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PRACTICAL GUIDE ON GAP ANALYSIS AND MPA SYSTEM PLANNING FOR THE MEDITERRANEAN AREA

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Practical guide on gap analysis and MPA system planning for the Mediterranean area

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EXECUTIVE SUMMARY

Marine Protected Areas (MPAs) are universally recognized as a primary tool to protect marine biodiversity, especially when they are well-enforced and fully protected, and are organized into networks. In 2016, 7.14 % of the Mediterranean Sea was covered by MPAs and Other Effective Area based Conservation Measures (OECMs). The number of designated MPAs increased almost 3 times over the previous 15 years, but fully protected MPAs increased less rapidly. Only 0.04 % of the Mediterranean is fully protected today. In spite of the growing number of MPAs, these still don't come near achieving international targets such as Aichi Target 11.

Properly designed networks of MPAs can theoretically outperform single marine reserves by fulfilling a variety of ecological, economic, and management goals with greater effectiveness. However, networks of MPAs should be comprehensive, effectively connected, efficiently managed, ecologically representative, and cost-efficient.

Identifying, prioritizing, and filling gaps in a protected area system is a core element of a protected area master plan. Ultimately, the gaps that need to be filled are "conservation gaps", e.g., deriving from an uneven distribution of protected areas in a network which causes important components of the marine biodiversity of the region covered by the network to remain unprotected. However, the starting assumption is, that ecological knowledge of the region is uniformly distributed and sufficiently available throughout, so that conservation gaps (e.g., in terms of representation) can be revealed. This rarely being the case, often "knowledge gaps" also need to be filled in order, for a "conservation gap analysis", to proceed, although it is common practice to make use of proxies or surrogates (e.g., morphological features, indicators or umbrella species) when detailed ecological knowledge is unavailable.

In performing a "conservation gap analysis" it is important to have an assessment of the conservation effectiveness of the single MPAs which are part of the network. In most cases, conservation effectiveness is directly related to management effectiveness. Even in a perfectly designed MPA network, its real conservation effectiveness will depend only on the MPAs that are effective; paper MPAs must be recognised as such, and conservation gaps will continue to exist even if the network is perfectly designed.

A Gap Analysis aimed to identify gaps in conservation should always start by setting up both feasible and reasonable goals. The analysis needs to be developed and adapted depending on need, data availability, expertise and the type of species or ecosystems being considered.

Every gap analysis should follow six basic steps:

1) identify focal biodiversity and set key targets;
2) evaluate and map the occurrence and status of biodiversity;
3) analyse and map the occurrence and status of areas-based protection;
4) use the information to identify the gaps;
5) prioritize gaps to be filled;
6) agree on a strategy and take action.

Based on the available resources, a gap analysis can vary from a simple exercise with a low level of complexity, such as one based on the spatial comparison of biodiversity with existing MPAs, to a more complex study based on detailed data collection and analysis, often benefiting from the application of dedicated software decision packages.

The aim of this document is to provide a practical guide on Gap Analysis to be used by Mediterranean national planners, decision makers and other stakeholders involved in the MPA planning processes. This guide contains the main Gap Analysis principles, steps and best practices developed in various parts of the world. Examples applied to the Mediterranean region are provided. It also provides a flow chart summarizing the key steps to follow when conducting a Gap Analysis, a range of web resources and tools available for evaluating and mapping the occurrence and status of a site of critical importance for biodiversity, and for analysing the status and connectivity of existent and planned MPAs. The document is complemented by a list of additional reading material, containing highly relevant references.

ACRONYMS

ABNJ	Area Beyond National Jurisdiction
ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
AoI	Area of Interest
AZE	Alliance for Zero Extinction
CBD	Convention on Biological Diversity
cIMMA	Candidate Important Marine Mammal Area
COCONET	"Towards Coast to Coast Networks of marine protected areas coupled with sea-based wind energy potential" project
COP	Conference of the Parties
DSS	Decision Support System
EBSA	Ecologically or Biologically Significant Marine Area
EcAp	Ecosystem Approach
EMODnet	European Marine Observation and Data Network
EUNIS	European nature information system
FRA	Fisheries Restricted Area
GA	Gap Analysis
GBIF	Global Biodiversity Information Facility
GES	Good Environmental Status
GFCM	General Fisheries Commission for the Mediterranean
IBA	Important Bird and biodiversity Area
IMAP	Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
IMMA	Important Marine Mammal Area
IOC	Intergovernmental Oceanographic Commission
IODE	International Oceanographic Data and Information Exchange
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
MAP	Mediterranean Action Plan
MAPAMED	Marine Protected Areas in the Mediterranean Database
MedPAN	Network of Marine Protected Area Managers in the Mediterranean
MED QSR	Mediterranean Quality Status Report
MGA	Marine Gap Analysis
MMPA	Marine Mammal Protected Area
MMPATF	Marine Mammal Protected Areas Task Force

MPA	Marine Protected Area
MSP	Marine Spatial Planning
OBIS	Oceanic Biogeographic Information System
OECM	Other Effective area-based Conservation Measure
PoWPA	Programme of Work on Protected Areas
PSSA	Particularly Sensitive Sea Area
SPA/BD	Specially Protected Areas and Biological Diversity
SPA/RAC	Specially Protected Areas Regional Activity Centre
SSC	Species Survival Commission (of the IUCN)
UNEP	United Nations Environment Programme (aka UN Environment)
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCPA	World Commission for Protected Areas (of the IUCN)
WDPA	World Database on Protected Areas


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I. BACKGROUND TO THE PRATICAL GUIDE

The Mediterranean Sea is considered a hotspot of biodiversity, comprising 7 to 9% of the planet's known marine and coastal species diversity. At the same time, the Mediterranean is strongly threatened by human activities. Fishing, aquaculture, chemical pollution, maritime traffic and sewage discharges are the most common sources of human impacts that affect biodiversity and the services it provides at regional scale. Marine Protected Areas (MPAs) are universally recognized as a primary tool in marine biodiversity conservation strategies (e.g., Agardy, 1997). The role of MPAs is to provide a secure base for threatened species, ecosystems and ecological processes, including the species that have not yet been discovered and for which therefore dedicated conservation actions are not possible. Well-governed and effectively managed MPAs are powerful tools to combat the over-exploitation of marine resources and degradation of ocean habitats, protecting both habitats and species' populations and delivering important ecosystem services (Dudley and Parish, 2006; Agardy et al., 2011). In spite of the growing number of MPAs in the Mediterranean, these don't yet come near to fulfilling global biodiversity commitments defined under the Convention on Biological Diversity's (CBD) Aichi Biodiversity Targets, and in particular Aichi Target 11 (Giakoumi et al., 2017).

BOX 1 - "AICHI TARGET 11":

> "By 2020, at least 17 per cent of terrestrial and inland water and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascapes."

Source: https://www.cbd.int/sp/targets/rationale/target-11/

In the Mediterranean Sea, these commitments are addressed in particular by the Barcelona Convention. Regarding MPAs specifically, it is the Specially Protected Areas Regional Activity Centre (SPA/RAC) through the Protocol concerning Specially Protected Areas and Biological Diversity (SPA/BD Protocol) which follows up in the support of Parties in the attainment of the CBD objectives. Unfortunately, an established and declared single marine protected area does not necessarily guarantee by itself an adequate level of protection to its species and marine ecosystems. First, any MPA needs to be effectively managed. Second, an effective approach to enhance protection involves moving from individual MPAs and groups of MPAs towards full-scale MPA networks (RAC/SPA, 2014). Properly designed networks of MPAs can theoretically outperform single marine reserves by achieving a variety of ecological, economic, and management goals (Laffoley, 2008; Grorud-Colvert et al., 2014).

However, these MPA networks need to be well managed to effectively conserve biodiversity. A successful management plan that produces actual benefits to the ecosystem should consider essential management elements such as surveillance and monitoring, enforcement, performance monitoring and evaluation, as well as education and outreach. In addition, an adaptive approach of MPA boundaries and regulations should be adopted as information increases and environmental conditions change (Agardy et al., 2011). Identifying, prioritizing, and filling gaps in the protected area system is therefore a core element of a protected area master plan (Dudley and Parish, 2006). In order to facilitate the achievement of Aichi Target 11, a "Roadmap for a Comprehensive Coherent Network of Well-Managed MPAs to achieve Aichi Target 11 in the Mediterranean (2017)" (hereafter, the "MPA Roadmap") was adopted by the Contracting Parties to the Barcelona Convention during their nineteenth ordinary meeting (COP 19, Athens, Greece, February 2016). The MPA Roadmap stressed the need for increased attention to MPA network principles such as representativeness, connectivity and management effectiveness of protected areas, bearing in mind the importance of complementarity and spatial configuration, to offer an adequate protection to marine species and ecosystems. The objectives of the MPA Roadmap are summarized in BOX 2.

BOX 2 - "OBJECTIVES OF THE ROADMAP FOR A COMPREHENSIVE COHERENT NETWORK OF WELL-MANAGED MPAS TO ACHIEVE AICHI TARGET 11 IN THE MEDITERRANEAN (as adopted by the Barcelona Convention)":

" **Objective 1:** Strengthen networks of protected areas at national and Mediterranean levels, including in the high seas and in ABNJ, as a contribution to the relevant globally agreed goals and targets.

Objective 2: Improve the network of Mediterranean MPAs through effective and equitable management.

Objective 3: Promote the sharing of environmental and socio-economic benefits of Mediterranean MPAs, and the MPAs integration into the broader context of sustainable use of the marine environment and the implementation of the ecosystem and marine spatial planning approaches.

Objective 4: Ensure the stability of the network of Mediterranean MPAs by enhancing their financial sustainability. "

Source: UN Environment/MAP, 2017.

Particularly important for the purpose of this document is the first objective of the MPA Roadmap which requires that the Mediterranean MPAs, and other effective area-based conservation measures, be organized into a network or system of networks. In particular, the following elements need to be considered:

- extending the protected surface through the designation of new areas, the expansion of existing areas, and the incorporation of areas benefiting from other types of protection measures;
- enhancing ecological representativity through the selection of marine protected areas based on scientific information, which are to be identified within all marine areas, including within ABNJ;
- enhancing ecological connectivity, with new areas strategically located to ensure that they are spatially distributed in an ecologically meaningful way;
- enhancing geographical balance, with area-based conservation more homogeneously distributed across the region, both within and outside national jurisdictions.

In addition, the Mediterranean countries should consider the key recommendations contained in IUCN's "Promise of Sidney" (IUCN World Park Congress, 2014), stating that the MPA network should include at least 30 % of each marine habitat type. The ultimate aim is to create a fully sustainable ocean, at least 30 % of which has no extractive activities. At the 2016 IUCN World Conservation Congress, members approved the target of 30 % to be set aside in "highly protected MPAs and Other Effective area-based Conservation Measures (OECMs)" by 2030.

In order to support the attainment of such important and challenging objectives through the MPA Roadmap, the Contracting Parties to the Barcelona Convention are required to undertake a Gap Analysis (GA) at the national level, in order to identify the ecosystems and other components of marine biodiversity that are under-represented in the existing national MPA system. A well-designed assessment of the existing gaps can help countries to protect their marine resources and is the first stage in achieving the ambitious aims of the CBD's Programme of Work on Protected Areas (PoWPA).

Gaps can occur both in knowledge and conservation. A "Knowledge GA" allows to evaluate the extent of the knowledge gaps against the existing knowledge. While main purpose of a Conservation GA is to identify areas lacking protection, reviewing the gaps in order to ensure that the system of MPAs is located in the optimal places to capture as much sensitive biodiversity in need of protection as possible.

Within the framework of the MPA Systems, Conservation GA represent the most effective tool to identify gaps in conservation and to plan corrective intervention though the expansion of existing areas or the designation of new areas. Far from being conceptually challenging, the process however requires assembling substantive knowledge which is not always readily available, and using ecological knowledge and rigorous analysis in order to make adequate conservation decisions (Ariño, et al., 2016).

The aim of this document is to provide a practical guide on GA to be used by Mediterranean national planners, decision makers and other stakeholders involved in the MPA planning processes. The first part of this guide contains the main GA principles, steps and best practices developed in various parts of the world. This part also provides a range of web resources and tools available for evaluating and mapping the occurrence and status of critical biodiversity, and for analysing the status and connectivity of existent and planned MPAs. Finally, the document is complemented by a list of additional reading material, containing highly relevant references.

II. GAP ANALYSIS CONCEPT AND PRINCIPLES

In conservation, GA is a method to identify inadequacies in the conservation of biodiversity (i.e. species, ecosystems and ecological processes) within a protected area network or through other effective and long-term conservation measures (Scott et al., 1993).

According to Dudley and Parish (2006), GA involves the comparison between the distribution of biodiversity with the distribution of protected areas in order to find where species and ecosystems are left unprotected or under-protected. The initial concept has been introduced by Scott and co-workers at the end of the 20th century, recognizing that protected areas of all types and in all parts of the world currently do not fully protect biodiversity (Scott et al., 1993; Dudley and Parish, 2006).

The main purpose of a GA is to identify lack of protection, reviewing the gaps in order to ensure that the protected area system is distributed in the optimal places to cover as much sensitive biodiversity in need of protection as possible. A GA should always start with setting up both feasible and reasonable goals. Requirements and expectations from the considered MPA system can constitute a good starting point to build GA (Ariño et al., 2016).

Scott (2000) summarizes the need for a gap analysis around four key questions:

- Where do we stand today in the area of concern?
- Where are we headed?
- Where do we want to go?
- How will we get there?

To conduct a successful GA, it is necessary to perform a systematic reconnaissance of the spatial distribution of individual species and of MPA, bearing in mind that often this information is available for only a fraction of all species or only for some protected areas. It should be also considered that a GA is not restricted to identify spatial gaps only, since gaps exist along many dimensions such as time, taxonomy, management, environment, etc. (Ariño et al., 2016).

GAs are frequently carried out at smaller scales such as within national or even provincial boundaries. However, GAs should be applied to larger areas across the whole of an ecologically defined region, such as sub regions (e.g. Western Mediterranean, Adriatic Sea, Leventine Sea). This scale of analysis allows the planning of conservation actions to ensure the effective conservation of biodiversity by using the best available ecological information rather than basing decisions on political boundaries. At sub-regional, GAs can become a powerful conservation tool particularly if, where appropriate, it is based on collaboration amongst neighbouring countries.

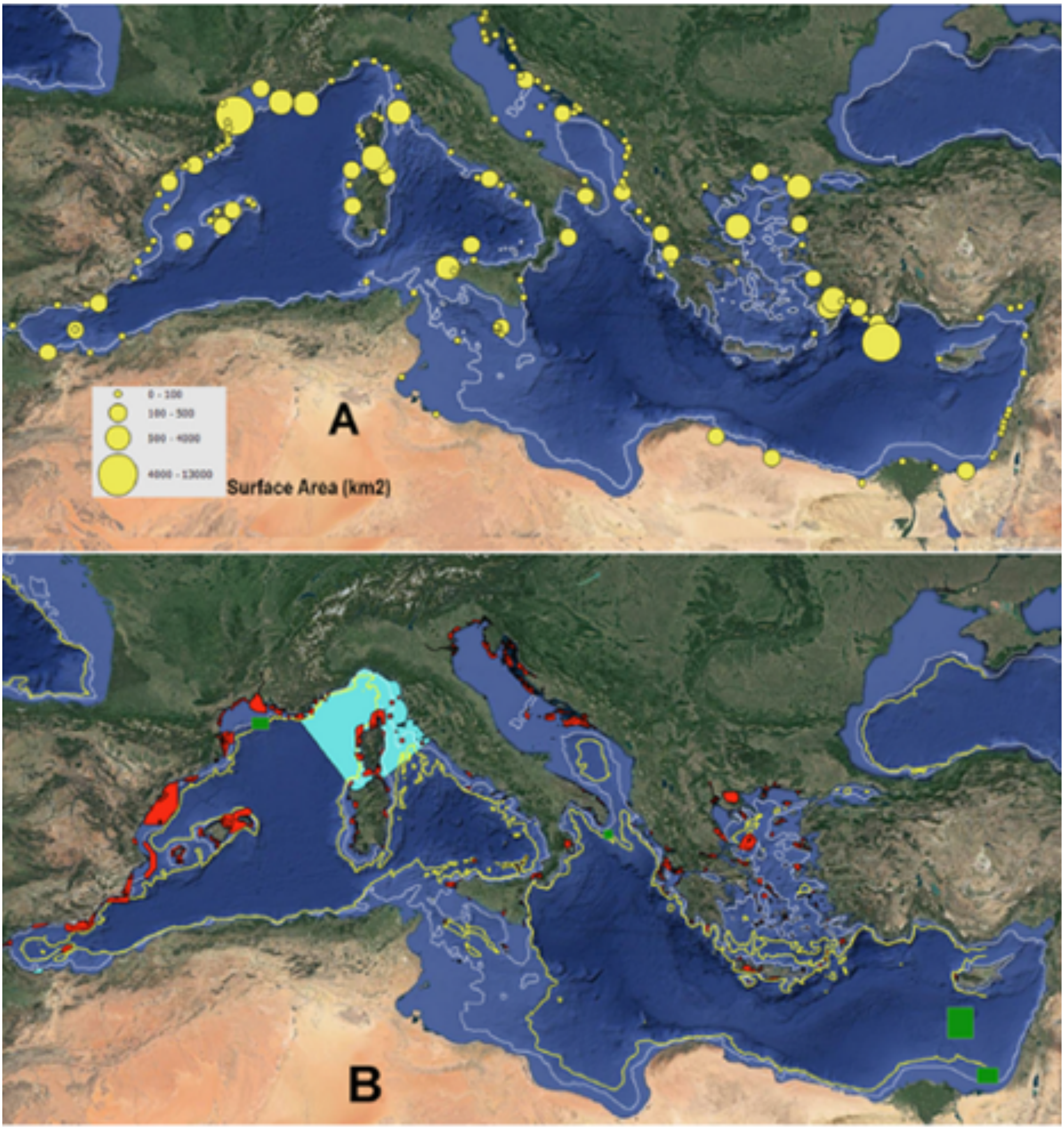

Figure 1. Maps show a gap in the geographic distribution of protected areas within the Mediterranean, as they are mainly located in the northwest portion of the region, and gaps in the type of ecosystems protected, as they are mainly coastal (from Amenguala and Alvarez-Berasteguib, 2018).
A: MPA (in yellow); B: Natura 2000 sites (in red), International Fisheries Reserve Areas (in green) and the Pelagos Sanctuary for Marine Mammals (blue)

BOX 3 - "Regional scale Gap Analysis"

"**TITLE:** The Mediterranean under siege: spatial overlap between marine biodiversity, cumulative threats and marine reserves.

PURPOSE OF THE ANALYSIS: Identify areas where the interaction between marine biodiversity and human pressure is more pronounced and to assess their spatial overlap with current marine protected areas in the Mediterranean.

METHODS: First, areas of high biodiversity of marine mammals, turtles, seabirds, fishes and commercial or well-documented invertebrates were identified. Secondly, potential areas of high threats, where multiple threats are occurring simultaneously, were mapped. Finally, the areas of conservation concern for biodiversity were quantified by examining the spatial overlap between high biodiversity and high cumulative threats, and the overlap with protected areas was also assessed.

RESULTS: Results show that areas of high marine biodiversity are mainly located along the central and northern Mediterranean coasts and the main areas of seriously threatened biodiversity are concentrated in the coastal areas of Spain, Gulf of Lion, North-East Ligurian Sea, Adriatic and Aegean Seas, South-eastern Turkey, the surrounding areas of the Nile Delta and in the North-west coast of Africa. The hot-spots (overlap 75%) are limited to six coastal regions of the Mediterranean Sea (East coast of Spain, the South of France, North coast of Tunisia, northern part of the Adriatic Sea, Ionian Sea and the coastal areas of the West, Northeast and Southeast Aegean Sea). This study notes that less than 2% of the priority conservation areas are currently covered by MPAs, decreasing to < 0.2% if the Pelagos Sanctuary is excluded (see Fig. 2)."

Source: Coll et al. (2012). The Mediterranean under siege: spatial overlap between marine biodiversity, cumulative threats and marine reserves. Glob. Ecol. Biogeogr. 21: 465-481

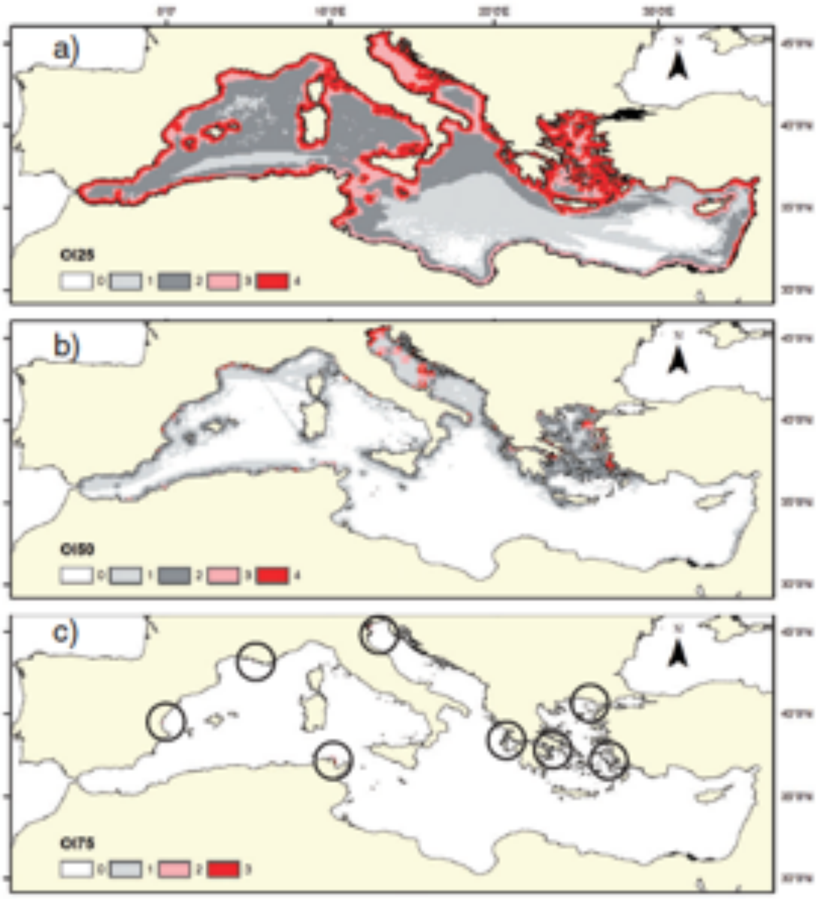

Figure 2. Global areas of conservation concern in the Mediterranean Sea where high biodiversity of invertebrates, fishes, marine mammals, turtles, seabirds, and high threats overlap. The overlap index (OI) indicates areas where both species diversity and intensity of cumulative threats were:
(a) >= 25 % (OI25), (b) >= 50 % (OI50) and (c) >= 75 % (OI75). 0 = no groups show high diversity and high cumulative threats; 1 = only one group shows high diversity and high threats; 2 = two groups out of four show high diversity and high threats; 3 = three groups out of four show high diversity and high threats; and 4 =all groups show high diversity and high threats. Black circles indicate cells with data.

BOX 4 - "National Gap Analysis":

" **TITLE:** Protected Areas Gap Assessment, Marine Biodiversity and Legislation on PAs and MPAs (Albania)..

PURPOSE OF THE ANALYSIS: Identify the key gaps of the PA system in Albania, and more specifically marine protected areas. .

METHODS: The document provides a review of the available knowledge about marine biodiversity and human impacts. The declaration of the first MPA in Albania was proposed based on this gap assessment..

RESULTS: 3 % of the territory covering the coastal wetland contains > 70 % of the country biodiversity value. The most important coastal wetlands for wintering birds along the Albanian coast are the Karavasta, Narta and Kune-Vaini lagoons. These areas serve as a refuge for more than 6 % of the wintering individuals of the Dalmatian Pelican *Pelecanus crispus*. Bottlenose dolphins (*Tursiops truncatus*) and common dolphins (*Delphinus delphis*) occur in the marine and coastal waters of Albania. The Mediterranean monk seal *Monachus monachus* is an occasional visitor. *Posidonia oceanica* meadows along the Adriatic coast of Albania are rare and isolated. Well-developed *Posidonia oceanica* are found along the littoral of Cape Rodoni, near Porto Romano and Vlora Bay. Albania includes about 13 % of its territory under conservation status but has no marine protected areas. Based on the findings of the analysis, the designation of first MPA in Albania in the Llogara-Karaburun-Sazan area has been proposed. "

Source: Protected Area Gap Assessment, Marine Biodiversity and Legislation on Marine Protected Areas, UNDP-Albania, 2010.

Based on analytical approach (qualitative or quantitative) and the available resources, a GA can vary from a simple exercise with a low level of complexity, such as based on spatial comparison of biodiversity with existing MPAs, to a more complex study based on detailed data collection and analysis, often benefiting from the application of dedicated software decision support packages to assist in the development of an MPA Network. GA is a dynamic process. Once a gap is filled, goals can be improved, so a new set of gaps will become evident between the state of the art and the new desirable state of knowledge. However, in order to allow a repeated or cyclic assessment of the gaps, the general principles guiding gap analysis, presented in the following section, must be followed (Ariño, et al., 2016).

2.1. GUIDING PRINCIPLES OF THE GAP ANALYSIS

GAs should be driven by a series of scientific, social and political principles. According to Dudley and Parish (2006), six are the guiding principles to follow in order to conduct a successful GA:

1. Representation: Choose focal biodiversity across biological scales (species and ecosystems) and biological realms (terrestrial, freshwater, and marine) to capture the full array of biodiversity in the protected area system. The goal of full representation is to have representative samples of all species and ecosystems within the protected area network, at a sufficient scale to ensure their long-term persistence.

   For example, in the Mediterranean Sea, the current MPA system is not representative of the Mediterranean's habitats and ecosystems diversity since most Mediterranean MPAs are currently coastal. MPAs are heavily concentrated only on certain kinds of biodiversity, with huge shortcomings within the pelagic domain (Agardy et al., 2011). The area beyond 12 nautical miles which represents 74 % of the Mediterranean surface is very poorly represented in the MPA network: only 2.7 % of which 2.6 % is Pelagos, the rest (0.1 %) is only represented by the Gulf of Lion Marine Nature Park (Gabrié et al., 2012). That notwithstanding, a high number of Mediterranean coastal zones are still unprotected despite their important ecological and socio-economical role at a national or Mediterranean level. In addition, 90.05 % of the total surface covered by MPAs and OECMs are found in EU waters, which emphasizes the low number of MPAs off the southern and eastern coastlines (MedPAN & UNEP/MAP-SPA/RAC, 2016).

2. Redundancy: Include sufficient examples of species and ecosystems within a protected area network to capture genetic variation and protect against unexpected losses. A strong protected area network will therefore include additional sites to prevent, wherever possible, potential losses caused by direct human pressures and/or natural stochastic events. In places where the ecosystem is already degraded, protected area networks need to include space for restoration.

   Seagrass meadows play an important ecological role in the Mediterranean's coastal waters. *Posidonia* *oceanica* is present in most of the Mediterranean. Together with *Posidonia* meadows, the coralligenous is also a key biodiversity habitat in coastal areas providing shelter, recruitment and nutrition for many species. Mediterranean Sea MPA and OECM designations cover only 16.99 % of the 0 to 50 m depth zone where the majority of seagrass meadows (*Posidonia oceanica* in particular) and coralligenous habitats are found, and where the level of the anthropogenic pressure is considerably high. However, the 2016 assessment on the status of Mediterranean MPAs reported a coverage of 39.77 % of *Posidonia* beds (Barcelona Convention's Reference List of Marine Habitat Types: III. 5. 1.; EUNIS class A5.5351), 12.92 % covered by national designations and 31.37 % by Natura 2000 designations. Regarding the coralligenous community (Barcelona Convention's Reference List of Marine Habitat Types: IV. 3. 1.; EUNIS classes A4.26 or A4.32), 32.78 % of the habitat is covered by all MPAs (4.68 % covered by national designation) and OECMs (25.40 % is covered by Natura 2000 sites). Although the results of these assessments are encouraging, they greatly depend on the quality and comprehensiveness of input data and will require greater mapping coverage as well as a fine scale assessment to understand the effective benefits of this kind of protection (MedPAN & UNEP/MAP-SPA/RAC, 2016).

3. Resilience: Design protected area systems to withstand stresses and changes, including future changes such as global warming and alien species invasions. Resilience involves maintaining or recreating viable ecosystems by enlarging or connecting protected areas. Protected areas networks built around core areas provide routes or stopping off places for migratory species, buffering protected areas against outside pressures, and offering resident species the opportunity of interbreeding with individuals from other populations. GAs and protected area planning are aimed at a holistic system of protection, and if necessary can cross national boundaries. In the marine realm, MPAs are intended to serve community and ecosystem functions involving species with different ranging habits, often largely unknown. Determining the optimal spacing of MPAs within a network requires a substantive knowledge of species' ecology to better understand requirements for MPA proximity and connectivity.

In the Mediterranean context, population connectivity studies have been undertaken in relation to MPAs at regional level (e.g. CoCoNET project - Towards COast to COast NETworks of marine protected areas coupled with sea-based wind energy potential - see BOX 5 for details). A valuable tool to enhance connectivity among Mediterranean MPAs has been also developed in 2014 by SPA/RAC ("Guidelines to improve the implementation of the Mediterranean Specially Protected Areas network and connectivity between Specially Protected Areas"). At the national scale, Di Franco et al. (2012) looked at dispersal patterns of the white seabream (*Diplodus sargus sargus*) around the Torre Guaceto MPA in the Adriatic Sea (Italy). Larvae were estimated to move from spawning areas up to 200 km before metamorphosing and settling in coastal habitats; after settlement the small fish were found to move up to tens of km from settlement sites (to a max of 30 km) to recruit to the adult population. This study emphasizes the key role of the network of MPAs in the post-settlement dispersal, since results indicate that only 1/3 of recruits accrue to the same site, about 20 % move to 6-8 km away, 20 % to ≤20 km, and 10% to about 30 km from their settlement site. In another study on D. sargus sargus' spatial distribution patterns of adults and settlers, Di Franco et al. (2012b) used models to simulate dispersal trajectories and travel distance combined with genetic analyses. Their results confirmed the role of Torre Guaceto MPA in protecting adults and favouring an enhanced propagules' production, representing the most significant spawning source over a spread of 200 km. These findings emphasize the need for the development of a network of MPAs in the Southern Adriatic Sea.

BOX 5 - "COCONET PROJECT":

"**TITLE**: Towards COast to COast NETworks of marine protected areas coupled with sea-based wind energy potential.

The Project identified groups of putatively interconnected MPAs in the Mediterranean and the Black Seas, shifting from local (single MPA) to regional (networks of MPAs) and basin (network of networks) scales. CoCoNet focused on the Mediterranean and the Black Seas and its objectives were the production of:

1- Guidelines for the institution of networks of Marine Protected Areas (MPAs);
2- Smart Wind Chart evaluating the feasibility of Offshore Wind Farms (OWFs).

Both objectives call for the identification of spatially explicit marine units where the management of human activities (either in terms of protection and in clean energy production) is based on the features of natural systems, as both the ecosystem approach and marine spatial planning require. Desk-based and field studies (carried out in two pilot areas) identified these natural units as Cells of Ecosystem Functioning: portions of the water column that are more connected with each other than with other portions. This novel concept is based on connectivity and will prove useful for any planning of the use of marine space. The data gathered during the project are stored into a multi-layered Geodatabase, an essential platform to achieve full awareness of the natural and socio-economic features of the marine environment. http://coconetgis.ismar.cnr.it/ "

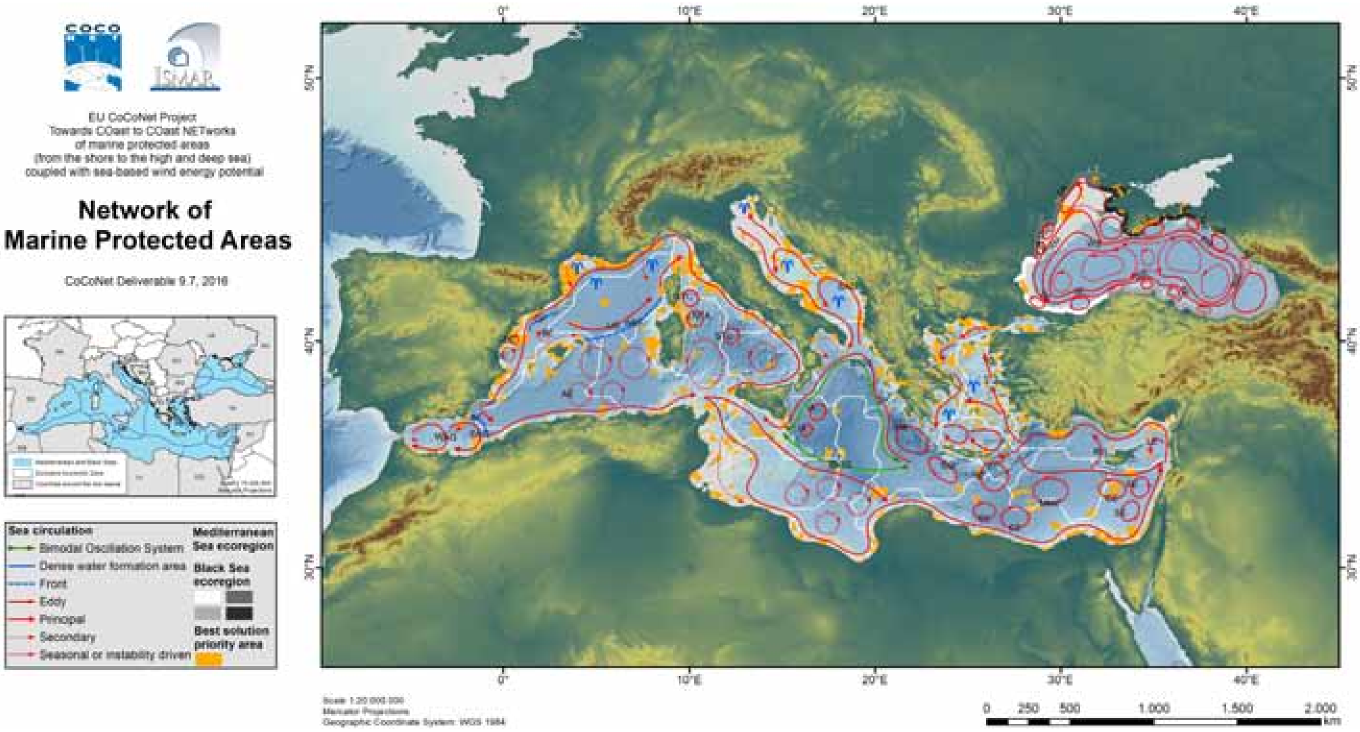

Figure 3. Map of the Network of MPAs developed by the CoCoNET project.

4. Different types of gaps: Investigate the different types of gaps affecting the protected areas system. The gap can be essentially of three types: representation gaps, ecological gaps and management gaps and are essentially asking three questions:
   (1) how much is protected? (representation gaps),
   (2) is that which is protected ecologically healthy? (ecological gaps),
   (3) is that which is protected under good management? (management gaps).

   Representation gaps flag up the species, ecosystems and ecological processes that are missed entirely by the protected area system; gaps in fact not only affect individual species but also whole ecosystems and ecological processes, many of which are not yet adequately protected (Dudley and Parish, 2006).

   For example, in 2012 a study was conducted with the aim to identify the epipelagic bioregional diversity of the Mediterranean Sea (Gabrié et al., 2012). Several environmental features, mainly derived from remote sensing, were used to perform the Mediterranean's bio regionalization (such as: depth, temperature, salinity, pH, dissolved oxygen, turbidity, chlorophyll-a concentration, the frequency of temperature fronts and chlorophyll-a and frequency of mesoscale ocean gyres). The temporal trends in the variables' descriptive statistics and in the extent of their distribution were analysed in order to identify bioregional clusters. In this analysis, 37 epipelagic bioregions were identified and grouped in different levels by using a number of oceanographic variables. The representativity analysis shows that epipelagic bioregions are poorly represented in the network of MPAs (i.e. less than 3 % of their surface is covered within the system of MPAs)

   Ecological gaps relate to biodiversity that exists within protected areas but at insufficient levels to provide long-term protection; in these cases, gaps can be related to issues of species composition, to the function and the health of ecological processes, and in having sufficient redundancy. Ecological gaps occur when protected areas systems are located in the wrong places, or have wrong boundaries, shape or size, or are missing critical ecological elements to function correctly. For example, most of protected areas are not large enough to support the full range of species indefinitely and rely on the presence of suitable habitat nearby or conservation measures such as ecological corridors or buffer zones.

   A Mediterranean example is the Pelagos Sanctuary, a transboundary MPA dedicated to the conservation of marine mammals. Eight cetacean species are regularly present in the Sanctuary. These include the striped dolphin (*Stenella coeruleoalba*), the common dolphin (*Delphinus delphis*), the common bottlenose dolphin (*Tursiops truncatus*), the Risso's dolphin (*Grampus griseus*), the long-finned pilot whale (*Globicephala melas*), the Cuvier's beaked whale (*Ziphius cavirostris*), the sperm whale (*Physeter macrocepha-*

lus) and the fin whale (*Balaenoptera physalus*). The Pelagos Sanctuary was established in the north-western portion of the Mediterranean in 1999 by a treaty among France, Italy, and Monaco. The placement of the borders of the Sanctuary, resulting from a decade of negotiations among the three nations, leaves very important habitat to the west and to the south east of the Sanctuary unprotected from high risk activities such as naval exercises and seismic prospecting (Notarbartolo di Sciara and Agardy, 2016). The study on the quantification of the proportion of cetaceans' species distribution range protected with the MPA system stated that only for fin whales the level of representation within the network of MPAs (including Pelagos) is around 10 % while for six others, the representation of their distribution range spans from 2.7 % to 7.9 % when considering all MPAs, and from 2.7 % to 7.3 % when considering MPAs with a management structure, including Pelagos (Gabrié et al., 2012).

In addition, the geographic distribution of the Mediterranean monk seal (*Monachus monachus*) classified as Endangered by the IUCN Red List of Threatened species, has been related to the MPA system. Results show that < 2 % of the monk seal distribution range at sea is included within a MPA (with a management structure) and 3.7 % if all MPAs are considered. This species is highly threatened in the short term and in addition to MPAs, integrated management measures to minimize human pressures are necessary on the coasts where the monk seals are present (Notarbartolo di Sciara and Kotomatas, 2016).

Recently, a substantial step forward the conservation of Mediterranean marine mammal important habitats was implemented by the IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force (MMPATF), through the identification of Important Marine Mammal Areas (IMMAs) in the Mediterranean region. In October 2016 a dedicated workshop, organized in partnership with the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), was attended by 34 experts covering all the Mediterranean region. Experts identified candidate IMMAs (cIMMAs) throughout the region for 10 species of marine mammals, which were reviewed by an independent review panel. After the review process, a total of 26 IMMAs were accepted for full status while five areas remain as cIMMA.

Additionally, 39 Areas of Interest (AoI) were also identified in the region which will form the basis of new recommendations for monitoring and future reassessments of the IMMA status (IUCN MMPATF, 2017; https://www.marinemammalhabitat.org/).

BOX 6 - “Important Marine Mammal Areas (IMMAs)”:

" Important Marine Mammal Areas (IMMAs) are a place-based conservation tool identifying discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation.

IMMAs can serve the function of promoting the conservation of a much wider spectrum of species, biodiversity and ecosystems, well beyond the specific scope of conserving marine mammals. The location of IMMAs can help to identify marine areas valuable in terms of biodiversity during the process of Marine Spatial Planning (MSP). IMMAs can also become an effective way of building institutional capacity at the international and national levels to make substantial contributions to the global marine conservation agenda. Marine mammals are indicators of ocean ecosystem health and thus will support the Convention on Biological Diversity (CBD) marine portfolio and descriptions of Ecologically or Biologically Significant Marine Areas (EBSAs) which aim to provide a basis for promoting awareness of marine biodiversity leading to conservation in specific areas of the world's oceans, as well as IUCN Key Biodiversity Areas (KBAs).

The IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force (MMPATF) promotes effective spatial solutions and best practices for marine mammal conservation within MMPAs. For the period 2016-2021, the MMPATF is rolling out a tool to apply criteria to begin to identify a worldwide network of Important Marine Mammal Areas (IMMAs) and to enhance their protection. Regional expert workshops are being organized in six large marine regions, beginning with the Mediterranean, followed by the South Pacific, Northeast Indian, Northwest Indian and Southeast Pacific oceans, and the waters of Oceania surrounding Australia and New Zealand.

Results and maps of the first Mediterranean regional workshop are available on the IMMA e-Atlas available on MMPATF website: https://www.marinemammalhabitat.org/imma-eatlas/ "

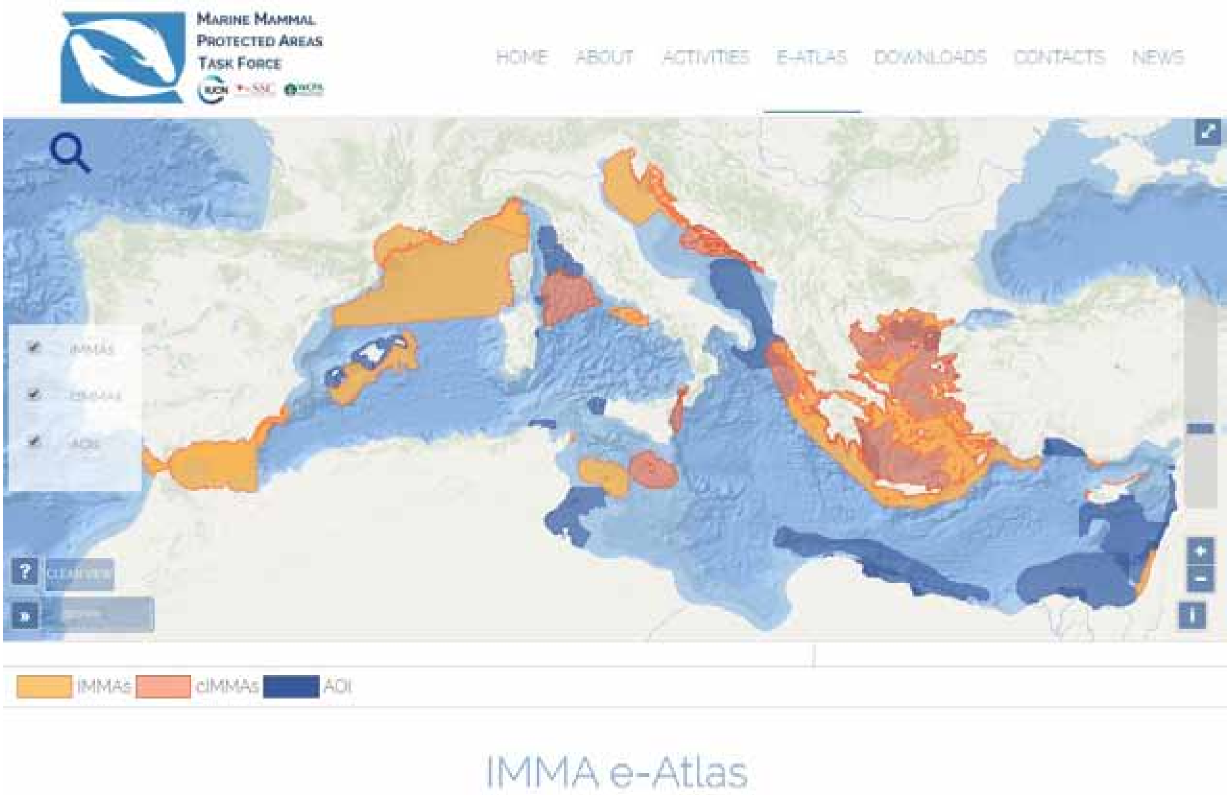

Figure 4. Important Marine Mammal Areas (IMMAs in orange) candidate IMMAs (cIMMA in pink) and Areas of Interest (AoI in blue) as reported in the IMMA e-Atlas (https://www.marinemammalhabitat.org/imma-eatlas/)

Management gaps can occur even when protected areas are in place and refer to inadequate protection for particular species or ecosystems due to poor or even absent management regimes (e.g., by inadequate management objectives, governance types, or management effectiveness). Protected areas are not all managed in the same way. IUCN has developed a set of guidelines which define a protected area and categorize a protected area through six management types and four governance types (Dudley, 2008; Day et al., 2012) (see Table 1). These categories range from strictly protected areas to protected landscapes and seascapes, which contain cultural landscapes and often settled human communities. According to Dudley and Parish (2006), a network that relies on only one or two types of management is likely to be unbalanced. In performing a "conservation gap analysis", it is important to have an assessment of the conservation effectiveness of the single MPAs which are part of the network. In most cases, conservation effectiveness is directly related to management effectiveness. Even in a perfectly designed MPA network, its real conservation effectiveness will depend only on the MPAs that are effective; paper MPAs must be recognised as such, and conservation gaps will continue to exist even if the network is perfectly designed.

For example, in the Mediterranean Sea no MPA in IUCN Category I has been declared according to the MedPAN & SPA/RAC assessment of the Status of Mediterranean MPA published in 2012 (Gabrié, et al, 2012), although it is likely that several strict nature reserves have been reported in some MPAs. The most represented Categories are IV (Habitat / Species Management Area) and II (National Park); there are few MPAs under Category VI (Protected area with sustainable use of natural resources), but they are much larger.

5. A participatory approach: collaborate with key stakeholders in making decisions about protected areas. Trade-offs between social, economic and environmental sectors are often essential for a successful management. The selection of a protected area to be part of a network should be made on the basis of scientific evidence, in partnership with many other stakeholders. The 2012 assessment on the Status of Marine Protected Areas in the Mediterranean reported a good participation from local stakeholders in the planning and management of MPAs (in 60% of MPAs). The SPA/RAC and IUCN-Med document "Stakeholder Participation Toolkit for Identification, Designation and Management of Marine Protected Areas" (2013) provides strategic orientations for stakeholders' participation in MPA management and planning with a view to improving good governance of MPAs. Several studies assessed the stakeholders' opinion through the development of dedicated interview/questionnaire. For example, among the results of the monitoring programme of COCONET, the stakeholders' observations of the impacts before and after the creation

of MPAs in Italy (Apulia region - Torre Guaceto, Porto Cesareo and Isole Tremiti MPAs) and in Albania (Karaburuni-Sazan MPA) were assessed, including their perspectives towards management scenarios and how these scenarios may affect their interests. Stakeholders' views allow to understand the potential implications for future marine protection and management measures. Stakeholders involved came from different sectors ranging from fisheries, conservation, tourism, scientific and administration to management, aquaculture and education. The results showed that most respondents consider conservation measures and plans to be insufficient and would like additional measures to target the control of coastal integrity, marine fisheries, water pollution and MPA connectivity.

Table 1: Number of Mediterranean MPAs per IUCN Category
(modified from Gabrié et al., 2012 - MedPAN & SPA/RAC report)

IUCN Categories		Number of MPAs	% of MPAs
Ia	Strict Nature Reserve	0	0
Ib	Wilderness area	0	0
II	National Park	55	34.16
III	Monument or natural feature	3	1.88
IV	Habitat/species Management area	69	42.86
V	Protected Landscape/Seascape	20	12.42
VI	Protected area with sustainable use of natural resources	14	8.70

BOX 7 - "Definition":

" Stakeholders are those who use and depend on the MPAs, whose activities affect it or who have an interest in it." "

Source: Stakeholder Participation Toolkit for Identification, Designation and Managementof Marine Protected Areas. RAC/SPA and IUCN-Med,

Figure 5. Stakeholder Participation Toolkit for Identification, Designation and Management of Marine Protected Areas developed by SPA/RAC and IUCN-Med, 2013.

International convention including the Barcelona Convention and the CBD recommends participation of stakeholders, in particular by directly affected communities including indigenous and traditional peoples in the MPA establishment and management process (Dudley and Parish, 2006). Many MPAs contain sacred sites or have significant cultural and heritage value and the understanding of this aspect is an important consideration in matters involving MPAs management. An example is the Papahnaumokukea Marine National Monument in the North West Hawaiian Islands (USA) considered as an important site for Native Hawaiians at cultural and spiritual levels.

6. An iterative process: review and improve the gap analysis as knowledge grows and environmental conditions change. Maps and guidelines generated by the GA may have to be revised and improved periodically following the growth of knowledge and changes in the environmental conditions. For example, the 2012 assessment on the status of MPAs and OECMs in Mediterranean Sea was updated in 2016 by considering where do we stand with MPAs in the Mediterranean, what progress has been made since the 2012 assessment and especially what is left to do to reach international marine conservation objectives by 2020. (The main findings of this assessment are summarized in Box 13; The document 'The 2016 Status of Marine Protected Areas in the Mediterranean - Main Findings'. MedPAN & UNEP/MAP-SPA/RAC is available here: http://www.rac-spa.org/sites/default/files/doc_medmpanet2/statut2016_brochure_en.pdf).

Figure 6. The 2016 Status of Marine Protected Areas in the Mediterranean - Main Findings developed by MedPAN & UNEP/MAP-SPA/RAC. Main results are reported in Box 13.

III. HOW TO CARRY OUT A GAP ANALYSIS?

A gap analysis cannot be carried out according to a rigid formula, but needs to be developed and modified depending on need, data availability, expertise and the type of species or ecosystems being considered (Dudley and Parish, 2006). All gap analyses should follow the same basic 6 steps (Fig. 7):

3.1. IDENTIFY FOCAL BIODIVERSITY AND SET KEY TARGETS;
3.2. EVALUATE AND MAP THE OCCURRENCE AND STATUS OF BIODIVERSITY;
3.3. ANALYSE AND MAP THE OCCURRENCE AND STATUS OF AREAS-BASED PROTECTION;
3.4. USE THE INFORMATION TO IDENTIFY THE GAPS;
3.5. PRIORITIZE GAPS TO BE FILLED;
3.6. AGREE ON STRATEGY AND TAKE ACTION.

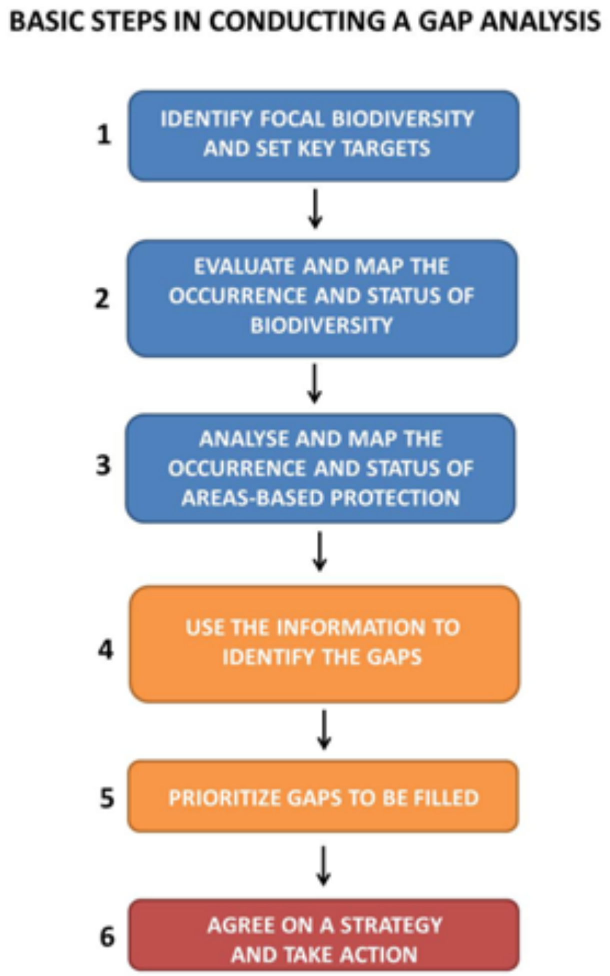

Figure 7. The 6 key steps to follow when conducting a Gap Analysis (modified from Dudley and Parish, 2006).

3.1. IDENTIFY FOCAL BIODIVERSITY AND SET KEY TARGETS

The marine environment is host to a broad array of biodiversity. With ever growing pressures on the marine environment there is an increasing need to assess how much of this biodiversity is currently protected and where new protection schemes should be established to move towards complete coverage or to achieve the target. One of the tools to identify, evaluate and possibly fill the present lacunae is Marine Gap Analyses (MGA). Most gap analyses focus on a representative sub-set of biodiversity taken both as an indicator for the analysis and a target for measuring the success of ensuing conservation actions.

The following focal biodiversity elements (targets) define species, communities and ecosystems to be evaluated. They can range from simple targets related to the area to be protected to more sophisticated targets of representation or endangerment. Targets can be grouped in:

Area targets: an overall area to be protected, such as the CBD Aichi target 11 to protect the natural realm with a 10 % marine protection objective by 2020.

Coarse filter targets: a certain portion of a marine ecosystem or any of its components (e.g. communities), as, for example, recommended under the Promise of Sydney (2014) aiming that at least 30 % of each Mediterranean marine habitat is covered by highly protected MPAs or OECMs by 2030.

Species targets: Species which are threatened or are keystone species should be prioritized for inclusion, as should rare or endemic species. Species may be selected as focal biodiversity elements due to their vulnerability at a particular life stage (e.g. larvae stage) or species that congregate for reproduction or migrate across environments (e.g. marine mammal feeding and breeding areas).

Species whose conservation status represents a concern or endemic species that would not be captured by ecosystem targets represent a “Fine Filter target”. In this context, it is important to consider those ecosystems and habitats included in the Barcelona Convention “Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean Sea” (SPA/BD Protocol) (Part II, Section One) comprising:

a) representative types of coastal and marine ecosystems of adequate size to ensure their long-term viability and to maintain their biological diversity;

b) habitats which are in danger of disappearing in their natural area of distribution in the Mediterranean or which have a reduced natural area of distribution as a consequence of their regression or on account of their intrinsically restricted area;
c) habitats critical to the survival, reproduction and recovery of endangered, threatened or endemic species of flora or fauna;
d) sites of particular importance because of their scientific, aesthetic, cultural or educational interest.

Fine filter targets ideally concern both the quantity (spatial extent) to be protected and its distribution, to ensure capturing the ecological and genetic diversity of a species or ecosystem. A simple target can be the decision to protect a stated proportion of remaining ecosystems or to maintain species. More sophisticated targets identify in detail what needs to be protected. An example is provided by the KBA criteria that use numerically driven thresholds to determine whether the features assessed within a site meet those determined as appropriate by experts across the range of marine and terrestrial taxa (e.g. KBA Criterion A1 - Threatened Taxa: "Site regularly holds ≥ 95 % of the global population of a globally Critically Endangered (CR) or an Endangered (EN) taxon; OR ≥ 0.5 % of the global population and ≥ 5 functional reproductive units of a globally CR or EN taxon; or ≥1 % of the global population AND ≥ 10 functional reproductive units of a globally Vulnerable (VU) taxon" etc.).

When carrying out a MGA the "coarse filter" / "fine filter" approach is recommended to guarantee that biological diversity is represented at multiple scales. Selection of focal biodiversity elements for a MGA should, therefore, consider a range of species, ecosystems and surrogates (Dudley and Parish, 2006).

Ecosystem targets: Among the ecological systems usually adopted in regional conservation planning, coral reefs and sea grass meadows (e.g. Posidonia oceanica meadows) are generally used since they provide structure, habitat and processes which support a suite of other species. For example, coral reefs are often used as a conservation target to protect both the diversity of hard and soft coral species and the diverse group of reef fish associated with coral reef systems. It is, in facts, known that sea grass meadows act as nurseries for several different species of fish and invertebrates.

BOX 8 - "*Posidonia oceanica* a target of the Mediterranean Marine Environment":

" *P. oceanica* has become one of the main targets of the protection and management of the Mediterranean marine environment. The European Union's Habitat Directive (92/43/CEE) includes *P. oceanica* beds among priority habitats (Habitat Type 1120: *P. oceanica* beds - *Posidonion oceanicae*). A dedicated Action Plan on marine vegetation is included within the framework of the Barcelona Convention, under the "Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean". *P. oceanica* has been selected as representative species of the Magnoliophyta quality elements for the assessment of the Good Environmental Status (GES) in the Mediterranean marine environment (Table 1 of Annex III "Indicative list of characteristics, pressures and impacts" of the Marine Strategy Framework Directive (MFSD) (2008/56/EC)). In addition, each EU Member State has defined its own method to evaluate the health status of *P. oceanica* meadows according to the Water Framework Directive (2000/60/EC). In coherence with the Ecosystem Approach (EcAp) process, this habitat bas been selected by the Contracting Parties to the Barcelona Convention to be considered among the minimum reference list of species and habitats to be monitored within the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (IMAP) (Appendix 1 to Decision IG.22/7 of COP 19; UNEP/MAP, 2016). *P. Oceanica* is considered a key common indicator for assessing the status of the Mediterranean ecosystem and the achievement of GES (2017 MED QSR; UN Environment/MAP, 2017). "

Surrogate targets: Surrogates are identified to address critical information gaps relating to specie distributions and habitat utilization. The mostly used surrogate includes the shoreline geomorphology or the sea floor topography that can reflect different types of habitats (i.e. a complex bathymetry correspond to higher levels of species diversity or aggregation), or remote sensing features (e.g. Chlorophyll-a concentration is employed to identify areas of primary productivity) used to characterize the pelagic environment.

BOX 9 - “Fine-scale assessment of *Posidonia oceanica* distribution”:

" **TITLE:** Sea grass meadows (*Posidonia oceanica*) distribution and trajectories of change.

PURPOSE OF THE ANALYSIS: The aim of this work is to provide a fine-scale assessment of the current and historical known distribution of *P. oceanica*, the most important and well-studied seagrass species of the Mediterranean, assessing the total area of meadows and quantifying the magnitude of regressive phenomena occurred in the last decades.

METHODS: A literature inventory, showing current and past distribution maps, has been done and integrated with point data of presence/absence of *P. oceanica* obtained in different countries across the Mediterranean basin. After a GIS standardization, maps of *P. oceanica* meadows distribution have been created. Using these maps, the authors assessed the differences in seagrass extension by comparing current and historical maps, evaluated the extent of regression and calculated meadows’ variations caused by regressive phenomena.

RESULTS: The current spatial distribution of *P. oceanica*, covering a known area of 1,224,707 ha, highlighted the lack of relevant data in part of the basin (21,471 linear km of coastline). The estimated regression of meadows amounted to 34 % in the last 50 years, showing that this generalized phenomenon had to be mainly ascribed to cumulative effects of multiple local stressors. The results highlighted the importance of enforcing surveys to assess the status and prioritize areas where cost-effective schemes for threats reduction, capable of reversing present patterns of change and ensuring *P. oceanica* persistence at Mediterranean scale, could be implemented. "

Table 2. Spatial extent of *Posidonia oceanica* meadows across the Mediterranean Sea (from Telesca et al., 2015).

	Mediterranean Sea	Western basin		Eastern basin	
Coastline length (km)	46,000	11,621	25 %	34,379	75 %
Coastline length with *P. oceanica* (km)	11,907	6,201	14 %	5,706	12 %
Coastline length without *P. oceanica* (km)	12,622	3,925	9 %	8,697	19 %
Coastline length without data (km)	21,471	1,494	3 %	19,977	43 %
Total area of *P. oceanica* (ha)	1,224,707	510,715	41.7 %	713,992	58.3 %

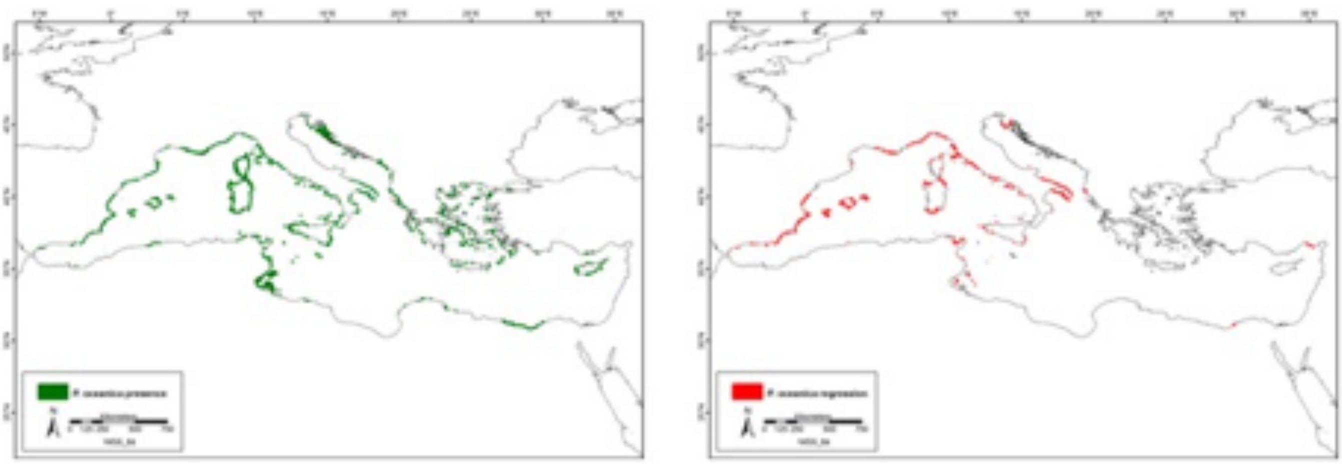

Figure 8. Current spatial distribution of Posidonia oceanica meadows (on the left) and areas with *P. oceanica* meadows loss (on the right) assessed by comparing historical and current maps of distribution (from Telesca et al., 2015).

Source: Telesca, L. et al. (2015) Seagrass meadows (*Posidonia oceanica*) distribution and trajectories of change. Sci. Rep. 5, 12505; doi: 10.1038/srep12505 (2015).

3.2. EVALUATE AND MAP THE OCCURRENCE AND STATUS OF BIODIVERSITY

In order to evaluate the occurrence and status of biodiversity, two essential information are needed:

1. Current distribution (observed and/or predicted) of biodiversity;
2. Current status and trends of the biodiversity.

3.2.1.Current distribution of biodiversity

An ideal MGA will consist of georeferenced maps of biodiversity that can be overlaid over maps of protected areas to geographically and spatially analyse and quantify the gaps. Most of the GA studies involve the use of consolidated data sets, GIS tools and/or predictive models. Mapping can be done at the ecosystem or habitat level ("coarse filter") or at the species and specialized habitat one ("fine filter"). Detailed information on biodiversity distribution can be available in digital - GIS portals, digital inventories of knowledge, shared databases with clear metadata and standard format databases (the most important databases are reported in the BOX 10 - Tool for biodiversity assessment)-, or analogical formats - papers and report figures, images, pictures (e.g. in the 2012 MPA status report, several examples of static distribution maps of different Mediterranean species). If available information is not collated using a standardized protocol, they can be incomplete and only partially provide the information about the nature of the data themselves. It is also important to bear in mind that digital accessible resources of knowledge do not necessarily mean easily accessible resources (e.g. if they are not freely available or require authorization to be downloaded or they are just kept private). Several different sources of information can be used in a GA. Potential sources of biodiversity data include but are not limited to: databases and data aggregators, scientific papers (digital or analogical), reports, management programmes, grey literature, remote sensing (RS) products, stakeholders' surveys, citizen science (CS) outputs as well as raw data from field surveys.

Table. 3. Access to and forms of biodiversity data
(from Ariño et al., 2016)

		Access / process difficulty		
		Easy	**Medium**	**Hard**
Capture or existance form	Digital	Database Indexes Digital inventories Cs outpout	Unstructured files Maps, digital RS Survey results	Loked Files Unknown files
	Analogical	Imaged reports, tables Imaged museum data labels, Structured ledgers	Unscanned papers Old imagery Unmarked literature Field notes	Loked, private collections Forgotten or unknown collections
	Future	Automated surveys and monotoring New CS endeavors	New field surveys Planned RS	Unsampled remote or inaccessible sites Unknown organisms

(black) Digitally Accessible Knowledge: Primary data that are both digital and accessible in standard formats;
(Blue) Locked knowledge: Data that are known to exist, but cannot be accessed because of some barrier (e.g. paywall, obsolete digital systems, inability to digitize);
(Green) Buried knowledge: Data that exist but whose existence is not known or cannot be ascertained by users;
Unknown or Forgotten data (Red); (Grey) Future data.

A data GA study conducted on a network of protected areas in Mexico demonstrated that similar data retrieved from different sources were complementary, but singularly did not fully represent the current species occurrences within the Reserves (Pino Del Carpio et al., 2014) (Fig. 9). For instance, biodiversity data on biosphere reserves can be found in at least three independent data sources: scientific literature, management plans, and databases. In addition, data could be derived from secondary products such as distribution models. However, in order to predict biodiversity distribution, abundance and trends, it is always necessary to be aware of the possible uncertainties or sampling biases (Ariñoet al., 2016).

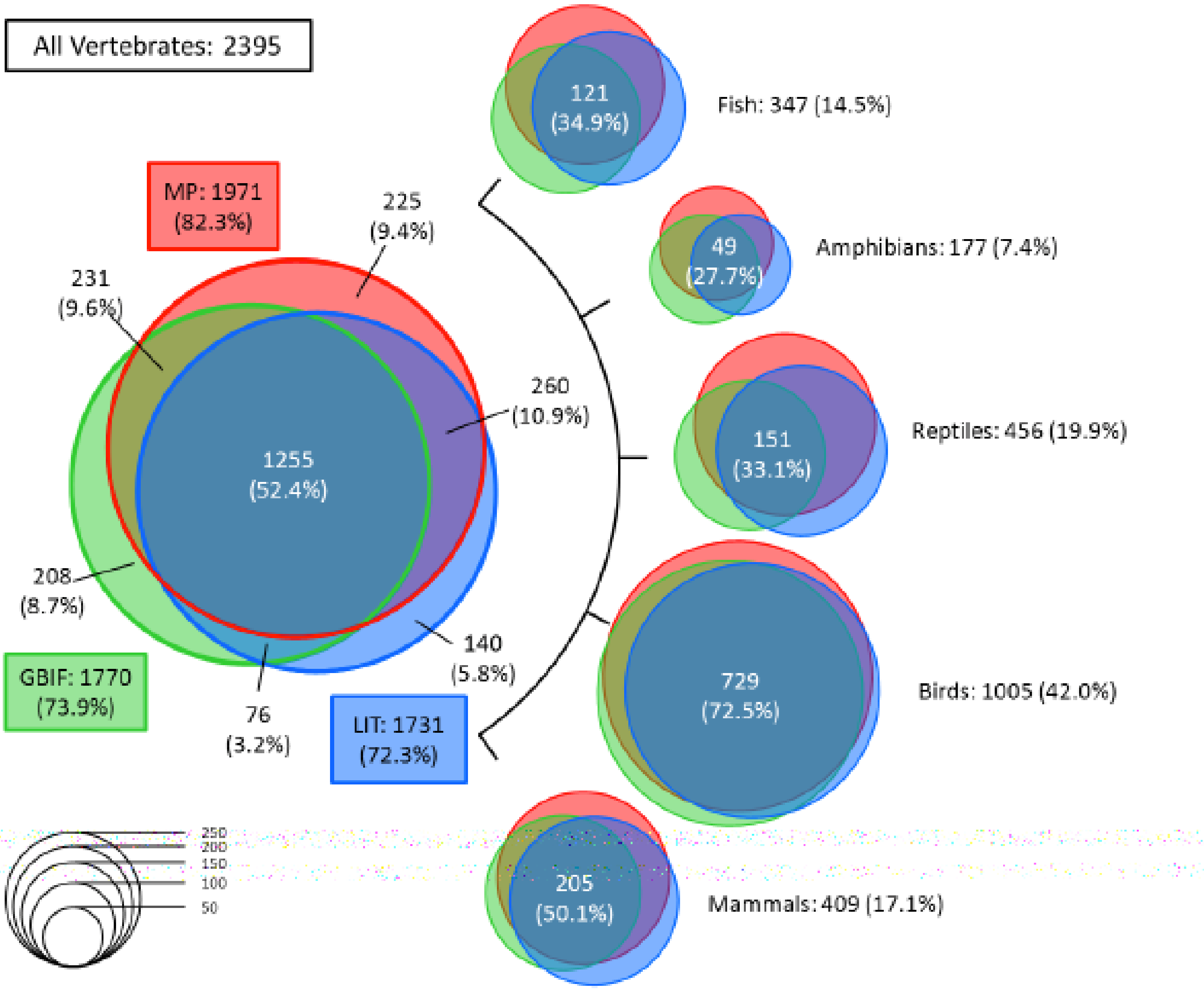

Figure 9. Number of vertebrate species listed in three separate sources
(GBIF, MP: management plan and LIT: literature) for a network of protected areas in Mexico.
Each source listed several species unknowns by other sources (Pino Del Carpio et al., 2014).

Mapping all species within a certain area is virtually impossible; therefore, GA has to rely on some form of surrogate. As a consequence, several kinds of information such as realms (in this case the marine environment), environmental domains (i.e. using topographic features to predict suitable ecosystem), particular habitats (e.g. coastal habitat) or species representing particular habitats and ecosystems (e.g. *Posidonia oceanica* meadows) or well-known species (e.g. marine mammals or birds) could be used.

Table.4. Strengths and limitations in choosing different options to evaluate biodiversity in a GA (from Dudley and Parish, 2006).

Option	Strengths	Limitations
Realms	· Quick · Provides initial broad targets · Data almost always available · Can be further defined by major habitat types and by ecoregons	· Does not distinguish between different ecosystems in biomes · Says little about environmental quality or survival of species within biomes
Environmental domains and enduring features	· Possible to survey rapidly using satellite imagery and existing maps · Useful in places where major changes have already taken place · Can find restoration sites	· Only gives a crude Indication at ecosystem scale · Tells little about species' status
Ecosystems	· Helps to represent species that have not been described or surveyed · Suitable for rapid analysis · Provides data in a form easily mapped	· Can miss local centres of diversity · Misses idiosyncratic threat (e.g. poaching) and species with special ecological needs, and thus can miss losses within ecosystems
Species groups	· Possibly a good surrogate for total biodiversity where well surveyed · Coherent data sets	· Data often lacking · Extent to which particular groups like birds represent all biodlversity unproven in many habitats
Focal species	· Possibility of capturing good information · Provide measurabte targets for conservation	· Depends on good data · Depends on correct choice of indicators · Expensive and time-consuming

BOX 10 - "Tools for biodiversity assessment in the Mediterranean Sea".

" In the recent years, the knowledge on species distribution at the Mediterranean scale has increased along with the number of shared databases on species occurrence and distribution both at the national and regional scale across the Basin. The following websites can help gathering the information needed to conduct a MGA and can frequently be enhanced by adding specific references to national or regional datasets and species lists:

Oceanic Biogeographic Information System (OBIS): http://www.iobis.org

More than 20 OBIS nodes around the world connect 500 institutions from 56 countries. 45 million observations of nearly 120 000 marine species, from bacteria to whales, ranging from the surface to 10,900 meters of depth, and from the Tropics to the Poles. The datasets are integrated so one can search and map them all seamlessly by species name, higher taxonomic level, geographic area, depth, time and environmental parameters. OBIS emanates from the Census of Marine Life (2000-2010) and was adopted as a project under IOC-UNESCO's International Oceanographic Data and Information (IODE) programme in 2009.

OBIS-SEAMAP: http://seamap.env.duke.edu

Ocean Biogeographic Information System Spatial Ecological Analysis of Mega Vertebrate Populations is a spatially referenced online database, aggregating marine mammals, seabird, sea turtles and rays and sharks' observation data from across the globe.

FISHBASE: http://www.fishbase.org

FishBase is a global biodiversity information system on finfishes. Its initial goal to provide key facts on population dynamics for 200 major commercial species has now grown to having a wide range of information on all species currently known in the world: taxonomy, biology, trophic ecology, life history, and uses, as well as historical data reaching back to 250 years. At present, FishBase covers more than 33,000 fish species compiled from more than 52,000 references in partnership with more than 2,000 collaborators. It includes more than 300,000 common names and an excess of 55,000 pictures.

AquaMaps: http://www.aquamaps.org

Aquamaps generates standardized computer-generated large-scale predictions of marine and freshwater species. Maps are available for all marine mammal species, and a subset has been expert-validated.

Global Biodiversity Information Facility (GBIF): http://www.gbif.org/developer/maps

It provides a single point of access (through this portal and its web services) to hundreds of millions of records, shared freely by hundreds of institutions worldwide, making it the biggest biodiversity database on the Internet. The data accessible through GBIF relate to evidence about more than 1.6 million species, collected over three centuries of natural history exploration and including current observations from citizen scientists, researchers and automated monitoring programmes.

OCEAN DATA VIEW - Global distribution of seagrasses: http://data.unep-wcmc.org/datasets/7

This dataset shows the global distribution of seagrasses, and is composed of two subsets of point and polygon occurrence data. The data were compiled by UNEP World Conservation Monitoring Centre in collaboration with many collaborators (e.g. Frederick Short of the University of New Hampshire), Regional Seas Conventions (e.g. OSPAR), and projects (e.g. the European project Mediterranean Sensitive Habitats "Mediseh"), across the globe (UNEP-WCMC, Frederich T. Short, 2018).

EMODnet: European Marine Observation and Data Network: http://www.emodnet.eu

EMODnet is a long-term marine data initiative developed through a step-wise approach. Available data is being used to create medium-resolution maps of all Europe's seas and oceans, spanning seven disciplinary theme – Bathymetry, Geology, Human Activities, Biology, Sea bed habitat, Chemistry, and Physics.

IUCN Red List of threatened species-spatial data: http://www.iucnredlist.org/technical-documents/spatial-data. The IUCN Red List contains information on taxonomy, conservation status, and spatial data on species distribution (available upon request) that are defined by IUCN as under threat.

Important Marine Mammal Area E-Atlas: https://www.marinemammalhabitat.org/imma-eatlas/ IMMA e-Atlas, allow users a quick access to the spatially-explicit IMMA layers and supporting information identified in various marine regions including the Mediterranean (First regional workshop: October 2016). In addition, candidate IMMA (cIMMA) and Areas of Interest (AoI) layers are also available. IMMA shapefiles can be made available on request. "

3.2.2. Current biodiversity status

Just as important as the distribution of biodiversity is its overall status and trends. To capture biodiversity that will persist within protected areas, it is important to know about its viability and vulnerability. Knowing the trends in biodiversity will also help later in the process when it comes to prioritizing actions (Dudley and Parish, 2006). The extent to which this information is available varies extremely among countries and regions, and relies on the use of surrogates (i.e. proxies of biodiversity such as indirect predictors, keystone species, umbrella species). Particularly important are trends in threatened species and threatened ecosystems, and in particular the status of irreplaceable biodiversity such as endemic species and ecosystems. The IUCN Red Data lists and any additional detailed lists available in individual countries, together with a comprehensive literature review can help provide a basis for examination.

BOX 11 - "IUCN Red List of threatened species":

> " The IUCN Red List of Threatened Species provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the risk of extinction. The main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The IUCN Red List also includes information on plants, fungi and animals that are categorized as Extinct or Extinct in the Wild, on taxa that cannot be evaluated because of insufficient information (i.e., are Data Deficient), and on plants, fungi and animals that are either close to meeting the threatened thresholds or that would be threatened if it is subject to an ongoing taxon-specific conservation programme (i.e., are Near Threatened). http://www.iucnredlist.org "

3.3. ANALYSE AND MAP THE OCCURRENCE AND STATUS OF AREAS-BASED PROTECTION

To carry out a successful MGA, the current extent and location of MPAs system should be available to be compared to maps of biodiversity.

Ideally, two kinds of information are needed:

1. Distribution: the existence of a protected area network (ideally maps of the location, area and boundaries of all protected areas, including supra-national, national, sub-national, municipal and private protected areas).

   At Mediterranean level, an important inventory of Mediterranean MPAs has been undertaken by MedPAN and SPA/RAC, resulting in the development of the MAPAMED database (http://www.mapamed.org). This database on sites of interest for the conservation of the marine environment in the Mediterranean Sea will allow users to view the Mediterranean network of MPAs through a map interface and access detailed information for each referenced MPA. Main MAPAMED objectives are to enable an analysis and assessment of the status and trends of the Mediterranean network of MPAs according to international targets, to promote access to data on Mediterranean MPAs, and to identify ecological and management issues on a supra-MPA level.

   The criteria for the inclusion of MPAs in MAPAMED are based on the IUCN definition of an MPA (Dudley, 2008) and adapted from Claudet et al. (2011). The MPAs were characterized as "any clearly defined geographical marine area – including sub-tidal, inter-tidal and supra-tidal or lagoon / coastal lake area which is continuously or temporarily connected to the sea, together with its overlying water - recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".

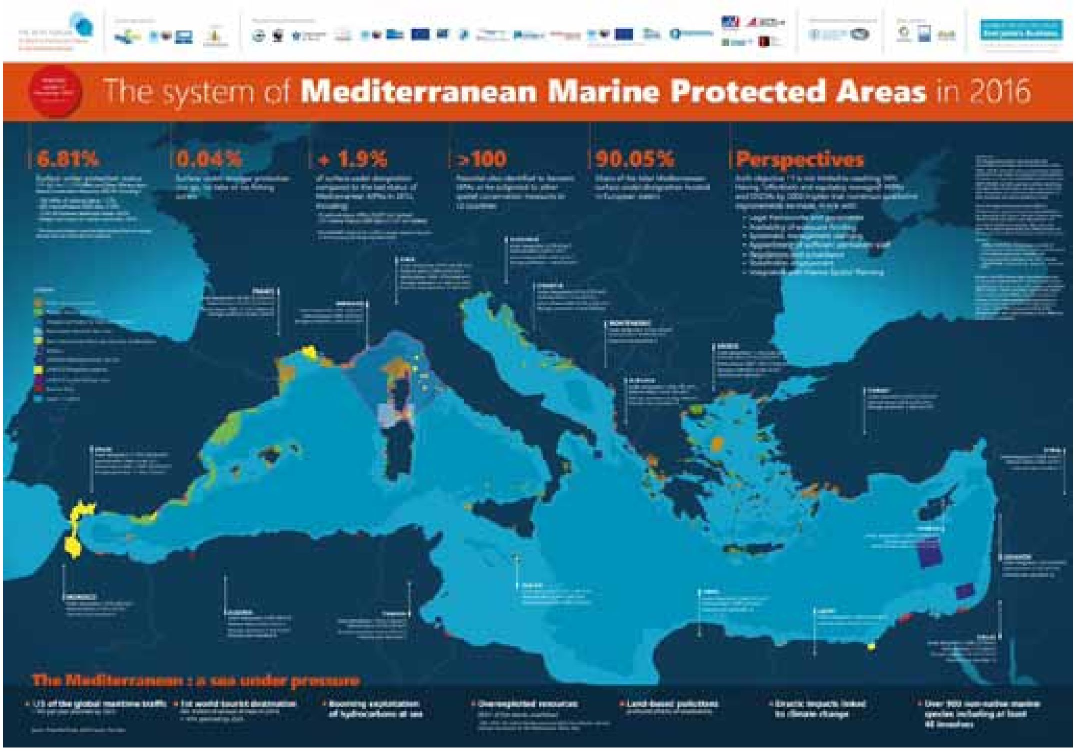

Figure 10. Distribution of MPAs in the Mediterranean
(from 2016 MPA Status, data extracted from MAPAMED, www.mapamed.org)

BOX 12 - “Other MPAs and OECMs Mapping Tools”

" World Database on Protected Areas (WDPA): https://protectedplanet.net. It is the largest and the most comprehensive global database on terrestrial and marine protected areas. It is a joint project between the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN), managed by UNEP World Conservation Monitoring Centre (UNEP-WCMC). It is updated regularly and provides basic information where available on location, area, name, data, IUCN category, etc.

BIRDLIFE: http://www.birdlife.org/datazone/. The dataset shows the global distribution of Key Biodiversity Areas (KBAs), Important Bird and Biodiversity Areas (IBAs) and Alliance for Zero Extinction (AZE) sites, with a marine component. Under the ‘umbrella term’ «KBA» are marine, freshwater and terrestrial sites which contribute significantly to the global persistence of biodiversity at the genetic, species and ecosystem levels. The «KBA network» hence encompasses sites of high biodiversity value of global significance.

Important Marine Mammal Area E-Atlas: https://www.marinemammalhabitat.org/imma-eatlas/ IMMA e-Atlas, allow users a quick access to the spatially-explicit IMMA layers and supporting information. In addition, candidate IMMA (cIMMA) and Areas of Interest (AoI) layers are also available.

Fisheries Restricted Areas (FRAs) (FAO, 2010): http://www.fao.org/gfcm/data/map-fisheries-restricted-areas/en/. It provides the likelihood that a population, community, or habitat will experience substantial alteration from short-term or chronic disturbance, and the likelihood that it would recover and in what timeframe. "

2. Protection status and management effectiveness: the status of a protected area is influenced by management objectives and governance regimes. Quantifying these aspects can provide additional layers of information in identifying gaps. There are, unfortunately, many protected areas that are poorly managed, or with management objectives or governance patterns that do not coincide with the needs of biodiversity. As stated above, identifying and addressing such management gaps can be critical for strengthening the national protected area system. An assessment on the status of MPAs and OECMs in Mediterranean Sea, carried out in 2012, has been recently updated by considering where we currently stand with MPAs. This updated assessment will provide additional information to understand the management effectiveness of the MPAs network. The main findings are reported in BOX 13.

BOX 13 - “Assessment Status of MPAs in the Mediterranean Sea”

" **TITLE:** ‘The 2016 status of Marine Protected Areas in the Mediterranean - Main Findings’

PURPOSE OF THE DOCUMENT: to present a highlight of the 2016 assessment of MPAs and OECMs in the Mediterranean, what progress has been made since the 2012 assessment (Gabrié et al., 2012), and especially to assess what is left to do to reach international marine conservation objectives by 2020.

METHODS: the results have been obtained through the analysis of a large inventory work on Mediterranean MPAs, undertaken by MedPAN and SPA/RAC, allowing to collect a full array of data used to create MAPAMED, an online database of Mediterranean MPAs.

RESULTS: the main findings are summarized below:

- 1,215 MPAs and OECMs covering 171,362 km^2 which places a surface of 6.81 % of the Mediterranean Sea under a legal designation.
- 190 sites are designated at national level covering 1.27 % or 32,065 km^2 of the Mediterranean Sea. 76 sites have at least one no-go, no-take or no-fishing zone covering 0.04 % of the Mediterranean Sea (945.67 km^2). Most no-go, no-take or no-fishing zones are smaller than 5 km^2, only 18 MPAs have such zones covering over 10 km^2 and only 2 sites cover more than 100 km^2.
- 882 Natura 2000 network sites cover 2.50 % of the Mediterranean Sea or 63,000 km^2.
- 8 Fisheries Restricted Areas (FRAs) established by the General Fisheries Commission for the Mediterranean (GFCM) in the high sea.
- 34 Specially Protected Areas of Mediterranean Importance (SPAMIs) including 1 site of international designation the “Pelagos Sanctuary” for the conservation of marine mammals (a tripartite international agreement) covering about 3.57 % or 89,856 km^2 of the Mediterranean.
- 1 International Marine Park of the Strait of Bonifacio was created in 2012 as a European Grouping of Territorial Cooperation between France and Italy, covering 1,855 km^2 or 0.07 % of the Mediterranean.

- 1 Particularly Sensitive Sea Area (PSSA) created by the International Maritime Organization in the Strait of Bonifacio, covers an area of 10,956 km² (0,44 % of the Mediterranean).
- Increased number of Ramsar sites (covers an area 0.12 %), UNESCO Man and Biosphere reserves (covers an area of 0.06 %), and UNESCO World Heritage Sites (covering 0.01 %) that contain coastal lagoons permanently linked to the sea and marine waters.
- 15 Mediterranean Ecologically or Biologically Significant Marine Areas (EBSAs).
- Over 100 sites have been proposed to become MPAs or OECMs identified or are in project in 12 countries.
- To reach the 10 % quantitative part of the Aichi Target, an additional 80,196 km² (3.19 % of the Mediterranean) would need to be placed under strong protection designations also targeting currently under-represented features. "

Source: The 2016 Status of Marine Protected Areas in the Mediterranean - Main Findings. MedPAN & UNEP/MAP-SPA/RAC.

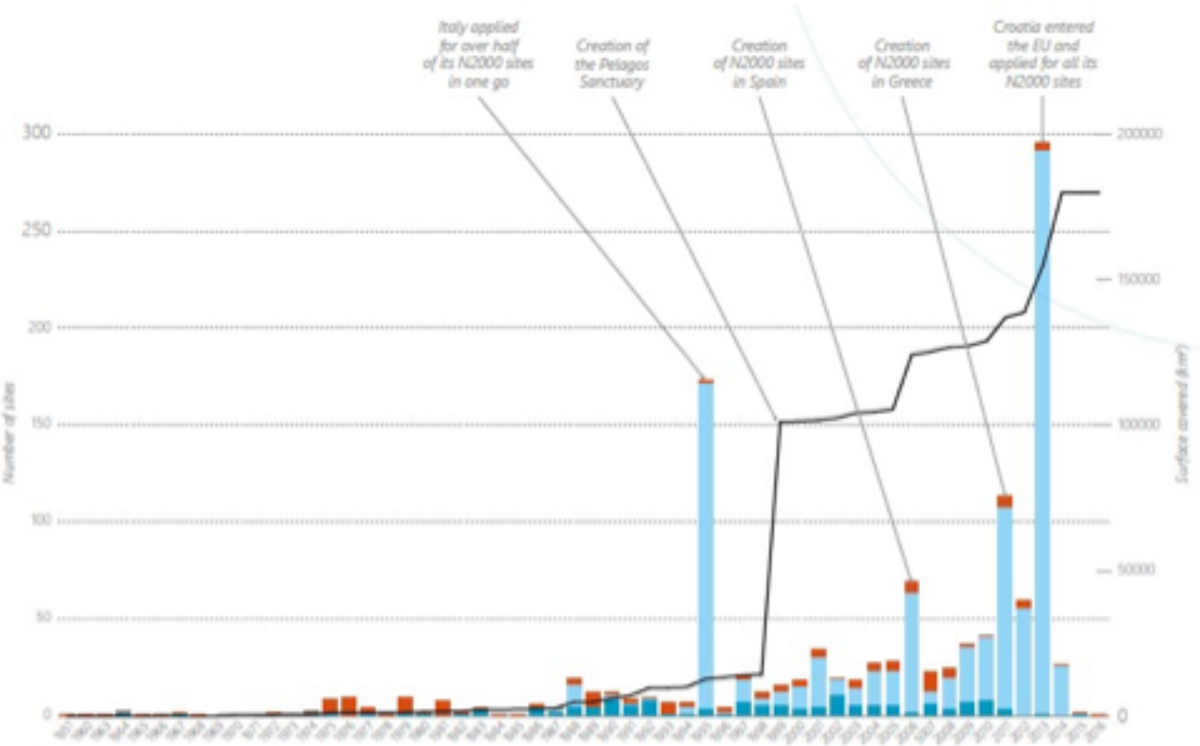

Figure 11. Number of MPAs created per year by type of designation: national (blue), regional (light blue) and international (orange); and cumulative surfaces from 1950 to 2016. (MedPAN & UNEP/MAP-SPA/RAC, 2016)

3.4. USE THE INFORMATION TO IDENTIFY THE GAPS

Various options exist for using data to identify gaps in protected area networks and the choice depends on the quality of the data and, as stated above, the different kinds of gaps under consideration. It is therefore important to define how to conduct the GA and what kind of gaps the analysis is trying to identify. Three are the general options, depending on data quality, the objective of the GA and the analytical approach selected:

1. Without maps: A MGA can be performed without mapping the species distribution but just by listing all the biodiversity elements not adequately represented.

   In general, species subject to fishing in unprotected waters tend to increase in fully protected MPAs. It has been observed that inside fully protected MPAs, there is a large overall increases in biomass, density, size and for some fish and invertebrate species. However, other species inside fully protected areas may either decline or not change. A worldwide analysis found that

61 % of fish species were more abundant inside fully protected MPAs than outside, while 39 % of species declined following protection.

Source: Partnership for Interdisciplinary Studies of Coastal Oceans and University of Nice Sophia Antipolis. 2016. The science of marine protected areas (3rd edition, Mediterranean). available from: http://gordon.science.oregonstate.edu/science-mpa/sites/default/files/SMR_Med-Final_lowRes.pdf)

2. With maps: this analysis includes species/habitats presence or absence from the protected area network as well as issues such as proximity, proportion of the population protected, and information about filling gaps.

BOX 14 – "GA performed using maps"

" **TITLE:** A global gap analysis of sea turtle protection coverage

PURPOSE OF THE ANALYSIS: to use a global dataset of sea turtle nesting sites to determine the extent to which the existing global PA network encompasses nesting habitats (beaches) that are vital for the persistence of the seven sea turtle species.

METHODS: To identify gaps in the coverage of existing protected sites, the authors overlaid maps showing the geographical centre of each nesting site with maps containing all protected areas around the globe. The authors first examined the PA coverage of nesting sites at the country level for all seven species, combined and separately, in relation to the IUCN protected areas category system.

They then analysed the data with respect to

(1) tropical, sub-tropical and temperate status,

(2) the economic status of the countries, including GDP,

(3) the presence of existing crises (e.g. civil unrest, wars or natural catastrophes),

(4) the regional-level, and

(5) sea turtle regional management units.

RESULTS: The majority of nesting sites (87 %) are in the tropics, and are mainly hosted by developing countries. Developing countries contain 82 % nesting sites, which provide lower protection coverage compared to developed countries. Protected Areas encompass 25 % of all nesting sites. Almost 80 % of the PAs containing nesting sites, are listed as Marine Protected Areas (MPAs), under various IUCN management categories. This study identified the countries that provide the highest and lowest nesting site protection coverage and detected gaps in species-level protection effort within countries. No clear trend in protection coverage was found in relation to gross domestic product, the Global Peace Index or sea turtle regional management units. However, countries in crisis (civil unrest, war or natural catastrophes) provided slightly higher protection coverage of all countries. "

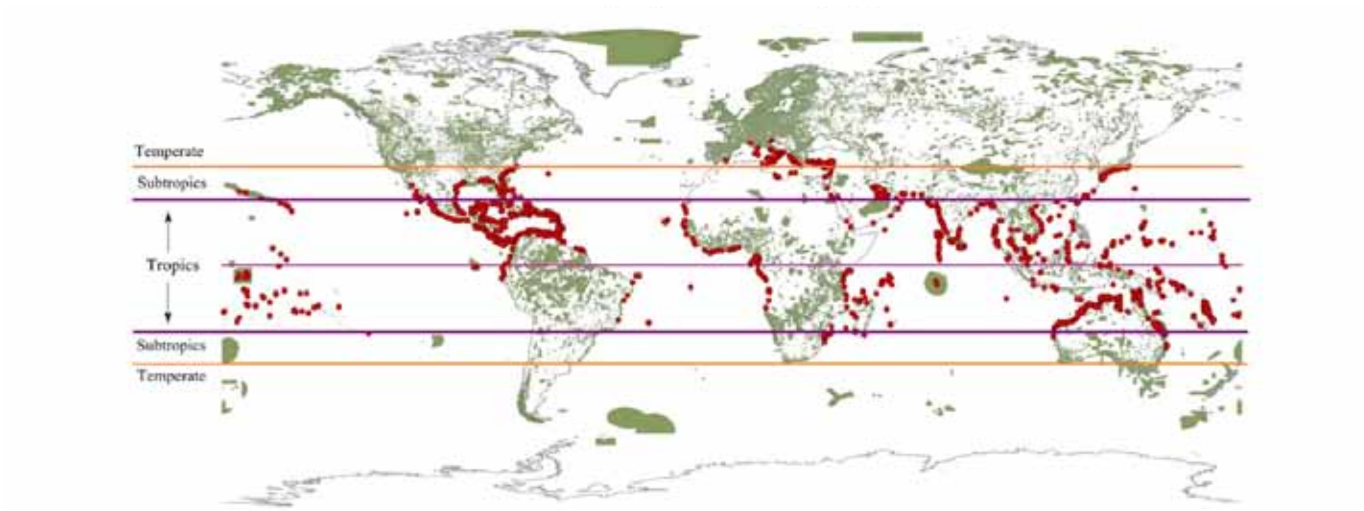

Figure 12. Global distribution of sea turtle nesting sites (filled red circles) and the location of current protected areas worldwide (green shaded areas) from Mazaris et al., 2014.

Source: Mazaris, AD, Almpanidou, V, Wallace, BP, Pantis, JD and Schofield, G 2014, A global gap analysis of sea turtle protection coverage, Biological conservation, vol. 173, pp. 17-23, doi: 10.1016/j.biocon.2014.03.005.

3. With maps plus software: where time and technical expertise allow, several dedicated programmes exist to assist in the assessment and planning of protected areas. Such approaches are generally seen as part of a longer systematic approach to conservation planning that embraces stages from initial scoping and development of targets through to monitoring the final network (an example is provided in BOX 15).

Box 15 - "Gap Analysis using map and software":

" **TITLE:** Area requirements and pelagic protected areas: is size an impediment to implementation?

PURPOSE OF THE ANALYSIS: To model a series of reserve networks for an oceanic region off eastern Australia. The primary goal of the MPA network was to protect five pelagic species targeted by the eastern Australian tuna and billfish longline fishery, as well as providing ecosystem-wide protection from negative fishery.

METHODS: The authors describe the use of the conservation planning software Marxan (http://www.uq.edu.au/marxan) to assist in developing a pelagic MPA network along Australia's east coast.

The identification of candidate MPAs was based upon the distribution of 35 pelagic species, collected through fisheries and tagging data, and the distribution of physical habitat features obtained primarily from remote sensing. The process targeted both static features such as seamounts and shelf breaks, as well as dynamic hydrographic features. The distribution of species and dynamic habitat features were divided into four seasons, each considered as a separate conservation feature. Marxan was then used to select MPA networks that captured 20 % of the extent of each feature, while trying to minimize the impact of the MPA network on fisheries' revenue.

RESULTS: This analysis quantified the area requirements of pelagic protected area networks created to meet threat mitigation objectives for a suite of pelagic species including both target and non-targeted species. Despite the inclusion of a large number of conservation features, area requirements remained proportionally small in relation to the size of the focus region until higher representation targets (from 10% to 40%) were imposed. "

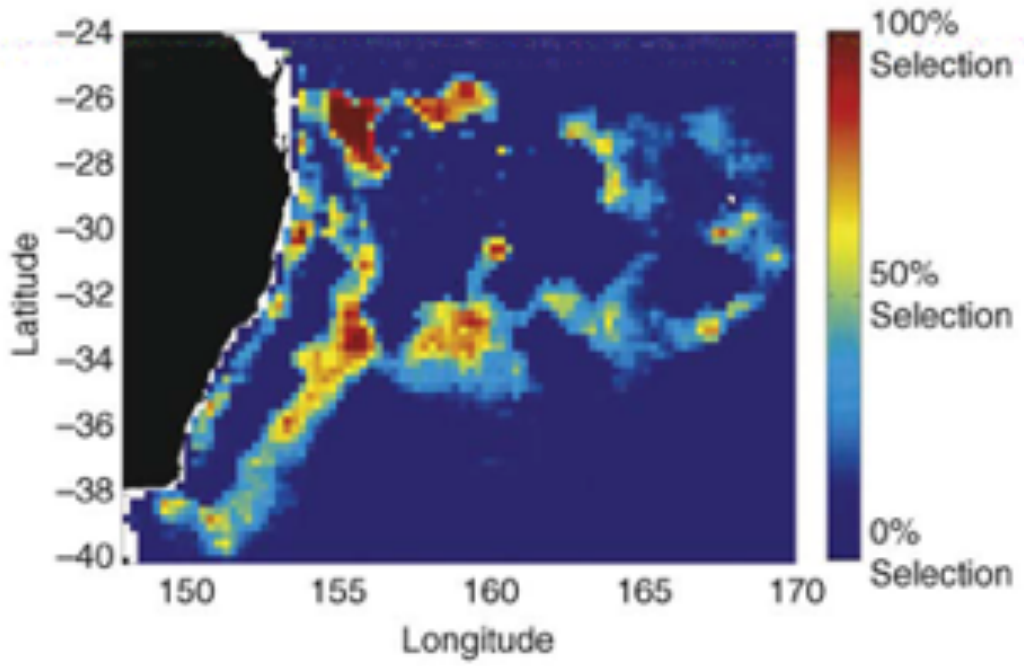

Figure 13. Example of priority areas for pelagic MPAs off the east coast of Australia, as identified by the conservation planning software Marxan. The colour of each cell indicates the frequency with which that site was selected as part of the 'best' MPA network across 100 runs of Marxan. Red cells were nearly always included as part of the optimal reserve network and can therefore be considered highly important areas for efficient pelagic conservation.
Each potential MPA network aimed to capture at least 20 % of the extent of 40 different physical and biological pelagic features, while at the same time minimizing the impact of prospective MPAs on fisheries revenue.

Source: Alpine, J.E. and Hobday, A.J. (2007) Area requirements and pelagic protected areas: is size an impediment to implementation? Mar. Freshw. Res. 58, 558–569

Due to the ever-changing nature of data availability, and also considering that gaps are significantly affected by the quality of management, GA has to be a continual process that needs to be conducted at regular intervals. The incomplete and in-progress state of biodiversity studies in different regions of the world continually generate new data, gathering new biological information which are more complete and comprehensive. Continuous mapping exercise as new or better data become available can provide realistic insights into the efforts required to bridge the gaps and to address pre-determined issues or data needs of a particular stakeholder community (Ariño et al., 2016; Chavan et al. 2010).

It is also important to understand what the GA is looking for. In this respect, two key issues are important:

- What type of gap exists? – Whether there are gaps concerning the representativeness (i.e. species, ecosystems and ecological processes that are missed entirely by the protected area system), ecological gaps (i.e. relating to biodiversity that exists within protected areas but at insufficient levels to provide long-term protection) or gaps in objectives, governance types or effectiveness (management gaps). In management gaps, a protected area itself appears as a "gap" if it has not been implemented or is not well managed.
- What is the extent of the gap? – Identifying the extent of the protection gap will help to chart the way forward for filling existing gaps. For example, how many populations are still needed to secure the long-term conservation of a particular species in the protected area system? Are whole new protected areas necessary, or would a corridor between existing protected areas or an extension of an existing park be sufficient to address the representation or ecological gap? These questions are central to prioritizing what is needed most.

The gap analysis is just the first stage in developing a representative protected areas network. The process of the gap analysis will often naturally lead to plans for developing new protected areas (Dudley & Parish, 2006). Prioritizing the gaps, defining a strategy and taking action are essential steps of the process.

3.5. PRIORITIZE GAPS TO BE FILLED

A gap analysis does not produce a precise plan, but rather a set of options that must be reconciled with other wants and needs. A good gap analysis will outline the priorities to be addressed and suggestions for action.

The identification of priorities involves a number of different assessment steps:

- Pressures and threats in both existing MPAs and unprotected ecosystems. The knowledge of threats is a key step in the prioritization process, both to identify areas where action is most urgent and to identify broad-scale threats acting across the whole protected area network.
- Opportunities for new protected areas: some places may already be under consideration as protected areas or have a designation that could be converted into full protection status.
- Other opportunities for effective protection: some gaps may be better filled by other kind of management than by creating protected areas in places where they are resisted or difficult to achieve.
- Capacity to implement an expanded protected area network: big plans are pointless without the capacity to make them happen
- Taking decisions about sequencing priorities: Once the various analyses have been undertaken, decisions have to be made about priorities. Dedicated software decision-support packages exist to help identify and prioritize protected area systems (e.g. MARXAN). Workshops of experts are also recommended, as have larger stakeholder-driven processes where people with different expertise have been involved in drawing up scenarios and debating which is the best option (i.e. the development of the cIMMA is an expert knowledge process - see BOX 6).

MARXAN (http://marxan.net/) is the most widely adopted site selection tool by conservation groups globally. Marxan is a stand-alone software programme that provides decision support to teams of conservation planners and local experts identifying efficient areas that combine to satisfy a number of ecological, social and economic objectives. Given data on species, habitats, ecosystems and other biodiversity features, Marxan was designed to minimize the cost of selected sites while meeting all representative goals. The Marxan decision support tool is designed to provide an objective approach to site prioritization which is adaptable and repeatable based on a function that evaluates millions of possible alternatives and retains "best" solutions given a stated set of criteria.

3.6. AGREE ON A STRATEGY AND TAKE ACTION

Once priorities are set, the gap analysis is complete. Future MPA network developing scenarios should then be proposed based on the different dimensions (i.e. time, taxonomy, management) of the identified gaps.
Critical aspects to consider are:

- Size and location of new protected areas: possibly with linking habitats (corridors and buffer zones). Decisions will be made on the basis of priorities, opportunities and capacity.

- Management objectives for the protected areas: they can vary from strict protection to cultural landscapes with human communities. All have their role, but are not equally applicable to all conservation needs. IUCN identifies six categories of management objectives that can help to plan protected area networks.
- Governance structures for the protected areas: who owns or manages the protected areas can influence if communities support or oppose protection. Most governments still rely mainly on state-owned protected areas, but many other options exist, including various forms of co-management, private protected areas and community conserved areas.
- Opportunities for conservation outside protected areas: if management is effective and secure. conservation benefits can influence the biodiversity also outside the MPA. These areas can play their role in the MPA system, acting as buffer zones or corridors supporting the cycles of certain species (i.e. migratory corridors).
- Opportunities to use restoration as a tool: The MPA system should encourage natural regeneration. GA can help to identify the most valuable sites for restoration. The conservation of these site allows natural dynamics to restore natural patterns or to build up particular species that are sensitive to disturbance.

CONCLUSIONS

This practical guide highlights a number of issues, principles, best practices and spatial tools that should be used by Mediterranean national planners, decision makers and other stakeholders involved in the MPA planning process, in order to conduct a gap analysis. A conservation gap analysis allows to decide whether the ecosystems and other components of marine biodiversity are under-represented in the existing MPA system, providing critical information to efficiently implement the network of MPAs, and enhance the connectivity among Mediterranean MPAs facilitating the attainment of the Aichi Target 11 in the Mediterranean Region.

These issues might initially seem challenging since limits still exist, particularly concerning the availability of information about current distribution (observed and/or predicted), and status and temporal trends of species and habitats at different spatial scales (i.e. local or regional). However, a large number of shared databases and geoportals on protected areas or species occurrence and distribution have become available in recent years at both national and regional scales, facilitating the gap identification process.

Due to the ever-changing nature of data availability, the analysis must be a continual process, that needs to be conducted at regular intervals. Updated gap analysis should be frequently conducted, as new or better information become available. The knowledge acquired by using this analytical process can provide realistic insights into the efforts required to upgrade MPA management and undertake the appropriate steps to increase the surface areas covered by MPAs in the Mediterranean.

It is also very important to maintain an updated information on the management effectiveness of the single MPA components of a network, because unmanaged or poorly managed MPAs offer insufficient or no conservation effects, and those MPAs would represent real conservation gaps even though the network would appear to be appropriately covering the region on paper.

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ANNEXES

ANNEX I – GA FLOW CHART

ANNEX II - SPATIAL DATA TOOLS

AquaMaps: http://www.aquamaps.org Aquamaps generates standardized computer-generated large scale predictions of marine and freshwater species. Maps are available for all marine mammal species, and a subset has been expert-validated.

Distribution of KBAs, IBAs and AZEs: http://www.birdlife.org/datazone/ The dataset shows the global distribution of Key Biodiversity Areas (KBA), Important Bird and Biodiversity Areas (IBA) and Alliance for Zero Extinction (AZE) sites, with a marine component. Under the 'umbrella term' «KBA» are marine, freshwater and terrestrial sites which contribute significantly to the global persistence of biodiversity at the genetic, species and ecosystem levels. The «KBA network» hence encompasses sites of high biodiversity value of global significance.

Distribution of Particularly Sensitive Sea Areas (PSSA): http://pssa.imo.org A PSSA is an area that needs special protection through action by the International Maritime Organization (IMO) because of its significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities.

Distribution of Specially Protected Areas of Mediterranean Importance list (SPAMI list): http://www.rac-spa.org/spami Map of the Mediterranean SPAMI (updated in 2017).

Distribution of Vulnerable Marine Ecosystems Database: http://www.fao.org/in-action/vulnerable-marine-ecosystems/vme-database/en This dataset shows the global distribution of Vulnerable Marine Ecosystems (VMEs) in relation to deep-sea fishing activities.

Fishbase: http://www.fishbase.org FishBase is a global biodiversity information system on finfishes. Its initial goal to provide key facts on population dynamics for 200 major commercial species has now grown to having a wide range of information on all species currently known in the world: taxonomy, biology, trophic ecology, life history, and uses, as well as historical data reaching back to 250 years. At present, FishBase covers >33,000 fish species compiled from >52,000 references in partnership with >2,000 collaborators: >300,000 common names and >55,000 pictures.

General Bathymetric Chart of the Oceans (GEBCO): http://www.gebco.net/data_and_products/gebco_web_services/web_map_service/ http://www.gebco.net/data_and_products/gridded_bathymetry_data/ GEBCO's aim is to provide the most authoritative publicly-available bathymetry of the world's oceans. It operates under the joint auspices of the International Hydrographic Organization (IHO) Global and the Intergovernmental Oceanographic Commission (IOC) (of UNESCO).

Global Distribution of Ecologically or Biologically Significant Marine Areas Ecologically or Biologically Significant Marine Areas (EBSAs): https://www.cbd.int/ebsa/.Delineate specific ocean areas in need of protection. EBSAs are defined as «geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics, or otherwise meet the [EBSA] criteria" (Secretariat of the Convention on Biological Diversity, 2008).

Global Bio-diversity Information Facility (GBIF): http://www.gbif.org/developer/maps It provides a single point of access (through this portal and its web services) to hundreds of millions of records, shared freely by hundreds of institutions worldwide, making it the biggest biodiversity database on the Internet. The data accessible through GBIF relate to evidence about more than 1.6 million species, collected over three centuries of natural history exploration and including current observations from citizen scientists, researchers and automated monitoring programmes.

Global Distribution of Regional Fishery: http://www.fao.org/figis/geoserver/factsheets/rfbs.html. This dataset shows the global distribution of approximately 50 Regional Fishery The main objective of the Regional Fishery Bodies is to ensure the sustainable exploitation of marine and freshwater resources by the establishment of a system of international regulation and by the development of marketing activities in conformity with the objectives of its members. RFBs have varied functions, including the collection, analysis and dissemination of information and data, coordinating fisheries management through joint schemes and mechanisms, serving as a technical and policy forum, and taking decisions relating to the conservation, management, development and responsible use of the resources.

General Fisheries Commission for the Mediterranean (GFCM): http://www.fao.org/gfcm/data/en/The General Fisheries Commission for the Mediterranean (GFCM) is a regional fisheries management organization (RFMO) established under the provisions of Article XIV of the FAO Constitution. GFCM main objective is to ensure the conservation and the sustainable use, at the biological, social, economic and environmental level, of living marine resources as well as the sustainable development of aquaculture in the Mediterranean and in the Black Sea. The website interactive maps allowed to visualize fishery restricted areas.

Global Register of Migratory Species (GROMS): http://www.groms.de/ GROMS supports the Bonn Convention by summarizing the present state of knowledge on migratory species in a relational database connected to a geographical information system.

Global Marine Traffic: http://www.marinetraffic.com Marine Traffic provides the most comprehensive maritime database on marine traffic. 800 million vessel positions are recorded monthly and 18 million vessel and port related events are recorded monthly. http://www.marinetraffic.com/en/ais-api-services

Geomorphology of the oceans: http://www.bluehabitats.org/?page_id=9.This dataset represents the first digital seafloor geomorphic features map (GSFM) of the global ocean, using methods outlined in Harris et al. (2014).The GSFM includes separate polygons in 29 geomorphic feature categories, used here to assess differences between passive and active continental margins as well as between 8 major ocean regions (the Arctic, Indian, North Atlantic, North Pacific, South Atlantic, South Pacific and the Southern Oceans)

IUCN Red List of threatened species: http://www.iucnredlist.org/technical-documents/spatial-data. It contains information on taxonomy, conservation status, and spatial data on species distribution (available upon request) that are defined by IUCN as under threat.

Maritime Boundaries incl. Exclusive Economic Zones: http://www.marineregions.org/.This dataset shows the global distribution of maritime boundaries, including Exclusive Economic Zones (EEZ), 12 and 24 nautical miles zones, archipelagic waters and internal waters. The dataset also contains information about treaties.

Mediterranean Marine Invasive Species database (MAMIAS database): www.http://mamias.org The Database includes among Alien species, cryptogenic ones. Tropical Atlantic species, which have expanded their geographic distribution in the Mediterranean, are noted as range expansion, or vagrant.
The Database includes also species that have been occasionally reported as alien but were subsequently excluded from lists, along with the reasoning of their exclusion.

Mediterranean Platform on biodiversity: http://data.medchm.net/en/ The Mediterranean Biodiversity Platform is an online tool developed to inventory, catalogue and store data on marine and coastal biodiversity in the Mediterranean, and view them on maps. This platform has been developed by the Specially Protected Areas Regional Activity Centre (SPA/RAC), within the MedKeyHabitats project, with a financial support of the MAVA Foundation.

Marine Protected Areas in the Mediterranean database (MAPAMED): http://www.mapamed.org MAPAMED is a GIS database that gathers information on marine protected areas of the Mediterranean, and more generally on sites of interest to the conservation of the marine environment. It is developed and jointly administered by MedPAN and SPA/RAC. The development of MAPAMED database arose from the need to have a resource center collecting and structuring information on Mediterranean MPAs.

Movebank: www.datarepository.movebank.org Movebank allows users to publish animal tracking datasets. Published datasets have gone through a submission and review process, and are typically associated with a written study published in an academic journal

Oceanic Biogeographic Information System (OBIS): http://www.iobis.org More than 20 OBIS nodes around the world connect 500 institutions from 56 countries. 45 million observations of nearly 120 000 marine species, from Bacteria to Whales, from the surface to 10 900 meters depth, and from the Tropics to the Poles. The datasets are integrated so one can search and map them all seamlessly by species name, higher taxonomic level, geographic area, depth, time and environmental parameters. OBIS emanates from the Census of Marine Life (2000-2010) and was adopted as a project under IOC-UNESCO's International Oceanographic Data and Information (IODE) programme in 2009.

Ocean Biogeographic Information System Spatial Ecological Analysis of Mega vertebrate Populations (OBIS-SEAMAP): http://seamap.env.duke.eduOBIS-SEAMAP, is a spatially referenced online database, aggregating marine mammal, seabird, sea turtle and ray & shark observation data from across the globe.

Ocean Tracking Network: https://members.oceantrack.org/projects The Ocean Tracking Network (OTN) is a global project headquartered at Dalhousie University in Halifax, Nova Scotia, Canada.

World Database on Protected Areas: https://protectedplanet.net/ The World Database on Protected Areas (WDPA) is the most comprehensive global database on terrestrial and marine protected areas. It is a joint project between the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN), managed by UNEP World Conservation Monitoring Centre (UNEP-WCMC). The dataset shows the global distribution of terrestrial and marine protected areas as well as sites that do not meet the standard definition of a protected area but do achieve conservation in the long-term, generically referred to as other effective area-based conservation measures (OECMs).

World Register of Marine Species (WoRMS): http://www.marinespecies.org/index.php The aim of a World Register of Marine Species (WoRMS) is to provide an authoritative and comprehensive list of names of marine organisms, including information on synonymy. While highest priority goes to valid names, other names in use are included so that this register can serve as a guide to interpret taxonomic literature.

Wildlife Tracking: http://www.wildlifetracking.org/ Wildlifetracking.org is a partnership of more than 300 projects, tracking 100 species (and counting) around the world.

PANGAEA: https://pangaea.de/ The information system PANGAEA is operated as an Open Access library aimed at archiving, publishing and distributing georeferenced data from earth system research. The system guarantees long-term availability of its content through a commitment of the hosting institutions.

Science and Conservation of Fish Aggregation Database (SCRFA): http://www.scrfa.org/database/ The SCRFA Fish Aggregation Database contains key parameters describing the characteristics of an aggregation including location, habitat, lunar and solar phase, fishing gear used, status, management and monitoring.

ANNEX III - ADDITIONAL READING LIST

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MAP

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Barcelona Convention

SPA / RAC

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