Implementation of the MSFD to the

Deep Mediterranean Sea

IDEM

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Report 4.3. Report on guidelines to define deep-sea protected areas

Leader: UNIVPM

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ABBREVIATIONS TABLE

ABNJs	Areas Beyond National Jurisdiction
AIS	Automatic Identification System
APEI	Areas of Particular Environmental Interest
ACCOBAMS	Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area
CBD	Convention on Biodiversity
CCZ	Clarion–Clipperton fracture zone
CeDAMar	Census of the Diversity of Abyssal Marine Life
CenSeam	Global Census of Marine Life on Seamounts
CWCs	Cold-water corals
D1-D11	Descriptors 1 to 11
EBSA	Environmentally or Biologically Significant marine Areas
EEZs	Economic Exclusive Zones
EEA	European Environment Agency
EUNIS	European Nature Information System
FRAs	Fisheries Restricted Areas
GES	Good Environmental Status
GIS	Geographical Information System
GFCM	General Fisheries Commission for the Mediterranean
IBA	Important Bird Areas
IDEM	Implementation of the MSFD to the DEep Mediterranean Sea
ISA	International Seabed Authority
IUCN	International Union for Conservation of Nature
MCA	Multi Criteria Analysis
MPA	Marine Protected Area
MedPAN	Mediterranean Protected Areas Network

MSFD	Marine Strategy Framework Directive
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PSSA	Particularly Sensitive Sea Areas
RFMO	Regional Fisheries Management Organizations
SAC	Special Areas of Conservation
SDG	Sustainable Development Goal
SCI	Sites of Community Importance
SPAs	Special Protection Areas (SPAs), Birds Directive
SPAMI	Specially Protected Areas of Mediterranean Importance
SEMP	Strategic Environmental Management Plan
UNCLOS	UN Convention on the Law of the Sea
UNGA	United Nations General Assembly
UNEP-MAP	United Nations Environment Programme-Mediterranean Action - Plan Barcelona Convention
VME	Vulnerable Marine Ecosystems
VMS	Vessel Monitoring System
WWF	World Wildlife Fund

1 Introduction and aims of the deliverable

Systematic conservation planning was first applied successfully for terrestrial conservation and has since been applied in the coastal environment (Pressey and Bottrill 2009; Fernandez et al., 2005). Recently, a systematic conservation planning framework was outlined for the high seas (Ban et al., 2013) and several examples exist in which this approach has been applied in practice (O'Leary et al., 2012; Österblom et al., 2010).

Systematic conservation planning requires the identification of conservation targets and robust ecological assessments that underpin the design and implementation of spatial conservation areas (Margules and Pressey, 2000). The ecological assessments used to identify these quantitative conservation objectives rely on well-established approaches enabling the documentation of the biodiversity patterns, habitat distribution, and other critical biological attributes, as well as guiding frameworks to include these assessments into conservation planning to set targets and develop action and monitoring plans (Margules and Pressey, 2000; Pressey and Bottrill 2009). However, for making these approaches effective, we need to take into consideration the specific ecological and socio-economic context of the region of interest (Wedding et al., 2013). In this specific case, the deep Mediterranean Sea.

This deliverable aims at defining guidelines for the protection of the deep sea focusing on the Mediterranean Sea. To achieve this objective, we first analyse and report: i) the existing guidelines for the protection of the deep-sea ecosystems, ii) the international jurisdictional framework, and iii) the approach utilized in the **IDEM** (**Implementation of the MSFD to the DEep Mediterranean Sea**) project in order to identify the most suitable deep-sea Mediterranean areas for the monitoring and protection, in the framework of the EU **Marine Strategy Framework Directive** (**MSFD**).

2 Towards the protection of the deep sea: the need for guidelines for appropriate management and conservation strategies

The research dedicated to deep-sea ecosystems has improved our understanding of ocean biodiversity, ecosystem functioning and provided goods and services, and at the same time has revealed the existence of many previously unknown species and even ecosystems (Danovaro et al., 2017). However, deep-sea ecosystems are under threat from human activities, such as fishing activities, especially bottom-trawl fishing, exploitation of gas, oil and methane hydrate resources and seabed mining of massive sulphide deposits. Increasing exploration and industrial exploitation of the vast and fragile deep-ocean environment for a wide range of biotic and abiotic resources (oil, gas, fisheries, new molecules, and soon, minerals; **Figure 1**) raises global concerns about potential ecological impacts (Ramírez-Llodra et al., 2011; Levin and Le Bris, 2015; Wedding et al., 2015). Indeed, multiple impacts on deep-sea ecosystems caused by human activities may act synergistically and span extensive areas, and there are concerns that the progress of such human activities could outpace conservation measures already designed to protect these vulnerable seabed ecosystems (Danovaro et al., 2017).

In response to the increasing impacts and their potentially synergistic effects, there have been calls for a precautionary approach to continue and start new activities in the deep sea, application of spatial and adaptive management tools, development of research programs to quantify goods and services provided by deep-sea ecosystems and continuing study of ocean governance and protection of the marine environment beyond national jurisdiction (van den Hove et al., 2007; Smith et al., 2008a; 2008b; Armstrong et al., 2012; Gjerde, 2012; Taranto et al., 2012; Ban et al., 2013). In addition, there is a consensus on the need to establish environmental baselines and to improve tools to predict, manage and mitigate anthropogenic impacts (van den Hove et al., 2007; Danovaro et al., 2008; Smith et al., 2008b; Robison, 2009; Collins et al., 2013). Recently, spatial management of the deep sea — including establishment of networks of marine sanctuaries and protected areas — has received considerable attention (Thiel, 2003; Ramirez-Llodra et al., 2011). Moreover, area closures and 'move-on' rules for high seas bottom fisheries have been implemented by **Regional Fisheries Management Organizations (RFMO**, Dinmore et al., 2003; Rogers et al., 2010; Taranto et al., 2012). Recently, a strategy that builds from existing infrastructures has been proposed in order to address research and monitoring needs to inform governments and regulators (Danovaro et al., 2017).

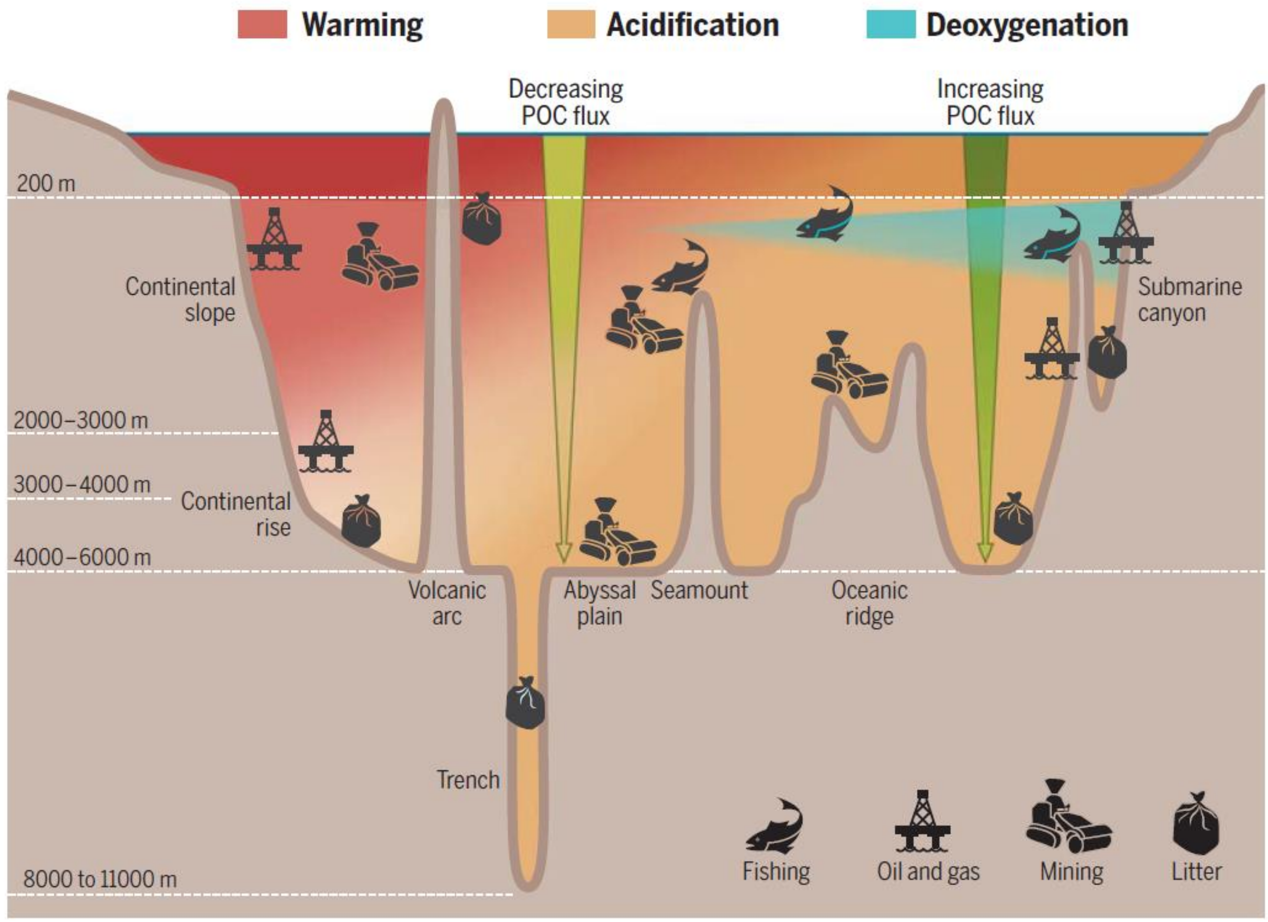

Figure 1. Overlap of anthropogenic and climate stressors, which will be greatest along continental margins and at bathyal depths, but changes throughout the deep ocean will compromise ecosystem services globally (from Levin and Le Bris, 2015).

3 The need of an ecosystem-based approach

Moving towards ecosystem-based protection requires comprehensive ecosystem assessments to characterize regions and develop conservation planning targets and areas (Foley et al., 2013). Ecosystem assessment has been previously defined as a '*formal synthesis and quantitative analysis of information on relevant natural and socioeconomic factors, in relation to specified ecosystem management objectives*' (Levin et al., 2009). However, in the European Seas, the ecosystem status is nowadays assessed by the **11 Descriptors (D1-11)** of the MSFD. The assessments are recognized as a critical step in systematic conservation planning, and provide critical information to inform planning targets (e.g. protecting 20% of a given area) and the spatial design of **Marine Protected Areas (MPAs)** networks (Wedding et al., 2013).

One of the examples of protection actions in the deep sea is represented by the **Clarion–Clipperton Fracture Zone (CCZ)**, which is a focal area for mining interests in the equatorial North Pacific, and mining operations are expected to be initiated in the CCZ by 2025 (Wedding et al., 2013 and citations within). Recent advances in technological capabilities have led to competing spatial demands between conservation of the unique deep-sea ecosystems and economic mining interests. These competing spatial interests are complicated by the consideration that deep-sea biota are particularly vulnerable to the impacts of extractive activities owing to slow growth rates and delayed maturity (Wedding et al., 2013). In light of the vulnerability of these unique ecosystems, it is critical to conserve areas of the deep sea in the face of imminent resource extraction.

In this case, the first step in the ecosystem assessment of the CCZ region was to define the spatial domain that bordered, but did not overlap with any **Economic Exclusive Zones** (**EEZs**) in the region (Wedding et al., 2013). The spatial domain covered approximately 6,000,000 km^2 of the deep sea, ranging between 4,000 and 6,000 m. Spatial datasets that represented biological and physical characteristics of the CCZ were synthesized from a variety of sources and included (i) bathymetry (m); (ii) seamounts; (iii) organic nitrogen flux (mmol N cm^{-2} d^{-1}) in sinking particulate organic carbon, i.e. an index of food availability in the detritus based deep sea; (iv) polymetallic nodule abundance (kg m^{-2}); and (v) macroinvertebrate abundance. All spatial datasets were synthesized in geographical information systems (GIS) to form the basis for the spatial ecosystem assessment and inform the systematic conservation planning process.

In the Mediterranean Sea, the amount of marine area under protection corresponds to 1,632,507 km^2, roughly 64.5% of the entire surface of the basin (Rodríguez-Rodríguez et al. 2016). However, according to the **European Environment Agency** (**EEA**), MPAs in European seas suffer of the following gaps: i) large regional differences (EU vs. non-EU countries), hinder the achievement of an overall **Good Environmental Status (GES)** of the Mediterranean Sea; ii) the current MPAs network is neither representative nor ecologically coherent; iii) evaluation of EU MPA networks needs harmonized and standardized information, based on scientific knowledge; iv) legislation ambiguity, low governance implication, insufficient funding, fragile monitoring plans and too small numbers of staff members; v) lack the designation of clear objectives and priorities; vi) lack of stakeholders support and involvement (EEA, 2015).

In the Mediterranean Sea there are several protected areas in the deep sea already in force. The project LIFE+INDEMARES has recently contributed to the protection and sustainable use of biodiversity in the Western sector of the Mediterranean Sea (Spanish seas) through the study, characterization and inclusion of areas within the Natura 2000 Network: 10 Sites of Community Interest (SCI) have been proposed to the European Commission which will subsequently be declared **Special Areas of Conservation (SAC)** and 39 **Special Protection Areas for birds (SPA)** have been designated, based on an inventory of **Important Bird Areas (IBA)** in the marine realm (www.indemares.es). During this project, several areas have been identified for protection actions. The Southern Almería - Chella bank (or Seco de los Olivos) is a marine area with 2,829 km^2, located in the south of the Iberian Peninsula and characterized by shallow coastal areas, deep sea, mountains (www.indemares.es). The Alborán Island is located approximately in the center of the sea that gives it its name. This is a transition zone between the Atlantic Ocean and the Mediterranean Sea, where the mixing of waters from both oceanographic basins creates special conditions that contribute to the wealth and uniqueness of the marine life. In addition, the Alborán Sea constitutes a feeding zone and migratory stopover for numerous species, particularly cetaceans, marine turtles and seabirds (www.indemares.es). The South-West Gulf of Lion canyons system houses a huge variety of ecosystems in a relatively small area: littoral ecosystems, platform and slope ecosystems, and submarine canyon communities, meaning there is a high level of biodiversity. The main canyon in this system is the Creus Canyon, which reaches a depth of 2,150 m (www.indemares.es). The Menorca Channel holds a great variety of habitats, from the sand banks and *Posidonia* beds typical of nearshore areas to communities on the bottom of the platform (50 to 100 meters deep) and slope (100 to 400 meters deep), which have a high ecological value and great diversity of species (www.indemares.es). Other examples are provided by off-shore areas in the Gulf of Lion and specifically, the National Park of Calanques, which comprises an off-shore area including the Cassidaigne canyon for the protection of cold-water corals (CWCs), and the MPA of the Gulf of Lion, which encompasses the Lacaze-Duthiers canyon, characterized by the occurrence of two CWC species, *Lophelia pertusa* (= *Desmophyllum pertusum*) and *Madrepora oculata*. Similarly, the LifeBahar for N2K project (https://lifebahar.org.mt/) identified five deep-sea sites in Maltese waters, having a total area of 2,075 km^2, which have been proposed as Sites of Community Importance (SCIs) and included within the Natura2000 network; these will eventually be declared as SACs. There are also off-shore areas in which trawling activities are banned or restricted. In 2006, Rec. GFCM/30/2006/316 established three **Fisheries Restricted Areas (FRAs)**: The *Lophelia* reef off Capo Santa Maria di Leuca (1,673 km^2, GSA 19, Italy), the Nile Delta Area - cold hydrocarbon seeps (6,043 km^2, GSA 26, Egypt) and the Eratosthenes Seamount deep-sea benthic habitats colonised by scleractinian corals and sponges (14,792 km^2 GSA 25, Cyprus), all of which established by Rec. GFCM/30/2006/3. In 2016, Rec. GFCM/40/2016/4 established three FRAs across the Strait of Sicily nursery areas of European hake and deep-water rose shrimp (GSAs 12-14, between Italy and Malta). In 2009, the restricted area to only authorized vessels includes the Eastern part of the Gulf of Lion, identified as important aggregations of spawners (European hake, monk fish, lobsters) area (3,742 km^2 GSA 07, France) established by Rec. GFCM/33/2009/1. In 2017, Rec. GFCM/41/2017/319 established the Jabuka/Pomo Pit FRA in the central Adriatic Sea (FAO, 2018). In 2016, the European Parliament approved a Regulation establishing new rules for fishing in the North-East Atlantic and a total ban of bottom trawling below 800 m in EU waters. This ban, setting a worldwide precedent, will help to protect vulnerable deep-sea marine ecosystems more effectively by setting stricter conditions on deep-sea fisheries.

Several international organizations have identified areas of importance for conservation, which are mostly overlapping with the areas designated as **Ecologically or Biologically Significant Areas (EBSAs)**. These include: i) priority areas for conservation of cetaceans, as identified under the Agreement on the **Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)** (today, the Pelagos Sanctuary is the only designated area for the conservation of Mediterranean marine mammals); ii) areas of high conservation value for Mediterranean seabirds, as identified by UNEP/MAP RAC/SPA; iii) priority areas for the conservation of demersal and pelagic fisheries, as identified by UNEP/MAP RAC/SPA; iv) undersea features (the Mediterranean deep sea is host to undersea features such as seamounts, hills, canyons, trenches, banks and mud volcanoes) (**Figure 2**; Piante and Ody, 2015).

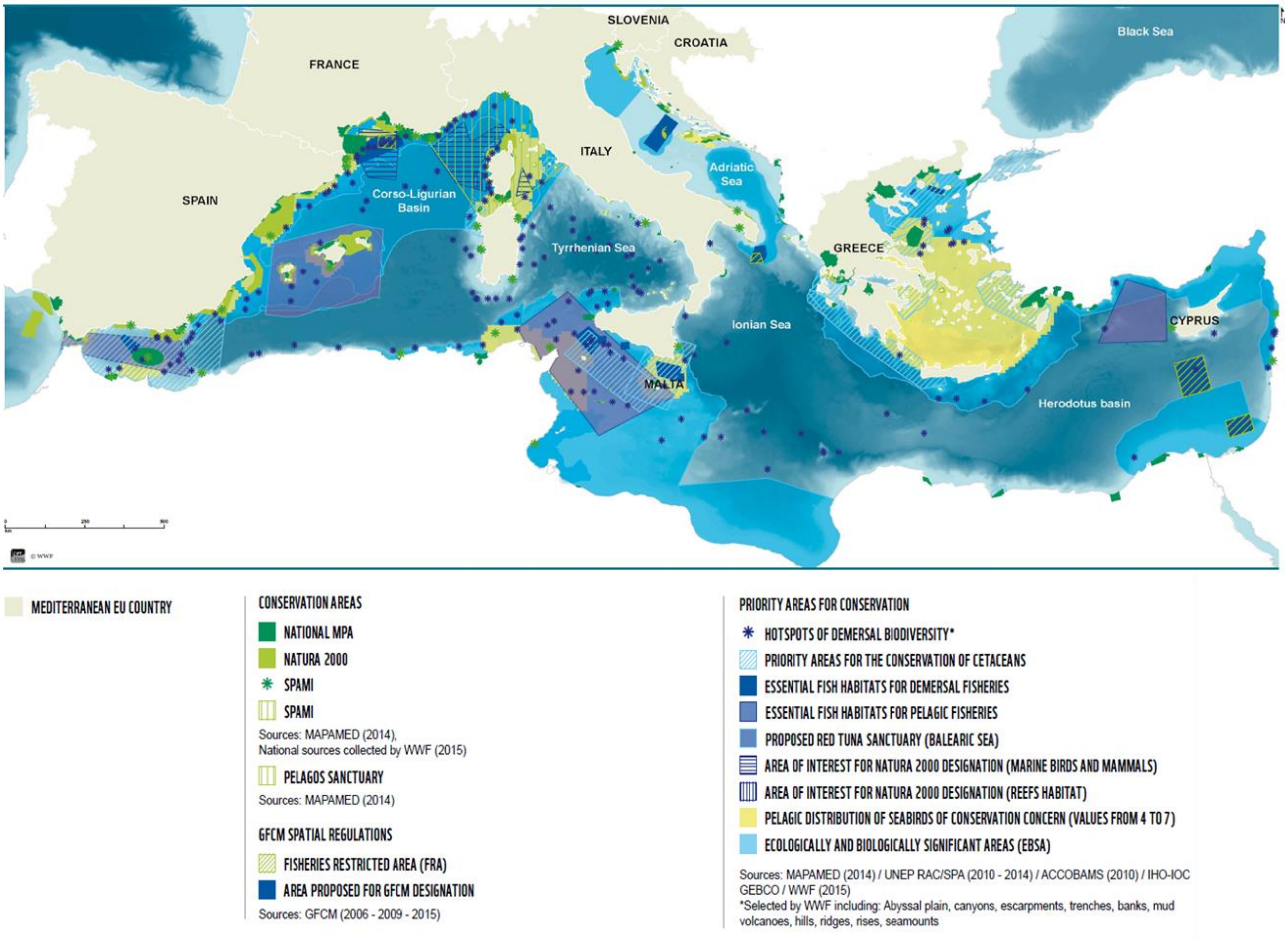

Figure 2. MPAs and priority areas for conservation (from Piante and Ody, 2015).

Since 2009, a series of large natural gas discoveries in the Levant Basin have engendered frenetic prospecting, bidding and extraction activity. Since Israel's discovery of the Tamar Field and the larger Leviathan Field, Cyprus and Egypt have also found new offshore gas deposits: The Aphrodite Field was discovered in Cypriot waters in late 2011 and the massive Zohr Field was found in Egyptian waters by Italian firm Eni in 2015. In 2018, Eni and Total announced a large gas discovery (230 BCM) at their Calypso prospect, offshore Cyprus, while drilling at the Noor gas field offshore Egypt. Exploration and extraction of mineral resources are incompatible with the purposes of protected areas corresponding to the **International Union for Conservation of Nature** (**IUCN**) Protected Area Management Categories I - IV (Ratner, 2016).

More in general, several areas of the Mediterranean basin, in which high interactions between Blue Growth and conservation interest in EU Mediterranean countries are foreseen, have been identified and mapped (**Figure 3**).

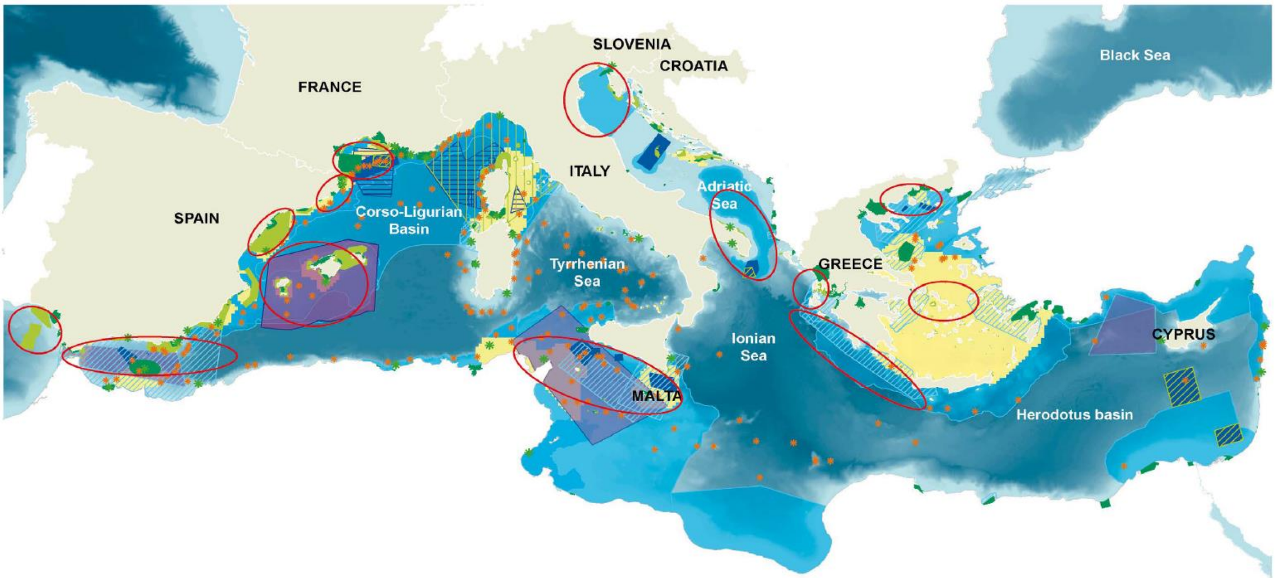

Figure 3. Red circles indicate the large-scale areas of high interactions between Blue Growth and sites of conservation interest in EU Mediterranean countries (from Piante and Ody, 2015).

4 Jurisdictional international framework

Marine biodiversity is protected by a range of international and national laws and agreements, as well as by voluntary codes of conduct. Among these, the **Convention on Biodiversity** (**CBD**) entered into force on 29 December 1993 and represents a global treaty concerned with the conservation and sustainable use of biodiversity. In 2004, the Conference of the Parties to the Convention on Biological Diversity (CBD), in its Decision VII/5 (paragraph 30) agreed to the "*urgent need for international cooperation and action to improve conservation and sustainable use of biodiversity in marine areas beyond the limits of national jurisdiction*", including through the establishment of marine protected areas that include seamounts, hydrothermal vents, cold-water corals, and/or other vulnerable ecosystems (Van Dover et al., 2018).

Although international law and national legislation largely ignore the deep sea's critical role in the functioning and buffering of Earth systems, there are promising developments in support of deep-sea protection at the **United Nations** and the **International Seabed Authority (ISA)** (Danovaro et al., 2017). The ISA is an autonomous international organization established under the 1982 United Nations Convention on the Law of the Sea and the 1994 Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea. The ISA manages deep-sea mineral resources in international waters, requiring organizations that have been granted exploration or prospecting licenses to prevent and control harms to the marine environment.

However, new policies of managements and protection are needed because (i) a large portion of deep-sea environments falls in **Areas Beyond National Jurisdiction (ABNJs)** and (ii) regulatory bodies for activities in ABNJs, such as the ISA and Regional Fisheries Management Organizations (RFMOs), are typically sector based, and this limits potential cooperation across sectors (Danovaro et al., 2017).

The **UN Convention on the Law of the Sea (UNCLOS)** recognizes the right of all states to access marine living resources in ABNJs, together with the obligation to cooperate with other states to protect and preserve the marine environment. More specifically, the UNCLOS provides a legal order for the seas and oceans that promotes the equitable and efficient utilization of their resources, the conservation of their living resources and the study, protection and preservation of the marine environment. UNCLOS includes the general obligation to protect and preserve the marine environment (Article 192), the duty to protect and preserve rare or fragile ecosystems, and the habitat of depleted, threatened or endangered species and other forms of marine life [Article 194(5)]. Further, States have a duty to cooperate on a global or regional basis in formulating and elaborating international rules, standards and recommended practices and procedures for the protection and preservation of the marine environment (Article 197). These obligations are further specified in the Implementing Agreements for UNCLOS related to the management of seafloor mining in international waters and of straddling and highly migratory fish stocks (UNGA, 1994; 1995). The opportunity exists to implement guidelines for restoration and rehabilitation as part of a sustainable and ethical environmental management strategy to protect and preserve the marine environment, rare and fragile ecosystems, and vulnerable species, while allowing the responsible use of marine resources (Van Dover et al., 2014). However, these environmental obligations have been neither well specified nor implemented (Danovaro et al., 2017). The UN is developing a new international agreement that could potentially overcome these challenges by enabling comprehensive ecosystem-based management of ABNJs. At the end of 2017, a preparatory committee (PrepCom) delivered recommendations to the UN General Assembly for a new, legally binding instrument under UNCLOS on the conservation and sustainable use of marine biodiversity in ABNJs. On the basis of those recommendations, in 2018, the UN General Assembly should have decided whether to negotiate a final treaty. The specific topics addressed to date are (i) marine genetic resources, including questions on sharing of benefits; (ii) area-based management tools, including marine protected areas (MPAs); (iii) environmental impact assessments; and (iv) capacity-building and the transfer of marine technology (Danovaro et al., 2017).

In parallel with the UN effort, the ISA is developing rules to govern exploitation of minerals in the deep seabed ABNJs. UNCLOS requires the ISA to administer seabed-mining activities on behalf of all humankind. Deep-sea ecosystems targeted by the mining industry require baseline assessments, monitoring strategies, and environmental impacts assessments to evaluate natural spatial and temporal variability and to develop mitigation and restoration strategies (Collins et al, 2013). The ISA's 2012 **Strategic Environmental Management Plan (SEMP)** in the equatorial eastern Pacific Ocean established a representative network of areas closed to mining, covering 1.44 million km^2 of seabed (Lodge et al, 2014). The ISA is not competent to regulate other activities, such as deep-sea bottom fishing on seamounts, which may impinge upon areas protected from mining. The new UN treaty offers an opportunity to incorporate provisions for comprehensive planning, coordinated management, and long-term monitoring to complement ISA regulations and plans (Wedding et al, 2013). This will require improved knowledge and holistic monitoring.

Other conservation and management tools and actions implemented through international treaties, conventions, and agreements include identification and protection of **Vulnerable Marine Ecosystems (VMEs**; UNGA61/105) (Taranto et al., 2012; Rogers et al., 2010) and **Ecologically or Biologically Significant Areas (EBSAs)** (Gilman et al., 2011; Weaver and Johnson, 2012), as well as a call for networks of Chemosynthetic Ecosystem Reserves (Van Dover et al., 2012) for deep-sea hydrothermal vent and seep ecosystems.

At European level, beside the MSFD, additional instruments for the protection of the marine habitats are already in force. Among these, the Habitat Directive (56/92 EC) in its Appendix 2 foresees two habitats that can include several deep-sea ecosystems: these are "H1170 *Reefs*" and "H1180 *Submarine structures made by leaking gases*". Under the H1170 all cold-water corals, black corals, gorgonian as well as *Lytocarpia*, *Isidella* and *Funiculina* facies/beds can be protected and areas with high occurrences of these species can be designated as SCIs.

The main strategies for protection adopted in the deep sea by different bodies/agencies/conventions are summarized in the Table 1.

Table 1. Main strategies for protection adopted in the deep sea by different bodies/agencies/conventions.

Promoting body / Authority	Form of protection	Tools	Major facing stressor
ISA	APEIs	Protected areas	Deep-sea mining
RFMO	HSBFC	Trawl-ban	Trawl-fishery
CBD	EBSA	Protected areas / Impact assessment	Different threats
IMO	PSSAs	Specific measures to control the maritime activities (e.g. routine measures etc.)	International shipping
EU Habitats Directive	SAC	Protected areas, trawl-ban	Different threats
National /transnational government	LMPA	Protected areas	Different threats
Marine National Monument (USA)*	FRA	Protected Area	Fishery, energy, minerals extraction
National government based on CBD	OEABCM	Different protection measures depending on the threat/pressure	Different threats
GFCM	FRA, EH, SH	Trawl-ban	Trawl-fishery

* Now 330,000 square miles including trenches, seamounts vents etc.

Legend. **Bodies/agencies/conventions:** ISA= International Seabed Authority; RFMO= Regional Fishery Management Organizations; IMO= International Maritime Organization; CBD= Convention on Biological Diversity. **Form of protection:** APEI= Areas of Particular Environmental Concern; HSBFC= High Seas Bottom Fisheries Closure; EBSA= Ecologically and Biologically Significant Areas (EBSA); PSSA= Particularly Sensitive Sea Areas; SAC= Special Areas for Conservation; FRA= Fishery Restricted Area; SH and EH= Sensitive and Essential Habitats; LMPA=transboundary Large Marine Protected Areas; OEABCM=Other Effective Area-Based Conservation Measures. *From Danovaro et al., under revisions in Nature Ecology and Evolution.*

5 Guidelines and processes for deep-sea protection in the international context

For the CCZ example, to develop guidelines for conservation planning in the deep sea, a workshop was convened with the support of the Pew Fellows Programme in Marine Conservation, as well as **Census of the Diversity of Abyssal Marine Life (CeDAMar)** and **Global Census of Marine Life on Seamounts (CenSeam)**. The goals of the workshop were to develop recommendations regarding the creation of a network of MPAs for the ISA to consider for implementation in the CCZ. In order to address this aim, the workshop was organized in three stages. First, a panel of scientists and legal experts reviewed the general principles of MPA network design, the legal framework of environmental protection in the high seas and conservation activities in the deep sea and areas beyond national jurisdictions to date. The second stage of the workshop concentrated on identifying and characterizing the distribution of anthropogenic threats (e.g. mining, fishing, etc.) to deep-sea biodiversity and developing a robust ecological assessment of the key physical, biogeographic, ecological and biodiversity features in the planning region. The final stage focused on applying the MPA network design principles to the ecological assessment to develop a series of management alternatives. The workshop was specifically designed to be participatory to ensure that all stakeholder interests were 'at the table' in negotiating both the design principles and in reviewing assessments and alternatives to be incorporated into the design process. Workshop participants comprised experts representing the interests of a broad consortium of stakeholders, including the ISA, consultants, non-governmental organizations and the scientific research community. Through this participatory process, a series of general, scientific-based design guidelines were developed (Wedding et al., 2013).

The seabed of the CCZ is located beyond national jurisdictions and has been declared as '*common heritage of mankind*' by the United Nations General Assembly (UNGA) and the parties to the Third United Nations Convention on the Law of the Sea (UNCLOS 1970; Baslar, 1998). The ISA is tasked with developing rules and regulations for exploration and extraction of minerals from the deep sea (ISA, 2000), and is required to use the precautionary approach, as reflected in Principle 15 of the Rio Declaration (*In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*).

The Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area stipulate that prior to the issuance of test-mining and exploitation permits, MPAs (e.g. 'preservation reference areas') will be delineated '*in which no mining will occur to ensure representative and stable biota of the seabed in order to assess any changes in the flora and fauna of the marine environment*' (ISBA, 2000).

Regulations for management of mining impacts clearly identify a requirement for MPAs, and establish an opportunity for spatial ecosystem-based management. In the case of the CCZ, an established MPA network had social advantages in reducing uncertainty about future restrictions among mining contractors and would assist in guiding the mining industry in minimizing impacts to the marine environment during resource extraction (**Figure 4**). Establishing protections at the international scale would also represent a major marine management accomplishment in areas beyond national jurisdiction, which has been the focus of much discussion for conservation action (Wedding et al., 2013 and citations therein).

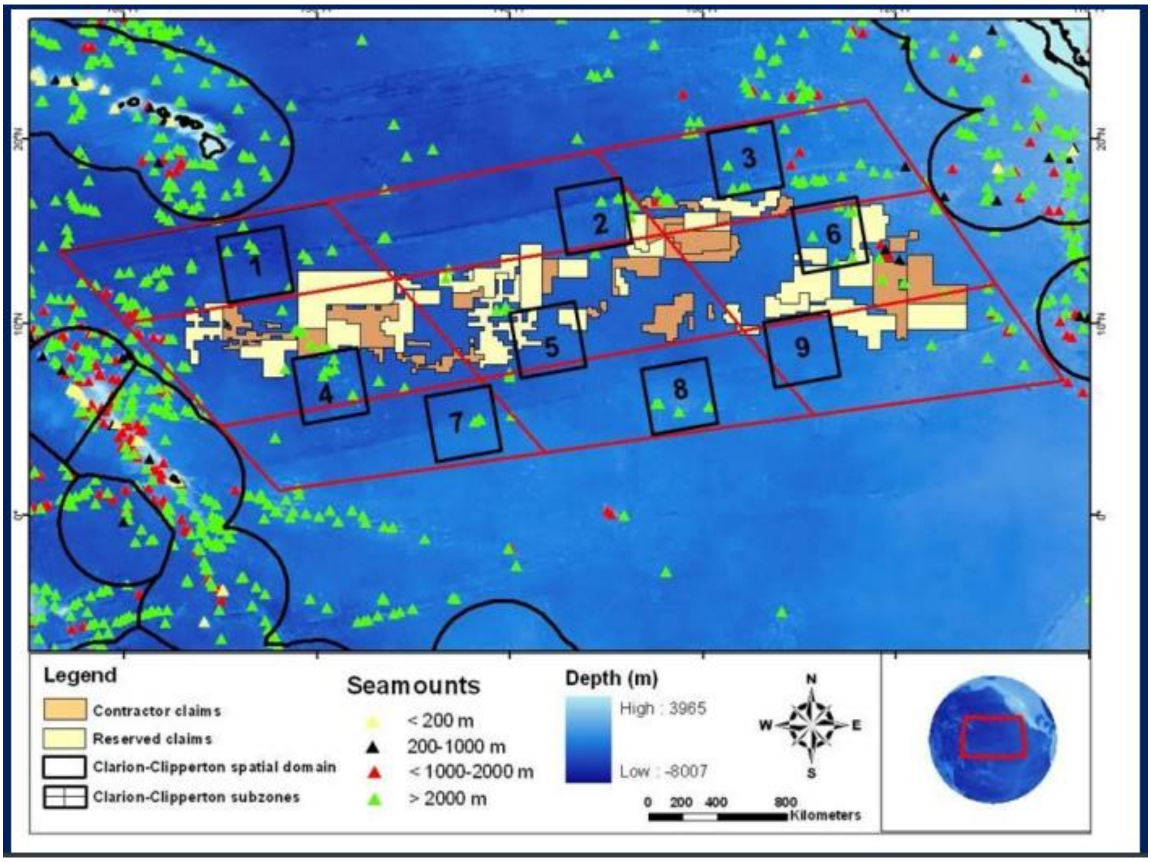

Figure 4. The nine 400 x 400 km protected areas (Areas of Particular Environmental Interest - APEIs) in the CCZ (from Wedding et al., 2013), covering 24% (1 440 000 km^2) of the total CCZ planning region.

In addition to the example provided by the process of institution of MPAs in the area of the CCZ, protection measures for hydrothermal vents provide another good example of how protection systems work in an international context. Such effort can help in defining guidelines for the protection of deep-sea ecosystems in general, including other unique ecosystems.

Several coastal States have enacted key legal norms to fully protect the ecosystems of active hydrothermal vents through the establishment and management of area-based protection (i.e. Canada, Mexico, New Caledonia, Portugal, and USA) (Le Bris et al., 2016). Canada recently augmented its 2003 implementation of the Endeavour Hydrothermal Vents Marine Protected Area by announcing the intention to protect all hydrothermal vents sites in its waters in a large offshore area (reported in Van Dover et al., 2018). A multitude of legal obligations, policy statements and precedents for the protection of hydrothermal vents are into force because of their rare and vulnerable (or "fragile") characteristics. In 2004, the UNGA adopted the Resolution 59/24, calling for States to manage risks to the marine biodiversity of hydrothermal vents. Moreover, with the Resolution 59/25, UNGA committed States to take action urgently to consider interim prohibitions on destructive fishing practices that have significant adverse impacts on VMEs including seamounts, hydrothermal vents and cold-water corals. UNGA Resolution 61/105 (adopted in 2006) committed States to "*protect vulnerable marine ecosystems, including … hydrothermal vents …, from destructive fishing practices, recognizing the immense importance and value of deep sea ecosystems and the biodiversity they contain.*"

The multilaterally negotiated International Guidelines for the Management of Deep-Sea Fisheries in the High Seas, adopted in 2008 to assist States in the implementation of UNGA Resolution 61/105 and subsequent UNGA resolutions, related to managing bottom fisheries in ABNJ, list hydrothermal vents and their endemic communities as an example of VMEs, that should be protected from significant adverse impacts caused by bottom fishing (FAO, 2009). While UNGA resolutions and International Guidelines are not legally binding, key provisions of these instruments (including criteria for identifying VMEs and requirements for protection of these ecosystems from significant adverse impacts), have become binding on States in most high seas areas through their incorporation into regulations adopted by Regional Fisheries Management Organizations (RFMOs), which have the legal competence to manage bottom fisheries in areas beyond national jurisdiction (Gianni et al., 2016). In 2016, the UNGA reaffirmed and strengthened the commitment of States and RFMOs to adopt and implement regulations to protect vulnerable deep-sea ecosystems from the adverse impacts of bottom fisheries and encouraged regulatory bodies with competence over other activities potentially impacting such ecosystems in areas beyond national jurisdiction (e.g., the ISA) to consider doing the same (Resolution 71/123).

The Council of the European Union requires the protection of hydrothermal vents from bottom fishing through Council Regulation 734/2008, adopted by the EU to implement UNGA Resolution 61/105, wherein member States are "*committed to the conservation of marine ecosystems such as … hydrothermal vents …*", and explicitly includes hydrothermal vents in the list of VMEs (EU 2008b; Article 2b). In 2008, parties to the CBD recognized hydrothermal vents as meeting criteria for designation as Ecologically and Biologically Significant Areas (EBSAs; CBD, 2008; Bax et al., 2016), where enhanced conservation and management measures may be needed. Provisions of the CBD related to States' activities regarding biodiversity protection apply beyond areas under national jurisdiction; States that currently sponsor exploration for polymetallic sulfides in such areas (India, Germany, France, Korea, Russia, China) are bound by the CBD (Van Dover et al., 2018).

The **Oslo and Paris Commission for the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)** recommends protection and conservation of hydrothermal vent fields as "priority habitats" (OSPAR, 2008a) in the OSPAR maritime area (NE

Atlantic). OSPAR also called for "*raising awareness of the importance of hydrothermal vents/fields occurring on oceanic ridges among relevant management authorities, relevant actors including industry sectors and the general public*" (OSPAR, 2008). Protection has also been accorded to vent ecosystems by the scientific community through responsible research practices, as outlined in the 2007 InterRidge Code of Conduct (Devey et al., 2007). The OSPAR Commission reiterated these practices for research activities in the northeast Atlantic (OSPAR, 2008b).

The UNESCO Marine World Heritage Program also recently highlighted the Lost City vent ecosystem on the Mid-Atlantic Ridge as one example of a site that meets criteria for outstanding, universal value in international waters (Freestone et al., 2017). From these actions, it is evident that active hydrothermal vent ecosystems are recognized through multiple international, regional, and State interventions as natural areas in need of protection and conservation. As a first step in implementing the UNCLOS obligations outlined in Articles 145 and 194, the ISA's Mining Code for exploration calls for application of a precautionary approach and protection of "*vulnerable marine ecosystems, in particular, hydrothermal vents…*" from serious harm (Regulations on Prospecting and Exploration for Polymetallic Sulfides in the Area; Regulation 33) (ISBA, 2010). This call for protection of vulnerable marine ecosystems is also included in draft exploitation regulations proposed by the ISA (ISA, 2016) and in a parallel discussion paper on environmental matters related to exploitation regulations (ISA, 2017). Protection of active hydrothermal vents by the marine mining sector would be consistent with "No-Go Zones" for mining on land, where avoidance of areas characterized by high biodiversity and endemism, rare or endangered species, rare habitats, and intactness, is practiced (Goodland, 2012).

The international community has recognized protection as a viable and proportionate option for particularly vulnerable species and ecosystems elsewhere. For example, moratoria have been applied to commercial whaling (IWC, 2016) and to all mineral resource activities in the Antarctic (Antarctic Treaty, 1991; Jaeckel, 2017). Protection of active hydrothermal vent ecosystems from direct and indirect impacts of mining on the international seabed would be consistent with the ISA designation of hydrothermal vents as vulnerable, the ISA's obligation to employ a precautionary approach, the obligations under UNCLOS Articles 145 and 194, and the aforementioned precedents for protection of hydrothermal vents under other international conventions. Full protection of all active hydrothermal vents would obviate the need to make difficult and incompletely informed decisions about environmental risks on a case-by-case basis, which would be a strategy fraught with potential for first-mover advantage, regulatory capture, and politically driven decision-making (Van Dover et al., 2018).

Further, protection of active vent ecosystems would be an important contribution by ISA member States to Sustainable Development Goal (SDG) 14, which calls for "*conservation and sustainable use of oceans, seas, and marine resources, and avoidance of significant adverse impacts*", and would be an appropriate precautionary response. Protection of all active vents from mining does not obviate the need for networks of protected areas, referred as **Areas of Particular Environmental Interest (APEI)** by the ISA (Lodge et al., 2014). APEIs are expected to work for broadly distributed organisms, but are likely inadequate for small, rare, and isolated habitats with idiosyncratic physico-chemical environments and with faunal assemblages endemic to and dependent on those environments (Van Dover et al., 2018).

For hydrothermal vents, in 2012 a group of stakeholders, including marine scientists, policymakers and industry representatives from 14 countries, produced the “Dinard Guidelines” to manage chemosynthetic environments on the seabed (Van Dover et al., 2012; **Figure 5**). The guidelines propose the establishment of reserves to protect the biodiversity, ecosystem functioning and resilience of these unique environments, while permitting reasonable use of their resources. The guidelines outline general principles to create effective reserves that can be managed at different scales (i.e. regional, national and international), within existing governance instruments, if possible. The reserves should meet the CBD criteria for ecologically or biologically significant areas and should be established with the goal of protecting biodiversity and ecosystem function. Conservation management should take an adaptive and precautionary approach, taking into account multiple impacts including fishing and mining. Cooperation among all stakeholders with an interest in the seabed would be the best way forward to ensuring the protection of high diversity seafloor ecosystems, while allowing for the possibility of responsible use of these ecosystem resources (Van Dover et al., 2012).

Box 1–Dinard Guidelines for Chemosynthetic Ecological Reserves (CERs) at deep-sea hydrothermal vents and cold seeps, initiated at a June 2010 workshop attended by 31 stakeholders from 14 countries, including scientists, policy makers, and industry representatives, and developed further in the report of the workshop [15].

A) Spatial Design of Chemosynthetic Ecological Reserves (CERs)

- Identify chemosynthetic sites that meet the Convention on Biodiversity criteria for Ecologically and Biologically Significant Areas (EBSAs) or are otherwise of particular scientific, historical, or cultural importance for priority consideration for protection.
- Define the regional framework for protection of biodiversity. Natural management units (biogeographic provinces and bioregions within these) form the ecological framework within which CERs should be established for the protection of chemosynthetic ecosystems.
- Establish the expected distribution patterns of chemosynthetic habitats to provide a spatial framework for capturing representativity.
- Establish CERs and design replicated networks of CERs within bioregions, using guidelines for size and spacing that ensure connectivity and that take into account the pattern of distribution of chemosynthetic habitats, which may vary from semi-continuous to widely dispersed.
- Define human uses and the levels of protection for each CER to achieve the conservation goal.

B) Management Strategies for Chemosynthetic Ecological Reserves

- Use a two-level approach for establishing CERs: (1) select CER sites of extraordinary stand-alone value; (2) fill in the "gaps" to establish networks of CERs that, combined, will contribute to the network-level conservation goals while taking into account the spatial demands of human activities.
- Use adaptive management strategies to account for uncertainty and new knowledge.
- Establish CERs in a manner that is consultative and transparent.
- Governance of CERs should be within existing governance regimes wherever possible.
- Where CERs include activities with the potential to cause significant adverse impacts, Environmental Impact Assessments (EIAs) should be required for these activities and should follow best practices.
- Establish monitoring strategies to assess the impacts of cumulative activities in space and time relative to the conservation goal and objectives.
- Use a set of prescriptive criteria, established before multi-use activities begin, to trigger closer monitoring or cessation of activities that jeopardize the conservation goal within a bioregion.

Figure 5. "Dinard Guidelines" (from Van Dover et al., 2012).

6 From guidelines to science-based recommendations for the establishment of MPAs in the deep sea

In a recent paper (Wedding et al., 2013), the authors described an expert-driven systematic conservation planning process that was used as part of a collaborative stakeholder initiative to develop science-based recommendations for the establishment of a network of MPAs in the deep sea. The stakeholders developed these recommendations by applying ecosystem-based management principles together with spatial analysis of biophysical and social datasets, which helped assess trade-offs in the planning region and ultimately select an approach that best balanced the competing interests of biodiversity protection and resource use. The authors stated that similar approaches can be used to implement ecosystem-based approaches in systematic conservation planning processes elsewhere.

Deep-sea regions, mostly where the planning region lies in areas beyond national jurisdiction, draw the attention to the diversity of stakeholders that need to be incorporated into the MPA network design process, including the policy leaders from the ISA, UNCLOS signatories, economic stakeholders, NGOs, marine scientists, legal and economic experts. The stakeholders should rely on a set of design principles that were initially developed to guide the establishment of networks of coastal MPAs (Wedding et al., 2013), and should work to adapt these guidelines to the biophysical, socioeconomic and governance context of the deep sea. These principles should be further developed as guidance for ecosystem-based management approaches in the open ocean (Foley et al., 2010; 2013). Below, the design principles already identified in the scientific literature (Wedding et al., 2013) are reported:

(1) Marine protected area (MPA) design and implementation should fit into the existing legal framework of the International Seabed Authority for managing seabed activities and protecting the marine environment.

(2) To the extent that it is scientifically sound, the proposed network should minimize socio-economic impacts.

(3) The MPA network should maintain sustainable, intact and healthy marine populations in the planning region.

(4) The MPA network should take into account biophysical gradients, which affect the biogeography of marine biodiversity in the planning region.

(5) Each MPA should protect a full range of habitat types found within each subregion.

(6) Each MPA should be large enough to maintain minimum viable population sizes for species potentially restricted to a subregion.

(7) Each MPA should be surrounded by a buffer zone to ensure that biota and habitats in the protected area are not affected by anthropogenic threats occurring outside the MPA.

(8) The boundaries of MPA should be straight lines to facilitate rapid recognition and compliance.

In the case study of CCZ, the proposed MPA alternatives describe a network of MPAs that cover 24% of the total 6,000,000 km^2 management area. In 2007, claim areas constituted about 19% of this total area, and the alternatives were optimized in their placement to minimize socio-economic impacts while still adhering to design principles that would ensure a scientifically sound biodiversity conservation outcome. This alternative balances the competing interests of biodiversity protection and resource use, resulting in an efficient allocation that maximizes benefits and minimizes the costs to mining claims (Wedding et al., 2013). Developing analyses that accurately assess trade-offs while optimizing outcomes can help support ecosystem-based management approaches in ocean environments (White et al., 2012). This is even more pressing for the CCZ considering that mining claim licenses continue to be granted by the ISA, with five new claims of 150,000 km^2 each granted since 2007, putting more than 30% of the management area within mining claims (Wedding et al., 2013). In the case of CCZ, mapping geomorphic features (e.g. seamounts) and dynamic oceanographic characteristics (e.g. primary production at multiple depth zones) were useful in ensuring that the guiding scientific principles were implemented in a spatial framework.

The challenges of implementing a geospatial approach in the deep sea and open ocean can be great, through also monitoring programs (according also to the MSFD principles), given the lack of comprehensive biophysical data (Treblico et al., 2011, Harris and Whiteway, 2009), the logistics of managing a large, dynamic MPA far from shore (Dunn et al., 2011), and the uncertainty surrounding connectivity and recovery timescales in these areas (Van Dover et al., 2012). The acquisition of such data at these broad spatial scales would have been cost prohibitive only a few years ago (Friedlander et al., 2011; Danovaro et al., 2017). These spatial datasets can be used as proxies for species distribution and make up for the lack of *in situ* biological assessments in the abyssal plains, seamounts and on the high seas. Continued efforts to map and monitor dynamic oceanographic characteristics and static geomorphic features across space and time will provide a strong foundation to support growing efforts to spatially manage the deep sea and open ocean (Harris and Whiteway, 2009; Clark et al., 2011; Watling et al., 2013).

7 The MSFD approach for the protection of the deep sea

The aim of the European Union's ambitious Marine Strategy Framework Directive is to protect more effectively the marine environment across Europe. The Article 21 of the MSDF reads "*It is crucial for the achievement of the objectives of this Directive to ensure the integration of conservation objectives, management measures and monitoring and assessment activities set up for spatial protection measures such as special areas of conservation, special protection areas or marine protected areas.*" (EU, 2008a).

The MSFD requires Member States to adopt Programmes of Measures (PoM) to achieve good environmental status in their marine waters by 2020. The PoM shall include spatial protection measures contributing to coherent and representative networks of MPAs. Marine protected areas are a measure used across Europe's seas for protecting vulnerable species and habitats. More precisely, they are: i) geographically defined marine areas; ii) whose primary and clearly stated objective is nature conservation and iii) which are regulated and managed through legal or other effective means to achieve this objective (EU, 2015). However, deep-sea environments are not mentioned (EU, 2008a; 2015).

The first document mentioning deep-sea species and habitats is the Comm. Dec. 848/2017 (EU, 2017) and regarding only the Descriptor 1. Species groups considered in the deep-sea application of the MSFD cover essentially three groups belonging to marine mammals (i.e. deep-diving toothed cetaceans), deep-water fishes and deep-water cephalopods. Concerning deep-sea habitats the Comm. Dec. 848/2017 mentioned the following (in brackets are reported the relevant EUNIS habitat codes after the 2016 version):

- Upper bathyal rock and biogenic reef (ME1, ME2)
- Upper bathyal sediment (ME3, ME4, ME5, ME6)
- Lower bathyal rock and biogenic reef (MF1, MF2)
- Lower bathyal sediment (MF3, MF4, MF5, MF6)
- Abyssal (MG1, MG2, MG3, MG4, MG5, MG6)

8 Approaches and recommendation proposed by the IDEM project

The analysis of the available documents during IDEM has revealed that the principles of the MSFD, GFCM and MedFIsh4Ever are complementary and should be integrated.

The FRAs established by the GFCM have been included in the MedPAN report on the status of Mediterranean MPAs (MedPAN et al., 2016). More specifically, there are currently seven FRAs established by the GFCM in the high seas, three of which clearly contribute, on a permanent basis, to the conservation of unique sea bottom biodiversity features thanks to the implementation of a set of regulations that prohibit fishing with bottom trawlers.

These three FRAs cover 0.62% of the Mediterranean Sea, corresponding to 15,688 km^2. The four other FRAs, where there are also specific regulations that manage fishing activities, were essentially established to protect fish stocks and can also bring ancillary benefits. In addition, a wider FRA was established below the depth of 1,000 m prohibiting all activities using towed dredges and trawl nets at depths greater than 1,000 m in the whole region. It covers 1,468,190 km^2 or 58.33% of the Mediterranean Sea surface (MedPAN et al., 2016).

In addition, protection of marine environments has been included in the GFCM mid-term strategy (2017-2020). The Target 4 reads: *minimize and mitigate unwanted interactions between fisheries and marine ecosystems and environment*. At this point, it is underlined that healthy and productive marine ecosystems are an important means to support maximum sustainable yield and facilitate blue growth (GFCM, 2017).

The protection of sensitive and vulnerable ecosystems has also been included in the Malta MedFish4Ever Ministerial Declaration, signed on 30 March 2017 by EU and Ministers from 13 countries for sustainable fisheries in the Mediterranean Sea. The MedFish4Ever Declaration is the outcome of the so-called *Catania process*, launched by Commissioner in February 2015 and entailing fruitful cooperation with stakeholders, the GFCM Secretariat, EU Member States and third countries. Important milestones included a first ministerial conference of Mediterranean fisheries ministers in April 2016, the GFCM annual session in June 2016, and the GFCM inter-sessional meeting in September 2016 (https://ec.europa.eu/fisheries/two-new-signatories-malta-medfish4ever-declaration_en).

Moreover, in 2012, GFCM and UNEP-MAP signed a Memorandum of Understanding, stating that the cooperation between environmental and fisheries experts and organizations is a prerequisite for achievement of Sustainable Development Goal (SDG) 14 of the 2030 Agenda "*to conserve and sustainably use the oceans, seas and marine resources for sustainable development*" (https://web.unep.org/unepmap/cooperation-between-environmental-and-fisheries-organizations-prerequisite-sdg14).

Conservation benefits of marine protected areas increase exponentially with the accumulation of five key features: **no take**, **enforcement**, **duration**, **size**, **isolation**. Greater emphasis is needed on management and compliance to ensure MPAs achieve their aim (Edgar et al., 2014).

According to the AICHI Targets, ecosystem-based deep-sea protected areas should cover at least 10% of the Deep Mediterranean Seafloor (≥200 m) (AICHI TARGET 11, CBD) and their identification should be based on actual, rather than modelled, sea-wide habitat mapping, and on a real understanding of the functioning and resilience of deep-sea assemblages.

The MPAs should combine:

i) **representativity** (covering the full range of Mediterranean biodiversity, as well as rare and threatened habitats);
ii) **connectivity** (ensuring linkages between sites through currents, migratory species, larval dispersal);
iii) **redundancy** (protecting more than a single example of a given habitat);
iv) **viability** (appropriate size, spacing, extent of human-induced change, including climate change). It is necessary that compliance is assessed and performance measure(s) adopted, as a required component of the MPA management plan, to evaluate efficacy and whether modification (i.e., adaptive management) is needed to meet management objectives.

Within this framework, in the IDEM project, three key actions have been proposed to be carried out through different steps, as detailed below.

Action 1. *Establish deep-sea protected areas, covering at least 10% of the Deep Mediterranean seafloor including representative and rare ecosystems (AICHI TARGET 11, CBD)*:

- provide a comprehensive list of Mediterranean deep-sea habitats and threatened species;
- identify biodiversity "hot-spots" (e.g., canyons, seamounts) for strict protection;
- identify unique habitats (e.g., chemosynthetic habitats) for strict protection;
- identify areas with representative soft-bottom habitats for strict protection;
- identify deep-sea habitats, including soft-bottom and trawlable grounds, adjacent to protected coastal areas, that would benefit from the protection of shelf-slope ecosystem;
- undertake a comprehensive and multidisciplinary monitoring of identified areas.

Action 2. *Extend FRA (GFCM) to protect deep-sea habitats from overfishing and habitat destruction*:

- use the list of ecosystems provided in Action 1 to propose the establishment of FRAs;
- create adequate buffer zones where trawling is banned around VMEs and critical habitats at depths <600 m;
- propose impact assessment for exploratory fishing;
- facilitate the accessibility of Vessel Monitoring System (VMS) and Automatic Identification System (AIS) data;
- propose the ban of trawling to below 600 m (instead than at 1000 as at present).

Action 3. *Apply the precautionary principle to gas and oil exploration and production (E&P) activities in the deep Mediterranean Sea:*

- assess the state of the environment in target areas prior to exploration activities;
- reduce the detrimental impacts on benthic ecosystems;
- undertake monitoring of target areas before, during and after activities;
- revise and harmonize Directive 2013/30/EU and the protocol against pollution resulting from exploration and exploitation of the continental shelf and the sea bed and sub soil of the Barcelona Convention in the light of current scientific knowledge.

This approach has been previously endorsed in some areas of the Mediterranean Sea. As an example, the Port-Cros National Park was created in 1963 and was recently (2012) expanded to deep-sea ecosystems by including the Stoechades canyon (**Figure 6**).

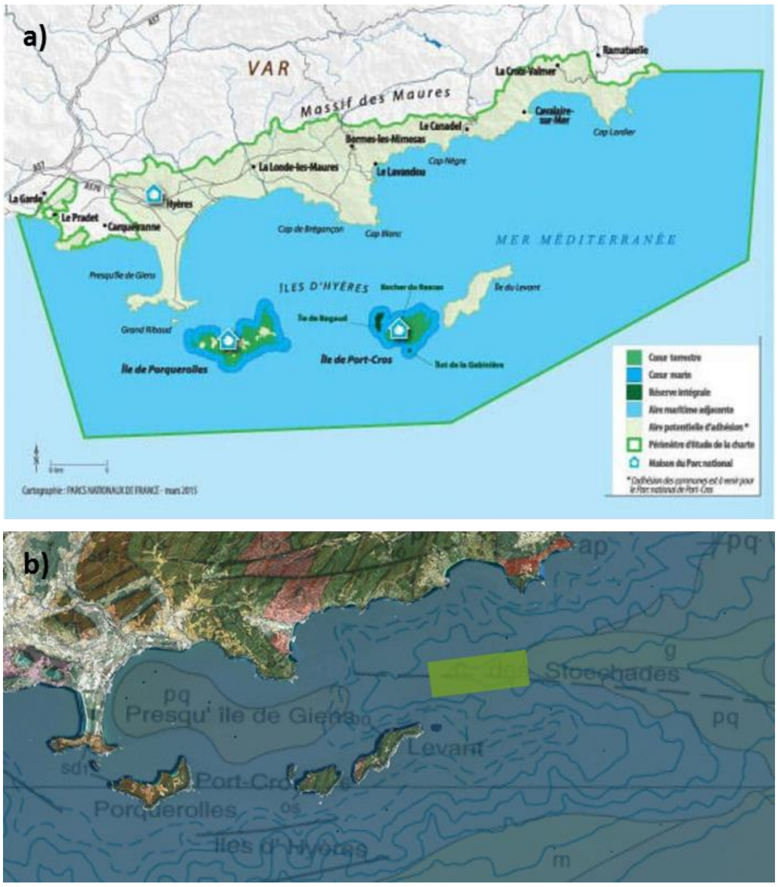

Figure 6. a) Map of the boundaries of Port-Cros National Park (source www.portcros-parcnational.fr); b) Ortho-photograph of the area overlaid to the geological map, with the indication of the Stoechades canyon. The green rectangle encompasses the Stoechades canyon head (2,904 ha, source https://inpn.mnhn.fr/viewer-carto/espaces/I032G293M000089).

Similar to the Stoechades canyon, two canyons facing the same situation and deserving protection have been identified in Italian waters. Indeed, the Dohrn and Levante canyons, hosting VMEs indicator species (Fanelli et al., 2017; Taviani et al., 2019), are located offshore already existing MPAs: the Regno di Nettuno (Naples, Southern Tyrrhenian Sea) and Cinque Terre (La Spezia, Northern Tyrrhenian Sea), respectively.

During the IDEM final meeting held in Rome in March 2019, the IDEM Consortium specifically insisted on the need to:

- Create adequate buffer zones around VMEs and critical habitats at depths <600 m where trawling is banned.

- Amend Recommendation GFCM/29/2005/115, to prohibit the use of towed dredges and trawl nets at depths greater than 600 m (in line with MSFD GES D1, D3 and D6, MedFIsh4Ever commitment and GFCM Mid-term strategy). It is necessary that compliance with the present self-management instrument is assessed, and performance measure(s) be a required component of the amendment, so as to evaluate efficacy and whether modification (i.e., adaptive management) is needed to meet management objectives.

- Use available information (VME list) and facilitate the accessibility of VMS and AIS data, to increase transparency and control.

- Launch the GFCM VME database as an essential tool for managers (integrated with other GIS databases, such as the IDEM WebGIS).

- Prioritize protection of threatened species also included in the VME list of indicator taxa (e.g. endangered coral species), in order to establish effectively managed deep-sea protected areas

- In view of the rapid development of extensive offshore gas fields we call for an appropriate UN agency/organization to establish deep sea extractive management guidelines for exploration, production and decommission in the Mediterranean Sea that emphasize environmental safety based on sound science and transparent results.

- Assess the projected impacts from climate change as stressors and threats to the Mediterranean deep-sea biodiversity. Identify (via Model-based connectivity research) trophic interactions, sources and sinks, and determine how MPAs may provide critical linkages and mitigate impacts from climate change. Account for biphasic life cycles, which inhabit different environments and may react differently to changes in climatological patterns. Design deep-sea MPA Networks for a changing climate with the aim of protecting Ecological Linkages and Connectivity Pathways for a wide range of habitats (Brock et al., 2012).

BOX 1. PROTECTION INITIATIVES

Specially Protected Areas of Mediterranean Importance (SPAMI) sites. Established by the Barcelona Convention (UNEP-MAP) as a system of protected areas for contributing to staving off further biodiversity loss. Reference: UNEP-MAP-RAC/SPA, 2010.

Ecologically or Biologically Significant Marine Areas (EBSA). Defined by the Convention on Biological Diversity (CBD) as special areas in the oceans that serve important purposes to support their healthy functioning and the many services that they provide. Reference: https://www.cbd.int/ebsa/

Particularly Sensitive Sea Areas (PSSA). Identified by the International Maritime Organization (IMO) and described as areas that need special protection because of their significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities.
Reference: http://www.imo.org/en/OurWork/Environment/PSSAs/Pages/Default.aspx

Fisheries Restricted Areas (FRAs). Established by the General Fisheries Commission of the Mediterranean (GFCM), FRAs are intended to protect essential fish habitats (EFHs) and/or deep-sea sensitive habitats of high ecological value, such as vulnerable marine ecosystems (VMEs), from significant adverse impacts of fishing activities. Reference: FAO, 2018.

Marine areas proposed as Site of Community Interest (SCI) by the INDEMARES project. This project identified areas of natural and socioeconomic value that were evaluated and

IDEM proposes key areas for monitoring in the deep Mediterranean Sea. Within the proposals for further work, a comparison between the approach for IDEM Task 3.3 and the multi criteria analysis foreseen in IDEM Task 2.3 (see next paragraph), for identifying key areas for conservation, is strongly advised.

9 Multi criteria analysis to design deep-sea Marine Protected Areas in the Mediterranean Sea

9.1 *Background information*

Decision-making in nature conservation requires comparing alternatives to achieve multiple and competing goals. Conservation goals involve complex and spatially explicit biophysical, socio-cultural and economic issues. The protection of habitats, vulnerable biological communities and economically important species should be achieved ensuring the maintenance of sustainable human activities and addressing the needs of stakeholders in the planning process (Richardson et al., 2006).

Over the last decades, the knowledge of theories underlying the design of MPAs has experienced an increase (Halpern and Warner, 2002), but theoretical studies about the general principles on which to base marine reserve design are still specific to a single situation and mostly focused to coastal and/or inshore waters (Leathwick et al., 2008). However, the increasing encroachment of anthropogenic activities on the deep-sea marine environment (Glover and Smith, 2003; Davies et al., 2007) has brought into sharp focus the need to conserve and manage this environment appropriately.

The paucity of empirical experience at large scale, in both shallow and deep marine environments, has led to an increasing use of models in the definition and planning of conservation areas at sea. In this context, various methods (e.g., Marxan, a decision support software for conservation planning) have been implemented and used to support protection areas design at shallow-water and deep-sea scenarios (Madden et al., 2009).

In this context, Multiple Criteria Analysis (MCA) encompasses a rich and diverse set of techniques allowing to make objectively informed choices and to consider social preferences, development needs, and conservation requirements. MCA evaluates a set of alternatives based on multiple criteria, which are quantifiable indicators representing the protection objectives to be achieved (Malczewski, 1999). The approach is particularly useful for examining tradeoffs in situations when multiple management objectives (i.e., biological conservation and activities preservation) has to be optimized simultaneously (Wattage and Mardle, 2005). MCA techniques commonly consist in two stages:

1. Scoring: the expected consequences of each option are assigned a numerical score on a strength of preference scale for each option for each criterion. More preferred options score higher on the scale, and less preferred options score lower.

2. Weighting: numerical weights are assigned to each criterion based on the relevance of the criterion in the achievement of the conservation objectives.

However, there are many different MCAs, distinguished from each other principally in terms of how they process the information provided by the criteria selected, and which may involve both or one of the previous stages. Several papers reviewed the application of Multi Criteria Decision-Making (MCDM) techniques in various disciplines such as fuzzy MCDM (Mardani et al., 2015b), classic

MCDM (Mardani et al., 2015a), and Weighted Sum Model (WSM). Weighted Sum Model (WSM) is the best known and simplest multi-criteria decision analysis (MCDA), and combines many criteria into one overall value by multiplying the value score on each criterion by the weight of that criterion, and then adding all those weighted scores together (Smith and Theberge, 1987).

9.2 *Data and methods*

Logic approach

The approach used (**Figure 7**) can be summarized in five main steps:

- Identification of no-go areas (i.e. mining/extraction areas, military zones or dumping zones) in the deep Mediterranean Sea that are not suitable for conservation plans and exclude them from the analysis (i.e., areas within 12 nm from extraction sites);
- Identification of sub-target, i.e. conservation targets and human activities;
- Selection of different criteria (i.e. Vulnerable Marine Ecosystems distribution) involved in different scenarios;
- Selection of quantitative spatial indicators (GIS layers) to defining the criteria;
- Determine weights to each indicators and construct the final linear weighting scheme.

For this exercise, we chose two sub-targets: "Biological Conservation" and "Activities Preservation". According to the availability of the data, we decided to assign a higher overall weight (70%) to "Biological Conservation" than "Activity Preservation" (30%).

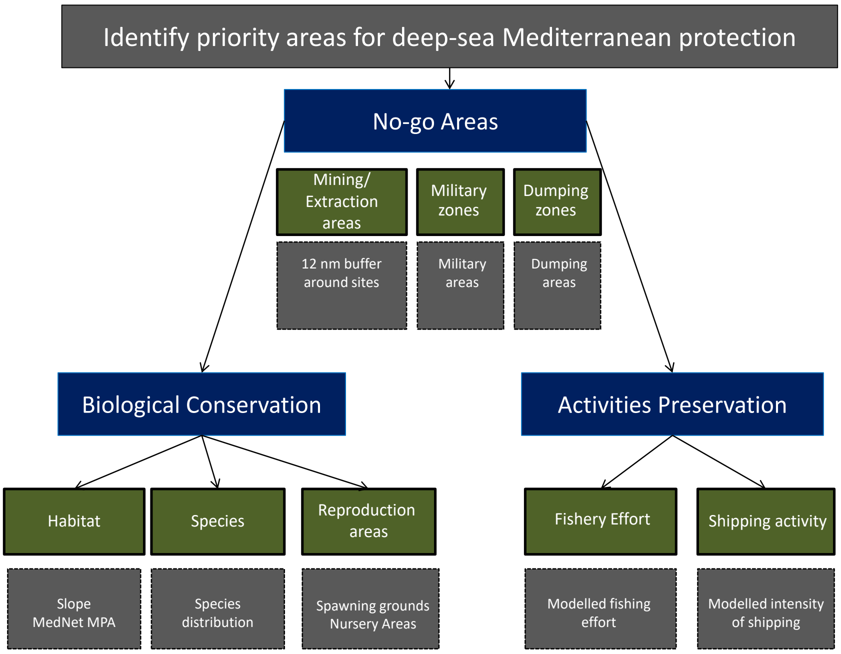

Figure 7. Workflow representing the multi criteria approach used in this exercise.

Although it is well known that mining, extraction and dumping activities at sea impact surrounding marine ecosystems (Ellis et al., 2012; Boschen et al., 2013), these effects have mostly been studied locally and, thus, a general spatial effect is still missing. For this reason, we decide to consider these areas as characterized “no-go areas”, according to ICMM, 2003 and ICMM, UNESCO and IUCN, 2008. In some European countries, oil-drilling activities are allowed to a few tens of miles from the coast and to 12 miles from Marine Protected Areas. We thus compute a buffer of 12 nm around the extraction and mining sites and we consider the area as “fully protected”.

The Table 2 shows the different criteria and the relative weights used in the two hypothetical scenarios.

In Scenario A, the “Habitat” criterion of the “Biological Conservation” target included only the “Slope” layer, since high-definition map of the seafloor characteristics (i.e. substrates) were not available (**Figure 9**). This represent a severe limitation, since habitat biotic components, distribution and extension are crucial to identify priority area for conservation purposes.

In the Scenario B (**Figure 10**), we included the Oceana MedNet MPA distribution in the Mediterranean Sea (Oceana, 2011) as proxy of biological relevance of areas where data were scarce or missing.

Table 2. Criteria and weights used in the Scenario A and B.

Scenarios	**Criteria**	**Indicator**	**Weight**
Scenario A	Habitat	Slope	0.05
	Species	Species distribution	0.3
	Reproduction Areas	Nursery Areas	0.175
		Spawning grounds	0.175
	Fishery Effort	Modelled fishing effort	0.2
	Shipping activity	Modelled intensity of shipping	0.1
Scenario B	Habitat	Slope	0.05
		MedNet MPA	0.05
	Species	Species distribution	0.3
	Reproduction Areas	Nursery Areas	0.15
		Spawning grounds	0.15
	Fishery Effort	Modelled fishing effort	0.2
	Shipping activity	Modelled intensity of shipping	0.1

Processing

The data used in this analysis were collected within the IDEM project lifetime and are now available through the IDEM Geoportal at the link: http://gismarblack.bo.ismar.cnr.it:8080/mokaApp/apps/idem/index.html.

"Biological Conservation" sub-target:

1- **Species classified according to IUCN Red List** (www.iucnredlist.org) ranking approach, with weights that linearly increase. The lowest weight was assigned to "Not Evaluated" and "Data Deficient" classes and the highest to "Critically Endangered" class.

2- **Distribution of geomorphological features:** high-detail datasets for different habitat types (e.g., canyons and seamounts) on the entire Mediterranean Sea is not available. We, thus, decided to use the slope as a proxy for identify areas, which may host ecological relevant communities. The slope for the whole Mediterranean Sea was obtained using Spatial Analyst tool "Slope".

3- **"Nursery areas" and "Spawning grounds" criteria** (from Colloca et al., 2015) are based on the modelled distribution of hot-spots areas in the deep Mediterranean Sea for several commercial demersal species reproduction (e.g., *Raja clavata, Parapenaeus longirostris, Pagellus erythrinus, Nephrops norvegicus, Merluccius merluccius)* using a standardized procedure.

"Activities Preservation" sub-target:

1- The "Fishery Effort" criteria involved the potential pressure generated by fishing activity in regions close to the coast. The layer represents an expert-based approach to estimate the spatial distribution of fishing activities and the related pressure of harmful fishing techniques on marine environments. This approach resulted in this cumulative fishing indicator, that aims at provide a spatial explicit estimation of main pressures exerted from fishing related activities, particularly trawling and dredging, taking into account the variables for which spatial data are available and that had a specific influence on marine ecosystem.

2- The intensity of shipping activity comes from Halpern et al. (2008).

The analysis was computed using ArcGIS 10.5 and the geoprocessing tool "Weighted Sum", which overlays several rasters, multiplying each by their given weight and summing them together. All the data were converted in raster format and normalized to obtain values ranging from 0 to 1.

9.3 *Results and discussion*

The model output is strongly biased by the lack of data for the southern and eastern margins of the Mediterranean Sea (Scenario A in **Figure 8**), were no high suitable areas have been recognized, representing a false negative. In the Scenario B (**Figure 9**), the inclusion on VME distribution favors the detection of moderate-value suitable areas in these parts of the basin, but still showing strongly lower values with respect to the northern-western Mediterranean Sea.

For both scenarios, highest suitability values for the area along Italian margin have been obtained, as consequence of the higher number of species occurrences with elevated rank (from “Vulnerable” to “Critically Endangered”) and the presence of nursery area and spawning grounds. In Greek waters, a high number of reproduction areas were present, increasing the resulting suitability index.

The Sicily Channel shows extended areas with moderate-to-high values due to the presence of Cold Water Corals (CWCs) species.

The Spanish and French margins are influenced by the less availability of spatial data, presenting overall low values with patchily distributed high-value areas related to the presence of high-ranked species and geomorphological features.

In the Gibraltar Strait, the results are critically influenced by shipping activity, which is intensive in the area, masking the presence of vulnerable species such as CWCs.

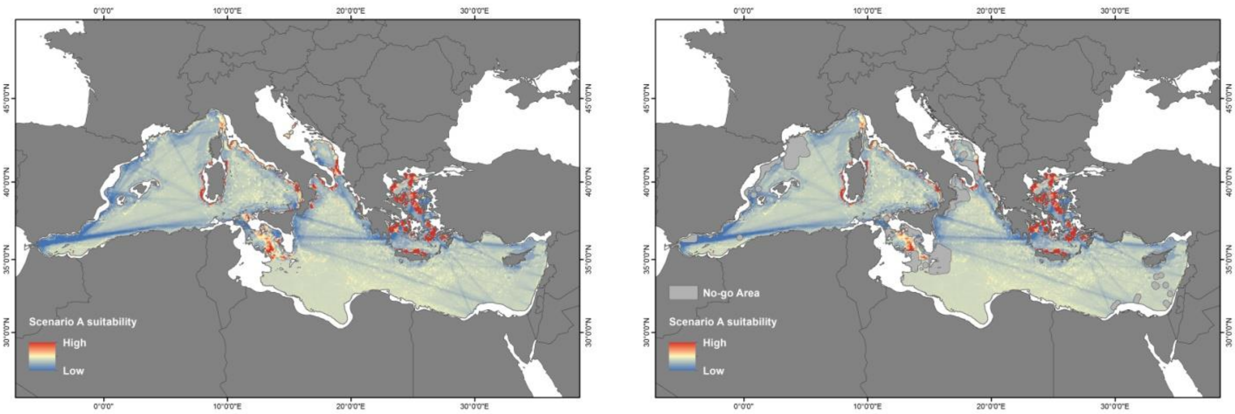

Figure 8. Model output for Scenario A reported complete (left) and with the exclusion of “no-go areas” (right)

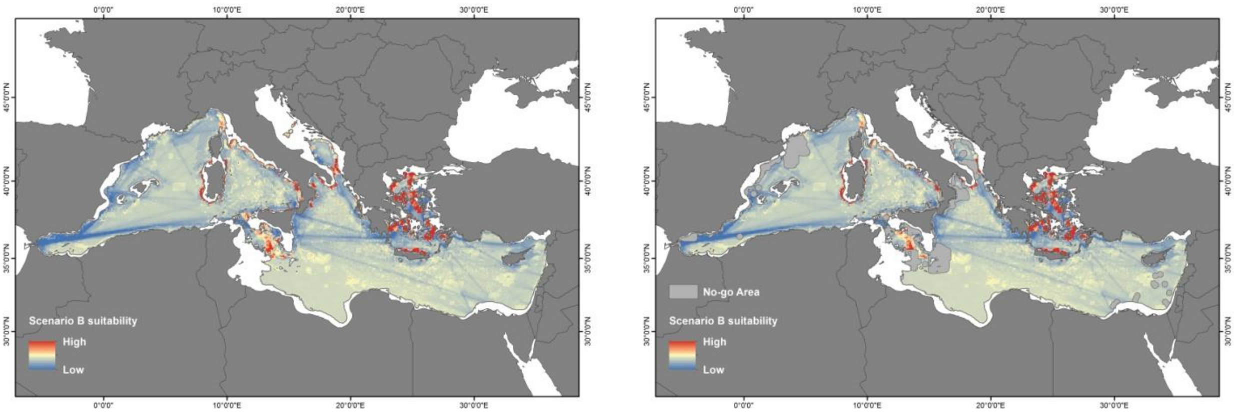

Figure 9. Complete model output for Scenario B (left) and with the exclusion of "no-go areas" (right).

The maps in **Figures 9** and **10** are only two of possible scenarios according to the availability of the spatial data collected in the framework of the IDEM project. The amount and the quality of the information across the basins are not homogenous and maybe not enough to produced effective scenarios. The MCA could be an efficient management tool and the maps of suitability a product able to reach a large slice of stakeholders. In this sense, it is crucial to provide to users the tools necessary for a correct interpretation of the results. The latter is strongly affected by the quality of the data and from the MCA operator that chooses criteria and weigh according to the final use of the maps. Increasing the background knowledge is fundamental when spatial tools as the MCA are applied with conservation aims.

10 Identification of key areas for future monitoring programs in the deep Mediterranean Sea

10.1 *Background information*

Identification of key areas for monitoring purposes is assigned to IDEM Task 3.3, together with the description of the available thresholds to identify GES. Accordingly, Task 3.3 has two distinct objectives:

i) identification of the available thresholds, and
ii) suggestion and evaluation of key areas for monitoring programs.

This chapter provides an overview of the approach developed for the fulfillment of the second of these objectives. The detailed description and the outcomes of the approach are available in Deliverable 3.3 (IDEM, 2019).

The process encompasses the compilation of background information and considerations, the establishment of two sets of criteria for the evaluation of suggested areas, the resulting selected areas described in individual descriptive sheets and a final compilation of the results with further recommendations, and the suggested final monitoring target (aim) for the deep Mediterranean Sea. Taking into account the boundary conditions of the IDEM project, the approach followed has been based on a suitable set of criteria assessed by expert's judgement.

This approach is directly related to the multi criteria analysis developed also within the IDEM framework for identifying priority areas for conservation and previously explained in chapter 9 of this deliverable (see also IDEM deliverable 2.3).

However, the multi criteria analysis is conditioned by the availability of quantitative data regarding the different criteria used for the detection of the areas. The two approaches could complement each other by partially overcoming some of the corresponding limitations. The multi criteria analysis might corroborate with data some of the key monitoring areas identified based on expert's judgement. In a related way, Task 3.3 approach would be able to highlight relevant areas where the lack of data hinders its identification in the multi criteria analysis.

10.2 *The evaluation framework and the classification process*

The selection of key areas for monitoring programs is based on the assessment of two sets of criteria targeting the ecological relevance (ER criteria) of the area and the anthropogenic threats (AT criteria) certainly or potentially impacting the area. The assessment has been performed following a three level scoring system that considered the level of relevance and/or applicability of each criterion to a particular area. The three level scoring system ranges from 0 to 3, giving a 0 when the criterion is not applicable or data insufficiency prevents a sound evaluation. Subsequently, 1 is set for low, 2 for medium and 3 for high applicability/relevance. It should be stated that the scoring of a 0 for an area due to data insufficiency should be highlighted to foster the acquisition of at least basic information.

Following the scoring of the two sets of criteria, an averaged score is obtained for each set. Accordingly, each candidate area is characterized by two scores (ER and AT averaged scores). The subsequent classification process, based on these two averaged scores and guided by a basic set of rules, defines two types of key areas symbolized by a graphic representation of the two averaged scores (Figure 10). **Type 1** key areas are nominated as regions for priority monitoring under AT (vs. GES), since they are characterized by high ER, but also high occurrence/intensity of anthropogenic threats. Key areas classified as **Type 2** are suggested for priority monitoring (vs. GES) because of their ER, even though they are devoid of identified high AT. **Type 2** identifies areas of priority monitoring (which likely deserve protection) because of their ER (high ER values) and naturalness, since they are currently experiencing low level of human-induced degradation (low AT scores).

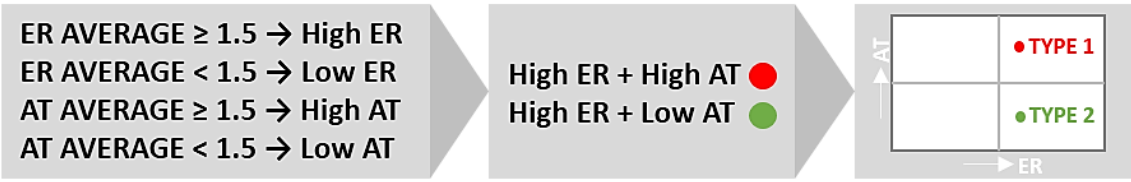

Figure 10. Diagram summarizing the process of classifying the areas suggested based on scores regarding Ecological Relevance (ER) and Anthropogenic Threats (AT). The red color represents Type 1 areas and the green refers to Type 2.

The set of ER criteria should compile all the relevant properties of key areas. The criteria already used in other initiatives (CBA, UNEP-MAP-RAC/SPA, PSSA and Habitats Directive 92/43/EEC) were revised and duly adapted when incorporated into the ER criteria set. Accordingly, AT criteria should reflect the most relevant pressures over the deep Mediterranean Sea. Consequently, apart from the Marine Strategy Framework Directive (2008/56/EC), peer-reviewed articles and publications were considered (Korpinen et al., 2012; Micheli et al., 2013; Piante and Ody, 2015). The final sets of criteria thus established consist of 11 ER and 12 AT criteria. A short description of each criterion is available below.

ER criteria

— **ER.1** ***Uniqueness***: Areas that contain either (i) unique, rare or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems, and/or (iii) unique or unusual geomorphological or oceanographic features.
— **ER.2** ***Dependency***: Areas that are relevant for different populations to survive and thrive.
— **ER.3** ***Importance for threatened, endangered or declining species*** and/or habitats.
— **ER.4** ***Vulnerability*** , fragility, sensitivity, or slow recovery.

- **ER.5** ***Natural representativeness***: Areas that are highly representative of ecological or physiographic processes, biodiversity, community or habitat types, or other natural characteristics.
- **ER.6** ***Bio-geographic importance***: Areas that either contain rare biogeographic qualities or are representative of a biogeographic “type” or types, or contain unique or unusual biological, chemical, physical, or geological features.
- **ER.7** ***Integrity***: Areas that are biologically functional units, effective self-sustaining ecological entities.
- **ER.8** ***High-energy processes relevant for deep-sea dynamics***: Areas of occurrence of relevant processes that are critical for the ecological functioning of the deep Mediterranean Sea since they involve significant vertical transfers of matter and energy.
- **ER.9** ***Water exchanges***: Areas where exchanges between different marine compartments are significantly taking place and involving horizontal transfers (basin and sub-basin scale) of matter and energy.
- **ER.10** ***Existing MPAs***: Areas that are already part of marine protected areas or other defined site of interest.
- **ER.11** ***Extreme scientific interest***.

<u>AT criteria</u>

- **AT.1** Introduction of alien species (D2-related).
- **AT.2** Overfishing and stock depletion (D3-related): refers to areas encompassing specific systems were overfishing lead to stock reductions below safe biological limits.
- **AT.3** High artificial nutrient inputs delivered to the deep sea (D5-related).
- **AT.4** Intensive, sustained fishing (D3 and D6 -related): refers to areas where intensive, sustained fishing results in serious harm to benthic habitats.
- **AT.5** Large-scale seascape change (D6-related): refers to areas where recurrent trawling has led to major modifications of the natural seascape.
- **AT.6** Deep-sea exploration and production activities (D6-related): includes hydrocarbon and mineral search and production, bioprospecting and the placement of infrastructures on the seabed.
- **AT.7** Significant alterations of hydrological processes (D7-related): refers to regions affected by climate-driven persistent physical changes and anomalous episodic events of either circulation, vertical mixing or other processes.
- **AT.8** Dispersal and accumulation of contaminants including marine litter (D8-D10).
- **AT.9** Presence of contaminants in fish and other seafood for human consumption exceeding levels established in relevant standards (D9-related).
- **AT.10** Persistent and intense underwater noise (D11-related).
- **AT.11** Significant effects of land-sourced, coastal and surface drivers of deep-sea ecosystems, namely chemical pollutants and litter (D8 and D10-related). This criterion is established to

consider deep-sea areas highly impacted by pressures originated mainly in land, along the coast or at the sea surface.

— **AT.12** Maritime traffic (D2, D8, D10 and D11-related).

10.3 *Proposing potential key areas for monitoring*

The proposal and selection of potential areas for monitoring was performed considering expert's judgement and relevant monitoring and conservation initiatives in the deep Mediterranean Sea (described in previous paragraphs and summarized in **Box 1**). Thus, the areas proposed by the following initiatives were considered: i) Specially Protected Areas of Mediterranean Importance (SPAMI) sites defined by UNEP-MAP-RAC/SPA; ii) EBSA defined by the CBD; iii) PSSA defined by the IMO; iv) FRAs defined by FAO; and v) the marine areas proposed for SCI by the INDEMARES project. Box 1 contains a brief description of these initiatives together with references where more information is available.

The areas here proposed are organized in six categories: Straits (ST), Dense Water formation areas (DW), Canyon Systems (CS), CWC Provinces/habitats (CWC), Seamounts (SM), and Other Relevant deep-sea systems (OR). The areas suggested by the different partners of the project were assigned to these categories according to their characteristics.

The evaluation enabled the classification of the key areas suggested and agreed by the IDEM consortium of partners. This was also the final output of IDEM deliverable 3.3. (IDEM, 2019). The output of the classification determined which areas are defined as Type 1 or Type 2 and thus got finally selected. The ones that did not fit neither within Type 1 or Type 2 requirements were discarded. The final selection consisted of 13 Type 1 key areas distributed along the Mediterranean Sea. A group of other 9 areas were established as potential key areas in need of further revision since the lack of expertise regarding those areas conditioned their evaluation. Details regarding the areas selected, their descriptive sheets and the evaluation results are available within Deliverable 3.3 (IDEM, 2019). A descriptive sheet was produced by the competent partner(s) for each of key areas selected. A common format has been designed in order to ensure a consistent output by providing each selected area with an easy-reading characterization (IDEM, 2019).

11 Future trends

Legislation is the key means by which the conservation of marine biodiversity is achieved in order to help ensure the marine environment is used sustainably. Since the 1960s, a raft of legislation has been introduced worldwide covering issues such as marine pollution, conservation of species and habitats and protection of fish stocks (Bell et al., 2013; Frost et al., 2016). More recently, the focus has been on establishing protected areas where some or all anthropogenic impacts could be excluded, and through taking a more holistic approach to achieve a desired state across the marine ecosystem. An example of the latter approach would be the Marine Strategy Framework Directive (MSFD).

However, MSFD fails to consider climate change as one of the main driver of change for marine biota in the future. Indeed, if it is true that MPAs are the main management tool for mitigating threats to marine biodiversity (Allison et al., 1998; Edgar et al., 2014), they, and the species they protect, are increasingly being impacted by climate change. Present predicting models for the Mediterranean Sea foresee increased temperature and oligotrophy in the Mediterranean Sea (Taucher & Oschlies, 2011). This will likely cause shifts in richness, assemblage composition and abundance of marine biota, including deep-sea species. Studies show that some features, for which marine protected areas have been designated, may have their distributions significantly affected by climate change leading to challenges in the ongoing management of the protected areas (Gormley et al., 2015).

In this context there is an urgent need to set up programs for multi-decadal time series of data or to globally analyze the few already existing ones. Long-term data series are needed for understanding of change in marine ecosystems, reducing scientific uncertainty and ultimately increasing the robustness of management decisions. For example, the separation of climatic and anthropogenic signals in marine ecosystems remains a basic scientific research question as well as a challenge to selecting indicators and setting environmental targets. The correct assignation of ecosystem responses to anthropogenic or climatic drivers is crucial in order to identify appropriate indicators, set attainable environmental targets, construct a realistic vision of GES and ultimately help decision-makers allocate management resources most effectively. Finally, long-term data series are necessary for the early detection of signals of impact, through simple and effective "indicators" such as shifts in species distribution or local extinctions (Danovaro et al., submitted).

12 Conclusions

A systematic conservation planning process for establishing preservation reference zones provides a unique and unprecedented opportunity for stakeholders to design a network of MPAs prior to the initiation of exploitation activities (Wedding et al., 2013). Furthermore, establishing a network of deep-sea MPAs would help meet important environmental and social goals.

A large-scale protected area network would ensure that biodiversity and ecosystem functions are safeguarded from resources extraction and exploitation, and could be designed to fulfil international commitments to sustainable development expressed in the United Nations Rio +20 Conference on Sustainable Development, as well as provisions of the Convention on Biological Diversity calling for the protection of biological diversity (UNGA, 2012; Veitch et al., 2012).

Implementation of an MPA network as an *a priori* conservation action also provides a buffer against current or future environmental threats and should be designed to mitigate those perceived threats (Gaines et al., 2010), and in the case of the Mediterranean Sea, to achieve and maintain the GES. Furthermore, the establishment of the MPA network may reduce uncertainty about future restrictions among users, protecting existing claims and economic investments in these claims (Wedding et al., 2013).

The integrated and collaborative approach has global implications for conservation also in areas beyond national jurisdiction or other complex ocean zones, and a similar framework may be useful for implementing ecosystem-based approaches in systematic conservation planning processes.

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