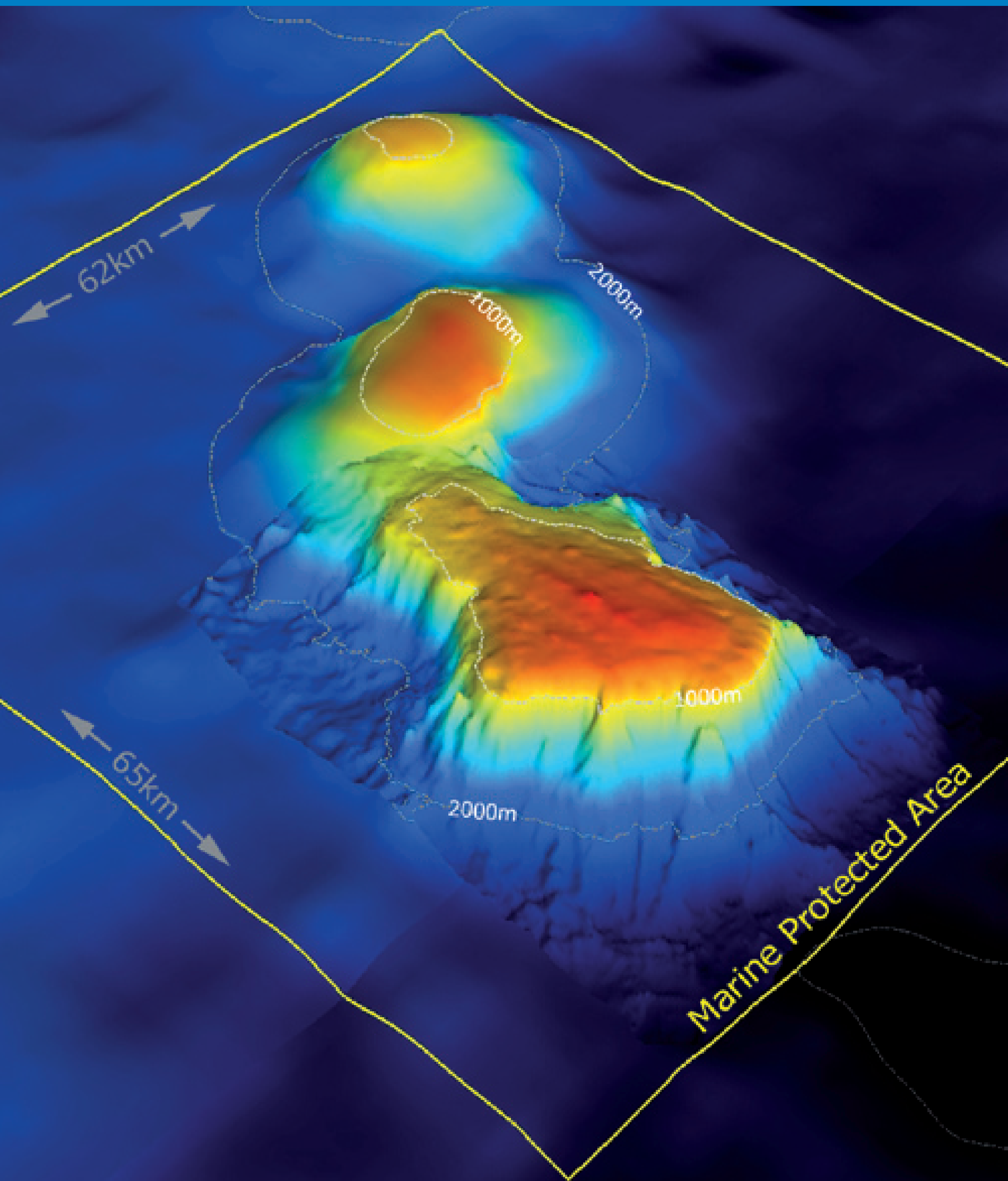
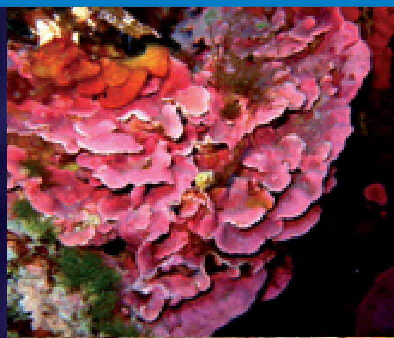
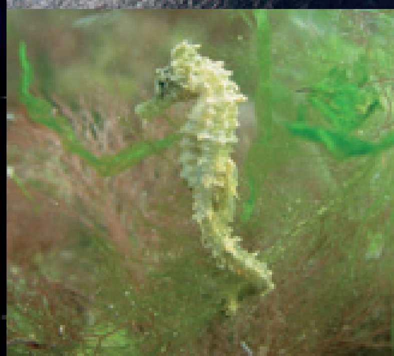
Position Paper 18

Achieving Ecologically Coherent MPA Networks in Europe: Science Needs and Priorities

April 2013







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Left: Sedlo seamount Marine Protected Area (vertical exaggeration: 5x). High-resolution bathymetry is only available for the southeastern-most peak. (Graphics courtesy, F. Tempera ©*Imag*DOP. Bathymetry data courtesy, project OASIS; Lourenço *et al.*, *Mar. Geoph. Res.*, 1998).
Right from top to bottom: Coral (courtesy, INAT, Italy); Juvenile Lobster, Columbretes Island (courtesy, David Díaz); Aerial photo of the main Island of the Columbretes Islands MPA (courtesy, Silvia Revenga); Seahorse (courtesy, National Institute for Marine Research and Development “Grigore Antipa”, Romania).

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This Position Paper is based on the activities of the European Marine Board Working Group on Marine Protected Areas (WG MPA) which held 4 meetings between March 2010 and October 2011.

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Foreword

This position paper highlights a set of science needs and priorities that can best contribute to the process of establishing a coherent network of Marine Protected Areas (MPAs) in Europe. The paper examines the different phases of MPA development, e.g. design, management and assessment, as a contribution towards the ecosystem-based management of European seas and oceans. The establishment of networks of reserves has been proposed by many scientists and wildlife managers as a way to effectively protect biodiversity (Santos *et al.*, 1995; Allison *et al.,* 1998; Sala *et al.,* 2002; Airamé *et al.,* 2003; Lubchenco *et al.,* 2003; Fernandes *et al.,* 2005; Green *et al.,* 2009). An effective network of MPAs needs to span large geographical distances and encompass a substantial area to protect against catastrophes (Lubchenco *et al.,* 2003) and increasing environmental variability as a result of climate change. The fisheries management benefits of these ecological reserves are also increasingly recognized and include protecting critical feeding, nursery and spawning grounds which in turn help to build and maintain fish populations resulting in improved fishing yields (United Nations General Assembly A/Res/61/105).

The main challenge in producing this position paper has been to ensure that its recommendations both reflect the complex and rapidly evolving landscape, while providing significant added value to the current scientific and policy debate on MPAs. Therefore, the working group has consulted with several stakeholder entities at both the international (IOC-UNESCO) and national (e.g. national agencies responsible for MPAs implementation) levels. This partnership has allowed the working group to identify specific research gaps and needs intended to improve prospects and approaches towards implementation of a coherent network of MPAs in Europe. It was not the intention of the working group to be exhaustive in detailing a complete global research effort; firstly because of obvious time constraints and secondly to ensure that the recommendations are targeted, concise and adapted to the current European situation. To comply with this overarching objective, the Group relied heavily on case studies, a number of which are included here for illustrative purposes.

In producing this position paper the primary objective of the working group has been to strengthen the research basis to inform, engage and empower stakeholders in planning **networks of MPAs** by:

I. Profiling and highlighting the key scientific priorities that will inform the development of a coherent network of MPAs in Europe, and support its management and monitoring processes.
II. Providing European research programme managers with a list of key research priorities and needs in order to best promote, inform and support the rapid implementation of a network of MPAs in Europe.
III. Providing science based recommendations to assist MPA planners, MPA managers and EU/national decision makers.

On behalf of the European Marine Board, we would like to sincerely thank all of the members of the working group who so willingly gave their time and expertise to support the production of this important position paper. Their work has been crucial to review the current practices for MPA management and to highlight the importance of scientific research in underpinning ecosystem-based management and the development of a coherent network of MPAs across Europe. Our special thanks goes to the working group Chair, Esben Olsen, and to Kate Larkin, Maud Evrard and Aurélien Carbonnière of the Marine Board Secretariat for their diligent support to the working group and and in finalizing this report. We also thank European Marine Board delegates and two external reviewers for their invaluable comments and suggestions.

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Executive summary

Marine Protected Areas (MPAs) are clearly defined geographic areas which are designated, regulated and/or managed to achieve specific conservation objectives. MPAs are an acknowledged tool for protecting marine biodiversity (marine species, habitats and ecological processes), contributing to an Ecosystem Approach for integrated management of marine resources. However, their establishment in Europe has lagged behind terrestrial equivalents and has taken place in an *ad hoc* and largely uncoordinated way in response to political drivers. European MPAs have been established for a variety of purposes and protection categories and, as with distribution globally, their coverage is both uneven and unrepresentative at multiple scales.

Networks of MPAs contributing to ecosystem-based marine spatial management are perceived as an optimal way to safeguard biodiversity assets. In Europe, the Natura 2000 network and networks promoted by the European Regional Seas Conventions have grown considerably in recent years, making significant progress towards global targets.

Designing MPAs encompasses both ecological and practical considerations. A variety of formal and informal guidelines have been developed but all rely on science to determine conservation objectives and evaluate site-specific considerations. Effective MPA network design encompasses considerations of scale, size and spacing, and definition and mapping of ecosystem components are an essential prerequisite for the management of MPAs. Within Europe this 'ecological mapping' has been undertaken at different spatial and temporal resolutions and often on a project basis, resulting in an incomplete and uneven coverage. In practice, MPA establishment therefore varies from *ad hoc* to more systematic approaches. Understanding and achieving ecological coherence is a major challenge. Critically, connectivity and ecosystem-engineered habitats are identified as important research priorities. Management practice is also variable, often driven by funding availability. However, science can inform success criteria to measure the effectiveness of management actions. Managers need to develop realistic operational objectives and related indicators against which effectiveness can then be measured. Enforcement and surveillance are also integral to MPA success. Stakeholder participation from the design stage is also critical. In the past, insufficient involvement of stakeholders in the planning process has been a common cause of failure for many MPAs.

A broad array of science needs and priorities, together with clear attainable and measurable objectives, are necessary to establish ecologically coherent MPA networks. Assessing the connectivity of marine populations remains a challenge for most species and multidisciplinary studies combining oceanographic modeling, larval ecology and population genetics are needed. Knowledge on connectivity is even more essential for designing networks of MPAs. A general understanding of the effectiveness of MPA networks as a fisheries management and conservation tool will depend on a broader range of case studies that apply new methods (such as genetics) to quantify connectivity. Assessing a coherent network of MPAs ideally requires an EU-wide coherent network of monitoring stations, particularly for evaluating recovery processes inside MPAs and connectivity between MPAs. Habitat structuring species have been identified as a conservation target. Biologically engineered habitats are important for the maintenance of biodiversity and ecosystem functioning. Such species provide the template for other ecosystem processes, making them useful for MPA management. Therefore, it is necessary to investigate under which status an ecosystem-engineered habitat can potentially be used within marine management strategies.

A significant limitation to assessing the effectiveness of some existing MPAs is the lack of before-after-control-impact assessment. In order to assess MPA effects there is inevitably a need to compare against baseline data prior to reserve establishment. Also, in order to separate protected area effects from other environmental changes, there is a need to compare against the control areas that are not connected to the MPA. Similarly, without no-take zones, it is not possible to assess the effectiveness of partial protection (e.g. the North Sea Plaice Box case study, page 38), or to gain knowledge about baseline ecosystem status. Integral to a precautionary approach is the recognition that in many areas, data for the marine environment is lacking and further work on the basic understanding of ecological functioning is needed. Such comparisons are extremely valuable as assessment tools. However, strong linkages in the marine environment mean that it will be difficult to establish true baselines, as exploitation of neighbouring ecosystems may, in turn, affect the protected area.

Establishing when a system has recovered to a state in line with its conservation objectives also poses a significant challenge. Monitoring series will need to track the development of a range of species and processes within MPAs for a considerable period, in comparison to the development outside protected areas. Long-term monitoring studies are essential and research funding schedules should be adapted accordingly. Changing environmental conditions may also lead to changes in species distributions and larval development times and connectivity patterns. Measuring the resilience of an MPA network in the face of climate change is, therefore, a major challenge.

Executive summary

To assist managers, scientific advice and adequate tools for monitoring and assessing MPA performance are required. The development of such approaches requires a sound collaboration between scientists and MPA managers. In addition, the evaluation of MPA performance involves assessing not only the state and evolution of ecosystems, but also anthropogenic pressures, in particular those due to uses that can be influenced by the MPA, and the attitudes of stakeholders. Empirical assessment of socio-economic effects of MPAs is sparse. Such assessment of MPAs must analyze and evaluate different groups of stakeholders to understand the overall magnitude of the costs and benefits of different conservation policies and their social implications.

Drawing on literature and practical case studies, this paper identifies science needs in the areas of data collection; habitat classification; baselines and monitoring; ecological coherence and connectivity, and ecological processes. These are complemented by a recognition of the need for further research and guidance for MPAs in the context of emerging issues, legal clarifications, stakeholder involvement, policy guidance informed by science, and the benefits of closer cooperation between scientific monitoring and surveillance and enforcement activities.

Summary of identified science needs and priorities

- Promote a coordinated, harmonized and open access approach to MPA-relevant data obtained through marine survey work;
- Refine habitat classifications using modelling distributions of critical or vulnerable marine ecosystem indicators at a scale relevant to both MPA planning and fisheries management;
- Promote systematic long-term monitoring of MPAs and their surrounding waters;
- Advance the understanding of ecological coherence gaps and critical components such as connectivity;
- Establish a core set of indicators to measure MPA network efficiency;
- Promote the incorporation of adaptive approaches and new and emerging issues such as climate resilience and blue carbon in MPA management;
- Provide legal clarity to establish clear guidelines for international bodies and Member States regarding cooperation in the high seas and implementation of stringent MPA management measures;
- Establish culturally appropriate guidance to promote stakeholder engagement and incorporate socio-economic issues;
- Develop policy-relevant guidance for systematic and harmonized MPA network development, management and review; and
- Promote cross-sector partnerships and develop pilot projects that link marine monitoring with maritime surveillance.

Further details on each of these research priorities is provided on p.56-57 of this paper.

A. General introduction

Striped dolphins from the Pelagos Sanctuary, Mediterranean (courtesy, C. Lanfredi, Tethys Research Institute)

A.1 Marine Protected Areas

The term Marine Protected Area (MPA) has been used to describe a wide range of marine areas where human activities are subject to some level of restriction to protect living, non-living, cultural, and/or historic values. MPAs are seen as a means, consistent with international law, for instituting protective conservation, restoration or precautionary measures related to specific areas or sites and related to specific species, habitats or ecological processes. The MPA concept has a long history, but the process leading to MPA establishment has gained momentum in recent years, largely through the recognition of political objectives to halt the loss of biodiversity. Following the first individual national efforts (e.g. in New Zealand), European policy-making has been in the vanguard of setting a more strategic collective agenda (see p.13, Natura 2000). Key steps along the way at global level, as outlined by the UNEP-WCMC (2008), have been:

- In 2002, the World Summit on Sustainable Development (WSSD) called for the "establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012".
- In 2003, the 5th World Parks Congress called on countries to establish a global system of MPA networks to cover 20 to 30% of the world's oceans by 2012.
- In 2003, the Evian Agreement signed by the G8 Group of Nations called for the creation of ecosystem networks of marine protected areas under international law by 2012.
- In 2004, the Convention on Biological Diversity (CBD COP7) agreed to the WSSD plan with the following statement that covers terrestrial and marine areas: "The establishment and maintenance by 2010 for terrestrial and by 2012 for marine areas of comprehensive, effectively managed, and ecologically representative national and regional systems of protected areas that collectively, *inter alia* through a global network, contribute to achieving the three objectives of the Convention and the 2010 target to significantly reduce the current rate of biodiversity loss at the global, regional, national and sub-national levels and contribute to poverty reduction and the pursuit of sustainable development." (http://www.cbd.int/decision/cop/?id=7765 item 18).

Decision VII/28 of CBD COP7 laid out the process by which these targets were to be met, with the following deadlines:

- By 2006, complete protected area system gap analyses at national and regional levels.
- By 2008, take action to address the under-representation of marine ecosystems in existing national and regional systems of protected areas, taking into account marine ecosystems beyond areas of national jurisdiction in accordance with applicable international law.
- By 2009, designate the protected areas identified through the gap analyses.
- By 2012, complete the establishment of comprehensive and ecologically representative national and regional systems of MPAs.

At the Nagoya CBD COP 10 in November 2010, the Parties recognized that the 2010 biodiversity targets had not been reached. Decision X/2 of COP10 provided a revised and updated strategic plan for 2011-2020 in which Aichi Target 11 under Strategic Goal C states that by 2020, at least 17% of terrestrial and inland water, and 10% 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.

The Ecosystem Approach (EA) is fundamental to the CBD process and is defined as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (http://www.cbd.int/ecosystem/), the ecosystem being defined as "an interacting complex of living communities and the environment, functioning as a largely self sustaining unit." It recognizes that humans, with their cultural diversity, are an integral component of ecosystems. Thus truly resilient and productive networks must also bring together marine-coastal-estuarine-riverine protected areas (see "What is a Marine Protected Area?" box on page 11).

Not all MPAs offer full environmental and species protection. Indeed in the design of an MPA, it is common practice to identify the management category as defined by the International Union for the Conservation of Nature (IUCN) (Dudley, 2008) – see Table 1. The categories range from totally protected areas to areas managed for sustainable use of resources. Different management plans are applicable to each category with Categories V and VI offering somewhat less protection to the ecosystems. Supplementary guidelines provide additional advice on applying these IUCN categories. These include guidance on how characteristics of the marine environment affect MPAs, applying the categories to different zones in an MPA, detailing relationships between the categories and different activities (Day *et al.*, 2012), and clearly indicating that areas allowing extractive use with no long-term conservation goal should not qualify as MPAs.

What is a Marine Protected Area?

The definition of an MPA has evolved over time, and relies on the same concepts. Until recently the most commonly used definition of an MPA was provided by the IUCN:
"Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (Kelleher, 1999).

The most recent definition was established in 2007 by IUCN-WCPA and covers all protected areas whether marine or terrestrial. Although this makes the definition less specific, it eliminates problems of definition when the MPA spans both land and sea. The definition clearly identifies the long-term conservation focus.

A protected area is ***"A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values"*** (Dudley, 2008).

Under this new definition, regulated fisheries (among other human activities) within an MPA may be possible where there is no conflict with long-term conservation objectives.

A current on-going debate about 'what counts as an MPA'[1] recalls two new global tabulations of MPAs – the MPA Atlas (http://mpatlas.org/) and a calculation by the Marine Reserves Coalition, both taking a more inclusive position that incorporates a wide range of sites than the stricter IUCN-WCPA definition. This presents an as yet unresolved choice on how global MPA coverage should be measured. Despite an estimated quadrupling of MPA coverage over the last 10 years (see Figure 1), there is concern that progress on defining MPAs, based on MPA coverage as the primary indicator, is very slow on a global scale. According to Spalding *et al.* (2010) approximately 4.21 million km^2, 1.17% of the world's oceans and 2.86% of the total marine area within Exclusive Economic Zones, were protected at the start of 2010. However, there is a growing trend to define very large MPAs such as the Chagos MPA of 545,000 km^2 that was defined in 2010, and prospective designations in Australia, New Caledonia and the Cook Islands. A re-evaluation by the Nature Conservancy (2012) estimates that coverage has increased to 8.3 million km^2, 2.3% of the world's oceans and 7.9% of continental shelf and equivalent areas (<200m deep) and 1.79% of off-shelf waters with only 0.17% of the high seas.

The global distribution of protected areas is both uneven and unrepresentative at multiple scales. The Nature Conservancy (2012) analysed both biogeographic and political coverage. They concluded that whilst there is now MPA representation in all coastal realms and provinces, this masks a spectrum of eco-region coverage and a paucity of coverage of pelagic provinces in offshore waters. Similarly, whilst 28 countries and territories (including 10 Member states of the EU) have over 10% coverage, 111 countries and territories have less than 1% MPA coverage (including 11 who have no recorded MPAs) (Nature Conservancy, 2012).

The progression from the single MPA vision to the MPA network vision is gaining momentum (Sala *et al.*, 2002; Dudley, 2008; Higgins *et al.*, 2008; Laffoley, 2008). Ecological benefits include protecting representative areas of species and habitats, including threatened species and habitats through all stages of their lifecycle. In addition, MPA networks have been recognised as beneficial to both fisheries (Hall and Mainprize, 2004; Pitchford *et al.*, 2007) and to socio-economic welfare (Pomeroy *et al.,* 2005). However, design and management of networks is still relatively poorly understood (Johnson *et al.*, 2008). It is important that MPAs cover the full spectrum of ecosystems and vulnerable species and that they are part of a broader ecosystem-based management approach in which networks of MPAs play a significant role (Rogers *et al.*, 2007). Currently the global set of MPAs does not represent an effective network on a hierarchical scale (e.g. national to regional to global) and most progress in the near future is likely to be made at the national and regional scales. Toropova *et al.*, 2010 and Agardy *et al.*, 2011 list 5 shortcomings of MPAs including 1) many MPAs are too small to achieve their goals, 2) many are inappropriately planned or managed, 3) many fail due to degradation of the surrounding unprotected area, 4) many do more harm than good due to displacement and unintended consequences of management, 5) MPAs may create a dangerous illusion of protection when in fact no protection is occurring. Like individual MPAs, once established, networks of MPAs need to be effectively managed with enforcement of the rules plus regular assessment to ensure that the objectives are being achieved (Toropova *et al.*, 2010). Management, enforcement and assessment are often more difficult and costly in marine sites as opposed to terrestrial sites, particularly in remote high-seas areas with a low level of regulation for fishing vessels. In areas beyond national jurisdiction legislation may also be more complex.

1 MPA News 14(3) November/December 2012 (http://depts.washington.edu/mpanews/issues.html)

Category	Main objectives or purposes
Ia	***Strict Nature Reserve managed mainly for science*** The objective in these MPAs is **preservation of the biodiversity and other values in a strictly protected area**. No-take areas/marine reserves are the specific type of MPA that achieves this outcome. They have become an important tool for both marine biodiversity protection and fisheries management. They may comprise a whole MPA or frequently be a separate zone within a multiple-use MPA.
Ib	***Wilderness Area managed mainly to protect wilderness qualities*** **Category Ib** areas in the marine environment should be **sites of relatively undisturbed seascape, significantly free of human disturbance, works or facilities and capable of remaining so through effective management**.
II	***National Park managed mainly for ecosystem protection and recreation*** **Category II** areas present a particular challenge in the marine environment, as **they are managed for "ecosystem protection", with provision for visitation, recreational activities and nature tourism.**
III	***Natural Monument managed mainly for conservation of specific natural features*** **Localized protection** of features such as seamounts has an important conservation value, while other marine features may have cultural or recreational value to particular groups, including flooded historical/archaeological landscapes. Category III is likely to be a relatively uncommon designation in marine ecosystems.
IV	***Habitat/Species Management Area managed mainly for conservation through management interventions*** **Category IV** areas in marine environments should play an important role in the **protection of nature and the survival of species** (incorporating, as appropriate, breeding areas, spawning areas, feeding/foraging areas) or other features essential to the well-being of nationally or locally important flora, or to resident or migratory fauna. Category IV is aimed at protection of particular species or habitats, often with active management intervention (e.g. protection of key benthic habitats from trawling or dredging).
V	***Protected Landscape/Seascape managed mainly for landscape/seascape conservation and recreation*** **Category V** protected areas stress the **importance of the "interaction of people and nature over time"** and in a marine situation. Category V might most typically be expected to occur in coastal areas.
VI	***Managed Resource Protected Area*** ***Managed mainly for the sustainable use of natural ecosystems and resources*** MPAs that **maintain predominantly natural habitats but allow the sustainable collection of particular elements**, such as particular food species or small amounts of coral or shells for the tourist trade, could be identified as category VI.

Table 1. Application of categories in marine protected areas (from IUCN Dudley, 2008)

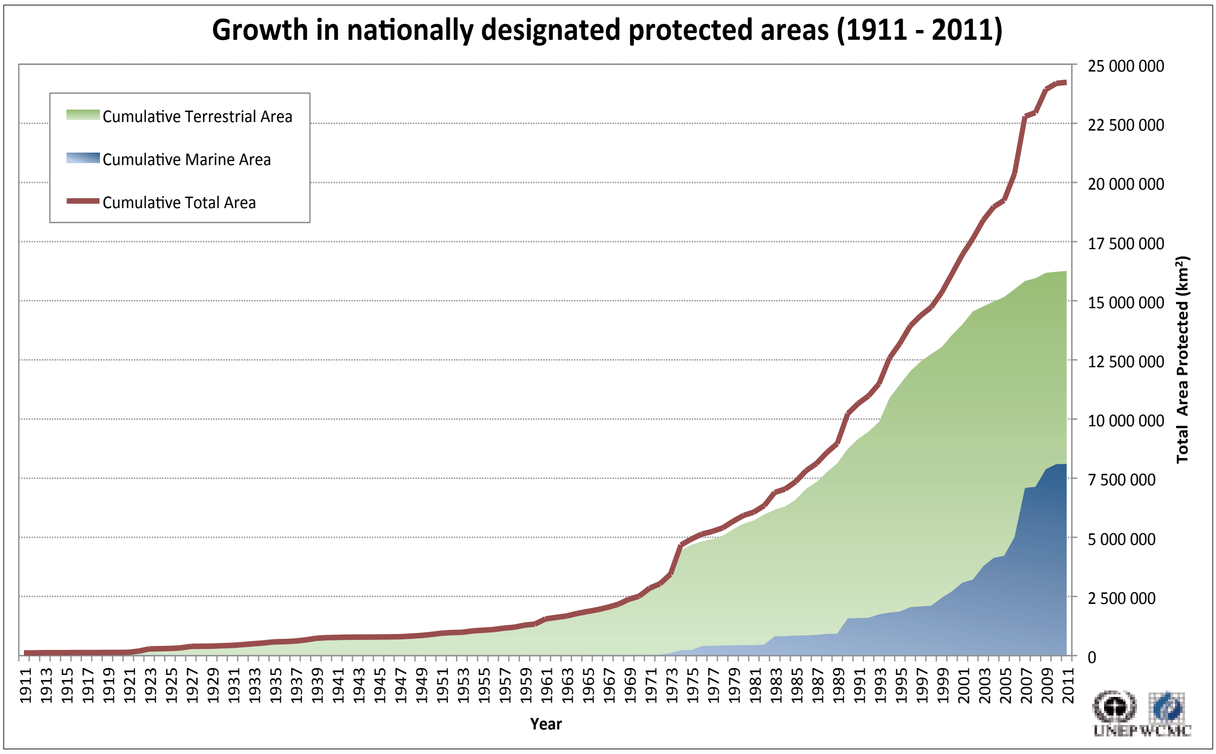

Figure 1. Growth in nationally designated protected areas (1911-2011). Graph excludes 43,674 protected areas with unknown year of establishment. Source: IUCN and UNEP-WCMC (2012) The World Database on Protected Areas (WDPA): February 2012. Cambridge, UK: UNEP-WCMC. http://www.bipindicators.net/pacoverage

A.2 European and regional initiatives

Within Europe a large number of different types of spatial marine management units have been defined (see Appendix II A1). Some of these are recognised internationally and some are country-specific e.g. a Marine Conservation Zone (MCZ) is new type of reserve introduced under the UK Marine Act. The establishment of European MPA networks should contribute to and take account of States' obligations under international Conventions and Directives, including EC Directives, measures taken under the Berne, Bonn and Ramsar Conventions, the Convention on Biological Diversity, Regional Seas Conventions, the Trilateral Wadden sea Co-operation and the commitments made, *inter alia*, at the World Summit on Sustainable Development and the North Sea Conferences.

EU Directives

Natura 2000 is an EU initiative which supports practical implementation of the Habitats Directive[2] and the Birds Directive[3], both of which include legally binding marine components. The Birds Directive requires the establishment of Special Protection Areas (SPAs) for birds, whilst the Habitats Directive requires Special Areas of Conservation (SACs) to be designated for particular species and habitats, which are listed respectively in Annexes I and II of the Habitats Directive. Sites designated under the Habitats Directive, are built in three stages: 1) National Lists of Sites of Community Importance (SCIs) are produced based on ecological criteria; 2) approval by the European Commission of the definitive lists of Sites of Community Importance for each biogeographical region; 3) Designation, at na-

2 Directive 92/43/EEGC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora, *PB L* 206, 22 July 1992 http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm.
3 Directive 79/409/EEG of 2 April 1979 on the Conservation of Wild Birds, *PB L* 103, 25 April 1979 http://eur-lex.europa.eu/LexUriServ/site/nl/consleg/1979/L/01979L0409-20070101-nl.pdf.

tional level, of Special Areas of Conservation, including the approval of the conservation measures required to support them (e.g. management plans). Marine SACs are in many aspects synonymous with the traditional concept of MPAs. However, only a small fraction of the listed species and habitats are marine. Compared with 230 terrestrial habitats, only 9 marine habitats are included in the EU Habitats Directive. Moreover, these conform only to very general categories and include no open-water habitats. In this respect, there are many gaps concerning marine species. For example, many deep sea habitats are not specifically listed and are not being considered for 'priority natural habitat' qualification. Deep-sea ecosystems which are integrated in the Natura 2000 framework, such as seamounts and hydrothermal vents, are included on a voluntary basis. The latest report lists 2,341 marine Natura sites covering an area of 217,464 km^2 (Natura 2000 Newsletter, no. 32, July 2012 http://ec.europa.eu/environment/nature/info/pubs/natura2000nl_en.htm). Many of these, however, are small and in coastal or inland waters. The Emerald network[4] extends the Natura 2000 network to some non-EU countries.

Although implementation of the Natura 2000 network is mandatory for all Member States there are issues about limiting some human activities such as fishing and shipping. The conservation of marine fisheries resources belongs exclusively to the competence of the EU, within the framework of the Common Fisheries Policy (CFP)[5]. Environmental issues however, are shared between the EU and the Member States[6]. Thus it is not clear to what extent the Member States have legal authority to take measures for the restriction of fishing activities within the framework of marine nature conservation, and whether such measures can be taken through the CFP. Four possible options exist: 1. fisheries can only be restricted by the EU within the framework of the CFP; 2. fisheries can also be restricted by Member States within the framework of the CFP; 3. restrictions to fisheries as a tool for MPA protection is seen as a nature conservation measure and is taken by the individual Member State; 4. nature conservation measures are taken by the EU. The final decision of the appropriate legal basis will eventually have to be taken by the European Court of Justice. However, the European Court of Justice has not yet had cause to make clear what should be the appropriate legal basis for measures restricting the activities of fishing vessels for the purposes of nature conservation (Owen, 2004a and b), although for individual MPAs (such as Bratten, Sweden – see box on page 15) a way forward has been found.

The **Water Framework Directive (WFD, 2006/60/EC)**[7] and the **Marine Strategy Framework Directive (MSFD, 2008/56/EC)**[8] both call for integrated ecosystem management and set targets of good ecological or environmental status. The WFD covers lakes, rivers, transitional and coastal waters, while the MSFD for all marine territorial waters (including coastal). The step from WFD to MSFD implies a better incorporation of an Ecosystem Approach to Management, as it requires elevating consideration from the structural community level to a functional ecosystem assessment (Van Hoey *et al.*, 2010). The MSFD has added a new impetus within the EU since it will establish a framework within which Member States will take measures to maintain or achieve 'good environmental status' (GES) in the marine environment by 2020. These measures must address spatial protection in order to contribute to coherent and representative networks of MPAs that adequately cover the diversity of the constituent ecosystems.

The challenge of establishing networks of MPAs and thereby protecting biodiversity and ecosystem function is recognised as an essential step by all the EU marine and maritime policies. The implementation of the Natura 2000 Network is at the core of the entire process. Within the framework of the CFP however, it can be argued that the aim of a 'sustainable' use (conservation and management of fishery resources) is primarily aimed at continuity of the fishing activity rather than solely environmental concerns. It is clear that a 'sustainable use' can only be achieved when pressure reduction plays a key role in the management of MPAs and marine areas in general. These conflicts can only be resolved via the use of ecosystem-based marine spatial management, which should become the essential approach for the integrated management of the sea (Katsanevakis *et al.*, 2011).

Regional Initiatives

The European Regional Seas Conventions, together with related Agreements, have promoted the designation of MPAs in marine areas under their respective jurisdictions as follows:

HELCOM[9]. In the Baltic, appropriate Natura 2000 sites are to be designated as Baltic Sea Protected Areas (BSPAs) and new BSPAs are to be designated by individual member states. A BSPA should give particular

4 http://www.coe.int/t/dg4/cultureheritage/nature/econetworks/default_en.asp
5 Article 3(1)(d) and article 4(2)(d) of the Treaty on the Functioning of the European Union (TFEU).
6 Article 4(2)(e) of the TFEU.

7 Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy
8 Marine Strategy Framework Directive (MSFD), Directive 2008/56/EC, of 17 June, *OJ L 164/19.*
9 http://www.helcom.fi/

Bratten and CFP

Bratten is a large offshore area in the Swedish Exclusive Economic Zone of Skagerrak which was recently added to the Natura 2000 and OSPAR MPA networks. Bratten characteristics are unique to Sweden, with different canyons cutting through the landscape including reefs (Natura 2000 habitat 1170) which are home to many unusual and threatened species (according to the Swedish red list, based on the IUCN criteria). The reefs include several unusual species of horn corals (of which some are threatened) eight species of sea pens and the Gorgons head basket star (*Gorgonocephalus caputmedusae*).

The main “threats” to the biological values of the area are identified as trawling and angling. Shrimp trawlers, mainly from Denmark and Sweden, operate in the eastern part of the area. Other commercial species of importance in the area are plaice, saithe, cod, nephrops, haddock and anglerfish. Commercial landings comprise a diverse range of species and can include deep living and threatened species. The area is also of importance for recreational fishing.

The management plan for Bratten falls within the Interreg Project “Hav möter Land” (Sea meets Land). Since the area was proposed by the Swedish Government to be included in the Natura 2000 network, permits are needed for all new activities that can damage the Natura 2000 habitats and species according to the Natura 2000 legislation in the Swedish Environmental Code. A management plan for the area is not yet established. However, during 2012 the process began and biological and social values of the area and threats to these values were identified by the Bratten area theme group, consisting of members from both national and regional authorities and scientists, representing Sweden, Norway and Denmark. Discussions followed with Greenpeace and the Swedish Minister of Environment, who want the fisheries in the Natura 2000 sites to be regulated by individual permissions. Neither the theme group for Bratten, nor the Danish government agree, preferring instead to use the CFP. At a meeting between the theme group and fishermen and their organizations from the three countries, the fishermen were informed about the values of the area and they, in turn, informed the theme group about fisheries. There were also discussions about how extensive the threats from the fisheries are and how they can be reduced. A similar meeting was subsequently held with the Swedish Angling Association.

Recent work on the management plan has included meetings in December 2012 with a representative group of fishermen and the Swedish Angling Association to discuss how the regulations should be designed, and a stakeholder workshop to present and discuss the proposed regulations as well as other parts of the Management plan. Following a further period of consideration, the management plan will be established and the proposed fishery regulations will be handed over to the Swedish Agency for Marine and Water Management (SwAM) for EU negotiations.

protection to conserve biological and genetic diversity and should protect ecological processes and ensure ecological function (HELCOM Recommendation 15/5 on BSPAs). To date, 159 BSPAs have been designated covering 42,823 km^2 and representing 10.3% of the marine area (HELCOM, 2010a). Analysis of network coherence in the Baltic was the subject of the EU-funded BALANCE project (2002-2005)[10]. Subsequently, despite encouraging developments, it has been concluded that full management plans are not in place and the MPAs established to date have been judged to not yet form a coherent or comprehensive network (HELCOM 2010b). This judgement took into account adequacy in terms of size, 21 indicator species and 7 biotype indicators, selected essential habitats, and the environmental quality of the network in relation to three key anthropogenic pressure criteria. An evaluation was also made of representativity, replication and connectivity.

10 http://balance1.uni-muenster.de/

OSPAR[11]. In the North East Atlantic, the OSPAR Commission is committed to establish a network of MPAs as part of its programmes and measures (OSPAR, 2003a). OSPAR maintains an annual status report of MPAs which have been established in waters belonging to their Contracting Parties (including appropriate Natura 2000 sites) and in Areas Beyond National Jurisdiction (ABNJ) included in the ‘OSPAR maritime area’. The interim 2012 report (OSPAR, 2012) lists 283 sites, including 276 MPAs situated within the national waters of Contracting Parties and seven MPAs in ABNJ. Collectively, these sites cover 654,898 km^2 or 4.83 % of the ‘OSPAR maritime area’ in the North-East Atlantic. This percentage, however, masks wide variability with 16% of coastal waters being designated as MPAs and 0.89% of offshore territorial waters. The distribution of MPAs across the five OSPAR Regions is also imbal-

11 http://www.ospar.org/content/content.asp?menu=00120000000011_000000_000000

anced. The Greater North Sea, the Wider Atlantic and the Celtic Seas are the best represented OSPAR Regions, with 9.44%, 7.56%, and 4.97% coverage respectively, while coverage of the Arctic Waters is at 1.47%, and the Bay of Biscay and Iberian Coast have less than 1% protected by OSPAR MPAs. Final figures for 2012 are expected to confirm that MPA coverage exceeded 5% of the OSPAR Maritime Area by the end of 2012 (pers. comm. OSPAR Secretariat; Based on Draft 2012 Status Report of the OSPAR Network of MPAs, to be published in June 2013).

The 6 MPAs in ABNJ were established by OSPAR at its Ministerial Meeting in 2010 (Bergen, Norway). They cover a total area of 287,065km^2 protecting a series of seamounts and sections of the Mid-Atlantic Ridge and hosting a range of vulnerable deep-sea habitats and species. Four of the MPAs were established in collaboration with Portugal. A seventh 'pelagic' High Seas MPA, Charlie-Gibbs North (178,094 km^2), was designated in 2012 in waters superjacent to an Icelandic submission to the Commission on the Limits of the Continental Shelf. Because of the constraints of the Law of the Sea Convention, major challenges can occur when MPAs are defined in areas that span the boundary from national jurisdiction to areas beyond national jurisdiction (Ribeiro, 2010). In these cases the approval of a man-

Case study 1: High Seas, designing MPAs beyond national jurisdiction

Background

OSPAR has taken on the responsibility to define MPAs in Areas Beyond National Jurisdiction in the North East Atlantic. From a legal point of view the 'Areas Beyond National Jurisdiction' include the 'high seas' and the 'Area'. According to the Law of the Sea Convention (LOSC), of 1982, the 'high seas' only includes the water column superjacent to the seabed beyond 200 nautical miles, if the coastal State declared an exclusive economic zone with this extension, and the living resources of the seabed beyond the limits of the (juridical) continental shelf. Actually, with regard to the seabed beneath the high seas, a distinction must be made between the 'Area' and the 'continental shelf'. The 'Area' only embraces the mineral resources found in the seabed and subsoil beyond national jurisdiction. The 'continental shelf' embraces the mineral and other non-living resources of the seabed and subsoil, as well as the living organisms belonging to sedentary species, under national jurisdiction. This distinction is of great relevance, namely in the situations where a coastal State has submitted a process to the Commission on the Limits of the Continental Shelf in order to establish the outer limits of its continental shelf. Cases may occur where an ecosystem includes features and organisms belonging to the outer ('extended') continental shelf (under coastal State jurisdiction) plus features and organisms belonging to the high seas (beyond coastal State jurisdiction).

MPAs in the Wider Atlantic

The legal divisions of the ocean are largely based on the situation that prevailed in 1982. Nevertheless, from an ecological point of view, the legal statute of the ocean may not be coherent. As an example, in the case of seamounts located in the outer ('extended') continental shelf, commitments must be concluded between the coastal State and regional organizations in order to protect the whole ecosystem. OSPAR gives good examples of this strategy. At its meeting in September 2010 (Bergen), OSPAR established six marine protected areas (Figure 2) covering a total area of 287,065 km^2 protecting a series of seamounts and sections of the Mid-Atlantic Ridge and hosting a range of vulnerable deep-sea habitats and species.

Figure 2. Map of the OSPAR Network of Marine Protected Areas (as of end of June 2012) prepared for OSPAR by Mirko Hauswirth, German Federal Agency for Nature Conservation (BfN).

Four of the MPAs (Altair, Antialtair and the Josephine Seamounts High Seas MPAs, as well as the Mid-Atlantic Ridge North of the Azores High Seas MPA) were established in collaboration with Portugal.

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Effectively, the four MPAs are complementary to another four MPAs embracing the (outer 'extended') continental shelf (seabed and subsoil) nominated by Portugal. With this solution Portugal and OSPAR overcame the difficulty to protect the whole seamount ecosystems; the protection and management of the seabed and subsoil is under Portuguese responsibility and the protection and management of the water column is under OSPAR responsibility. This approach obviously requires an effective collaboration between the two parties.

Issues

Due to the legal divisions of the ocean (Figure 3) and the inherent distribution of jurisdiction and competences, the protection and management of the water column related to the four OSPAR high seas MPAs faces other complicated factors. Namely, OSPAR does not have competent authority for controlling fishing activities, which is covered by the North East Atlantic Fisheries Commission (NEAFC), eventually combined with the European Union fisheries policy (as regards its Member States), or international shipping which is covered by the International Maritime Organization (IMO). With regard to the other two MPAs established by OSPAR in the Bergen meeting – the Milne Seamount Complex MPA and the Charlie-Gibbs South MPA – another complicating factor must be added. These MPAs embrace the seabed and the superjacent water column, being both beyond national jurisdiction. This means that, according to LOSC, the seabed is qualified as 'Area' and the water column as 'high seas'. Therefore, mining is covered by the International Seabed Authority (ISA) competence. Hence OSPAR now needs to reach further agreements with the mentioned bodies before full protection can be given to the six new sites. The North-East Atlantic Fisheries Commission has already imposed closures for bottom fisheries in four of the new MPA locations though Milne Seamount and Josephine Seamount do not have any current protection.

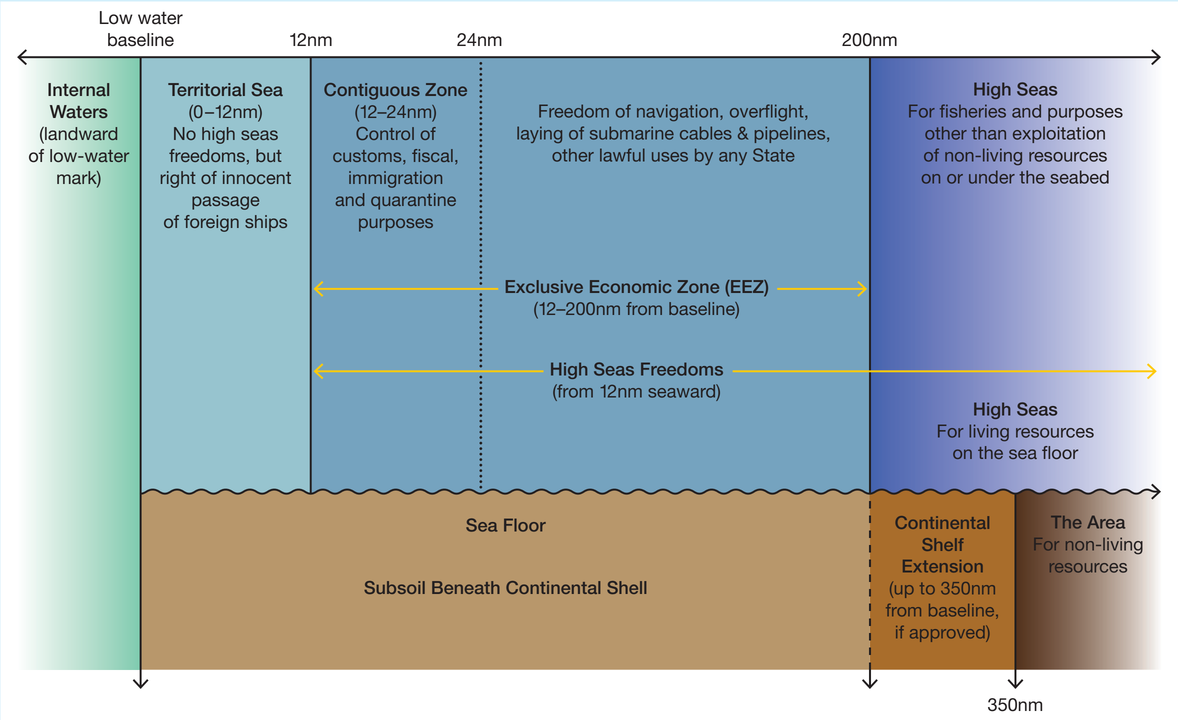

Figure 3. Maritime Zones under United Nations Convention on the Law of the Sea (UNCLOS) of 1982 (redrawn from original figure provided by Montserrat Gorina-Ysern, PhD, Independent LOS Consultant, USA). nm = nautical mile

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Lessons learnt	Research priorities and needs
Seabed and subsoil that are part of the outer ('extended') continental shelf are under jurisdiction of the relevant coastal state. Hence the water column and seabed may be subject to different jurisdiction	1) Seamounts: A) direct study and comprehensive understanding of seamount ecosystems; B) specifically research on the interaction between features and living organisms related to the seabed and the ones related to the water column (e.g. complementarity; high, medium or low dependency etc.) 2) Hydrothermal vent fields: improve knowledge about the interaction with the water column of the living communities, in order to find out if an MPA may be effective with the sole protection of the seabed 3) Codes of conduct and guidelines
Synergistic management efforts are essential 1) between Member States and OSPAR, 2) between OSPAR and other competent authorities (RFMO; EU; IMO; ISA)	1) Research on the damaging effects of fisheries and other human activities related to deep-sea ecosystems (e.g. seamounts, hydrothermal vent fields, cold coral reefs etc.) 2) Develop science-based autonomous management measures concerning the seabed and the water column that, as a whole, assure the protection of the whole ecosystem 3) Support development of a supra-national approach to deep-sea ecosystems management (for the ones located in areas beyond national jurisdiction)

agement plan or individual conservation measures may need to respect both national requirements and those of international bodies.

Barcelona Convention: Most countries bordering the Mediterranean only recognize their offshore territory to 12 nautical miles, with the area beyond being defined as 'Area' and high seas. The designation of MPAs within territorial waters is very uneven across the Mediterranean with, for example, 26 listed in the MPA GLOBAL database (http://mpaglobal.org/) for France, 19 for Greece, 85 for Italy and 36 for Spain, whilst many other countries have very few. Many of the MPAs declared in the Mediterranean are very small. For example, of the 26 MPAs listed in French territory 14 are less than 5 km^2 in area. In contrast, the Columbretes Islands MPA at the edge of the Spanish Mediterranean continental shelf offers full protection from fishing to 55 km^2 of rocky and coralligenous habitats (see case study 6). The largest by far is the Pelagos sanctuary for marine mammals (qualified as a Specially Protected Area of Mediterranean Importance – SPAMI) which extends for 87,492 km^2 including an area beyond national jurisdiction. Within the Mediterranean there are numerous MPA network initiatives to encourage more MPA designations. The Barcelona Convention embraces both MPAs established in maritime areas belonging to their Contracting Parties[12] and in areas beyond national jurisdiction (e.g. the SPAMI) and the most recent Mediterranean-wide evaluation of designation progress in the biodiversity 'hotspot' can be found in the 2012 status report (Gabrie *et al.*, 2012).

The Regional Activity Centre for Specially Protected Areas (RAC/SPA) was established in 1985 by a decision of the Contracting Parties to the Barcelona Convention with the aim of assisting Mediterranean countries in the conservation of habitats, ecosystems, sites and species in the Mediterranean[13]. MedPan (http://www.medpan.org/) is a network of MPA managers, with 63 members and partners from 17 countries around the Mediterranean. The objective of the network is to improve the effectiveness of MPA management in the Mediterranean. The IUCN's Centre for Mediterranean Cooperation is actively promoting MPA designation in the region. Nevertheless, the IUCN/WWF/MedPan report (Abdulla *et al.*, 2008) predicted that despite the large number of existing protected sites, "the present system of Mediterranean marine protected areas is not representative and the objectives set by the Biodiversity Convention for 2012 will most likely not be attained. The management effectiveness of Mediterranean marine protected areas must be improved. Furthermore, marine protected areas are threatened by substantial external pressures at local, regional and global levels." This has prompted an initiative to identify large scale ecological units, based on

12 http://www.unep.ch/regionalseas/regions/med/t_barcel.htm

13 http://ec.europa.eu/world/agreements/prepareCreateTreatiesWorkspace/treatiesGeneralData.do?step=0&redirect=true&treatyId=598

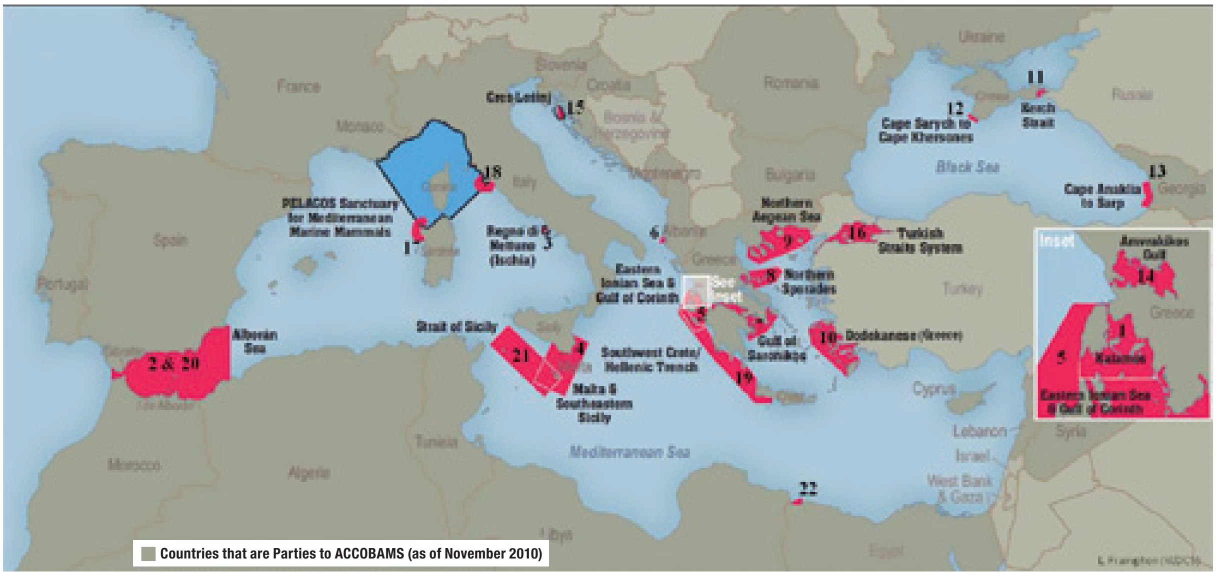


Figure 4. Recommendation for 22 MPAs in the Mediterranean and Black Sea to protect cetaceans as defined by ACCOBAMS (source ACCOBAMS-MOP4/2010/Res 4.15). Disclaimer: *The designations employed and the presentation of the information on this figure do not imply the expression of any opinion whatsoever on the part of ACCOBAMS concerning the legal status of any country, territory, city or area of its authorities, or concerning the delimitation of its frontiers or boundaries.*

biogeographic eco-regions and associated sub-regions, assessment of critical habitats (Hoyt and Notarbartolo di Sciara, 2008), and acknowledgement of knowledge gaps (e.g. ecology and biomass of key species such as northern krill in the Ligurian-Corsican area) reflecting a geographical and seasonal imbalance of data availability. A proposal was put forward by Oceana (2011) for a network of Mediterranean MPAs that would cover a wide variety of habitats and, when combined with existing MPAs, would reach a total of 12% of the surface of the Mediterranean (see http://oceana.org/en/eu/our-work/habitats-protection/mediterranean/mednet/overview).

ACCOBAMS: ACCOBAMS (http://www.accobams.org/) is a cooperative tool for the conservation of marine biodiversity in the Mediterranean and Black Seas. It has recommended the establishment of 22 MPAs in the Mediterranean and Black Sea to protect cetaceans (ACCOBAMS Resolution 4.15; see Figure 4).

CoCoNet: CoCoNet (http://www.coconet-fp7.eu/) is a European project tackling the need for interconnected MPAs in the Mediterranean and the Black Sea regions. Involving 22 countries from three continents (Africa, Asia, Europe), the project has created a network of scientific excellence for issuing guidelines for effective transnational environmental management, encompassing local (single MPA) to regional (networks of MPAs) from the shore to the high and deep sea, coupled with sea-based wind energy potential.

A.3 Towards ecosystem-based marine spatial management

Individual MPAs often end up being rather small in size owing to numerous competing demands for use of the marine space. In contrast, the range of many mobile species can be large. Migratory mammals, birds and fish can travel hundreds or even thousands of kilometres to breed or to feed. Adequate protection for these organisms can be provided by defining a coherent series of MPAs that are designed to address the vast home ranges of some species, whilst leaving areas in between open to commercial activity. Such networks have been defined by the WCPA/IUCN as *"A collection of individual MPAs operating cooperatively and synergistically, at various spatial scales, and with a range of protection levels, in order to fulfil ecological aims more effectively and comprehensively than individual sites could alone." (WCPA/IUCN 2007, p.3).* These networks of MPAs can also be designed to include representative examples of all the different ecosystems, habitats and communities over a wide area, providing stepping-stones of genetic, demographic and ecological connectivity. MPA networks are equivalent to creating vegetation corridors on land. The concept of the MPA network also opens up the possibility to design from the outset the possibility to manage species and ecosystems under a changing climate regime.

MPAs within the context of ecosystem-based marine spatial management

Ecosystem-based marine spatial management (EB-MSM) is an emerging paradigm of ocean management, which is being promoted by institutions worldwide as the best way to deal with conflicts among various users of the seas and to ensure the sustainability of marine ecosystems and their services to humans (Katsanevakis *et al.*, 2011). EB-MSM recognizes the full array of interactions among ecosystem components and human users, rather than considering in isolation single sectors, species, or ecosystem services. Its goal is to maintain marine ecosystems in a healthy, productive and resilient condition by balancing the increasing diversity and intensity of human activities with the ocean's ability to provide ecosystem services. Although there are ecosystem approaches to marine management that are not necessarily place-based, in most cases marine ecosystems are fixed in space. Hence, the spatial component is inherently critical in the concept of ecosystem-based management (Katsanevakis *et al.*, 2011).

Marine Spatial Planning (MSP) is a crucial tool for EB-MSM that has emerged as a means of resolving inter-sectoral and cross-border conflicts over maritime space (Ehler, 2008; Halpern *et al.*, 2008; Douvere, 2010). MSP is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that have usually been specified through a political process (Ehler and Douvere, 2007). MSP sits within the field of environmental planning taking an integrated approach towards the stewardship of natural systems and adopting a long-term approach. The emphasis is on a nested or hierarchical approach with overarching policy frameworks, national plans and local actions.

MPAs and EB-MSM or MSP are not interchangeable concepts. EB-MSM has a broader remit and provides an overall spatial framework for managing maritime activities. Both MPA networks and MSP are recognised as practical tools for implementing the EB-MSM approach, and both represent area-based tools that are recognised as being insufficient in achieving the all-encompassing EB-MSM goals if applied on their own (Douvere, 2008; Halpern *et al.*, 2010; Katsanevakis *et al.*, 2011). A key difference between MPA networks and MSP is that the former places emphasis on the protection of ecological features and processes that merit site-specific management measures by controlling pressures due to human uses, while the latter also (sometimes primarily) addresses inter-sectoral conflicts that might not be related to conservation. In comparison to MSP, there are fewer economic sectors involved in MPAs in general, and MPA zoning restrictions mainly target various forms of fishing, shipping, and recreational use. Nevertheless, as more and more multiple-use MPAs are being designated, MPA networks also serve multiple ecological, socio-economic, and cultural purposes (Jones 2001; Halpern *et al.*, 2010).

Some countries have begun to plan networks of MPAs as part of larger frameworks of ecosystem-based management, integrated ocean governance and integrated coastal management. This concept, known as Ecosystem-Based Marine Spatial Management (EB-MSM), is gaining momentum as a planning tool to make informed and coordinated decisions about how to use marine resources in a sustainable manner (see box above). EB-MSM is being promoted by several European countries and by OSPAR and HELCOM and is being informed by current research (e.g. MESMA[14]). By using this approach a variety of management plans can be devised ranging from areas with full protection – that is, areas where no extractive activities such as fishing or the removal of resources are permitted, to areas with controlled use.

14 www.mesma.org

B. Design of MPAs

Aerial photo of Columbretes Islands Marine Reserve (courtesy, Columbretes Islands Marine Reserve, Spain)

B.1 Design criteria from binding agendas and legal texts

Design issues have long been addressed by MPA practitioners and many organizations are dedicated to the creation of protected areas for both conservation of biodiversity and sustainable use of resources, e.g. the IUCN, the Nature Conservancy, or the UNEP-MAP Regional Activity Centre for Specially Protected Areas (RAC-SPA), and those agencies in charge of designating marine reserves or protected areas at the national level.

Guidelines for the identification and selection of MPAs established by OSPAR provide a useful template, combining ecological criteria/considerations (subject to prioritisation) with practical criteria/considerations (e.g. comparatively higher stakeholder support and political acceptability). Table 2 (From OSPAR 2003b, Appendix 3) correlates the two sets of OSPAR criteria in the context of the aims of the OSPAR MPA network.

Similar guidelines have been adopted by the Department of Fisheries and Oceans of Canada (DFO, 2004) based on Uniqueness, Aggregation[15], and Fitness Consequences, while accounting for Resilience and Naturalness of the area; by other Regional Conventions (e.g. HELCOM 2010b); and by a number of groups who are actively defining MPAs, such as Natural England and the JNCC in the UK (Ashworth *et al.*, 2010). All of the above general selection criteria pertain to the objectives of conservation of biodiversity and associated resources, a major and common goal of most MPAs.

With respect to networks, IUCN has promoted five general criteria to define a MPA network (IUCN-WCPA, 2008): i) include the full range of biodiversity present in the biogeographic region; ii) ensure ecologically significant areas are incorporated; iii) maintain long-term

15 Aggregation refers to the existence of species aggregations or to the occurrence of critical ecological process within the area, even temporarily

Aims of the OSPAR Network	Protect, conserve and restore species, habitats and ecological processes which are adversely affected as a result of human activities	Prevent degradation of and damage to species, habitats and ecological processes following the precautionary principle	Protect and conserve areas which best represent the range of species, habitats and ecological processes in the maritime area
Ecological considerations	(1.1) High priority habitats & species which meet the Texel-Faial criteria of 'Decline'	(1.1) High priority habitats & species which meet the Texel-Faial criteria of 'high probability of a significant decline' (1.2) Important habitats & species which meet the other Faial criteria (global importance, local (species)/regional (habitats) importance, rarity, sensitivity, keystone species, ecological significance) (1.6) Sensitivity	(1.3) Ecological significance (1.4) High natural biological diversity (of species within a habitat and of habitats in an area) (1.5) Representativity, including the biogeographic regions (1.7) Naturalness
Practical considerations	(2.1) Size (2.2) Potential for restoration (2.3) Degree of acceptance (2.4) Potential for success of management measures (2.6) Scientific value	(2.1) Size (2.3) Degree of acceptance (2.4) Potential for success of management measures (2.6) Scientific value (2.5) Potential damage to the area by human activities	(2.1) Size (2.3) Degree of acceptance (2.4) Potential for success of management measures (2.6) Scientific value

Table 2: OSPAR Commission criteria for MPA selection
Note: Numbers in brackets refer to the specific criteria in the Guidelines for the Identification and Selection of MPAs in the OSPAR maritime area.

protection; iv) ensure ecological linkages; and v) ensure maximum contribution of individual MPAs to the network (Appendix I, B1). Practical guidance for planners and managers were produced quite early by IUCN, particularly for tropical MPAs (Salm *et al.*, 2000)
At the CBD COP9 in 2008, scientific guidance for selection of representative MPA networks was adopted (see Table 3).

Criteria	**Definition**	**Applicable site specific considerations (*inter alia*)**
Ecologically and Biologically Significant Areas (EBSA)	Ecologically and biologically significant areas are 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 criteria as identified in annex I to decision IX/20.	1. RARE: Uniqueness or rarity 2. LIFE HISTORY: Special importance for life history stages of species 3. ENDANGERED: Importance for threatened, endangered or declining species and/or habitats 4. FRAGILE: Vulnerability, fragility, sensitivity or slow recovery 5. PRODUCTIVE: Biological productivity 6. DIVERSE: Biological diversity 7. NATURALNESS: Naturalness
Representativity	Representativity is captured in a network when it consists of areas representing the different biogeographical subdivisions of the global oceans and regional seas that reasonably reflect the full range of ecosystems, including the biotic and habitat diversity of those ecosystems.	A full range of examples across a biogeographic habitat, or community classification; relative health of species and communities; relative intactness of habitat(s); naturalness.
Connectivity	Connectivity in the design of a network allows for linkages whereby protected sites benefit from larval and/or species exchanges, and functional linkages from other network sites. In a connected network individual sites benefit one another.	Currents; gyres; physical bottlenecks; migration routes; species dispersal; detritus; functional linkages. Isolated sites, such as isolated seamount communities, may also be included.
Replicated ecological features	Replication of ecological features means that more than one site shall contain examples of a given feature in the given biogeographic area. The term "features" means "species, habitats and ecological processes" that naturally occur in the given biogeographic area.	Accounting for uncertainty, natural variation and the possibility of catastrophic events. Features that exhibit less natural variation or are precisely defined may require less replication than features that are inherently highly variable or are only very generally defined.
Adequate and viable sites	Adequate and viable sites indicate that all sites within a network should have size and protection sufficient to ensure the ecological viability and integrity of the feature(s) for which they were selected.	Adequacy and viability will depend on size; shape; buffers; persistence of features; threats; surrounding environment (context); physical constraints; scale of features/processes; spillover/compactness.

Table 3. Scientific Guidance for selecting areas to establish a representative network of MPAs, including in open ocean waters and deep-sea habitats* (COP9/20 Annex 2).
* Referred to in paragraph 3 of annex II of decision VIII/24

At the European level, the CDB strategy is implemented through the Natura 2000 network of terrestrial and marine protected areas. The Birds Directive (EC, 2009a) and the Habitats Directive (EC, 1992) are legally binding for the establishment of the Natura 2000 network. Natura 2000 is thus a major driver for the establishment of protected areas in the waters of EU Member States.

With regard to the Habitats Directive, this network aims at protecting sites that are important for conserving (i) the natural habitat types listed in Annex I of the Directive, and (ii) the habitats for the species listed in Annex II of the Directive, in order to ensure that these features can be maintained or, where appropriate, restored at a favourable conservation status in their natural range (see more details in Section A and C). Member States are obliged to ensure that the site designation process is exclusively based on scientific criteria.

The first step consists in elaborating a list of Sites of Community Importance (SCI). The criteria prescribed for selecting eligible sites are in accordance with Annex III of the Habitats Directive and relevant scientific information (Annex I, B2). Member States will identify and carry out an assessment at national level of the relative importance of sites for each natural habitat type in Annex I and each species contained in Annex II (including priority natural habitat types and priority species). On that basis, each Member State proposes a list of SCIs. The list, including appropriate information for each site, is transmitted to the European Commission.

In a second step, the list of proposed SCI is to be adopted by the Commission in accordance with a procedure laid down in Article 21 of the Habitats Directive. This step gives formal legal effect to the protective safeguards defined in Article 6 (2) (3) and (4) of the Habitats Directive.

The third step corresponds to the designation of Special Areas of Conservation (SAC). Once a SCI has been selected, the concerned Member State shall designate that site as a SAC as soon as possible and within six years at most. In designating the SAC the Member State must establish priorities according to the importance of the sites for the maintenance or restoration to a favourable conservation status of a natural habitat type in Annex I or a species in Annex II, and in the light of the threats of degradation or destruction to which those sites are exposed.

Article 3.1 of the Habitats Directive states that a coherent European ecological network of sites shall be set up, hosting the habitats of species listed in Annex II. However, Article 4.1 of the Habitats Directive also states that for aquatic species which range over wide areas, SACs will be proposed only where there is a "clearly identifiable area representing the physical and biological factors essential to their life and reproduction". The areas of ecological connectivity are also poorly safeguarded under the Habitats Directive (Article 3.3).

Special Protection Areas (SPA) are identified and designated in accordance with the provisions of the Birds Directive. In Article 4 of this Directive, it is established that Member States shall classify in particular the most suitable territories in number and size as SPAs for the conservation of these species, taking into account their protection requirements in the geographical sea and land area where this Directive applies. The European Court of Justice has emphasized that the selection of sites and the delimitation of boundaries should be carried out on the basis of exclusively ornithological criteria.

B.2 The role of science in designing MPAs

In general, setting conservation objectives (for examples see Day *et al.*, 2012, Annex 2) and evaluating candidate areas with respect to ecological criteria requires a sound scientific understanding of marine species, ecosystems, habitats and their susceptibility to environmental change and human impact. Most of the strategies and approaches described above are explicit that MPA design must be science-based.

The first step is to obtain a comprehensive overall description of an ecosystem, its marine biodiversity and functional roles either at species, genus and/or habitat levels (Heip and McDonough, 2012; Fraschetti, 2008). An assessment of the anthropogenic pressures and socio-economic stakes together with considerations of territories and regulations already in place are also crucial. In addition, the design and management of MPA networks, under a general scheme of ecosystem-based marine spatial management, should recognize the full array of interactions across ecosystem components and between ecosystems, human uses and other anthropogenic pressures, while accounting for environmental stressors and drivers (e.g. climate change). Integrating stakeholders early in the designation process to achieve buy-in is also perceived as good practice, with some approaches (e.g. UK Marine Conservation Zones, see www.findingsanctuary.org) favouring a facilitated stakeholder-led process from the outset using tools such as interactive web GIS (www.mczmapping.org) (JNCC, 2011).

An important part of the scoping process is the definition and mapping of ecosystem components, especially those that corresponds to a defined set of operational objectives. Such ecosystem components include both natural components, such as habitats, species, or pro-

Climate change

Global climate change is underway and this change is having, and will have, progressively more influence on the structure and functioning of marine ecosystems, human activities and public health, with important repercussions also for the social structure of human populations and for the economy (IPCC, 2007; Rosenzweig *et al.*, 2008; EEA, 2010). It has been stated that dynamics caused by climate change, such as rapid species migrations, will possibly pose problems to reach obligations put forward in 'static' nature conservation legislation (Cliquet *et al.*, 2009). Therefore, adaptation to climate change requires a more flexible approach (Verschuuren, 2007; Woldendorp, 2009), especially in highly dynamic environments such as marine environments.

Conservation of biodiversity and maintenance of ecosystem structure and functioning are important climate change adaptation strategies because genetically diverse populations and species-rich ecosystems have a greater potential to adapt to climate change (SCBD, 2003). Networks of MPAs within a broader ecosystem-based marine spatial management context are much more resilient to the threats of climate change than single MPAs, as they address uncertainty by spatially spreading potential risks, building redundancies (especially among key species, groups, and drivers of ecosystem structure) and buffer areas, and allowing species to shift their distribution among reserves in response to large scale changes (Katsanevakis *et al.*, 2011). The increase of reserve connectivity is the most urgent recommendation for climate change adaptation strategies for biodiversity management, according to the review by Heller and Zavaleta (2009).

cesses describing the ecosystem, and socio-economic components, i.e. different human uses and sectors. Incorporating ecological functioning requires a multivariate, multifunctional approach (Frid *et al.*, 2008). Ecological mapping is viewed as the creation of appropriate geographical information systems that allow the collation, visualization, and analysis of spatial information for all relevant ecosystem components.

The use of single habitat structuring species key to critical habitats, including forage species eaten by a wide variety of animals, or species that impose top-down controls on an ecosystem, has been proposed by labelling them as 'surrogate species'; that is, umbrella species whose health and abundance affects a wide variety of other species (Lambeck, 1997). Surrogate species can be considered legitimate conservation targets on their own (Favreau *et al.*, 2006) as well as being effective in the selection of networks of areas for conservation (Larsen *et al.*, 2007). However, the application has proven to be difficult, especially in the marine environment (Rees *et al.*, 2006). Moreover, umbrella species are popularly used in conservation strategies as surrogates for regional biota whose spatial distributions are poorly known. The choice of surrogates is often *ad hoc* and the assumptions underlying those choices are usually not explicit. It has been argued that the utility of umbrella and flagship species as surrogates for regional biodiversity may therefore be limited (Andelman and Fagan, 2000).

Appointing a species, or a suite of species, as an 'indicator' for the state of the ecosystem within an MPA is a common option in monitoring schemes. However, the 'indicator' label has been questioned by some who point out ambiguous selection criteria and the use of inappropriate taxa. Moreover, species at high taxonomic levels are often suggested as indicators, which can be hard to interpret, since the trophic linkages to levels lower in the system are usually varied. Therefore, if indicators are desired to monitor specific processes, lower taxonomic levels may be preferable. On the other hand, where a system is undergoing change and is highly variable, higher level indicators can be more stable, indicating general trends emerging from the environmental variability. For example, looking at seabirds can be a helpful indication of the abundance of certain guilds of prey species (e.g. Davoren and Montevecchi, 2003), or of marine pollution (Perez *et al.*, 2008). There is no single correct approach in the selection of indicators, and care must be given in choosing indicators that can reflect the desired ocean health objectives. There is a large body of published research on environmental indicators, but little effort to date to resolve the mismatches of scales and management intent (Hilty and Merenlender, 2000). For example, while some conservation efforts may focus on charismatic species, it is important not to discard the rest of biodiversity because rare and/or inconspicuous species could play a critical role as lower level "engineers" in retaining community and ecosystem integrity and function (Crain and Bertness, 2006; Boero and Bonsdorff, 2007).

Ecosystem engineers can exert a strong influence on ecosystem properties, maintaining biodiversity and ecosystem functioning (Hooper *et al.*, 2005). To understand the impact of different human activities on these habitats, and hence their use in MPA management, it is important to understand their natural dynamics and their resilience towards a changing environment. Moreover, engineers can protect numerous associated species and functions by expanding species distributional lim-

Ecological mapping

Ecological mapping is viewed as the creation of appropriate geographical information systems that allow the collation, visualization, and analysis of spatial information for all relevant ecosystem components.

Various methods have been used to map natural components. For seabed habitats mapping has been assisted by the use of single- or multi-beam echosounders, sidescan sonars, satellite imagery, airborne light detection and ranging (LiDAR), and other remote sensing techniques, combined with ground-truthing by visual observations (by SCUBA, ROVs, towed cameras, or submersibles) and sampling. The distribution of many species (marine mammals, seabirds, marine turtles, fish, and invertebrates) has been mapped using data from various fisheries or ecological surveys. For example, the international bottom-trawl surveys regularly conducted in European waters (IBTS, BITS, BTS, MEDITS) have provided valuable data for the mapping of the distribution and abundance of many demersal fish and invertebrate species.

Several initiatives and research projects promoted the mapping of natural components. The Census of Marine Life (www.coml.org) established a baseline of marine life diversity, distribution, and abundance and created the Ocean Biogeographic Information System (OBIS; www.iobis.org), the world's largest repository of marine geo-referenced data. The MESH project (www.searchmesh.net) focused on establishing standards to produce a framework for quality seabed mapping; protocols and habitat maps have been produced and made available through the project's website, which, although the project ended in 2008, is still active. EUSeaMap (http://jncc.defra.gov.uk/page-5020) – an integral part of the European Marine Observation Data Network (EMODnet) – is a broad scale modelled habitat map for over 2 million km^2 in the Celtic, North, Baltic, and western Mediterranean Seas. MAREANO (www.mareano.no) is a large continuing project aiming to map the seabed of Norwegian waters. The CHARM 3 project (http://wwz.ifremer.fr/charm) pursues a multidisciplinary ecosystem-based approach that will encompass the whole English Channel and includes ecological mapping of many ecosystem components. The necessity of ecological mapping has been stressed in the MESMA project (www.mesma.org) as an essential step to effectively implement, monitor, and evaluate spatially managed marine areas; maps of ecological components were produced within 9 case studies.

To date several habitat and species mapping efforts have been carried out by different research institutes and European countries at different spatial and temporal resolutions (e.g. www.MeshAtlantic.eu). For certain regions of the European Seas such information is available (at various degrees of detail and quality), while for other areas this is still lacking. Yet, it is impossible to establish "ecologically coherent networks of MPAs", accounting for representativeness, replication, inclusion of ecologically significant areas, and ensuring ecological linkages, without a good knowledge of the spatial distribution of all relevant ecosystem components. In order to design and manage efficient networks of MPAs in all European regions, further effort and funds should be invested to ecological mapping, especially in regions with poor data. Without such fundamental information the design and management of MPA networks will be far from optimal.

its and it has been advocated to use these organisms as conservation targets (Crain and Bertness, 2006). Epibenthic ecosystem engineers modify sedimentary habitats mainly through their physical structures (Bouma *et al*., 2009). Habitat structuring species provide the template for other ecosystem processes, making them useful for MPA management. Therefore, it is necessary to investigate under which status this ecosystem engineered habitat can potentially be used within marine management strategies. Whilst ecosystem engineers are by no means the only useful indicator, it is an important step to include more ecosystem functions and to come to target an ecosystem approach to management.

B.3 General scientific recommendations for designing MPA networks

Because MPAs are a key instrument for conservation and provide natural laboratories for research, conservation biology, marine ecology and fisheries science have long been interested in the potential of MPAs for preserving and restoring ecosystems and resources. The first contribution of a scientific committee to the issue of MPAs was the Committee on the Evaluation, Design, and Monitoring of Marine Reserves and Protected Areas in the United States, which examined in depth the relevance of MPAs for marine resource management, and published its outcomes in 2001 (NRC, 2001). With respect to MPA design, three important questions were covered: (1) How should the location of MPAs be chosen? (2) How large should MPAs be? (3) What kind of zoning is useful in MPAs? Early approaches for selecting sites attempted to combine ecological and socio-economic criteria, but were then replaced by approaches relying exclusively on ecological criteria, in order to avoid the risk of biological values being overridden by social and economic priorities during the process of site selection (Roberts *et al.*, 2003). Biogeographic and habitat representations are, therefore, at the heart of site selection algorithms and these can offer crucial tools for conservation planning, once any constraints from local human activities are identified (Fraschetti *et al.*, 2009). This approach is also consistent with the design of ecologically sound MPA networks. In view of establishing MPA networks, the Committee recommended that the process be piloted by coordinated efforts between relevant agencies in order to reduce the costs of planning, implementation, and enforcement. Questions (2) and (3) were considered by the Committee as inherent to MPA design, consistent with the scientific definition of MPA design which encompasses not only location, but also size and zoning. With respect to MPA size (question (2), this review underscored the arbitrary nature of the 20% target figure promoted by several agendas, and suggested that less area would have to be protected as management outside MPAs improves.

An interesting academic debate, applied to terrestrial reserves in the 1970s and 1980s, concerns whether conserving biodiversity in a fragmented habitat can best be achieved by a single large or several small (SLOSS) protected areas. In ecological terms, a diversity of marine conservation objectives will dictate that a mixture of sizes is needed. However, in terms of management, national preferences vary between focusing specifically on what needs protecting (usually small areas) or adopting a larger area with sub zones. With respect to MPA zoning (question (3), smaller MPAs may be effective when the exploitation of species outside the MPA is well managed or when the proportion of protected area is increased, but beyond these general predictions, the Committee concluded that there are no hard-and-fast rules about how large an MPA must be for persistence. It underlined that the effectiveness of protection also requires adequate enforcement and compliance. In contrast, the Ecology Centre of The University of Queensland (2009) called for 30% of each bioregion off Australia to be protected. The Australian Government acted on this advice and declared one third of its ocean territory as a MPA in 2012.

Lately, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO[16]) has produced "rules of thumb" to assist policy-makers in designing effective MPA networks and helped to answer a variety of scientific questions arising during the design process, and particularly: How should MPAs be designed to best meet their intended goals? What is the best available science for informing that design? These rules of thumb[17] amount to three ecological statements that describe the core objectives of a network of MPAs:

1. **MPAs should encompass a variety of marine habitats across a range of depths and environmental gradients** (e.g. define biologically distinct regions and identify the scales across which habitats should be replicated within MPAs);
2. **MPAs should be large enough that adult marine organisms do not move out of them too frequently and become vulnerable to fishing** (e.g. the movement range of fish and invertebrate species has implications for MPA size guidelines).
3. **MPAs should be close enough together that sufficient larvae can disperse from one to the next** (e.g. hydrodynamic models and a synthesis on population genetics of marine species have allowed the generation of estimates of larval dispersal distances for algae, invertebrates, and fishes in order to generate guidelines for spacing adjacent MPAs).

B.4 How is the design of MPA networks currently achieved?

Current procedures for designation of MPAs at national levels are quite diverse, mostly depending on the resources allocated to managing the environment and on the size of the country. In large countries, strategies have been set up at national level to achieve coherence of a national system of MPAs. For instance, in Australia and New Zealand, guidelines for establishing the National Representative System of MPAs were produced by a joint Task Force in 1998 (ANZECC TFMPA 1998). Candidate sites were primarily identified according to ecological criteria including representativeness, comprehensiveness, ecological and biogeographical importance, uniqueness, productivity, naturalness, but also depending on estimated vulnerability and international or

16 PISCO is a long-term ecosystem research and monitoring program aiming at understanding the dynamics of the coastal ocean ecosystem along the U.S. west coast, sharing knowledge with ocean managers and policy-makers for fostering science-based decisions, and training scientists in interdisciplinary collaborative approaches, see www.piscoweb.org

17 http://www.piscoweb.org/policy/marine-protected-areas/marine-protected-area-design

national importance. Social, cultural and economic criteria were applied at a second stage. In 2012 the Federal Government of Australia created marine reserves covering 2.3 million square kilometres of ocean with varying levels of protection (see also Section C1.1). However, this impressive network of Commonwealth marine reserves has already been criticized for predominantly focusing protection in deeper waters of the continental shelf, lacking representativity of provincial bioregions and being largely outside areas currently subject to fishing and/or oil and gas interests[18].

In Canada, MPAs have to be established and managed within an integrated oceans management framework, so that the network of MPAs has to be linked to continental and global networks (Government of Canada, 2011). The system is under a shared responsibility of Fisheries and Oceans Canada, Environment Canada and the Parks Canada Agency, all of which have mandates for creating MPAs. Within the objective of a more systematic approach to MPA planning and establishment, the strategy requires to collaboratively develop and use science-based guidelines and decision-tools to identify and select new MPAs by: 1) identifying and mapping ecologically significant sites and candidate representative areas within integrated management planning areas and other strategic planning initiatives; 2) selecting appropriate tools for conservation; 3) identifying priorities for advancing the MPA network; and 4) developing shared criteria and guidelines and seeking opportunities for achieving multiple conservation objectives. The first stage entails the collection, review and analysis of data from widespread sources (DFO, 2010). The list of areas is then collectively reviewed to determine which kind of management tool is needed for conservation of the area, and the final selection and prioritization is the responsibility of the department or agency concerned. These have developed specific selection criteria and, where possible, priority is given to those sites that contribute to the MPA network.

In the United States of America, the National System of MPAs relies on a framework (US National Marine Protected Areas Centre, 2008)[19] which provides guidance: 1) for increasing collaboration and integration across existing MPA sites, programs, and stakeholders at regional, national and international levels; 2) for comprehensive MPA planning, and identification of enhanced or new MPAs that may be needed. The framework makes explicit how to prioritize conservation objectives, depending on: 1) the availability of existing scientific or other data necessary to achieve the objective; 2) the importance of the objective; and 3) the effort necessary to achieve the objective, i.e. the ability to complete the nomination of existing areas and the identification of conservation gaps relative to the objective(s). The design and implementation principles have been adapted from recommendations of the Marine Protected Areas Federal Advisory Committee[20] and IUCN-WCPA (2008). The designation of MPAs is first subject to proposal from the managing entity, and goes through the whole process described in the Framework. Conservation gaps in the National System are identified and can be used to establish new or strengthen existing MPAs, to address these gaps through other management tools, and to facilitate regional planning.

In Europe, an expert group has been working from 2003 "to develop a common understanding of the provisions of Natura 2000 with respect to the marine environment in order to facilitate the designation and future management of these areas". The resulting guide provides information on the best means to locate and assess marine habitats and species as well as a rationale for site selection ("Guidelines for the establishment of the Natura 2000 network in the marine environment", 2007, at http://ec.europa.eu/environment/nature/natura2000/marine/). The guide was complemented by the revision of the "*Interpretation Manual of European Union Habitats*" (European Commission, 2007), a scientific document without legal and binding nature (at the time of writing).

For Annex I habitat-related sites, the group recommended a two-step approach: 1) to use available physical information mapped at a regional scale to predict the location of potential Annex I habitat; and 2) to refine and complement this information using ground-truthed remote sensing data sets. Representativity should be assessed with respect to the range of habitat types present within the territory of the Member State. Recognizing the difficulties in estimating habitat surfaces, data may be entered in broad classes, but precise assessment of surfaces would be useful. Another important selection criterion deals with the conservation of structure and function. In general, knowledge about the structure and function of marine habitats is sparse and incomplete. These may be indirectly appraised through the degree of naturalness of the habitat using information on location and intensity of damaging activities.

For Annex II species-related sites, existing data for locating concerned species and determining essential habitats for their life and reproduction have been used, but such data are available only for some species, e.g. some cetaceans and turtles, and they are not available in all marine areas. Estimating the proportion of a species

18 http://www.crikey.com.au/2012/12/06/massive-new-marine-reserves-but-are-they-phoney/
19 The final framework was published after taking into account comments from the public and institutions.

20 The MPA FAC gathers 30 representatives of the range of the nation's MPA stakeholders and geographic areas; an MPA State Advisory Group convened by the Coastal States Organization and the MPA Center; and the Federal Interagency MPA Working Group.

present within an area requires abundance estimates over the whole territory of the Member State, and raises the issue of transboundary populations. Again, proportions have to be entered in broad classes to cope with the limited available data. Degrees of conservation and restoration possibilities have to be estimated based on expert opinion. The degree of isolation of the population is an approximate measure of the contribution of the population to the genetic diversity of the species also based on expert opinion.

Both OSPAR and HELCOM have considered how to determine ecological coherence (OSPAR, 2006). A background document (OSPAR, 2007) reviewed the literature and grouped the OSPAR selection criteria (see Table 1 in OSPAR, 2007) into four coherence categories namely adequacy/visibility, representativity, replication and connectivity. Based on these categories OSPAR developed three tests – spatial distribution, the distribution of MPAs across biogeographic regions and the coverage of species and habitats. The third of these tests states that the network should 'represent most (i.e. 70%) of the OSPAR threatened and/or declining habitats and species (with limited home ranges), such that at least 5% of each habitat type/species distribution for each OSPAR Region in which they occur (or at least 3 replicate sites per Region) is/are protected' (OSPAR, 2008). Data gaps and uncertainties make this particularly challenging (Ardron, 2008) and it has been suggested that establishing a representative network may be more feasible (Jones and Carpenter, 2009). Attempts to assess ecological coherence have illustrated lack of network coherence and potentially poor protection status. For example a study focussing on deep-sea sponge aggregations (Kodeih, 2010) illustrated the mismatch between sponge occurrences and existing OSPAR MPAs and/or fisheries closures established by competent authorities. However, a summary by Prior (2009) of principles for the design of networks of MPAs, and recommendations for the design of a UK-wide ecologically representative network of MPAs provides a useful checklist (see Annex I B3 below).

B.5 Where are we now in the process of MPA implementation at the European level?

More than 217,000 km^2 representing 2341 individual sites have now been designated as marine areas for conservation within the Natura 2000 network (Natura 2000 newsletter, July 2012). Most of these sites are near-shore areas. An ecologically coherent network is currently lacking, particularly in offshore areas (ETC/BD, 2009; EC, 2009b).

SACs have been established for the few marine habitats and species listed in the Habitats Directive. However, marine habitats and species are listed in a much lower degree of detail than their terrestrial counterparts in the Annexes to the Habitats Directive. The seas around Europe are home to an exceptionally wide range of marine biotopes (EUNIS, 2002) and many of them are underrepresented or not represented at all in the Natura 2000 network as there is no such requirement. In particular, many rare or vulnerable habitats (e.g. deep-sea hydrothermal vents) are insufficiently represented in the Natura 2000 network. Nevertheless, the process of enlarging the Natura 2000 in the marine off-shore environment is currently ongoing. Habitats cannot be considered as sufficiently replicated within the Natura 2000 network. Even where some Natura-habitats occur in more than one SAC they are not necessarily comparable as they may refer to very diverse biotopes.

Connectivity issues have generally been ignored during the design phase of the Natura 2000 network (for details see Appendix I B2 below). Site selection was mostly based on expert opinion guided by the criteria set by the Habitats Directive. A recent connectivity analysis of the marine Natura 2000 network of the Atlantic region, suggested that many sites are too small and too isolated to support populations with intermediate dispersal capabilities without depending on the surrounding non-protected areas (Johnson *et al.*, 2007). Furthermore, in many Natura 2000 sites clear management plans with specific operational objectives are lacking and monitoring, enforcement and adaptive management practices are generally poorly applied. No-take zones, especially to protect vulnerable, rare, and essential habitats such as nursery and reproduction areas, are often missing. In many countries, there was very limited participation of stakeholders in the initial design of the Natura 2000 network, and thus many local communities are reluctant to accept any restrictions to their traditional uses of the sea.

Hence the Natura 2000 network is not a real 'network' of MPAs, but rather a set of independent and rather isolated sites. Further research is needed to build up the scientific basis for the design, monitoring, and adaptive management of real networks of MPAs. Recent developments in the field of ecosystem-based marine spatial management (Rice *et al.*, 2010; Katsanevakis *et al.*, 2011), including marine spatial planning (Douvere, 2010), and the many successful examples of MPA networks, such as the Australia's Great Barrier Reef Marine Park (Day, 2002, 2008; Fernandes *et al.*, 2005) should inspire a fresh view on the design and management of the Natura 2000 network. The Natura 2000 network, despite its drawbacks, is a good starting point towards creating "coherent and representative networks of marine protected areas", as requested by the Marine Strategy Framework Directive (EC, 2008). However, to achieve this there is a strong need of a radical reform of the Natura 2000 network.

Case study 2: Belgium

Background

The Belgian part of the North Sea (BPNS) is a shallow shelf area of 3600 km², characterized by the presence of several sandbank systems, in which a diversity in soft-bottom habitats is found (Van Hoey *et al.*, 2004). It is a well known and heavily exploited marine area with a rich marine management history where an 'MPA-process' is evolving. It is also characterized by a high institutional complexity and multi-level government (Rabaut *et al.*, 2009).

In 2005, two SACs in the Belgian marine environment were designated in Belgian legislation by Royal Decree of 14 October 2005 (Bogaert *et al.*, 2008, Cliquet, 2008, Cliquet *et al.*, 2008, Cliquet and Decleer, 2007) after having been included in the list of sites of community importance (SCIs). These sites were called 'Trapegeer-Stroombank' (habitat type 1110) and the 'Vlakte van de Raan' (habitat type 1110). The smallest SAC, the 'Vlakte van de Raan' was later annulled by the Belgian council of State. The 'Trapegeer-Stroombank' has recently been included in a larger newly designated SAC - the 'Vlaamse Banken' (Figure 5). This area was proposed by Belgium in June 2010, based on scientific advice (Degraer *et al.*, 2009), for further protection of habitat type 1110 and reef like features ('1170') after which it was included in the list of sites of community importance. In October 2012 the Royal Decree of 14 October 2005 was adapted to designate the SAC 'Vlaamse Banken' as a MPA in Belgian legislation. This timing coincides with the agreement taken in the framework of the Convention on Biological Diversity to establish a system of MPAs by 2012. The measures for this area are developing and will come into force in parallel with the current MSP process going in Belgium. The BPNS also contains three Special Protection Areas for birds under the Bird Directive.

Figure 5. MPAs in Belgium. 3 SPAs for bird protection in purple, 2 initial SACs in dotted lines (Trapegeer-Stroombank in the West, Vlakte van de Raan in the East). The Vlakte van de Raan has been annulled by the Council of State because of insufficient scientific motivation; an enlargement of this area based on new insights was scientifically advices (see Degraer *et al.*, 2009 for more details). An enlargement of the SAC Trapegeer-Stroombank into a large area called 'De Vlaamse Banken' was designated by Royal Decree in 2012. This designation was based on scientific advice (green area). Further, there is one integral reserve next to the Zeebrugge harbour (in red).

Design/management/assessment scheme in place

The protection of marine habitats in Belgium is basically achieved through designation of SACs within the framework of the Habitats Directive. The design of MPAs is largely driven by international legal obligations and commitments and most designated areas have been established in the framework of the European Natura 2000 Network (Rabaut *et al.*, 2009).

The design of an MPA in Belgium requires an individual policy to be set up for its protection. The creation of this policy consists of a public investigation of the proposed area, a meeting with representatives assigned by the users of the area and a public consultation meeting. The policy needs to contain information about the protection measures and user agreements that will be applied in the MPA. It also needs to contain the results of monitoring and a judgement of the effects of the proposed protection measures and user agreements.

The demarcation of MPAs in Belgian marine waters has been based on ecological information (Derous, 2007). The main objective concerning the management of the MPAs in a first phase was to safeguard them from future threatening activities (such as building of artificial islands etc.). The existing activities were considered to have no significant impact or belong to another level of competence (e.g. fisheries). Other marine management initiatives have largely focused on the maintenance of the benefits that come from exploitation of resources.

Activities forbidden by Royal Decree in SACs:	Activities that cannot be restricted or banned from SACs include:
- Activities of civil engineering - Industrial activities - Advertising and commercial activities - Dumping of dredged material or inert material of natural origin	Observation and control activities; monitoring and scientific research; military activities; fisheries; pilotage and beaconing services from and to ports; rescue and towing services at seas; dredging.

Issues

Mobile fishing gear has a significant impact on the ecology of benthic systems. However, none of the existing fishing activities were restricted in the designated MPAs. A new policy in the recently designed SAC 'Vlaamse Banken' will take measures for the activities that interfere with the seafloor. Sand extraction activities will be limited while fisheries measures will be negotiated between the federal state (marine environment competence) and regional state (fisheries competence). These measures are embedded in a larger marine spatial plan for the Belgian part of the North Sea which is due by the end of 2013, not even within the two SACs. Social implications make it politically delicate to restrict fisheries and this probably explains in part why no fisheries restrictions currently exist for the Belgian MPAs. Furthermore, the federal government has only limited competence in this matter due to the state structure.

Currently, there is enough evidence to classify the Belgian SACs sandbank habitat type (1110), with an associated reef habitat type (1170). Reduction of bottom disturbance within MPAs (with no take zones) would provide a chance to quantify anthropogenic impacts on the functioning of the ecosystem. Both rare and still abundant ecosystem engineers need to be used as it comes to the protection of biodiversity, the safeguarding of ecosystem functioning and the provision of very important ecosystem services (e.g. buffer against eutrophication).

Lessons learnt	Research priorities and needs
Research on ecosystem functioning will gain importance if the aim is EAM.	Habitat structure should be studied in depth.
Habitat mapping has identified areas of high biodiversity (e.g. gravel bed/geogenic reef) Structures built by ecosystem engineers deserve special attention in MPA design and management (Crain and Bertress, 2006).	Contributions of common ecosystem engineering invertebrates such as the tube building bristle worm (*Lanice conchilega*) and consequences of their human-induced degradation (Godet *et al.*, 2008) A process-based understanding of the functioning of whole systems.

C. Science-based management and assessment of MPA networks

Fisher interview in the Parc Marin de la Côte Bleue, French Mediterranean (courtesy, E. Charbonnel PMCB)

C.1 Current practice

C.1.1 Management practices

Protected areas are managed for different purposes, and, therefore, this protection can give varied effects on particular taxa. Networks of MPAs represent an integrated system of multiple protected areas, often designed to conserve regional biodiversity, and ecosystem function across habitats. In some cases (e.g. Baja California), scientific guidance has informed management and been used to revise size and spacing guidelines in an MPA network (Sala *et al.*, 2002). After an extensive consultation the Australian Government created in 2012 a National Representative System of Marine Protected Areas (NRSMPA) that will be managed primarily for biodiversity conservation[21] . This represents more than 30% of the marine area of Australia (see Figure 6).

As explained previously, numerous Marine Protected Areas (MPAs) have been created in Europe in the last few years (e.g. Claudet *et al.*, 2008). However unfortunately, the establishment of MPAs is not consistently accompanied by good policies of management and enforcement. For instance, in the Mediterranean Sea, Abdulla *et al.*, (2008) reported that management is unlikely to be adequate in approximately half of the MPAs and in a recent study Fraschetti *et al.*, (2011) noted that the classification scheme used in the Mediterranean Sea is still incomplete and needs optimization to be of use in conservation planning (see case study 3: The Pelagos Sanctuary). Among the main weaknesses are the lack of resources and inadequate surveillance and enforcement. In most cases (>75%) MPAs did not have at their disposal boats or staff for surveillance, affecting the implementation of management decisions and suggesting that most management problems are rather related to economic budgets than to scientific policy. More details and examples of European national implementation can be found in Annex II of this document.

To address this, within European waters, dedicated eco-regional collaborative projects and initiatives (e.g.

21 http://www.environment.gov.au/marinereserves/index.html

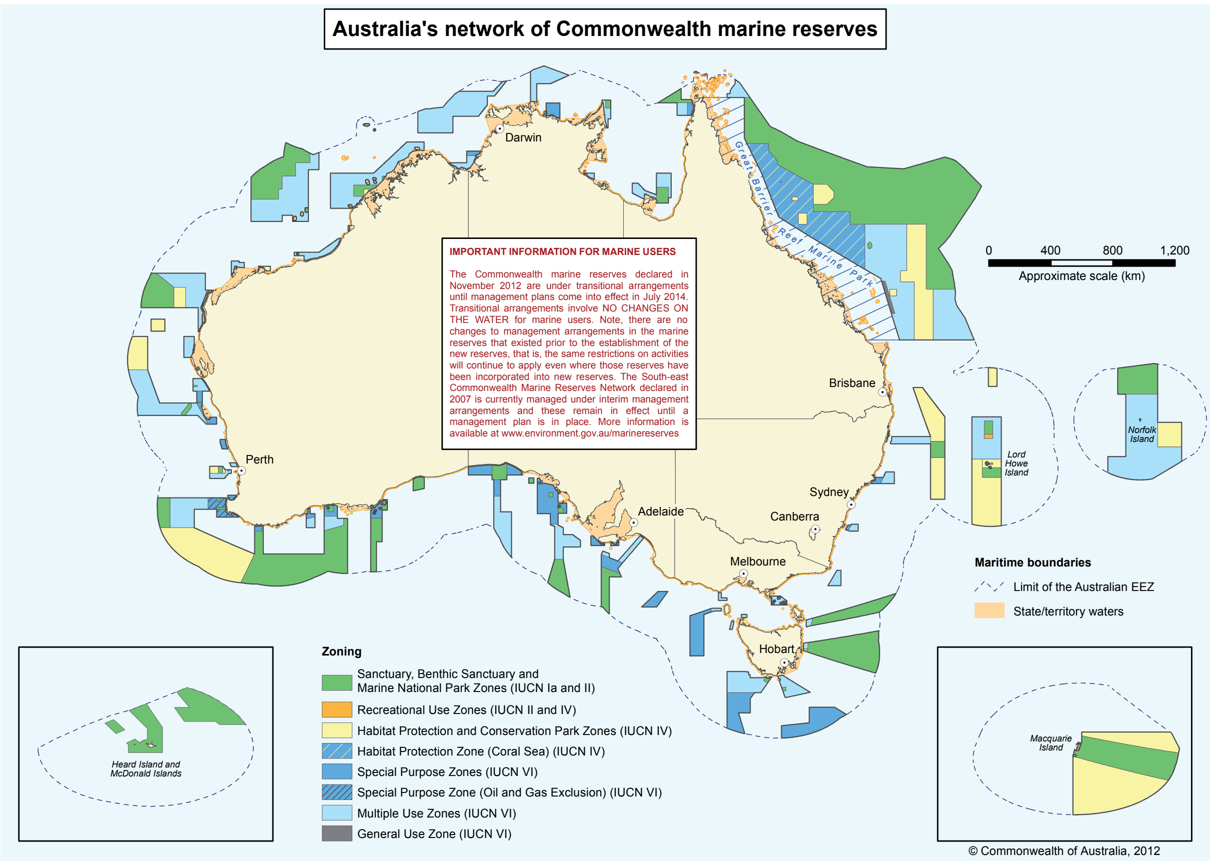


Figure 6: Australia's network of Commonwealth marine reserves (Source: Department of Sustainability, Environment, Water, Population and Communities 2012).

Case study 3: Pelagos Sanctuary, NW Mediterranean

Background

The Agreement between France, Italy and Monaco establishing an international sanctuary for Mediterranean marine mammals came into force In February 2002. The resulting Pelagos Sanctuary encompasses over 87,500 km^2 of the north-western Mediterranean Sea, extending between south-eastern France, Monaco, northern-west Italy and northern Sardinia, and surrounding Corsica and the Tuscan Archipelago (Figure 7). By expanding protective measures beyond national waters, the Pelagos Sanctuary set a precedent for the implementation of pelagic protected areas in the high seas and, as such, met with high acclaim. In November 2001 the Sanctuary was adopted by the Parties to the Barcelona Convention as a Specially Protected Area of Mediterranean Importance (SPAMI). The impetus for the Sanctuary proposal was threefold: (i) recently acquired knowledge of the presence of important populations of cetaceans in the area; (ii) awareness of the existence of serious threats to these populations; and (iii) a lack of legal instruments to protect the Mediterranean high seas beyond the 12 nautical mile (22.3 km) buffer provided by the national territorial seas - the location of most of the habitats of the cetacean populations (Notarbartolo di Sciara *et al.*, 2008).

Management

Management goals of the sanctuary are: i) protection of Pelagos cetaceans and their habitats; ii) protection of cetacean food webs and ecosystems and iii) protection of highly migratory cetaceans in the Mediterranean basin. However, in the 10 years since its creation, Pelagos has failed to fulfil its goal of significantly improving the conservation status of the area's marine mammal (Notarbartolo di Sciara, 2009). The principle threats to cetaceans in the area include fisheries, maritime traffic, military exercises, climate change, coastal construction, downstream effects of land use, and whale watching. To mitigate these threats a suite of management measures to establish precise regulations addressing and mitigating impacts exerted on the local cetacean populations by human activities is required (e.g. ACCOBAMS Guidelines for implementing a Pelagos/Accobams label for Commercial Whale Watching activities). An ecosystem-based management approach including regulation of marine resource use and activities, control of land based and maritime sources of pollution, integrated coastal zone/ocean management, and an adaptive management approach

Figure 7: Location map of the Pelagos Sanctuary
http://www.tethys.org/sanctuary.htm

able to deal with rapidly changing patterns of use as well as with technological, socio economic, political and natural change is needed (Notarbartolo di Sciara, 2009). It is also necessary to use the national coast guard and navies to ensure compliance, increase public awareness and education, and implement a systematic programme of monitoring – all of which require an adequately empowered management body (Notarbartolo di Sciara, 2009).

Issues

The existing governance regime within the Sanctuary severely limits management and conservation actions and the Sanctuary lacks a proper management body. The Contracting Parties adopt resolutions on conservation measures approximately every three years. The Agreement Secretariat is undermanned and lacks sufficient powers and means to prevent or control activities that conflict with the aims of the protected area. Parties to the Agreement erroneously assume that the Agreement Secretariat should act as a surrogate management body of the Pelagos SPAMI. This misunderstanding has resulted in severely deficient management. The ongoing limitations in the management of the Pelagos Sanctuary raises the question of how do the parties to the Barcelona Convention envisage managing such high seas protected areas, or indeed, whether it is conceivable to establish MPAs without providing for a solid and effective management mechanism. (Notarbartolo di Sciara, 2009).

Lessons learnt	Research priorities and needs
Management lacks resources and authority to be effective.	Provide evidence of the status of conservation objectives to inform future management decisions.

MedPAN, PANACHE, MAIA) related to the management of protected areas have been established, the aims of which encompass the development of management tools and practices, monitoring and assessment, stakeholder involvement and manager networks.

Furthermore, although much discussion has surrounded the success of protected areas at small spatial scales (i.e. considering only one small MPA), little evaluation has been done at a larger scale (i.e. considering all MPAs in a large area). This point should be a focal objective in the management of the European MPAs network. There are numerous studies in recent years demonstrating the importance of the presence of a range of functional groups, e.g. large predators, in the resilience and recovery of protected areas (e.g. Mora *et al.*, 2006). These aspects, as well as other important processes, such as spillover (Goñi *et al.*, 2006, 2010) and larval connectivity (Planes *et al.*, 2000), might be analysed at a larger scale (regional networks of MPAs).

The type of protection applied within MPAs is very diverse and reflects cultural and political differences existing among countries. Some areas are designated IUCN Category 1a, a strict nature reserve, where human visitation, use and impacts are strictly controlled and limited (for example Cape Kaliakra in Bulgaria). However, the majority have been classified as multiple-use MPAs (Francour *et al.*, 2001). MPAs are often divided into various zones, with different degrees of avoidance of human impact. Some important MPAs, e.g. Cabrera National Park in Spain, Port-Cros National Park in France, or Portofino Marine Protected Area, include areas totally restricted to any human activity (ranging from 10 to 50% of the total MPA area); in the rest of the protected area limitations to human activities have been imposed

Marine Protected Areas in the Atlantic Arc (MAIA)

MAIA is a European cooperation project with the aim of creating a network of MPA managers and stakeholders. The project was established in 2010 and scheduled to end in December 2012. Recognizing the need to understand the wide array of tools, approaches and goals behind the acronym "MPA", the project promotes initiatives in MPA designation, governance and management on an international scale. The project partners aim to enhance and share their knowledge to facilitate mutual understanding and to development an efficient, coordinated and recognized network of marine protected areas in the Atlantic arc. MAIA's ambition is to integrate all marine protected areas officially recognised as such by the five countries bordering the North-East Atlantic (Ireland, the UK, France, Spain and Portugal), whether they are coastal or offshore, and totally or partially marine.

To support the process, the MAIA network encourages and structures experience-sharing and pooling of different approaches as well as developing common methods and contributing to the emergence of a network of MPA managers.

The project is composed of four technical working groups (Work Packages) i) State of play, ii) Common monitoring strategies, iii) Management plans and iii) Stakeholder integration. Communication action and coordination tasks are covered by two additional work packages.

The MAIA 2010-2012 Action Plan comprises technical workshops; site visits in each partner country; a dedicated website offering a specific collaborative space, a document database, a GIS database (Eynaudi *et al.*, 2012); field studies and the development and distribution of documentary resources. New technical tools have been developed (e.g. Web GIS, relational GIS databases) and monitoring systems have been applied in the field and evaluated, together with a comparative analysis of management laws (Alvarez *et al.*, 2012).

MAIA is part of the international legislative landscape relative to the conservation of biodiversity and the marine environment and contributes to European commitments particularly as regards:

- The Convention on Biological Diversity (CBD - Aichi Target 11) for the creation and efficient management of marine protected areas;
- Regional cooperation to be conducted under Article 13 of the Marine Strategy Framework Directive (MSFD).

MAIA works closely with the OSPAR Commission, the current legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic, namely within the framework of activities of the Intersessional Correspondence Group on Marine Protected Areas. MAIA acts as a conduit, ensuring that its work is in line with the Convention and passing on to MPA managers the OSPAR Recommendations and Guidelines relating to MPAs.

MAIA is jointly funded 65% and 35% respectively by the European Regional Development Fund, Interreg IV B Atlantic Area programme under Priority 2 to "protect, secure and enhance the marine and coastal environment sustainably" and the nine project partners based in the UK, France, Spain and Portugal (www.maia-network.org).

(see case study 4: Medes Island). Zoning often greatly reduces the actual protected area from the declared MPA area, since most of it is under a minimum level of protection.

In the Mediterranean, from a total surface of 97.410 km^2 of managed or protected areas (4% of the total surface of the Mediterranean Sea), the area covered by coastal MPAs is only 9.910 km^2 (0.4% of the Mediterranean surface) and the surface of no-take areas is reduced to merely 202 km^2 (0.01% of the Mediterranean surface) (Abdullah *et al.*, 2008). Similar results were obtained in an overview of coral reef MPAs by Mora *et al.* (2006), concluding that existing MPAs are largely insufficient for the protection of coral reef diversity.

Case study 4: Medes Island

Background

In 1983, the Department of Agriculture, Livestock and Fisheries of the autonomous Catalonian Government banned fishing and the extraction of living resources from the littoral of Medes Islands. The purpose of this provision was to prevent the degrading effects of human activities and safeguard the species and ecosystems in that environment.

Management and Assessment

The Medes Islands marine reserve was created in 1983, establishing a no-take zone encompassing a perimeter of 75m around the outermost points of the emergent landmass of the islands (approximately 50ha). The current configuration, established in 1990, extended a perimeter of 200m around the outermost points of the islands, and a Partially Protected Reserve *buffer zone* was established in the section closest to the islands of the neighboring coast of Montgrí, with the aim of facilitating the possible '*spillover'* from the marine reserve. Since 2011, the whole area has formed part of the Montgrí, Medes Islands and BaixTer Natural Park, without having changed the conditions for the protection of the MPA. Currently, 95ha are fully protected, in which any mining/harvesting activity is absolutely prohibited, while other activities are allowed, such as marine tourism, swimming and scuba diving. The anchoring of vessels is also strictly prohibited in the marine protected area, and a limited number of mooring buoys have been installed for recreational boaters, cruise ships, underwater activities and snorkelling.

The management of the Medes Islands protected area lies with the General Secretary of Environment and Sustainability, Department of Territory and Sustainability of the Government of Catalonia (Secretaria General de Medi Ambient I Sostenibilitat, Dpt. de Territorii Sostenibilitat de la Generalitat de Catalunya). Interaction with stakeholders is theoretically guaranteed by the Advisory Council (in which all activities affected by the marine protected area are represented) and the Permanent Commission (a reduced version of which deals with specific items). Surveillance of the Medes Islands marine protected area is ensured throughout the year by two guards. During the summer they are supported by one or two additional guards and occasionally they are reinforced by forest rangers and the Civil Guard.

Issues

Theoretically, adaptive management should be assured by the monitoring of some vulnerable populations (highly prized fish, spiny lobsters, red coral and sea fans) and benthic communities of ecological interest (infralittoral algae, *P. oceanica* meadow, sea urchins). However, in the recent years the monitoring has lost impetus due to the economic crisis. In addition, changes in the management of the Medes (frequently moving from one department to another) and changing protection laws make it difficult to implement truly effective adaptive management.

Lessons learnt	Research priorities and needs
Current economic crisis has led to reduction on monitoring.	Set out cost-effective monitoring proposals that remain scientifically credible
Changes in management and protection laws make implementation of effective adaptive management difficult.	Continuity and long-term assessment and monitoring on the basis of integrated approaches

C.1.2 Assessment practices

It is imperative for the long-term success of a marine protected area that a plan to assess effects of management actions is designed in conjunction with the development of MPA goals (OSPAR, 2003). Too often implementation of MPAs has taken an intuitive practical approach where focus is first on design and then management by assigning some degree of protection to an area that is believed to promote the MPA goals. Thus the assessment of marine protected areas is often designed after the MPA is up and running. However, it is very difficult to assess the effectiveness of an MPA without determining the baseline before the MPA regulations are applied. Without such data, MPA actions that have taken many years to accomplish may quickly lose their political and public support (see, for example, case study 5, North Sea Plaice Box).

Case study 5: North Sea Plaice Box, a failure by mismanagement or not?

Background

The Plaice Box (PB) is an example of a poor assessment strategy which has not only generated a failure to evaluate effects but also presented the opportunity for stakeholders to claim alternative effects in line with their own interests. The PB is a measure to enhance the plaice stock by protecting recruitment areas thereby reducing the discard of undersized fish that concentrate in shallow waters. The PB applies to larger boats (engine power >221 kW) and covers an area of 38 000 km^2 in the south-eastern North Sea, along the coasts of the Netherlands, Germany and Denmark. Small boats and beam trawling for shrimp are still allowed. The PB was implemented stepwise between 1989 and 1994 and remains active today.

Management and Assessment

The main management goal of the PB was to decrease discards of young plaice from the plaice fishery. Discard within the PB is now lower but this has not lead to an expected 25 – 30 % increase in spawning stock biomass of plaice. The PB is therefore widely questioned as a management tool. On the contrary, stock biomass of North Sea plaice has declined since the 1990s and the occurrences of juvenile (young of the year) plaice within the PB have decreased steadily. Notably, records demonstrate a change in the distribution of young plaice where peak distributions have moved out from the coast. However, the design of the PB makes it impossible to assess its effects. This has given rise to alternative speculative explanations for the lack of increase in recruitment and spawning stock of plaice.

Fishermen excluded from the PB view it as a failure. They argue that decreased physical impact of trawling has decreased the productivity of the system as trawling ploughs the seabed exposing damaged invertebrates as prey for plaice. In their opinion, lack of trawling has created a desert for juveniles and the plaice have abandoned the PB due to the less disturbed habitat conditions. Nature conservation organizations and managers on the other hand argue that the PB has worked poorly because it was not closed to all fisheries. The largest discard of plaice is now by shrimp trawlers. Shrimp trawling within the Box increased by 3.5 times from 1995 to 2005. It is also argued that enforcement has been too loose, and that many boats with engine powers > 221 kW limit still fish in the area. Since no no-take areas were included and enforced in the PB, there is no way to separate these two hypotheses scientifically.

Issues

Many variables co-vary with the decrease of juvenile plaice. From 1995 to 2005 nutrient concentration in the area decreased by two thirds, possibly contributing to a decrease in production of the food base for juvenile plaice. A simultaneous increase in average water temperature of 1-2 °C may explain why plaice seem to have moved out from the coast towards deeper and cooler water. However, the lack of reference areas and of no-take areas make it impossible to evaluate the partial contributions by environmental changes, increased shrimp trawling and decreased plaice trawling.

Lessons learnt	Research priorities and needs
Lack of reference areas and no-take areas	The effects of: i) trawling intensity on benthic productivity, food availability and the spatial distribution of plaice, ii) density of plaice and other competitors on growth rate, iii) temperature on the distribution of plaice. Evaluation of the current PB on the survival and re-recruitment of pre-recruit plaice

C. Science-based management and assessment of MPA networks

Marine protected area (MPA) effectiveness is also termed MPA *management* effectiveness to emphasize that it pertains to how well the protected area is being managed, and primarily the extent to which it achieves the objectives for which it was created (IUCN-WCPA Guidelines, Hockings *et al.*, 2006). MPA management is driven either implicitly or explicitly by high-level goals, which may include the protection of ecosystem services and functions, biodiversity, landscape and geomorphological features, as well as cultural, socio-economic, and research- and education-related aspects. To achieve high-level goals, managers should translate them into clear, measurable, short-term goals, usually termed *operational objectives*, before any specific targets, limits and measures can be elaborated (Katsanevakis *et al.*, 2011).

Assessing MPA effectiveness has become a crucial issue as many MPAs are designed all over the world in response to international commitments regarding biodiversity conservation and resource management. Such strong commitments will not be achieved through ineffective MPA management, either because of poor enforcement ("paper parks") or poor initial design.

Therefore, the assessment phase should be considered in the light of decision-support for MPA management. It should provide reliable and quantitative science-based advice for supporting management and decision-making (Pelletier, 2011).

According to the IUCN World Commission on Protected Areas Guidelines, management effectiveness evaluation is defined as "the assessment of how well the protected area is being managed" (see above). A way to assess effectiveness lies in the provision and documentation of indicators able to track progress toward this achievement of MPA management operational objectives. An indicator is commonly defined as a function of observations or of the outputs of a model, the value of which indicates the present state and/or dynamics of the system of interest (Food and Agriculture Organization, 1999). A challenge to management is how to develop realistic operational objectives and related indicators against which effectiveness can be measured (Katsanevakis *et al.*, 2011).

The selection of descriptors may be based on the main features of marine systems and their suitability for a long term monitoring. The aim of the monitoring of the different variables (biological and non-biological), inside and outside the protected areas, is to understand the natural ecological processes that alter the ecosystem as well as natural and anthropogenic disturbances that affect them (see for example case study 6 and 7).

Although the need for developing operational tools and guidance "to evaluate the ecological and management quality of existing Protected Areas (PA)" has long been acknowledged by conservation organizations such as the International Union for the Conservation of Nature (IUCN) (for instance at the 3rd World Parks Congress in Bali, Indonesia in 1982), the issue of management effectiveness appeared much later in the work of the IUCN World Commission on PA. More recently, the Programme of Work for PA of the CBD (http://www.biodiv.org) called on parties to "develop and adopt appropriate methods and standards, criteria and indicators for evaluating management effectiveness and governance by 2008, and to assess at least 30% of their protected areas by 2010".

Given that MPAs are increasingly recognized as a crucial element of sustainable development (IUCN, 2003), this makes MPA assessment a larger and even more compelling issue than it used to be. Also, in a number of cases, MPAs are poorly accepted by local populations (see e.g. Christie, 2004) or suffer from a lack of human and financial resources for management. These conditions compromise the success of the MPA in terms of both conservation and management of uses and governance. Such examples are also detrimental to the concept of MPAs as a management tool for coastal ecosystems (Agardy *et al.*, 2003). In this respect, management effectiveness evaluations provide a mechanism to encourage accountability of MPA management and foster its acceptance by stakeholders and the public. MPA assessment results are used for several purposes: i) to improve MPA management performance through adaptive management; ii) to promote accountability and transparency; and iii) to assist effective funds and resource allocation within the protected area system (Hockings *et al.*, 2006).

Several frameworks have been developed for evaluating progress towards MPA management objectives, including the generic pressure-state-response framework developed by the Organisation for Economic Cooperation and Development (OECD) (2003) and the IUCN-WCPA framework aimed more directly at marine protected area management (Hockings 2006) (Table 4). These frameworks may be considered at a global-, national-, and regional scale (Table 5) and can form the basis of regional reviews of lessons learned (e.g. Gomei and Di Carlo, 2012).

Assessment Frameworks	Level of application and mechanisms	Reference
Pressure-State-Response (PSR); DSR (Driving force-State-Response); DPSR (Driving force-Pressure-State-Response); DPSIR (Driving force-Pressure-State-Impact-Response).	Generic frameworks; Anthropogenic impact explicit linked with environmental consequences and with the consideration of remediation measures; Mostly in use in the frame for biodiversity conservation measures (CBD frameworks).	OECD (2003)
IUCN-WCPA Framework	Applied to Protected Area Management; Cyclical process with six mechanisms (context, planning, inputs, processes, outputs, outcomes) to be assessed for effectiveness	Hockings (2006) Wells and Dahl-Tacconi (2006)

Table 4: Assessment frameworks for evaluating progress toward MPA management objectives.

Scale	Framework
Global	The Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including socio-economic Aspects (the Regular Process). The Regular Process will assess both the state of the environment and the impacts of key human interactions with ocean ecosystems. (www.un.org/Depts/los/global_reporting/global_reporting.htm)
National Scale	NOAA, US National Marine Sanctuary, Conditions Reports: – Evaluate the management outcomes; – Support management processes and are used for reporting by policy makers and education/outreach. (sanctuaries.noaa.gov/science/condition/)
Fine Scale/Local	Guidebook “How is your MPA doing?” To assist marine protected area (MPA) managers in assessing the performance of their MPA. IUCN, WWF and NOAA (Pomeroy *et al.*, 2004; 2005).
	The Nature Conservancy 5-S Framework assesses the context of a site (systems, stresses and sources) to produce short-term conservation strategies and measures for conservation success. (Nature Conservancy Council, 2003).

Table 5: Example of scale for Assessment Frameworks.

Case study 6: Spiny lobster in the Columbretes Islands Marine Reserve (Western Mediterranean, Spain). An example of a MPA monitoring scheme

The MPA and scientific monitoring objectives

The Columbretes Islands Marine Reserve ("the MPA") is situated 50 km from the Mediterranean coast of the Iberian Peninsula at the edge of the continental shelf. It protects 55 km² of volcanic rock and coraligenous habitats from the coast down to 80 m depth (Figure 8). This MPA was established in 1990 and harbours traditional fishing grounds of the lobster *Palinurus elephas*, the most commercially important spiny lobster species in the Mediterranean and North-eastern Atlantic and a key representative of infralittoral rocky and coraligenous communities in the Western Mediterranean. Although the MPA is a zoned MPA, the zoning affects primarily recreational activities and its legislation prohibits all commercial fisheries. This prohibition is well enforced and lobster grounds closed to fishing in the MPA amount to 18% of the regional lobster grounds. In 1998 an ongoing monitoring study was launched to: a) assess the evolution of lobster biomass and demography in the MPA, b) evaluate MPA effects on the adjacent artisanal fishery, and c) monitor lobster movement patterns and trends. Along with these objectives, the assemblage of mega-benthic fish, crustaceans and molluscs that share lobster habitats has also been monitored in the MPA and adjacent fished areas.

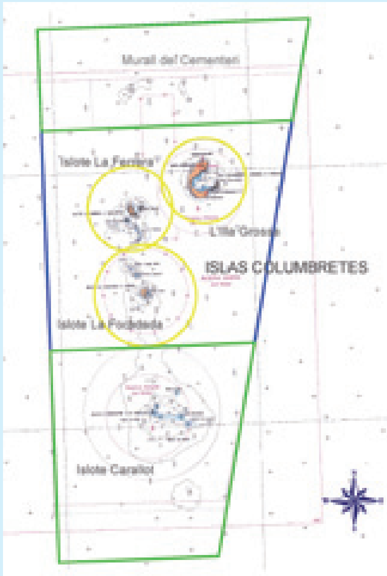


Figure 8: Map of the Reserva Marina de las Islas Columbretes MPA showing the zoning. Key: No professional fishing anywhere in the MPA; yellow circles: limited recreational diving allowed; rest of MPA: limited recreational fishing without anchoring. Extension of the MPA 55 km²; emerged land: 0.19 km². (Columbretes Islands Marine Reserve, Spain).

Monitoring scheme

Inside the MPA: Scientific experimental fishing surveys to collect data on lobster abundance and demography, and those of associated mega-benthic species, have been carried out annually during 1998 to 2012 with the same gear used in the commercial fishery outside the MPA. Outside the MPA: An observer sampling programme in the fishery operating in the region adjacent to the MPA collects data on catch, effort and demography of the lobster and associated species. Tag-recapture experiments: Lobsters caught in surveys inside the MPA have been routinely tagged and released inside the MPA. A €12 reward is advertised and given in return for every recapture reported by fishermen outside the MPA. This provides information on lobster size as well as the location and date of recapture.

Main results

After 22 years without fishing in the MPA, lobster biomass is 15 times greater than in the fished areas while mean body size continues to increase, confirming that *P. elephas* maximum age exceeds 20 years. Spillover of lobster from the MPA to the adjacent fished areas, demonstrated by tag-recapture data, provides an annual net benefit to the local fishery of 13% of the catch in weight. (Goñi *et al.*, 2006, 2010). Furthermore, the MPA has increased reproductive potential of lobster in the region by 6-fold (Díaz *et al.*, 2011).

Lessons learnt	Research priorities and needs
Good long-term comparable data, while necessary, are difficult to obtain because of short-term funding cycles, and or/ changes in MPA configuration or zoning, changes in fishing activity outside the MPA, etc, all affecting the comparability of data.	Baseline data critical to know status prior to protection and responses in the early years of MPA. Essential long-term (>20 years, depending on species longevity) comparable data inside and outside the MPA to understand recovery processes in MPA and effects in adjacent fished communities.
Good planning, studying and consulting with experts is key to designing data collection programmes that are fit for purpose into the future.	Critical to understand population dynamics of key species protected in the MPA to determine whether they depend on upstream unprotected populations.
Fisheries may provide spatially and temporally intensive data that adds value to research.	Involve fishermen as much as possible in studies of MPAs where fishing is or was present.

Case study 7: Lobster reserves in Norway: implementing the BACI design for assessing reserve effects

Background

The European lobster (*Homarus gammarus*) is a popular catch for both recreational fishers and commercial fishers in southern Norway. However, the lobster population has been in decline and the species was recently red listed as near threatened. Consequently, four lobster MPAs (0.5 – 1 km^2) were established on the Norwegian Skagerrak coast in 2006 (Pettersen *et al.*, 2009). The main objective is to provide knowledge about the effect of small-scale closures on the local lobster population development. The MPAs are protected under the saltwater fishery law, excluding the use of standing gear such as traps and gillnets. Hook and line fishing for species such as the Atlantic cod (*Gadus morhua*) is still allowed.

Assessment Scheme

The Institute of Marine Research, Norway, has designed and initiated an assessment program to evaluate the effects of the MPAs. Since 2004, a research survey is conducted once every year inside the MPAs as well as in adjacent control areas where lobster fishing is permitted. The survey design therefore represents an implementation of the BACI (Before-After-Control-Impact) design advocated by Russ (2002) as a general guide to measuring MPA effects (see Moland *et al.*, 2013 for latest findings). During each survey, 25 standard lobster traps are baited and hauled every day for four days simultaneously within the MPA and nearby control area. All lobsters are measured for length and tagged to allow for individual-based assessment of growth, maturation and mortality rates. Based on the number of lobsters caught, the estimated catch-per-unit-effort (lobsters per trap per day) is used as an estimate of population density. From each lobster a tissue sample is stored in ethanol to allow for future studies on population genetics. An egg sample is taken from each egg-bearing female to assess the development of maternal effects within the reserves. As part of the assessment process, detailed studies on lobster behaviour using advanced tags have been conducted to estimate site fidelity, home ranges, and spillover of adults from reserves to surrounding areas (Moland *et al.*, 2011).

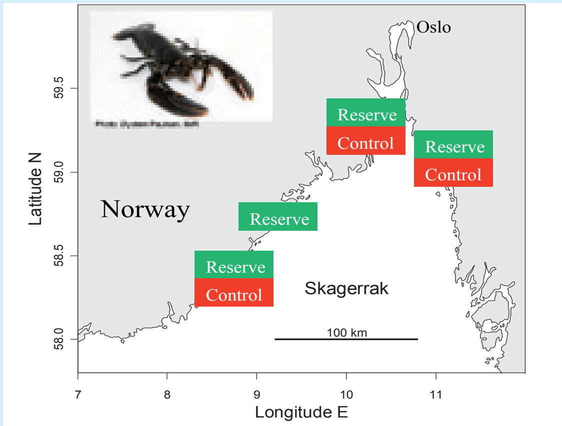


Figure 9. Map of Lobster MPAs and control areas on the Norwegian Skagerrak coast monitored since 2004 (MPAs established in 2006). Map source: Esben Moland Olsen, IMR. Lobster image credit: Øystein Paulsen, IMR

Issues

The MPAs were designed in collaboration with local commercial lobster fishers. A survey of stakeholders showed that recreational fishers were not included in the implementation process although many of them expressed that they would have liked to be (Pettersen *et al.*, 2009). Recreational fishers are an important stakeholder group and contribute to the majority of the fishing effort for lobster in Skagerrak (Kleiven *et al.*, 2012). Therefore, recreational fishers should be included in future MPA-implementation and assessment processes. Second, the current assessment scheme does not allow for strong inference about connectivity from larval dispersal. Like many other marine organisms, lobsters have pelagic larvae that may potentially disperse over vast distances. Still, little is known about this and therefore it is difficult to predict to what extent the reserves may benefit surrounding lobster fisheries. Third, the absence of fisheries will expectedly change the selective landscape of the protected population and hence it's evolutionary course (Baskett *et al.*, 2005). Therefore, there is a need to assess evolutionary as well as ecological responses to MPA implementation.

Lessons learnt	Research priorities and needs
It is possible to implement a BACI design for coastal MPAs, allowing for a quantitative assessment of MPA effects.	Quantify effects beyond MPA boundaries. Assess both evolutionary and ecological responses to protection.
All important stakeholder groups, including recreational fishers, should be identified and included in the implementation and assessment process.	Ensure a broader inclusion of stakeholder groups during MPA planning and implementation.

C.2 Gaps in protection for unexploited species

In the past, many MPAs have been created with respect to too loosely specified conservation benefits rather than explicit management objectives (Jennings, 2001). In the absence of explicit management objectives for MPA design, the *post hoc* assessment of MPA effectiveness is difficult or impossible. Such evaluation might be used to draw lessons for future designs and monitoring programmes. Replicates of both reserves and harvested populations monitored before and after reserve establishment will be needed to unambiguously assess fishery benefits of reserves (Carr and Reed 1993; Russ, 2002).

Even no-take zones do not mean actual protection from human activity for certain highly vulnerable communities and species, even though they are not being fished. Therefore, other management practices should be considered, e.g. in the Great Barrier Reef no-entry zones show a better response to protection than no-take areas (McCook *et al.*, 2010). Valuable exploited species (mainly fish) react quite well to prohibition of fishing, but fragile unexploited species (such as the purple gorgonian, many bryozoans and other benthic organisms) and communities (submarine caves, coralligenous) are exposed to a quick devastation due to over-frequentation of divers attracted by the big fish inhabiting no-take zones inside the MPAs (Ballesteros, 2006). Nevertheless, the effectiveness of large-scale MPA networks has been demonstrated in numerous studies, e.g. the Great Barrier Reef, which exhibit rapid benefits of no-take areas for fish and invertebrates (McCook *et al.*, 2010).

The results of protection are overwhelming on fish populations, especially in those species highly vulnerable to fishing, but it is not clear that all species and/or communities prosper as well inside MPAs. For instance, some groups such as slow-growing algae or sessile invertebrates are key species in the settlement processes of numerous fishes and are essential to general ecosystem functioning. These groups are mostly neglected in the management protocol of MPAs. As a result, the objectives of future and existing marine protected areas should be to clarify and redefine purposes. The marine reserves engaged in fishing management must have the appropriate degree of protection to preserve effectively a significant part of the exploited populations, while in the conservation-dominated MPAs it should be clear what to protect and how this should be done to achieve positive results (see case study 8, Sedlo Seamount). Both conservation and fishing management are compatible in large MPAs, where the aim is to get an ecosystemic and sustainable fishery management.

C.3 Enforcement & surveillance of networks of MPAs

'Enforcement' of MPAs or networks of MPAs includes all actions to achieve compliance with a given set of rules or regulations governing them that vary from customary laws and local regulations to national and international legislation.

'Surveillance' is the most important operational component of enforcement and is defined as the maintenance of an observation infrastructure (encompassing a wide range of technical platforms, equipment and trained personnel) capable of detecting and notifying authorities of conditions, activities, or events of interest within an area (Bailet *et al.*, 1999). At-sea surveillance can be strengthened by technological means such as Vessel Monitoring Systems (VMS), radar, aircraft support, and satellite observation platforms (see case study 9, Darwin Mounds). In terms of networks of MPAs, surveillance is relevant not only for the designated MPAs but also for the surrounding areas, especially regarding extractive activities and marine pollution, as a common risk for MPA failure is the degradation of surrounding unprotected ecosystems (Agardy *et al.*, 2011). In fact, surveillance innovation and monitoring, such as using satellite technology and drones that can observe vessels' thermal spectrums, can cost-effectively assist specific management actions (such as no-take policies), which in turn might inform management approaches.

The enforcement strategy in a network of MPAs may encompass a range of discursive and coercive measures, ranging from self-regulation to aggressive enforcement activities. Discursive (or preventive) enforcement through environmental education and awareness, community participation projects, and volunteer programmes aims to increase community capacity. This capacity, referring to the rules, procedures and values that people hold, which predispose them to work collectively for mutual benefit (Rudd, 2000; Jameson *et al.*, 2002). If community capacity is low, illegal activities are likely to occur (Rudd *et al.*, 2001).

However, discursive enforcement will not suffice alone. Economic gains from illegal fishing can be very high and thus the potential for poaching will always exist especially in MPAs that have succeeded to enhance fish biomass. By increasing the severity and likelihood of sanctions (criminal or civil penalties, catch and vessel seizures, permit sanctions) and thus raising the opportunity cost of non-compliance, enforcement systems act directly upon resource users to foster adherence with established rules (Mascia, 2004). There are many examples where aggressive enforcement dramatically increased compliance (Mascia, 2004). Enforcement systems also affect compliance indirectly by affecting rates

Case study 8: Sedlo Seamount Marine Protected Area

Background

Sedlo is an isolated seamount in the north-east Atlantic, 180 km north-west of Graciosa Island, within the Azores exclusive economic zone (Portugal), and one of the components of the Azores Marine Park (DDR, 2011). Sedlo is elongated, flat-topped, about 75 km by 30 km, and has three peaks, reaching 660m at its shallowest part (Figure 10). The benthic epifaunal community is dominated in most places by sessile megabenthos, chiefly Hexacorallia – anemones and true corals – and sponges. The seamount is known to accommodate one of the Azores' most important spawning orange roughy aggregations, with higher abundances between 1000 and 1200 m. Important reproductive aggregations of alfonsino (*Beryx splendens*) and cardinal fish (*Epigonus telescopus*) were also found at Sedlo (Menezes *et al.*, 2009). In 2007, Sedlo was proposed by Portugal for inclusion in the OSPAR MPA Network, and was accepted by the Parties in 2008. A preliminary management plan has already been discussed and agreed upon among the main stakeholders (Santos *et al.*, 2009), and is expected to be the core of the regulatory law decree.

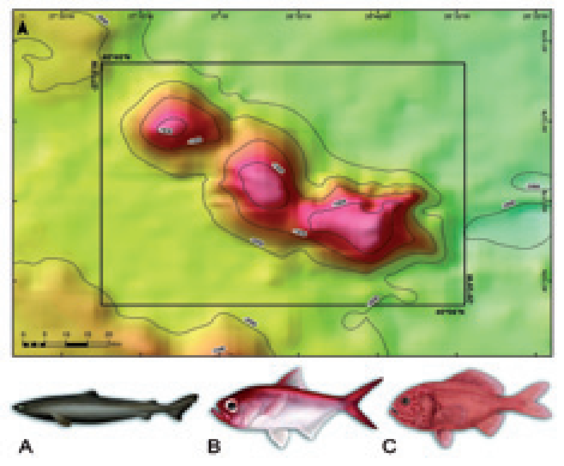


Figure 10: Map of the Sedlo Marine Protected Area adapted from Ribeiro & Santos 2011 (credit F Tempera & R Medeiros ©*Imag*DOP). Illustration of three species of fishes which occur in Sedlo and whose conservation is considered a priority: A - *Centroscymnus coelolepis* - Portuguese dogfish–; B – *Beryx splendens* – alfonsino; C – *Hoplostethus atlanticus* – orange roughy *(credit Les Gallagher © fishpics & ImagDOP).*

Management scheme

The management plan is discussed in detail by Santos *et al.* (2009). Key elements are:

- To safeguard the biodiversity of Sedlo and its surrounding waters for seamount-associated marine communities, including aggregating species, and visiting species.
- To avoid unsustainable exploitation of species and disruption of the natural processes which support the structure and function of the Sedlo ecosystem.
- To safeguard the potential for species using Sedlo as a spawning, nursery or feeding ground to enhance the biodiversity of surrounding areas.
- To increase scientific understanding of processes governing seamount ecosystems in the absence of human impacts.
- To increase local, national and international public interest for and understanding of the conservation of offshore areas in the OSPAR Maritime Area.

Issues

Sedlo is an unusual case because at present there is very low level of human activity in the area. Bottom trawling, gill netting and trammel netting are currently banned by the Council of European Union (Regulation 1568/2005 of 20 September). However, fishing bans are not permanent. Long-term protection is regarded as vital to preserve the spawning grounds from future commercial fishing activities. Sedlo therefore falls under Category 1a of the IUCN (1994) – "strict nature reserves/wilderness protection areas managed mainly for science or wilderness protection".

Lessons learnt	Research priorities and needs
Long-term protection is regarded as vital to preserve the spawning grounds from future commercial fishing activities.	Deep ROV observations on species, densities and distribution of coral water corals and sponge aggregations.
Given the isolation of Sedlo there may be little enhancement of surrounding fish stocks by a "spill over". However, it is possible that fish spawning around Sedlo Seamount support a widely dispersed stock (Santos *et al.*, 2009).	Standardized sampling allowing reliable inter-seamount comparisons of occurring fish species, density and/or biomass. Genetic studies.
MPA proposals should not be viewed in isolation but would benefit from being set into the context of a fisheries strategy as well as a biodiversity conservation strategy for the Azores EEZ (Santos *et al.*, 2009).	Study and comprehensive understanding of seamount ecosystems.

Case study 9: Darwin Mounds

Background

The Darwin Mounds area of cold water corals was discovered in May 1998. They are a novel geographical formation in the northeast corner of the Rockall Trough at around 1000 m depth scattered across approximately 1500 km^2. The field contains hundreds of individual mounds typically 5 m high and 100 m in diameter that support a substantial population of the cold water coral *Lophelia pertusa* and xenophyophores (giant protozoans) and a diversity of benthic invertebrates and deep water fish (Bett, 2001). Surveys in 1999 and 2000 identified trawling damage, so in early 2001 the UK Government made a commitment to protect the mounds as a Special Area of Conservation (SAC) under the Habitats Directive. It was not until June 2003 that a formal approach was made to the EC for their protection. An emergency closure was put in place in August 2003 and was made permanent in March 2004 when the EU Fisheries Council adopted a permanent regulation to protect the Darwin Mounds area from the effects of trawling (see De Santo and Jones, 2007 for full details). In 2008 the Darwin Mounds were designated as a Natura 2000 site.

Management Scheme

A management plan was proposed by WWF (Gubbay *et al.*, 2002). This lists areas of vulnerability, which were included in the proposal to include the Darwin Mounds as a Natura 2000 site. The vulnerability case concentrates mainly on the impact of bottom trawling, which can cause physical loss and damage to the reefs, destroy the communities and resuspend sediment. The oil and gas industry is not currently active in the area but could add chemical contamination to this list if it were to begin operations nearby. The vulnerability list highlights the areas where management measures and targets are required e.g. to conserve the total area of living coral and to retain the species diversity.

Issues

Extensive trawling damage was recorded in the area (Wheeler *et al.*, 2005). The 5-year interval between first discovery of the mounds and the initial fishing closure allowed ample time for trawlers to target the site knowing that it would eventually be out of bounds. A second problem highlighted by the Darwin Mounds is enforcement in remote areas. The main tool for this is the mandatory Vessel Monitoring System (VMS) that is fitted to all vessels fishing in EU waters in excess of 15 metres length (12 m from 2012), though for the rest of the NE Atlantic (NEAFC area) the requirement relates to vessels over 24 m long. Since 2005, all European Community vessels automatically transmit vessel identification, date, time, position, course and speed every 2 hours (position information every hour in NEAFC area). As bottom trawlers regularly fish along the boundaries of closed areas 2-hourly interval is insufficient to ensure compliance. The VMS information does not currently include gear type or information on fishing activity e.g. bottom trawling or pelagic fishing which is critical if the site protects the seabed but not the water column. In this case pelagic fishing would be allowable but not bottom trawling.

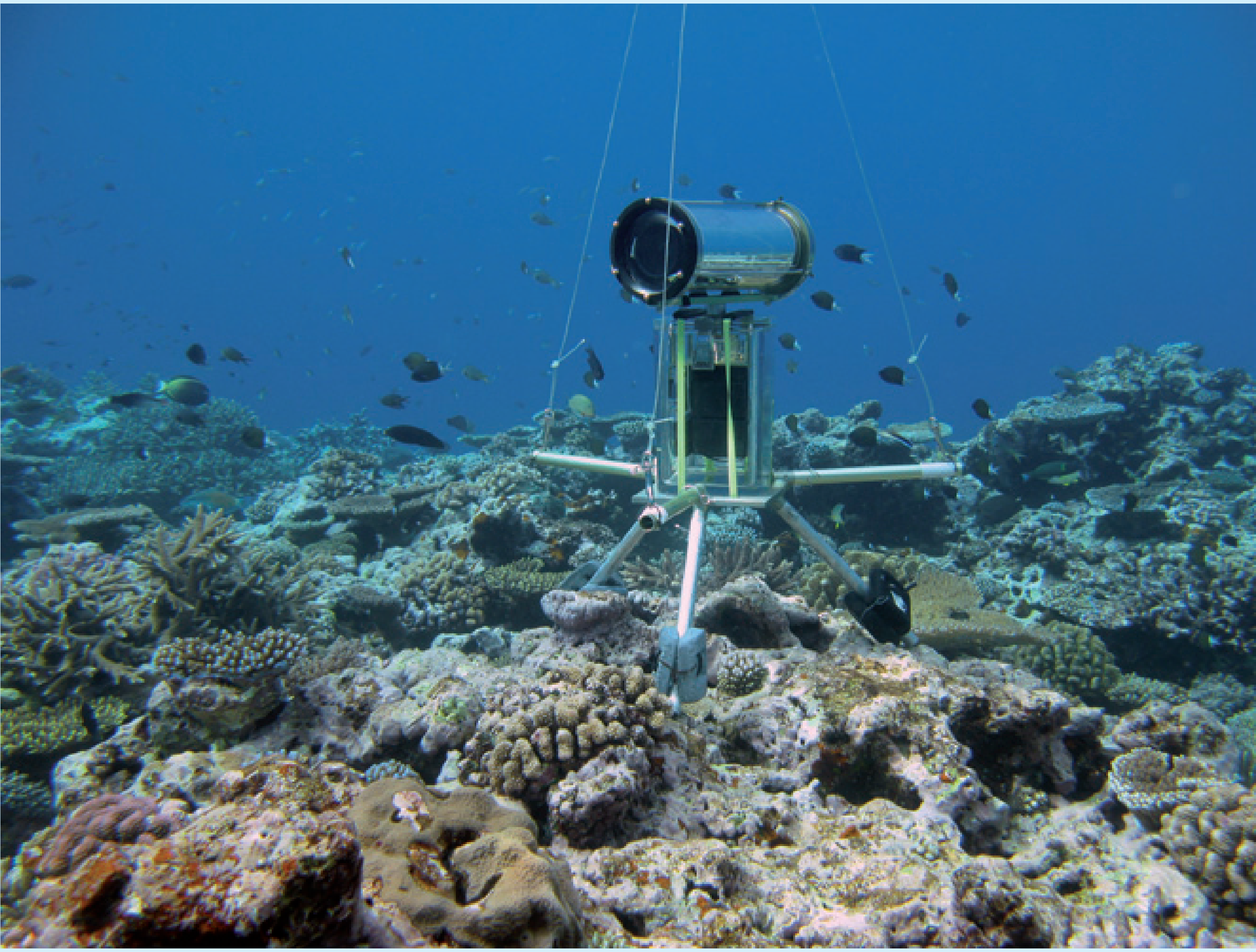
Lessons learnt	Research priorities and needs
Introduce temporary closures at an early stage during which the potential of the site can be evaluated.	
Enforcement and Vessel Monitoring System (VMS): i) A 2 hour interval is insufficient to ensure compliance. ii) iVMS information does not currently include gear type or information on fishing activity.	Researchers need access to aggregated VMS data.

of "contingent compliance", where individuals base their decision to comply with regulations upon the perceived rate of compliance by others (Mascia, 2004).

Funds available for management of MPAs globally are extremely limited; this seems to be the most important limiting factor for effective surveillance and enforcement. Other limiting factors include lack of necessary equipment, facilities and training, insufficient political support, lack of government commitment, corruption, bureaucracy, and ineffective power-sharing and decision-making. Partnerships between governmental and private NGOs or foundations might enhance the surveillance and enforcement potential. Such is the case of the broad enforcement partnership between the management agency of the Galapagos Marine Reserve and the Sea Shepherd Conservation Society.

Ultimately governing MPAs involves coordination through involvement of a wide range of institutions and actors (Jones *et al.*, 2011) and the IUCN protected area matrix (Day *et al.*, 2012, Annex 1) provides a useful tool for plotting governance types against protected area categories.

D. Science needs and priorities for achieving coherent MPA networks in Europe



Remote underwater video system on a New Caledonian reef (courtesy, Ifremer)

D. Science needs and priorities for achieving coherent MPA networks in Europe

D.1 A more rigorous scientific approach, including baselines and controls

From a scientific perspective, MPAs can be viewed as part of the full-scale "experiment" that human beings are conducting in the marine environment, with MPAs acting as control areas for the impact of the various human activities in various habitats and ecological communities in non-protected areas. The aim of using MPAs as control sites is to confirm not only mere differences among protected and unprotected zones, but to understand how protected zones evolve differently from the others, hence unravelling the effects of the various human "treatments". Furthermore, one should replicate the "experiment" regionally, to ensure the generality of the result.

Beyond the scientific value of MPAs, there is also a broad societal expectation that MPAs in some way help marine ecosystems to recover as well as to absorb human impacts; i.e. that they increase the resiliency of affected marine ecosystems. While these are both valid expectations, current design and management of European MPAs has hampered the achievement of these roles. In this section, it is argued that the scientific as well as societal value of MPAs could be increased through: a) broader monitoring; b) consistency and stringency of management control measures; and c) explicit application of experimental design principles.

D.1.1 Monitoring

Documenting human effects outside reserves requires appropriate monitoring both outside and within MPAs as well as recognizing the different categories of MPA protection (see Table 6). The design and subsequent monitoring should include long-term gradients of fish biomass and yield across reserve and treatment locations (e.g. Goñi *et al.*, 2006, 2008, 2011; Stobart *et al.*, 2009). Some benefits within reserves may be expected to affect the immediate surroundings, and could include the movement of some adults and particularly juveniles from the reserve to non-protected areas (the 'spillover' effect); the transport of early life stages (eggs and larvae) from reserve to non-protected areas (the 'recruitment' effect); as well as an overall increase in reproductive potential due to a greater density of mature adults (e.g. Diaz *et al.*, 2011). To separate out these various effects, monitoring should include sampling of both early and older life stages (see Russ (2002) for a more complete explanation).

Reserves will affect trophic levels differently, with the top levels often predicted to recover somewhat at the expense of mid-trophic levels (e.g. Salomon *et al.*, 2002), as might be expected since the opposite effect has been observed with regard to fishing outside reserves (Polovina *et al.*, 2009). In order to separate out such effects, monitoring should be stratified according to broad trophic categories.

Effects inside reserves:

- Significantly lower fishing mortality than in fished areas.
- Significantly higher density of target species.
- Significantly higher mean size/age of target species.
- Significantly higher biomass of target species.
- Significantly higher production of propagules (eggs/larvae) of target species.

Effects outside reserves:

- Effects 1-4 above result in net export of adults (the spillover effect).
- Effects 1-5 above result in net export of eggs/ larvae (the recruitment effect).

Table 6. Expected effects of marine reserves (Russ, 2002).

A commonly stated goal of MPAs is to "preserve biodiversity". In such cases, monitoring should be designed to measure biodiversity in its three dimensions: species richness, abundance, and taxonomic distance (e.g. taxonomic distinctness as per Clarke and Warwick, 1998). This will require more comprehensive sampling than normally takes place inside and outside of European MPAs.

D.1.2 Management control measures

Site-specific management measures can be expected to be effective according to a) their relevance to all of the stated MPA's objectives; b) the degree which they alter human behaviours inside, as compared to outside, protected areas, and c) the level of compliance (which is further discussed below). Hence, sweeping and stringent management measures, such as no-take regulations, are more likely to produce readily measurable results than partial ones (e.g. Aburto-Oropeza, 2011). Should partial management measures nonetheless be applied, then a greater level of investment will be needed to support more frequent monitoring, allowing for statistical analysis capable of detecting the likely reduced effect.

MPA networks are based on multiple assumptions about connectivity, spillover and recruitment effects (Kaplan *et al.*, 2009). Measurement of network-level effects involves designing controls for many more variables than site-specific effects, thus requiring sophisticated and co-ordinated monitoring programmes across the network. Successful monitoring is likely to hinge on consistency of protocols and management measures across sites, ecological regions, and ideally, jurisdictions. Currently, MPA management plans are usually developed on a site-by-site basis, varying in management and sometimes also monitoring methods, thereby introducing additional variables to an already very complicated picture. In this current situation, the likelihood of detecting network level effects is greatly reduced. As with single MPA sites, broader more restrictive network-wide controls are more likely to be detected than a collection of partial measures.

An essential prerequisite is setting clear management measures right from the outset, based upon understanding the nature of the problem that the MPA or MPA network is attempting to address. A good example of this approach was initiated by the EU FP6 PROTECT Project that devised detailed GOIS (Goals, Objectives, Indices and Success Criteria) tables both for Baltic and North Sea Case Studies and deep sea corals (Protect, 2009).

D.1.3 Experimental design

Ideally experimental design should introduce controls for before and after treatment effects, and hence ideally there is the need to collect baseline data prior to reserve establishment (Russ, 2002), although this is seldom done. As discussed above, in order to better separate reserve recovery effects from other environmental changes, there is a need to monitor both within and outside of the MPA(s), stratified according to similar habitats and biomes. Abundant species are more easily sampled and also are often a good indication of ecosystem health. Also discussed above, the selection of indicator species will be driven by several considerations, including their sensitivity to environmental and human stressors that are of interest, as well as the role that they may play in the ecosystem as "umbrellas". Likewise, habitat engineers are often important in maintaining biodiversity and ecosystem function (Hooper *et al.*, 2005), and have been suggested as conservation targets (Crain and Bertness, 2006). To understand the impact of different human activities on key species and habitats, responses to natural dynamics (as well as changing environmental variables) will need to be separated out in the design of the MPA monitoring programme. Again, the principles of good experimental design apply; e.g. Before-After/Control-Impact (BACI) studies.

D.2 Understanding connectivity

A coherent network of MPAs hinges on good connectivity. While connectivity can be approximated through network design "rules of thumb" (e.g. minimum spacing requirements), a more comprehensive approach requires gathering considerably more information about the connectivity of the marine populations in question, at various spatial scales (see also, Fenberg *et al.*, 2012). Proper connectivity between protected areas is necessary to ensure both the persistence of local populations and the export of adults/larvae outside the boundaries of the MPAs (Harper and Warner, 2003; Gaines *et al.*, 2010). In addition to size and spacing of MPAs, locating reserves should consider, when possible, patterns of connectivity in view of source/sink populations and habitat fragmentation. In general, biological connectivity is linked to larval dispersal and to movements of recruits and adult stages of populations.

A coherent network of marine protected areas should produce synergistic effects on the ecosystem, meaning that there is a positive effect on the system as a whole which is more than the sum of contributions from individual sites. Such synergistic effects rely upon MPAs each affecting the others in the network: a) spatially through larval dispersal and adult movements (Gaines *et al.*, 2010), b) temporally meeting the various life-history requirements of the species in question; and c) functionally through the interaction of different ecosystem components that influence each other (e.g. multiple predator-prey relationships, carbon cycling, oxygen production, etc.). Hence, connectivity is a multi-dimensional measure containing spatial, temporal, and functional components. It is perhaps the most often stated goal of MPA network design, while being the least understood.

In coastal areas, structuring species such as seagrasses and algae as well as coastal fishes and invertebrates usually function as metapopulations, i.e. a large number of sub-populations dynamically linked by connectivity through larval (and in some cases, adult) dispersal. Connectivity due to movement of older life stages can often be quantified using traditional methods such as capture-mark-recapture. Furthermore, fine scale movement patterns between protected and unprotected areas can be tracked by new tools such as acoustic telemetry monitoring arrays (e.g. Meyer *et al.*, 2000; Meyer and Holland, 2005). Understanding patterns of connectivity caused by dispersal of early life stages (eggs and larvae) remains a major challenge with only a few case studies available to date (e.g. Pelc *et al.*, 2009). One genetic parentage analysis revealed larval dispersal distances ranging from 15 to 184km, including recruitment from MPAs (Christie *et al.*, 2010). In another genetic parentage study, reserves, which accounted for just 28% of the lo-

Studying larval dispersal

Many marine species are characterised by a pelagic larval phase, which can connect otherwise sedentary or restricted range populations over large distances. Together with the lack of obvious barriers for dispersal in the marine environment, this has led to the paradigm that marine populations are demographically open, potentially over hundreds to thousands of kilometres. This paradigm was supported by some studies that found little genetic variation of some common species over broad spatial scales (e.g. Babucci *et al.*, 2010; Hamdi *et al.*, 2012).

However, a second body of research has shown evidence of restricted dispersal for many other species, pointing to the existence of fine-scale structure in dispersal patterns, thus challenging the paradigm that marine populations are demographically open at broad spatial scales (Jones *et al.*, 2005; Almany *et al*,. 2007; Cowen and Sponaugle, 2010). Recent syntheses argue against broad generalization of the relative open or 'closedness' of marine populations.

Connectivity in marine populations is not uniformly polarized towards long or short distances, but instead distributed over a wide continuum of scales (Bradbury and Snelgrove, 2001; Mora and Sale 2002; Kinlan and Gaines 2003; Shanks *et al.*, 2003; Shanks 2009). Furthermore, evidence from hydrodynamic models and genetic structure data indicates that the average scale of larval-propagule connectivity can vary widely even within a given species, at different locations in space and time (e.g. Cowen *et al.*, 2003; Sotka *et al.*, 2004) and the degree to which a population is 'open' or 'closed' depends on the temporal and spatial scales at which population dynamics are being studied.

The wide variation in scales of propagule connectivity argues that the only answer to the often-debated question 'How open are marine populations?' is, 'It depends.' (Mora and Sale, 2002). Thus, connectivity amongst MPAs in a region will also vary widely across spatial and temporal scales. Management needs should be examined case by case, according to the conservation objectives and the particular characteristics of the species and habitats in question. Stronger focus is often given to key species, ecosystem engineer species and species with explicit legal requirements (e.g. red listed species). The study of connectivity through larval-propagule dispersal is multidisciplinary involving oceanographic and population modelling, larval ecology and population genetics.

cal reef area, produced approximately half of all juvenile recruitment to both reserve and fished reefs within 30 km (Harrison *et al.*, 2012). These case studies, albeit few, show promising results and point the way by using new approaches such as genetic parent-offspring analyses to determine the source of juvenile life stages (e.g. Saenz-Agudelo *et al.*, 2009).

A general understanding of the effectiveness of MPA networks as a fisheries management and conservation tools will depend on a broader range of case studies that apply new methods (such as genetics) to quantify connectivity. Assessing a coherent network of MPAs ideally requires an EU-wide coherent network of monitoring stations, particularly for evaluating recovery processes inside MPAs and connectivity among MPAs. For the dispersive propagules it may be possible to monitor movement of coastal water masses. For adult dispersal, tag-recapture (e.g. Williams *et al.*, 2009; Goñi *et al.*, 2006, 2010) or networks of telemetry receiver stations (references above) may be used (See: http://imos.org.au/about.html).

D.3 Ecological mapping and classification as a means of determining MPA network representativeness

As discussed in Section B, ecological mapping is a prerequisite to effectively design and implement ecologically representative networks of MPAs. At a sufficiently fine scale, the results of ecological mapping can inform the characterisation and delineation of ecological biomes. If comprehensive data are not available, biomes can be determined through habitat sampling and classification procedures (Howell, 2010). Once a classification is developed, MPA networks and proposals can be checked for representation across classes. However, due to mismatches of scale, in a broad scale habitat classification, important ecological details can still be unintentionally overlooked, creating a false sense of homogeneity (Williams *et al.*, 2008). Geomorphic classification systems, while one step removed from habitat classification, can nonetheless offer insight into ensuring better ecological representativeness of an MPA network (Harris and Whiteway, 2009). If a given region has more than one credible classification system, all should be used in the assessment of representativity, since different systems tend to emphasise different habitat components and process scales.

Several efforts to map habitat and species distributions have been carried out in Europe. However, information on the spatial distribution of ecological components remains poor in many regions, although in some cases this can be augmented by modelling studies (e.g. Druon *et al.*, 2012).

D.4 Considering resilience to climate change.

Climate change is now considered to be a certainty, though how the change will occur is still very uncertain. Within this context of increasing environmental change and variability, MPAs remain fixed in space. Species in European waters might move northward out of protected areas, while some southern species, as well as exotics, could thrive. Larval development times, and therefore connectivity patterns, will be influenced by climate change. Measuring the responses and resilience of an MPA-network in the face of climate change is a major challenge. In the face of this challenge, strategies will need to be developed that allow for maximising network resilience, whereby even if one or two MPAs are adversely affected, the overall network can continue to function (see e.g. IUCN and MedPAN, 2012). Common strategies usually call for greater redundancies; i.e. increased replication and size of sites (McLeod *et al.*, 2009). This approach is supported by modelling that suggests fewer but larger reserves could absorb variability more robustly than several tightly fitted, purpose-specific, smaller reserves (McCarthy *et al.*, 2011).

D.5 No-take zones and recovery

No-take zones (NTZs), or marine reserves (Fenberg *et al.*, 2012), are marine areas in which the extraction of living and non-living resources is prohibited, except as necessary for monitoring or research (Jones, 2006). As such, they are amongst the most restrictive types of MPAs (only exceeded by no-entry areas) and thus equivalent to Category I (strict nature reserve/wilderness area) under the IUCN's protected area management categories. Although, as explained previously, a wide variety of designation terms is used to describe them, e.g. marine reserves, highly protected marine areas, marine preservation zone, scientific zone, etc. These NTZs make up a small fraction of the total area encompassed by existing MPAs. The case studies that have been conducted show that NTZs can display particularly strong responses to protection (Claudet *et al.*, 2008, 2010; Vandeperre *et al.*, 2011). NTZs are therefore extremely valuable as assessment tools, because partial protection is either ineffective (e.g. Denny and Babcock, 2005) or demonstrably less effective than NTZs (e.g. Lester & Halpern, 2008), although enforcement issues may be involved (see Section C.3). Also without no-take zones, it is very difficult to assess the effectiveness of partial protection (example case study 5: North Sea Plaice Box, page 38), or to better understand the ecosystem baseline and how it could be shifting. However, heavily impacted ecosystems may, under protection, take years to reach equilibrium (Clutton-Brock & Sheldon, 2010) and this may not mean a return to the pre-exploitation state, but rather a novel mixture of old and new elements. Hence, for the purposes of studying the effects of human pressures, both (quasi-) pristine and recovered control sites can offer differing insights, concerning the fall and rise of ecosystem structure, function, and process. This is particularly the case for informing the fishery size/age debate. Research on the impacts of fishing for commercially exploited fish (Law, 2000; Walsh *et al.*, 2006; Hsieh *et al.*, 2006) suggests a 'genetic truncation' resulting from extracting the majority of larger/older individuals from wild populations.

D.6 Human responses, socio-economic effects

Empirical assessment of socioeconomic effects of MPAs is sparse. The complexity of the human responses is due to a vast array of interactions ranging from local traditions to complex national and international legislation that is constantly evolving (Badalamenti *et al.*, 2000; Roncin *et al.*, 2008). Some examples have demonstrated the positive effects of MPAs in adjacent areas, for instance marine reserves may displace fishing effort and could, potentially, lead to increased fisheries yields in areas surrounding protected sites (Russ *et al.*, 2004). In the Mediterranean Sea, Medes Islands MPA (see case study 3) represents an interesting example of the joint use of extractive and non-extractive activities, demonstrating the benefits for artisanal fisheries and for non-extractive activities (e.g. tourism) as income and employment generators (Merino *et al.*, 2009). Pressures due to tourism activities can be very significant, and should not be disregarded in the development of MPA management and monitoring protocols (e.g. Zakai and Chadwick-Furman, 2002).

D.7 Possible linkages between scientific monitoring and surveillance

Surveys of MPA users, managers and researchers indicate that many MPAs are "paper parks" which lack compliance on the part of resource users and enforcement on the part of management agencies (Jameson *et al.*, 2002). Ineffective or even absent surveillance and enforcement will clearly lead to failure to reach the MPA objectives, which can increase the negative reactions of local communities who see little benefits from the protected areas (Guidetti *et al.*, 2008). Once communities become used to breaking the rules, the cost to reverse and invert such a negative established position can be much greater than what it would have cost to instigate comprehensive surveillance and enforcement from the very beginning. Paradigms of MPA failures will create

PAMPA: A collaborative and interdisciplinary project for assessing MPA performance

The French PAMPA project (funded from 2008 to 2011 by the French Ministry of Ecology, with additional support from the French Initiative for Coral Reefs, and the Marine Protected Area Agency) aimed at defining, testing and validating indicators of MPA management effectiveness. It involved close collaboration between French scientists from several disciplines and managers from eight MPAs located in the Mediterranean and in French coral reef areas (Pelletier *et al.*, 2010). The first step in the project was to devise a consensus formulation of management objectives, corresponding actions, and managers' constraints and needs (Figure 11). A large number of indicators related to biodiversity, resources, uses and governance were then tested from numerous field data. Finally, validated indicators were organized into performance tables for each management goal. Operational and documented tools for indicator production were developed such as a database, analytical and computational software, and recommended protocols for data collection. Considerable effort was devoted during the project to the validation of data collection methodologies and indicators describing uses and governance.

In a follow-up of the project, the methodologies, tools and guidance documents developed are, at the time of publication, in the process of being transferred to a number of candidate MPA managers. From the PAMPA experience, it appears that future research studies to evaluate the dynamic of managed coastal ecosystems and to support management actions should explicitly account for the relationships between biodiversity, pressures, governance and management responses. This would also provide system-wide insights for improving the understanding of the carrying capacity of coastal ecosystems (from an ecosystem service point of view) and ecosystem resilience. The collaboration between scientists and MPA managers could be a win-win strategy where adaptive management and monitoring provide data for improving knowledge, and in return indicator-based assessments provide meaningful advice for decision-support.

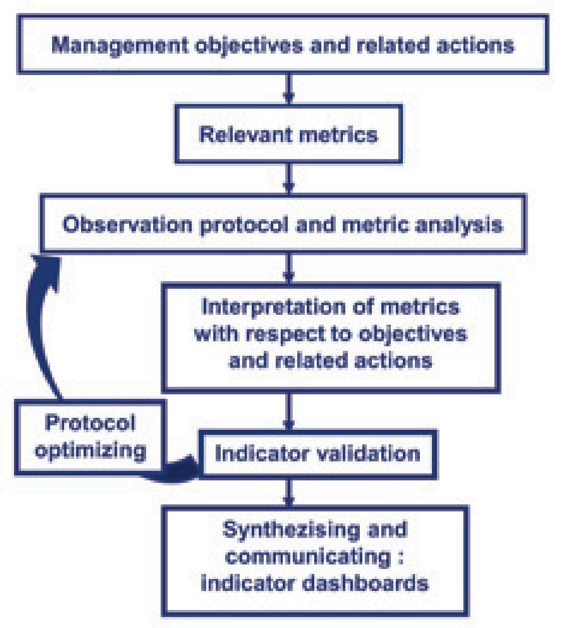


Figure 11. Overall scheme of the PAMPA methodology. Most steps involve collaboration with MPA managers (from Pelletier, 2011). http://wwz.ifremer.fr/pampa

a general public feeling of bad management of marine areas and useless restrictions, risking the abandonment of MPAs by decision makers and politicians. On the contrary, successful MPAs that meet their objectives can encourage compliance and a positive attitude by users in neighbouring MPAs as well.

An issue shared by enforcement and research programmes is chronically low funding. Scientific monitoring shares operational similarities with surveillance in several ways which could allow for cost savings, e.g. in the use of remote devices such as buoys and satellites, or manned over-flights and cruises to gather data. To date, the two very different cultures of enforcement and scientific research have rarely come together. Differences in approach could be reconciled. For example, surveillance activities are generally in real-time or near-real-time, whereas scientific monitoring may rely on longer time lags before remote sensor data are uploaded. However, scientific sensors can usually be readily upgraded to provide near-real-time data, at much less cost than the installation of a completely new surveillance device. Likewise, surveillance cruises often encounter wildlife, which could be readily recorded using an on-board recorder or human observer. Clearly, a better understanding of human activities within an MPA network would benefit both worlds, allowing for better direction of limited enforcement assets, as well as better focussed scientific monitoring of the effects of those human activities. Arguably the biggest obstacle is cultural: the mutual reluctance of each side to approach the other.

D.8 Clarifying legal issues for enforcement and surveillance of national/international networks of MPAs.

As noted above, certain European legal questions have slowed down or blocked the effective management of protected areas. Legal research to clarify these issues would benefit scientific endeavours as well. For example, it is unclear how the management of the water column beyond national jurisdiction (the high seas) by an international body can be jointly managed with a State laying claim to an outer continental shelf, and if there is a legal requirement for cooperation. Likewise, within European waters, there is disagreement concerning the relative powers of Member States to enact measures in order to meet their requirements to protect the environment versus the powers of the European Commission to regulate activities under the Common Fisheries Policy. Legal clarity on how to balance and reconcile these two, at times conflicting, management activities, would also be very helpful in setting up scientific controls (no-take zones) and other related research.

D.9 Improving the social science surrounding stakeholder participation

Insufficient involvement of stakeholders has been a common cause of failure for many MPAs. A contributing factor might be that certain stakeholder groups were under-represented or were brought in too late in the planning process (Pettersen *et al.*, 2009; Agardy *et al.*, 2011). When MPAs are established based on a top-down approach, they are viewed as being imposed on locals by “outsiders” creating negative reactions (Badalamenti *et al.*, 2000). Conversely properly facilitated stakeholder participation processes can reduce potential user conflicts and increase public understanding and support (see Merino *et al.*, 2009). Perceptions that MPAs have no clear benefits, unfairly highlighting a particular user group, or that their establishment is just an attempt to restrict legitimate uses by local communities, will adversely affect compliance and therefore lead to the necessity for increased enforcement (Kritzer, 2004; Agardy *et al.*, 2011).

Persuasive methods which increase awareness through education and actively involving the local communities can often be more effective to enforce MPA regulations than coercive measures, such as financial penalties or prosecution. MPA success is higher when communities collectively support the MPA and government agencies provide the necessary financing, monitoring, enforcement, and technical expertise (Jameson *et al.*, 2002). “Co-management” frameworks constitute the strongest form of stakeholder participation, wherein management authorities, decision-making powers and enforcement responsibilities are shared among representatives of user groups, government agencies, and research institutions through various mechanisms (Jentoft *et al.*, 1998; Christie *et al.*, 2002; Davis and Moretti, 2005). Such co-management ventures can collapse due to the much greater efforts required from both sides. A better understanding of successful and unsuccessful approaches to stakeholder relations would in the end also benefit sustainable use and the protection of marine biodiversity (see case study 10).

Case study 10: Working with people for coastal wildlife - the North East Kent European Marine Sites Management Scheme

Background

The North East Kent European Marine Sites (NEKUMS) have been recognised as being of international importance for over a decade. The area comprises a number of nature conservation designations:

- Two Special Areas of Conservation (Thanet Coast SAC; Sandwich Bay SAC to the high watermark)
- Special Protection Area (Thanet Coast and Sandwich Bay SPA)
- Ramsar site
- National Nature Reserve
- Site of Special Scientific Interest (SSSI)
- Natura 2000 site

The area is subject to high social and economic pressures from the key towns and tourist resorts which fall within the coastal fringe of the marine sites. Local inhabitants and thousands of visitors use the coast for sport and relaxation. Bait and shellfish are harvested; there is a port and several harbours; the cliffs and shore are managed for sea defence. The area also faces pressures from new development and the disposal of treated waste water.

Management scheme

In 2001, following a stakeholder consensus-building process, the first Management Scheme for the NEKEMS was released. The scheme established a robust management structure for marine sites while fostering good working relationships between all relevant authorities and engaging the community in the active management of the sites. It also created the Thanet Coast Project (http://www.thanetcoast.org.uk/default.aspx) which was set up as a result of workshops held with stakeholders. The aim of the project is to drive forward the priorities which had been identified. In conjunction with people involved in coastal activities the project developed a series of voluntary codes for various coastal activities including shell-fish harvesting and netting, bait digging and collecting and marine wildlife watching. In 2006 the first Management Scheme expired. This offered an opportunity to review and redraft a new scheme to run between 2007–2012. The Management Group and the Science Advisory Group also took the opportunity to take a more holistic approach through the adoption of the Ecosystem Approach. The revised Management Scheme would go beyond the designated features of the site to include other habitats and species, ecosystem functions and also human interactions within the area. A stakeholder dialogue process was used to support development of the updated scheme. This included a series of facilitated workshops at which stakeholders could actively contribute to the creation of the scheme through dialogue and a series of Subject Assessment Tables for all the activities occurring in the area.

Lessons learnt	Research priorities and needs
Management measures identified as particularly successful: • Effective working relationships between all relevant authorities • Implementation of the Coastal Codes • Awareness raising by the Thanet Coast Project	Communicating scientific messages in an understandable form to a wide range of stakeholders is beneficial to long-term acceptance of conservation goals.

Conclusions and recommended research priorities

Juvenile Lobster, Columbretes Islands, Spanish Mediterranean (courtesy, David Díaz)

European MPA initiatives are essential and integral for achieving the goal of 'good environmental status', which in turn supports the effort needed to meet international targets seeking to achieve reduced loss of biodiversity and sustainable development. However, European MPA designation has been somewhat *ad hoc*, which has left open questions about MPA efficacy at the site- and network-level. With human activity increasing in the maritime sector, marine protected area science poses several policy-relevant research questions. By providing the prospect of bringing together theoretical ecology, supported by *in situ* species and habitat monitoring, with practical management implementation advice, MPA research has a unique opportunity to gather the European marine research community to address these critical issues. In the preceding chapters, through case studies and literature review, themes for further research have been discussed. Here, these themes are distilled into ten research recommendations:

1. Coordinate the work of marine surveys and collate the data across projects and jurisdictions

If MPAs are to protect the full range of marine biodiversity at multiple levels then multi-beam surveys with biological surface and deep-water sampling are a critical first step in understanding the three-dimensional marine environment. Existing data (often from separate research cruises) should be collated, on-going work should be completed, and geographical gaps filled. There are several questions concerning different methodologies and how they can be combined or harmonised. In some cases, it may be necessary to simply let them stand alone. But, where possible, data should be collated and merged across collection areas and jurisdictions, and made available to all European researchers. MPA data should be held in a central European marine data repository, or accessed via a common portal such as EMODnet, building on the lessons of national, sub-regional and regional attempts (e.g. MAIA and MedPAN).

2. Refine and establish marine habitat classifications across European waters

In order to establish representative networks of MPAs, survey data will need to be combined, analysed, and synthesised into biogeographic classifications, and recommendations for future data collection methods based on past experience. Finer scale products, using scales relevant to local and sub-regional planning should be encouraged. Modelling the distribution of critical or vulnerable marine ecosystem indicators (e.g. deep water corals, threatened fishes and sharks) at a scale relevant to MPA planning and fisheries management would greatly expedite current efforts to secure synergies between MPAs and sustainable fisheries.

3. Establish comprehensive baselines and monitoring for selected MPAs and surrounding waters

Several researchers have decried the lack of systematic long-term monitoring of MPAs and their surrounding waters in which human activities are taking place, and pointed out the need for a network of observatories in connection with MPAs. To fully understand the benefits of MPAs and for MPAs to provide baselines for unimpacted ecosystems, researchers should be encouraged to share information. Attempts should be made to fund monitoring in as many habitats/MPA types/human management regimes as possible. In addition, monitoring activities should be as comprehensive and long-term as possible – preferably at least 10-20 years – and should have an appropriate spatial scale.

4. Evaluate MPA network bioregional ecological coherence, connectivity, gaps, and critical components

Ecological coherence and connectivity remain poorly understood, though they are often listed as MPA network-level goals. It is still a relatively new branch of marine research, with recent genetic studies making significant contributions, but upon which a consensus view has yet to be achieved and is urgently needed. Within European waters, a better understanding of the connectivity of existing protected areas is required, including site-specific requirements to support viable populations. Beyond that, a strategic approach has to be taken to narrow down the myriad of research possibilities to the few that can be readily linked to management measures; for example, directing the selection of optimal locations and coverage for highly protected sites.

5. Determine indicators that reflect the integrity of ecosystems and ecological processes

Considerable efforts have been invested in the selection of indicators to measure Good Environmental Status, and, whenever possible, these should be adapted for use in measuring MPA network efficacy. Additional indicators to demonstrate the role of MPAs in enhancing the well-being or recovery of the ecosystem as a whole should be developed and piloted, such as species biomass and density, restoring the complexity of food webs and delivering ecosystem-based management. Particular effort is required to identify those indicators that can readily reflect the health of ecosystem processes and functions. The scientific literature is already rich with examples of species-specific indicators, but it is also divided by strong opinions. A cohesive approach is required to bring together core suites of indicators that are suitable for regular monitoring which are both relevant to European MPA network objectives, linked where possible to MSFD objectives, and affordable. Additional indicators should be selected for those instances when the core set provides ambiguous results, for diagnosing problems, and in regional-specific situations, as required.

6. Consider new and emerging issues such as climate resilience and blue carbon

To date, researchers have focussed on the protection of existing ecologically important features. However, management in a rapidly changing world dominated by humans will require adaptive approaches that take into consideration resilience, robustness to uncertainty, and the possibility of ecosystem shifts and re-organization. Policy-makers and managers currently have little guidance on which approaches are appropriate in which situations. For example, how can MPA design build resilience to ocean acidification? Additionally, there are several considerations that are now recognised as important, though they reside outside of the conventional approaches to MPA designation, e.g. protecting the features that facilitate the sequestration of carbon by marine ecosystems; so-called *blue carbon.*

7. Clarify European maritime legal issues as they affect MPA research and implementation

Certain questions in European law and policy have hampered the effective development of MPAs and their management. In particular, the lack of power of the Member States to unilaterally implement stringent management measures within the confines of their protected areas needs to be clarified. Furthermore, the requirement of international bodies and Member States with claims to the outer continental shelf to cooperate in the high seas needs to be demonstrated and operationalized.

8. Establish realistic guidance around European stakeholder involvement

Stakeholder engagement and expectations is a largely cultural question that can vary from place to place. Nonetheless, certain approaches are more likely to ensure positive outcomes. To date, social science in the planning of MPAs has been largely *post-hoc*, examining what worked and what went wrong. The active engagement of social scientists to produce culturally-appropriate guidance could greatly facilitate MPA designation and also compliance (see also Recommendation 9, below). Specific research could include work on assembling more explicit evidence of the socio-economic benefits of MPAs.

9. Develop policy-relevant guidance for systematic MPA network development, management and review

The transition from the current largely *ad hoc* site-by-site selection to a more systematic and network-level approach will require clear guidance. While the science behind such guidance may be complicated (as evidenced by the preceding chapters), the guidance itself should be straight-forward and easy to understand. Options, such as the use of systematic conservation planning tools like Marxan and Zonation, should be objectively tackled, pointing out their pros and cons. Making good policy decisions with limited data in a rapidly changing world requires a new way of seeing the available options, weighing reversibility and adaptability of decisions alongside conventional concerns such as operations and budget. This research would largely be an assimilation of all of the other research listed in these recommendations and could evolve as new information became available. Specific research could include work on consistency and harmonisation of management measures across MPA networks.

10. Develop pilot projects that link marine monitoring with maritime surveillance

Increasingly, marine researchers are becoming concerned with the level of compliance within (and outside of) MPAs. Areas with poor compliance make for poor research controls and treatments with inconclusive results or benefits. In some circumstances marine scientific monitoring could be combined with maritime surveillance, providing cost savings and efficiencies for both. Pilot projects to link these two very different cultures could also increase mutual understanding, making MPA design more likely to succeed from an enforcement standpoint, and making enforcement more likely to focus on ecosystem components critical to the success of the MPA network.

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List of acronyms

ABNJ: Areas Beyond National Jurisdiction

ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area

BPNS: Belgian part of the North Sea

BSPAs: Baltic Sea Protected Areas

CBD: Convention on Biological Diversity

COCONET: Towards Coast to Coast Networks of marine protected areas (from the shore to the high and deep sea), coupled with sea-based wind energy potential.

COP: Conference of the Parties (governing body of the Convention on Biological Diversity)

EA: Ecosystem Approach

EAM: Ecosystem Approach to Management

EB-MSM: Ecosystem-Based Marine Spatial Management

EEZ: Exclusive Economic Zone

EMODnet: European Marine Observation Data Network

G8: Group of Eight (Forum for governments of eight of the world's wealthiest countries)

GES: Good Environmental Status

IBTS: International Bottom Trawl Survey Working Group (amnd components BITS, BTS, MEDITS)

IMO: International Maritime Organization

OECD: Organisation for Economic Cooperation and Development

IOC: Intergovernmental Oceanographic Commission

IUCN: International Union for Conservation of Nature

IUCN – WCPA: IUCN World Commission on Protected Areas

LiDAR: Airborne light detection and ranging

LOSC: The Law of the Sea Convention

MPAs: Marine Protected Areas

NEAFC: North East Atlantic Fisheries Commission

MAIA: Marine Protected Areas in the Atlantic Arc

MedPAN: Network of Marine Protected Area Managers in the Mediterranean

MESMA: Monitoring and Evaluation of Spatially Managed Areas

MSFD: Marine Strategy Framework Directive (EU)

MSP: Marine Spatial Planning

OBIS: Ocean Biogeographic Information System

PISCO: Partnership for Interdisciplinary Studies of Coastal Oceans

PROTECT: Marine Protected areas as a tool for ecosystem conservation and fisheries management

RAC / SPA: Regional Activity Centre for Specially Protected Areas

ROVs: Remotely Operated Vehicles

RSC: Regional Sea Conventions

SACs: Special Areas of Conservation

SCIs: Sites of Community Importance

SPAs: Special Protection Areas for birds

SPAMI: Specially Protected Area of Mediterranean Importance

UNEP: United Nations Environment Programme

UNEP-WCMC: UNEP – World Conservation Monitoring Centre

UNESCO: United Nations Education, Scientific and Cultural Organization

WSSD: World Summit on Sustainable Development

Annexes

Annex I: Supporting tables

A1: Selected management units used internationally and within Europe

Management unit title	Management unit description
Special Areas of Conservation (SACs)	Protect marine habitats or species of European importance (for example sea caves and reefs).
Special Protection Areas (SPAs)	Protects populations of specific species of birds of European importance.
'European marine sites' or 'Natura2000 sites'	SACs and SPAs are together termed 'European marine sites' or 'Natura 2000 sites' designated under the European Habitats and Birds Directives.
Sites of Special Scientific Interest (SSSI)	Although most SSSIs are on land and intertidal areas there are some which extend into the marine environment below water mark.
Marine Conservation Zones	Designated in England and Wales as management units that protect nationally important habitats, species and geology.
Chemosynthetic Ecosystem Reserves	Aimed at conservation of vent and seep ecosystems at regional and global scales.
No Take Zones. Sometimes known as Highly Protected Marine Areas (HPMA)	No Take Zones (NTZ) are areas permanently set aside from direct human disturbance, where all methods of fishing extraction of natural materials, dumping, dredging or construction activities are prohibited.
Particularly Sensitive Sea Areas(PSSA)	An area that needs special protection through action by IMO because of its significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable todamage by international maritime activities.
Preservation Reference Areas	Established by the International Seabed Authority to sustainably preserve representative biota for all mining claim areas in terms of species composition and biodiversity.
Specially Protected Areas of Mediterranean Importance (SPAMI)	The SPAMI List may include sites which: • are of importance for conserving the components of biological diversity in the Mediterranean; • contain ecosystems specific to the Mediterranean area or the habitats of endangered species; • are of special interest at the scientific, aesthetic, cultural or educational levels.
Biosphere Reserve (UNESCO)	Areas of terrestrial and coastal ecosystems promoting solutions to reconcile the conservation of biodiversity with its sustainable use. Biosphere reserves serve in some ways as 'living laboratories' for testing out and demonstrating integrated management of land, water and biodiversity.
RAMSAR site	Areas promoting the wise use of wetlands. 'Wise use' is defined as the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development.

B1: IUCN criteria for MPA design

Include the full range of biodiversity present in the biogeographic region

This criterion encompasses several considerations:

Representativeness

MPA networks should represent the range of marine and coastal biological diversity (from genes to ecosystems) and the associated physical environment within the given area. By definition, different biogeographic regions and different habitats have distinct biota, and thus examples of all biogeographic regions and all habitats in each region must be represented in a no-take marine reserve system, simply to contain the full range of species and habitats (Ballantine, 1997; Day and Roff, 2000; Roberts *et al*., 2003). If MPAs encompass representative portions of all ecologically relevant habitat types within each biogeographical region in a replicated manner, they have the greatest chance of including most species, life stages, and ecological linkages. Habitats are generally a better focus for protected area design than species because they are easier to map, are more closely tied to ecological processes, and in fact are a good surrogate for species, so that a network of MPAs that includes all habitat types is likely to offer protection for most species (Ward *et al*., 1999; SladekNowlis and Friedlander 2004). There is no agreement on how much habitat should be protected to preserve biodiversity and maintain ecological links between reserves, and there is a variety of approaches in practice. For example, in designing a network of marine reserves in the Gulf of California, Sala *et al*., (2002) set a goal of protecting 20% of each representative habitat and 100% of rare habitats, while the new network of no-take areas in the Great Barrier Reef has at least 20% protection per bioregion and has different coverage targets for the various habitats varying between 10% (e.g. for *Halimeda* beds) to 100% for major turtle nesting and foraging sites (Fernandes *et al*., 2005).

Replication

All habitats in each region should be replicated within the network and distributed spatially throughout the network. Replicates of all represented habitats should be included in a network of MPAs, based on the following expectations (Ballantine, 1997; SladekNowlis and Friedlander, 2004; Allsopp *et al*., 2009): (1) to provide stepping-stones for dispersal of marine species; (2) to buffer against natural or human-induced extreme events or accidents (e.g. oil spills, extreme storms) that may damage local habitats or populations, by spatially spreading potential risks; (3) to allow species to shift their distribution among reserves in response to large scale changes (e.g. climate change); (4) in a network of MPAs, marine reserves cannot be mutually supporting unless there are similarities in the habitats and species they contain; (5) to allow rigorous evaluation of the effectiveness of protection, which requires spatial replication in protected and unprotected areas.

Resilience

MPA networks must be designed to maintain ecosystems' natural states and to absorb shocks, particularly in the face of large-scale and long-term changes (such as climate change).

Ensure ecologically significant areas are incorporated

Ecologically and Biologically and Significant Areas (ESBA) that play a crucial role in sustaining populations and maintaining ecosystem function should be central to MPA network design. These include rare habitats (e.g. deep-sea hydrothermal vents), especially vulnerable habitats (e.g. cold-water coral carbonate mounds or Mediterranean coralligenous communities), habitats where fish are especially vulnerable to overfishing (e.g. over seamounts where many fish form spawning aggregations and are easier to massively be caught), and habitats that are crucial for reproduction or for growth of juveniles and also adults (e.g. turtle nesting beaches, fish spawning aggregation sites, seagrass beds, nursery areas) (SladekNowlis and Friedlander, 2004; Allsopp *et al.*, 2009). ESBA should preferably be included in the no-take zones of an MPA network.

Maintain long-term protection

Network design must provide long-term protection, including no-take zones, to effectively conserve diversity and provide ecosystem benefits; long-term arrangements for funding, management and enforcement are essential for effective management.

Ensure ecological linkages

MPA network design should seek to maximize and enhance the linkages among individual MPAs and groups of MPAs within a given network. Connectivity describes the extent to which populations in different parts of a species' range are linked by the exchange of eggs, larvae recruits or other propagules, juveniles or adults (Palumbi 2003). A network of MPAs should maximize connectivity between individual reserves to ensure the protection of ecological functionality and productivity.

Ensure maximum contribution of individual MPAs to the network

The size, shape and spacing of the MPAs in the network greatly influence the connectivity in the network, the degree to which there are edge effects and the ease of enforcement of the MPAs. MPAs will be most effective if they are substantially larger than the distance that individual adult and juvenile fish and invertebrates move. MPAs that are larger in size will capture the adult movement ranges and larval dispersal distances of more species than small MPAs. Although small-sized reserves can certainly have positive impacts, larger MPAs provide a benefit to a wider diversity of species. A network of smaller-sized MPAs can be a viable alternative to one large MPA.

B2: Prescribed criteria for the selection of sites related to the Habitats Directive

Sites related to Annex I
As set out in Article 4.1 of the Habitats Directive, Annex III of the Directive prescribes the criteria to be applied at the national level to assess the relative importance of sites during the first stage of the site selection process. These criteria have to be considered for each habitat listed in Annex I to the Directive, as amended in 1997 and 2004: • Degree of representativity of the natural habitat type on the site; • Area of the site covered by the natural habitat type in relation to the total area covered by that natural habitat type within the national territory; • Degree of conservation of the structure and functions of the natural habitat type concerned and restoration possibilities; • Global assessment of the value of the site for conservation of the natural habitat type concerned. Additional selection principles may be used to assist in the site selection process: • Priority/non-priority status (see Habitats Directive Article 1 (d)); • Geographical range (see Articles 1 (e) and 3.1); • Special responsibilities (see Article 3.2); • Multiple interests (Annex III Stage 2.2(d)); • Rarity; • Ecological coherence of the Natura 2000 network (Annex III Stage 2.2).
Sites related to Annex II-species
Stage 1 assessment criteria (listed below for species) are applied at a national level to assess the relative importance of sites for each species listed on Annex II to the Directive, as amended in 1997 and 2004: • Size and density of the population of the species present on the site in relation to the population present within the national territory; • Degree of conservation of the features of the habitat which are important for the species concerned and restoration possibilities; • Degree of isolation of the population present on the site in relation to the natural range of the species; • Global assessment of the value of the site for conservation of the species concerned.

NB. Annex I and Annex II refer to the Habitats Directive.

B3: Principles for the design of networks of MPAs and recommendations for the design of a UK-wide ecologically representative network of MPAs (Prior, 2009)

	Defra[1]	OSPAR[2]	BALANCE[3]	ANZECC[4]	WWF-UK[5]
Bioregional/ biogeographic areas	x	x	x	x	Bioregional units should be used as the basic scale for development of MPA networks
Comprehensiveness – full range of biodiversity at multiple levels			x	x	Each network should include the full range of biological diversity (i.e. ecosystem, habitats, communities, populations, species, genetic (i.e. within each bioregion and across bioregions
Adequacy	x	x	x	x	Enough of each conservation feature must be included in the network to provide ecological viability and integrity. Targets for protection should be set according to a feature's vulnerability, rarity, sensitivity, heterogeneity, resilience, naturalness, diversity, level of threat, historical extent and significance
Size of network		x		x	Scientific literature generally refers to 30-50% of each habitat or ecosystem needing to be protected in each bioregion, with particular features such as vulnerable ecosystems requiring much higher targets, even 100% in some cases. For a few robust and common features lower targets may be sufficient
Size, configuration and shape of sites	x	x	x	x	Individual sites should be as large as possible, avoiding dissecting conservation features, include a buffer or area of transition where possible, and have a simple shape with easily identifiable boundaries. A body of scientific work suggests that minimum site size should be 2-6km in diameter and a maximum of 20km apart
Replication	x	x	x	x	All conservation features should be replicated (a minimum of three occurrences, where possible) within each network across their full geographic range
Level of protection	x			x	A range of levels of protection are possible. However, high levels of protection should be adopted for at least one replicate of each conservation feature and for all vulnerable, rare and endangered features
Quality of site including naturalness	x	x	x	x	Where possible, sites should be natural. Where degradation or change has taken place, sites should be of a sound quality or have potential for restoration
Connectivity	x	x	x	x	The networks should maximise the connectivity between sites, sites should be placed at the mean dispersal distance of the species for which connectivity is required
Viability	x			x	Self-sustaining, dispersal sites of sufficient size to ensure species and habitats continue through natural cycles of variation should be included

1 Department for the Environment, Food and Rural Affairs, UK
2 OSPAR Commission for the Environmental Protection of the North-East Atlantic
3 EU-funded BALANCE project
4 Australian and New Zealand Environment and Conservation Council Task Force on MPAs
5 Recommendation for a UK-wide ecologically representative network of MPAs

	Defra[1]	OSPAR[2]	BALANCE[3]	ANZECC[4]	WWF-UK[5]
Safeguard integrity of ecological processes	(x)		x	x	Each network should include sites which provide for protection for ecological processes which sustain ecosystem function
Representativeness	x	x	x	x	Each network should encompass representative examples of all biodiversity
Heterogeneity				x	Each network should include the full range of environmental variation that occurs across a feature – larger MPAs are more likely to cover the full range of biological variation
Proportionality				x	As a minimum, ecosystems and habitats should be represented in proportion to the level at which they occur in the bioregion
Unique or special areas	x	X [6]		x	Sites important as spawning nursery or breeding grounds, or where unique physical or oceanographic features occur should be included in the network
Rare or threatened species	x	x		x	Rare, threatened or endangered communities and species should be well represented, possibly including 100% of the feature in cases of extreme rarity, and high threat of danger
Sensitivity	x	x			All sites of high sensitivity should be considered for inclusion in the network
Highly protected sites	(x)		x	x	The presumption should be for highly protected sites (i.e. IUCN category I or II) unless a lower level of protection (IUCN III-IV) is considered sufficient to protect the conservation feature. Highly protected examples of each conservation feature should be included in the network
Resilience			x	x	The resilience of the network should be addressed through special attention to replication of sites, location of sites, representation, connectivity and highly protected sites
Precautionary best available evidence	x			x	The best available scientific information should be used in the design of the network, and where information is lacking, MPAs should be larger

Annex II: Examples of MPA status at National level

MPA Inventory (Belgium, France, Greece, the Netherlands, Norway, Portugal Spain, Romania, UK)

MPAs in Belgium	
Guidelines and criteria used for MPAs implementation	Guidelines: Management plans are partly based upon the 2007 "EU-Commission guidelines". They are approved by the competent State Secretary. Criteria: European Directives, RAMSAR and Federal based criteria
National legal instruments used for MPAs implementation	Marine Environment Law (20/01/1999)
National MPAs coverage	3 Special Protection Areas established by Ministerial Decree (KB 14 October 2005) 2 Special Areas of conservation (EU-Habitats Directive) 1 potential site of Community Importance in the EEZ is in design phase (SAC; EU-Habitats Directive)
National Strategic plans	National legislation will endorse the foreseen new MPA; implementation of a management plan will follow.
Cross-border/international cooperation for MPAs implementation	Interactions with neighbouring countries (NL, FR, UK) primarily in view of implementing new fishery measures in co-managed areas
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	Federal Ministry on Health, food chain safety and environment. www.health.fgov.be Contact: Geert Raeymaekers Within Europe a large number of different types of spatial marine management unit have been defined, some of these are recognised internationally and some are country specific e.g. the term Marine Park is widely used for permanent marine reserves for the conservation of species, whereas a Marine Conservation Zone (MCZ) is new type of reserve brought in under the UK Marine Act
MPAs in France	
Guidelines and criteria used for MPAs implementation	European Directives (Natura 2000)
National legal instruments used for MPAs implementation	National law 14/04/06 on marine national parks, and regional natural parks with 6 different tools at disposal for MPAs implementation.
National MPAs coverage	12 253 km^2 protected
National Strategic plans	National strategy (20/11/07) for the creation of MPAs in EU: methodological principles and short-term priorities in terms of: - Natura 2000 network extension in the Sea; - creation of 8 natural marine parks along the French metropolitan coastline; - support projects;
Cross-border/international cooperation for MPAs implementation	
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	French Marine Protected Areas Agency Brest, France http://www.aires-marines.fr/french-marine-protected-areas-agency.html

MPAs in Greece	
Guidelines and criteria used for MPAs implementation	Top down approach which impedes the implementation of shared management plans with local/regional stakeholders. The trends evolve towards a more integrated and participatory management approach with local communities. Criteria: Protection of endangered species (e.g. loggerhead sea turtle, Mediterranean Monk seal) and of remarkable ecological habitats.
National legal instruments used for MPAs implementation	National Law 1650/1986 for the protection of the environment (implementation of national marine parks)
National MPAs coverage	Two national marine Parks each in the Ionian Sea and Aegean Sea (with only one marine zone of strict protection representing 0.06% of the territorial waters) 114 Natura 2000 sites (6.12% - 6.344 km2 of the total area of the territorial waters) To have *a protection status, the Natura-2000 marine sites need to be announced "protected areas" according to the national legislation (Law 1650/1986).*
National Strategic plans	No official national plan for future strategic implementation. Priorities of the Ministry of Environment, Energy, and Climate Change are to announce all Natura-2000 areas as protected areas according to national legislation (Law 1650/1986) and to establish Management Bodies and Management Plans to all of them. There are also proposals (mainly by NGOs and Research Institutes) to extend the Natura-2000 by adding new sites that will also include deep and offshore habitats.
Cross-border/international cooperation for MPAs implementation	no
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	Ministry of Environment, Energy, and Climate Change www.ypeka.gr
MPAs in the Netherlands	
Guidelines and criteria used for MPAs implementation	Guidelines: the Netherlands does not assign areas based on the OSPAR criteria if they do not overlap with Natura 2000 areas. Criteria: protection of marine mammals, birds and fish.
National legal instruments used for MPAs implementation	Natuurbeschermingswet 1998 (National Nature protection law)
National MPAs coverage	In 2008 the Netherlands assigned the Voordelta (900 km^2) as the first Dutch marine Natura 2000 area in the North Sea. In 2011 two more areas were assigned: the Noordzeekustzone (1500 km^2) and the Vlakte van de Raan (190 km^2). The former designation amended an existing decree (2009) which designated a small part of the North Sea area and it extended the N2000 area to the -20 mtr line and extend the northward boundary to the south
National Strategic plans	In 2011-2012 the Netherlands will designate three more marine Natura 2000 sites in the Dutch EEZ (Frisian Front, Dogger Bank and the Cleaver Bank). Designation decrees have not yet been published because the Natura Conservation Act (1998) does not yet apply to the EEZ. Amendment of the Act has been submitted to parliament (2010)

Cross-border/international cooperation for MPAs implementation	Not when it comes to the existing MPA's; for the Dogger Bank site (to be designated in 2011/12) an international cooperative project (FIMPAS) has been established
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	Ministry of Economic Affairs, Agriculture and Innovation, Postal Box 20401, 2500 EK THE HAGUE, THE NETHERLANDS Contact: mr. Hans Nieuwenhuis (general marine protected areas) and mr. Ton IJlstra (fisheries / FIMPAS) http://www.noordzeenatura2000.nl/
MPAs in Norway	
Guidelines and criteria used for MPAs implementation	Guidelines: set-up a network of MPAs for benthic habitats protection. Traditional use of the protected areas (e.g. fishing) is permitted, as long as the conservation goals are not threatened. Criteria: protection of benthic habitats. In addition, 3 lobster reserves have been established on the Skagerrak coast, mainly for research purposes. A criteria for implementation was that each area should contain good lobster habitats.
National legal instruments used for MPAs implementation	Saltwater Fishery Law Biodiversity Law
National MPAs coverage	Four small (1 km^2) MPAS have been established (2006) on the Skagerrak coast (southeast Norway). They are primarily for research purposes and specifically set up as lobster reserves.
National Strategic plans	Plan for implementation of MPAS to protect a representative selection of benthic habitats in order to secure the national diversity of marine nature types and species. A working group has recommended 36 areas of national interest to be included in the plan. In 2010, 17 areas are being evaluated and about to enter a hearing process, as stage one of the national plan. Norway currently has 0% no-take MPAs. There are plans for two no-take areas on the South coast (Tvedestrand and Kragerø), mainly to protect local cod stocks. In one of these (Kragerø) a formal application has been sent from the local community to the Directorate of Fisheries. The application is currently being evaluated.
Cross-border/international cooperation for MPAs implementation	No There is an agreement between Norway, Sweden and Denmark (1966 – the Skagerrak agreement) stating that fishers from all three countries are allowed to fish as close as 4 nautical miles from all countries coastlines. At least one suggested MPA within the national plan will go beyond 4 nautical miles in Skagerrak, potentially in conflict with the Skagerrak agreement.
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	The Norwegian Directorate for Nature Management is one of five government agencies under the Ministry of the Environment www.dirnat.no National terms: 1. Bevaringsområde for hummer 2. Marine verneområder In English: 1. Lobster reserves 2. Marine protected areas

MPAs in Portugal	
Guidelines and criteria used for MPAs implementation	Guidelines and criteria: - Natura 2000 criteria and guidelines; - OSPAR criteria and guidelines; - Azores criteria (mainly, the ones provided by IUCN) are used for the designation and implementation of new MPAs (not designated as Natura 2000).
National legal instruments used for MPAs implementation	**Mainland:** Decree-Law No. 142/2008 of 24 July; Decree-Law No. 140/99, of 24 April, republished by Decree-Law No. 49/2005, of 24 February. Decree- Law No. 380/99, of 22 September, republished by Decree-Law No. 46/2009, of 20February. **Azores:** Regional Legislative Decree No. 15/2007/A, of June 25**.** Regional Legislative Decree No. 28/2011/A, of November 11 (Azores Marine Park)**.**
National MPAs coverage	Total marine coverage: 114406 ha **Mainland** Approximately 130 000 ha of marine areas have a conservation status (national protected areas or Natura 2000); One offshore MPA (*Josephine seamount*) was nominated/designated by Portugal (seabed / extended continental shelf) to the OSPAR Network of MPAs, in 2010. One Natura 2000 SPA (Berlengas Islands) is under designation partly in EEZ, mostly in territorial waters (<12 Nm); The process of the extension of Natura 2000 to the marine environment is ongoing. **Azores:** - several coastal MPAs were created within each Island Natural Park (territorial sea) and somewhat included in the Natura 2000 Network; the Faial-Pico Channel, the Corvo Island and the Formigas /Dollabarat Bank (specific location regarding the main islands) were nominated to the OSPAR Network of MPAs; - so far, one offshoreseamount (D. João de Castro) and two offshore hydrothermal vents fields (Lucky Strike and Menez Gwen) have been approved as *Site of Community Importance*; these ecosystems, together with the Sedlo seamount, were nominated to the OSPAR Network of MPAs; - the Portuguese Government also nominated to the OSPAR Network of MPAs the following offshore ecosystems (all located in the outer continental shelf): the Rainbow hydrothermal vent field (2006), the Altair Seamount, the Antialtair Seamount and the Mid Atlantic Ridge – North of the Azores (2010). **Madeira:** Five MPAs have been created within the limits of the territorial sea.
National Strategic plans	**Mainland:** the Natura 2000 Network Sectorial Plan (Ministers Council Resolution No. 115-A/2008, of 21 July). There are, as well, political commitments under the Spatial Planning National Programme (2007; the Marine Spatial Planning Plan is under appreciation) and the National Strategy for the Integrated Coastal Zone Management (2009). **The extension of Natura 2000 to the marine environment is a major priority.** **Azores:** the Natura 2000 Network Sectorial Plan (Regional Legislative Decree No. 20/2006/A, of 6 June). **Madeira:** no regional plan available.

Cross-border/international cooperation for MPAs implementation	**Mainland:** the possibility is considered under Decree-Law 142/2008 ('cross-border protected areas') and under the OSPAR Convention framework (*Josephine Seamount MPA*/seabed, nominated by Portugal, and, complementarily, *Josephine Seamount High Seas MPA*/water column, selected by the OSPAR Commission, 2010). Probably cooperation also will need to be considered under the framework of Marine Strategy Framework Directive (already transposed). **Azores:** There is cooperation in terms of scientific research; under OSPAR, cooperation started with the nomination/selection of the Altair and Antialtair Seamounts MPAs as well as the Mid-Atlantic Ridge North of the Azores MPAs: the seabed section was nominated by Portugal, and, complementarily, thewater column section was selected by the OSPAR Commission, 2010. **REMARK:** previous cooperation under NEAFC (fishing closures, in force since April 2010) **Madeira**: Probable cooperation in terms of scientific research.
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	**A) National terms:** 1. Parque marinho; 2. Reserva marinha; 3. Paisagem marinha protegida; 4.Monumento natural marinho; 5. Área protegida para a gestão de habitats ou espécies; 6. Área protegida de gestão de recursos **In English:** 1. Marine park; 2. Marine reserve; 3. Protected marine landscape; 4.Marine natural monument; 5. Protected area for habitats or species management; 6. Managed resources protected area **B) National authorities:** **Mainland** ICNB: Institute for the Conservation of Nature and Biodiversity www.icnb.pt **Autonomous Region of Azores** Regional Secretariat for the Environment and the Sea, Regional Directorate for the Maritime Affairs of the Azores http://www.azores.gov.pt/Portal/en/entidades/sram/?mode=entity&ct=&lang=en&area=ct **Autonomous Region of Madeira** Regional Secretariat for the Environment and the Natural Resources; Madeira Natural Park http://www.sra.pt http://dramb.gov-madeira.pt/berilio/berwpag0.home http://www.pnm.pt/
MPAs in Romania	
Guidelines and criteria used for MPAs implementation	Guidelines: IUCN technical reports[7], Black Sea Commission strategic documents[8] and EU directives (e.g. Natura 2000) Criteria: Representativeness, replication, viability, precautionary design, permanence, connectivity, resilience, size and shape

7 WCPA/IUCN: Establishing networks of marine protected areas: a guide for developing national and regional capacity for building MPA networks. Full Technical Report: 212 (2007)

8 Convention on the Protection of the Black Sea against Pollution, 1992; Strategic Action Plan for Rehabilitation and Protection of the Black Sea, 1996, amended 2002; The Black Sea Biodiversity and Landscape Conservation Protocol to the Convention on the Protection of the Black Sea against Pollution, 2002

National legal instruments used for MPAs implementation	Government Emergency Ordinance No.57/2007 regarding the regime of natural protected areas, natural habitats, wild flora and fauna preservation. Order of the Ministry of the Environment and Sustainable Development No. 1964/December 13 2007 regarding the establishment of natural protected area regime as integrant part of the Natura 2000 ecological network in Romania Government Decision No. 1284/2007 regarding the declaration of avifaunistic protection areas as integrant part of the Natura 2000 ecological network Minister's Order No. 374 2004 for approval of the action plan regarding the preservation of cetaceans in the Romanian waters of the Black Sea Emergency Ordinance No. 71/June 30 2010 regarding the establishment of the marine environment strategy
National MPAs coverage	Seven sites (one under the Birds Directive and six under the Habitats Directive); other two sites are to be designated (under HB). Total actual area: 1,162.86 km^2; relative to EEZ: 4.65%; Relative to shelf: 3.88%; the marine part of DDBR represents 88.57% of the total surface.
National Strategic plans	There is no national strategic plan dedicated to MPAs. The issue of protected areas is dealt with within the National Biodiversity Preservation Strategy (2000), renewed by the National Strategy regarding the Biodiversity and the Action Plan (2010), still under public debate.
Cross-border/international cooperation for MPAs implementation	Yes In 2005, an attempt was made to expand the Romanian Marine Reserve in the Bulgarian waters. Cooperation with Ukraine on the Danube Delta Biosphere Reserve.
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	Ministry of Environment and Forests - Direction of Biodiversity www.mmediu.ro, Contact: Mr. John Smaranda *No special national definition and classification of spatial marine management unit regarding the MPAs, only the following provisions linked with the coastal zone management:* *GO no. 202/2002 onintegratedcoastal zonemanagement (approved and amended by Law no. 208/2003):* *Art. 52.-* *(1) In order to ensure the sustainable protection of the coastal area, the biological and landscape diversity, the productivity of species and of marine and terrestrial habitat, coastal or marine reserves/parks are established, under the law.* *(2) Impact studies for works within the perimeter of the park or reserve or on the outside, which are likely to affect directly or indirectly the protected objectives by the provisions which established the park or reserve will be developed in consultation with the park administration or reserve.* *(OUG nr. 202/2002 privind gospodărirea integrată a zonei costiere (aprobata si modificata prin Legea nr. 208/2003):* *Art. 52. – (1) În scopul asigurării protecţiei durabile a zonei costiere, a diversităţii biologice şi peisagistice, a productivităţii speciilor şi a habitatului marin şi terestru se instituie rezervaţii sau parcuri costiere ori marine, în condiţiile legii.* *(2) Studiile de impact al lucrărilor prevăzute în interiorul perimetrului parcului sau rezervaţiei ori la exteriorul acestora, care sunt susceptibile de a afecta direct sau indirect obiectivele protejate prin actele care au instituit parcul sau rezervaţia, vor fi elaborate cu consultarea obligatorie a administraţiei parcului sau rezervaţiei.)*

MPAs in Spain	
Guidelines and criteria used for MPAs implementation	Guidelines: Fishing regulations within MPAs: different fishing activities allowed (artisanal, recreational etc.), gears and efforts. Criteria: OSPAR criteria, Red Natura 2000; Regional criteria established by local stakeholders.
National legal instruments used for MPAs implementation	Fisheries legal instruments National established MPA =marine reserves Regional established MPA = national parks
National MPAs coverage	The total marine area encompassed by the Spanish MPAs is 1964 km^2, of which 97 km^2 (5%) are 'integral reserves' – or no-take areas closed to all extractive activities and 95% restricted use areas 27 operational MPAs, of which 2 are National Parks, one in the Atlantic and one in the Mediterranean. Of the 25 marine reserves, 15 are solely under regional jurisdiction, 6 are solely under State jurisdiction and 4 have shared regional and State jurisdiction; 7 are in the Atlantic (+ 1 OSPAR MPA) and 18 in the Mediterranean. Existing MPAs protect about 4.5% of the seabed at depths less than 100 m and only the three MPAs in the Canary Islands extend to depths greater than 100 m, reaching in short distance from the coast 500-1000 m of depth. The protection of deep water ecosystems is contemplated in the future Red Natura and already covered in the existing OSPAR MPA. The size of the Spanish MPAs varies widely, from as small as 0.03 km^2 to as large as 707 km^2. Most of the MPAs have integral reserves within them, which also range from small (e.g. 0.02 km^2) to large (e.g. 20 km^2). The first Spanish MPA was created in 1982 in the Mediterranean and since the mid 1990s the total area protected has been increasing at steady rate.
National Strategic plans	Preparation of a national strategy to protect deep-sea ecosystems.
Cross-border/international cooperation for MPAs implementation	Attempts in the Gulf of Lyons (Mediterranean Sea) by Spain and France.
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	State MPAs http://www.mapa.es/rmarinas/index_rm.htm Spanish MPAs excluding National Parks and OSPAR http://www.reservasmarinas.net

MPAs in UK (this information is relevant to English inshore waters and offshore waters adjacent to England, Wales and Northern Ireland only).	
Guidelines and criteria used for MPAs implementation	Guidelines: The Ecological Network Guidance (ENG) is to be used to enable identifying Marine Conservation Zones (MCZs). ENG is Natural England's and the JNCC's statutory advice which contains practical guidelines to enable groups to identify Marine Conservation Zones that will contribute to an ecologically coherent Marine Protected Area (MPA) network. It does not cover the consideration of socio-economic interests in MCZ identification. Criteria: *Ecological coherence* is a key concept in the design of an MPA network (seven design principles: representativity, replication, adequacy, viability, connectivity, protection, best available evidence).
National legal instruments used for MPAs implementation	Marine and Coastal Access Act 2009 has created a duty on Ministers to create a network of conservation sites (i.e. MPAs) in UK seas. The Act also provides for the designation of new areas of national importance called Marine Conservation Zones.
National MPAs coverage	The network is made up of existing and new MPAs, including: European marine sites: Special Areas of Conservation (SACs), to protect marine habitats or species of European importance; Special Protection Areas (SPAs) to protect populations of specific species of birds of European importance; The marine components of Sites of Special Scientific Interest (SSSIs) and Ramsar sites; Marine Conservation Zones (MCZs) designated under the Marine and Coastal Access Act 2009.
National Strategic plans	The Government's strategy for contributing to the delivery of a UK network of marine protected areas. Policy guidance from DEFRA – not UK wide UK Marine Science Strategy by DEFRA: government mandate on sustainable use of the seas and managing climate change. Our seas –a shared resource. High level marine objectives. Joint statement from Scottish Government, Welsh Assembly Government, Northern Ireland Executive and UK Government.
Cross-border/international cooperation for MPAs implementation	Cross-border/ international cooperation has occurred for relevant offshore SACs. For example, Bassurelle Sandbank is a linear sandbank in the Dover Strait which straddles the boundary between UK and French waters and our site is aligned with the French site "Ridens et dunes hydrauliques du Detroit du Pas de Calais".
National definition and classification of spatial marine management unit (+ national terms used – also translation in english if possible) + National authority and contact person	Natural England is the UK Government's statutory advisor on the conservation of England's marine environment (from the coast out to 12 nautical miles offshore). JNCC is the public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation, and is responsible for nature conservation advise from 12nm to 200nm, or the limit of the UK continental shelf. Together Natural England and the Joint Nature Conservation Committee are responsible for recommending Marine Conservation Zones (MCZs) to Government.

Annex III: Members of the Marine Board MPAs Working Group

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National Institute of Aquatic Resources

Academy of Finland

cnrs

Ifremer

UNIVERSITÉS MARINES

DFG Deutsche Forschungsgemeinschaft

HELMHOLTZ ASSOCIATION

hcmr

Irish Marine Universities Consortium

Marine Institute

CoNISMa
Consorzio Nazionale Interuniversitario per le Scienze del Mare

Consiglio Nazionale delle Ricerche

OGS

NIOZ
Royal Netherlands Institute for Sea Research

NWO
Netherlands Organisation for Scientific Research

INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET

The Research Council of Norway

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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