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Monitoring and evaluation of spatially managed areas: A generic framework and its application

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Abstract

The application of an ecosystem approach to management of the sea requires both integrated and strategic frameworks such as Integrated Coastal Zone Management (ICZM) and the use of marine spatial planning (MSP) to minimize spatial use conflicts and environmental degradation. Such an integrated management promotes sustainable development based on achieving a balance of environmental, social and economic objectives. Here we introduce a first draft of a generic framework which is developed in the EU FP7 project MESMA that gives guidance on how to assess the effectiveness of an existing management within a spatially defined area. More precisely, we define spatially managed areas as geographical entities where a marine planning framework is or will be used to manage multiple human activities in space and time while aiming to maintain ecosystem integrity. The framework consists of seven steps and comprises practical guidance on the selection of operational objectives and related criteria (step 1), the collation and integration of information (steps 2, 3 and 4), performance assessment (step 5), and feedback processes (steps 6 and 7). In the course of the MESMA project, this generic framework will be applied and tested in nine case studies, representing all European seas. Here we highlight the processes and practical tasks involved in each of the framework steps, reflect on the first attempts to implement this framework and identify the requirements for practical tools such as standardized methods to map human activities and assess their cumulative impacts .

Key-words: adaptive management, ecosystem based management, marine spatial management, management effectiveness,

1 Introduction

Ecosystem based management (EBM) is a widely accepted concept among scientist and managers as it aims to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need (Rosenberg and McLeod, 2005). More precisely EBM is an environmental management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation. However, the implementation of adaptive management is often constrained by policy, difficulties in monitoring populations and their responses to interventions, lags in system responses, and limits in the ability to depict all possible states of nature and institutional fragmentation (Parma and the NCEAS Working Group on Population Management, 1998; Day, 2008). Although EBM is accepted worldwide as a concept, its practical implementation still faces a number of challenges such as the need for immediate implementation of a comprehensive governance framework that moves away from a sector-by sector management approach (Foley et al., 2010), or the need of tools that help to operationalise EBM (Arkema et al., 2006).

For instance, tools which support the practical implementation of marine EBM are the advanced Organization for Economic Cooperation and Development's (OECD) Pressure - State - Response (PSR) framework (OECD, 1993), and the Driving-Force, Pressure- State- Impact- Response (DPSIR) adopted by the European Environment Agency (EEA, 1995). These frameworks are based on the link between pressures exerted by human activities on the environment resulting in changes in its quantity, quality or state (see also Curtin and Prellezo, 2010). The most recent frameworks are integrated ecosystem assessments (IEA) (Levin et al., 2009; Tallis et al., 2010). The IEA framework proposed by Levin et al. (2009) aims to organise the synthesis and analysis of scientific information of natural and socio-economic factors that are relevant to specified ecosystem objectives. The authors described five key steps that enhance the likelihood of the successful implementation of EBM: 1) scoping; 2) indicator development; 3) risk analysis; 4) assessment of ecosystem status relative to EBM goals; and 5) management strategy evaluation. The last step of this IEA should not be confused with the closely

related concept of management strategy evaluation (MSE) which is traditionally used to evaluate fisheries management regimes (Rochet and Rice, 2009). In a recent study by Tallis et al. (2010) an extension of this IEA to seven steps has been advocated by together with more practical guidance on methods and strategies that can be used for the assessment.

Other tools which describe rather a process of implementing management measures than a conceptual process to support the implantation of EBM in the marine environment are marine spatial planning (MSP) and ocean zoning (OZ). 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 usually have been specified through a political process (Douvere et al., 2007; Douvere, 2008). A recent study by Foley et al. (2010) defines ecosystem based MSP as an integrated planning framework that informs the spatial distribution of activities in and on the ocean in order to support current and future uses of ocean ecosystems and maintain the delivery of valuable ecosystem services for future generations in a way that meets ecological, economic and social objectives. Recently a guide of ten practical steps on how to make MSP operational was launched, based on international examples of MSP at different stages of development from all around the globe (Ehler and Douvere, 2009). Ocean zoning (OZ) is a set of regulatory measures used to implement marine spatial plans and it is considered as one tool for MSP (Ehler and Douvere, 2009).

Further the concept of a marine protected area (MPA) as spatial management measure relates very much to EBM and MSP and has a fairly long history. An MPA has been defined as 'any area of intertidal or subtidal terrain together with their overlying waters and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or the entire enclosed environment' (IUCN, 1988). The process of designing, implementing, monitoring and evaluating MPAs has been reviewed for temperate continental shelf areas (Rabaut et al., 2009). The MPA-process turns out to be an iterative process in three phases: setting policy objectives, making decisions and evaluating the eventual effects of the MPA. The authors highlight that the decision making phase is the most complex one as the interactions with ongoing on planned human activities proof fuel conflict. Furthermore, dispersed competences between different authorities were considered as important factors slowing down the process.

Thus the concept of EBM is closely linked to the monitoring, evaluation, reporting and adaptive management the essential components for effective marine management (Day, 2008). The fundamental principles for monitoring include identifying the objectives; monitoring options, scale and identification of costs and benefits. The most important reasons for evaluating management performance and effectiveness in marine ecosystems is to demonstrate the extent to which the objectives of marine planning and management have been achieved as well as providing evidence-based feedback about what's working and what's not, and learn more about interactions between ecological components and management efforts.

The increasing interest in approaches to place-based or spatial management such MSP is accompanied by an increasing body of literature aiming to define good practices for spatial management which account for the concepts inherited in EBM (see e.g. Foley et al., 2010; Tallis et al., 2010; Olsen et al., in press). In line with the increasing interest in practical tools to support adaptive spatial management the EU funded under the FP7 framework a large collaborative project on Monitoring and Evaluation of Spatially Managed Areas (MESMA), that runs from November 2009 till October 2013. MESMA aims at developing strategies, guidelines, tools and a systematic framework to facilitate integrated monitoring, evaluation and implementation of Spatially Managed Areas (SMAs). An integral part of the MESMA spatial management tool box is the development of a generic and flexible framework describing a best practice process on how to assess a given spatial management within a discrete marine area with clearly defined boundaries in space and time. Within MESMA spatially managed areas are defined as areas where a marine spatial planning framework is in place or is being developed in order to conserve structure, function and processes of the constituent marine

ecosystems through the management of the cumulative pressures of different sectoral activities inside or outside the area concerned, and including the threats posed by environmental factors such as climate change and geohazards.

In this study we built on the lessons learned from existing frameworks to support the implementation of EBM, and present a first draft of the MESMA framework which will be applied in nine case studies across Europe.

2 Lessons learned from existing frameworks

From the above reviewed frameworks and concepts, including IEA, MSP and MPAs, it can be concluded that the practical steps should comprise the definition of key desired outcomes, identification of management objectives, performance indicators and benchmarks, monitoring and risk analysis, assessment of findings in relation to objectives, and evaluation of current management and recommendations for adaptation. These key steps reflect the principles of an adaptive environmental management cycle. To deliver on the implementation of EBM it can be concluded that the MESMA framework for monitoring and evaluation of SMAs must consider explicitly interactions of ecosystem components and management sectors, cumulative impacts of sea uses, humans as integral part of the ecosystem, and trade-offs between ecosystem services and management goals. Therefore the framework must inherit components of ecological risk assessment (ERA).

3 The MESMA framework

We propose for the MESMA framework to evaluate and monitor SMAs through seven key steps reflecting 1) the definition of goals and operational objectives; 2) identification of relevant ecosystem components (natural and socio-economic); 3) definition of related performance measures; 4) risk analysis to assess the relative state of the performance measures; 5) evaluation of results against the operational objectives; 6) evaluation of management effectiveness; and 7) recommendations to adapt management (see Figure 1). The MESMA framework reflects a process which can be conducted iteratively and should be completed for any defined SMA with a certain set of objectives. The framework should also give practical guidance of the required tasks and state of the art methods for each of the framework steps. In the following a first draft of the framework steps are described in more detail.

Set temporal and spatial boundaries for the SMA assessment (1a) - In a first step, the spatial and temporal limitation of the SMA assessment should be defined. In cases where a spatial management plan is implemented the boundaries are defined in the management plan. In other cases potential administrative, ecological, economic or social boundaries should be considered. Thus the application of the process and therefore the outcomes of the assessment relate to the defined set up of the SMA. Thus for further applications of the MESMA framework other boundaries may be tested.

Define goals and operational objectives for SMA (1b) - Any planning or management process is driven either implicitly or explicitly by goals. Goals are high-level outcomes that a planning process or management aims to achieve through the implementations of measures and are based on societal or cultural values. In contrast, criteria, attributes and indicators that are associated to a high level objective are developed in the scientific domain (Moilanen et al., 2009). However, high-level goals and objectives need to be translated into more operational objectives before specific targets, limits and measures can be elaborated. In recent years the formulation of operational objectives and operational deliveries has been proposed in the wider context of an ecosystem based approach to marine management. For instance Rogers (2007) described a hierarchical framework that incorporates the marine objectives and delivery statements of ecological, social and economic sectors. This framework

outlines the relationship between high-level goals and principles, a high-level and operational delivery. Another practical example of operational descriptions is given by Pomeroy et al. (2005) where a GOIS (Goal – Objective – Indicator - Success Criteria) framework was used to assess the management performance of marine protected areas. Here operational objectives are defined as those for which operational, quantifiable, targets can be set such that management measures can be targeted and performance can be evaluated (specific-measurable-achievable-realistic-time limited objectives).

For an existing or already proposed spatial management plan high-level goals and related operational objectives may be defined. In other cases where there is no predefined set of goals and operational objectives numerous marine policies may apply at an international, regional and local level where high-level goal are clearly defined and operational objectives can be derived. The international legal obligations and commitments proved a very important driver for instance in the MPA-process (Rabaut et al., 2009). The definition of suit of objectives should be obtained through a stakeholder consultation process. However, as the MESMA framework describes an iterative process many applications of the assessment framework can be tested for a SMA by using different sets of objectives.

Identify ecosystem components (2a) - An important part of the scoping process is the definition of ecosystem components (natural and socio-economic) which are relevant for the defined set of operational objectives. Natural ecosystem components can comprise ecotypes, relevant species and/or the characterisation of environmental services. In contrast, economic components relate to relevant current and future human activities. The set up of a Geographical Information system (GIS) allows for the collation, visualisation and analysis of spatial information.

Identify pressures and impacts (2b) - This step requires the analysis of the spatial overlap of the distribution pattern of the relevant natural and socio-economic ecosystem components. For the cases where a spatial and temporal overlap can be identified a more detailed analysis on the pressures exerted by the current and future human activities and their combined impacts on recognized ecosystem components can be performed. In general, the assessment of an impact of a human activity on an ecosystem component requires both a method for translating human activities into ecosystem specific pressures, and a measure of sensitivity of ecosystem components to those pressures. Human activities have already been grouped by the type of pressure, such as contamination, abrasion, extraction, that they exert on ecosystem components (Eastwood et al., 2007). The footprint and intensity of human activities should be considered when they are aggregated in spatial information on human pressures (Stelzenmüller et al., 2008; Stelzenmüller et al., 2010). The impact of a generic human pressure on an ecosystem component can be assessed as a function of the measure of the footprint and intensity of human activities causing the same generic pressure, and a measure of the degree to which a ecosystem component responds to a pressure (sensitivity) (Zacharias and Gregr, 2005). Cumulative impacts can be described as the combined impact of multiple pressures over space and time (McDonald et al., 2007).

Identify and adopt existing management measures (2c) - Alongside to the list of goals and objectives of a SMA the management measures implemented within the spatial and temporal boundaries of the SMA should be listed. Such management measures could comprise for instance spatial measure such as areas closed for fisheries or any other regulations in relation to human uses.

Select indicators and benchmarks (3) - As briefly described in step 1b operational objectives are described in more detail by related attributes and criteria. To measure the status of those attributes and criteria, indicators are required (e.g. abundance of a certain species, diversity measure, surface area covered by a habitat, etc.). The selection of indicators provides the basis for the assessment of the status of the relevant ecosystem components and should therefore follow a structured and objectives process (Rice and Rochet, 2005; Rochet and Rice, 2005). Furthermore, the set of indicators should reflect a wide range of ecosystem processes, relevant functional groups and structures (see e.g. Fulton et al., 2005). Another important step is the definition of benchmarks against which the status of the indicators can be assessed in step 4. Those benchmarks or reference points

should ideally reflect the high level goals such as the sustainable use, thus a benchmark indicating a level of sustainable use or development (see Rice, 2009). In some cases where a benchmark cannot be established the assessment of trends may be sufficient (Tallis et al., 2010). It must be recognised that the selection of indicators may involve stakeholder engagement.

Risk analysis (4) - After having selected the suit of indicators, the risk analysis aims to assess whether those indicators are in an undesirable state in relation to the defined benchmarks or reference points, taking into account different levels of uncertainty. Like in step 2b a risk approach should be applied to determine quantitatively or qualitatively the risk that an indicator is affected by human pressure or natural processes. Thus a risk based approach combines the measure of the indicator with the occurrence likelihood of pressures exerted by human activities or by natural processes (hazards). Thus the inventory of human pressures produced under step 2b can be used to explore threats. Another important aspect of the risk analysis is the assessment of interactions between indicators.

Assess findings against operational objectives (5) - This step reflects a technical summary of the risk analysis. For each operational objectives defined in step 1b the results for the indicator assessment should be summarized. This summary may contain a table with objectives-indicators matrices or a description of the findings. At this stage lessons learned and identified gaps from the selection of the operational objectives and associated sets of indicators should be extracted and transferred into a structured manner to the next framework steps.

Evaluate management effectiveness (6) - A comprehensive assessment of the management effectiveness is conducted in step 6. Thus a synthesis of the findings should identify what works and what doesn't (e.g. mismatch in management measures, governance structure). Here the source of uncertainty should be identified and it should be described how the uncertainty accumulates in the overall assessment. This includes also some guidance on how to deal with uncertainty or unforeseen consequences in time and space. A comprehensive synthesis should also describe the level of stakeholder satisfaction and acceptance, as well as an assessment of the overall balance between top-down set objectives versus local objectives.

Recommend adaptations of current management (7) - The final step of the MESMA framework concerns adoption of the current management regime. The results of the assessments in step 5 and 6 will be used to decide if adjustments to the current spatial management of the area should be recommended. If this is the case the recommendations should comprise alternative sets of operational objectives and/or management measures. The costs and benefits of alternative management scenarios should be described in at least a qualitative manner. Any alternative scenarios should be realistic and linked to the respective policy drivers. Further, any alternative set of objectives may require recommendations on the monitoring programs to allow for the performance assessment of the respective indicators. The defined alternative set of operational objectives can be used for a new application of the MESMA framework. Finally, a general evaluation of the level of implementation of the EBM in the area of concern should be provided for instance by relating the objectives to the criteria of EBM (see Arkema et al., 2006).

4 The general applicability of the MESMA framework

One of the key criteria on the development of the MESMA framework is its general applicability, so that it can be used at any spatial scale independent from the natural and socioeconomic factors relevant in a certain area. The first draft of the framework will be tested in nine specified MESMA case studies covering a variety of these factors, which have been selected with the help of standardised criteria such as the presence of potential conflict between human uses or data availability (Figure 2). All selected case studies are SMAs representing discrete spatial entities at different spatial scales where a spatial management framework such as MSP is in place, is under development or is considered. The definition of SMAs allows in general for the inclusion of such different areas showing

a great variation of the advancement of spatial management plans. Thus the application of the MESMA framework will consequently lead to different types of assessment outputs. From the set up of the case studies it can be expected that the outputs may fluctuate from one extreme which is a sustainability appraisal of an existing marine spatial plan, including an assessment of the process used to develop the plan, to the other end of the spectrum which rather reflects an IEA with a set of qualitative recommendations to support an EBM. To facilitate a first characterisation of the SMAs together with expected contents of the assessment output a conceptual flow diagram has been produced (Figure 3). Before the proposed MESMA framework is applied to a SMA, it is recommended to conduct a relative positioning of the SMA concerned within this conceptual flow diagram. A close examination of the flow diagram reveals that the relative characterisation of the expected outcomes (varying from detailed quantitative assessments to qualitative recommendation) depends not only on the advancement of the spatial management in place but also on the data available for the assessment. As a result, an assessment of a SMA with an implemented marine spatial plan can also result in a rather qualitative description of issues and recommendations when data are absent. This highlights the fact that the assessment must be data driven to produce a set of quantitative results.

5. Next steps and general challenges for the application of the MESMA framework

The above described framework and the practical guidance will be tested in the nine MESMA case studies throughout the duration of the project, and a structured feedback process will be implemented to revise the MESMA framework to reflect good practice. The case studies are all in European marine waters and some include even transnational waters and have different stages of spatial management planning. Albeit the current absence of this feedback from the case studies some general challenges can be derived from the literature for the application of such a framework. As described by Levin et al. (2009) the spatial scale defined for the SMA and its assessment is important as ecological processes and functions are scale dependent and any boundaries defined may be arbitrary making the detection of response and changes difficult. On the other hand side the temporal scale is an important factor influencing the assessment outputs. As the spatial boundaries the temporal scale is also relevant for the detection of response for instance the response of indicators to implemented management measures (Rice and Rochet, 2005). In the recent literature it has been recognised that the governance structures can have a great influence for instance on data availability (Day, 2008).

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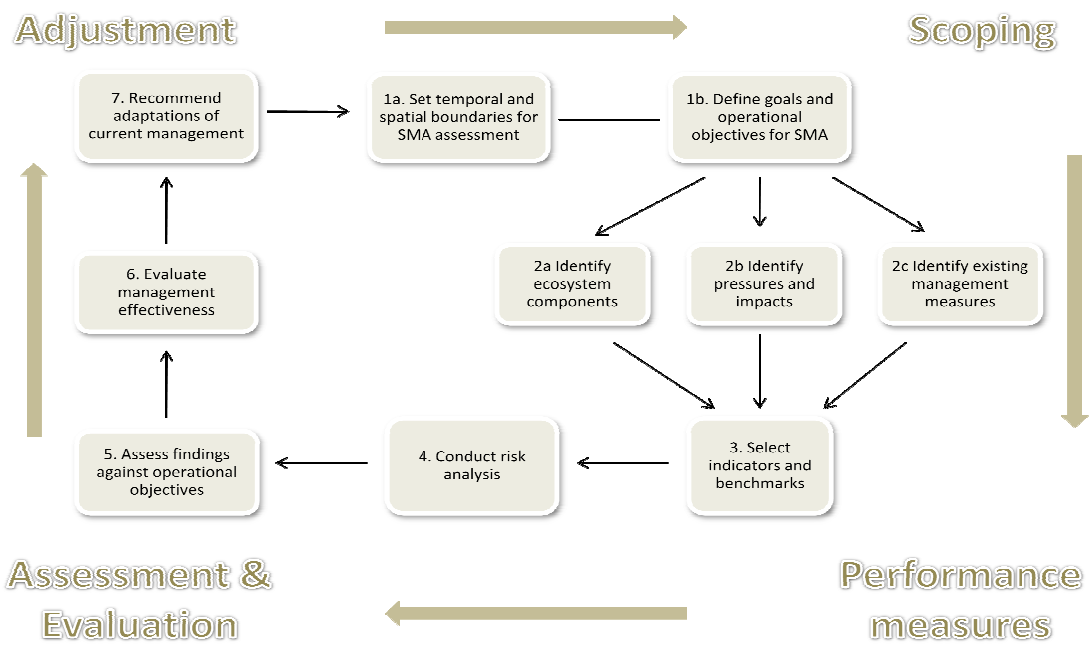


Figure 1: Proposed MESMA framework to monitor and evaluate spatially managed areas (SMAs) through seven key steps.



Figure 2: MESMA case studies: 1) Southern North Sea, 2) Penland Firth & Orkney Waters, 3) Barents Sea & Lofoten area, 4) Celtic Sea, 5) Basque country continental shelf (SE Bay of Biscay), 6) Strait of Sicily, 7) Inner Ionian Archipelago & adjacent gulfs, 8) Baltic Sea, and 9) Black Sea.

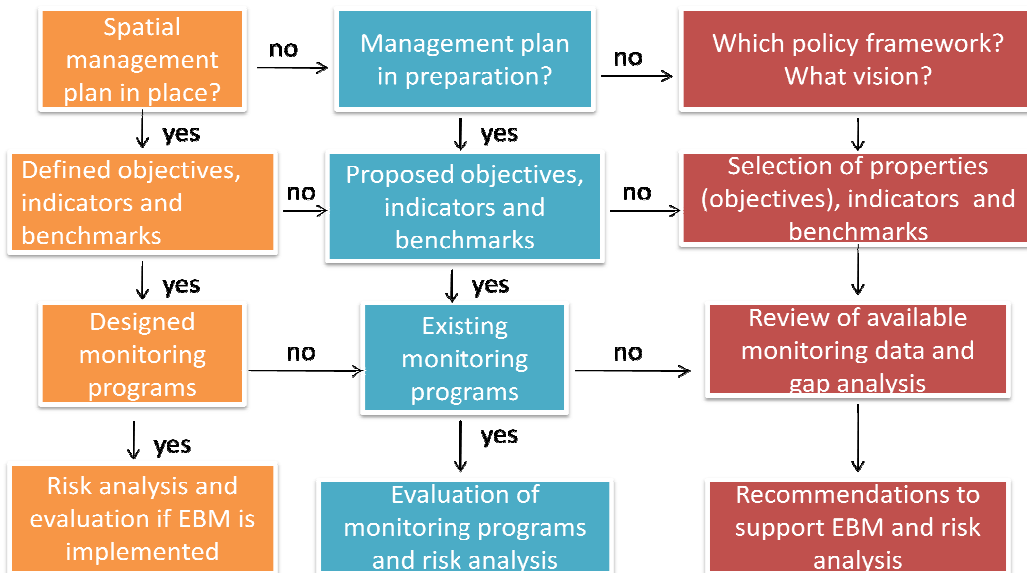


Figure 3: Conceptual flow diagram which relates the advancement of a given spatial management in a SMA together with the available data to expected assessment outcomes.