MAIA

Marine protected areas in the Atlantic arc

MPA indicators and context of use: literature overview with emphasis on applicability to the Northeast Atlantic

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Overview Report

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MPA indicators and context of use: literature overview with emphasis on applicability to the Northeast Atlantic

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Summary

MAIA aims to contribute towards a more interrelated system of MPAs in the European waters of the UK, France, Spain and Portugal, despite the distinct starting points of constituent MPAs (in terms of management priorities, monitoring implementation and governance regimes). In relation to MPA monitoring, it proposes to achieve the above by setting common baselines, facilitating spatial comparisons and providing a framework of more general understanding of MPA impacts at a regional scale.

This report provides a literature overview of indicators used to monitor Marine Protected Areas around the world, in terms of ecological, socio-economic and governance performance. Emphasis is placed throughout in indicator relevance, i.e. the necessity of monitoring to be guided closely by management goals and objectives during its design and to be communicated efficiently during its implementation to inform management effectiveness evaluation in the context of an emerging network.

The rationale for the definition of the document scope is provided in section 1. Section 2 demonstrates the need to look both upstream (governance and management systems, MPA goals and objectives) and downstream (effectiveness evaluation and adaptive management decisions) when considering MPA monitoring and indicator use, and provides a theoretical contextualization of MPAs as complex social-ecological systems (both individual and extending to networks). Section 3 provides specific examples from the MPA indicators literature, separately for the biophysical, socio-economic and governance components. Section 4 briefly sets the current situation within the north-east Atlantic waters of Europe, while section 5 provides a proposal and a calendar for the rest of the action plan related to MPA monitoring and use of indicators within MAIA and beyond.

The research papers and reports considered for this overview are listed at the end of the report. Given that this document is meant predominantly to be used for collective reflection within MAIA and not for publication, entire phrases, paragraphs or Figures are copied from the literature when considered relevant, providing always the appropriate citation of the source.

1. Background

Performing some structured queries in the ISI Web of Knowledge (September 2011) demonstrated that:

i) The prime literature on MPAs is already large (3177 hits for search "marine" and "protected" and "areas") and growing exponentially (with close to 300 papers and more than 6000 citations produced just in the first 9 months of 2011);

ii) The literature on indicators is even larger (5286 hits for search "marine" and "indicators" with frequent special issues in various journals in recent years);

iii) There is a clear unbalance towards research outputs dedicated to bio-physical indicators (1195 hits for search "marine" and "indicators" and "biological" or "ecological" "physical") versus those dedicated to socio-economic (180 hits for search "marine" and "indicators" and "social" or "economic") or governance indicators (24 hits for search "marine" and "indicators" and "governance");

iv) Finally, although more than half of the MPA literature includes some reference to management (1808 hits for search "marine" and "protected" and "areas" and "management"), less than 15% of it include explicit reference to goals or objectives (453 hits for search "marine" and "protected" and "areas" and "goals" or "objectives") or are dedicated to comparisons or effectiveness (394 hits for search marine" and "protected" and "areas" and "comparisons" or "effectiveness").

In addition, some prime literature review papers (e.g. Pelletier et al 2005; Pomeroy et al 2005) and several gray literature reports (e.g. NOAA 2004; Pomeroy et al 2004; Recchia and Whiteman 2010) have already described the principles for defining MPA monitoring frameworks or provided guidelines for specific MPA indicators application. This early exploration of the literature also demonstrated that any document on MPA monitoring and indicators is meaningless unless considered within the context of the system to be followed (goals and objectives) and providing clear ideas on how monitoring outputs will inform future system decisions. As a result, the objective of this overview is to serve to the MAIA partners as background in a process to identify relevant monitoring initiatives and propose the implementation of a handful to a system of MPAs in the near future. Further, considering also the current state of the system of MPAs in the NEA (see section 4), specific options were taken to narrow the scope of this document in relation to the following issues:

- Indicator <u>*relevance*</u> vs *effectiveness*;
- Indicators of <u>*socio-economic and governance*</u> vs *bio-physical* MPA properties;
- Monitoring a <u>*network*</u> vs a *single MPA;*
- <u>*Fisheries*</u> vs *various MPA user groups;*
- <u>*Inshore*</u> vs *offshore.*

Finally, IUCN defines marine protected areas as any area of intertidal or sub-tidal terrain, together with its overlaying waters and associated fauna, flora, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment (Pomeroy et al 2004). Although this very wide MPA definition – basically encompassing any specific management intervention that is spatially organized within the marine realm – will deliberately be used, literature, requirements or conclusions that are specific to marine reserves (that include areas where all extractive and most non-extractive human activities are prohibited) will be specifically flagged.

2. Operational context for environmental indicators

Any monitoring program requires a methodological framework (based on sampling theory and an appropriate design – e.g. Guidetti 2002), measurements (based on standardized data collection procedures and appropriate instruments – e.g. Murphy and Jenkins 2008) and assessment statistics (based on data analysis – e.g. Addison 2011). As Nicholson and Fryer (2002) suggest, using the term indicators has obliged to focus on the relevance of environmental monitoring, both in terms of underlying management objectives and of intended communication to program customers. However, the same authors warn that undue emphasis on relevance could mean that the technical aspects of monitoring programs are pushed in the background, potentially leading to ad-hoc monitoring, misleading results and wasted resources (i.e. *indicator effectiveness* taken to mean the management questions that can be answered using the collected data, the precision of the answers and their presentation in ways that make conclusions accessible to the target audience).

Despite the obvious need to consider thoroughly indicator effectiveness while designing an MPA monitoring framework, the rest of this review will exclusively focus on indicator relevance (effectiveness aspects will have to be considered at a later stage, once the scope of common monitoring under the MAIA initiative becomes clearer). However, indicator relevance is intrinsically linked to the operational context defined by the questions that are meant to be answered (management objectives) and the form these answers are to be used (associated governance system). Hence, the rest of this section explores alternative forms that monitoring may take depending on management objectives and the attributes that indicators may need depending on how and where results are communicated and used within the governance system. Section 2.1 describes alternative conceptual paradigms that can shape management and are usually associated with distinct governance types. Section 2.2 uses a specific analytical framework to consider an MPA as a complex social-ecological system, and section 2.3 extends this approximation to a network of MPAs and describes current systemic approaches for harmonizing monitoring across MPAs.

2.1. Conceptual paradigms

Monitoring and indicators are used to inform management for a plethora of sectorial and integrated human activities (e.g. Olsen 2003; Heslenfeld and Enserink 2008; Piet et al 2008; Charles et al 2009; Borja et al 2011 for activities in the marine realm, often together with associated transition and catchment areas and the respective terrestrial zones). Apart from the differences inherent to the characteristics of the system under consideration, roles of monitoring and desired attributes of indicators can differ considerably, even within a single policy framework. For example, within the European Water Framework Directive that aims to assess the quality status of surface waters and manage them by river basin plans, three monitoring types are prescribed (surveillance, operational and investigative) depending on implementation phase and objectives (Borja et al 2010).

Within natural resources and environmental management, there has been an evolution away from the management of individual species, sectors, activities or concerns and towards a system approach, broadly termed ecosystem-based management (e.g. Olsen et al 2006; Christie et al 2009). The underlying rationale for this shift is common (ecosystems are facing growing multiple pressures and ecosystem function should be central component of the management regime design), but approaches can differ in problem definition, scale, institutional approach and balance of environmental and socioeconomic goals (Christie et al 2009). The most marking differences between approaches seem to relate to whether the Social and Ecological components of the system under management are treated separately and the prevailing conceptual paradigm that describes their relations and anticipated dynamics (but see also Jentoft et al 2007 for alternative description of MPAs as combination of governing system and system to be governed components).

Under the **DPSIR framework** (Driver-Pressure-State-Impact-Response – e.g. Brown and Riley 2003; Borja and Dauer 2008; Ojeda-Martinez et al 2009) the system under focus is eminently Ecological. Driving forces of social and economic development are assumed to exert pressure on the environment thereby changing its state that may result in impacts to human health and/or ecosystem function hence requiring environmental management responses and regulation. Under this paradigm, although environmental management occurs at the societal Response component (with strategies to halt, ameliorate, mitigate or reverse unacceptable conditions and protect human health and a healthy ecosystem), most monitoring attention is given to the Impact component, which requires (Borja and Dauer 2008):

> assessment of ecological integrity;

> evaluation of whether significant ecological degradation has occurred;

> identification of the spatial extent and location of ecological degradation;

> determination of the causes of unacceptable degradation in order to guide management actions.

Within the DPSIR paradigm, monitoring has an important role in policy implementation and indicators may become explicit enforcement tools in the regulatory process (Rees et al 2008). In a regulatory context, an indicator must relay information about the environment in a manner that will determine the necessity for corrective action (*a measure, index or model used to estimate the current state and future trends in physical, chemical, biological or socio-economic conditions of the environment, along with thresholds for management actions to achieve desired ecosystem goals* - cited in Rees et al 2008). An ideal environmental indicator should therefore be (according to the overview of an ICES Symposium on the utility of environmental indicators on meeting regulatory needs – Rees at al 2008):

i) Capable of conveying information that is responsive and meaningful to decision-making;

ii) Linked to a conceptual stressor-response framework;

iii) Capable of measuring change or its absence with confidence;

iv) Highly sensitive and anticipatory;

v) Applicable over a variety of spatial scales and conditions;

vi) Desirable operationally;

vii) Integrative;

viii) Non-destructive;

ix) Easy to understand and communicate;

x) Scientifically and legally defensible.

Under the **Social-Ecological System framework** (SES – e.g. Muñoz-Erickson et al 2007; Ostrom 2007; Chapin et al 2009; Pollnac et al 2010) the system under focus explicitly passes to also incorporate the Social component and its Interactions with the Ecological component. The underlying conceptual paradigm is that such systems are complex and adaptive, with a capacity of self-organization and an ability to acquire information about the environment and adapt to changing and uncertain conditions. Resilience (the ability to absorb and recover from disturbances) becomes a desirable system property central to management, where renewal and reorganization through experimentation and mutual learning are processes that are favoured to the detriment of static, idealised solutions driven by model forecasts. Within the SES paradigm, monitoring is what allows institutions to learn as individuals do, requiring feedback loops linking monitoring information to the revision of management goals within an adaptive management framework (Muñoz-Erickson et al 2007).

Charles and Wilson (2009) list ten reasons why the human dimension should also been into consideration when planning, implementing and managing MPAs (ranging from attachment to place and the "people side" of knowledge, to aspects of rights –

management, access and withdrawal – and the distribution of costs and benefits), recognizing that the balancing act between the biophysical and the human dimensions will be a continuing challenge in the world of MPAs. Ehler (2003) considers that indicators for the evaluation of integrated coastal management performance should be simple, quantifiable and communicable, with the following main attributes:

i) relevant to management objectives and scientifically valid;
ii) developed with all those involved in management (unlikely to work if imposed from above);
iii) credible, easy to understand and unambiguous;
iv) part of the management process, not an end to themselves;
v) focusing in the use of information, not gaining it;
vi) clear link with the environmental outcome being monitored;
vii) continuously reviewed and refined when necessary, as part of adaptive management;
viii) providing early warning of emerging issues or problems;
ix) capable of being monitored easily to show trends over time;
x) accepted and clearly documented methods and units;
xi) as simple and cheap as possible;
xii) adaptable to use at a range of scales, wherever possible.

Jones (2002) in reviewing MPA objectives, selection, design and management worldwide, concludes that blueprint solutions do not exist and identifies two prevailing and competing stances with respect to MPAs: the first (top-down) is government-led and science-based, with greater emphasis on set-aside and nature conservation; the second (bottom-up) is community-based and science-guided, with greater emphasis on multiple use and sustainable development of coastal communities (see Figs 1 and 2 for main differences between the two stances and their infrastructures). Although each of these stance seems closer to one of the two general frameworks described above (top-down stance with DPSIR framework and bottom-up stance with SES framework), these combinations do neither seem compulsory nor necessarily mutually exclusive. Finally, irrespective of the stance or the conceptual paradigm adopted in an MPA, monitoring should always inform management, especially in relation to three themes: design issues, adequacy and appropriateness of management systems and delivery of protected area objectives (Pomeroy et al 2004; Leverington et al 2008).

2.2. MPAs as social-ecological systems

Pollnac et al (2010) provide concrete examples of why MPAs, and even marine reserves, should be seen as linked social-ecological systems. Using data from 56 marine reserves across gradients of socio-economic conditions showed that human population density in the surrounding area and compliance with reserve rules had the strongest effects on ecological performance and that the effects were region-specific. Further, using data from 127 reserves demonstrated that compliance with reserve rules were related to complex social interactions rather than just level of enforcement, thus demonstrating that ecological and social dynamics are linked through complex processes surrounding human dimensions of marine reserves. The rest of this section provides a theoretical framework for the generic MPA conception as a complex social-ecological system (SES) and the role of monitoring in its function and dynamics.

Assuming that it is difficult to effectively exclude beneficiaries from a delimited area in the marine realm that has multiple resources and users and that exploitation by a user or user-group reduces resource availability for other users and groups (Ostrom et al 1999; Brown et al 2001), a MPA can naturally fit within the conceptual context of the multiple-use commons situation described by Edwards and Steins (1998). In that sense, a MPA system contains physical characteristics that result in constraints in the extraction of resource units and other non-extractive uses (that may also include the enjoyment of non-use as in marine reserves), decision-making arrangements that regulate access and resource allocation and provide for sanctions and non-compliance through operational, collective choice and constitutional rules (the former two internal to the system, the latter external) and social characteristics usually distinct for specific user groups (see Fig. 3 for system visualization). These three system components interact among themselves and with contextual factors (external to the system) to shape the action strategies of groups and individuals, whose actions and patterns of interaction result in a given state of the MPA in terms of ecological, economic and social sustainability (outcome).

This analytical framework permits also to consider MPA temporal dynamics, where specific outcomes can affect subsequent patterns of interaction through a process of learning, by which individuals and groups modify their strategies and modify institutional arrangements to produce preferred outcomes. However, as Edwards and Steins (1998) recognize, defining these preferred outcomes and performing long-term system measurements to aid the judgment of their fulfillment are difficult to determine and operationalize. These acts, according to Kim and Oki (2011) fall within the scope of visioneering, (see Fig 4 for system definition and visualization) which is the engineering of a sustainable and resilient social-ecological system through the cooperative interplay of governance (defining a vision and resolving trade-offs), management (operationalizing the vision) and monitoring (synthesizing observations to provide feedback that serves for sustainability learning). This concept is considered pertinent for the rest of this review, as it vividly demonstrates that monitoring cannot be considered outside the context of management and governance.

Ostrom (2007) warns that complex SESs are not amenable to quick fixes and simple, universal solutions; rather developing nested conceptual maps to analyse systematically multitier interactions and respective outcomes and creating enabling conditions for experimenting with adaptive policies are proposed ways to improve and systematize knowledge while avoiding major disasters. Jentoft et al (2007) recommend that MPAs should be viewed as a system resulting from the relationship between two sub-systems: a governing system (eminently social, made up by institutions and steering mechanisms) and a system to be governed (social-ecological, consisting of the ecosystem with the resources it harbours and of stakeholders and users with their political coalitions and institutions).

Although it is still difficult to elucidate general effectiveness principles from existing MPA literature (Christie and White 2007), effective commons governance is generally considered to be facilitated when (Dietz et al 2003):

i) the resources and use of resources by humans can be monitored and the information can be verified and understood at relatively low cost;

ii) rates of change in resources, resource-user populations, technology, and economic and social conditions are moderate;

iii) communities maintain frequent face-to-face communication and dense social networks that increase the potential for trust, allow people to express and see emotional reactions to distrust and lower the cost of monitoring behavior and inducing rule compliance;

iv) outsiders can be excluded at relatively low cost from using the resource; and

v) users support effective monitoring and rule enforcement.

The above list emphasizes the importance of designing, performing and communicating appropriate monitoring for effective commons governance. Within the specific context of MPAs, this is expressed by the IUCN management effectiveness framework (Pomeroy et al 2005) within which learning and adaptation through relevant and useful monitoring is a central issue in the iterative process of MPA management (adaptive management – see Fig. 5 for an annotated example from California). Within this context, monitoring is one step in a wider cycle, not happening for its own sake but rather being deliberately designed and timed to feed into the MPA adaptive management loop (Recchia and Whiteman 2010).

Community involvement can take various forms and can also shape monitoring and indicator choices: Heck et al (2011) describe a process of including the involvement of MPA stakeholders in the development of performance indicators; Himes (2007) uses a similar approach to define the notion of MPA “success” through the compilation of the different stakeholder viewpoints; finally, Vella et al (2009) describe a method for selecting and prioritizing indicators involving stakeholder inputs, also moving towards a stakeholder-engaged approach to policy development, selection and evaluation.

2.3. MPA networks

Although the description of an analytical framework for multiple-resource commons in the case of a network of distinct areas (national or international) has not been found in the literature, it is natural to anticipate that it would make Fig. 3 considerably more complex (Ostrom et al 1999; Ostrom 2007):

- the physical characteristics of the system could scale-up those of an individual MPA and acquire new possible ecological properties (e.g. resilience and representativity for scalable properties, connectivity for a new property at the network level – e.g. UNEP-WCMC 2008; Ardon 2008), while biophysical gradients across the system may introduce sources of variation that are unrelated to MPA performance but need to be accounted for to avoid spurious interpretations (e.g. Hamilton et al. 2010);
- the decision-making arrangements could diversify at the operational and collective-choice levels (MPAs in the same network may have distinct objectives, governance and management systems, especially in international contexts – e.g. Christie and White 2007; Pajaro et al 2010), possibly internalize the constitutional layer (especially in contexts of top-down regulatory national initiatives – e.g. NOAA 2004; Christie et al 2009) and add extra layers of international frameworks and regimes (in the case of regional networks where two or more countries are involved – e.g. Paavola et al 2009; Grilo 2011);
- the possible interactions and outcomes would multiply at each level and would become possible across more tiers (Ostrom et al 1999; Ostrom 2007), requiring vertical and horizontal institutional interplay to guarantee management at multiple levels (Berkes 2007).

MPA networks invariably operate at multiple spatial and institutional scales, and the larger their span (larger geographical range or wider management objectives), the larger the difficulty to find, implement and maintain a common system of preferred outcomes and long-term measurements (see Figure 6 from Pajaro et al 2010).

Design, implementation and reporting of network monitoring is clearly facilitated in situations where the extra layers of international frameworks and regimes are not in action. As such, the United States of America provide an interesting example of monitoring systems at regional and systemic (national) level that deserves some attention. describe the chosen approach towards monitoring of an MPA network (21 MPAs of 3 types) in the north-central coastal region of California. The document provides a scientifically based generic framework to guide monitoring workplans and implementation plans of individual MPAs, along with specific options and recommendations for generating interpretable and synthesizable data. The plan contains orientation on two complementary stages of monitoring, starting with a baseline program and extending towards long-term monitoring. The plan aims to be hierarchical and efficient, consisting of two core monitoring elements: assessing the condition of the ecosystems and how conditions change over time (i.e. “status and trends” monitoring) and evaluating specific MPA design and management decisions (i.e. “management effectiveness” monitoring).

Nine ecosystem features (7 habitat types together with consumptive and non-consumptive uses) were selected to collectively represent the network for monitoring purposes. In relation to the status and trends monitoring of the 9 features, apart from the resource-intensive monitoring methods considered for feature assessment, an alternative implementation module of feature checkups is also instituted. This latter option was developed to take best advantage of potential community-based or citizen-scientist monitoring partnerships, using comparatively simpler sampling protocols and methods to monitor a set of vital signs (Recchia and Whiteman 2010). In relation to management effectiveness monitoring, evaluation of design and management decisions uses structured designs separately for short term and long-term evaluations (i.e. conclusive response aimed within a single or multiple 5 year cycles of the adaptative management process – see Fig. 5). Finally, specific attention in this framework document is provided to reporting highly synthesized and interpretable monitoring results, developing partnerships to conduct and support monitoring and in designing cost-effective monitoring implementations.

At the national level, the National Marine Sanctuary Program devised the system-wide monitoring program (SWiM) to enable the development of effective, ecosystem-based programs that address management information needs using a design process that can be applied in a consistent way at multiple spatial scales and to multiple resource types (NOAA 2004). Within SWiM the role of consistency among MPAs is not necessarily to conduct the same monitoring at all sanctuaries, but rather to apply a set of design, implementation and reporting principles for all monitoring. This is because it is recognized that each area has its own concerns and requirements for environmental monitoring, but ecosystem structure and function in all these areas have similarities and are influenced by common factors that interact in comparable ways. Furthermore, the human influences that affect the structure and function of these sites are similar in a number of ways.

SWiM identifies four primary components common among marine ecosystems: water, habitats, living resources and maritime archaeological resources. By assuming that a common marine ecosystem framework can be applied to all sites, the Office of National Marine Sanctuaries developed 14 “system questions” that are posed for every sanctuary and used as evaluation criteria to assess resource condition and trends. They are widely applicable across the system of areas managed by the sanctuary program and provide a tool with which the program can measure its progress toward maintaining and improving natural and archaeological resource quality throughout the system. Because the questions are fairly broad, they are likely to include all questions posed at any finer scales. Furthermore, they represent useful reporting categories for the synthesis of more extensive and detailed findings at the sanctuary, issue, resource, network or regional scales.

Overall, the American experience in building coherent monitoring for systems of MPAs clearly deserves close attention and study. From the above description can also be shaped two rather counter-intuitive conclusions:

i) despite the apparent simplicity of a monitoring system that is built within a single country, the layers of distinct jurisdictions and interests are still pretty complex and thick in the US - successful implementation seems rather to emanate from a capacity to adopt an incremental approach building on existing strengths and progressively adapting following a clear but flexible general guideline;

ii) despite the regular reference to the human dimension of MPAs, both framework documents analysed above clearly focus on the biophysical features of the system – this seems to be in line with the generic observation that management and governance levels of MPA networks having received very limited monitoring attention, despite their potential impact on effectiveness (UNEP-WCMC 2008).

3. MPA monitoring and indicators

Following the IUCN guidelines and definitions (Pomeroy et al 2004), we can state that an MPA **indicator**

MPA indicator: A unit of information measured over time that will allow to document changes in specific attributes of an MPA, by gauging an MPA aspect that is not measurable or very difficult to measure

gauges aspects of the MPA that emanate from the selected MPA **goals**

MPA goal: A broad statement in a management plan of what the MPA is ultimately trying to achieve (defines long-term vision and or condition resulting from effective MPA management, typically phrased as a mission statement that is simple to understand and effective to communicate.

and are expressed as specific MPA **objectives.**

MPA objective: A more specific, measurable, statement in a management plan of what must be accomplished to attain a related goal (defined in terms of accomplishment not in terms of methodology, specific, easily understood, realistic, time-framed and achieved by being measured and validated).

The ultimate role of MPA indicators is to contribute towards the MPA **management effectiveness** framework

MPA management effectiveness: The degree to which management actions are achieving the goals and objectives of an MPA in a system that is based on an iterative cycle of design, management, monitoring, evaluation and adaptation.

by informing the MPA **evaluation process**.

> *MPA evaluation process: Component of the MPA management effectiveness framework, in which appropriate indicators are identified, customized, measured and combined to answer simple relevant questions on MPA context (where we are?), planning (where we want to be?), input (what do we need?), processes (how do we go about it?), outputs (what did we do/produce?) and outcomes (what did we achieve?) and thus improve MPA learning, efficacy and achievement.*

Pomeroy et al (2004; 2005) after performing a worldwide survey of goals and objectives of MPAs, concluded that they fell within three categories: biophysical, socioeconomic and governance. Comprehensive lists of indicators were also compiled and reviewed, leading to a recommended and annotated list of 42 indicators linked to the three categories of goals and objectives together with methodological and guidance information (Pomeroy et al 2004). Beyond this generic guide, Pelletier et al (2005) provide a thorough worldwide review of indicators used to assess the effects of MPAs on coral reef ecosystems (with some relevant literature from other ecosystems), and their associated social and economic consequences. Although the review is specific to coral reefs, it provides a useful starting point for identifying and characterizing indicators constructed from MPA sampling and monitoring.

In the following sections, selected literature examples of ecological (3.1), socio-economic (3.2) and governance indicators (3.3) that can be used to evaluate MPA effectiveness are presented after a brief description of the main findings of Pelletier et al (2005) for each type of indicators. To the extent possible, the selected literature examples address and highlight issues relevant to the monitoring of MPA systems rather than single MPAs.

3.1. Ecological (or Bio-physical)

Pelletier et al (2005) classify the expected ecological effects of an MPA into those at the population, community and habitat level, while they consider an indicator to be a variable appropriate to measure an expected effect using a specific scale of measurement. The review finds that most observational studies focus on effects at the population level (like protection of spawning biomass of exploited species, rehabilitation of demographic structure or exportation of biomass), with fewer addressing community effects (restoration or changes in assemblage structure, protection of biodiversity or indirect effects on algae and invertebrates). Habitat-related effects area rarely analysed, while no results were found on the following potential effects:

- protecting intra-specific genetic diversity;
- protecting and promoting biodiversity through protection of endangered species;
- protecting against fishery-related depletion at community level;

> facilitating recovery from catastrophic human and natural disturbances;
> increasing population stability and resilience;
> recolonisation of shallow habitats by target species;
> maintaining areas with undisturbed habitats.

In addition, effects like protecting recruitment, increasing fecundity, egg and larval production, exploration of density-dependent effects, improving ecosystem stability and protecting essential fish habitats have rarely been addressed by published studies related to coral reefs. Garcia-Charton et al (2008) condense the above expected ecological MPA effects into a list of 11 and compile updated literature information on the evidence resulting from observations in Atlanto-Mediterranean MPAs (together with a meta-analysis on the impact of MPA design aspects to ecological effectiveness of MPAs).

Friedlander et al (2007) use remote sensing technology (combining orthorectified aerial photographs with satellite and hyperspectral imagery to produce GIS-based benthic habitat maps) together with carefully crafted in situ observations under stratified random sampling within a seascape constituted by a mosaic of 4 habitat types and 3 management regimes (MPAs, fisheries management areas and open access areas) to evaluate the efficacy of MPAs in Hawaii. Although this system of 11 MPAs does not constitute a designed network (varying in size, habitat quality and management regimes, since they were originally established to provide opportunities for public interaction with the marine environment), this study provides an interesting methodological proposition on how to make use of ad-hoc MPA systems to test hypotheses concerning MPA design and function (making the *"space-for-time" substitution*) and to use the results to guide further decisions to improve the ecological relevance of the system. In terms of variables measured, the indicators considered were among those commonly used (species richness, biomass and diversity, fish size spectra, relative abundance of larger fish and biomass by main trophic guilds), with the inclusion of a metric of topographic complexity in the habitat characteristics.

Using a similar rationale and sampling design but applying it on a much larger scale (thousands rather than hundreds of kms), Edgar and Stuart- Smith (2009) investigated ecological differences between reefs in no-take areas within MPAs and adjacent fished zones. Although the variables of study were again among the commonest used, the novelty lied in the *use of volunteer divers* to perform a standardized broad-scale study (11 MPAs across 5000 km, 131 sites and 557 transects sampled within 9 months). The underlying premises of the project were that:

i) when appropriately trained and resourced, the most enthusiastic and knowledgeable recreational divers can undertake routine investigation of the marine environment to a level equivalent to a professional scientific diver;

ii) a large proportion of the best recreational divers are willing to assist scientific studies, and will maintain long-term enthusiasm, if provided appropriate feedback, recognition and support to cover some costs of field activity.

The results showed no significant differences between data produced by volunteers and professionals in any of the metrics examined, proving that selected volunteers became adept even at species-level field identification of fish and invertebrates. However, the screening process (for enthusiasm and diving experience), associated to a self-selection process (least skillful or enthusiastic dropping out earlier) resulted in a rather small fraction of the recreational dive community effectively participating in the program. The authors conclude that this largely untapped recourse possesses huge potential value when assessing ecological patterns over continental and global scales.

On a different line of extending MPA monitoring with the involvement of local communities, Yasué et al (2010) compare evidence of ecological change in and around a no-take zone in the Philippines between visual censuses and perceptions of local people. Methodologically, the conversion of rating responses into ordinal scores and the use of generalized linear mixed models for their analysis following a Poisson distribution is an interesting example of performing quantitative analysis on perceptions data. In a counter-intuitive outcome, the results show more evidence for positive ecological change in the analysis of the community perceptions rather than in the underwater visual census. The authors discuss a series of alternative hypotheses for this mismatch (from limited statistical power to detect change in the biological surveys or different spatio-temporal references to unintentional - wishful thinking - or intentional - desire to please – deception in the local community), concluding that although it is difficult to foresee how participatory monitoring can attain the scientific rigor deemed necessary, there is scope to develop monitoring techniques appropriate to the interests and resources of communities linked to MPAs.

Finally, aspects with interest to the design of ecological monitoring of MPAs can be found in: Recchia and Whiteman 2010 for adaptability of monitoring through the creation of a nested modular plan, and for the distinction between coarse-grained evaluations of vital signs based on simplified sampling protocols with community participation and full–scale assessments of ecosystem conditions and trends based on more costly and rigorous monitoring of key attributes and indicators; Hamilton et al (2010) for incorporating biogeography considerations in the design of network-wide monitoring along biological and environmental gradients and Cook et al (2011) for accounting for species ecology when defining monitoring regions for detecting population variation in highly mobile species (seabirds in this case); McCook et al (2010) for before-after and no-take/no-entry area comparisons and wider ecosystemic benefits from the marine reserve network of the Great Barrier Reef; Borja et al (2011) for the list of indicators selected by the EU across the 11 descriptors of good environmental state defined by the EU and their tentative implementation.

3.2. Socio-economic

Pelletier et al (2005) opt to treat economic and social effects of MPAs separately, further separating economic effects of MPA implementation to *priced* (i.e. effects on human activity that can be measured using market prices, like financial costs of setting and managing an MPA, opportunity costs of protection – see also Smith et al (2010), and other effects on extractive and non-extractive activities) and unpriced effects (i.e. effects that require application of specific valuation methods as they relate to goods and services not traded in markets, like benefits associated to recreational experience or the changing status of the ecosystem – including non-use). Overall, the review considers that MPAs have rarely been the focus of rigorous policy analysis that consider a full range of economic costs and benefits, and alert for the difference between measuring economic impacts (MPA effects on levels of economic activity) and values (variation in total consumer – derived from demand function for MPA goods and services - and producer – sum of net benefits after accounting for production and opportunity costs - surplus associated to MPA existence), the difficulty to estimate the difference in valuation due to MPA protection and the need to account for discount rates in valuations over long periods of time.

On social effects, Pelletier et al (2005) consider that these are poorly documented in comparison with ecological and economic, partly because are more difficult to distinguish from economic and partly because they are mainly viewed as constraints to MPA management rather than expectations. For the purposes of their review, Pelletier et al (2005) distinguish social effects of MPAs into those reducing conflicts, improving satisfaction and increasing knowledge. Existing literature is limited and revolves around perceptions, attitudes and relationship between and among stakeholders, users and managers, although the authors admit that social studies about MPA effects are mostly in grey literature, books or proceedings and hence not adequately covered by their review.

Pollnac et al (2006) in an attempt to construct a social impact assessment system for fisheries, chose well-being as the response variable of interest, which they define as the degree to which an individual, family, or larger social grouping can be characterized as being healthy (sound and functional), happy and prosperous. According to the heuristic model developed, well-being is directly influenced by individual attributes, social/community attributes and social problems that interact between themselves and also with job satisfaction, activity attributes, management and other external forces (see Fig. 7 left for schematic representation) to define the socio-cultural system which is also considered to include the ecosystem. The study also demonstrates how the general model can be tailored to specific types of fisheries and in the annex lists a series of variables and measuring strategies that can be used to monitoring each class of independent variables affecting well-being (see for example variables related to job satisfaction in Fig. 7 right), together with methodological tips on how to measure perceptions using graded ordinal judgments.

Smith and Clay (2010) operationalise the above concepts, by measuring well-being in five commercial fishery communities and performing comparisons over time, among fisheries and with wider social groups. They consider such an indicator to be useful if it can be easily developed from available data, enables temporal and spatial comparisons, can be applied at multiple scales and possesses subjective and objective elements. Measuring subjective well-being relies on how a respondent (to a set of open-ended survey questions, an interview, or a ranking instrument) places him or herself on a scale. In this case, *self-actualization* (the desire to reach one´s potential) is used to measure job satisfaction and compare it with a measure of income on a bivariate plot that is then compared among case-studies. In the discussion, suggestions on ways to increase the comparability of income measurements across professions and communities and to set questions for measuring job satisfaction or for linking with broader metrics obtained regularly at a wider scale (like the Gallup-Healthways well-being index) are provided.

Holt et al (2011) and Ruiz-Frau et al (2011) use participative processes (workshop and interviews respectively) to identify, prioritize and map *stakeholder values* in an estuarine and a marine area respectively. Benefits ranged from provision (e.g. food or energy) and regulation (e.g. coastal protection) to recreation (e.g. angling or windsurfing) and culture (e.g. public education or heritage) and could be distinguished into those having direct or indirect economic potential (although going beyond economic valuation is among the objectives of both studies). In the former, the workshop participants were asked to illustrate the important uses of the estuary, the interactions between the different components and whether there were any positive or negative factors influencing these interactions (see Fig. 8 for resulting diagrams converted into single matrix and represented by a benefits network). In the latter study, individual interviews were used to identify the areas of the Welsh marine environment where each participant thought provided the most important benefits to society and why and to identify the areas where the participant would like to see protected from certain human uses (resulting in distribution maps by category of benefits).

Vella et al (2009) demonstrate a method for selecting and prioritizing socio-economic indicators with the involvement of MPA stakeholders, through the example of an application to a Maltese MPA (despite using indirect stakeholder participation through expert judgment of stakeholder contribution during public hearing and comment period, the authors recognize that direct stakeholder participation in all steps of the process is the desirable approach). The evaluation protocol involves establishing goals and objectives that link environmental and socio-economic sustainability at a level of detail that permits empirical evaluation of success; identifying indicators that assess success; ranking indicators according to their usefulness to a greater number of goals; determining the most effective and efficient way of acquiring data. In the study case, 4 stakeholder groups with significant management interest were identified (commercial, government, public/NGOs and research/education), 10 socio-economic goals prioritized and linked to specific MPA objectives and 32 socio-economic indicators measuring change towards the management objectives selected. Relative weights were attributed to the MPA goals according the stakeholder input and a goal-indicators matrix was created to indicate relevance and importance of the indicators (see Fig. 9). Finally, the stakeholder-goal vector was multiplied by the goal-indicator matrix to provide a stakeholder-indicator preference vector, thus ranking socio-economic indicators according to their contribution to most important stakeholder-defined management values. Similar to the studies of Holt et al (2011) and Ruiz-Frau et al (2011), these participatory methods provide new ways of generalizing insight and promoting collective choices, but also crucially linked to an accepted process of defining stakeholder groups and meaningful representatives in proportion to their relevance in the system.

Finally, aspects with interest to the design of socio-economic monitoring of MPAs can be found in: Charles et al (2009) for the failure of traditional economic indicators in Atlantic Canada to anticipate the demersal fisheries collapse in the 1990s and the development and application of the Genuine Progress Index in Nova Scotia, through the monitoring and estimation of 9 ecological, socioeconomic (including the age structure of fishers as a measure of fishery and community resilience) and institutional indicators; Cullen-Unsworth et al (2011) for constructing community-derived (and hence locally comprehensible and relevant) economic performance indicators in subsistence and developing communities of Indonesia (with educational attainment of household head and household assets being strongly correlated with total annual household income); Pollnac et al (2001) for exploring and identifying factors that influence community–based MPA success from a case-study of 45 MPAs in the Philippines (e.g. community population size, alternative income projects); Oikonomou and Dikou (2008) for a process of evaluating perceptions of socio-economic implications of MPA creation to distinct stakeholder groups by replies to questionnaires during interviews (181 questionnaires completed by fishers, agents in the tourist industry, tourists, students, authorities and NGOs) and its temporal evolution (study took place 13 years after MPA implementation).

3.3. Governance

Governance indicators are naturally linked to processes (measuring structures but mainly functions of governing the interactions among the social components of a SES and their behaviour towards the resources it contains). Olsen (2003), recognizing that integrated coastal management initiatives are long-term processes spanning across the lifetime of many funding cycles, proposes a general framework and respective indicators for assessing progress over extended time periods. This framework highlights that changes in state are correlated with changes in behaviour of key partners and stakeholders within the sphere of influence of the management activity. It thus separates outcomes to four orders over time (enabling conditions, changes in behaviour, achievement of goals and sustained course of action) that operate at three spatial scales (local, regional and national). Distinct indicators are proposed to measure each order of outcomes, while linking the above framework to the policy cycle framework (issue definition, program preparation, adoption and funding, implementation and evaluation), allows for better integration among consecutive projects on the same locale or across locales at a larger geographical scale.

Olsen et al (2006) and Olsen et al (2009) provide guidelines for the implementation of the above framework to the governance of Large Marine Ecosystems and more generically to the governance response to ecosystem change respectively. Further, Ehler 2003 reviews experience from integrated coastal management initiatives to identify common problems in the integration of MPA management within the wider ocean governance system and proposes specific governance indicators for addressing them (these indicators are integrated in Pomeroy et al 2004). Apart from lists of indicators, Olsen et al (2009) provide a structured worksheet of progress evaluation for first and second order outcomes, thus allowing regular updating of ranking responses in each question and reviewing total scores. This approach is also helpful for identifying the tipping points between first and second order outcomes that allow overcome the implementation gap that frequently looms such projects (insufficient links between issue analysis, planning and generation of political will on one side and effective and sustained implementation of an integrated plan of action in the other).

Within first order outcomes, important challenges are the securing of formal commitments and the creation of demand for the services that will be provided, both needing to be operationally viable within the existing power structure and among those affected by the program. Indicators for this re-allocation of authority can be formed around the constituencies that are actively supporting the initiative, the formal demonstration of governmental mandate towards the authority necessary to implement a course of action, the resources allocated to this plan or the institutional capacity to achieve it. Within second order outcomes, evidence is required that a formally-endorsed and adequately funded ecosystem-based program has been successfully implemented. This includes evidence for behavioural changes that relate to how institutions and groups relate to one another (e.g. collaboration for more integrated planning and decision making), how user groups relate to their ecosystem (e.g. cessation of destructive practices and improvements in compliance) and how investment decisions are taken towards supportive infrastructures (e.g. sources and sustainability of financing, type of supported infrastructures).

Paaovola et al (2009), in reviewing the governance of biodiversity in Europe during recent decades conclude that it is important to distinguish between governance frameworks and regimes and pay attention to the physical time and jurisdictional scales at which interplay occurs. Governance frameworks define specific institutional arrangements put in place to attain specific goals, while regimes encompass all formal and informal institutions that influence the behavior of relevant actors. Action and participation take place at multiple levels, accommodating interplay both horizontally (at the same level) or vertically (across levels) and giving rise to a polycentric governance regime. Identifying key structural elements of this complex system (with its in-built redundancy) as governance indicators and defining appropriate scales for monitoring interplay are key challenges that needs addressing with specific knowledge to the MPA system under study.

4. The North-east Atlantic

This section provides summary information on the current situation in the Atlantic European waters on issues that may be linked to the governance, management and monitoring of MPAs. Section 4.1 provides a brief update of the OSPAR network of MPAs, section 4.2 describes the marine Natura 2000 network of the EU, and section 4.3 summarizes the current situation in relation to the operationalization of the Marine Strategy Framework Directive and the ensuing monitoring requirements.

4.1. OSPAR

OSPAR represents the mechanism by which governments of 15 European countries, together with the European Union have cooperated since 1992 to protect the marine environment of the Northeast Atlantic, comprising territorial waters, EEZs, and areas beyond national jurisdiction. In 1998, the OSPAR Commission decided to promote the establishment of a network of MPAs to ensure the sustainable use and protection and conservation of marine biological diversity and its ecosystems. In 2003, a target date of 2010 was set for achieving an ecologically coherent network of well-managed MPAs, which, together with the Natura 2000 network (see below) would aim to:

- protect, conserve and restore species, habitats and ecological processes which have been adversely affected by human activities;
- prevent degradation of, and damage to, species, habitats and ecological processes, following the precautionary principle;
- protect and conserve area that best represent the range of species, habitats and ecological processes in the maritime area.

OSPAR (2011) is a status report aiming to summarise the information made available by participating countries and assess to what extend the target has been achieved. By the end of 2010, the OSPAR network of MPAs comprised 1818 sites, 6 of which in areas beyond national jurisdiction. Clear unbalances were found between coastal and offshore waters and across OSPAR regions, creating major gaps in the network. Despite the lack of ecological data, this geographical imbalance was sufficient to judge that the network was not ecologically coherent yet. Further, lack of detailed information on site management made impossible to conclude on the adequacy and effectiveness of management measures.

Ardon (2008) traces the work within OSPAR to define ecological coherence for MPA networks and to assess it within the context of the Northeast Atlantic scenario. An ecologically coherent network of MPAs is taken to:

i) interact and support the wider environment;

ii) maintain the processes, functions, and structures of the intended protected features across their natural range;

iii) function synergistically as a whole, such that the individual protected sites benefit from each other to achieve the previous objectives;

iv) may be designed to be resilient to changing conditions.

The OSPAR documents indicate that it is the ecological linkages between MPAs that are the essential basis of a coherent network, as without such linkages a network is not jointed up and might better be termed a representative network (Jones and Carpenter 2009).

In the face of growing urgency to evaluate progress towards meeting OSPAR targets, Ardon (2008) identified three fast and frugal heuristics that can be employed in data limited situations for the spatial assessment of ecological coherence:

i) is the network spatially well distributed without more than a few major gaps?

ii) Does the network cover at least 3% of most (7 of 10) biogeographic provinces?

iii) Are most (70%) of the threatened and/or declining habitats and species represented in the network?

Jones and Carpenter (2009) recognize that this pragmatic approach is understandable in order to avoid network design being stalled in the urge for unfeasibly rigorous approaches given the high degree of complexity and uncertainty associated with larval dispersion analyses. However, they postulate that such an evaluation based on rules of thumb is too vague and arbitrary, leading to politically realistic but ecologically unrealistic heuristics. In their opinion, the aim of establishing ecologically coherent networks of MPAs is not a practical and relevant policy aim that can be objectively evaluated. Instead, the aim should be in establishing representative networks, such as that set by the World Summit on Sustainable development and adopted by the Convention on Biological Diversity, the properties of which include ecological connectivity but are not based on it.

4.2. Marine Natura 2000 network

The Natura 2000 network of the European Union comprises Special Protection Areas (SPAs) classified under the Birds Directive (79/409/EEC) and Special Areas of Conservation (SACs) designated under the Habitats Directive (92/43/EEC). Under the Birds Directive, member states select the most suitable sites based on scientific criteria and designate them directly as SPAs, becoming automatically part of the Natura 2000 network, while the Commission determines whether the designated sites are sufficient to form a coherent network for the protection of vulnerable and migratory bird species. Under the Habitats Directive, member states have the responsibility for proposing Sites of Community Importance (SCIs) using a scientific process and standard selection criteria. On the basis of proposed national lists, the Commission, in collaboration with member states, uses expert analysis to establish if sufficient high-quality sites have been proposed to ensure the favourable conservation status of each habitat type and species through their range in the EU (separately by regional sea). Once a list of SCIs have been adopted, it is for member states to designate them all as SACs and install the necessary management and restoration measures to ensure favourable conservation status.

Favourable conservation status is interpreted to mean that i) habitat extent is stable or increasing; ii) the specific structure and functions necessary for its long-term maintenance exist and are likely to exist in the foreseeable future and iii) populations of typical species associated with that habitat are viable in the long term (Jenings and Le Quesne 2012). Depending on the conservation objectives of the marine SPAs and SCIs (the marine Natura 2000 sites), member states may envisage the implementation of fisheries management and control measures. Such measures have distinct jurisdictions and procedures of implementation depending whether the MPA is located within or beyond the 12 nautical miles of the member state´s coast (EU 2007).

Johnson et al (2008) provide an initial characterization of the marine Natura 2000 network for the Atlantic region of Europe from northern Portugal to Denmark in terms of site areas and inter-site distances. The analysis focused on six marine habitat types (sandbanks slightly covered by seawater at all times; estuaries; mudflats and sandflats not covered by seawater at low tide; large shallow inlets and bays; reefs; and submerged or partly submerged sea caves) of the 8 present in Annex I of the Habitat Directives (habitats of "community interest whose conservation requires the designation of SACs"). The 298 sites containing at least one of these habitats (Figure 11) had a median size of 7.6 km2 and a median separation among neighbouring sites of 21 km (range 2-138 km). Although the study is just based on a bibliographic review of MPA features and first principles spatial analysis, it concludes that the existing network will likely be both too small and too isolated to support populations at intermediate dispersion scales (2-20 km) entirely within the network. The network is speculated to be ecologically coherent only for good dispersers (>20 km) with broad habitat preferences and for habitat types with large spatial coverage.

4.3. Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD; 2008/56/EC) is a framework legislation to guide sustainable use of the marine environment within the European Union. This Directive specifies 11 qualitative descriptors that constitute the basis for the evaluation of Good Environmental Status - GES: biodiversity; non-indigenous species; exploited fish and shellfish; food webs; human-induced eutrophication; sea-floor integrity; hydrographical conditions; contaminants in water and sediment; contaminants in fish and shellfish; marine litter and introduction of energy/noise. Member States are expected to take the necessary actions to initiate appropriate monitoring and analysis that would permit a first assessment by June 2012 (at the level of ecoregions or sub-regions) and achieve or maintain GES in their marine environment by 2020. During 2009 and 2010 several task groups have worked to select adequate indicators to be used in the assessment of each descriptor (e.g. Rice et al. 2012 for seafloor integrity). Assessing GES involves indicator-based assessment of status of each descriptor, including an integration both within and across descriptors (e.g. Borja et al 2011).

Efforts to support the integration of European environmental and fishery management are largely in place (e.g. Borja et al 2010, Jenings and Le Quense 2012) in an attempt to obtain a harmonized approach and a seamless transition from catchment through transitional waters and coast to the open marine system. High-level relations among the MSFD, the Water Framework Directive, the Habitats Directive and the Common Fisheries Policy are increasingly well defined, but issues related to achieving compatibility among management, assessment and reporting regions, coordinated monitoring and assessment and better integration of research and advisory support are still in the process of definition (Jenings and Le Quense 2012). The latter authors recommend that, in order to meet the pressing and ambitious timetables of the MSFD, priorities should be given to developing targets for impacts with a high risk of compromising sustainability, rather than dissipating research and advisory effort to achieve broader coverage of state, function and process.

5. A way forward

This section narrows the scope of proposed monitoring action (at a post-MAIA timeframe) along a few main lines that seem worth pursuing and have a minimal risk of overlapping with other monitoring initiatives in the Atlantic European space. These main lines focus on the interaction of small-scale fisheries with MPAs (section 5.1), the complementarity of objective and subjective indicators for informing management effectiveness evaluations (section 5.2) and the potential of community-based monitoring as a cheap source of information associated to increased stakeholder interest and involvement (section 5.3). For each of these lines, some basic rationale and description is being provided, while additional work will aim to provide specific guidelines and respond the following questions (taken from effectiveness evaluation in Pomeroy et al 2004) until the end of the project:

- Why develop this line?
- What is proposed to be done?
- How can it be done?
- Where will be tested?
- When will be implemented?

5.1. Small-scale fisheries interaction with MPAs

Why: Small-scale fisheries exist in and around most of the MPAs of Atlantic European waters; Relative spatial fidelity and high temporal variability in fishing patterns, together with multiple fishing targets and higher informality suggest worthy the exploration of area-based rather than stock-based monitoring, assessment and management options (e.g. Hilborn et al 2004; McClanahan et al 2009; Batista et al 2011); Relationship with

MPAs very variable across the MAIA space, ranging from major source of conflicts and lack of compliance to main reason of MPA creation (e.g. Jones 2008; Pita et al 2011); Most of SSF activity takes place outside the current Common Fisheries Policy management and respective monitoring and remote inspection, hence duplication risks are minimal.

What: Build on existing (or plans) of Small Scale Fisheries (SSF) monitoring in MPAs to inform common performance indicators; Aim at informing a few ecological, several socio-economic and a few governance indicators.

How: Set common baselines, perform spatial comparisons and experiment procedures of common monitoring in the MPA system; Requires the collaboration of fisheries biologists with good links in the local fishing communities.

Where: In as many MPAs in the European Atlantic space as possible (conditioned by availability and compatibility of data or resources availability to perform additional monitoring tasks); Preference for maximum span across countries, governance scenarios and MPA goals and objectives.

When: Pilot exercise among 3 MPAs (Iroise, Cedeira and Arrabida) to be initiated in 2012; Wider application within the remit of new project or by informal collaboration within the MAIA network in subsequent years, informed by experience of pilot study.

5.2. Complementary use of objective and subjective indicators

Why: Identifying the perceptions, views and values of MPA stakeholders and users and using them to inform monitoring, management and eventually governance is a way to approximate MPAs to the theoretical framework of complex social-ecological systems; For several socio-economic and governance indicators use of interviews and questionnaires is the commonest or most appropriate methodology (Pollnac et al 2006); Even in the case of biophysical indicators, comparing objective, science-based metrics to subjective perceptions may provide the means to identify sampling deficiencies or community misconceptions (Yasué et al 2010).

What: Identify indicators that can be simultaneously evaluated by metrics and perceptions.

How: Associate with small-scale fisheries monitoring, possibly considering population of users (fishers) and other stakeholders (scientists, managers, etc.); Requires the collaboration of social scientists with experience in application of interview or questionnaire surveys.

Where: In as many MPAs in the European Atlantic space as possible.

When: Pilot exercise among 3 MPAs (Iroise, Cedeira and Arrabida) to be initiated in 2012, probably with interviews with key informants; More thorough expansion with larger number of questionnaires in following years (separate project required).

5.3. Community-supported monitoring

Why: Relying on users, stakeholders and wider society to perform monitoring acts is a widely underutilized potential source (Edgar and Stuart-Smith 2009); Satisfactory involvement can lead to empowerment and appropriation of the MPA, facilitating its acceptance to the local and wider society; Community-supported monitoring is a cheap means to scale-up data collection to regional levels and beyond for evaluation of MPA effectiveness in the medium and longer term.

What: Amateur diving; Marine wildlife-watching; Litter collection and monitoring campaigns (in articulation with MSFD descriptor 10); Upper sub-littoral algae coverage monitoring.

How: Identify key Associations/NGOs willing to test initiatives in pilot projects, with capacity and interest for subsequent scaling-up at national and regional level; Define training, data storing and processing, reporting and community feedback requirements and test them in pilot project.

Where: In a few MPAs in as many Atlantic countries as possible.

When: Identify potential partners and topics in 2012; Pilot study to perform under new project.

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Emphasis on Enforcement	Executive cross-sectoral authority	Education to justify restrictions and promote compliance	Reliance on comprehensive scientific information	Little scope for compromise
↓	↓	↓	↓	↓
↑	↑	↑	↑	↑
Emphasis on stakeholder participation and cooperation	Community-based partnership	Education to promote support and participation	Science used for guidance where appropriate and available	Greater scope for compromise

Bottom-up: based primarily on socio-economic priorities guided by science

Figure 1: Different stances concerning the selection, design and management of MPAs (**from Jones 2002**).

Sectoral law	International-national-regional policy	Statutory objectives and imperatives	Institutional “ways of doing business”
↓	↓	↓	↓
↑	↑	↑	↑
Customs	Largely local view	Collective & selfish objectives	Informal communications and “ways of working”

Figure 2: Different between bottom-up and top-down infrastructures (**from Jones 2002**).

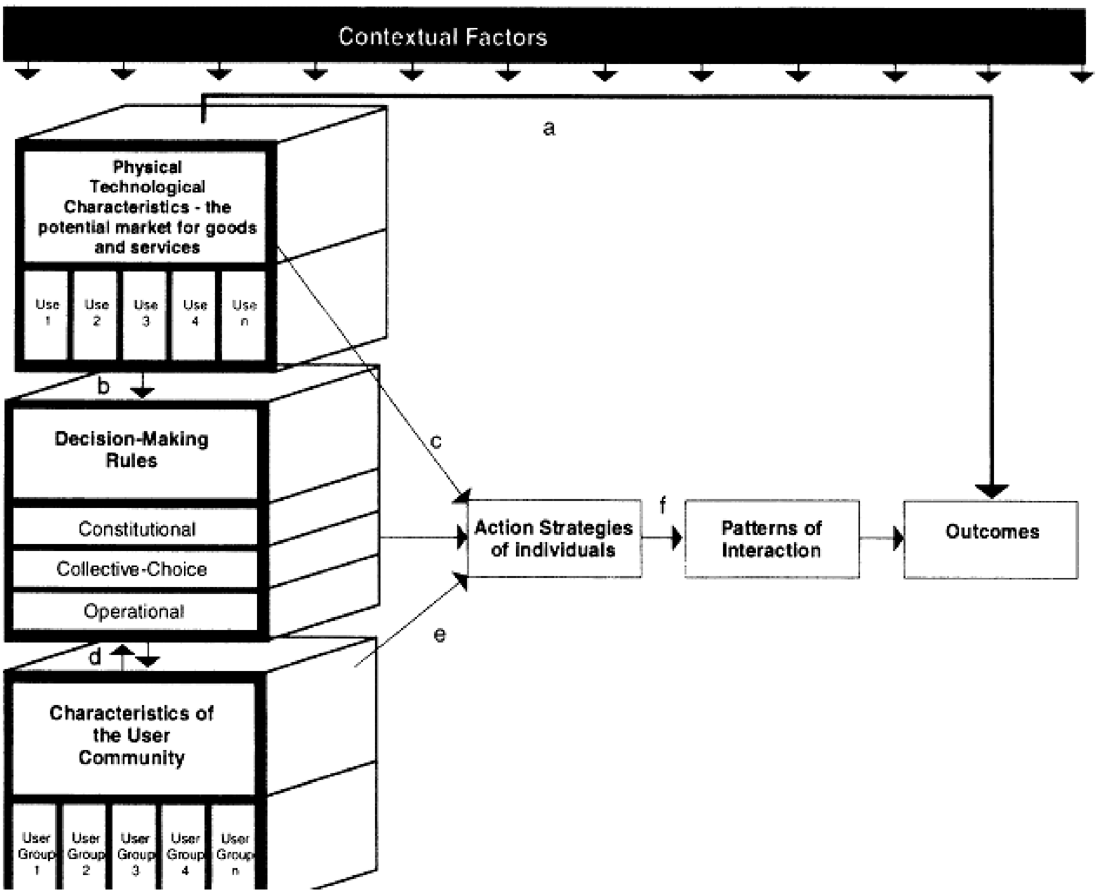
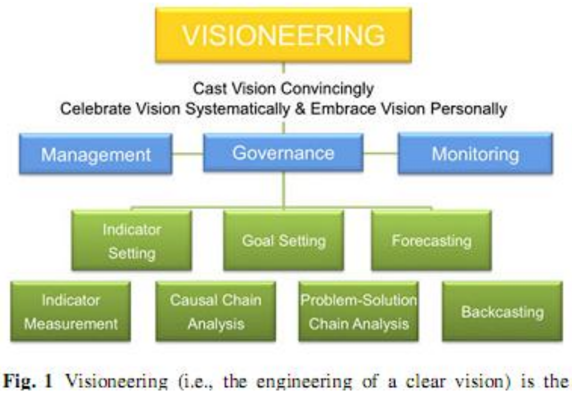


Figure 3: Basic framework for multiple-use commons system (**from Edwards and Steins 1998**).



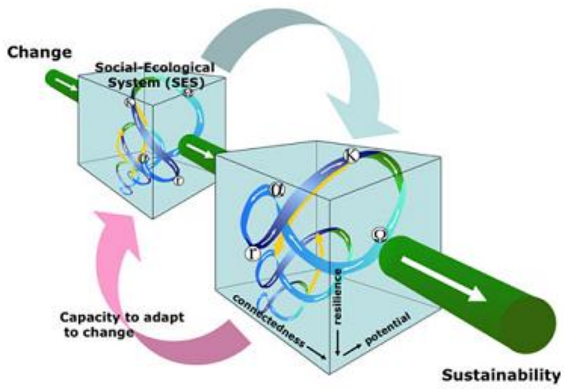


Figure 4: Left - Visioneering as the cooperative triad of governance, management and monitoring; Right - envisioning of a sustainable future: sustainability is a dynamic process that requires adaptive capacity in resilient social-ecological systems (SES) to deal with change; at all scales SES move through their own adaptive cycle consisting of rapid growth (r), conservation (k), release (omega) and reorganization (alpha); these adaptive cycles are pictured in 3 dimensions: 1) potential (or capital) 2) interconnectedness and 3) resilience. Upper blue arrow is transformation of SES with change and bottom pink arrow is resilience of SES to go back - adapted from Gundersons and Holling 2002; Berkes et al 2003. (**from Kim and Oki 2011**).

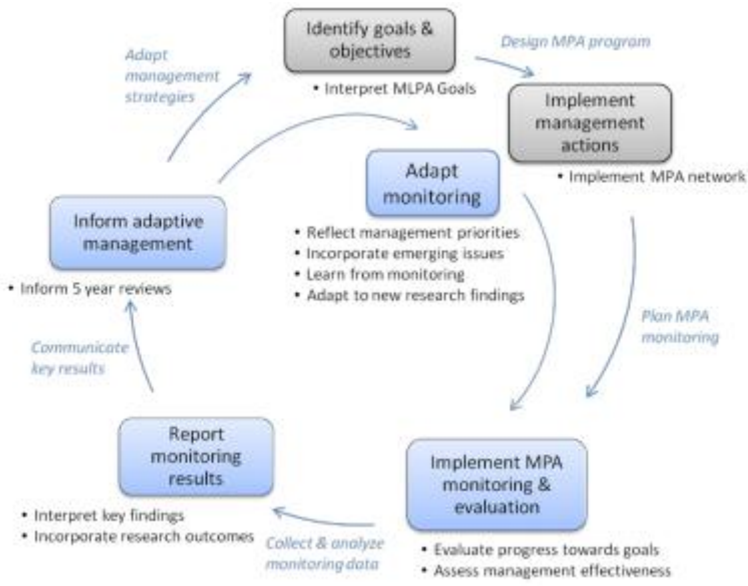


Figure 5: An illustration of an adaptive management process, annotated to show application to the California Marine Life Protection Act: Monitoring must be designed to evaluate management actions in order to inform management review and adaptation. And monitoring itself must be adapted periodically to remain relevant and useful (**from Recchia and Whiteman 2010**).

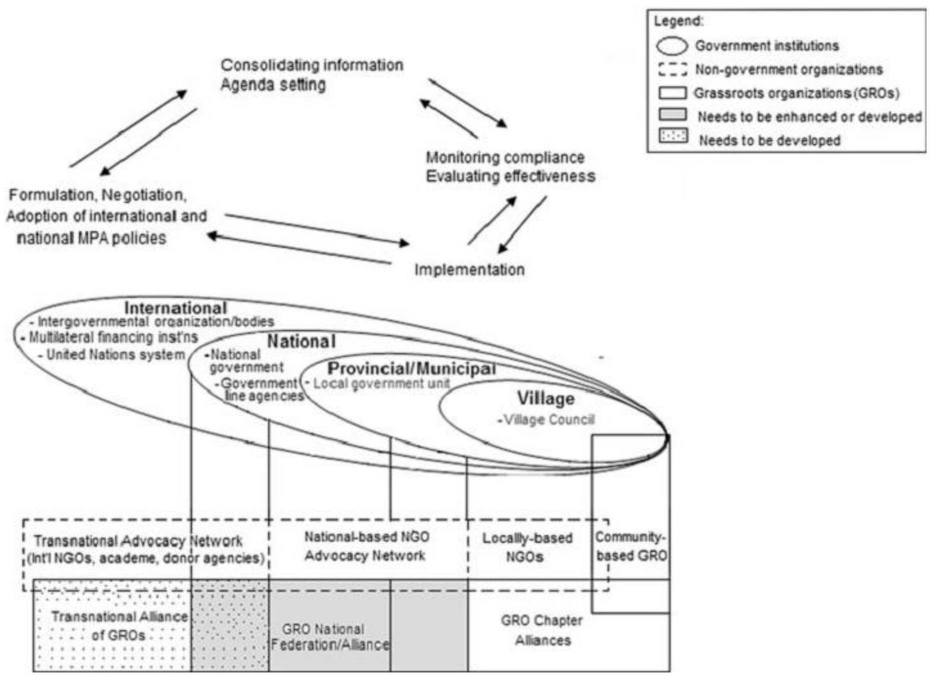


Figure 6: Nested scale and cross-cutting levels of engagement by various actors in MPA policy development (**from Pajaro et al 2010**).

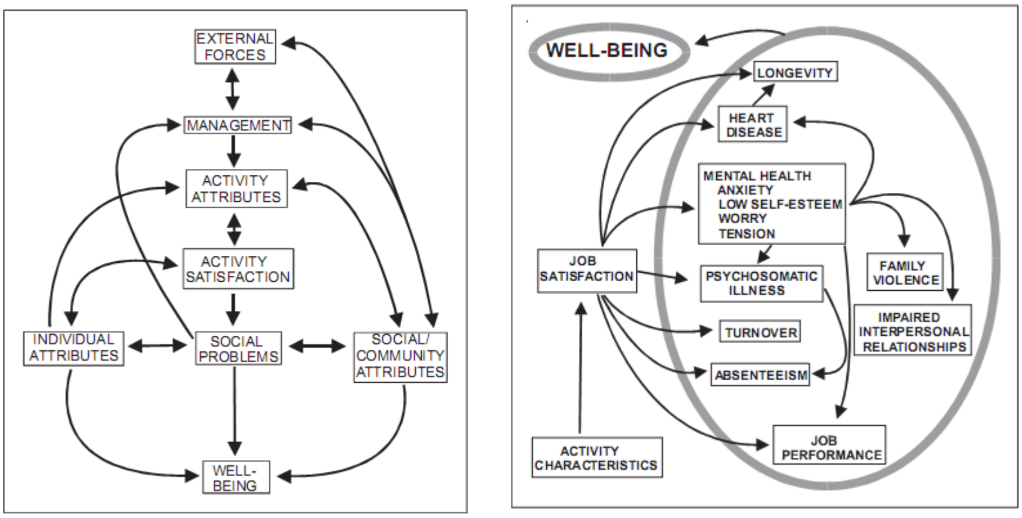


Figure 7: General marine resource social impact assessment model (left) and impacts of job satisfaction to well-being (right) (**from Pollnac et al 2006**).

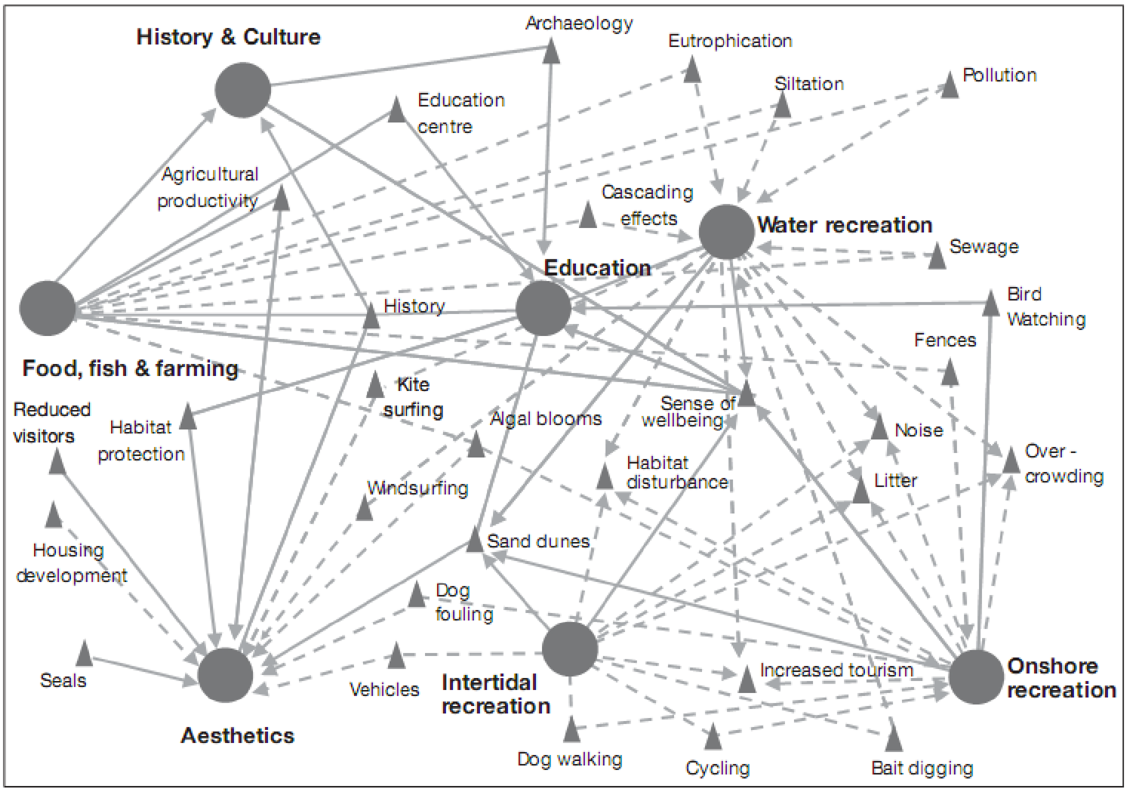


Figure 8: Benefits that stakeholders derive from the Ythan estuary (circles) how they interact and what factors (triangles) determine whether these interactions are positive (solid lines) or negative (dashed lines) (**from Holt et al 2011**).

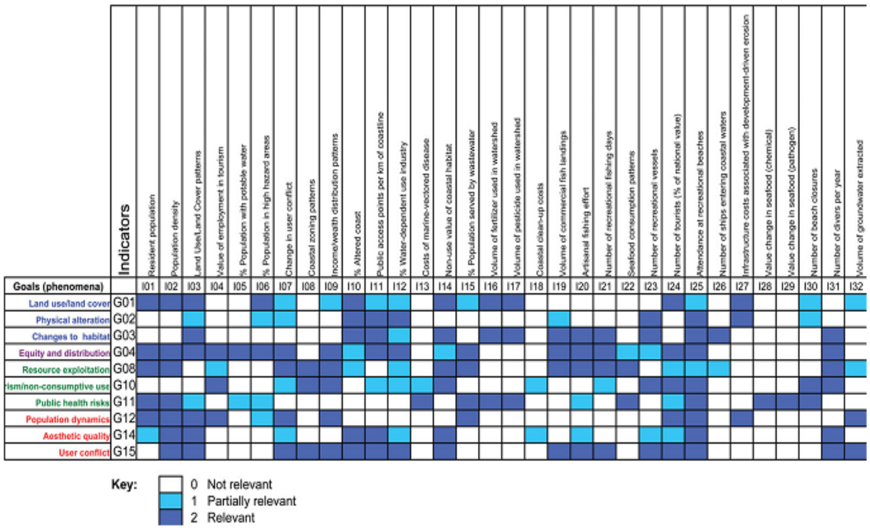


Figure 9: MPA goals vs Indicators matrix from expert group analysis – colours indicate a goal-indicator association by relevance (0 – not relevant; 1 partially relevant; 2 relevant) (**from Vella et al 2009**).

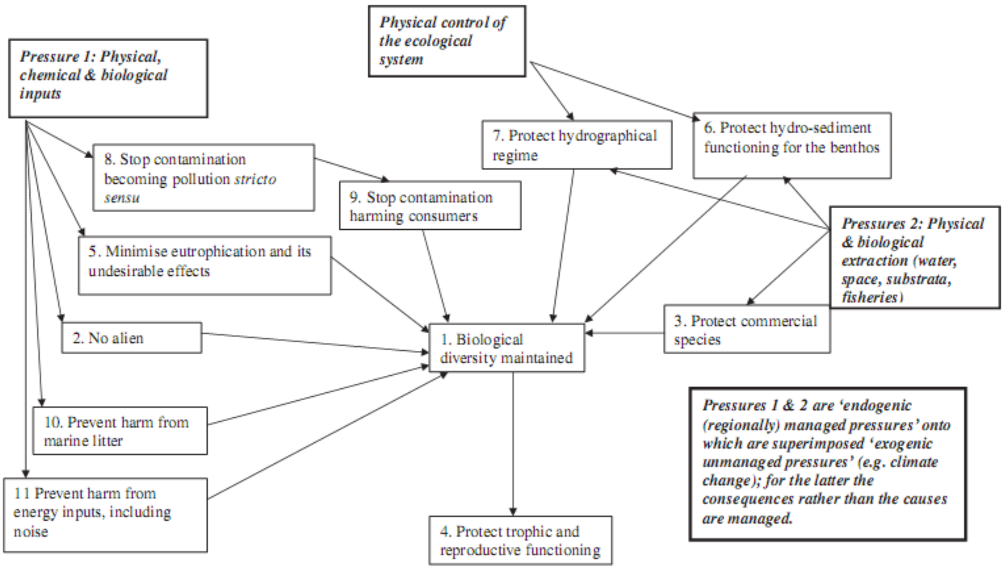


Figure 10: Relationships among the 11 descriptors of GES in the MSFD (**from Borja et al 2011**).

CHARACTERIZING THE MARINE NATURA 2000 NETWORK FOR THE ATLANTIC REGION 89

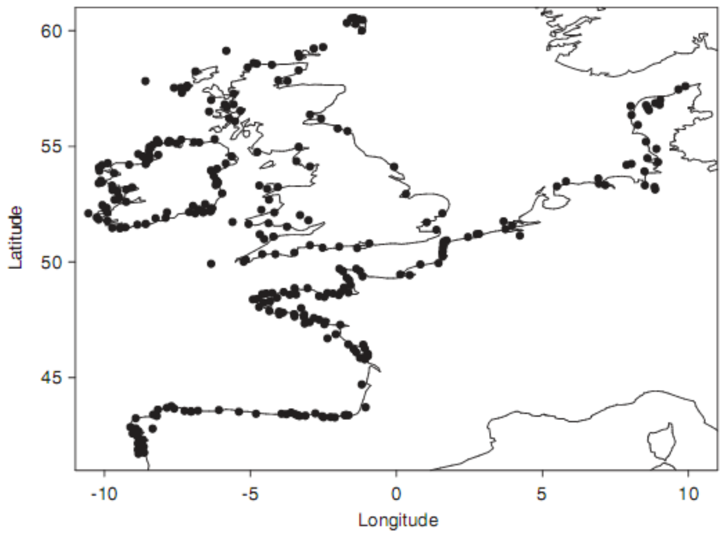


Figure 1. Locations of sites of community importance for the Atlantic biogeographical region that contain marine habitats (excluding lagoons). Apparently inland sites are predominantly estuarine.

Figure 11: Location of sites of community importance for the Atlantic biogeographic region that contain marine habitats (excluding lagoons). (**from Johnson et al 2008**).

MAIA

Marine protected areas in the Atlantic arc

Towards an Atlantic network of Marine Protected Areas

The purpose of the European Marine Protected Areas in the Atlantic arc (MAIA) project is to create a **network of MPA managers and stakeholders**, who will take initiatives on an international level in terms of designation, governance and management. This will be to enhance the **development of a consistent, efficient and accepted MPAs network** in the Atlantic arc.

MAIA is structured in four main technical lines of work:

- Establishing a status report on the existing MPAs
- Setting up common monitoring strategies
- Implementing management plans
- Involving stakeholders

MAIA gathers 9 partners from 4 countries: United Kingdom, France, Spain and Portugal, **involved in MPAs designation and management.**

As lead partner, the French Marine Protected Areas Agency, coordinates the project implementation.

The 2010 – 2012 Action Plan

Organisation of technical workshops on common MPA management issues in the Atlantic arc.

Site visits in each partner country to enhance the sharing of information, knowledge and know-how.

Overview reports to compare MPAs' situation in the Atlantic arc.

Field studies to be carried out by MAIA partners, promoting the exchanges within the network.

Creation of a dedicated website, including a private collaborative space, a document database and a GIS database used to establish a baseline on the status of MPAs in the Atlantic arc.

Production and dissemination of document resources.

www.maia-network.org

ATLANTIC AREA Transnational Programme
ESPACIO ATLÁNTICO Programa Transnacional
ESPACE ATLANTIQUE Programme Transnational
ESPAÇO ATLÂNTICO Programa Transnacional

European Union
European Regional Development Fund

INVESTING IN OUR COMMON FUTURE