–64. and 220–1.
- Morales-Nin, B., Moranta, J., García, C., Tugores, M.P., Grau, A.M., Riera, F., et al., 2005. The recreational fishery in Mallorca Island (Western Mediterranean): implications for coastal resources management. *ICES Journal of Marine Science* 62, 727–739.
- Norse, E., Brooke, S., Cheung, W.W.L., Clark, M.R., Ekeland, I., Froese, R., et al., 2012. Sustainability of deep-sea fisheries. *Marine Policy* 36, 307–320.
- Notarbartolo-di-Sciara, G., Agardy, T., Hyrenbach, D., 2008. The Pelagos sanctuary for Mediterranean marine mammals. *Aquatic Conservation: Marine and Freshwater Research* 18, 191–367.
- Ordines, F., Massutí, E., 2009. Relationships between macro-epibenthic communities and fish on the shelf grounds of the western Mediterranean. *Aquatic Conservation: Marine and Freshwater Ecosystems* 19, 370–383.
- Oshima, K., Masayuki, A., Kurota, H., Nakano, H., Takeuchi, Y., 2010. Evaluation of effects of current TAC on eastern Atlantic Bluefin tuna by future projection. *Collective Volume of Science Paper ICCAT* 65, 928–943.
- Pascoe, S., Gréboval, D., 2003. Measuring Capacity In Fisheries. FAO Fisheries Technical Paper. No. 445, p. 314.
- Peña, V., Barbara, I., 2008. Maërl community in the north-western Iberian Peninsula: a review of floristic studies and long-term changes. *Aquatic Conservation: Marine and Freshwater Ecosystems* 18, 339–366.
- Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A., Bonfil, R., Conover, D.O., et al., 2004. Ecosystem-based fishery management. *Science* 305, 346–347.
- Pita, C., Pierce, G., Theodossiou, I., 2010. Stakeholders' participation in the fisheries management decision-making process: fishers' perceptions of participation. *Marine Policy* 34, 1093–1102.
- Sciberras, M., Rizzo, M., Mifsud, J.R., Camilleri, K., Borg, J.A., Lanfranco, E., et al., 2009. Habitat structure and biological characteristics of a maërl bed off the northeastern coast of the Maltese Islands (central Mediterranean). *Marine Biodiversity* 39, 251–264.
- Suárez de Vivero, J.L., Martínez Alba, I., Martín Jiménez, J., Jiménez Sánchez, C., 2010. Jurisdictional waters in the Mediterranean and Black seas. Directorate general for internal policies. policy department B: structural and cohesion policies. IP/B/PECH/IC/2009-087. Fisheries, 140.
- Suuronen, P., Sarda, F., 2007. The role of technical measures in European fisheries management and how to make them work better. *ICES Journal of Marine Science* 64, 751–756.
- Tserpes, G., Politou, C., Peristeraki, P., Kallianiotis, A., Papaconstantinou, C., 2008. Identification of hake distribution pattern and nursery grounds in the Hellenic seas by means of Generalized Additive Models. *Hydrobiologia* 612, 125–133.
- Tudela, S., 2004. Ecosystem Effects of Fishing in the Mediterranean: An Analysis of the Major Threats of Fishing Gear and Practices to Biodiversity and Marine Habitats. In: Studies and Reviews, General Fisheries Commission for the Mediterranean, vol. 74. FAO, Rome, p. 44.
- UICN, 2010. Vers une meilleure gouvernance de la Méditerranée towards a better governance of the Mediterranean. In: Martínez, C., Bel-Hadjali, M., Habib, S., Oral, N., Gland, Simard F. (Eds.), Suisse et Malaga, Espagne, p. 39.
- UNEP-MAP RAC/SPA, 2010. In: Bazairi, H., Ben Haj, S., Boero, F., Cebrían, D., de Juan, S., Limam, A., et al. (Eds.), The Mediterranean Sea Biodiversity: State of the Ecosystems, Pressures, Impacts and Future Priorities. RAC/SPA, Tunis, p. 100.
- UNEP-MAP-RAC/SPA. Overview of Scientific Findings and Criteria Relevant to Identifying SPAMIS in the Mediterranean Open Seas, Including the Deep Sea. by Notarbartolo di Sciara G, Agardy T. Ed. RAC/SPA, Tunis 2010; p. 71.