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(Article begins on next page)

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Abstract

The deep sea covers about 79% of the Mediterranean basin, including habitats potentially able to deliver multiple ecosystem services and numerous resources of high economic value. Thus, the deep Mediterranean Sea represents an important frontier for marine resources exploitation, which is embedded within the European Blue Growth Strategy goals and agendas. The deep sea is crucial for the ecological functioning of the entire basin. For this reason, the deep Mediterranean deserves protection from the potential cumulative impacts derived from existent and developing human activities. Marine Spatial Planning (MSP) has been identified as key instrument for spatially allocating maritime uses in the sea space avoiding spatial conflicts between activities, and between activities and the environment. Indeed, MSP incorporates the ecosystem-based approach (EB-MSP) to balance both socio-economic and environmental objectives, in line with the Maritime Spatial Planning Directive and the Marine Strategy Framework Directive. Despite MSP is under implementation in Europe, the Directive is not applied yet for the managing and monitoring of the environmental status of the deep sea. In the Mediterranean, deep areas fall both in internal and territorial waters, and in High Seas, and its management framework turns out to be complicated. Moreover, a certain level of cumulative impacts in the deep Mediterranean has been already identified and likely underestimated because of paucity of knowledge related with deep-sea ecosystems. Thus, the implementation of scientific knowledge and the establishment of a sustainable management regime of deep-sea resources and space is urgent. This study aims at reflecting on the best available ecological knowledge on the deep Mediterranean to incorporate conservation objectives in EB-MSP. We propose a framework to include key ecological principles in the relevant phases of any EB-MSP processes taking in consideration existing socio-economic and conservation scenarios in the region. We add the uncertainty principle to reflect on the still unexplored and missing knowledge related to the deep Mediterranean. Here, we resume some guidelines to overcome limits and bottlenecks while ensuring protection of deep-sea ecosystems and resources in the Mediterranean Sea.

Keywords: deep sea, Mediterranean, EB-MSP, marine conservation, MSFD

Acronyms

ABMTs	Area-Based Management Tools	IMO	International Maritime Organization
ABNJ	Area Beyond National Jurisdiction	IUCN	International Union for Conservation of Nature and Natural Resources
CBD	Convention of Biological Diversity	MPAs	Marine Protected Areas
CWCs	Cold Water Corals		
DSWC	Dense Shelf Water Cascading	MSFD	Marine Strategy Framework Directive
GFCM	General Fishery Commission for the Mediterranean	MSP	Marine/ Maritime Spatial Planning
EBA	Ecosystem-Based Approach	PSSA	Particularly Sensitive Sea Area
EBM	Ecosystem-Based Management	RAC/SPA	Regional Activity Center for Specially Protected Areas
EB-MSP	Ecosystem-based Marine Spatial Planning	SPAMI	Special Protection Area of Mediterranean Importance
EBSA	Ecologically and Biologically Significant Marine Area	UNCLOS	United Nations Convention of the Law of the Sea
EEZ	Exclusive Economic Zone	UNEP/MAP	United Nations Environment Programme/Mediterranean Action Plan
EUSAIR	European Strategy for the Adriatic-Ionian Region	VME	Vulnerable Marine Ecosystem
FAO	Food and Agriculture Organisation	WESTMED	Western Mediterranean (blue economy initiative)
FRA	Fishery Restricted Area		

Marine waters jurisdictional framework under UNCLOS

Internal waters: waters on the landward side of the baseline of the territorial sea.

Territorial sea: area delimited by the outer limit of the territorial sea, which is the line every point of which is at a distance from the nearest point of the baseline equal to the breadth of the territorial sea, which corresponds to 12 nautical miles.

Exclusive Economic Zone: area beyond and adjacent to the territorial sea, subject to the specific legal regime established in this Part, under which the rights and jurisdiction of the coastal State and the rights and freedoms of other States are governed by the relevant provisions of UNCLOS. Its outer limit does not exceed 200 nautical miles.

High Seas: all parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State.

1. Introduction

The ecosystem-based (EB) approach is widely recognized as the approach to acquire for the sustainable use of nature space and resources while limiting the environmental impacts of present and future activities (Douvere 2008). Marine Spatial Planning (MSP) is crucially important for the development of the EB approach in the marine environment (Ansong et al. 2017). MSP indeed allows to avoid spatial and management conflicts between maritime uses, and to support the long-lasting preservation and exploitation of marine species and ecosystems (Ehler 2008, Outeiro et al. 2015). MSP is being implemented in the Mediterranean Sea. The Barcelona Convention is supporting all the Mediterranean countries (both Member States and non-EU countries) to implement MSP towards conservation and sustainable development (UNEP(OCA)/MED IG.6/7, 1995). Moreover, Member States are implementing MSP under the Framework Directive on MSP 2014/89/EC (MSPD, EC, 2014). The Directive conceives MSP as a comprehensive process that adopt an EB approach, potentially leading the achievement of the goals of both the Blue Growth Strategy (EC, 2012) and the Marine Strategy Framework Directive (MSFD, EC, 2008). MSP can play a fundamental role in supporting environmental conservation (Fraschetti et al. 2018; Shabtay et al. 2019), contributing in decreasing of cumulative impacts to enhance environmental protection and the achievement of Ecosystem-Based Management (EBM) goals (Halpern et al. 2010).

In the Mediterranean Sea, about 79% of the basin (ca. 2 million km^2 with an average depth of 1,500 m) includes the sea bottom and the water column below 200 m of depth, thus corresponding to deep-sea habitats potentially able to deliver multiple ecosystem services (ES) and numerous resources of high economic value. Thanks to technological advances, the exploitation of marine resources is moving off-shore and at greater depth, increasing the impacts that deep-sea ecosystems are already facing (Ramirez-Llodra et al. 2011, Fanelli et al. 2016, Grehan et al. 2017). In this context, there is the need of setting up appropriate marine plans for managing and spatially allocating future human uses in the deep sea preserving such environment (Danovaro et al. 2017a). Indeed, the sustainable exploitation and the protection of deep-sea ecosystems is a priority for the sake of preserving the wide and still unexplored biodiversity they host, as well as the outstanding numbers of benefits they provide for humans, as climate mitigation (Thurber et al., 2014; Levin and Le Bris 2015).

The MSPD, like the MSFD, has not specifically addressed the deep Mediterranean Sea, despite the growing demand for marine resources exploitation in this environment. Nonetheless, Micheli et al. (2013) found that medium-high cumulative impact levels largely cover the entire Mediterranean basin, reaching pelagic and benthic off-shore ecosystems. The level of impact in deep-sea ecosystems may be even underestimated because of the paucity of knowledge available for assessing their abiotic and biotic features, as well as their biodiversity, functioning and fragility. In fact, data and information are scattered amidst deep-sea environments and marine ecoregions (Ramirez-Llodra et al. 2010, Pape 2017, Danovaro et al. 2017b). Despite the raising studies and knowledge on these remote environments (UNEP/MAP-RAC/SPA, 2015), when modelling cumulative effects in the Adriatic and Ionian seas, Gissi et al. (2017) found that deep-sea areas were the least impacted of the entire marine area likely because of the scarcity of knowledge for the deep part of this sub-basin. Nevertheless, decision-makers need to handle this knowledge gap when incorporating deep sea in Ecosystem-Based MSP (EB-MSP). This is especially urgent for the Mediterranean Sea, where the deep sea is part of the territorial waters of several countries.

In the present study, starting from the information collected within the framework of three EU-funded projects (IDEM, SUPREME and SIMWESTMED, Friess and Grémaud-Colombier 2019; Danovaro et al., 2020), we revisited the best available knowledge on the deep Mediterranean Sea to incorporate conservation objectives in EB-MSP. Thus, we proposed a framework that includes the ecological principles elaborated by Foley et al. (2010) by distilling and bringing out the necessary and available knowledge more relevant at the basin scale to operationalize conservation in EB-MSP for the deep Mediterranean Sea. Specifically, the four key ecological principles (*EPs*) for EB-MSP implementation focus on maintaining: *EP1) native species diversity*, *EP2) habitat diversity and heterogeneity*, *EP3) key species*, and *EP4) connectivity*. Because of the extensive fragmented knowledge regarding the deep sea and its responses to human impacts, especially on a long-term scale, and the willing in considering the precautionary principle (Kriebel et al. 2001), we added the uncertainty principle *(UP)*, which is *to consider and incorporate the uncertainty*. In section 2, we presented the characteristics of the deep sea in the Mediterranean, including the future perspective related with its resources' exploitation, and its legal and environmental protection status. The presented information is essential to identify management and conservation priorities in the Mediterranean Sea. Then, in section 3, we described the four *EPs* plus uncertainty (*UP*), based on the environmental characteristics and ecological traits of the deep-sea ecosystems of the Mediterranean. Here, the basic and essential ecological knowledge framework is built to depict deep-sea ecosystems at the basin scale, to inform both deep-sea experts and non-experts (i.e. authorities, decision-makers, planners, NGOs, multi-level stakeholders). In section 4, we incorporated the principles in the relevant phases of any EB-MSP processes (Ehler and Douvere, 2009, Foley et al. 2010), by linking the ecological knowledge to the management and conservation needs. Here, we resumed some guidelines and delivered some suggestions to overcome the bottlenecks and limits while implementing the EB-MSP in the deep Mediterranean Finally, in section 5, on the base of the main results of our study, we identified the most urgent political agenda's priorities to boost EB-MSP in the deep Mediterranean Sea.

2. The deep Mediterranean Sea

2.1 The new frontier and identified future impacts

Despite the great technological advancements (Aguzzi et al., 2019), the exploration of the deep sea is still one of the main great challenge on Earth (Danovaro et al. 2014, Cunha et al. 2017). The deep Mediterranean Sea represents part of this new frontier providing both biotic (i.e. fishery, genetic resources) and abiotic (minerals and hydrocarbons) resources thanks to its environmental characteristics. Indeed, this basin faced a wide variety of environmental phenomena and changes during its geological history, which make it highly heterogeneous and bio-diversified (Bianchi and Morri 2000, Danovaro et al. 2010). The deep Mediterranean is characterized by different habitats/ecosystems and various geomorphological features supporting high biodiversity and endemism presence, from prokaryotes to vertebrates, as well as high organisms' biomass (Danovaro et al. 2010), also concerning species of high commercial values for fishery, such as red shrimps and European hakes. It also greatly offers non-living resources in the seabed and subsoil, such as oil, gas, and minerals (Piante and Ody 2015).

Beyond the overexploitation of fishery resources, which has long affected the basin even in the deep (Tsikliras et al. 2015), many are the growing maritime activities that may potentially affect the deep Mediterranean Sea, such as oil and gas extraction, deep-sea mining, and bioprospecting. For instance, oil and gas research and extraction are growing in the Maltese, Egyptian, Israeli, Syria, Cyprus and Greek agendas (The Petroleum Economist Ltd, 2013). The mining of mineral resources is developing particularly in the Tyrrhenian Sea in the form of sulphide deposits (Safipour et al. 2018). Off-shore sand deposits in the Gulf of Lion will be likely exploited in the near future (Campostrini et al. 2018). On-going plans to increase electricity transmission and communication with new cables and pipelines are present between Italy, Tunisia, and Malta, and among the Greek islands (Campostrini et al. 2018, SUPREME Project, 2017). The outstanding genetic diversity is promising in the bioprospecting scenario (Tortorella et al. 2018). Indeed, the deep Mediterranean hosts a great functional diversity (Mindel et al. 2016), as deep-sea organisms, need to cope with different environmental conditions, showing a wide range of strategic adaptive characteristics. This is particularly true in the deep Mediterranean at all biological levels (Danovaro et al. 2017b).

Finally, studies have been carried out to explore the opportunity of inject carbon dioxide under the seafloor, practice that can greatly acidify and sterilize the deep seabed (Carneiro et al. 2015).

Other than these natural resources, the deep Mediterranean is able to deliver many other ecosystem services, which are key in making this marine basin a hotspot of biodiversity, favouring biogeochemical processes, and mitigating the effects of climate change and anthropogenic C release (Thurber et al. 2014). In addition, deep-sea fauna and habitats are highly vulnerable (Rigby and Simpfendorfer 2015) to direct and indirect human impacts, such as climate change, especially in the

Mediterranean, because of both environmental and topographic characteristics (Lejeusne et al. 2010, Giorgi 2006, Micheli et al. 2013) and historical human activities, such as the deep-sea fishery to red shrimps (Fanelli et al., 2017). Thus, a sustainable management of deep-sea resources is extremely urgent, under a scenario of increasing exploitation.

2.2 Boundaries and jurisdictions

The Mediterranean Sea falls within a complex geopolitical context (Mazor et al. 2013). The countries that surround this basin are both EU and non-EU countries, with different political, legislative, and cultural systems. Furthermore, the partial political instability due to ongoing conflicts in the Middle-East and in some southern countries, such as Libya, prevent from sharing objectives and principles for conservation (Mazor et al. 2013).

The deep sea covers more than ¾ of the entire Mediterranean Sea, being a predominant part of this marine basin to be planned and managed. It falls both within and beyond countries' jurisdiction. On the base of the spatial measurement calculated starting from the updated national legislative boundaries (DOALOS, Suárez-de Vivero, Juan L. Marineplan, 2019, Figure 1), about 32% of the deep Mediterranean Sea can be defined as 'High Seas' (ca. 646,829.6 km^2). It corresponds to the waters on the continental shelf of those states that have not declared the Exclusive Economic Zone (EEZ) yet (Popova et al. 2019). The presence of geopolitical tensions and the lack of agreements relating to the exploitation of natural resources hampers the declaration of the EEZs among the Mediterranean countries (Katsanevakis et al. 2015). At present, only 11 Mediterranean countries have already declared their own EEZ (Table S1A). Considering both EEZ and high seas, several areas of intermediate jurisdiction are present, covering 5.6% of the deep sea. These areas have no official jurisdiction yet defined and agreed between coastal States, so related marine areas remain unmanageable (Suárez de Vivero, pers. Comm.)

With the exception of Slovenia, all countries of the Mediterranean basin contain deep-sea waters in their territorial seas. In ten countries, deep-sea areas are present also within inland waters. For instance, Italy and France include 30.8% and 15.7% respectively of deep-sea coverage in their internal waters (Table S1A). Spain is the EU country having declared the EEZ with the highest percentage of deep sea in all its own waters (9.6%), followed by France (3.3%) (Table S2A). If Italy and Greece would declare their EEZ, they would greatly exceed such percentages, reaching ca 21% in both cases, being the Mediterranean countries with the greatest coastline extension (Table S2A). Since MSP is a process carried out at the country level (Article 4, MSP 2014/89/EC), meaning under costal States' jurisdiction, planning the deep-sea space is and will be part of the MSP processes of the Mediterranean states because of its presence in both internal and territorial waters. Once all EEZs will be defined and declared, no high seas will be present in the Mediterranean Sea, and the deep sea in the EEZs will be part of the national marine plans.

2.3 Area-based management tools (ABMT) for conservation

On the base of the spatial measurement relatively to each ABMT, assessed through the use of data from November 2017 of MAPAMED dataset, about 4.9% of the deep Mediterranean falls within an ABMT for conservation (Table S3A). This percentage poorly represents the whole deep-sea environment (UNEP/MAP-RAC/SPA, 2015; Amengual and Alvarez-Berastegui 2018). More specifically, only the 0.62% of the protected deep sea falls within national MPAs, the only ABMT that manage different human activities entailing multiple conservation objectives (Amengual and Alvarez-Berastegui 2018). The ABMTs for conservation that include high seas in the Mediterranean are mainly designated at international level for specific conservation targets aiming at controlling environmental impacts from individual sectors, or protecting only specific environmental features, not specifically targeting the deep-sea environment. For instance, the Particularly Sensitive Sea Area (PSSA, 0.3% of the deep) was designated by International Maritime Organization (IMO) in the Strait of Bonifacio to control maritime transport impacts. The Pelagos Sanctuary focuses solely on cetaceans' protection and pelagic environment, covering 3.4% of the deep Mediterranean. This is the larger MPA established internationally in the Mediterranean, but its boundaries have been set based on political convenience rather than on ecological priorities, and, nevertheless, it has never been concretely enforced, being defined as a “paper park” (Agardy et al. 2011, Fenberg et al. 2012). The Specially Protected Areas of Mediterranean Importance (SPAMIs), defined under the Barcelona Convention, were indicated as a good example of MPA management (Amengual and Alvarez-Berastegui 2018). Nonetheless, excluding the area corresponding to the Pelagos Sanctuary, also the SPAMIs slightly cover deep-sea areas (0.01%).

ABMTs for conservation targeting deep-sea ecosystems have been designated. Seven Fishery Restricted Areas (FRAs) covering 0.9% of the deep were established by the General Fishery Commission of the Mediterranean (GFCM) to control and manage fishery, beyond the already legally binding banning of bottom trawling activity below 1000 m depth. Beyond the MAPAMED dataset, we measured the extent of the ban finding a coverage of ca. 58.4% of the deep Mediterranean. The institution of two new FRAs has been requested to GFCM, because of the occurrence of Essential Fishing Habitats (EFH) and Vulnerable Marine Ecosystems (VME) on one hand, and high human pressure (mostly in terms of trawling activities) on the other. These are the Bari Canyon (recognized as a new coral province, for which the process is running), and the Otranto channel (where both EFH and VME occur), for which the process is just at the beginning. Despite their conservation objective is focused against the fishing impact, the FRAs have been recently proposed to be considered as effective MPAs for their contribution on protecting comprehensively biodiversity and vulnerable deep-sea habitats, actually representing legally-binding multi-objectives conservation tools (Rodríguez-Rodríguez et al. 2016).

Finally, the Mediterranean counts for 15 Ecologically or Biologically Significant Areas (EBSAs), defined through scientific criteria and aiming at identifying priority areas for protection for guiding their sustainable use (Johnson et al. 2018). The EBSAs cover ca. 40% of the total deep Mediterranean Sea (Table S3A). Despite they are not an ABMT, because not subjected to proper conservation management regimes, they were been intentionally identified in offshore waters to promote conservation beyond coastal areas (Portman et al. 2013).

3. The five key principles needed to manage the deep Mediterranean Sea

In this section, we fed the four ecological principles developed by Foley et al. (2010) for the deep Mediterranean Sea with the available knowledge to support their operationalization, as well as the fifth principle *UP* related to the uncertainty. We did not pretend to include all of the existing ecological information, but resume some key features more relevant at the scale of the Mediterranean basin to start building the informative framework for an EB-MSP in the deep Mediterranean.

3.1 Ecological principle no.1: Maintain native species diversity

Studies on the deep Mediterranean Sea showed that diversity and abundance of the native deep-sea species vary widely, eventually following longitudinal-latitudinal and depth-range gradients, or even any evident patterns. The geological history of the basin, its complex mosaic of habitats, the variability in trophic resources availability throughout its length, its peculiar biological and ecological characteristics (among which the presence of endemism), drive the biodiversity in the deep Mediterranean (Fanelli et al. 2018). In Table S4A, we resumed the knowledge on the distribution trends of several groups of species that inhabit and spend part of their life in the deep Mediterranean. In general, sharp longitudinal and latitudinal gradients of benthic biodiversity are present in the deep Mediterranean, largely driven by changes in food availability (Danovaro et al. 2008b). Indeed, with increasing water depth, food sources become more limited for deep-sea productivity, which often strongly depends on surface primary production and coastal organic matter inputs (Danovaro et al. 2017b). However, the drivers guiding meio- and macrofauna diversity change at different spatial scales, affecting biodiversity pattern estimates (Danovaro et al. 2013).

Diversity distribution in deep-sea environments is mostly studied for benthic assemblages because of the difficulties in observing and sampling pelagic organisms. Knowledge on deep pelagic species is scant despite their importance as trophic source for predators, for being predators, and for the many ecological functions they support (Robison 2009), as the case of mesopelagic fishes which act as top-down controllers (Fanelli et al., 2014). However, deep-sea fishes and cephalopods of the

Mediterranean were observed facing a community shift at 800 and 200 m depth, respectively (Table S4A). Despite the limited knowledge available, also deep-sea sharks have been observed inhabiting widely the deep Mediterranean Sea, showing different abundance and bathymetric distribution patterns (Carrassón et al. 1992, Sion et al. 2004). Nevertheless, we did not find information on their diversity distribution patterns at the basin scale (Fanelli et al. 2018). Also, some cetacean species have been detected swimming in the deep Mediterranean, some of them showing a predilection for depths even greater than 1200 m, like the sperm whale *Physeter macrocephalus* and the Cuvier's beaked whale *Ziphius cavirostris* (Fiori et al. 2014).

Overall, a global study on deep-sea ecosystems, including the Mediterranean, demonstrated a strong relationship between biodiversity and functional diversity, and that ecosystem functioning is positively and exponentially correlated with species number (Danovaro et al. 2008a). Therefore, each single species plays a fundamental role in deep-sea ecosystems to keep them working.

3.2 Ecological principle no. 2: Maintain habitat diversity and heterogeneity

The deep Mediterranean Sea is almost homoeothermic in the deep sea beneath 200 m depth, and lowest temperatures never drop below ca 13°C (12.7-13.5 °C in the western basin and between 13.5 and 15.5°C in the eastern basin, on average). Deep waters area also characterised by a high salinity levels and oxygen concentrations despite the presence of several deep-water formation sites that make the circulation highly dynamic (Yasuhara and Danovaro, 2016, Skliris et al. 2018, Powley et al. 2016). A strong seasonality and the presence of different topographic contours influence the water circulation in the Mediterranean (Astraldi et al. 1999): Gibraltar Strait, Almeria-Oran Front, Ibiza Channel, Balearic Front, Sicily Channel, Otranto Channel, and the southern margin of the Aegean Sea (Pascual et al. 2017). Generally, regional barriers, as those just mentioned, favour the definition of distinct subregions, and the formation of diverse marine communities (Treml and Halpin 2012, Popova et al. 2019).

These peculiarities make the Mediterranean highly heterogeneous hosting diverse valuable habitats. Despite the still limited knowledge on the pelagic domain, Hyrenbach et al. (2000) distinguished the three pelagic hotspots habitats in ephemeral (i.e. up and downwelling systems), persistent (i.e. currents and gyres), and static systems (i.e. the water masses surrounding seamounts). Among these habitats, upwelling and downwelling areas are of paramount importance, and are scattered within the entire Mediterranean basin (Bakun and Agostini 2001). These vary over time being mainly seasonal, but they can also present quasi-permanent or even permanent nature (Sarhan et al. 2000, Di Lorenzo et al. 2017). In both cases, they underpin primary productivity phenomena supporting the whole marine life. For instance, the Pelagos Sanctuary falls within one of these systems becoming a feeding ground for cetaceans (Zeichen et al. 2017). Dense shelf water cascading (DSWC) events are among the main responsible of the transport of organic matter to the deep sea (Canals et al. 2006, Sanchez-Vidal et al. 2008), strongly influencing the functioning of deep-sea benthic communities.

As for benthic habitats, a specific zonation for the deep Mediterranean, based on the EUNIS classification (Davies et al. 2004), comes from the experience of the EU Project CoCoNet (towards COast to COast NETworks of marine protected areas, https://cordis.europa.eu/project/rcn/101654/reporting/en; Fabri et al. 2018). All of the benthic deep-sea habitats that are present in the Mediterranean basin are listed in Table S5A. Their ecological role and spatial distribution are here summarized. Furthermore, the ones mapped until today are represented in Figure 2a.

3.3 Ecological principle no. 3: Maintain key species

In the deep Mediterranean, three main kinds of key species can be identified: 1) ecosystem engineers/habitat forming species; 2) flag species; 3) rare/endemic deep-sea species. For instance, cold-water corals (i.e. *Desmophyllum pertusum* (=*Lophelia pertusa*), *Madrepora oculata, Desmophyllum dianthus*) are habitat forming species that support entire ecosystems for their three-dimensionality (Maier et al. 2011). The bamboo coral *Isidella elongata* was recognized as a near-endemic key species of the Mediterranean, creating “beds” which can offer shelter to a large associated fauna, as well as endangered. Although this species has been observed up to 1000 m depth, its main distribution range is 500-700 m (Fabri et al. 2014, Mastrototaro et al. 2017). It is a soft-bottom organism highly threatened by bottom trawling fishery (Cartes et al. 2013), since it is present on muddy soft bottoms and at depth where trawling is permitted (UNEP/MAP-RAC/SPA 2015). The same condition can be described for the colonies of black corals *Anthipatella subpinnata* and *Leiopathes glaberrima*, sharks' nesting sites hosting high biodiversity, which are impacted by by-catch and the disposal of any lost material from the fishing vessels (e.g. long-lines, trammels, ropes; Bo et al. 2014). Demersal sharks, acting as top predators, play a key functional role in deep-sea food web equilibrium highly affecting minor functional groups (Tecchio et al. 2013). These include species of major concern of protection, such as the Bluntnose sixgill shark *Hexanchus griseus*, the dogfish *Squalus acanthias* and *S. blainvillei*, the Kitefin shark *Dalatias licha* and the gulper shark *Centrophorus granulosus* (Cartes et al., 2013; Barría et al. 2015, Navarro et al. 2014). Many endemic species inhabiting the deep Mediterranean have been described up today, belonging to different taxonomic groups (e.g. the ray-finned fish *Paralepis speciosa*, the rays *Raja radula* and *Leucoraja melitensis*, and the decapod crustacean *Zariquieyon inflatus*; Tortonese 1985, Bouchet and Taviani 1992), and many have yet to be discovered. However, because of the fragmented knowledge concerning deep-sea biodiversity and species ecological roles, the identification of key species in the deep Mediterranean is challenging. Nonetheless, we list and map the proposed species of priority for protection in the deep Mediterranean Sea starting from the common consensus of both scientific and political communities (Oceana 2009, Oceana 2017, Table S1B, Figure 2b), to create awareness on their presence and ecological status. The list does not include only species strictly associated with deep-sea habitats and the Mediterranean, with the intent of including the ecological connectivity that drives species distribution and its variability. Indeed, species that spend part of their life in the deep sea, likely accomplishing specific life stages and satisfying peculiar behaviours, and that have been identified in the Mediterranean, are included. In Figure 2b, the species listed in Table S1B are grouped and represented in Phyla.

3.4 Ecological principle no. 4: Species and habitat connectivity

In the Mediterranean Sea, either longitudinal, latitudinal and vertical (i.e., surface waters and deep-sea environments) connectivity is strong. In fact, the deep Mediterranean is characterised either by upwellings and DSWC events (mainly in the Gulf of Lions, in the northern Adriatic and in the northern Aegean), allowing oxygenated waters to penetrate down to >1500 m depth (Goriup 2017, Canals et al. 2009). Moreover, the water column funnels the organic matter produced at the surface towards the greatest depths, greatly supporting deep-sea food webs (Conese et al., 2019). Both DSWC and organic matter transport to the deep sea are enhanced by the presence of submarine canyons, especially in the western part of the basin. As described in Table S5A, submarine canyons act as corridors for the transport of large amount of organic matter towards the greatest depths, enhancing DSWC and participating to the formation of upwelling systems (Canals et al. 2006).

Connectivity allows also populations and species movements and survival strategies through larval recruitment and gene fluxes, both vertically and horizontally, which numerous deep-sea organisms adopt to underpin their reproductive success and resilience to disturbances (Popova et al. 2019). Dubois et al. (2016) argued the influence of convergence and divergence currents (down and upwelling, respectively) on the retention or supply of larval stages in the entire Mediterranean Sea. Deep-sea habitats can, in fact, represent sinks of resting stages, contributing to the supply of new recruits to shallower populations (Della Tommasa et al. 2000, Canepa et al. 2014). Vice versa, some deep-sea populations can depend by external larval supply. As an example of connectivity, the economically valuable shrimp *Aristeus antennatus* migrates towards shallower depths promoting a significant larval dispersal and vertical adults' recruitment, supporting, through gene flow, the homogeneous structuring of meta-populations along the entire Mediterranean basin (Company et al. 2008, Maggio et al. 2009). This biological behaviour prevents the collapse of this species, despite the great fishery pressure acting on it.

However, different oceanographic processes lead to the formation of frontal systems, as described in *section 3.2*, which create real pelagic ecotones, concrete boundaries able to influence marine communities' structure and distribution (Louzao et al. 2017). Both environmental (current systems and geomorphologic features) and biological processes in the Mediterranean can limit the connectivity between deep-sea populations, thus affecting their dispersal potential. Then, also species with long dispersal capability can be separated through speciation processes, specifically when their reproductive period temporally overlaps with these fronts' formation (Pascual et al. 2017).

The strong connectivity across habitats is able to supply larvae and propagules from source areas to degraded deep-sea systems, thus offering opportunities for resilience.

Connectivity can also lead to negative implications. Contaminants can reach and accumulate within the organisms even at the greatest depths (Ramirez-Llodra et al. 2011), for example through submarine canyons, which play a role in deep-sea contamination processes (Fernandez-Arcaya et al. 2017). In addition, deep-sea environments are not isolated and protected from the effects of climate changes, which are also foreseen as drivers influencing important episodic events, as DSWC (Canals et al. 2006, Pusceddu et al. 2013). Danovaro et al. (2004) also observed strong effects even at slight temperature variations on deep-sea biodiversity in the Mediterranean.

3.5 Uncertainty principle (UP): Uncertainties (what we know not to know)

It has been estimated that about 75% of the diversity inhabiting the deep Mediterranean is still unknown (Costello et al., 2010). If deep-sea biodiversity is so far from being extensively assessed, even less the functioning of deep-sea ecosystems and their status are. For instance, most of the deep seabed corresponds to soft bottoms, whose ecological role is not fully understood, and therefore easily underestimated as priority conservation habitats. As an example, the bamboo coral *I. elongata*, an endangered key species mentioned in *section 3.3*, is mainly distributed on muddy bottoms of the open slope.

From one side, novel habitats and biotopes are continuously discovered in the deep Mediterranean. This is the case of the hydrothermal vents (Esposito et al. 2018), and of the novel deep-water corals-bivalve biotope (Taviani 2014, Taviani et al. 2019), both found in the Tyrrhenian Sea (Western

Mediterranean). From the other side, the distribution and extension of these and of other known habitats is almost completely unknown. The risk, related also to authorizations for industrial activities, is assuming that nothing is in the deep because information is not available, whereas priority habitats and species for conservation do exist, and are widely spread.

Because of the paucity of knowledge on deep-sea species composition, behaviour, and functions, Ramirez-Llodra et al. (2011) tried to score human impacts on deep-sea habitats at global scale, facing concrete difficulties. So far, the uncertainty related to the effect of anthropogenic and climate impacts impinging on deep-sea ecosystems is real, especially in the deep Mediterranean (Lejeusne et al. 2010, Giorgi 2006). The vulnerability and potential recovery estimates for the species and habitats that populate this environment are scarce. In addition, the unbalance of data availability among the Mediterranean sub-regions leads to the presence of important biases in the knowledge framework at the basin level (Fraschetti et al. 2011). Thus, the uncertainty principle explains the need of embedding the precautionary principle in the ecosystem-based management of deep-sea ecosystems (Danovaro et al. 2017a).

4. Setting EB-MSP in the deep Mediterranean Sea

In this section, we incorporated the knowledge about the four ecological principles and the uncertainty principle in the relevant phases of any EB-MSP processes (Ehler and Douvere, 2009, Foley et al. 2010). We reported some considerations based on the evidences emerged from the description of the above cited principles for the deep Mediterranean Sea and resumed in Figure 3. The incorporation of the ecological principles and uncertainty within the EB-MSP process for the deep Mediterranean Sea is also schematically summarized in Figure 4. These are initial considerations based on described ecological knowledge presented in section 3 with the intention of paving the way toward an EB-MSP of the deep Mediterranean.

Step 1. Planning goals and objectives

The main goal of EB-MSP is of balancing socio-economic development and environmental conservation, anticipating conflicts between uses, and between uses and the environment, and contrasting single sectorial policies (Douvere 2008, Day 2008). In the perspective of the claimed CBD target of protection by 2020, conservation objectives should be of priority in the deep Mediterranean. On one hand, the deep Mediterranean Sea is witnessing an intensification of demand for space and natural resources (see *section 2.1*). On the other hand, we found that only the 0.62% of the deep Mediterranean Sea falls within a National MPA, and also considering the existing FRAs, as recently suggested in the count of the enforced and legally binding MPAs (Rodríguez-Rodríguez et al. 2016, Fanelli et al. submitted), the percentage of protected deep sea rises to 1.52%. Including the extension of the trawling ban within the count would greatly increase the deep-sea area under protection in the Mediterranean; but this ABMT, as well as the FRAs, are actually enforced only toward fishery limitation, not fitting the existing ecosystem-based approach context, *sensu* MSFD.

To overcome these limitations, the achievement of the 10% conservation target should pass through the designation and enforcement of new and existing ABMTs for conservation in the Mediterranean. This should be done on the base of the available ecological knowledge related to habitats and species of priority for protection, and by balancing the costs and benefits of conservation (Gissi et al. 2018). Indeed, beyond MPAs declaration and enforcement, considerations related to trade-offs and synergies between protection and use of the natural resources of the deep Mediterranean should guide the sustainable and long-lasting use of the deep marine space and services as a priority objective to be set. Such approach would favour the achievement of the range of goals to which the EB-MSP aims: controlling, monitoring, and limiting human impacts, which are essential actions for supporting the protection of the deep Mediterranean ecosystems. The planning objectives should be articulated in sub-levels of measurable objectives based on the existing knowledge (described in section 3). Moreover, objectives should incorporate already the uncertainty and its sources, and set as priority goal the improvement of the ecological knowledge necessary to inform MSP in the deep Mediterranean.

Overall, the planning objectives should be clear and transparent to enable a proper gathering of knowledge that needs to be scientifically-based. Clear planning and conservation goals, in fact, enable the science-based collection and production of data and information that should drive their achievement (Galland et al. 2018).

Step 2. Defining the existing and future conditions

Though knowledge is scarce and scattered, we can draw some initial considerations that can guide planners and decision-makers in approaching the analysis of existing and future conditions in the deep Mediterranean Sea. In *section 3.1* related to the ecological principle 1 (maintain native species diversity), we have identified some critical depths for pelagic populations of the deep Mediterranean (Table S4A). In particular, fish and cephalopods have been found shifting in community structure and increasing in abundance after a previous decreasing with water depth (800 and 200 m depth, respectively). Thus, effective management measures for these two components, as well as their response to any types of pressures, could change at those depths depending on the different species present and their biological characteristics. This type of considerations may orient vertical zoning, hypothesis that can be further analysed and tested, for example, with modelling strategies (e.g., Levin et al. 2018). Furthermore, the dependency of fish species on trophic source availability means that any impact affecting their preys can indirectly have great effects on their status. Thus, human impacts affecting different levels along the pelagic food web should be identified and managed properly. Moreover, we found the occurrence of certain cetaceans at greater depths, which indicates their preferences in swimming and feeding in deep environments, despite they are not exclusively deep-sea species. This information has great implication for controlling potential drivers of stressors from human uses (e.g., oil and gas exploration, mining).

Moreover, the analysis of current and future conditions can focus on the habitats described in *section 3.2* as biodiversity hotspots, needful for the Mediterranean Sea productivity, and for the existence of both shallow and deep-sea organisms. For instance, the particular influence of upwelling currents is an evidence for pelagic-benthic coupling. Canyons and seamounts are defined as biodiversity hotspot supporting both benthic and pelagic organisms and complex food webs (i.e. cetaceans, see *section 3.1*), and their presence within the MSP planning area should be carefully acknowledged.

Information on the reported benthic communities (meio- and macrofauna, Table S4A) highlighted the importance of the spatial scale of the analysis for their biodiversity estimates. This evidence suggests the need to define the geographical scope of the plan, the spatial extension of the area to be planned and managed, before the gathering and interpreting of the ecological data related to marine communities. Eventually, the application of a nested approach can be a suitable strategy in order to consider in parallel different spatial scales. However, the species composition of the deep Mediterranean communities is far from having been thoroughly assessed and even observed, poorly orienting biodiversity conservation priorities at this large scale. Nonetheless, the benthic habitats recognized as hotspots of biodiversity (Table S5A, Figure 2a), and the listed species in Table S1B and mapped in Figure 2b, can help in identifying priority areas for conservation within EB-MSP. In fact, information on biogenic reefs, submarine canyons, and seamounts of the deep Mediterranean are many. These habitats are widespread and partially localized along the entire basin. These key habitats and features need protection from all the activities that can directly impact their status. Indeed, albeit their key role, submarine canyons are highly threatened by fishery and marine and land-based pollution, and potentially by many of the human activities that are growing in the deep Mediterranean, as oil and gas exploration and extraction (see section 2, Fernandez-Arcaya et al. 2017).

Limiting the allocation of activities that directly impact priority habitats for conservation may not be enough to preserve them. We highlighted the role that bioregions can play in determining and isolating distinct marine communities thus affecting their resilience to human impacts (*section 3.2*). In *section 3.4* we also depicted many connectivity mechanisms, both vertical and horizontal between deep-sea species and habitats. When analysing and assessing potential drivers of threats for the deep, it is necessary to consider all these mechanisms influencing connectivity. For instance, deep-sea biogenic reefs exist thanks to key benthic megafaunal organisms, namely cold-water corals (CWC). These organisms live mostly within canyons and seamounts, where they find the appropriate substrate and the suitable trophic and oceanographic conditions to settle and thrive (Table S5A). Thus, marine currents are critical since filter feeders, as CWCs, prefer areas characterised by steep slopes and elevated topography, where moderate currents occur (Davies and Guinotte, 2011). As described in *section 3.4*, currents not only bring nutrients, oxygen, and larvae, but also contaminants and pollutants, even of land origin, which cross long distances reaching the greatest depths and affecting CWCs and other deep-sea communities.

Three main sites of origin of DSWC, which are important engines of deep-sea currents and underpin upwelling systems, have been identified so far (*section 3.4*). Furthermore, submarine canyons, besides being biodiversity hotspots, have been identified as structures that favour downwelling currents as well as litter and pollutants transport. These sites and submarine structures, and everything that happens close to them, should be considered critical to manage in order to protect deep-sea habitats.

The definition of the future trends of deep Mediterranean ecological status seems a challenge, when the assessment of the present one is still based on scarce and fragmented knowledge. Habitat connectivity, the trophic links amidst species, and the seasonal variability of dynamic processes are part of the missing knowledge. To overcome the limits due to this lack of empirical knowledge, several strategies can be put in place. Firstly, habitat mapping techniques (Fraschetti et al. 2011) and predictive suitability models are highly informative because fundamental to assess both habitats and species distribution, when supported by reliable data. Supporting scientific research in the deep is essential, as well as incorporating timely new knowledge in the plans. Secondly, climate and cumulative impacts models, aiming at assessing present and future environmental conditions through scenario analysis can be suitable tools, since they often incorporate multiple sources of information through expert judgement, which is necessary to overcome the lack of knowledge when decisions are needed (Martin et al. 2012). However, cumulative models have never been applied specifically to the deep Mediterranean, and, still, uncertainty hampers the robustness of tools' results (Gissi et al. 2017).

Nonetheless, predictive models can be of great support especially when coupled with real data, and the gathering of new knowledge in real-time can make them more reliable. Finally, the continuous up-take of new knowledge and strict relationship between science, policy, and managers will be essential to predict future conditions.

Step 3. Spatially-explicit measures

Here, we reported some considerations for incorporating the four ecological principles and the uncertainty principle that may be inspirational for the future purposes of EB-MSP.

Since conservation is considered as priority objective of EB-MSP in the deep Mediterranean, the spatial allocation of human uses should be set once priority conservation areas are defined and their ecological status assessed. Biodiversity hotspot and vulnerable habitats represents the most effective conservation targets, at the current level of knowledge (O'Leary et al. 2012). Anyway, protection goals should go beyond the protection of single species.

So far, the spatial identification of deep-sea priority areas of conservation has followed two main approaches. One is the definition of Vulnerable Marine Ecosystems (VMEs), identified on the base of predefined scientific criteria (FAO, 2009), which are set up against significant adverse impacts from fishing activities with bottom-contact gears. According to FAO (2009) VMEs are defined on the base of their i) uniqueness or rarity, ii) functional significance, iii) fragility, iv) recovery difficulty and v) structural complexity. Another approach is the identification of Ecologically or Biologically Significant Marine Areas (EBSAs), which apply similar criteria, but taking into account all human activities, beyond fishery, although never enforced. However, the identification process of both VMEs and EBSAs poorly embedded functional connectivity (Kenchington et al. 2019, Johnson et al. 2018). In the deep Mediterranean, the approach of the critical habitats seems more promising, because it incorporates connectivity. Critical habitats, in addition of being essential for the existence of a vast and precious biodiversity, are intended as nodes of connectivity suitable for hosting the recovery of endangered species in the future, thus ensuring their persistence in time (Camaclang et al. 2015). The identification of connectivity nodes amidst deep-sea habitats are of priority concern for protection from both present and future threats. Moreover, the identification and conservation of nursery and spawning grounds of mobile species are essential prerequisites to guarantee pelagic and nekto-benthic species survival (Colloca et al. 2015).

Spatial decision should be addressed towards the multiple dimensions of the marine environment and its dynamism (Manea et al. 2019), as emerged in the previous step (*Step 2*). Despite IUCN's guidelines (Day et al. 2012) discourage the application of vertical zoning when dealing with MPAs for the limited knowledge related with benthic-pelagic connectivity, such approach may be beneficial when dealing with multiple planning objectives. Furthermore, beyond static spatial zoning, the dynamic management would be highly beneficial to protect diverse and highly mobile pelagic species (Maxwell et al. 2015). Finally, to ensure a continuous improvement of knowledge, and the long-term monitoring and research activities, the allocation of areas for scientific research and for observing and monitoring systems is suggested, giving priority to historically-studied sites.

Step 4. Marine Spatial Plan implementation

The stewardship of the different maritime activities as well as of deep-sea conservation should be coordinated, shared, and act in synergy at both country and regional levels.

We found the 32% of the deep Mediterranean corresponds to high seas, whose water column is outside the jurisdiction of any countries until they will declare their EEZ. Moreover, 5.6% of deep-sea waters falling within undefined jurisdictional areas, witnessing a series of geopolitical concerns which are out of the scope of this paper. All these un-managed areas are likely understudied, and no competent authority exists yet to designate and implement them for conservation purposes. However, EB-MSP has to consider conservation priorities towards significant and sensitive deep-sea areas, regardless they fall or not within national jurisdiction.

The jurisdictional coverage of deep-sea space between countries is differently distributed. Indeed, we found Spain and France embracing a wider portion of deep sea within their EEZs, and Italy and

Greece potentially overtaking with their future EEZs (ca. 21% both). Despite this may raise the idea that the responsibility of the parties involved could be proportional to the potential area managed by each, this may not be the right conclusion. Despite EEZs will be the planning units of MSP in the Mediterranean, the intrinsic ecological connectivity of marine systems contrasts the existing geopolitical boundaries and suggests that, despite the existing difficulty in its implementation, cross-country collaboration makes sense (Mackelworth 2012) to both sustainably exploit and protect deep-sea ecosystems, as already demonstrated for the Adriatic and Ionian Region (Gissi et al. 2018). Nonetheless, the value of declaring the EEZ is on manage and control the sustainable and coordinated exploitation of natural resources, and for this reason, there is the need of multilateral agreements (Chevalier, 2005). Indeed, Mazor et al. (2013) found that conservation efficiency in the Mediterranean would be higher with coordinated plans among multiple countries, highly decreasing its costs.

While waiting for EEZs declaration, areas under intermediate jurisdictions should be given priority to apply the precautionary principle, because understudied and unmanaged. These areas can be of priority for international scientific efforts. Moreover, the convergence and collaboration of multiple initiatives towards conservation can be an effective strategy for the deep Mediterranean. The UN Mediterranean Action Plan (UNEP/MAP) and the Barcelona Convention, which are regional initiatives for protecting the Mediterranean Sea, brings good expectations in the view of future international conservation agreements (Rochette et al. 2014). Moreover, the European Union may represent the starting platform for establishing transboundary collaboration (Kark et al., 2009). The two regional strategies for the East (EUSAIR, EC, 2014) and the West Mediterranean (WestMED, EC, 2017) are envisaged as the platforms to collaborate and coordinate the efforts of EU Member States for sustainable blue growth in the Mediterranean. Conservation and sustainable development programmes embracing also the North African countries exist and identify MSP as empowering tool (IUCN, North Africa Programme 2017-2020). MSP is indeed advocated to be one of the most promising tools able to operationalize international agreements under a common regional umbrella, as well as to support conservation (Fraschetti et al. 2018).

Step 5. Plan monitoring

The monitoring and evaluation of the plan are the basis to implement EB-MSP as an adaptive process (Ehler 2014). Indeed, monitoring is essential to test past and new plans, feed predictive models, learn from the experience, and reflect habitats and species peculiarities, thus following the mutable nature of both marine environment and human needs (Gissi et al. 2019). The continuous up-take of new knowledge and strict relationship between science and policy will be essential to test on-going plans and predict future conditions, especially in the deep Mediterranean, where knowledge is being produced with multiple efforts from public funds (e.g. HERMES, HERMIONE, MIDAS projects financed by the European Commission).

Thus, the planning process of the deep Mediterranean Sea, especially the first planning cycle, should be envisaged as a co-learning process with all the actors that operates in the deep, to gather both existing and missing knowledge. To overcome barriers and bottlenecks, the strict collaboration with multidisciplinary expert groups turns out to be relevant, as past experience demonstrated (Ramirez-Llodra et al. 2011). The identification of knowledge needs for the decisions is confirmed as a priority.

5. Conclusions

On the light of the results of the present study the following:

1. Capitalize on the available knowledge while acquiring data. Most of the scientific knowledge available today needs to be elaborated and harmonized to be functional for a scientifically informed plan. Data-poor marine areas exist, but this does not mean that where data are present, they are actually used to develop effective management plans. The absence of data cannot be an excuse for inaction and all the available data should be actually used to act effectively and oriented. Moreover, climate change impacts on deep-sea ecosystems need to be explored, and related knowledge must be used to orient possible mitigation measures.

2. Incorporate connectivity and multidisciplinary approach. EB-MSP, by anticipating all the potential impacts affecting the marine components of priority for conservation, whether pelagic or benthic and even beyond the establishment of MPAs, does incorporate the connectivity principle on a large scale. The spatial distribution of species and habitats coupled with a molecular analysis of the relatedness of populations across deep-sea areas is crucial to take into consideration the interactions between Mediterranean areas, source and sink areas, and to identify the priority areas to be protected.

3. Natural capital and ecosystem services of the deep sea. At present we have no clear idea of the quantitative relevance of the natural capital of deep-sea Mediterranean ecosystems and we have to adopt a conservative approach or use proxies. At present, the best proxy of ecosystem services is represented by biodiversity, and EB-MSP and the identification of biodiversity hot spots is a priority.

4. Move forward for deep-sea protection. There is no way to achieve the Aichi targets without including the deep sea within the target areas for protection. However, the identification of the best areas to be protected requires as a pre-requisite an informed EB-MSP. We support the reinforcement of the already existing conservation tools, as the FRAs, through their implementation as an ecosystem-based conservation measure and not only fishery-oriented. However, this model of marine protection does need clear enforcement and must be fed by the connectivity principle to guarantee that deep-sea species and habitats are actually protected.

5. Calling for multi-lateral agreements. Managing deep-sea habitats means, especially in the Mediterranean Sea, the definition of bi- or multilateral agreements, as all of the deep-sea biogeographic areas are shared between at least 2 countries.

We proposed that marine spatial plans coordinate with each other respecting the sub-regional strategy set up and adopted by the ongoing conservation initiatives.

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Figures

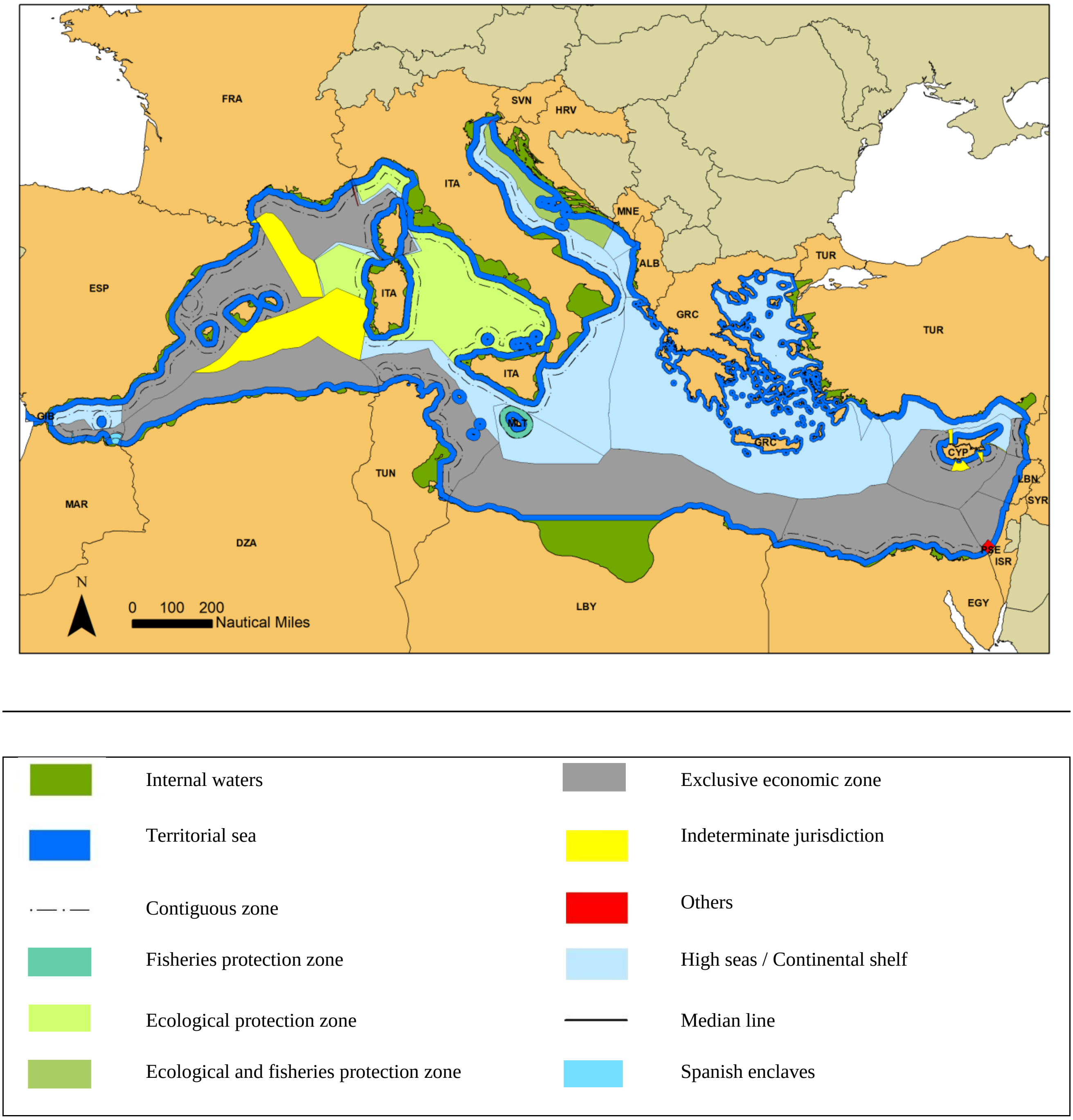

Figure 1. Existing national legislation on the United Nations website: DOALOS. Source: Suárez-de Vivero, Juan L. Marineplan, 2019 (www.marineplan.es).
*Disclaimer: The mapped jurisdictions are those that each state has declared and do not imply their recognition by third states.

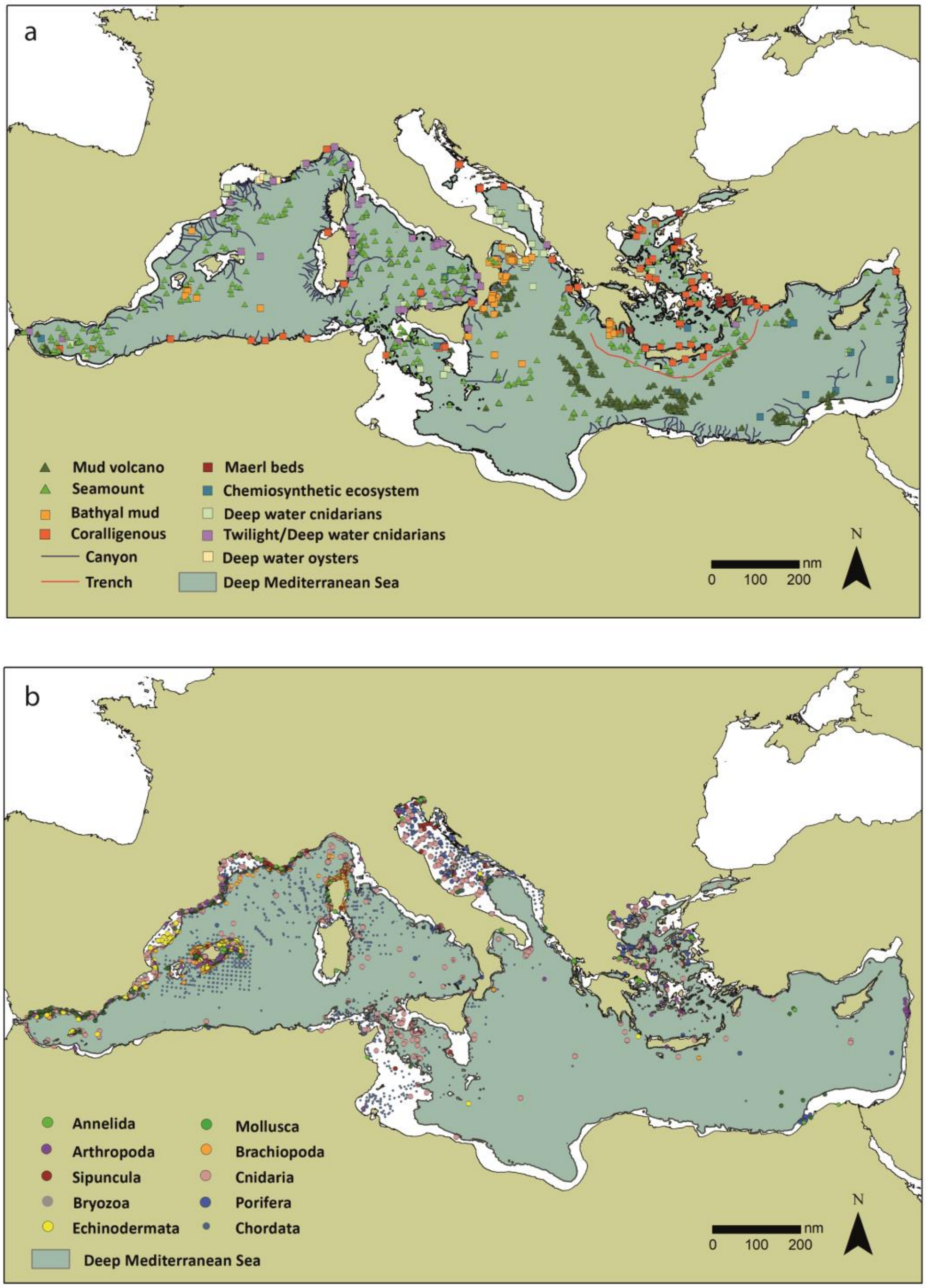

Figure 2. (a) Map of the benthic deep-sea habitats of the Mediterranean Sea mapped until today. Source: Chemosynthetic ecosystems come partly from the literature review made in the framework of the IDEM Project (Fabri et al. 2018), and are partly adapted from the CoCoNet database. Mud volcanos and seamounts come partly from UNEP database (http://data.unep-wcmc.org/), and partly from Mascle et al. 2014 and Würtz and Rovere 2015 (https://portals.iucn.org/library/node/45816), respectively. Submarine canyons were adapted from Migeon et al. (2012) by Fabri et al. (2018), which also mapped the Hellenic trench. **(b)** Map of the sightings of the species proposed as of priority for protection in the deep Mediterranean Sea (Oceana 2009, Oceana 2017) grouped and represented in Phyla. The species are not only the ones strictly associated with deep-sea habitats and the Mediterranean, but also species that spend part of their life in the deep Mediterranean Sea, during specific life stages and following peculiar behaviours. Source: OBIS database (Ocean Biogeographic Information System, https://mapper.obis.org/)

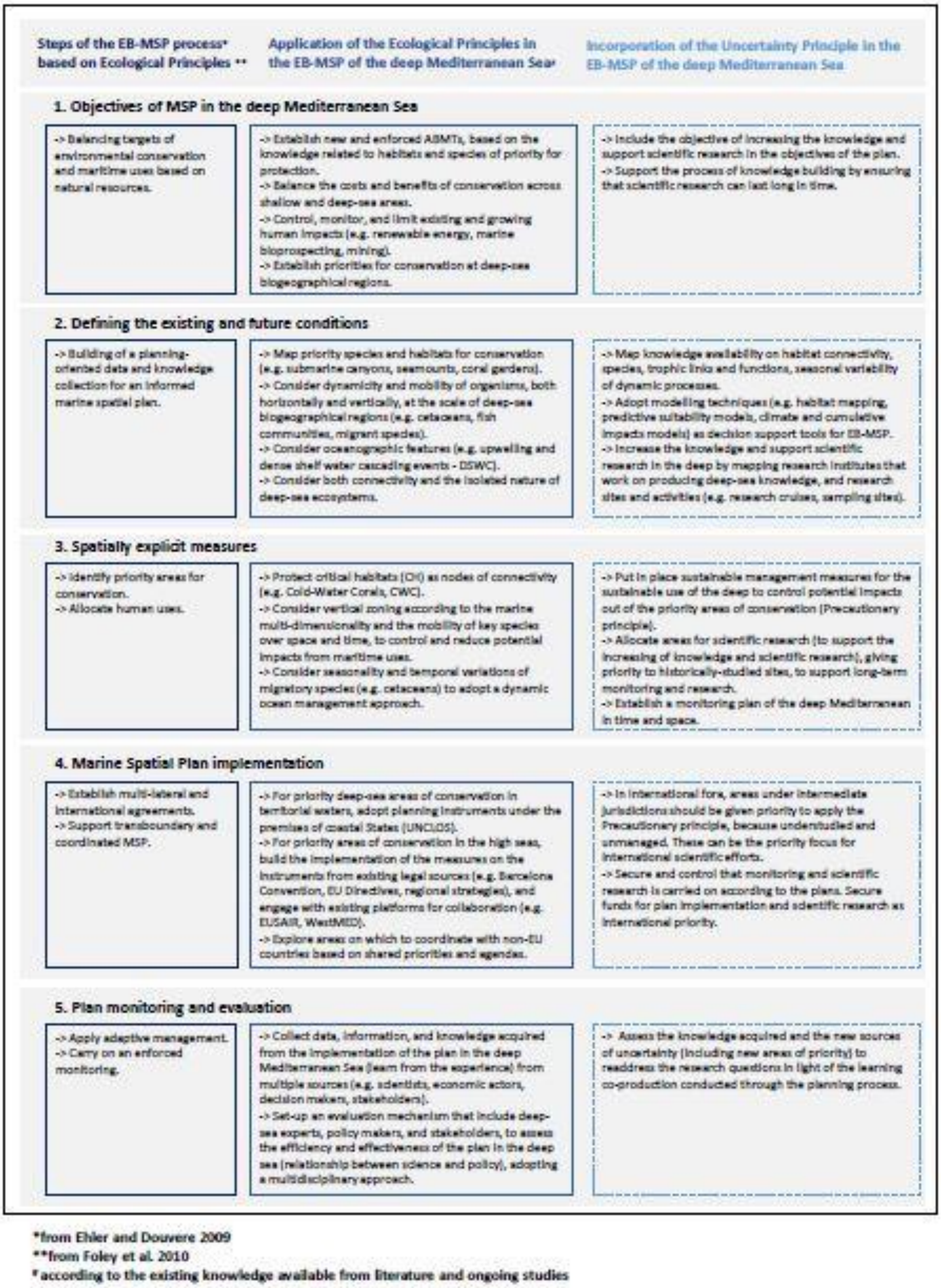

Figure 3. Guidelines to implement an EB-MSP of the deep Mediterranean Sea built on the existing and available knowledge. The recommendations are developed on the basis of the four ecological principles (according to Foley et al. 2010), and the uncertainty principle, and are reported per each key step of the EB-MSP process (Ehler and Douvere 2009).

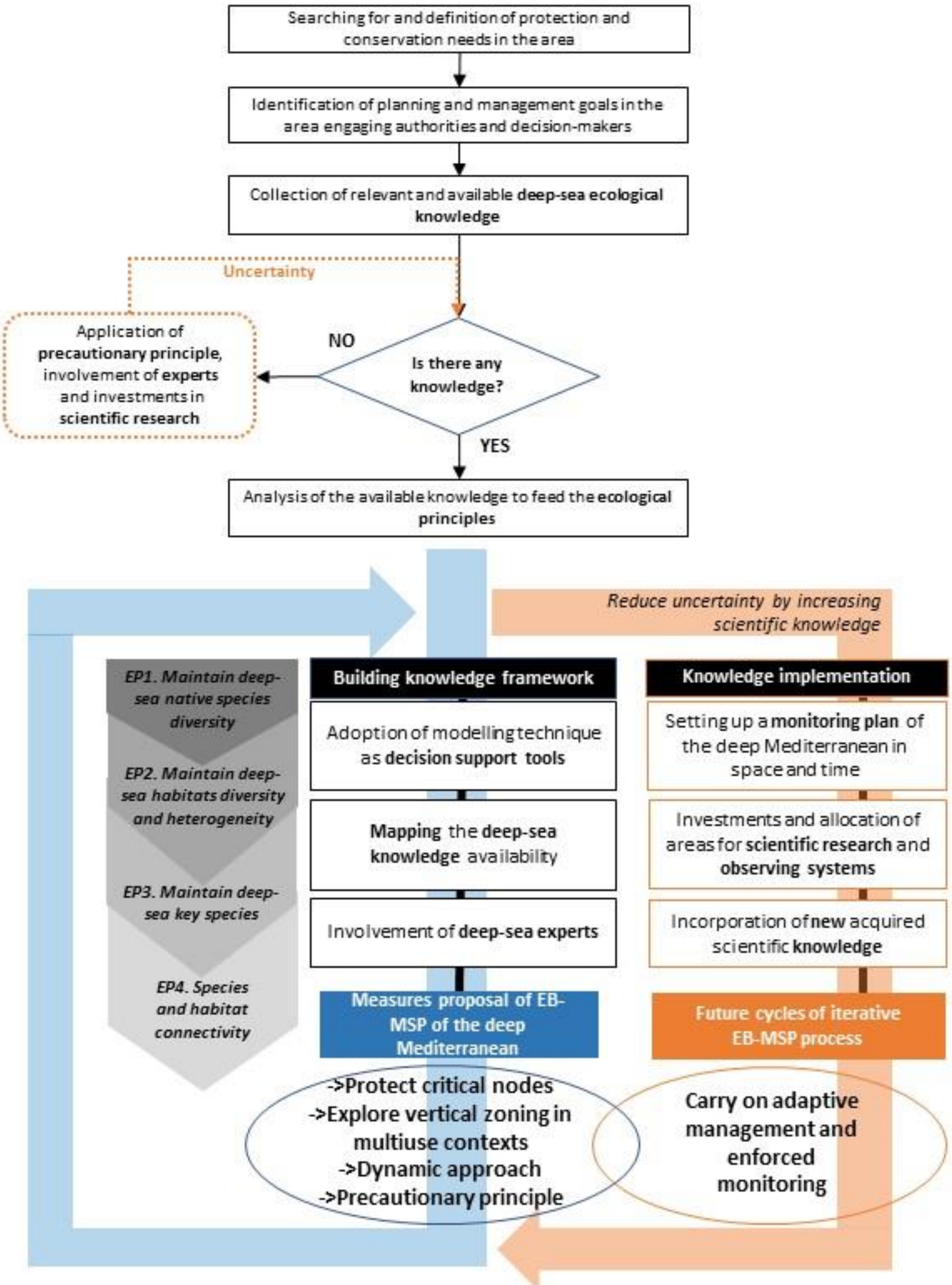

Figure 4. Incorporation and application of the ecological principles (*EPs*) and uncertainty principle (*UP*) in the EB-MSP of the deep Mediterranean Sea. The use of the **light-blue color** is related to the incorporation of the *EPs* within the EB-MSP process to build the necessary knowledge framework on which to base the measures proposal. The use of the **orange color** is related to the *UP*, which is incorporated in the EB-MSP process through the adoption of the Precautionary principle and which is reduced by implementing the available ecological knowledge. The actions related to the integration of all principles are synergistic and are embraced in an adaptive and iterative process that foresees future cycles of the EB-MSP. More details are present in Figure 3.