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EMPAFISH
European Marine Protected Areas as tools for Fisheries management and conservation

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Towards an European strategy for the management and networking of Atlanto-Mediterranean marine protected areas

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Towards an European strategy for the management and networking of Atlanto-Mediterranean marine protected areas

EMPAFISH D26

Contents

Foreword

The present report constitutes the deliverable nº 26 of the EC research project EMPAFISH. With this document, the EMPAFISH consortium intends to transfer to marine protected areas (MPAs) managers and practitioners a set of recommendations for the management of these protected areas, based on the best data and evidences available. This source information is primarily issued from EMPAFISH works, and also from the cumulate experience in each of the 20 MPAs used as case studies in this project.

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Executive summary

The ultimate goal of EMPAFISH project is to provide the EU with a set of integrated measures and policy proposals for the implementation of MPAs as fisheries and ecosystem management tools. The works performed throughout the project were mainly based on existing and new data on ecological, fisheries, and socio-economic aspects of 20 already established, well-studied Atlanto-Mediterranean MPAs selected as case studies. Within this context, the present report includes a set of recommendations for MPA management, and constitutes the Deliverable nº 26 of this project.

To put this common effort by the EMPAFISH consortium into perspective, the background and context of MPA management has been reviewed. Firstly, assessments of the evidence –positive, neutral or negative for ecological, fisheries and socio-economical effects of MPAs have been reviewed for some of the EMPAFISH 20 case studies. On the other hand, the number of documents dealing with different aspects of MPA management is growing exponentially during the last years. This documentation reviewed includes those issued from:

- International commitments and targets regarding MPAs (Convention for Biological Diversity, FAO, SPA Protocol, OSPAR, HELCOM, European Habitats Directive, Common Fisheries Policy, European Integrated Maritime Policy)
- MPA networks in Europe and the Mediterranean (e.g. Natura 2000, MedPAN)
- Other MPA-related research projects
- Scientific and technical publications (both peer-reviewed and grey literature)
- Conclusions of scientific and technical meetings

Another source of information concerning MPA management comes from the actual management actions and challenges experienced by the EMPAFISH case-studies; therefore, this problematic has been raised case by case, in order to extract lessons to learn and to be generalized to the entire region.

The main sources of ideas and concepts to be translated into management actions in this document are the results and findings of the 6 work-packages of EMPAFISH:

- The most compelling result from WP1 (about ecological effects of MPAs) has been that the response to protection for densities of commercial species is reserve size-dependent: increasing the size of the no-take zone increases density of commercial fishes within the reserve compared to outside; in contrast, increasing the size of the buffer zone reduced the effectiveness of the reserve. In addition, it has been shown that older European marine reserves are more effective than newly implemented reserves in increasing catchable sizes of commercial fishes and in conserving fish species richness; it appears that MPA effect on fish populations of commercial species is long-lasting, so that after 30 years (the limit of this study) their abundance is still growing. In contrast, no effect has been found related to the distance among MPAs, but other factors not considered in the meta-analytical study could be influencing these results (so that additional work is to be done).
- WP2 works (on fisheries effects of MPAs) showed that, for most MPAs studied, the distance to the border of the marine reserve has a significant influence on fishing effort allocation; the spatial scale of effort attraction is probably related to reserve size. Also, the factor depth determines the spatial distribution of the

artisanal fishing fleet. In terms of catch and landings, paradoxically there was a trend towards lower CPUEs adjacent to MPAs compared with more distant regions. This is generally due to the concentration of the fishing effort in the proximity of the reserve boundary. In contrast, the results suggest that, despite the high concentration of effort, a clear decline in catch rate can be distinguished with an increasing mean distance from the reserve boundaries. Catch rates declined between 25% and 60% for each 10 km away from the MPA. On the other hand, the analyses showed a positive relationship between effect size of protection on CPUE and time: a gradual increase of CPUE was identified for the period represented in this study (30 years). Therefore, the effects of MPAs on catch rates develop over long time periods, which is critically important both for management as well as for the interpretation of MPA effects. The analyses suggest a CPUE increase for target species fished with a single gear of 4% for each year of protection and a 90% to 185% increase for each increment of 10 ha of the MPA. An important result of our analyses has been the difference between response variables for marketable catch and catch of target species. In terms of CPUE, the greatest benefit for the fishermen seems to be realised through the increase of by-catch per unit effort. This constitutes a real benefit, because it increases return to the fishermen relative to the effort they invest.

- The results of the assessment performed under WP3 (devoted to study the socio-economic effects of MPAs) display a variety of situations, depending on the relative importance of commercial fishing and of recreational activities. Recreational activities are the major economic driver in most cases; within the recreational sector, SCUBA diving has a larger local economic impact than recreational fishing. Estimated local money incomes generated by the investigated activities are generally significantly higher than MPA management costs. The reserve effect is substantially clearer in the case of SCUBA diving than in the case of fishing, a conclusion that seems consistent with biological evidence concerning the impact of protection on marine ecosystems and fish populations.
- Within WP4 (on indicators of MPA performance) we first reviewed studies that evaluated all aspects relating to the effectiveness of MPAs in order to describe how the studies were conduced and to detect fields in which research is lacking. Several gaps were identified in the objectives assigned to MPAs and the way in which they have been evaluated. From these results we proposed to analyze some study subjects that remain poorly or not at all considered. Moreover standardised methods of study, to be applied by both researchers and administrators, should be implemented enabling *a posteriori* comparison of obtained results over a wide geographical range. On the other hand, we stated the different components related with the presence and functioning of a MPA and the relationships among them using the driver-pressure-state-impacts-response (DPSIR) framework. By means of a participatory process we developed a conceptual framework that helped to select an appropriate suite of parameters potentially usable as indicators to support an ecosystem approach, an evaluation of the MPAs functioning and policy considerations. Gaps from management and policy responses can be derived too. DPSIR is a suitable tool simplifying the analysis of the complexity of MPAs management, showing specific strategies to improve the assessment of the effectiveness of MPAs. Combining three different approaches –managers' expertise knowledge, availability in institutions and statistical analysis- we evaluated the suitability of

each proposed parameter. Joining the results of the three different approaches, only 16 parameters can be selected as good indicators to assess the effects of MPAs.

- WP5 firstly produced a review of bio-economic models in MPA; based on this review and the shortcomings identified, an original simulation model called "Bio-Economic Analysis of Marine Protected Areas" (BEAMPA) was developed. The computer application associated to this model is freely available to the public and can be downloaded from the EMPAFISH project website. The BEAMPA model is a spatially structured simulation model incorporating a fisheries bio-economic model for extractive uses and a demand model for non-extractive (recreational) uses. The biological sub-model follows a partially age-structured model. The economic sub-model follows a standard cost and revenues economic fisheries model at the level of fleet or metier. In BEAMPA a model MPA is constructed on an arbitrary grid of square $m \times n$ cells. In each cell the protection type, the habitat type and the depth are set up, to define the MPA layout. Each cell has additional attributes regarding the biomass of the adult population, the number of recruits and the mean weight of the adult population, as well as the initial effort distribution and types of recreational uses permitted. This initial configuration of the model MPA can be projected forwards in time to simulate the likely development of the system under the initial conditions according to the equations of the model. The effect of policy or management measures can be tested by changing parameters of the different components of the model or by changing the initial configuration of the MPA layout. BEAMPA can be used to address both scientific questions and management questions. A series of scientific research and management questions can be addressed by the current version of BEAMPA. With the bio-economic analyses performed in EMPAFISH, based on different scenarios and realistic data obtained from biological and economic field sampling during the project, we can conclude that:
  - ? In coastal MPAs where the main extractive use is small scale artisanal fisheries, the protection of a small portion of the coastal area produces low or barely detectable economic fisheries benefits. Fisheries yield in the area immediately adjacent to the no take area benefits from adult biomass spillover for moderately to highly mobile species.
  - ? Due to the low profits, in absolute terms, of commercial fisheries the institutional costs of protection are high if only professional extractive uses are considered. When other non-extractive uses are added, the costs of protection become small, due to the higher economic importance of eco-tourism uses. In many cases, institutional costs of setting a MPA are amply covered by taxes perceived from recreational uses.
  - ? Enlarging the protected area by increasing its size from 725 to 1225 ha would not impact excessively on the economy of commercial fisheries, but would considerably increase institutional costs of protection.
  - ? The negative impact of commercial fisheries on habitats where ecotourism is a paramount activity can adversely affect recreational activities, both in terms of frequentation and economic profits. Because recreational activities have much higher economic and social relevance than small scale artisanal fisheries, it is recommended to clearly separate the areas where both types of activity take place in order to avoid reciprocal interferences.

- ? We estimate that the overall benefit:cost ratio of Atlanto-Mediterranean Marine Protected Areas is at least 10:1, and revenues from tourism are larger than revenues from commercial fisheries. The valuation of economic effects of protection, based on socio-economic surveys, provided a first assessment of the benefit of conserving seascapes in southern Europe. Additionally, in many cases, the taxes perceived by the managers of individual marine reserves from recreational uses probably cover the expenses of running the marine reserve. Hence, by investing in MPAs, society as a whole would obtain larger benefits than those produced by commercial fisheries exploitation; benefits that can be sustainably accrued over time. However, these results must be put in the context of the Atlanto-Mediterranean MPAs studied in EMPAFISH: in these MPAs, commercial fisheries have relatively low fishing power (mostly artisanal fisheries) and are not open access fisheries (they are effectively closed fisheries to local stakeholders, which possess a sort of monopoly power allowing them to benefit from rents due biomass spillover without permitting new entrants).

- The aim of WP6 was to provide the EU with guidelines and tools that can be integrated into the decision-making regarding the use of MPAs as tools for fisheries management and conservation. In order to reach these objectives, WP6 employed a multi-criteria evaluation using outputs from WP1, WP2, and WP3 with a stakeholder consultation of the objectives and zoning of MPAs. Our main findings include:
  a) Fisheries benefits are maximised by having MPAs that comprise of a fully protected zone (no-take area) that is larger than the surrounding buffer zone. Using the windows-based software DEFINITE (decisions on a finite set of alternatives) we concluded that a large MPA in which the size of the partially protected zone is half that of the no-take zone was the most preferred scenario.
  b) Local stakeholders of MPAs in southern Europe agree that the core objectives of establishing MPAs are conservation and fisheries management while research, education and tourism development are secondary.
  c) There is a large difference between fishers and other stakeholders on which of the two core objectives of marine protection is more important than the other. The fishers would like to see MPAs established to manage fisheries while the other stakeholder groups see MPAs as places of conservation. Our findings are important to understand local perceptions and values from the people who have a direct impact on the achievement of management objectives.
  d) Local stakeholders of MPAs in southern Europe would like to see a hierarchical limitation on the use of marine resources and the separation of conflicting activities.
  e) Local stakeholders would like to see MPAs comprised of a central (no use) zone that is bordered by a regulated (no extraction) zone with an outer regulated (extraction) zone. Stakeholders viewed such an MPA to meet all the objectives of marine protection highly.
  f) Perceptions of fishers using fishing grounds adjacent to older MPAs show that they are not experiencing the spillover effect and are not convinced that MPAs are working for them, despite increasing evidence that closing off areas is one of the most effective management tools for sustaining or

increasing fish harvests. This could be conditioned by the own fishermen behaviour who concentrate the fishing effort close to the reserve boundary forcing as a consequence lower CPUE.

From the above sources of information, as well as discussions within the EMPAFISH consortium, a set of recommendations has been produced, to serve as a seed toward a European strategy for MPA management and networking:

- General considerations

  - ? MPAs constitute an invaluable tool for fisheries management and conservation.
  - ? MPAs are a socially and economically efficient way to manage marine natural resources.

- Institutional partnership and synergies

  - ? Increase collaboration and coordination and avoid conflict of competencies between environment and fisheries government officials at all administrative levels (from local to European and international) in charge of the creation and management of MPAs.
  - ? Funding and surveillance activities should be shared and monitoring programs should be developed jointly among different institutions when different protection figures coincide in space.
  - ? Member states of EU should immediately transpose (i.e. fulfilling the international commitments) the international protection figures (SPAMIs, SPAs, SCIs, Ramsar areas, etc.) applied to marine areas onto their national legislations.

- Public participation

  - ? Active involvement of all stakeholders in the MPA establishment process is a prerequisite for MPAs to work well.
  - ? Enlarge the MPA management body structure by including scientists in the planning and management process.
  - ? Implement measures to improve governability wherever necessary.

- Setting MPA goals and objectives

  - ? Goals and objectives should be simple, attainable, and ambitious; but they should not exaggerate the benefits the MPA is going to provide.
  - ? MPA goals and objectives should be stated attending to long-term benefits.
  - ? MPA general objectives should be translated into quantitative targets that can be subject to measurable evaluation and assessment .
  - ? Obtaining stakeholder perceptions on objectives of marine protection provides a viable way of addressing stakeholder concerns raised by the establishment of MPAs.
  - ? MPA research and monitoring is to be considered as an explicit objective of MPA creation.

- ? Emphasis on the precautionary principle as a basis for MPA creation should be made.

- MPA site selection

  - ? Site selection criteria must be related to the objective of the MPA.
  - ? Include sound scientific information to select new sites to be protected.
  - ? A minimum of prior knowledge of potential sites for protection is needed.
  - ? Traditional knowledge by local users (especially fishers) should be gathered and used to complement scientific information when selecting the best sites to become an MPA.
  - ? Socioeconomic and governability evaluation is necessary for site selection.

- Zoning and planning an MPA

  - ? Use the best available scientific information in zoning and designing MPAs.
  - ? MPA design and zoning should be intimately linked to explicit objectives.
  - ? MPAs should ideally include as many habitat types as possible as critical information is often lacking on species life cycles and habitat preferences.
  - ? Where possible, design should take into account the need to conduct scientifically rigorous progress monitoring.
  - ? Marine protected areas in southern Europe should be established with a no-use zone.
  - ? Large MPAs are to be preferred to small-to-medium sizes; in addition, sizes of each zone within the MPA should be scaled to maximize the size of the no-take area (> 600 ha) in detriment of buffer zones (about half size of no-take area). Large MPAs (i.e. larger than 2000 m in radius) offer the maximum capacity for recovery (close to 100% of the system carrying capacity) and nearly the maximum flux of individuals per unit boundary length. Very large MPAs could be a guaranteed means of providing resilience in order to prevent population crises due to extremely high natural mortality or recruitment failure, with the added advantage that the flux of individuals is slightly higher at larger distances from the boundary. However, in practice they provide no further advantage towards increasing the density of individuals or the exportation of biomass, and therefore other management strategies could be more beneficial, both from the point of view of conservation and of benefits to fisheries taking into account that total management costs increase with reserve size, and total cost per ha shows a minimum for integral reserves between 600 and 1500 ha (1400-2200 m radius). Therefore, an upper limit seems to exist, further from which the ideal is to build a network of several MPAs.
  - ? Apply adaptive management schemes where possible, so that flexibility to change zoning and designing is allowed.
  - ? The management activities of a given MPA (or MPA network) should always be planned through a management plan, giving special accent to the public use of different zones within the MPA.
  - ? Management activities of a given MPA (or MPA network) should be planned from a pro-active perspective –i.e. not focusing exclusively on prohibitionist measures, but rather on positive actions; these actions should count with sufficient financial support.

- ? Ways to regulate human activities in protected areas should be pursued to improve the success of MPA implementation; in particular, spatial separation of uses should be promoted to avoid conflicts.
- ? Planning should include the provision of time and resources to conduct rigorous baseline 'before', in addition to 'after' studies.
- ? Flexibility to adapt planning and objectives to changing situations should be the rule.

- Management measures

  - ? Specific personnel staffs of MPAs (led by a Director – Conservator) should be in charge of co-ordinating and implementing management actions; their number should be high enough to ensure effective management in all aspects of planned MPA management activities.
  - ? Effective enforcement of MPAs should be pursued to improve their ecological significance and public success.
  - ? Key governance principles should be pursued as a management priority.
  - ? New uses are to be considered in the MPA planning process.
  - ? Tourism activities (especially diving) should be oriented towards a sustainable use of the protected area; in particular, quotas should be established and adequately complied in order to keep human frequentation below the carrying capacity of the MPA.

- MPA monitoring and evaluation

  - ? Integrated monitoring and evaluation constitute a key factor for MPA success.
  - ? Monitoring of MPA effects and evolution should be an objective of MPA management.
  - ? Monitoring objectives are to be set up in relation to expected goals and objectives of the MPA.
  - ? Monitoring should be undertaken clearly specifying the targets to be evaluated.
  - ? Monitoring plans should be designed in the long-term, based on appropriate, sound sampling strategies.
  - ? There is a pressing need for directed monitoring of exploited stocks with the objective of analysing the effect of marine protection on adjacent fisheries.
  - ? Monitoring fisheries effects should preferentially target species that are most likely to show a response to protection.
  - ? Special attention should be paid to fishing effort redistribution and the effect this may have on nearby fishing grounds.
  - ? Special emphasis should be put on the effects of (and the consequences on) recreational fishing activities.
  - ? Major emphasis should be done on the socio-economic effects of MPAs, which has been regularly neglected to now.
  - ? Clear and operational definitions concerning the categories of users of MPA ecosystem services should be formulated, and the various zones related to these uses and their "local" economic impact well defined.
  - ? It is necessary to get a clear and regularly updated view of the MPA frequentation.

- ? It is essential that the ecological, socio-cultural and economic value of marine landscapes ("seascapes") be properly assessed to reconcile seascape conservation with human demands on natural resource utilization.

- MPA research

  - ? Ecological causes and consequences of MPA effects need to be studied; particular research subjects should be addressed.
  - ? Fisheries-specific questions need to be addressed if we continue to hope that MPAs can play a role in sustainable exploitation of stocks.
  - ? Empirical research on the economics of MPAs is scant and there are several issues that merit further investigation.

- Communication and exchange

  - ? Need to set up programs for improving key variables of governability linked to communication and exchange.
  - ? There is a need for greater communication between scientists, managers, fishers and other users to improve the disparity in understanding the fisheries benefits of marine protection.
  - ? Dissemination of MPA functioning and results should be a priority.
  - ? If necessary, assign persons specifically serving as links among scientific fields of expertise, between scientists and other MPA practitioners (managers, stakeholders, etc.), and/or among sectorial economic activities converging in the coastal zone, in order to improve multi-disciplinarity and communication / exchange.

- Capacity building

  - ? Enhance opportunities for training and exchange among MPA managers.

- Financial durability

  - ? Financing of the running costs and management of MPAs should be warranted, in view of their financial durability in the long term.
  - ? New ways of generating complementary revenues with MPAs should be considered.

- MPAs and other management tools

  - ? Activity management inside and outside MPA should be coordinated.
  - ? Conservation measures should be combined with access regulation measures.

- From MPAs through IMCAM to Maritime Policy

  - ? Networks of MPAs at proper ecological spatial scales instead of isolated MPAs should be the main focus of planners for the (re)design of future and existing MPAs.

- ? MPAs should serve as small-scale laboratories, on which testing management goals and objectives, decisions and options, and assessment techniques, in order to be implemented in a true IMCAM approach.
- ? The “Ecosystem Approach” and Marine Spatial Planning within the framework of the Maritime Policy should be implemented by combining ecosystem structure and process, environmental, and socio-economic (including governability issues) research findings, such as that applied in EMPAFISH project.

1 Introduction

1.1 The EMPAFISH project

1.1.1 Objectives

The EC project EMPAFISH ("*European Marine Protected Areas as tools for FISHeries management and conservation*", contract nº SSP8-006539) was a 3-year research programme (2005-2008) aiming at:

I) investigating the potential of different regimes of MPAs in Europe as measures to protect sensitive and endangered species, habitats and ecosystems from the effects of fishing;
II) developing quantitative methods to assess the effects of marine protected areas;
III) providing EU with a set of integrated measures and policy proposals for the implementation of MPAs as fisheries and ecosystem management tools.

The works performed throughout the project were mainly based on existing and new data on ecological, fisheries, and socio-economic aspects of already established, well-studied MPAs selected as case studies (Fig. 1). In all, 14 research labs from 6 countries participated in the project (Table 1).

1.1.2 Workplan

The EMPAFISH project was organized in 6 work-packages (WPs), plus one (WP0) devoted to co-ordinate the overall project activities, as follows (leading teams of each WP are indicated between brackets):

WP0 Coordination (University of Murcia – Spain)

To ensure the adequate level of co-ordination and communication among WPs (and other participants in the project), several tasks will be undertaken:

a) Orientating and completing the general scientific, administrative and financial works and reports to EC.
b) Launching a Network at two levels: restricted (among participants) and extensive (i.e. including stakeholders), using internet resources (web page, e-mailing list, etc.), and meetings at different stages (plenary meetings, thematic congress, individual exchanges, etc.).
c) Organising a Steering committee to assess the progress of the project.
d) Establishing a Reference User Group

e) Establishing an Editorial committee aiming at organising and providing guidelines to the published deliverables, both at the scientific (research articles, reviews, etc.) and dissemination (booklets, guides, protocols, DSS, etc.) levels.
f) Facilitating co-ordination with other EC projects addressing the ecological and social impacts of fisheries management in EU, through the launching and participation in Clustering initiatives

Importantly, the *European Symposium on MPAs as a Tool for Fisheries Management & Ecosystem Conservation* was organised and held in Murcia; the statistics of this meeting are demonstrative of its success: 5 invited keynotes, 255 communications (122 oral presentations, and 133 posters), and 2 participatory roundtables provided the occasion for the 397 attendants (from 32 countries) to contribute with their view to analyse the current situation and prospects of MPAs in Europe and worldwide[1].

WP1 Ecological effects of MPAs (CNRS – France)

This work-package targeted into identifying and quantifying ecological effects of MPAs and producing a database of field data for subsequent global meta-analysis and modelling. Special emphasis was given to identifying main parameters necessary to describe ecological effects of MPAs, from a fishery management perspective. The following tasks were undertaken:

a) Identify and list the data required for subsequent development of bio-indicators and bio-economic modelling.
b) Characterise and list the MPA features of the case studies to be used as model.
c) Develop an online database management system (DBMS) for compiling biological and ecological field data obtained from MPA monitoring programmes or surveys, to be filled online.
d) Compile biological and ecological data available regarding reserve effects in the most studied European MPAs.
e) Complete dataset with specific and targeted collections of field data following the identification of major lacks requires for further global analysis and comparisons of case-studies.
f) Meta-analysis of the database to identify common trends in the various datasets.

[1] See http://www.mpasymposium2007.eu/

<u>WP2</u> Fishery effects of MPAs (IMAR – Portugal)

Case studies were analysed considering:

a) Evolution of captures and yields: target species, aggregated catch, mean size of catch, maximum size of catch, trophic groups.
b) Spatial distribution of effort, and effort relocation.
c) Management regime.

Data from MPA fisheries surveys were compiled and meta-analysed following a procedure similar to that of WP1.

<u>WP3</u> Socio-economic impacts of MPAs (Université de Bretagne Occidentale – France)

Case studies were analysed considering:

a) Consumptive benefits and costs: Commercial and recreational fishing, coral harvesting, other extractive uses (mineral extraction, pharmaceutical prospecting).
b) Non-consumptive benefits and costs: Diving, eco-tourism, nursery grounds, biodiversity conservation.
c) Institutional benefits and costs: planning, set-up, operating, maintenance, enforcement, other fishery resource management tools.

In most cases, data were acquired *de novo* in the different case studies, by means of field surveys using questionnaires to the main stakeholder groups.

<u>WP4</u> Providing and evaluating impact indicators of MPAs (University of Alicante – Spain)

Starting from the results of WP1-3, in a sequential scheme, a set of potential indicators was evaluated in function of the MPA objectives, and under the different management regimes and MPA typologies identified. Indicators should reflect the state of the system with respect to MPAs goals and objectives. The purpose of indicators is to enhance communication, transparency, effectiveness and accountability of management of MPAs. They are a readily understood tool for describing the state of a MPA at certain moment and for assessing trends regarding sustainable development objectives. Moreover, they should also stimulate actions to better achieve the proposed objectives and simplify and harmonise reporting of management of an MPA. Three types of indicators were considered:

a) Ecological indicators.
b) Fisheries indicators.
c) Socio-economic indicators.

From this, the best subset of indicators was proposed, and protocols to implement, monitor and evaluate them were provided.

<u>WP5</u> Bio-economic modelling of MPA effects (Institut de Ciencies del Mar/ CSIC – Spain)

Work in this WP was organised around three axes:

a) Theoretical framework for bio-economic modelling.
b) Definition of scenarios and alternative regimes.
c) Enhancement, adaptation and running bio-economic models.

The BEMMFISH model (see below) was adapted to the bio-economic modelling of implementation of MPAs in the framework of EMPAFISH project. The results of the BEMMFISH were used to help in producing the quantitative analysis of the socio-economic effects of MPAs. The model includes multiple species and multi-species interactions, multiple fleets (disaggregated at the level of vessel) and gear types. Bio-economic models are mathematical models of the interaction between (at least) two compartments:

(i) Biological sub-model encompasses the dynamics of the stock, at different levels of precision (from global production models to the more detailed age-structured models).
(ii) Economic sub-model focuses on the dynamics of fishing effort and catchability, and their combination in fishing mortality to the stock.

Other issues to be taken into account are:

(i) Spatial structure of the model, in order to capture at least the spatial dynamics arising from a "protected patch" and an open-access patch.
(ii) Explicit consideration of fisherman behaviour in the bio-economic model, as an essential step to capture accurately the social and biological responses to protected areas.
(iii) Incorporation of *uncertainty* sources ("process uncertainty", "model uncertainty" "observation uncertainty", "implementation uncertainty" and "institutional uncertainty"

<u>WP6</u> Management tools – Policy proposals (Plymouth Marine Lab – UK)

This work-package was devoted to proportionate guidelines and tools to be integrated into the decision-making and management process, to constitute an improved basis for the design, the selection and the management of protected areas, in order to identify the relationships between management and protection initiatives and their effects on biodiversity and fish and invertebrate stocks, as well as to propose management plans

and tools to harmonize fisheries, other productive uses, and conservation. In addition, this WP aims at identifying effective fisheries management frameworks by integrating the establishment of protected areas with other management tools, e.g. input restrictions, other technical measures, output limitation, fishing vessel limitation.

A decision support tool was developed to enable more comprehensive incorporation of the wider effects of fishing within management decisions. A management manual for decision makers and an interactive website was produced to ensure that the results are readily available, to aid transfer of these techniques to other areas, and to assist the formation of future fisheries regulation. A more comprehensive multi-criteria decision support tool was developed, based on the existing proven decision support tool DEFINITE. This model is suitable because it is designed to use the results of experiments in complex decision environments involving many objectives and/or many participants. A management manual was produced to set the results of the ecological modelling and economic analysis in the context of the current fisheries policy and regulatory framework, as management issues will extend beyond changes in fishing effort and yield. An interactive website will allow stakeholders to explore the models, the decision tool and the consequences of varying assumptions and parameters.

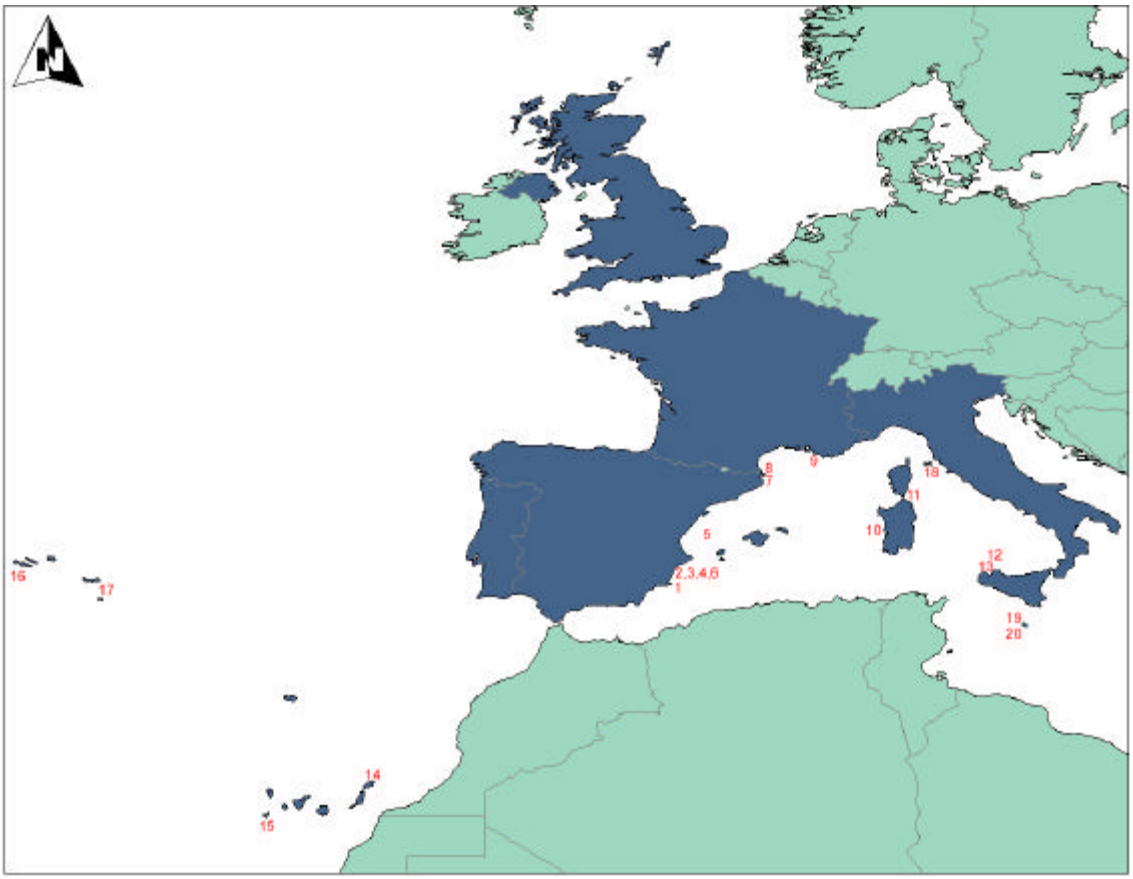

Figure 1. Location of case studies considered in the EMPAFISH project (correspondence of numbers with names of MPAs are indicated below).

1	Cabo de Palos - Islas Hormigas	11	Bouches de Bonifacio
2	Tabarca	12	Ustica Island
3	San Antonio	13	Gulf of Castellamare
4	Sierra Gelada & Benidorm islets	14	La Graciosa e Islotes del Norte de Lanzarote
5	Columbretes Islands	15	La Restinga – Mar de las Calmas
6	Anti-trawling zones (SE Spain)	16	Monte da Guia - Faial
7	Medes Islands	17	Formigas Islets - Dollabarat Bank
8	Cerbère – Banyuls	18	Tuscany archipelago
9	Parc marin de la Côte Bleue	19	25-NM Fisheries Management Zone around Malta
10	Sinis - Mal di Ventre	20	Rdum Majjiesa/Ras Ir-Raheb

Table 1. List of participants in the EMPAFISH project

Partic. Role*	Partic. no.	Participant name	Participant short name	Country
CO	1	Universidad de Murcia	UMU	Spain
CR	2	UMR 8046 CNRS-EPHE	CNRS	France
CR	3	Institut de Ciències del Mar	ICM	Spain
CR	4	Instituto Español de Oceanografía	IEO	Spain
CR	5	International Marine Centre	IMC	Italy
CR	6	Instituto dell'Ambiente Marino Costiero	IAMC	Italy
CR	7	Plymouth Marine Laboratory	PML	United Kingdom
CR	8	Universidad de Alicante	UA	Spain
CR	9	Universidad de La Laguna	ULL	Spain
CR	10	Instituto do Mar – Universidade dos Azores	IMAR	Portugal
CR	11	Università degli Studi di Palermo	UPA	Italy
CR	12	Université de Bretagne Occidentale	UBO	France
CR	13	University of Malta	UMT	Malta
CR	14	Università di Pisa	UPI	Italy

*CO = Coordinator
CR = Contractor

1.2 Objectives

The general objectives of this report are:

I. To review international commitments and targets regarding MPAs.
II. To examine results and/or goals of existing European MPA networks.
III. To recapitulate previous MPA-related initiatives (EC and other research-funded projects, publications, scientific and technical meetings).
IV. To summarise the main results of EMPAFISH project that could be applied to MPA management.
V. Based on the above information, to set up a series of recommendations for the management of MPAs in Europe.

1.3 Structure of this report

Section 2 of this document is devoted to summarising the background and context of the use of MPAs as a tool for fisheries management and conservation. The European Community (EC) is committed to reach a series of goals regarding the protection of marine and coastal biodiversity, which are synthesised in section 2.1. Section 2.2 focuses on the existing MPA networks in Europe and the Mediterranean. Section 2.3 intends to have a look to the previous EC and national projects dealing with MPAs and fisheries management. Finally, section 2.4 revises the main general publications dealing with MPA management, and summarises the key conclusions of selected scientific and technical meetings about these issues. Section 3 analyses the present situation and problems of the 20 MPAs selected as EMPAFISH case-studies. Section 4 is entirely dedicated to summarising the main findings of the EMPAFISH project, by WPs. Finally, all this information is summarised to produce a synthetic set of recommendations for MPA practitioners (section 5), which intends to serve as a seed for building a strategy for MPA management in Europe.

2 Background and context

2.1 Brief overview of the expected effects of Atlanto-Mediterranean MPAs

Ward *et al.* (2001) -see also Pelletier *et al.* (2005)- synthesized the literature existing to date to list the ecological, economical and social effects that can be expected from the implementation of an MPA, distinguishing between effects pertaining to marine populations and ecosystems (including fisheries effects), from those affecting economical and social aspects (Table 2) (see also García-Charton *et al.* in press). A number of studies have been performed to explore the actual occurrence of such effects in Atlantic and Mediterranean MPAs, especially in the EMPAFISH case studies (Planes *et al.* 2008). This set of studies constitutes a convincing body of evidence to support the idea that MPAs constitute an invaluable tool for fisheries management and conservation, and that MPAs are a socially and economically efficient way to manage marine natural resources.

Table 2. Expected effects of MPAs (after Ward *et al.* 2001 and Pelletier *et al.* 2005)

Type of effect		**Expected effect of MPAs**
Ecological / fisheries effects	Population level	1. Protecting critical spawning stock biomass of species from fishery-related depletion 2. Rehabilitating population structure 3. Exportation of biomass 4. Enhancing fisheries yield 5. Increasing fecundity and production of eggs and larvae 6. Density-dependent changes in life history traits and parasitism 7. Protection of recruitment
	Community level	8. Restoration of / changes in assemblage structure 9. Protection of biodiversity 10. Indirect effects on algae and invertebrates (cascade effect, food-chain reactions) 11. Increasing ecosystem stability and resilience
	Habitat	12. Protecting essential habitats for larvae settlement, recruitment, spawning and feeding; maintaining areas with undisturbed habitats 13. Detrimental effects due to non-exploitative uses
Economical effects	Priced	14. Costs of designing and implementing an MPA 15. Management costs and revenues 16. Opportunity costs of protection 17. Change in fishing activity and net benefits derived from fishing inside and outside the MPP 18. Change in recreation-based activities, and associated net benefits to private businesses 19. Public costs and benefits associated to the development of recreation-based commercial activities
Social effects	Non-priced	20. Benefits associated to changes in the number and value of recreational experience 21. Benefits associated to changes in the status of the protected reef ecosystem 22. External costs of the development of recreational activities (ecological impacts and loss of amenity)

Type of effect		Expected effect of MPAs
		23. Reducing conflicts between user groups 24. Improve satisfaction of visitors and local dwellers 25. Increasing knowledge about marine ecosystems and biodiversity

Table 2 (cont.)

2.2 International commitments and targets regarding MPAs

2.2.1 Convention on Biological Diversity[2]

The Convention on Biological Diversity (CBD) serves as a framework agreement for the conservation of biodiversity (including biological productivity), sustainable use of biological resources and the sharing of benefits from the use of biodiversity. The Convention supports the need of conservation in the marine environment and the establishment of Marine Protected Areas. Under this Convention, countries are obliged to develop national biodiversity strategies, to identify and monitor important components of biodiversity, to establish a system of protected areas to conserve biodiversity, to promote environmentally sound and sustainable development in areas adjacent to protected areas and to rehabilitate and restore degraded ecosystems.

In 1995, the Parties to the CBD affirmed under the Jakarta Mandate on Marine and Coastal Biological Diversity the importance of marine and coastal biodiversity. Marine and Coastal Protected Areas (MCPAs) were identified as one of the five thematic issues for action.

The Conference of the Parties (CoP) of the CBD adopted the Strategic Plan for the Convention on Biological Diversity. In its mission statement, Parties committed themselves to a more effective and coherent implementation of the three objectives of the Convention, to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth. The CoP decided to develop a framework to enhance the evaluation of achievements and progress in the implementation of the Strategic Plan and its 2010 Biodiversity Target. This target was subsequently endorsed by the World Summit on Sustainable Development (WSSD, Johannesburg 2002[3]).

Within this framework, a programme of work on protected areas was designed by CoP of CBD with the overall purpose to support the establishment and maintenance by 2012 of comprehensive, effectively managed, and ecologically representative national and regional systems of marine protected areas that collectively, *inter alia* through a global

[2] http://www.cbd.int/marine/
[3] http://www.worldsummit2002.org/

network contribute to achieving the three objectives of the Convention and the 2010 target to significantly reduce the current rate of biodiversity loss at the global, regional, national and sub-national levels and contribute to poverty reduction and the pursuit of sustainable development, thereby supporting the objectives of the Strategic Plan of the Convention, the WSSD Plan of Implementation and the Millennium Development Goals.

As a contracting party to the CBD the European Community has prepared an EU Biodiversity Strategy and Biodiversity Action Plans (BAPs) which aim, *inter alia*, to integrate biodiversity considerations into other Community policies. Marine biodiversity issues are addressed by both the BAP for Natural Resources, and the BAP-Fisheries. Marine issues have also been raised in relation to the impact of European fishing fleets in international waters.

2.2.2 FAO[4]

The EC is committed to implement the FAO Code of Conduct for Responsible Fisheries[5]. This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity; it provides principles and standards applicable to the conservation, management and development of all fisheries, and also covers the capture, processing and trade of fish and fishery products, fishing operations, aquaculture, fisheries research and the integration of fisheries into coastal area management. Among the envisaged technical measures, this Code includes closed areas and zones reserved for selected fisheries, particularly artisanal fisheries. Such measures should be applied, where appropriate, to protect juveniles and spawners.

2.2.3 Specially Protected Areas Protocol[6]

The "Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean" (SPA Protocol) was adopted on 1995 by the Conference of Plenipotentiaries of the Barcelona Convention[7]. The SPA Protocol is the Mediterranean's main tool for implementing the 1992 CBD, as regards the *in situ* sustainable management of coastal and marine biodiversity. The Protocol deals with 6 aspects to be promoted:

- Conservation of species that are threatened with extinction, endangered, or to be managed;

[4] http://www.fao.org/fishery/
[5] http://www.fao.org/fishery/ccrf/1
[6] http://www.rac-spa.org/index.php?option=com_content&task=view&id=87&Itemid=143
[7] http://www.unep.ch/regionalseas/regions/med/t_barcel.htm

- The sustainable use of biological resources;
- Protecting habitats that are in danger of disappearance or are necessary for the survival, reproduction and restoration of threatened or endemic species;
- Conservation of types of marine and coastal ecosystem that are typical of the Mediterranean;
- Protecting sites of scientific, aesthetic, cultural or educational interest;
- Setting up and promoting Specially Protected Areas.

The SPA Protocol recommends concrete protection measures to safeguard elements of biological diversity though action plans and technical inventorying tools. The Protocol also recommends setting up Specially Protected Areas of Mediterranean Interest (SPAMIs), including transboundary areas, in areas where several states have sovereignty and in international waters.

In the context of the SPA Protocol, the "Strategic Action Program for the Conservation of Mediterranean Marine and Coastal Biological Diversity" (SAP BIO) was adopted in 2003. The principal objective of SAP BIO is to establish a logical base for implementing the 1995 SPA Protocol, that is providing Contracting Parties to the Barcelona Convention, international and national organisations, NGOs, donors and all other actors involved in the protection and management of the Mediterranean natural environment, with principles, measures and concrete and coordinated actions at national, transboundary and regional level for the conservation of the Mediterranean marine and coastal biodiversity, within the framework of sustainable use and through the implementation of the 1995 SPA Protocol. SAP BIO established two main targets regarding MPAs by 2012:

- increase by 50% the coverage of marine protected areas, in relation to 2003, and
- protect 20% of the coast as marine fishery reserves

In SAP BIO, a series of problems of regional importance regarding MPAs were identified:

- Confusion of competency, or fragmentation of responsibility (leading to problems of implementation of the existing laws)
- Lack of coordination between administrations, competencies overlap
- Interference with other human activities occurring in the coastal zone, mainly tourism
- Low or no participation of stakeholders and other agents in the decision-making process
- Poor effort to improve public awareness on marine conservation issues
- Lack of effective enforcement measures in some cases
- Lack of effective scientific monitoring

- Lack of sufficient economic resources to achieve the protection measures, so that a number of MPAs receive only nominal management and protection ("paper MPAs")
- Problems of mismanagement and deterioration caused by the limited experience of the people administrating the MPAs
- Lack of effective conservation measures to protect particular species (monk seal, sea turtles, cetaceans, etc.) and/or communities (e.g. seagrass meadows)
- Need to set up a network of MPAs, and therefore define of goals, mechanisms and management organization for such a network
- Need for integrated coastal zone planning and management.

Other identifiable general problems that affect the selection, installation, management and evaluation of Mediterranean MPAs were the following:

- Need to clearly establish the specific goals of each MPA
- Lack of scientific basis for the selection (location, habitats included, depth range, etc.) and design (size, shape, number, proportion of total surface protected, etc.) of MPAs
- Need for appropriate monitoring and evaluation of the effectiveness of MPAs, based on sound sampling designs
- Lack of empirical evidence for potentially complex effects of MPAs, e.g. spillover, indirect effect on ecosystems ("cascade" effects), effects on larval replenishment of commercially and/or ecologically important species, genetic effects, socio-economic results, etc.
- Need to ascertain the relationship of MPAs with other management tools.

Within SAP BIO, the setting up of protected areas offshore (including the high seas) to protect pelagic ecosystem and sensitive species and important and partially unknown benthic areas such as the "white coral community", seamounts and submarine canyons was acknowledged to be a priority.

In order to accelerate on the ground implementation of the SAP BIO, a collective effort for the protection of the environmental resources of the Mediterranean - the Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem - is being proposed by UNEP and the World Bank to all the countries of the Mediterranean and to all international cooperation Agencies, IFIs and bilateral and multi-lateral donors. The proposed Strategic Partnership will consist of two individual components. One of the proposed Projects will focus on and assist the countries to respond to the SAP BIO targets related to MPAs in the Mediterranean.

2.2.4 OSPAR[8]

The "Convention for the Protection of the Marine Environment of the North-East Atlantic" (the OSPAR Convention) was opened for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992, and entered into force on 25 March 1998. Although great emphasis is done on pollution aspects, there is a Biological Diversity and Ecosystems Strategy having a very broad focus, since it is concerned with all human activities (excluding those which may cause pollution) which can have an adverse effect on the protection and conservation of the ecosystems and the biological diversity of the North East Atlantic. However, programmes and measures relating to questions of fisheries management cannot be adopted by the OSPAR Commission. The Strategy has four elements:

- ecological quality objectives: in support of the ecosystem approach to the management of human activities, a pilot project on ecological quality objectives for the North Sea has been started;
- species and habitats: assessments are made of species and habitats that are threatened or in decline, and programmes and measures are developed for their protection;
- marine protected areas: an ecologically coherent network of well managed marine protected areas is being created;
- human activities: the human activities in the OSPAR maritime area which may adversely affect it are being assessed, and programmes and measures to safeguard against such harm are being developed.

The OSPAR network of MPAs is complementary to the Natura 2000 network (see below).

2.2.5 HELCOM[9]

The Helsinki Commission, or HELCOM, is the governing body of the "Convention on the Protection of the Marine Environment of the Baltic Sea Area" - more usually known as the Helsinki Convention; it works to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental co-operation between Denmark, Estonia, the European Community, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden.

The protection and conservation of marine and coastal biodiversity is one of the five priorities of HELCOM. In 1994, 62 Baltic Sea Protected Areas (BSPAs) were designated. Although preference was given to areas already under some form of protection, very few of the designated areas have been finally incorporated in the BSPA

[8] http://www.ospar.org/
[9] http://www.helcom.fi/

network yet. There still remains the additional task to incorporate 24 offshore areas identified by experts in 1998 into the network.

2.2.6 European Habitats Directive[10]

The aim of the Habitats Directive is to contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora in the European territory. It is built around two pillars: the Natura 2000 network of protected sites and the strict system of species protection. Under the Directive, Member States are obliged to establish a comprehensive network of Special Areas of Conservation (SACs) for endangered and vulnerable species and habitats. All in all the directive protects over 1000 animals and plant species and over 200 so called "habitat types" (e.g. special types of forests, meadows, wetlands, etc.), which are of European importance.

Objectives and priority areas for action on marine biodiversity laid down by the European Parliament and the Council in the 6th Community Action Programme include[11] to promote the protection of marine areas, in particular with the Natura 2000 network as well as by other feasible Community means.

2.2.7 Common Fisheries Policy[12]

The Common Fisheries Policy (CFP) is the European Union's instrument for the management of fisheries and aquaculture. Today, the CFP integrates a major emphasis on the environmental dimension of fisheries, by applying a long-term approach to management, a precautionary approach to protect and conserve living aquatic resources, and to minimise the impact of fishing activities on marine ecosystems; also it aims at progressively implementing an ecosystem-based approach to fisheries management.

2.2.8 European Integrated Maritime Policy[13]

In October 2007 the European Commission published a Communication for the development of an integrated maritime policy for the European Union, accompanied by an Action Plan which sets out the first concrete steps in developing an integrated approach to maritime affairs. Of particular interest for the development of MPAs are the actions related to “Maritime spatial planning and integrated coastal zone management”. More specifically, the Commission committed itself to elaborate a road map in 2008 to facilitate and encourage the further development of maritime spatial planning in the Member States; also in 2008, it will examine the needs and different options, including

[10] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
[11] http://ec.europa.eu/environment/nature/natura2000/marine/index_en.htm
[12] http://ec.europa.eu/fisheries/cfp_en.htm
[13] http://ec.europa.eu/maritimeaffairs/

for zoning, to making compatible different maritime activities, including the maintenance and strengthening of biodiversity; and in 2009, the Commission will set up a system for the exchange of best practice among authorities in maritime spatial planning and integrated coastal zone management.

2.3 MPA networks in Europe and the Mediterranean

2.3.1 Natura 2000[14]

Natura 2000 is the EU-wide network of nature protection areas established under the 1992 Habitats Directive. The aim of the network is to assure the long-term survival of Europe's most valuable and threatened species and habitats. It is comprised of Special Areas of Conservation (SAC) designated by Member States under the Habitats Directive, and also incorporates Special Protection Areas (SPAs) which they designate under the 1979 Birds Directive. Natura 2000 applies to Birds Sites and to Habitats Sites, which are divided into 9 ecologically coherent biogeographical regions. It also applies to the marine environment. In all, 9 marine habitat types have been identified:

- Sandbanks slightly covered by sea water all the time
- *Posidonia oceanica* beds
- Estuaries
- Mudflats and sandflats not covered by sea water at low tide
- Coastal lagoons
- Large shallow inlets and bays
- Reefs
- Submarine structures made by leaking gases
- Submerged or partially submerged caves

Very recently, the Commission adopted a decision to update the list of Sites of Community Importance (SCIs) for the Mediterranean biogeographical region[15].

Related to Natura 2000 network is the Emerald network. The Emerald Network is a network made up of “areas of special conservation interest” (ASCIs), which was launched by the Council of Europe as part of its work under the Bern Convention. It involves all the European Union states, some non-Community states and a number of African states (Tunisia, Morocco, Senegal and Burkina Faso are Contracting Parties; Algeria, Cape Verde, and Mauritania have been invited to accede). The European Union, as such, is also a Contracting Party to the Bern Convention. In order to fulfil its obligations arising from the Convention, particularly in respect of habitat protection, it produced the Habitats Directive in 1992, and subsequently set up the Natura 2000

[14] http://ec.europa.eu/environment/nature/natura2000/index_en.htm, see also http://www.natura.org/
[15] http://vlex.com/vid/38200351

network. The Emerald Network is based on the same principles as Natura 2000, and represents its *de facto* extension to non-EU countries.

2.3.2 Ramsar Convention[16]

Although initially focused on wetlands for migratory waterbirds, the Convention now takes into account the full range of wetland functions and values, and the need for an integrated approach to their management. Some 48% of the designated Ramsar sites include the coast and so may contain marine components. MPA managers may therefore see a Ramsar designation as an additional form of protection that could be added relatively easily to at least part of their sites. The CoP to the Convention has urged countries to give priority to designating new sites from wetland types that are currently under-represented on the Ramsar List so far, including coral reefs and other invertebrate formations, mangroves and sea-grass beds.

2.3.3 Europarc[17]

Europarc is the umbrella organisation of Europe's protected areas. It unites national parks, regional parks, nature parks and biosphere reserves in 38 countries, with the common aim of protecting Europe's unique variety of wildlife, habitats and landscapes. As a professional organisation for European protected areas and an independent, non-governmental organisation, its membership brings together the organisations responsible for the management of over 400 protected areas. It includes national sections, and one section specific to Atlantic islands, as well as three working groups (marine and coastal areas, wetlands, and Natura 2000 parks).

2.3.4 MedPAN[18]

MedPAN is the network of managers of marine protected areas in the Mediterranean. This three-year project (2005 - 2007) has been funded by the Interreg IIIC South Programme. It brings together 23 partners from 11 countries around the shores of the Mediterranean, of which 14 partners are European (from France, Italy, Greece, Malta, Slovenia, Spain) and 9 partners from non-European countries (Morocco, Tunisia, Algeria, Croatia, Turkey). These partners manage more than 20 marine protected areas and are working towards the creation of several new sites. At present MedPAN is managed by WWF-France.

[16] http://www.ramsar.org/
[17] http://www.europarc.org/
[18] http://www.medpan.org/

2.4 Other MPA-related projects

2.4.1 ECOMARE[19]

The overall aim of the EU MAST-III concerted action ECOMARE ("*Ecological effects of protection in Mediterranean marine reserves*", contract nº MAS3-CT97-0155, 1998-2000) was to unite and coordinate efforts of a broad group of research teams involved in assessing the effects of cessation of fishing in Mediterranean littoral ecosystems. The specific objectives of this project were:

- To establish the state of knowledge at this time of the responses of marine communities to protective measures in Mediterranean littoral ecosystems;
- To identify the main research needs and steps forward to progress from the assessment of effects on exploited populations to the assessment of effects at the ecosystem level;
- To review and recommend working methodologies so that future investigations could be carried out in a coordinated and comparable manner

In the scope of ECOMARE project, five reviews were conducted to understand the full ecological impacts and social-economic implications of MPAs. The reviews highlighted the thin scientific basis for predicting the consequences of halting fishery exploitation; part of their purpose was to identify researchable topics. ECOMARE results established the state of the art in five areas of research on the ecological effects of marine reserve protection and consisted of five review articles published in the June 2000 of the journal *Environmental Conservation* (Badalamenti *et al*. 2000; García-Charton *et al*. 2000; Pinnegar *et al*. 2000; Planes *et al*. 2000; Sánchez-Lizaso *et al*. 2000).

The subject of the above cited reviews can be summarized as follows:

1) The cessation or reduction of fishing in MPAs generally promotes increases of the abundance and of the mean size of exploited species. Hence, density-dependent changes in life history characteristics should occur when populations are allowed to recover in MPAs. This ECOMARE review synthesized the existing information on resource limitation in marine ecosystems, density-dependent changes in life history traits of exploited populations and evidence for biomass export from MPAs.
2) In connection with the increase in biomass of protected populations in MPAs, the available evidence of recruitment export from MPAs both in the Mediterranean and elsewhere was also reviewed. The general questions of interest were whether the increase in biomass of the protected species in an MPA has an effect on recruitment

19 http://cordis.europa.eu/data/RESU_MAST/ACTIONeqDndSESSIONeq18859200595ndDOCeq90ndTBLeqEN_RESU.htm

in the MPA or in neighbouring areas and if it affects competition and predation on new recruits inside the MPA. The review highlighted the almost total absence of studies addressing even the most elemental questions of recruitment in the context of marine reserves.

3) The third review tackled the subject of trophic cascades in MPAs with the aim of establishing how widespread cascades are and of inferring how likely they are to affect community outcomes of MPAs.
4) The forth review looked into our ability to distinguish between the influence of management measures in MPA and that of natural variability by tackling the question of the scale of the responses of populations to protection against their normal spatio-temporal heterogeneity.
5) The fifth ECOMARE review addressed the socio-economic impacts of Mediterranean MPAs and highlighted the importance of not neglecting their social, cultural and economic effects. No single model of community participation was valid for the whole Mediterranean: the variable characteristics of coastal areas, from those of small uninhabited islands to those of cities, require different weightings to be assigned for each factor in order to achieve a durable equilibrium and realize the original objectives of an MPA.

In addition, an "*Introductory guide of methods for selected ecological studies in marine reserves*" (Goñi *et al*. 2000) was produced to present the advantages and limitations of some methods widely used to study the effects of protection on a variety of ecological processes.

2.4.2 VALFEZ[20]

The VALFEZ project ("*Value of exclusion zones as a fisheries management tool in Europe: A strategic evaluation and the development of an analytical framework*", contract nº QLK5-CT-1999-01271, 2000-2002), approached several inter-related principal aims and targeted achievements:

1) To undertake a strategic evaluation of the ecological and socio-economic value of exclusion zones as a tool of fisheries management and to develop a robust multi-disciplinary analytical framework, to be readily used for their evaluation and development in Europe.
2) To build on existing frameworks of analysis and modelling tools to formulate a robust multi-disciplinary analytical framework, drawing on bio-ecological, socio-economic and institutional data, with bio-economic modelling as the core.

20 http://cordis.europa.eu/data/PROJ_FP5/ACTIONeqDndSESSIONeq112482005919ndDOCeq2890ndTBLeqEN_PROJ.htm

3) To provide the basis of a practical analytical tool for use by fisheries managers for the evaluation and development of exclusion zones as a management tool, which utilises, as far as possible, existing sources of secondary data and the findings of research to-date.
4) To target and prioritise any further research work necessary to optimise management decision-making: to be achieved through the development of work on the empirical evaluation of expected returns from research and data collection in conjunction with above bio-economic model(s).

A broad array of observations were drawn, many unique to each case study in hand, but with others of more generic significance. The benefits of exclusion zones were found to be diverse, justifying their consideration as a fisheries management tool. However, one of the clearest outcomes was that value cannot be assumed nor taken for granted. The benefits and the balance of outcomes were shown to be application specific, with situational specific factors contributing to and undermining that value. Prior evaluation of any proposed exclusion zone is highly recommended, given that it may or may not be the most appropriate management option and in design requires careful planning to ensure that it is both appropriate and effective.

The analytical framework(s) utilised in the study employed developments in bio-economic, temporal and spatial modelling and also drew on prior experience and knowledge within the field. During the progress of the study it was found that the methodological approach applicable was also necessarily case study/application specific, being dependent on both data availability and the specifics of the case study. Correspondingly, a toolbox of approaches has culminated from the study. Illustrations of the development and application of each are contained within the case study[21].

2.4.3 EDFAM[22]

The overall objective of the EDFAM Concerted Action project ("*European decapod fisheries: Assessment and management*", contract nº QLK5-CT-1999-01272, 2000-2003) was to provide a framework for the future data requirements, assessment and management of European decapod crustaceans. This procedure included issues of standardisation of data and methods to enable comparability across regions and new approaches for assessment that specifically recognise stock structure and life history features. In addition, the management structures for these fisheries were considered. Other approached issues were: optimising the acquisition of data from industry,

[21] For further information, see VALFEZ final report at http://www.port.ac.uk/research/cemare/publications/pdffiles/valfez/filetodownload,27351,en.pdf

[22] http://cordis.europa.eu/data/PROJ_FP5/ACTIONeqDndSESSIONeq112482005919ndDOCeq1010ndTBLeqEN_PROJ.htm

implementation of policies within the socio-economic framework, recognising local preference to the resources and the biological metapopulation structure of the stocks.

2.4.4 COST-IMPACT[23]

The EC research project COST-IMPACT ("*Costing the impact of demersal fishing on marine ecosystem processes and biodiversity*", contract nº Q5RS-2001-00993) addressed the conflicting EU objectives of maintaining sustainable fisheries in European waters with all their economic benefits, whilst at the same time maintaining biodiversity and avoiding negative effects on the environment. The primary objectives were to provide advice to decision makers on:

- How demersal fishing impacts the biodiversity of marine benthos and the associated goods and services, such as nutrient cycling that they provide
- How these impacts influence other marine ecosystem processes and then
- What the likely values of marine ecosystem goods and services are and how these values are affected by fishing.

Meta-analysis, field and mesocosm experimental studies provided information on the vulnerability of benthic communities to trawl fishing, highlighting that the effects of different types of fishing gear are dependant on the nature of the sea-bed in which they are deployed and that impacts on benthic processes such as nutrient cycling may have an impact on pelagic productivity. This indicates the need for a holistic approach to the management of coastal waters.

From these research findings, coupled physical-ecological models were used to investigate the impact of demersal trawling on the benthic and pelagic ecosystems. Perturbation experiments successfully simulated trawl fishing in the North Sea and for spatially resolved ecosystem models in the Cretan Sea. The realistic results and the range of scenarios that can be run demonstrate that the modelling approach is a very powerful tool for assessing anthropogenic impacts such as trawling and assessing potential management strategies such as the use of MPA's.

Through close collaboration between economists and natural scientists, changes in goods and services from different sea-bed habitats in the North Sea under different fishing scenarios were valued with monetary and non-monetary valuation techniques including stakeholder analysis. A decision support tool, utilising Multi Criteria Analysis (MCA), was developed in collaboration with the potential users.

A bio-economic model, incorporating the MCA, was developed as a decision support tool using a combination of all the research within COST-IMPACT. It provides the

[23] http://www.ecoserve.ie/costimpact/index.html

basis for a scenario driven analysis to demonstrate the impact of various fishing management strategies on the benthic marine ecosystem goods and services. The methodology is readily transferable, temporally and spatially, and could be developed and used to assist spatial management decisions in regional seas.

To ensure that this project was closely tied to the needs of the customers COST-IMPACT set up a Reference User Group (RUG) from both commercial and government sectors, covering fisheries and aquaculture management and nature conservation. Scientists gained a much clearer understanding of the policy and management requirements for the research as well as the dissemination possibilities. Equally, the RUG was able to understand more clearly the benefits and limitations of research to solve their needs.

COST-IMPACT indicated how policy makers and management could adopt an Ecosystem Approach that integrates both fisheries and environmental management simultaneously. COST-IMPACT was an extremely useful contribution towards the development of the ecosystem approach particularly within the context of the EU Marine Strategy as well as local policy in the UK, Netherlands and Ireland.

The expression of ecosystem goods and services in economic terms should enable policy makers and the general public alike to develop a wider understanding of the importance of biodiversity. This allows the comparison of the importance of fisheries, biodiversity and ecosystem processes in the same terms: economic value. As a result, the implementation of management and policy decisions on the relative costs and benefits of fisheries-related activities, including MPA's, can be weighed against the associated damages to ecosystems on a more robust and rational basis. This should enable the factors resulting in management decisions to be more easily understood by all affected parties.

2.4.5 BEMMFISH[24]

Mediterranean fish stocks are not routinely assessed or monitored (with the exception of large pelagic fish). Existing assessment data show that many target species are overexploited or not exploited efficiently economically. Given the importance of artisanal fleets in the Mediterranean and their technical interaction with other fleets (especially trawl), potential conflicts may arise that may aggravate the conservation state of stocks. Due to these technical interactions, but also the multi-species nature of the fisheries' catches and the dispersion of landing sites, single species approaches and output measures are often inappropriate for Mediterranean fisheries.

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http://cordis.europa.eu/data/PROJ_FP5/ACTIONeqDndSESSIONeq112482005919ndDOCeq266ndTBLeqEN_PROJ.htm

The BEMMFISH project ("*Bio-economic modelling of Mediterranean fisheries*", contract nº Q5RS-2001-01533, 2001-2004) addressed these questions by developing bio-economic models and a software package for the simulation and testing of various management strategies in Mediterranean and Mediterranean-type fisheries. The project integrated fisheries economists, fisheries biologists and computer scientists.

The bio-economic model developed (MEFISTO: MEditerranean Fisheries Simulation Tool[25]) is the result of two interacting sub-models:

- a biological (or stock) sub-model, including the dynamics of the resource and their interaction with human activity in the form of fishing mortality; and
- an economic sub-model (including fleet, market and fishermen) accounting for the dynamics of fleets and markets, and the rules of the fishermen's behaviour.

BEMMFISH has contributed both in practical and theoretical ways to the understanding of the functioning of Mediterranean fisheries and their management, thus to the strengthening of the Common Fisheries Policy scientific basis, as applied to the Mediterranean. It has provided a fully documented, easy-to-use software package for distribution among fisheries policy makers and managers, fisheries scientists, the industry and administrators of Mediterranean fisheries at all levels: EU, FAO, national and local administrations. The software produced allows managers to assess the biological and economic consequences of Mediterranean fisheries applying different policy tools; it should thus serve particularly as a tool to guide the evaluation of alternative management strategies for Mediterranean fisheries.

2.4.6 AFRODITE[26]

The 'Sistema Afrodite' was an Italian project conceived to reach four main objectives (Greco *et al*. 2004): (1) to create a uniform knowledge base, (2) to aid the creation of a national Italian system of MPAs, (3) to foster co-operation among scientists at national level, and (4) to set the foundations for a Mediterranean network of MPAs.

This triennial programme (2001–2004) encompassed a number of coordinated activities, generally focused on the 'A' zones (integral reserves) within 15 of the 16 gazetted Italian MPAs, because one of these (Secche di Tor Paterno) does not have any 'A' zone. These activities included:

- Detailed mapping
- Monitoring of water column, phytoplankton and sediments

[25] http://www.mefisto.info
[26] The present section is extracted from Greco *et al*. (2004). For further information, see also http://www.regione.piemonte.it/parchi/conferenza2002/abstract/dwd/a12p_tunesi.pdf

- Habitat and species inventory
- Benthic sampling
- Pollution monitoring

All the data were fed into a single database, enabling the creation of an information system designed to cater for the needs of a range of different user groups.

In order to meet the challenge of undertaking simultaneous surveys and to foster co-operation among scientists at the national level, ICRAM has sought the collaboration of a large number of scientific partners, mostly within the National Consortium of Marine Science Institutes of the University system (CoNISMa) and the National Research Council (Consiglio Nazionale delle Ricerche: CNR). These include institutes from the Universities of Cagliari, Genoa, Lecce, Messina, Naples, Palermo and Siena and the CNR institutes IRMA (Castellamare del Golfo) and IST (Messina). Furthermore, an International Advisory Committee, comprising international experts in the field of MPA science, provided advice on research standardization.

After the first 3-years phase, it was envisaged that 'Sistema Afrodite' continues encompassing the entire suite of Italian MPAs, extending its scope to other MPA systems within the Mediterranean region. To this purpose, the European Commission (General Directorate for Scientific Research) founded an international workshop in summer 2002 to evaluate ways for extending the research protocol and direction of 'Sistema Afrodite' to the Mediterranean area.

2.4.7 RESPONSE[27]

The RESPONSE project ("*Response of benthic communities and sediment to different regimens of fishing disturbance in European coastal waters*", contract nº QLRT-2001-00787, 2002-2005) was conceived as an integrated strategy to know the response of the biotic environment structure and the changes of the particulate matter dynamic, caused by the disturbance of fishing activity. This research focused on providing new perspectives and management options to the CFP in order to achieve sustainable fisheries and of protection of biodiversity, a widely recognised problem in moving towards ecosystem-based management in fisheries.

The main objective was to obtain more knowledge on mid- and long-term effects to different regimens of fishing trawl perturbation on the seabed. The study was performed in fishing grounds off European coasts (the North Sea, Irish Sea and Mediterranean Sea). The specific objectives, estimation of changes in sedimentologic process, benthic and fish community, estimation of secondary production of the lower trophic levels, and

[27] http://www.icm.csic.es/rec/projectes/response/

analysis of the synthesis and integration of the results, was achieved with six multidisciplinary work-packages. The main achievement of this project were related to understanding how long it takes for the benthic community to recover and what is its response to fishing activity, and the consequences of the sediment re-suspension caused by trawlers.

2.4.8 BIOMEX[28]

While sometimes not the main focus for establishing marine reserves in the Mediterranean, the ideas of protecting breeding stocks, improving recruitment to neighbouring areas, or restocking marine species of commercial interest have often been put forward as important goals. However, no real study has been carried out in Europe, and few elsewhere, to assess the value of MPAs as sources of biomass to surrounding fisheries, although this is certainly a crucial point. BIOMEX ("*Assessment of BIOMass Export from marine protected areas and its impacts on fisheries in the western Mediterranean Sea*", contract nº QLRT-2001-0891, 2003-2005) aimed to investigate the efficiency of MPA as sources of biomass. The main objective of BIOMEX was to assess the export of fisheries-related biomass from MPAs to surrounding areas.

The existence of gradients in fish biomass and mean fish size supports the existence of fish exportation outside MPA, following the initial hypothesis. However, this exportation would benefit local fisheries only at a small spatial scale, from tens to hundreds of meters, even if fishes were able to migrate longer distances. The small scale (100 to 1000 m) on which fish biomass gradients from the MPAs studied were revealed was probably related to the high fishing pressure existing in the Western Mediterranean outside MPA and, in some case, to habitat discontinuities.

Results of the BIOMEX project have brought evidence of fish biomass export from MPA to fished areas in the NW Mediterranean, for adults as well as for eggs and larvae of some species or groups of species depending on the MPA. It was concluded that, even if fish biomass export from MPA varies greatly in space and intensity according to fish species, and is restricted to a small distance from MPA border, it is likely to have positive effects on adjacent fisheries.

Some of these results have been already published (Stelzenmüller *et al*. 2007; Stobart *et al*. 2007; Goñi *et al*. in press; Harmelin-Vivien *et al*. in press), while other are still in preparation.

[28] http://biomex.univ-perp.fr

2.4.9 EFIMAS[29]

The overall objective of EFIMAS project ("*Operational evaluation tools for fisheries management options*", contract nº 502516, 2004-2008) has been to develop an operational management evaluation framework that allows evaluation of the trade-off between different management objectives when choosing between different management options. The overall approach used stochastic simulation techniques. Amongst its outputs, a book was produced to deal with a multidisciplinary perspective of fisheries management (Motos and Wilson 2006).

2.4.10 PROTECT[30]

The aim of the PROTECT project ("*Marine protected areas as a tool for ecosystem conservation and fisheries management*", contract nº SSP8-CT-2004-513670, 2005-2008) has been to provide policy advice and develop methodologies to assess the potential of different MPA management regimes. MPAs were assessed for their effectiveness in protecting sensitive species, habitats and ecosystems from the adverse effects of fishing, in promoting the enhancement of vulnerable species or ecosystems and in assisting in the sustainable harvesting of economically valuable species.

PROTECT aimed at defining, assessing and evaluating the parameters determining the success and failure of different regimes of protected areas based on resource, ecosystem and socio-economic objectives. Because of the large variety of marine issues and conflicts that arise in connection with European MPAs, different approaches were studied, ranging from "no take zones" to protected areas, where different levels of fishing are accepted either on a seasonal or activity basis. Project partners did work together within 3 regional case studies and in common work packages on the methodology development, assessment and modelling of European MPAs. These case studies encompassed:

- A top-down controlled ecosystem in the Baltic Sea
- A "wasp-waist" ecosystem in the North Sea
- Deep-water *Lophelia* reefs in the Northeast Atlantic

In each of the case studies identified, the project performed the following tasks:

- Evaluate the design of marine protected areas in terms of location, size, level of regulation of human activities, ecosystems characteristics, temporal scale as well as monitoring, assessment and management structures.

[29] http://www.efimas.org/
[30] http://www.mpa-eu.net/

- Identify the potential fishery benefits as well as adverseness in terms of protection of exploited populations and protection of essential habitats, including the benefits in adjacent areas.
- Investigate the socio-economic impacts of the MPA, or proposed MPA, on local communities, user groups and impacts on the decision making process.
- Integrate and model the expected performances of protected areas in terms of the pre-defined objectives and develop management tools to increase their effectiveness.

Outputs of PROTECT include:

- An improved basis for the design, selection, implementation, monitoring and management of European MPAs, including legal strategies.
- A better understanding of the effects of MPAs on target species, habitats and ecosystems.
- An evaluation of impacts of the different regimes of protected areas on socio-economic activities, including fleet behaviour.
- Scientific tools for the greater use of MPAs in European waters as an ecosystem-based approach for fisheries management.
- Creation of an "MPA forum" in cooperation with FP project EMPAFISH to provide an opportunity for dialogue between scientists, policy makers and stakeholders on the issues of MPA design and management.

Among the reports produced, a "Review of MPAs as a Tool for Ecosystem Conservation and Fisheries Management" was released in 2006[31].

2.4.11 PROFET POLICY[32]

This is a project funded by the EC within the 6th Framework Programme. Its main aim was to provide an opportunity for interested stakeholders in aquaculture and fisheries to become better informed on the European policies and research efforts that affect their sectors. The project organised different workshops in different countries throughout Europe, on a thematic and regional basis covering fisheries and aquaculture, being an important forum for the exchange on views of National and European policy makers and stakeholders. Their active participation in these events will provide the Commission with clear recommendations for scientific support to policy.

[31] Available at http://www.dfu.min.dk/dfu/data/filemanager/protect/$00000302_PROTECT%20WP2%20MPA%20REVIEW.pdf

[32] http://www.profetpolicy.info

2.4.12 AMPAMED[33]

The Project AMPAMED ("*Le rôle des Aires Marines Protégées dans la gestion durable d'Activités économiques, telles que la pêche artisanale et le tourisme, en harmonie avec l'identité culturelle des régions de Méditerranée Occidentale*") has been funded by the European Union (Interreg IIIB Medocc). The project involved five partners: the Office de l'Environnement de la Corse (France), the Foundation IMC (Italy), the IAMC-CNR (Italy), the Sinis Marine Protected Area (Italy), and the University of Murcia (Spain). The main aim was to evaluate the role of MPAs in the sustainable development of local economical activities, artisanal fishery and tourism. Three MPAs of western Mediterranean (Bouches de Bonifacio, Corsica, France; Sinis – Mal di Ventre, Sardinia, Italy; and Cabo de Palos – Islas Hormigas, Murcia, Spain) have been considered as case studies to analyze methods and criteria for the management of artisanal fisheries, nautical tourism and SCUBA diving in the framework of protection measures. The project involved the collection of socio-economical data, biological and ecological studies, pilot project in order to experiment innovative management measures, and diffusion of results.

2.4.13 EMPAS[34]

The project EMPAS ("*Environmentally Sound Fishery Management in Protected Areas*)" was started in ICES in February 2006 based on funding from the German Federal Agency for Nature Conservation (BfN). The main aim of the project is to develop fisheries management plans for each of ten German NATURA 2000 sites.

2.5 Other guidelines for MPA management

2.5.1 Publications

The number of publications (both peer-reviewed and grey literature) dealing with MPA science and management has been growing exponentially during the last years – see reviews by Pelletier *et al*. (2005, 2008). Amongst them, some key books deal specifically with management aspects (e.g. Kelleher 1999; Salm *et al*. 2000; Pomeroy *et al*. 2004). Of particular interest are the special issues of scientific journals dealing with MPA management[35]. Also, some publications are devoted to disseminate the "MPA

[33] http://www.ampamed.org
[34] http://www.ices.dk/projects/empas.asp
[35] See, for example:
Ecological Applications vol. 13 (1), Suppl. (2003)
Conservation Biology vol. 19 (6) (2005)
Ocean & Coastal Management vol. 48 (11-12) (2005)
Hydrobiologia vol. 606 (1) (2008)

Science" to a wider audience (e.g. Roberts and Hawkins 2000; Ward *et al*. 2001; PISCO 2007 amongst other). In addition, the newsletter "*MPA News*"[36] is a very good way to exchange information and opinions amongst MPA practitioners. All this constitutes a wide basis to establishing guidelines for MPA management.

2.5.2 Conclusions of scientific and technical meetings

2.5.2.1 MEZ in Europe 2000[37]

This facilitated conference was funded by the European Commission as part of the project VALFEZ (see above), and was held in Southampton from 26th to 28th April 2000. The stated objectives of this conference were: (1) to share existing knowledge, (2) to identify gaps in our knowledge, and (3) to identify research needs and priorities, based on the experience of MPA practitioners (researchers, managers and stakeholders). The facilitation process provided a large array of considerations about (a) defining and assessing / monitoring success or failure criteria and objectives, (b) understanding ecosystem, (c) MPA design, and (d) decision-making process. In addition, a series of research priorities were identified.

2.5.2.2 Vth World Park Congress 2003[38]

This congress was organised by IUCN in Durban (South Africa) during 8-17 September 2003. Its final considerations and recommendations[39] were stated along the four streamlines which guided the discussions during this meeting: governance, capacity building, management effectiveness and finances and resources. One of the messages sent for the CBD is the need to solve the gaps in protected areas coverage and the need to develop a representative MPA system.

2.5.2.3 WCPA/IUCN scoping meeting 2004

This meeting (Livorno, Italy, 6-8 December 2004) aimed at supporting Mediterranean States to meet the 2012 WSSD target on networks of Mediterranean MPAs. As relevant conclusions, we can extract the following needs:

1) Political, social, economic and legal aspects
   a) assessment of capacity building needs and development of programmes
   b) stakeholder identification
   c) identification of fund raising opportunities

ICES Journal of Marine Science (in press, Proceedings of the "European MPA Symposium 2007")

[36] http://depts.washington.edu/mpanews/

[37] http://www.port.ac.uk/research/cemare/researchandconsultancy/pastprojects/ValueofExclusionZones/events/marineexclusionzonesineurope/

[38] http://www.iucn.org/themes/wcpa/wpc2003/

[39] http://www.iucn.org/themes/wcpa/wpc2003/pdfs/outputs/wpc/recommendations.pdf

2) Research and monitoring activities
   a) standardisation of monitoring systems (choice and implementation of ecological and socio-economic indicators).
3) Capacity building
   a) MPAs and network design and planning
   b) management;
   c) institutional building;
   d) legislation and enforcement at both levels, national and high sea;
   e) public awareness, education and communication skills;
   f) fund raising.

2.5.2.4 IMPAC1 2005[40]

The first International Marine Protected Areas Congress (Geelong, Australia, 23-28 October 2005) reached the following conclusions and relevant key recommendations:

- Ecological aspects
  - need for comprehensive, adequate and representative networks;
  - consider connectivity, sustainable development and issues like connectivity and resilience;
  - realistic time-scales and a transparent, structured approach
  - need for a clear problem statement.

- Economical aspects
  - need to establish clear goals and objectives, ambitious, measurable and verifiable;
  - a balanced and proportioned approach to resource protection driven by the precautionary principle;
  - consider resource allocation issues and displacement of existing uses;
  - flexibility in approach, depending on socio-economic setting, and cultural and political context

- Social aspects
  - importance of education to inform the public, stakeholders and Indigenous people, and gain their support;
  - actively seek the views, experience and support of other sectors (particularly fisheries managers);
  - invest significant time up front to build formal and informal relationships with indigenous peoples, local communities and the wider public - foster trust and respect;

[40] http://www.impacongress.org/

- appropriate targeting of messages relevant to the audience;
- importance of a champion, good leadership, and building political will for the MPA network;
- local information can sometimes provide more reliable and comprehensive
- effective policies supporting MPA networks are underpinned by effective public participation.

- Spatial aspects
  - recognize need for significant scaling up of effort in all regions if the 2012 target is to be met;
  - match policies and action on developing MPA networks to the large ecological scales involved.
  - networks should be developed as an integrated & integral element of wider ocean/coastal management;
  - utilize international instruments, programs and conventions to facilitate progress.

- Temporal aspects
  - best practice may be represented by implementing an entire network in one go, while in other situations, an incremental process may be more appropriate.

- Scientific aspects
  - acknowledge and use science, traditional ecological knowledge and socio-economic information;
  - use the best available science to underpin network development;
  - current world database on MPAs is deficient and there is a need to obtain better data on MPAs;
  - capture, and share globally, current experiences & best practices;
  - DSS are valuable, but do not replace human judgment and will not provide a final solution.

- Institutional aspects
  - recognize the limitation that MPAs are unable to address certain threats, and efforts must be made to coordinate with other relevant agencies
  - effective MPA networks need to involve a ‘top down’ planning process, combined with ‘bottom up’ community efforts
  - where jurisdictional or ownership issues occur, all parties should work to identify and progress common conservation goals
  - long term success of a network relies on an effective process by responsible focused agencies undertaking a consistent long-term program of MPA planning

2.5.2.5 CBD expert workshop on MPAs 2006[41]

This workshop was held in Curitiba (Brasil), during 20-31 March 2006, about "Marine and coastal biological diversity". Especially relevant are the goals and targets adopted by the participants, and the evaluation matrix decided to review the implementation of the programme of work on protected areas[42]. The CoP of CBD took a series of decision about enhancing the implementation of integrated marine and coastal area management[43].

2.5.2.6 MedPAN workshops[44]

Very recently, MedPAN published the conclusions of the complete set of workshops held within this network and dealing with MPAs, and celebrated between 2005 and 2007, which included the following themes (organising MPAs between brackets):

- Workshop 1 (Miramare, Italy): Education and communication
- Workshop 2 (Cabo de Gata, Spain): Management planning
- Workshop 3 (Cerbère-Banyuls, France – Medes Islands, Spain): Sustainable management of tourism
- Workshop 4 (Asinara, Italy): Financing and economic impacts of MPAs
- Workshop 5 (Straits of Bonifacio, Corsica, France): Sustainable management of fisheries and surveillance
- Workshop 6 (Zakynthos, Greece): Consultation and consensus building
- Workshop 7 (Cabrera archipelago, Balearic Islands, Spain): Management of habitats and species

All these workshops gave a large series of recommendations for MPA managers.

2.5.2.7 ICES WKFMMPA 2007[45]

The "Workshop on Fisheries Management in Marine Protected Areas" [WKFMMPA] was held at the ICES Headquarters, Copenhagen, Denmark, from 10–12 April 2007 to review and discuss results of analysing international fishing activities, fishing efforts in and around the ten designated Natura 2000 sites in the German EEZ, in relation with EMPAS project. This meeting also intended to develop monitoring strategies and guidelines to provide information about the key aspects of fisheries operations identified in these areas, progress towards conservations objectives, and potential conflicts.

[41] http://www.cbd.int/doc/?mtg=PAWS-01
[42] UNEP/CBD/COP/8/INF/27, 19 March 2006, Annex II (http://www.cbd.int/doc/meetings/cop/cop-08/information/cop-08-inf-27-en.pdf).
[43] http://www.cbd.int/decisions/?m=COP-08&id=11036&lg=0
[44] http://www.medpan.org/_upload/1085.pdf
[45] http://www.ices.dk/iceswork/wgdetail.asp?wg=WKFMMPA

Ultimately, the aim was, through reviewing fishermen information and industry interests to be considered in fisheries management plans in the Natura 2000 sites, socio-economic aspects to be considered in fisheries management plans in the Natura 2000 sites, as well as national/international knowledge/experiences with the integration of scientific studies, monitoring, and fishermen information/knowledge, to develop proposals for managing fisheries in the German Natura 2000 sites, including consideration of co-management systems appropriate for management, within an ecosystem approach[46].

2.5.2.8 European Symposium on MPAs 2007[47]

The *European Symposium on MPAs as a Tool for Fisheries Management & Ecosystem Conservation* was held in September 2007 in Murcia (Spain), organised by the project EMPAFISH together with the project PROTECT. It constituted a unique opportunity to bring together researchers from different disciplines, managers, authorities and representatives of different sectors directly concerned by MPAs, to discuss the advancements of this management tool to achieve fisheries and conservation goals. The main conclusions of this meeting can be summarised in the following points (García-Charton *et al*. 2008):

1. Need to integrate fisheries and biodiversity goals
2. Importance of participatory process and community involvement
3. The essential role of science in the whole MPA process
4. The future of the MPA tool

From the points above, a set of problems emerges to be urgently faced in order to fully develop MPAs:

- elucidating fisheries – environment conflicts,
- achieving effective public participation,
- building up multidisciplinary approach to MPA science,
- filling gaps in scientific and management issues.

Other aspects of marine management converge to define marine policies in the near future. Importantly, consensus was reached during the *MPA Symposium* to the necessity to be much more ambitious when stating the goals and objectives of fisheries conservation and biodiversity protection, because of the highly degraded state of marine populations and ecosystems, as evidenced by establishing reference points of harvested populations at much longer temporal (i.e. historical) scales. Hence, although many benefits will become apparent soon after protection, full ecosystem recovery will require decades to centuries. In addition, there is the mandate to protect a very significant part of the marine areas within MPA networks – bearing the 2012 target in

[46] For further information, see http://www.ices.dk/reports/MHC/2007/WKFMMPA07.pdf
[47] http://www.mpasymposium2007.eu/

mind. From this perspective, scientists claim for the need to protect up to at least 40% of the global ocean.

Regarding the role of scientific advise in the MPA process, the dichotomy "low-tech, expert opinion and local knowledge-based" (e.g. rapid assessment of coastal areas) *vs*. "high-tech, high-quality data-based" methodologies was raised in the *MPA Symposium*; due to urgency reasons, there is clearly a need to develop the first type of methods to be applied in certain situations, as already done by some international agencies (e.g. UNEP-MAP). But, perhaps more importantly, scientists should improve their capacity (and allocate further efforts) to translate the results of MPA research into readily applicable management measures. Alternatively, it is conceivably necessary to assign persons (or field of expertise) to serve as links amongst disciplines (scientific, technical, social) and productive / administrative sectors, given the reductionist way to face the problems by the different parts.

Finally, it appears increasingly compulsory to expand the MPA concept (close "horizontal" consensus amongst scientific disciplines, administrations, and stakeholders) to a wider area, at larger geographical scales beyond the MPA limits. Definitely, MPAs emerge as a paradigm towards the development of a true Oceans Policy, based on the interdisciplinary spatial planning and the ecosystem-based management of the littoral areas and the high seas. Problems to be immediately faced to accomplish such an expansion are the need to adapt the MPA concept to emerging countries, and establishing the legal framework to build transboundary MPAs.

Additional information about the European MPA Symposium of Murcia can be found in the Technical Memorandum of the meeting[48], as well as in the extended abstract (both available at the EMPAFISH webpage). Selected papers are to be published in a special issue of the *ICES Journal of Marine Science*.

[48] Downloadable at http://www.mpasymposium2007.eu/Memorandum-_European_Symposium_on_MPAs.pdf

3 Management mechanisms and problems in EMPAFISH case studies

3.1 Cabo de Palos – Islas Hormigas[49]

The Cabo de Palos – Islas Hormigas Marine Reserve (CPIHMR) was created in 1995 under fishery legislation rules. The entire marine reserve is rectangular in shape and 1,898 ha in size. It is formed by a no-take area (integral reserve) as a 270 ha circle centred around the archipelago of Hormigas islands, where all activity is prohibited (except scientific research), the remaining surface being a partial reserve, which is intended to work as buffer zone, where some kind of artisanal fishery (clear trammel net and bottom long-line) and SCUBA diving are allowed under strict regulation measures. All kind of recreational fishing is prohibited within the limits of the marine reserve.

Management and financing of CPIHMR is shared between regional and national administration: the Regional Fisheries and Aquaculture Service (Autonomous Community of Murcia) is responsible for the internal waters, while the Spanish Secretariat for Marine Fishing of the Ministry of Rural, Marine and Natural Environment is in charge of managing the external waters. The actions of both administrations are co-ordinated by means of a convention, which is updated on a regular basis. There is a Monitoring Commission formed by representatives of both regional and national administrations, devoted to follow-up the effective implementation and achievement of the convention and the elaboration of reports and proposals for management.

The management actions are mainly addressed to: enforcement measures; installing and maintaining the buoys signalling the limits of the CPIHMR as well as the mooring buoys on the diving spots; and publishing advertisements for the general public (panels and brochures). The surveillance is performed by a team of 4 coastguards (hired by a sub-contracted public company), and it is done from two boats and from land; enforcement is done the whole 24 h in high season (summer and main holidays, when 2 additional wardens are temporally hired), and during 12 h at daytime the rest of the year.

The scientific monitoring is regularly entrusted to the Department of Ecology & Hydrology at the University of Murcia through a convention of collaboration, which is updated yearly. Main monitoring activities include visually censusing fish assemblages, surveying the artisanal fishing, studying the impact of recreational divers, assessing gorgonians populations, and exploring the agreement of stakeholder groups regarding

[49] http://www.mapa.es/rmarinas/index_rm.htm

the protection measures. Other monitoring actions are occasionally committed to other organisms (usually private consulting companies) to survey the diving activity, which is the main economic activity in the CPIHMR apart from fishing. In addition, a high number of research projects are being developed in the area, either from the University of Murcia or from other research institutions.

The main management problems in the CPIHMR rely on the following points:

- Lack of a specific management body related to the marine reserve: the personnel staffs at the Regional Service are also in charge of managing all fisheries and aquaculture activities in the region, while the personnel at the Ministry are responsible for all the Spanish network of fisheries marine reserves.
- Lack of a management plan; no activities are developed other than signalisation, general advertisement, enforcement, and monitoring.
- Some poaching by recreational fishers is detectable (mainly by spearfishing and troll-line).
- No compliance of the diving quotas (i.e. maximum number of divers allowed each day / week), due to conflicts among regional administrations (fisheries *vs*. tourism); at present, more than 20 000 dives occur each year within MPA limits.
- Derived from the above point, conflicts amongst users (namely fishermen and diving centres).
- Lack of co-ordination with environmental authorities.

3.2 Columbretes Islands[50]

The Columbretes Islands Marine Reserve (CIMR) is located in the Mediterranean 30 miles from the Spanish mainland coast, and is managed exclusively by fisheries administration of the central government, namely the Spanish Secretariat for Marine Fishing (Secretaría General de Pesca Marítima, SGPM) of the Ministry of Rural, Marine and Natural Environment. The main objective of the CIMR is to protect and regenerate resources exploited by local fisheries. This objective is achieved by minimising the impacts of fishing and other uses such as diving. The reserve is divided into general use, restricted use and integral zones. Although limited professional fishing and recreational fishing are allowed in the general use area they are very restricted and therefore rarely pursued by fishermen. The entire reserve therefore essentially acts as a no-take area.

[50] http://www.mapa.es/rmarinas/index_rm.htm , see also http://www.cma.gva.es/contenido_ParquesNaturales/montarparques.asp?nodo=2979&idioma=I

The remote location of the CIMR has far reaching consequences for management. There is no resident civilian population on the islands except for the wardens. This greatly simplifies governance of the reserve whose entire area can be viewed with radar located at the ranger station (the only dwelling on the island, though the old lighthouse is currently being renovated for use by scientists etc.). Though patrolling the reserve is complicated by the fact that for most of the year the three small boats the rangers use need to be launched from dry land with a crane, the incidence of unauthorised fishing is thought to be negligible. Due to limited space availability on the island the rangers' salaries (a total of 6 fully employed and 2 part-time) are shared between the SGPM and the regional government in charge of the management of the terrestrial reserve. The marine reserve also has a full time biologist who is based on the mainland and visits periodically, and two full time administrative staff on the mainland. Access to the reserve facilities can be complicated in bad weather as the entire area is highly exposed with no safe anchorage. This greatly increases management costs and the logistics of supply and ranger shifts.

3.3 Medes Islands[51]

The legal status of Medes Islands Marine Protected Area is Marine Natural Park, established by Order of the Ministry of Agriculture and Fisheries of the Catalan Autonomous Government (25 November 2003, D.O.G.C. 291, 21-12-1983). This initial declaration prohibited extractive uses (recreational or professional fishing) 75 m from the coast of the islands. The No Take Zone (Integral Protection Area) was enlarged to 200 m from the coast of the islands in a later decree (Law 19/90 of the said Ministry of Agriculture and Fisheries, 17 December 1990, D.O.G.C. 17-12-1990). In this decree a partially protected area was also established, were only professional fishers located in the nearby port of L'Estartit can operate. The resulting configuration of the MPA is 93 ha as No Take Zone (*Reserva Integral*) and 418 ha of Partially Protected Area (*Reserva Parcial*).

The same decree transferred the administration of the marine park to the Ministry of Environment of the Autonomous Government, which is the current management body. This management body is advised by an Advisory Council, which includes the Park manager, a representative of the Fishers' Association, a representative of the University of Barcelona (responsible until for the monitoring of the MPA; since 2007, this task has been taken by the Centre d'Estudis Avançats de Blanes – CSIC), and a representative of non-extractive, recreational activities. The current management regulations forbid any type of extractive uses from the No Take Zone and regulated diving and anchoring during daytime (by issuing daily permits). In the Partially Protected Area trawling is

[51] http://mediambient.gencat.net/cat/el_medi/parcs_de_catalunya/medes/

forbidden, but extractive uses by the local fishers are regulated (by issuing annual permits). In the Partially Protected Area, there is no further restriction on recreational uses (diving, anchoring, recreational fishing), but the main two recreational activities (SCUBA diving and excursions glass-bottom boat) are conducted in the framework of commercial companies that must be authorized by the Park.

3.4 Cerbère-Banyuls[52]

The Marine Natural Reserve of Cerbère-Banyuls was created in 1974 to protect the remarkable ecological heritage of the "Côte Vermeille". Since 1977, the French department of Pyréneées-Orientales is financing (80% of the budget) and managing this 650 ha MPA with two protection levels:

- no-take zone (65 ha) protecting rocky grounds with a high complexity of habitat and high biodiversity of flora and fauna in the core including *Lithophyllum* and coralligenous constructions and *Posidonia oceanica* meadows; all types of fishing, diving and mooring are banned excepted for scientific studies agreed by the Consultative Committee of the reserve;
- partially protected zone (600 ha) surrounding the no-take zone, where fishing and speed of boats are limited, and where spearfishing and harvesting are forbidden.

The Consultative Committee is constituted by representatives of coastal towns, State, stakeholders, nature protection associations and scientific authorities. This Committee is in charge of the management plan and to ask for scientific monitoring. It gives opinion about the reserve functioning and management.

The staff of 5 permanent persons (3 extra more, hired during summer) works daily to face 3 management stakes:

1. the need to be effectively present each day on the field to act, to develop, to make the public aware, to inform, to supervise, to report and to alert;
2. the need that each individual considers the marine ecosystem as his own and understands its value, its fragility and the necessity to preserve it;
3. the need to know the environment and to monitor the human activities, i.e. to manage sailing activity and anchoring, to manage scuba diving, to monitor and control fisheries, to supervise the evolution of others recreational practises.

The rocky coast is an important tourism spot of the department and the human frequentation has literally boomed during the last 30 years. The management of the

[52] http://www.cg66.fr/environnement/espaces_naturels/reserve_marine/index.html

reserve has to face this evolution and to cope with two somehow antagonist goals: the preservation of marine environment and the public welcome.

The managers have to develop means of signalling to guide and inform the public and to provide respect of the regulation, and report if necessary. If the need to compel is necessary, the duty to convince is more important in order that all the users and the species themselves could keep their place as long as possible. The more aware the stakeholders, the more respectful they are towards the environment. Awareness starts with children and scholar animations, then consultation with professional fishermen, diving companies and clubs. Finally, an information point and a scuba trail are hosted too. Moreover, the managing staffs are in charge of scientific monitoring, to census vegetal and animal and patrimonial species abundance, size and richness and evaluate the conservation state of each habitat. What a challenge for this staff to conduct so multiple tasks with competence and few persons!

The creation of a Marine natural Park of the “Côte Vermeille” takes part of the application of the actual politic of development of marine protected areas on the French littoral coast including overseas MPAs. New zonations and new management organisations are planned taking into account the Natura 2000 directives and the politic willingness of integrative management of the coastal zone. The stakes are numerous and change completely the way of managing space and relations between partners and this is not always easy for managers to success in the application of these decisions on the field.

3.5 Côte-Bleue[53]

The “Côte Bleue Marine Park" (hereafter CBMP) is a public establishment including the regional authorities, the department, the five municipalities distributed along the 30 km Côte Bleue coastline and, as associated members, the Prud’homies and fisheries local committees of Marseilles and Martigues. A first no-take zone (85 ha) was created in 1982 on the Côte Bleue, in Carry-le-Rouet, as marine reserve dedicated to professional fishing, with a status of association. Another no-take zone was created in 1996, at fishermen’s request, lesser than 8 km to the West of Carry-le Rouet: the Cap Couronne marine reserve (210 ha). Both constitute the biggest marine zones with enforced protection in the French continental zone grouped together with surrounding waters in the CBMP, created in 2000.

The CBMP was created with the following objectives: management, protection and restoration of naturals habitats, sustain to professional fishing activities, information and

[53] http://www.parcmarincotebleue.fr/

public awareness, scientific studies and experimentation. Within the reserve all fishing activities are forbidden and production artificial reefs have been installed to enhance the fisheries resources. Boats are allowed to cross the reserves. Bathing and snorkelling are allowed inside both MPAs but diving and mooring are forbidden, in order to protect grounds and facilitate recovering of stocks of the different exploited species. Several studies and surveys, visual censuses and experimental fishing surveys, were performed around and inside Carry reserve since its creation, and before and after creation of Cap Couronne marine reserve, to qualify and quantify the modifications of marine communities inside and outside those reserves.

The French general regulation imposes banning of trawling inside the 3 nautical miles limit from the coast. To fight against illegal trawling, anti-trawling artificial reefs have been deployed in the CBMP close to the reserves, but forty traditional fishing boats, originating from 6 harbours, operate in the area of influence of the reserves.

Management and financing of CBMP is shared by a Syndical Committee, with numerous members, the State representation and the Water Agency. The actions decided by the Syndical Committee are co-ordinated by the director of the park and executed by the permanent staff. They have to report about the effective implementation and achievements of the decisions; they elaborate activity reports and proposals for management.

The management actions are first addressed to enforcement measures, installing and maintaining the buoys at the limits of the reserves. The surveillance is performed by a team of 3 coastguards from two boats and from the land. Enforcement is done the whole 24 h in high season (summer and main holidays, when 3 additional wardens are temporally hired), everyday the rest of the year. In 2007, a management plan has defined strategic objectives: enforcing knowledge about the Côte Bleue natural patrimonial resources, managing, protecting and developing marine natural environment of the Côte Bleue, sustaining the coastal artisanal fishery and the fishery resources, answering to social demand of information, awareness, public education and local actors, enforcing environmental partnership and sustainable development.

The Scientific Committee is constituted by scientists from the main scientific organisms (CNRS and several Universities, IFREMER); they help the park in the definition of priorities in monitoring activities and initiate themselves or with students scientific programs. Other monitoring actions are occasionally committed to other organisms (usually private consulting companies).

The main actual management problems are the following:

- Even if integrated management of coastal zone is an actual preoccupation, the decisions are often divided in main topics as urbanism, economy, social and environment.
- The management plan has been finalized in 2007 with 86 actions, but some are difficult to set for institutional, technical or financial reasons; among these reasons, we can mention a higher involvement of the Park in the towns' littoral and environmental projects. The Park team is asked to be expert in pollution, natural risks, and littoral planning impacts, but human resource is really too limited to insure the multiplicity of tasks they are supposed to carry out on top of enforcement and maintenance tasks. They have to report on everything and are often captured by administrative tasks. They are supposed to monitor the marine environment but they have no money, no time, nobody to do it.
- The evolution of French littoral management zoning, Natura 2000, a new MPA Agency and a National Park project have multiplied meetings, consultations, co-ordination between State representations, regional and local authorities, stakeholders and managers during the last years. This evolution, even in the positive sense, creates some local perturbations in the patient work of years conducted by managers to conceal sometimes divergent activities, interests and conservation. New zonations or new management plans of the littoral create some incertitude about the place and the role of the actual Park in the future.
- Sworn guards are in charge of protection and information at sea and along the coast, trawling is banned inside the 3 miles line but often happens and the pressure of trawling close to the reserves is a real preoccupation. Repression against offences is not sufficiently applied by authorities.

3.6 Sinis – Maldiventre[54]

The MPA is subdivided into different zones with different levels of protection: Zone A (2 no-take/no-entry zone, tot area 529 ha), Zone B (general protection, 1,031 ha), and Zone C (partial protection, 24,113 ha).

The management of the MPA is accomplished by the town of Cabras, with a convention signed on February 5th 1998. The president of the MPA is the mayor of Cabras. The director of the MPA is chosen by the mayor. An MPA commission is in place, composed by a president and eleven members, representing the town and the regional government, the Ministry for the environment, the Ministry for cultural activities, the Port Authorities, the environmental associations, and various business associations (chamber of commerce, fisheries associations). The commission aids the MPA in the management, by proposing issues concerning the well functioning of the MPA: In

[54] http://www.areamarinasinis.it/

particular, the commission provides suggestions regarding the organization of the MPA, including the management expenses. Four MPA employees are in charge of the scientific and operative coordination of the MPA, while four part-time employees are in charge of technical and administrative issues.

The legal entities in charge of surveillance of the MPA are very diverse, as enforcement is in charge either of the Port authorities, the municipal police of the town of Cabras, the state police, the 'carabinieri', the ranger service, the finance police, the association A.DI.NA, the association VO.S, and the MPA employees. But, paradoxically, surveillance is not as strict as desirable.

Despite 25000 ha of extension and 700000 euro of annual budget (in 2006) and 10 years of history, the Sinis AMP has not provided clear advantages in terms of ecological variables (abundance), socioeconomic indices and fishing. The main problems are (1) the zonation has not been decided on solid scientific bases, (2) a strong local tradition for fishing, (3) the lack of permanent staff, and (4) the lack of strict surveillance.

3.7 Bouches de Bonifacio[55]

Being classified as a natural reserve, under the designation "Natural Reserve of the Strait of Bonifacio" (Department of southern Corsica, city government of Porto-Vecchio, Bonifacio, Figari, Pianottoli-Caldarello and Monacia-d'Aullène), which are the parts of land domains, territorial waters and marine public domain located on the watermark. The MPA was created with decree of the 23rd September 1999. The management of natural reserve entrust at prefect of Southern Corsica, is responsible for putting into effect the planned clauses of the decree.

A consulting committee of the reserve was created, presided over by the prefect or his/her representative, the vice-president post being assured by the marine prefect or his/her representative. The structure of this committee is fixed. It comprises representatives from the interested regional authorities, proprietors and environmental users, representatives from the administrative structures, qualified scientists, notably those who are members of the scientific council described in article 7 of the decree, representatives from associations for the protection of nature and two people, appointed by the minister in charge of the protection of nature, following suggestion of the national council for the protection of nature. The members of the committee are nominated for a term of three years. Their position can be renewed.

[55] http://www.parcmarin.com/

To assure the conservation of the natural patrimony and of the biodiversity of the reserve, the manager of the reserve can conceive and put into action an ecological management plan for the reserve, which will be dependent on scientific evaluation of the reserve as well as its own evolution.

A scientific committee for the reserve is created, of which the composition and operation are approved by the prefect. Its opinion is required for the management plan of the reserve and can be solicited for any question concerning the scientific side of the natural reserve.

Surveillance is accomplished through the MPA's guardians, the "gendarmeria" (a local police force) and the state police. The MPA of Bonifacio occupies 80000 hectares. Monitoring of the marine resources shows a careful management of the protected area. The efficient control of the area by the MPA's guardians allows making frequent and detailed checks, ensuring that visitor obey the MPA's rules. The management of fisheries and tourism is coordinated by the MPA which has the consensus of the local population and the various stakeholders, with whom the MPA achieves the management of the area.

3.8 Ustica[56]

At Ustica Island the management of the marine protected area has been effective for many years in the past and clear positive ecological effects were detected. However, the Ustica Island MPA has experienced several management troubles in very recent years. Due to political reasons, the former management body (the Ustica municipality) has been removed by the *Italian Ministry of the Environment and Protection of the Territory*, being substituted by a provisional body: the National Coastguard. This has led to a cut in the reserve personnel. Despite research or monitoring activities continued in these years, public perception of the MPA has dramatically decreased.

At present, there is a management plan for 7 licensed local fishing boats, and only traditional artisanal fishery (trammel nets, bottom line, traps) is allowed, being trawling and spearfishing strictly forbidden within 3 miles around the island. In theory, this should have allowed an actual recovery of target fish and a sustainable use of the resources by the local community. However, the small local fishermen community have not recorded any increase in the fishing catches, attributing this to a lack of surveillance by the management authority. In particular, in the last 2-3 years they suffer from some poaching events by recreational fishermen and boaters. Both fishermen and hoteliers do

[56] http://www.parks.it/riserva.marina.isola.ustica/

require a real involvement in the decision making process and in the enforcement of the marine protected area.

3.9 Golfo di Castelammare

The Gulf of Castellammare no-trawl zone lies under the jurisdiction of the Sicilian Regional Government because Sicily is an autonomous region. More specifically, the *Regional Council for Handicrafts, Cooperation and Fisheries* issues laws and regulations concerning the Sicilian fisheries under the wider national and European legislative framework. The national coastguard and police corps are entitled for the enforcement of the no-trawl regulation just like in any other Italian marine area. There is not either a specific management body or a responsible person. A local Fisheries and Restocking Consortium is charged for the development of artificial reef projects and for the enhancement of the small scale fishery, but has no role in the management of the no-trawl area.

This lack of a management body has caused serious problems to the proper evaluation of the trawl ban effects on ecosystems and fisheries, because there has not been any serious planning of research or monitoring activities so far. Although the Sicilian Regional Government has financial provisions and legal capacity to fund research projects on regional fisheries, no assessment programs have been funded so far, thus research organizations like CNR had to raise funds elsewhere (EC, Italian government) to carry out studies in the area.

3.10 La Graciosa – Islotes del norte de Lanzarote[57]

The reserve (total size: 70,700 ha; integral size: 1,225 ha) was created in 1995, although the enforcement did not begin at least two years later, and is divided into internal and external waters, or waters inside and beyond baselines respectively. Internal waters are of regional administrative responsibility (Government of the Canary Islands), while external ones are regulated by the Spanish State, through the Ministry of Agriculture, Fishing and Food (currently within the Ministry of Environment, Rural and Marine).

The management body, called Management and Monitoring Joint Commission, comprises managers, political representatives and/or technicians from state, regional and local fisheries administrations, a technician from the Spanish Institute of Oceanography (“Instituto Español de Oceanografía”, hereafter IEO), representatives from the local fishermen associations (“Cofradía de Pescadores”) and, eventually and

[57] http://www.mapa.es/rmarinas/index_rm.htm

for specific invitations, from other local associations. This commission meets once a year approximately. Another Control Commission composed by managers and fishermen representatives meets twice a year to deal with urgent routine matters. Directly located in the zone, there is a biologist in charge of the coordination of the regular activities of the reserve (i.e. information, surveillance, data gathering, etc.) and the Surveillance Service, comprised of one boat with one skipper and two sailors each shift. This biologist takes part of both Management and Monitoring Joint and Control commissions.

In parallel, there is a Scientific and Consultative Committee, comprised of the manager from the Canary Government and representatives from the Canary research institutions (i.e. University of La Laguna, University of Las Palmas de Gran Canaria, Canary Institute of Marine Sciences ("Instituto Canario de Ciencias Marinas"), and IEO.

Some shortcomings have been identified in the above organization chart. First, and up to date, the Scientific and Consultative Committee continues being a 'paper' committee, since it has never been called. Second, it would be desirable the participation of representatives from the Canarian research institutions at the Management and Monitoring Joint Commission further from the representation of IEO as the "official" scientific institution in charge of the reserve monitoring that the use of European Funds for MPA establishment imposes. Third, public participation level in the Commission is very low, since only one person from the fishermen association (usually the president) may join the meetings, and there are no representatives of other organizations of the civil society (linked to scuba diving, tourism, etc.), except for specific invitations. Fourth, the frequency of the Commission meetings –once a year-seems to be low. Fifth, there is an absence of a pre-established and continuous monitoring program integrating the study of the ecological, fisheries and socio-economical effects of the reserve; apart from the IEO fisheries monitoring program, there are only punctual and disconnected actions financed by any of the administrations involved. The several administrations implied are not coordinated to implicate their budgets in this desirable multidisciplinary multi-institutional monitoring program. Fourth, surveillance at La Graciosa is one of the most important problems, since funds directed to enforcement are insufficient for such a vast reserve. And at last, during the first decade of reserve, the "Cofradía de Pescadores" failed to play the important role of well-representing the professional fishermen common interests, failing governance in this sense given the absence of a good fishermen leadership.

3.11 La Restinga – Mar de las Calmas[58]

The reserve (total size: 750 ha; integral size: 180 ha) was created in 1996 and, as in the above case study, is also divided into waters inside baselines (internal) and beyond baselines (external) waters, under the responsibility of regional (Government of the Canary Islands) and national (Ministry of Agriculture, Fishing and Food, currently within the Ministry of Environment, Rural and Marine) administrations.

The management body (i.e. Management and Monitoring Joint Commission), which meets once a year approximately, is similar to the one of La Graciosa case study, and also comprises managers, political representatives and/or technicians from state, regional and local fisheries administrations, a technician from the Spanish Institute of Oceanography ("Instituto Español de Oceanografía", hereafter IEO), representatives from the local fishermen associations ("Cofradía de Pescadores") and, only for specific invitations, from other local associations (e.g. diving clubs). There is also another Control Commission composed by managers and fishermen representatives meets twice a year to deal with urgent routine matters. Directly located in the zone, there is a biologist in charge of the coordination of the regular activities of the reserve (i.e. information, surveillance, data gathering, etc.) and the Surveillance Service, comprised of one boat with one skipper and two sailors each shift. This biologist takes part of both Management and Monitoring Joint and Control Commissions.

There is also a Scientific and Consultative Committee, comprised of the manager from the Canary Government and representatives from the Canary research institutions (as above).

Except for the surveillance and the fishermen leadership, which seem to be acceptable, in La Restinga have been identified similar problems in the organization chart than in La Graciosa, regarding the non-functioning in practice of the Scientific and Consultative Committee, the lack of participation of scientific from different Canary research institutions at the Management and Monitoring Joint Commission, the low level of public participation in the Commission and low frequency of the meetings, and the lack of an integrated and continuous monitoring program (see La Graciosa case study).

Besides the low frequency of Commission meetings –which should be increased-, in both La Restinga and La Graciosa marine reserves, though there are theoretically some social representatives in the Management and Monitoring Joint Commission, in practice local people do not take an active part in the decision-making. Only the president of the fishermen organization –or somebody delegate- may join the meetings, and there are no representatives of other organizations of the civil society (linked to scuba diving,

[58] http://www.mapa.es/rmarinas/index_rm.htm

tourism, etc.), except for specific invitations. It would be desirable to increment the number of local representatives joining these meetings, but also to improve information channels from the MPA to the local fishermen and the general public and vice versa. It is supposed that the "Cofradía" may address these tasks, but frequently this is not the case, and may be more appropriate to emphasize these processes from the MPA management. Furthermore, establishing a local monitoring commission with adequate competencies may also improve both participation and compliance.

3.12 Monte da Guia / Faial

There is no specific management body in place for Monte da Guia MPA. Four wardens, employed by the state, actively patrol the MPA region from shore on a rotating basis such that wardens are active every day of the week but are responsible for all environment enforcement (not only MPA) for the entire island of Faial. There is no sea-based patrolling of the MPA. All other management and administrative tasks for Monte da Guia are developed by the Faial Environment Operational Service that monitors not only MPA but all environmental affairs. The Department of the Environment of the Regional Government of the Azores is the administrative authority for the MPA. Monte da Guia does not, as yet, have a particular management body dealing solely with the business of the MPA. This body should, hopefully, be operational shortly given that the new Decree Law (DLR# 15/2007/A - Rede Regional de Áreas Protegidas dos Açores), that creates the framework for the management of all MPAs in the Azores, is being regulated. The Monte da Guia MPA will be included in the Faial Natural Park.

3.13 Formigas islet / Dollabarat Bank

There is no specific management body in place for Formigas islet / Dollabarat Bank MPA, since the management decree was never published. There is little sea-based patrolling of the MPA, with naval marine services being responsible for monitoring this area in addition to the rest of the Azores archipelago. The Department of the Environment of the Regional Government of the Azores is the administrative authority for the MPA. Formigas islet / Dollabarat Bank MPA does not have any particular management body dealing solely with the business of the MPA. This body should, hopefully, be operational shortly given that the new Decree Law (DLR# 15/2007/A - Rede Regional de Áreas Protegidas dos Açores), that creates the framework for the management of all MPAs in the Azores, is being regulated. There is not, as yet, full agreement if the Formigas Marine Reserve is to be managed as part of the Natura Park of Santa Maria or as part of the Azores Marine Park.

3.14 Tuscany archipelago[59]

In 1996 the role of the "Ente Parco Nazionale dell'Arcipelago Toscano" was established as an authority of public law was established for the National Park of Tuscany Archipelago. It is subject to supervision by Ministry of Environment and is responsible for both the terrestrial and the marine protected areas.

The staff of the Ente Parco Nazionale Arcipelago Toscano is constituted by a President, a Technical Administrative Coordinator, a Director and some Administrative personnel. Occasional field technical collaborators, wardens ("Corpo Forestale dello Stato", "Capitanerie di Porto", "Arma dei Carabinieri" and other police forces) and guides (private or from local co-operative societies) are present but external to the Ente Parco permanent staff.

The protection on the National Park of Tuscany Archipelago is ruled by laws established in 1996 and 1997, where also the provisional regulations for management were stated. So far a management plan is still not available, but a legal text has been proposed and is under acceptance. Apart from biological, geological and ecological conservation purposes, objectives of the area include the application of methods of management and environmental restoration aimed at realizing an integration between humans and natural environment, and promotion of educational and developmental activities, scientific research and compatible recreational activities. With this purpose, professional fishermen associations participate to some extent in the management of the marine areas, and scientific studies have been and are made by some universities (e.g. University of Pisa, University of Florence). In particular, the University of Pisa recently contributed to the editing of a document for the Ministry of Environment, to update the scientific knowledge on the Tuscany Archipelago.

The MPA is structured into Zone 1 (no take/no entry) and Zone 2 (partial protection). The islands of Montecristo and Pianosa are now protected areas with extremely limited access for a restricted number of visitors. In the past century some islands has been preserved to some extent for the presence of national prisons. Today, "Corpo Forestale dello Stato", "Capitanerie di Porto", "Arma dei Carabinieri" and other police forces have responsabilities of surveillance. Even if different forces are responsible for surveying the land and sea, the ascertaining of each violation is established by Ente Parco. The consequent penalties are decided on the basis of current national laws.

[59] http://www.parks.it/parco.nazionale.arcip.toscano/, see also http://www.islepark.it/

3.15 25-Nautic Miles Fisheries Management Zone around Malta[60]

The 25-NM FMZ was originally established in 1971 as an Exclusive Fishing Zone (EFZ) under the United Nations Convention on the Law of the Sea, and then established as a Fisheries Management Zone (FMZ) following Malta's accession to the EU in 2004 (EU Council Regulation (EC) No 813/2004 of 26.04.2004). With an overall area of 11980 km^2, the key objective of the Malta FMZ is to protect the fisheries resources of Malta's sea area and the ecosystems on which they depend. The management authority for the whole area is the Veterinary Affairs and Fisheries Division of the Ministry for Resources and Rural Affairs.

The measures adopted for the management of resources within the FMZ are designed to limit fishing effort and capacity by restricting size and engine power of fishing vessels. Fishing with vessels longer than 12 m is not permitted in the FMZ, except for 'lampara' fishing (using a light source to attract fish) and fishing for dolphinfish, tuna, swordfish and other migratory species. Only Maltese fishermen are allowed to fish for dolphinfish within territorial waters (12 NM from the Maltese shores). Trawling is forbidden within 3 NM from the shores and is allowed only in designated areas within the rest of the FMZ. Only trawlers smaller than 24 m can fish and where the depth is less than 200 m the engine capacity of such vessels must not exceed 185 kW. The total trawling capacity within the 25 NM zone will be maintained at its present level. Efficient monitoring and control of the activities of vessels within the Malta FMZ is supported by an electronic Vessel Monitoring System (VMS). Vessels over 24 m in length along with those vessels over 12 m in length that are authorised to carry out fishing operations by the Maltese authorities are obliged to carry the required electronic tracking equipment on board at all times. Swimming, diving, boating, anchoring and spear-fishing are allowed within the 25 NM FMZ, unless otherwise specified.

The monitoring activities within the FMZ include trawl surveys for demersal species, ictyoplankton and acoustic surveys for small pelagic species and monitoring of catches and landings for large pelagic species. Although these monitoring activities cover a large part of the fisheries resources within the FMZ, monitoring should also cover catches and landings of demersal species since surveys only give snapshots. Furthermore monitoring activities should also include benthic and oceanographic surveys.

With respect to management, although regulations and management activities exists, no proper management plan exists for the FMZ. This should be improved with council regulation EC1967/2006, however, the management's plans within this regulation only covers part of the fisheries within the FMZ.

[60] http://home.um.edu.mt/biology/11_researchPJS4c.html

3.16 Rdum Majjiesa / Ras ir – Raheb[61]

In November 2005, the marine area between Rdum Majjiesa and Ras ir-Raheb was declared as a Special Area of Conservation (SAC) and as a Candidate Site of International Importance in terms of the Flora, Fauna and Natural Habitats Protection Regulations, 2003, which have now been replaced by the Flora, Fauna and Natural Habitats Protection Regulations, 2006. Designation under these regulations is the legal basis for designating MPAs in Malta. The Nature Protection Unit within the Malta Environment and Planning Authority is responsible for managing this marine protected area. Key objectives of the MPA are: protection of marine biodiversity, rehabilitation of degraded ecosystems, maximization of the sustainable social and economic benefits, scientific research and monitoring, education and public awareness.

Surveys of the natural resources and user activities within this MPA has led to a zoning scheme with four levels of protection, which is designed to facilitate the achievement of the objectives listed above. Zones include; a 'no entry – no take area' (Zone A), 'entry – no take with guided access' areas (Zones B, C, D); an 'entry – no take with free access area' (Zone E); and a 'general protection area' (Zone P). Fishing, angling and anchoring within this MPA are only allowed with some restrictions in Zone P. Spear fishing is forbidden altogether within the MPA. Boating is restricted in Zone E but allowed in Zone P. Swimming, SCUBA diving and scientific research are allowed in all zones except for zone A. However, SCUBA diving is restricted in zones B, C and D. No activities are allowed in Zone A, except for scientific research, which is allowed with some restrictions.

One shortcoming is the overall lack of scientific data available for the Rdum Majjiesa to Ras ir-Raheb marine protected area. While comprehensive information (albeit in need of updating) is available for the distribution of marine benthic assemblages and geomorphological characteristics in the area, quantitative data for the biological attributes are generally lacking. The only biological quantitative data available for the area are for *Posidonia oceanica* morphometric parameters (recorded from a single site in 2000 and 2006), and for attributes of the *Pinna nobilis* population (collected in 2006). Physico-chemical data for the water column (e.g. nutrient levels) and the seabed (e.g. sediment granulometry) are also lacking.

Another shortcoming in the management of the Rdum Majjiesa to Ras ir-Raheb marine protected area is that, although a management plan has been drawn up and approved, it has yet to start being implemented. Difficulties are anticipated in enforcing regulations and restrictions on user activities within the MPA once the management plan is

[61] http://home.um.edu.mt/biology/11_researchPJS4b.html

implemented. The management plan should incorporate an effort to provide users and the general public with information on the natural resources of the area and benefits obtained from establishing it as an MPA. In the meantime, there is a dire need for monitoring anthropogenic activities and pressures (some of which may be illegal) in an effort to assess whether the Rdum Majjiesa to Ras ir-Raheb marine protected area is serving the purposes for which it has been established.

4 Synthesis of main of EMPAFISH results

4.1 Ecological effects of MPAs (WP1)

WP1 was committed to list, explore, and evaluate the ecological effects of MPAs using data issued from the 20 EMPAFISH selected case studies. These effects were firstly reviewed case by case, with the contribution of the partners working on each of the case studies[62]; complementary, this review included a compilation of the physical, ecological, socio-economical and administrative features of the case studies. Based on the above information, a literature review has been done, in order to assess and synthesise the generality and gaps of research done to now in the Mediterranean and Macaronesian MPAs[63]. In a second step, after assembling all ecological data for each case study under a common format to allow statistical comparisons, a meta-analytical approach was used to compare fully-protected vs. unprotected situations against several potential sources of variation (time since protection, size of the marine reserve and of the buffer zone, and distance to the nearest MPA, amongst other)[64, 65, 66].

From the literature and datasets reviewed, a considerable amount of empirical evidence emerges to illustrate the ecological effects of MPAs in the Mediterranean and Macaronesia. Hence, we can assert that establishing an MPA in this geographical context is very likely to reverse the population and ecosystem impacts of fisheries on coastal areas, by: (i) increasing the abundance and/or biomass of target species (fish, decapods, other invertebrates) within MPAs compared to unprotected sites; (ii) allowing the recovery of a more "natural" population structure of these commercially harvested

[62] Planes S., García-Charton J.A., Marcos C. & Pérez-Ruzafa A. (2008). *Ecological effects of Atlanto-Mediterranean marine protected areas in the European Union.* EMPAFISH Project, Booklet nº 1. Editum, Murcia. 158 pp. (available at http://www.um.es/empafish).

[63] García-Charton J.A., Pérez-Ruzafa A., Marcos C., Claudet J., Badalamenti F., Benedetti-Cecchi L., Falcón J.M., Milazzo M., Schembri P.J., Stobart B., Vandeperre F., Brito A., Bulleri F., Chemello R., Dimech M., Domenici P., Guala I., Le Diréach L. & Planes S. (in press). Effectiveness of European Atlanto-Mediterranean MPAs: do they accomplish the expected effects on populations, communities and ecosystems? *Journal for Nature Conservation.*

[64] Claudet J., Planes S., García-Charton J.A., Sánchez-Meca J., Benedetti-Cecchi L., Domenici P., Badalamenti F., Bayle-Sempere J., Brito A., Bulleri F., Culioli J.M., Dimech M., Falcón J., Guala I., Milazzo M., Somerfield P., Stobart B., Vandeperre F., Valle C. & Pérez-Ruzafa A. (2008). *Synthesis of results of meta-analysis of ecological data*. EMPAFISH Project, Deliverable nº 17 (available at http://www.um.es/empafish).

[65] Claudet J., Osenberg C.W., Benedetti-Cecchi L., Domenici P., García-Charton J.A., Pérez-Ruzafa A., Badalamenti F., Bayle-Sempere J.T., Brito A., Bulleri F., Culioli J.-M., Dimech M., Falcón J.M., Guala I., Milazzo M., Sánchez-Meca J., Somerfield P.J., Stobart B., Vendeperre F., Valle C. & Planes S. (2008). Marine reserves: size and age do matter. *Ecology Letters* 11: 481-489.

[66] Claudet J., Osenberg C.W., Domenici P., Badalamenti F., Milazzo M., Falcón J.M., Bertocci I., Benedetti-Cecchi L., García-Charton J.A., Goñi R., Borg J.A., Forcada A., de Lucia A., Pérez-Ruzafa A., Afonso P., Brito A., Guala I., Le Diréach L., Sánchez-Jerez P., Somerfield P. & Planes S. (in prep.) Marine reserves: Fish ecology and life history traits matter.

populations, by increasing the proportion of larger/older individuals; (iii) enhancing the fecundity of these populations; (iv) enhancing local fishery yields through biomass exportation to surrounding non protected areas[67]; and (v) inducing shifts in fish assemblage structure, chiefly by increasing the dominance of large predator species. However, this increased health of the ecosystem becomes in turn an attractor for tourism and diving; if the subsequent over-frequentation is not controlled, damage can occur and some of the MPA effects reversed.

Other expected effects are more subject to uncertainty, or, at best, would need more research, such as: (vi) causing certain density-dependent changes in the life history traits of target species; (vii) protecting the recruitment of commercially important species; (viii) protecting marine biodiversity (including genetic diversity); (ix) causing ecosystem-wide effects such as trophic cascades, and conceivably counteracting detrimental catastrophic shifts in coastal ecosystems; and (x) increasing community and ecosystem stability, consequently promoting resilience and faster recovery from disturbance.

From the meta-analytical approach performed to ascertain the global effects of Mediterranean and Macaronesian MPAs included as EMPAFISH case studies, further lessons can be extracted. Firstly, the meta-analysis confirmed the wide occurrence of positive responses to protection by fish species targeted by fishing. Moreover, this response is higher in the case of large-bodied species and, unexpectedly, occurs also for very mobile species. On the contrary, species with no commercial value rarely responded to protection measures. Also, it is increasingly clear that the effects of MPAs, although detectable after few (2-3) years, build up over time so that these effects become more evident the longer the MPA remains functional; their actual importance and magnitude are therefore to be perceived only after several decades (Fig. 2). In addition, the size of the no-use zone (i.e. part of the MPA where all human activities, including fishing, are banned) appears to exert a significant influence on the magnitude of the "reserve effect" on fish abundance and biomass; more controversially, increasing the size of the buffer area (i.e. part of the MPA where some uses –e.g. fishing, diving, or swimming are allowed) seems to reduce the effectiveness of the MPA (Fig. 3). The latter statement, however, needs further corroboration.

Here we have shown that older European marine reserves are more effective than newly implemented reserves in increasing catchable sizes of commercial fishes and in conserving fish species richness. This could be explained in part by the life span of some commercially targeted large species (e.g. Serranidae) that can live as long as 40 years. Since recovery of fish communities occurs at a relatively slow rate, a rotating temporal system of spatial closures may therefore be inadequate for conservation purposes. As different reserves were sampled at different times, the effect of years since protection partly accounts for the heterogeneity among reserves.

[67] See also results of EC research project BIOMEX (http://biomex.univ-perp.fr).

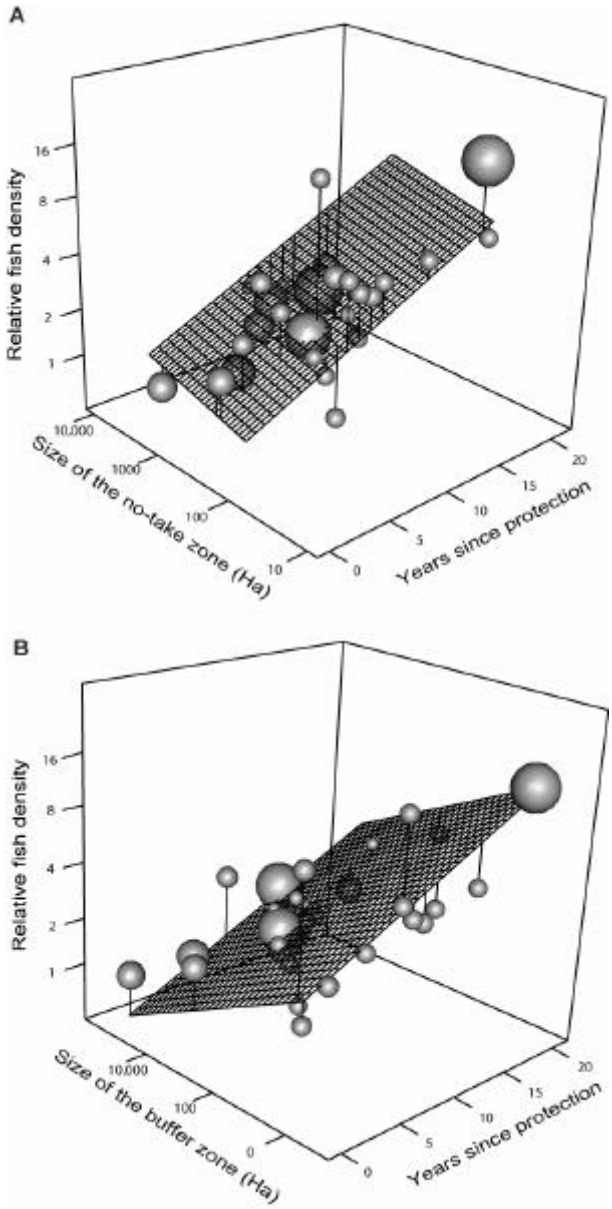

Figure 2. Effects of Mediterranean and Macaronesian marine reserves on commercial fish densities as a function of years since protection and (A) the size of the no-take zone and (B) the size of the buffer zone, as inferred by meta-analysis on data issued from EMPAFISH case studies. Planes give the fitted effect. The size of the points is proportional to the weight of each study. Stems indicate the distance between the calculated weighted effect size and the fitted effect (from Claudet et al., 2008).

Distance to the nearest neighbouring marine reserve was another feature included in our analyses. Mathematical models of marine reserve networks advocate for different optimal distances between reserves according to the management goals, the input data considered and the assumptions made. Our study is the first empirical evaluation of the effects of distance among marine reserves. We found no evidence of an optimal distance between reserves. We caution that other factors (in addition to distance) can play also a

major role in marine reserve connectivity. In particular, accounting for habitat discontinuities and fragmentation, larval dispersal and species and disturbance dynamics will be relevant for optimised marine reserve networks. Moreover, experimental frameworks using reserve networks could be employed in order to test ecological hypotheses relative to the above-mentioned effects. Such an effort would require the cooperation of scientists and decision-makers.

None of the marine reserve characteristics explained a part of the heterogeneity in the response to protection of non-commercial species. Non-commercial species are not supposed to be directly affected by protection but indirectly by predator intensity and also by habitat characteristics. Therefore, trophic cascades and habitat variables at fine scale should be considered when studying the response to protection of such species.

We anticipate that our study will be the starting point for more sophisticated assays on optimal marine reserves design. Future efforts to manage and protect costal ecosystems should take into account our results on marine reserves size together with unbiased biological data and sound socio-economic local information to best satisfy the management goals when allocating space for no-take and buffer zones.

4.2 Fisheries effects of MPAs (WP2)

The objective of **WP2** was to explore more fully the fisheries in operation in the vicinity of the selected EMPAFISH case study sites, and to use fisheries data to determine the general effects that this type of marine conservation might have on local fisheries. The first goal of WP2 was to characterise fishery regimes in each area according to the main fishing gears, fished areas, seasonality, target species, and fishing regulations. In addition, the objectives of the MPAs with regard to fisheries were described and illustrated[68,69]. Pre-existing fisheries data were gathered from a variety of sources including: landings records, biological sampling programs, fishing fleet enquiries, on-board sampling, and logbooks. The information assembled focussed on commercially important individual species and specific gears, as well as on aggregated catch from all gears. Working with catch per unit effort (CPUE), catches for regions around each protected area were assessed using meta-analysis. Various parameters were considered as potential determinants of the reserve effectiveness, including: time since protection started, total size of the reserve, size of the no-take area, size of the no-take area as a

[68] Vandeperre F., Higgins R., Santos R., Marcos C. & Pérez-Ruzafa A. (2008). *Fishery Regimes in Atlanto-Mediterranean European Marine Protected Areas*. EMPAFISH Project. Booklet nº 2. Editum, Murcia. 108 pp. (available at http://www.um.es/empafish).

[69] Higgins R.M., Vandeperre F., Pérez-Ruzafa A. & Santos R.S. (in press) Priorities for fisheries in marine protected area design and management: implications for artisanal-type fisheries as found in southern Europe. *Journal for Nature Conservation*.

proportion of total size, size of restricted-take area, level of compliance with regulations, number of zones present, distance to the closest MPA, etc. A spatial approach was developed to 1) estimate continuous maps of spatial distribution of fishing effort and 2) determine the factors driving the representative fishing effort allocation around 5 out of 19 EMPAFISH marine reserves (sites for which the necessary data were available). This innovative approach combined GIS, spatial and multivaritate statistical tools and uses the geographical information on gear positions and factors having a potential influence on the fishing activity as input data.

For all EMPAFISH case-studies (except the 25-Nautic Miles Fisheries Management Zone around Malta) an increased fishing effort was estimated around the borders of the respective MPAs resulting in areas of inhomogeneous effort concentrations around the borders. Results showed that for all marine reserves (except the 25-NM FMZ around Malta) the distance to the border of the marine reserve has a significant influence on the fishing effort allocation and that the spatial scale of effort attraction is probably related to reserve size. Also the factor depth determines the spatial distribution of the artisanal fishing effort. The distance to the (nearest) port reflecting costs / effort of the fishermen to reach a certain fishing ground seems to be of lesser importance for the investigated fishing fleets around Banyuls, Cabo de Palos and Medes. This was the factor that was of greatest influence in the Malta 25-NM FMZ case study, where fishing activity of the fleets concentrated within the 3 nm of the ports.

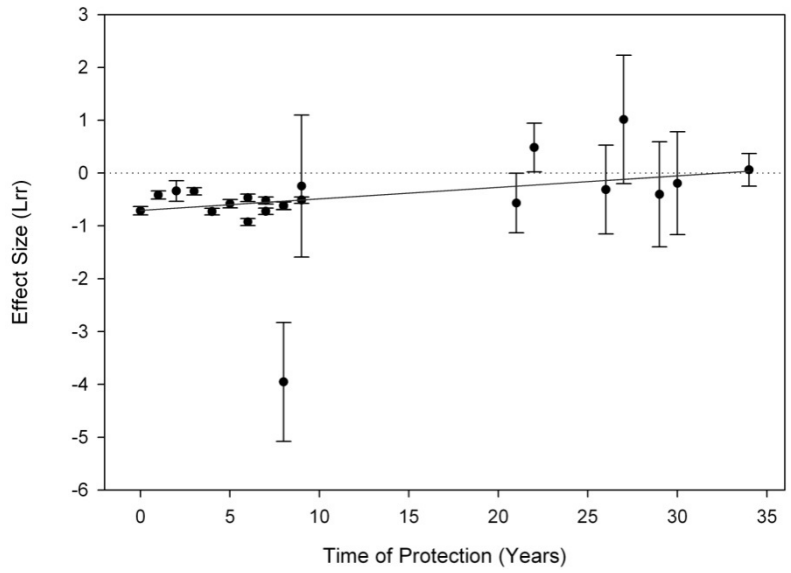

Figure 3. Effect sizes (log response ratios) comparing average CPUEs of target species in sites closer to the reserve with control sites, for MPAs of differing age. A negative effect size reflects lower CPUE at sites closer to the reserve. Error bars represent 95% confidence intervals.

In terms of catch and landings data, there was a tendency towards lower CPUEs adjacent to protected areas compared with more distant regions. Four different "effect sizes" (ratios of CPUEs adjacent and distant) were considered here: (a) CPUE of target species for integrated (standardised) gears, (b) CPUE of target species for selected (single) gears, (c) CPUE of marketable catch for integrated gears, and (d) CPUE of the marketable catch for selected gears. Only three explanatory variables showed significant and consistent relationships with effect sizes: time since protection, distance from the MR boundary and size of the MR. For all four categories, the analyses showed a positive relationship between effect size and time, which was significant for all marketable catch and integrated gears for target species. Results showed that higher CPUEs occurred adjacent to older reserves, suggesting a response to protection over time. We identified a gradual increase of CPUE of 2% to 4% per year for the period represented in this study (30 years) (Fig. 3). Scarcity of data between 10 and 20 years of protection prohibits the precise estimation of recovery rates or investigation of more complex, i.e. non-linear, relationships. EMPAFISH-WP2 has shown that the effects of MPAs on catch rates develop over long time periods, which is critically important both for management as well as for the interpretation of MPA effects. CPUE ratios of marketable catch for integrated and selected gears became comparable (ratios between CPUEs adjacent and distant approached zero) after approximately 20 years (22 and 19 years respectively). Catch and landings results suggested that, despite the high concentration of effort, a clear decline in catch rate can be distinguished with an increasing mean distance from the reserve boundaries.

The greatest difference was observed in relation to the size of the MPA. While catch rates of single gears were higher for larger MPAs, the opposite was observed for standardised gears. WP2 results for the entire fishery in the vicinity of the MPAs suggest that the fisheries objectives of maximising yields would be best met with smaller reserves, because they tend to maximise larval export outside the reserve boundaries. On the contrary, smaller reserves could adversely affect catch rates of gears that are closely related to the MPA, a phenomenon that suggests itself in WP2 results.

An important result of our analyses was the difference between response variables for marketable catch and catch of target species. Mean effect sizes were higher and the effects were generally similar or stronger for marketable catch. This indicates that effects of MPAs on catch rates are more easily detectable for marketable catch. Furthermore, simple regressions demonstrate that the difference becomes greater with time, although this could not be formally tested here. Only effect sizes of marketable catch become positive during the period of the study (after approximately 20 years). In terms of CPUE, the greatest benefit for the fishermen seems to be realised through the increase of by-catch per unit of effort. By the definition of by-catch, this is a real benefit, because it increases return to the fishermen relative to the effort they invest.

4.3 Socio-economic effects of MPAs (WP3)

Within **WP3**, firstly the existing literature on the economic analysis of MPAs was reviewed[70]. The focal aim of WP3 was to assess the socio-economic impact of human activities representing major uses of the ecosystem services provided by MPAs in southern Europe. Compared to previous monographic surveys, the assessment that was performed within the framework of EMPAFISH relies on a fairly large empirical basis, composed of 14 case-studies which were analysed with the help of a standardised methodology. Though these MPAs are heterogeneous in terms of size, biogeographical characteristics and management regimes, they share two major similar patterns: (i) related commercial fishing activities are mainly or exclusively small-scale (with provision for one case); and (ii) they are located in highly tourist zones. As a result, it was necessary to dedicate an important part of the analysis to recreational activities. Due to the very limited availability of pre-existing socio-economic data, the case-studies were investigated by means of a large scale socioeconomic field survey (more than 4,000 questionnaires filled), with the aim to gather homogenous information about the profile of users of MPA ecosystem services, their activity and their perception of the MPA[71]. This information, complemented with data provided by MPA authorities and with exogenous ratios concerning commercial fishing and seaside tourism industry, was processed in order to obtain an estimation of the money incomes and jobs locally generated by MPA ecosystem services uses[72, 73]. The methodology that was adopted to this end relies on two salient features: i) a distinction between activities transforming MPA ecosystem services into commodities, and activities directly consuming these services for recreational purposes; ii) for this second type of activities, a conservative approach of their local economic impact relying on local expenditure of non-resident users, with a filter based on the motivation of these users.

The results of the socio-economic assessment display a variety of situations, depending on the relative importance of commercial fishing and of recreational activities. Though full evidence could not be derived from the field survey, it seems likely that recreational activities are the major economic driver in most cases. Within the recreational sector, the analysis of documented cases suggests that SCUBA diving has a larger local

[70] Alban F., Appéré G. & Boncoeur J. (2008). *Economic analysis of marine protected areas. A literature review*. EMPAFISH Project. Booklet nº 3. Editum, Murcia. 40 pp. (available at http://www.um.es/empafish).

[71] Alban F., Roncin N. & Boncoeur J. (2006). *Methodological guidebook for socio-economic field surveys of MPA users*. EMPAFISH Project., Deliverable nº 9 (available at http://www.um.es/empafish).

[72] Alban F., Person J., Roncin N. & Boncoeur J. (2008) *Analysis of socio-economic survey results*. EMPAFISH project, Deliverable nº 22 (available at http://www.um.es/empafish).

[73] Roncin N., Alban F., Charbonnel E., Crec'hriou R., de la Cruz Modino R., Culioli J.-M., Dimech M., Goñi R., Guala I., Higgins R., Lavisse E., Le Diréac'h L., Luna B., Marcos C., Maynou F., Pascual J., Person J., Smith P., Stobart B., Szelianszky E., Valle C., Vaselli S. & Boncoeur J. (in press). Uses of ecosystem services provided by MPAs: how much do they impact the local economy? A southern Europe perspective. *Journal for Nature Conservation*.

economic impact than recreational fishing. Another interesting feature is the fact that estimated local money incomes generated by the investigated activities are generally significantly higher than MPA management costs. The question of sorting out the reserve effect from the site effect was addressed with the help of information provided by the field survey concerning MPA ecosystem users' perceptions (Fig. 4). This subjective and mainly qualitative approach suggests that the reserve effect is substantially clearer in the case of SCUBA diving than in the case of fishing, a conclusion that seems consistent with biological evidence concerning the impact of protection on marine ecosystems and fish populations.

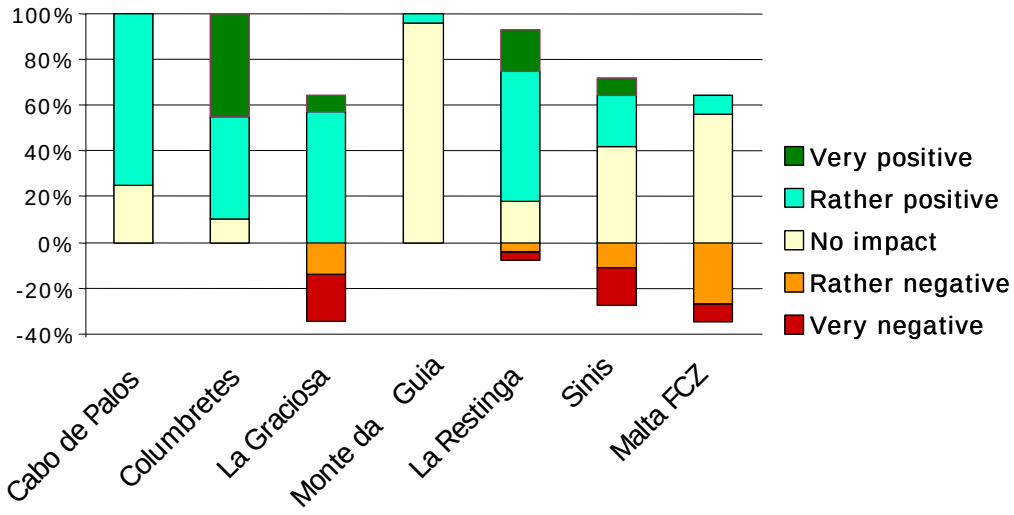

Figure 4. EMPAFISH socioeconomic field surveys: opinions of professional fishers concerning the impact of MPAs on fishing activities (cumulative values, with negative opinions as negative percentage values).

The socio-economic analysis performed within EMPAFISH suffers from several limitations. Some of these limitations are due to the field survey itself, other concern complementary information that was required for the assessment, and a third category is due to the methodology.

Concerning the field survey, practical considerations imposed hard constraints on the scope of investigation. With few exceptions, this scope was limited to fishing and scuba diving (snorkelling was also investigated in three MPAs, but this part of the survey took place in the specific context of submarine trails, a feature which was found only in these MPAs). Moreover, due to the decentralised organisation of field survey implementation, the range of activities covered and the sampling rates differed substantially from one case-study to another.

As regards complementary information, three major limitations were encountered: i) knowledge concerning MPA frequentation is perfectible; ii) activity zoning is fuzzy (notion of "local" economy) or not fully appropriate (use of administrative limits of the MPA as a proxy for the zone where reserve spillover effects are significant); iii) due to a lack of data at the proper scale, ratios concerning one of the countries surveyed were conventionally used for estimating incomes and jobs in the other countries.

Concerning methodology, the following limitations probably resulted in underscoring the economic impact of the activities under survey: i) non-cash incomes, as well as indirect and induced effects, were not considered; ii) in the case of recreational fishing and SCUBA diving, the attribution factor that was adopted may be considered as excessively restrictive, since it amounts to retain only the local expenditures of non-resident users who are mainly driven in the area by the motivation of fishing or diving. However, this was accepted as a counterpart of the decision to propose a conservative estimation. A more serious problem lies in the fact that the question of the reserve vs. site effects could be addressed only on the basis of subjective and qualitative considerations. Considering the state of available data, overcoming this limitation requires the help of bio-economic modelling (see WP5), in order to simulate the consequences of the protection measures that are adopted within the MPA.

4.4 Indicators of MPA performance (WP4)

WP4 reviewed studies that evaluated all aspects relating to the effectiveness of MPAs in order to describe how the studies were conduced and to detect fields in which research is lacking. In total 224 publications were reviewed. On the other hand, within this WP the different components related with the presence and functioning of a MPA and the relationships among them were stated using the driver-pressure-state-impacts-response (DPSIR) framework[74]. DPSIR is a suitable tool simplifying the analysis of the complexity of MPAs management, showing specific strategies to improve the assessment of the effectiveness of MPAs. By means of a participatory process a conceptual framework was developed that helped to select an appropriate suite of parameters potentially usable as indicators to support an ecosystem approach, an evaluation of the MPAs functioning and policy considerations. Gaps from management and policy responses were also derived. Combining three different approaches – managers' expertise knowledge, availability in institutions and statistical analysis- the suitability of each proposed parameter was evaluated[75]. Finally, a document was

[74] D19 (avaliable at www.um.es/empafish)

[75] Bayle- Sempere J. (Coord.) (2008). *Set of documents with the best indicators in each defined dimension to assess effects of MPA*s. EMPAFISH Project, Deliverable nº 21 (available at http://www.um.es/empafish).

produced to provide with protocols for data acquisition methods addressing some focus areas relevant to the assessment of MPAs effects[76].

Since the early 1980's there has been a near exponential increase in the number of peer reviewed publication on MPAs which peaked in the period 1998-2001. Most of the studies concentrated on biological parameters, though there have been a few socio-economic studies. Most peer reviewed studies were based on control vs. impact designs, while technical reports involved only a protected area replicated in time and/or space. BACI and mBACI designs were used in very few studies. Several gaps were identified in the objectives assigned to MPAs and the way in which they have been evaluated. From these results we proposed to analyze some study subjects that remain poorly or not at all considered. Moreover standardised methods of study, to be applied by both researchers and administrators, should be implemented enabling *a posteriori* comparison of obtained results over a wide geographical range.

On the other hand, we stated the different components related with the presence and functioning of a MPA and the relationships among them using the DPSIR framework (Fig. 5). By means of a participatory process we developed a conceptual framework that helped to select an appropriate suite of 167 parameters potentially usable as indicators to support an ecosystem approach, an evaluation of the MPAs functioning and policy considerations. Gaps from management and policy responses can be derived too.

From the experts' point of view parameters categorized as driving forces and responses were the best evaluated meanwhile those so used that are categorized as states or impacts did not obtain a high scoring. The existence of information about these parameters in the institutions is around 70% but the accessibility is quite low. From the statistical analysis performed the results exhibited a change of the importance of MPA characteristics such as total size or the size of the buffer area over time, increasing the role of management issues such as hours of enforcement or budget. Relating parameters descriptors of the fish assemblage and captures with MPA characteristics by means of multiple linear regressions, total biomass of fish assemblages, the delta plus diversity index and the total catch in trammel net were the best correlated. Joining the results of the three different approaches, only 16 parameters can be selected as good indicators to assess the effects of MPAs.

[76] Bayle-Sempere J.T., Sánchez-Jerez P., Barberá-Cebrian C., Forcada-Almarcha A., Luna-Pérez B., Ojeda-Martínez C. & Valle-Pérez C. (2008). *Suitable methodologies to collect and analyze indicators, and suitable experimental designs to test different situations on MPAs*. EMPAFISH Project, Deliverable nº 24 (available at http://www.um.es/empafish).

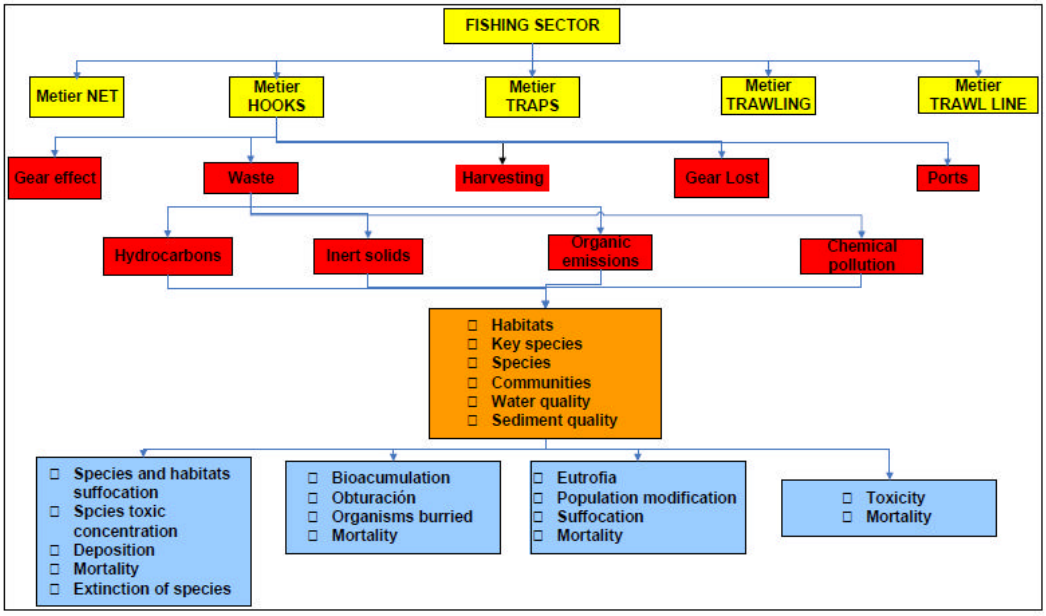

Figure 5. Example of DPSIR flow diagram concerning the impact of hook fishing, illustrating the relationships between driving forces (yellow), pressures (red) and impacts (blue).

4.5 Bio-economic modelling of MPAs (WP5)

WP5 produced a review of bio-economic models in MPA. Based on this review and the shortcomings identified, an original simulation model called "Bio-economic Analysis of Marine Protected Areas" (BEAMPA) was developed[77]. The computer application associated to this model is freely available to the public and can be downloaded from the EMPAFISH project website[78]. The BEAMPA model is a spatially structured simulation model incorporating a fisheries bio-economic model for extractive uses and a demand model for non-extractive (recreational) uses. The application of the model as a simulation tool allows the scientist or the manager to assess the outcome of alternative management strategies, which could help reduce undesired pressures on the MPA system, diminish conflicts among users or enhance the productivity of the MPA in a sustainable way. The bio-economic model is based on a 3-layer grid derived from a Geographic Information System analysis of a real MPA. Each layer contains information on protection regime (No Take Zone, Partial Protection Zone and Unrestricted Fishing Zone), habitat type (user-defined, e.g. rocky, sandy, seagrass beds) and depth. The basic grid layout is populated with biological data on biomass, number of recruits and mean weight of adults, derived from field data surveys, for each fish species considered. Additional spatial components of the model are the distribution of fishing effort. The basic configuration of the model MPA is projected forwards in time

[77] Maynou F. & Boncoeur J. (2007). *A bioeconomic model of Marine Protected Areas.* EMPAFISH Project, Deliverable nº 20.

[78] http://www.um.es/empafish/files/BEAMPA.RAR

(simulation) according to the parameters and equations of the bio-economic model. Running the model under different simulation scenarios allows comparing the likely evolution of the MPA system under different management strategies and should help the manager choose a strategy based on the policy objectives set. The BEAMPA model was applied on particular MPA cases to evaluate its validity and extract some preliminary results[79].

The BEAMPA model is a spatially structured simulation model incorporating a fisheries bioeconomic model for extractive uses and a demand model for non-extractive (recreational) uses. The biological sub-model follows a partially age-structured model, which describes the dynamics of the population as recruits and adults.

In BEAMPA a model MPA is constructed on an arbitrary grid of square m x n cells. In each cell the protection type, the habitat type and the depth are set up, to define the MPA layout. Each cell has additional attributes regarding the biomass of the adult population, the number of recruits and the mean weight of the adult population, as well as the initial effort distribution and types of recreational uses permitted. This initial configuration of the model MPA can be projected forwards in time to simulate the likely development of the system under the initial conditions according to the equations of the model. The effect of policy or management measures can be tested by changing parameters of the different components of the model or by changing the initial configuration of the MPA layout.

BEAMPA can be used to address both scientific questions and management questions. It is important to note that the model is a simulation model, not an optimization model, i.e. the results of a simulation scenario cannot be taken directly as an optimal management option. Due to the complexity of the model, the data needs are important and the problem of parameter estimation can be formidable. For this reason the user may choose to concentrate on parts of the model and weigh carefully the results of a simulation, as some of the parameters and processes (equations) used may be highly uncertain.

The main scientific research questions that can be addressed by the current version of BEAMPA are:

- Examine the effect of adult biomass spillover on fisheries
- Assess parameter uncertainty on the robustness of simulation results (especially: mobility parameter, recruitment, natural mortality).
- Test different dispersion models (random, random walk, density-dependent).

[79] Maynou F. (Coord.) (2008). *Results of the bio-economic and cost-benefit analysis of selected case studies.* EMPAFISH Project, Deliverable nº 25 (available at http://www.um.es/empafish).

- Evaluate different models of fishing effort redistribution (random, function of past profits, tradition).The main management questions that can be directly addressed by BEAMPA are:
- Study the effect of changing the configuration of the MPA (layout, distribution of No Take Zone, network of MPAs).
- Test the effects of effort control on fisheries revenues.
- Assess the impact of habitat degradation on recreational uses and total value of MPA.

We tested this model during the development of the EMPAFISH project, based on different scenarios and realistic data obtained from biological and economic field sampling during the project in some case studies (Fig. 6).

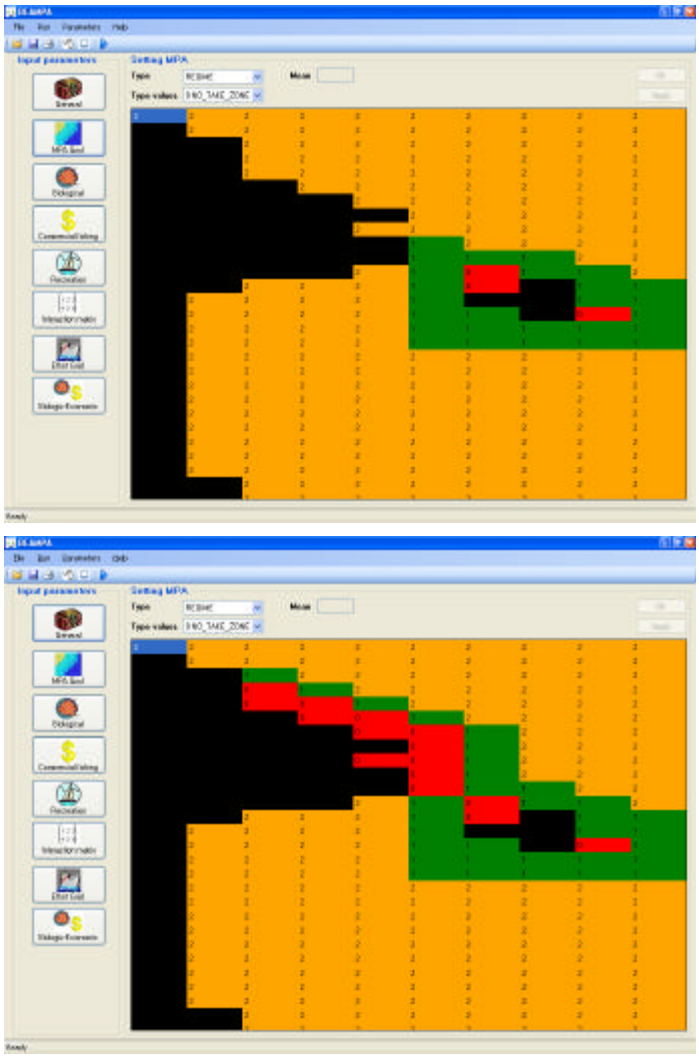

Figure 6. Testing the BEAMPA model: Current configuration of the Medes islands MPA (base scenario, up) and alternative management strategy (AMS, down) consisting in enlarging protection to the adjacent coast. Black cells: land; red cells: No Take Zone; green cells: Partial Protection Zone; orange cells: Unrestricted Fishing Zone.

From these first results we can conclude that in coastal MPAs where the main extractive use is small scale artisanal fisheries:

- The protection of a small portion of the coastal area (e.g., 1% of the area as No Take Zone; 10% of the area as Buffer zone) produces low or barely detectable economic fisheries benefits. This is due to two factors: i) the relatively low fisheries impact of small scale coastal fishing, which ensures that stocks suffer low fishing pressure, and ii) the low spillover, in absolute terms, of biomass from the protected area, due to its small size.
- Fisheries yield in the area immediately adjacent to the no take area benefits from adult biomass spillover for moderately to highly mobile species.
- Due to the low profits, in absolute terms, of commercial fisheries the institutional costs of protection are high if only professional extractive uses are considered. When other non-extractive uses are added, the costs of protection become small, due to the higher economic importance of eco-tourism uses. In many cases, institutional costs of setting a MPA are amply covered by taxes perceived from recreational uses.
- Enlarging the protected area by effectively doubling its size would not impact excessively on the economy of commercial fisheries, but would considerably increase institutional costs of protection.
- The negative impact of commercial fisheries on habitats where ecotourism is a paramount activity can adversely affect recreational activities, both in terms of frequentation and economic profits. Because recreational activities have much higher economic and social relevance than small scale artisanal fisheries, it is recommended to clearly separate the areas where both types of activity take place in order to avoid reciprocal interferences.

We estimate that the overall benefit:cost ratio of Atlanto-Mediterranean Marine Protected Areas is at least 10:1, and revenues from tourism are larger than revenues from commercial fisheries. Due to the difficulty in assessing non-market benefits of conservation, we provide a conservative cost:benefit analysis based on institutional costs and revenues to commercial operators in marine protected areas, as proxy for benefits.

The institutional costs of maintenance and enforcement of 10 existing Atlanto-Mediterranean MPAs ranged from 250000 to 750000 € / yr (the 10 MPAs for which data on institutional costs was available ranged in size from ca. 10 to 2000 ha Integral Reserve size, or 500 to 70000 ha total size: Tabarca, Cabo de Palos, Côte Bleue, Medes Islands, Columbretes, Sinis, Monte da Guia, Banyuls-Cerbère, Graciosa, Restinga). For these reserves, the revenues of the commercial fisheries are estimated at 20000 to 200000 € / yr (mean 53000 € / yr), while the revenues to operators producing non-extractive uses can be estimated to be in the order of 1 million € (in Medes Islands it is in excess of 2 million €) in each MPA. Even based on an incomplete cost-benefit

analysis (including only revenues to commercial fisheries and tourist operators), the economic benefits of protection to the local economies far outweigh the costs to society (using as approximation the institutional costs only), probably on a ratio 10:1. A complete cost-benefit analysis, by taking into consideration non-monetary benefits, of the economic benefits of MPAs would surely increase this ratio. Additionally, in many cases, the taxes perceived by the managers of individual Marine Reserves from recreational uses probably cover the expenses of running the marine reserve.

4.6 Management tools and policy proposals (WP6)

The aim of **WP6** was to provide the EU with guidelines and tools that can be integrated into the decision-making regarding the use of MPAs as tools for fisheries management and conservation. In order to reach these objectives, WP6 employed a multi-criteria evaluation using outputs from WP1, WP2, and WP3 with a stakeholder consultation of the objectives and zoning of MPAs. Using models from WPs 1 and 2, we teased out a wide range of sizes of no-take and partial protected zones for their levels of fish densities and catch per unit effort (CPUE) based on different lengths of time. Using the windows-based software DEFINITE (decisions on a finite set of alternatives), we 1) standardized the data to make the measured units comparable across the scenarios; and 2) weighted each criteria based on ranks of objectives provided by local MPA stakeholders to come up with a value for each scenario[80, 81, 82]. From this framework a web-based tool has been developed to enable stakeholders explore the EMPAFISH models and hence to support their decisions concerning the design and selection of MPAs. Further information of our approach can be found on the decision support manual (Deliverable 31). The web page guides the interested user through the different factors that influence the successful ecological and socio-economic outcomes of MPAs in Southern Europe. The web page asks the users to input the following design criteria: time they are prepared to allow for protection and the size they would like the MPA to be, including size of the fully protected and partially protected zones. Based on the users criteria, the tool then provides predicted outcomes of the MPA such as relative fish density, fisheries catches, CPUE for targeted and by-catch species with single or mixed fishing gear, value of landings for professional fishers expenditure of recreational fishers, income for diving operators and diver's budgets.

[80] Mangi S. & Austen M. (2008*). Developing a management tool for MPAs in southern Europe: the EMPAFISH project*. EMPAFISH Project, Deliverable nº 28(available at http://www.um.es/empafish).

[81] Mangi S. & Austen M. (2008). Stakeholder Report. EMPAFISH Project, Deliverable nº 29 (available at http://www.um.es/empafish).

[82] Mangi S. & Austen M. (2008). Guidelines for the Assessment of Marine Protected Areas as Tools for Fisheries Management and Conservation. EMPAFISH Project, Deliverable nº 31 (available at http://www.um.es/empafish).

The aim of WP6 was to provide the EU with guidelines and tools that can be integrated into the decision-making regarding the use of MPAs as tools for fisheries management and conservation. In order to reach these objectives, WP6 employed a multi-criteria evaluation using outputs from WP1, WP2, and WP3 with a stakeholder consultation of the objectives and zoning of MPAs. Our main findings include:

g) Fisheries benefits are maximised by having MPAs that comprise of a fully protected zone (no-take area) that is larger than the surrounding buffer zone. This result stems from the main outputs of WP1 and WP2 which showed that the size of the no-take zone and partially protected zone interacts with time since the MPA was established to influence fish density and catch per unit effort (CPUE). Ideal scenarios to assess MPAs as tools for fisheries management and conservation would therefore include a full set of combinations of 1) length of time of protected area management, 2) size of no-take zone and 3) size of partially protected zone. Using the models from these two work packages, we teased out a wide range of sizes of no-take and partial protected zones for their levels of fish densities and CPUE based on different lengths of time. We termed MPAs as small if they were less than 150 ha, medium if they were between 151 and 600 ha and large if they were over 601 ha. The sizes of partial protection zones (buffer zones) we used included having a partial protected zone that was half the size of the no-take zone, or having a partial protection zone that was the same size as the no-take zone, or a partial protection zone that was twice the size of the no-take zone. Using the windows-based software DEFINITE (decisions on a finite set of alternatives) we 1) standardized the data to make the measured units comparable across the scenarios; and 2) weighted each criteria based on ranks of objectives provided by local MPA stakeholders to come up with a value for each scenario (usually a number between zero and one; see EMPAFISH Deliverable no. 28). Having a large MPA in which the size of the partially protected zone is half that of the no-take zone was the most preferred scenario.

h) Local stakeholders of MPAs in southern Europe agree that the core objectives of establishing MPAs are conservation and fisheries management while research, education and tourism development are secondary. This result comes from the stakeholder consultation that we carried out as part of the activities of work package six. We developed a questionnaire, translated it into local languages and used it to assess the perceptions of stakeholders of the importance of MPAs as areas for conservation, fisheries management, research and education, or tourism development. Questions concerning objectives of marine protection provided the respondent with a list of nine

specific objectives including whether MPAs are sites to protect representative sections of marine environment, protect marine biodiversity from damaging activities, prevent overexploitation of species, improve or sustain yields in adjacent areas, provide undisturbed localities for research or promote the development of tourism. Each respondent was asked to rank the objectives in order of importance using 1 for the most important objective, 2 for second most important …and 9 for least important. In the data analyses, we calculated the mean score for each objective from the ranks provided by the stakeholders. Comparison of these ranks showed that conservation had the highest followed by fisheries management, research and education while tourism development had the lowest rank (For more explanation see Deliverable no. 29).

i) There is a large difference between fishers and other stakeholders on which of the two core objectives of marine protection is more important than the other. The fishers would like to see MPAs established to manage fisheries while the other stakeholder groups see MPAs as places of conservation. It is worth noting that categorizing the objectives of marine protection as we have done in this survey suggests a dichotomy between conservation goals and human needs whereas in fact there is a considerable overlap between these objectives. For instance, fisheries will not be sustained unless vulnerable life stages of exploited species are protected, nor will fisheries production be supported if essential natural ecosystem functioning is impaired. However, our findings are important to understand local perceptions and values from the people who have a direct impact on the achievement of management objectives.

j) Local stakeholders of MPAs in southern Europe would like to see a hierarchical limitation on the use of marine resources and the separation of conflicting activities. This is a result we derived during the stakeholder consultation reported in 2 above. The questionnaire we used included questions on the best zonation of MPAs in southern Europe using a model MPA. The model MPA we described to the stakeholders in the questionnaire would have three zones including Zone A (no use zone) where all forms of use are prohibited except for research and education; Zone B (Regulated no extraction zone) which is the area of the MPA where uses such as for diving and research are allowed but no resource extraction activities are permitted; and Zone C (Regulated extraction zone) where resource extraction is permitted under certain conditions e.g. for specified fishing gear types and / or seasons. We then asked each respondent to rank how the different zonation of the MPA contributed to each of the marine protection objectives using a four point scale: using 4 where the MPA contributed very highly, 3

for highly, 2 for medium, 1 for low and 0 where it did not contribute to that objective at all. The MPA zonations teased out included having an MPA comprised of Zone A only, Zone B only, Zone C only, Zones A, B and C together, Zones A and B only, Zones A and C only, or Zones B and C only.

k) Another section of the questionnaire focused on specific issues dividing stakeholder opinion. For instance, should recreational fishers be allowed to fish in no-take areas for sport purposes when professional fishers are not allowed? To ascertain the stakeholders' views on these issues, each respondent was asked to choose on a 10 point scale whether they agree or disagree ('strongly disagree' = 0, strongly agree = 10) with statements such as 'Certain areas of the MPA should be permanently designated where any form of fishing including recreational fishing is not allowed'. All stakeholders were asked the same questions and the results were compared. Our data analyses showed that local stakeholders would like to see MPAs comprised of a central (no use) zone that is bordered by a regulated (no extraction) zone with an outer regulated (extraction) zone. Stakeholders viewed such an MPA to meet all the objectives of marine protection highly.

l) Perceptions of fishers using fishing grounds adjacent to older MPAs show that they are not experiencing the spillover effect and are not convinced that MPAs are working for them. This finding stems from the fact that scores provided by fishers on MPAs as areas to manage fisheries decreased with the length of time of protected area management. This should be of concern for management as MPAs are expected, over time to increase yields in adjacent fishing zones and sustain the ecological basis of fisheries production. Among many other benefits, MPAs protect and increase fish stocks for spawning, and export larvae, recruits and adults into adjacent fishing grounds, reduce the risk of fishery collapse by maintaining a more diverse age structure and genetic base, and hedge against inevitable uncertainties (Alcala and Russ 1990, Roberts and Polunin 1991, 1993, Rowley 1994, Bohnsack 1998). A number of studies in the region have demonstrated how the present MPAs satisfy both fisheries and ecosystem management objectives (e.g. Badalamenti *et al*. 2000, Planes *et al*. 2000, Francour *et al*. 2001, Claudet *et al*. 2008). Goñi *et al*. (2006) studied the spillover of spiny lobsters from Columbretes Marine Reserve using catch per unit effort data from commercial fishing boats. Their results showed that there was an export of lobsters from the reserve to the adjacent fishing grounds that was maintaining catch rates for fishers. Similar results were reported from Kenya by Kaunda-Arara and Rose (2004) and McClanahan and Mangi (2000). Kaunda-Arara and Rose (2004) used fish tagging experiments to study migration patterns of exploited species in Malindi and Watamu Marine

parks. They found that three species of commercial importance exhibited consistent out-migrations from the parks into adjacent fishing grounds. McClanahan and Mangi (2000) conducted a fish trapping survey of the fishing grounds adjacent to the Mombasa Marine Park. Their study found that catch per trap, mean size of trapped fish, and number of species caught per trap were higher nearer the park edge and declined away from the park edge. While there is increasing evidence that closing off areas is one of the most effective management tools for sustaining or increasing fish harvests, perceptions of fishers using adjacent areas of older MPAs indicate that they are not experiencing the benefits of the spillover effect.

5 Recommendations for MPA management

5.1 General considerations

1. MPAs constitute an invaluable tool for fisheries management and conservation

The scientific evidence available to date indicates that MPAs represent an efficient way to conserve marine fishing resources, as well as to protect ecosystems from human nuisances. On the other hand, even in the case of fishing effort being efficiently managed, MPAs have additional properties (such as buffering against wide fluctuations of stock size, or being robust policy measures in the face of assessment uncertainty) that make them desirable as fisheries management tools. In addition, the spatial orientation and permanency of MPAs often makes it easier to monitor than other fisheries management tools.

2. MPAs are a socially and economically efficient way to manage marine natural resources

As showed by the studies performed to date on the economical and social effects of MPAs, in addition to conserving fish stocks, habitats and biodiversity in general, MPAs (particularly coastal MPAs) may have additional socio-economic benefits that are not achievable by other fisheries management tools.

5.2 Institutional partnership and synergies

3. Increase collaboration and coordination and avoid conflict of competencies between environment and fisheries government officials at all administrative levels (from local to European and international) in charge of the creation and management of MPAs

4. Funding and surveillance activities should be shared and monitoring programs should be developed jointly among different institutions when different protection figures coincide in space

Reserves administrated at different government levels (e.g. regional and national), or when different protection figures (marine and/or terrestrial) coincide totally or partially in space (e.g. protection coming from environmental and fisheries

legislation), advantage should be taken of this fact through the coordination of the administrations implied. Budgets from the different administrations should be added and used in a complemented manner taking advantage of the total financial resources directed to reserve management. Total complemented budget should be used to develop joint monitoring programs with the participation of multidisciplinary scientific teams which focus their work from different scientific approaches. These joint monitoring programs should take place in time in a continuous manner. Additionally, end-users demand coherence and coordination to the diverse administrations that have competencies in the protected areas, because any contradictory criteria may create confusion and conflict as has been the case in some MPAs.

5. Member states of EU should immediately transpose (i.e. fulfilling the international commitments) the international protection figures (SPAMIs, SPAs, SCIs, Ramsar areas, etc.) applied to marine areas onto their national legislations

5.3 Public participation

6. Active involvement of all stakeholders in the MPA establishment process is a prerequisite for MPAs to work well

Ensuring that stakeholders (in particular fishermen, diving centres and public associations) take part to the planning and managing of MPAs is a key factor to ensure duration and avoidance of local conflicts. Clearly the more people are involved in setting something up the less likely they are to try and damage it. Where peoples livelihoods are negatively affected by the creation of an MPA participation could include re-training in order to benefit from the MPA (we need to deal with displacement). However, public participation must clearly be balanced and no stakeholder, individual or group, should be too powerful as compared to the other or even to fisheries and nature conservation authorities. It is definitely important to ensure and stimulate public participation, at any time since the creation of a MPA, in particular at the beginning of the creation process.

7. Enlarge the MPA management body structure by including scientists in the planning and management process

Our experience suggests that the presence of a scientific committee as part of the management body of each MPA represents an efficient tool for the correct ecological management of the area.

8. Implement measures to improve governability wherever necessary

Governability is a key concept for assessing the quality of natural resource management practices, focused on the capacity to address the most urgent concerns while minimizing conflicts (Kooiman and Chuenpagdee 2005; Jentoft 2007; Jentoft *et al.* 2007; Frangoudes *et al*. 2008). This element may prove especially relevant for the site selection, design, management and evaluation. An evaluation of the institutional design of the MPA taking into account these concerns may be extremely relevant, and we can already find some instruments that may be useful for that (Pomeroy *et al*. 2004). Also, it may be possible to improve the governability of the MPA, although it may take some time and effort (Frangoudes *et al*. 2008).

5.4 Setting MPA goals and objectives

9. Goals and objectives should be simple, attainable, and ambitious; but they should not exaggerate the benefits the MPA is going to provide

Goals and objectives should be laid out clearly before the MPA is created, or even designed, as they are the basis for the design. Goals and objectives should also be made explicit from the start and defined such that attainment of those objectives can be assessed. Undefined or broadly vague should be avoided as MPA effectiveness cannot be evaluated. Nevertheless, caution is to be put on the fact that a degree of uncertainty remains on the effects of MPAs, and also that some expected benefits still need to be supported by empirical evidence.

10. MPA goals and objectives should be stated attending to long-term benefits

We need to be much more ambitious when stating the goals and objectives of fisheries conservation and biodiversity protection because of the highly degraded state of marine populations and ecosystems, as evidenced by establishing reference points of harvested populations at much longer temporal (i.e. historical) scales. Although many benefits will become apparent soon after protection, full ecosystem recovery will require decades to centuries to occur.

11. MPA general objectives should be translated into quantitative targets that can be subject to measurable evaluation and assessment

12. Obtaining stakeholder perceptions on objectives of marine protection provides a viable way of addressing stakeholder concerns raised by the establishment of MPAs

The findings from our case studies in eliciting stakeholder opinions on objectives and zoning of MPAs allows us to evaluate how stakeholders perceive marine protected areas as well as add new insights regarding similarities and differences between stakeholder needs, interests and concerns. The management of complex marine ecosystems should be simplified if there are shared perceptions among stakeholders on the objectives and ways to zone marine protected areas. In particular, traditional fishermen are an invaluable source of information and knowledge of the natural environment in areas targeted for designation as MPAs. The stakeholder consultation we conducted in EMPAFISH examined the perceptions of stakeholders to determine areas of agreement and disagreement. Once areas of agreement are identified, the potential effects of these management methods can further be explored to determine if the management achieves the expected or desired effects. Similarly, once areas of conflict are identified, managers can focus on resolving them through further discussions or look into alternative management systems. This also stresses the urgency of clearly stating and clarifying specific objectives of MPA setting to stakeholders, especially in the case of those more easily perceived, such as fisheries-enhancement goals. In this context, particular attention should be paid to the setting of and the advertisement of spillover-dependent goals, given the lack of evidence for a general positive effect on fisheries independently of local specificities.

13. MPA research and monitoring is to be considered as an explicit objective of MPA creation

MPAs are true natural experiments of species, communities and ecosystem recoveries form decades or centuries of fisheries exploitation and the only places where this knowledge can be obtained.

14. Emphasis on the precautionary principle as a basis for MPA creation should be made

MPA benefits may accrue in ways that are not easily perceived or measured (e.g. increased recruitment, increased productivity or stability associated with better habitat quality). The MPA creation process should serve as an educational tool on the importance of the precautionary principle to hedge against risk of collapse or environmental uncertainty, as well as one if not the only way to achieve an ecosystem-level management strategy of fisheries.

5.5 MPA site selection

15. Site selection criteria must be related to the objective of the MPA

Site selection for MPAs with fisheries management objectives should continue to focus on areas that are likely to show large increases in abundance and biomass with protection, even though this gives an artificially high impression of what MPAs can deliver. The idea is that this allows a maximum generation of large reproductive species with the minimum space available. As more MPAs are created one can then justify protecting less productive areas.

16. Include sound scientific information to select new sites to be protected

Marine protected areas, and in particular no-take zones, are a key element of the ecosystem management approach with the ultimate goals of sustain fishery and preserving biodiversity. To ensure that these objectives can be achieved, it is crucial that the criteria used to designate MPA areas include consideration of environmental quality, importance of the site for reproduction of overexploited or protected species and presence of hotspots of biodiversity. Particularly good candidate sites are also those that match these criteria, but are embedded in an otherwise poor environment. The connectivity of marine populations should ensure the recovery of biodiversity also in these circumstances.

17. A minimum of prior knowledge of potential sites for protection is needed

In particular, MPA site selection should be made on the basis of explicit objectives. When particular species are targeted for protection, knowledge of source-sink dynamics and connectivity is a must.

18. Traditional knowledge by local users (especially fishers) should be gathered and used to complement scientific information when selecting the best sites to become an MPA

19. Socioeconomic and governability evaluation is necessary for site selection

Frequently the criteria used for defining the areas to be protected take into account mainly criteria related to biological or ecological realm. However, not considering socioeconomic and governability criteria may create long term problems for the MPA that compromise their success, because the human side of the protected area may be as relevant for its future as the ecological considerations. Additionally, site selection may take these elements as key factors for choosing between areas with similar ecological conditions, because in the long term the success of the institution may vary precisely for these aspects.

5.6 Zoning and planning an MPA

5.6.1 Zoning and designing

20. Use the best available scientific information in zoning and designing MPAs

The process of designing and zoning a MPA has usually involved little scientific justification in the past. However, identifying meaningful ecological variables represent an important tool for decision making. In particular, in addition to considerations on reproductive output, dispersal, mobility, connectivity and size of the organisms to be protected, our experience ascribes a value also to spatial heterogeneity of habitats, as additional driving information for the zoning and implementation of MPAs. The lack of such information can be responsible, as it was documented in some Italian cases, for a mismatch between ecological goals and planning of the MPA.

21. MPA design and zoning should be intimately linked to explicit objectives

22. MPAs should ideally include as many habitat types as possible as critical information is often lacking on species life cycles and habitat preferences

Ideally, MPAs (and MPA networks) should include a representative sample of all marine habitats present in the area. This again highlights the need for concise objectives to properly design an MPA.

23. Where possible, design should take into account the need to conduct scientifically rigorous progress monitoring

Suitable zoning could greatly reduce the cost of monitoring (e.g. nº of replicates needed to demonstrate changes).

24. Marine protected areas in southern Europe should be established with a no-use zone

Such an area would allow recruitment of fish to reach larger sizes before they are caught. The combined effect of 1) the migrations and movement of adult fish out of these no-use areas, and 2) the increased larval export from the protected, more productive populations, should enhance or maintain sustainable catches in the adjacent fishing grounds, given the right effort control conditions.

25. Marine protected areas should have all three zones together: a central (no use) zone that is bordered by a regulated (no extraction, but other uses allowed) zone with an outer regulated (extraction and other uses) zone

Most Mediterranean MPAs are characterised by the presence of a fully protected (no-take, A) zone, a partially protected zone (B) and an external zone (C). In particular, the presence of the B zone, where only local artisanal fishers are usually permitted to fish, is intended as a buffer to the exploitation of resources coming from the no-take zone. Most MPAs in southern Europe show this zonation already. However, there are MPAs that are still unzoned. Most of these are either integral reserves (comprised on a no-take area over the entire reserve e.g. Côte Bleue) or are regulated for a single use throughout their area e.g. Lavezzi Nature Reserve used as a spear fishing area. Stakeholders view such one-zoned MPAs as not fulfilling fully the objectives of marine protection. On the other hand, there are examples where the fully protected zone is lacking and only B and C zones have been established. This is the case for the Secche di Torre Paterno (Italy), where the lack of a fully protected zone does not prevent impacts associated with various human activities (e.g. fishing and anchoring) and therefore provides an example of bad management strategy. In order to separate uses, stakeholders consider that an MPA having a zone B planned as a regulated no extraction zone, and a zone C (regulated extraction zone) where resource extraction is permitted under certain conditions, meets all the objectives of marine protection highly.

26. Large MPAs are preferred to small-to-medium sizes; in addition, sizes of each zone within the MPA should be scaled to maximize the size of the no-take area (> 600 ha) in detriment of buffer zones (about half size of no-take area); an upper limit seems to exist, further from which the ideal is to build a network of several MPAs

Our study – based on MPAs with generally small no-take areas - suggests that there is little benefit in buffer zones while benefits increase with the size of the no-take area. According to our results, having a large MPA in which the size of the partially protected zone is roughly half that of the no-take zone would be the most preferred scenario. Thus, although this requires further research for confirmation, it would be advisable to include large no-take zones (no smaller than 600 ha) and comparatively small buffer zones (roughly half sized) in future MPAs, as smaller no-take areas do not warrantee a correct replenishment of fish stocks. However, our study also highlight that there is an upper limit to the size of an MPA, signalled by the high economic cost of maintaining such a big MPA. Thus, the ideal size of no-take zone ranges between 600 and 1500 ha, and that of buffer zone ranges from about 300 to 750 ha, so that an MPA could be ideally be between 900 and 2250 ha in size

(depending on local ecological, fisheries and socio-economic singularities). Therefore, further from the suggested limit, the benefits of building a network of several closely related large MPAs should be planned, and taking into account that the effects on fisheries would be improved when the distance between MPAs is not higher than a few tens of kilometers.

27. Apply adaptive management schemes where possible, so that flexibility to change zoning and designing is allowed

When the effectiveness of a MPA is not as good as expected or the objectives of its creation are difficult to reach due a wrong design (including the size and site selection), demonstrated by suitable monitoring and evaluations programs, laws (decrees and regulations) should be susceptible of being changed easily, facilitating a re-design if necessary.

5.6.2 Planning uses

28. The management activities of a given MPA (or MPA network) should always be planned through a management plan, giving special accent to the public use of different zones within the MPA

29. Management activities of a given MPA (or MPA network) should be planned from a pro-active perspective –i.e. not focusing exclusively on prohibitionist measures, but rather on positive actions; these actions should count with sufficient financial support

30. Ways to regulate human activities in protected areas should be pursued to improve the success of MPA implementation; in particular, spatial separation of uses should be promoted to avoid conflicts

Our findings revealed that stakeholders would support the separation of areas for commercial fishing, diving and recreational fishing from those that protect marine habitats and species. One of the factors influencing the success of a MPA is how well human activities within the protected area are controlled. For each activity, the effects on the environment and the conflicts it generates with other activities are important considerations.

31. Planning should include the provision of time and resources to conduct rigorous baseline 'before', in addition to 'after' studies

With a view to monitoring studies to be conducted in MPAs, this measure should not be an afterthought.

32. Flexibility to adapt planning and objectives to changing situations should be the rule

Fisheries are characterized by their complexity, diversity, dynamic and vulnerability (Kooiman *et al*. 2005; Jentoft 2007), and in local scenarios these elements are as relevant as in wider perspectives (Pascual-Fernández *et al*. 2005). Local scenarios may change in the short or long term, and new activities may arise that need regulation in order to optimise the biological, ecological socio-economic or governability aims. For these reasons it is necessary to develop evaluation and monitoring of every aspect of the MPAs, in order that their institutional design be able to cope with these characteristics of fisheries. This implies the capacity to change and adapt to new demands and scenarios, modifying planning and objectives accordingly.

5.6.3 Management measures

33. Specific personnel staffs of MPAs (led by a Director – Conservator) should be in charge of co-ordinating and implementing management actions; their number should be high enough to ensure effective management in all aspects of planned MPA management activities

34. Effective enforcement of MPAs should be pursued to improve their ecological significance and public success

Patterns of recovery of target fish are related to MPA enforcement. However, many Southern European MPAs failed to meet their conservation targets, because little effort has been spent to enforce those (Guidetti *et al*. 2008). We found that only 11 out of 20 EMPAFISH case studies had adequate enforcement. In a meta-analytical framework – aimed at generalizing response patterns – positive ecological responses in properly managed reserves can be masked by neutral/negative results in 'paper' parks (where enforcement is low, if any). If enforcement is not pursued, this will lower the perceived legitimacy of management decisions, will increase compliance with restrictions, and likely will lead to the conclusion that marine reserves are ecologically ineffective. The development of specific protocols and metrics to

monitor and assess enforcement levels within protected areas certainly deserves major attention by the management bodies in the future.

35. Key governance principles should be pursued as a management priority

In addition to enforcement, MPA planning, design and management should consider as a priority the following governance principles (see Bavink and Chuenpagdee 2005): equity, inclusiveness, legitimacy, transparency, and representativeness. Stakeholders will accept use restrictions or bans much more easily if they feel the management measures are equitable, transparent, fair and strictly enforced for all.

36. New uses are to be considered in the MPA planning process

Design, planning and management should also foresee the development of new uses nonexistent prior to MPA creation and prevent or manage their development in the initial legislation, as once developed will be hard to restrict or eliminate (e.g. some types of recreational fishing).

37. Tourism activities (especially diving) should be oriented towards a sustainable use of the protected area; in particular, quotas should be established and adequately complied in order to keep human frequentation below the carrying capacity of the MPA

5.7 MPA monitoring and evaluation

38. Integrated monitoring and evaluation constitute a key factor for MPA success

The monitoring of MPAs constitutes a key element in their long term success. This monitoring should be comprehensive and holistic, integrating concerns related to biological and ecological variables with socio-economic and governability ones (Pomeroy *et al*. 2004, 2005). This means that monitoring should ideally begin before the design and implementation process, and have continuity in order to show the long –term evolution of key variables during the time span of the protected area.

39. Monitoring of MPA effects and evolution should be an objective of MPA management

Monitoring actions should be embedded in the budget of the MPA, and should start as soon as the zoning and design are in place.

40. Monitoring objectives are to be set up in relation to expected goals and objectives of the MPA

There are three crucial objectives of MPA monitoring: (1) to assess MPA effectiveness, (2) to allow and nurture adaptive management (changes in design, surveillance, zoning, etc) of the MPA, and (3) to fulfil the responsibility with society to learn from the nature laboratory experiments that MPAs are.

41. Monitoring should be undertaken clearly specifying the targets to be evaluated

Target ecological effects of protection are commonly unspecified and thus at present using wide scope ecosystem indicators is the only possibility. When narrowly defined ecological targets are chosen, monitoring studies may be designed to evaluate progress on those targets.

42. Monitoring plans should be designed in the long-term, based on appropriate, sound sampling strategies

The evaluation of the MPA effects (including ecological effects, socio economic effects and effect of fisheries) should be accomplished through long-term monitoring. Experimental designs for ascertain the effect of MPA should include the monitoring of a number of areas in protected and non protected zones, including therefore spatial and temporal replications.

43. Monitoring actions should be ensured to be undertaken in a periodic basis, and always under the direct advice of competent scientific personnel

For both ecological and fisheries effects, our experience suggests the need for more coordinated and continuous monitoring activities, including the currently lacking assessment of the achievement of conservation goals. This would be obtained through a national commitment in financing periodical monitoring activities, carried out by each MPA with the help of competent scientific researchers.

44. There is a pressing need for directed monitoring of exploited stocks with the objective of analysing the effect of marine protection on adjacent fisheries

The first challenge is to understand more fully the underlying dynamic of the stocks in question, and the second is to ensure that the fishermen are operating in a manner that ought to sustain productivity, and in some cases, the survival of these stocks.

Assessing fisheries without knowledge of the underlying stock status is a challenge, and although the EMPAFISH project has shown that it is possible to analyse patterns in the fisheries and catches, in terms of catch per unit effort and in terms of the spatial distribution of vessels, this information is limited without supporting awareness of the underlying system. It is meaningless, also, without strict enforcement. It is imperative that total fishing effort be monitored in a consistent way, in addition to effort spatial distribution.

45. Monitoring fisheries effects should preferentially target species that are most likely to show a response to protection

46. Special attention should be paid to fishing effort redistribution and the effect this may have on nearby fishing grounds

47. Special emphasis should be put on the effects of (and the consequences on) recreational fishing activities

Recreational fishing has generally been neglected in MPA studies but potentially has a very large effect on MPA development and nuisance to professional fishermen operating in the vicinity of the MPA.

48. Major emphasis should be done on the socio-economic effects of MPAs, which has been regularly neglected to now

Regular monitoring should therefore also include changes in use of resources and an evaluation of the added value MPAs provide to the local community. Proving to the community that it will benefit financially from the MPA is one of the best ways they can be encouraged. For all lines of monitoring there should be an adaptive management channel through which to direct new findings and change the rules as necessary.

49. Clear and operational definitions concerning the categories of users of MPA ecosystem services should be formulated, and the various zones related to these uses and their "local" economic impact well defined

- Users of MPA ecosystem services: a useful typology should include the following distinctions:
- Extractive (e.g. fishers) / non extractive (e.g. eco-tourists, scuba divers…)

- Resident (i.e. users whose main home, or home port is located in the neighbouring coastal zone) / non-resident (e.g., tourists)
- Market-oriented (commercial fishers, scuba diving or charter fishing operators…) / non-market (recreational fishers…)

- Zoning:
  - Zoning at sea: distinction between the various institutional zones of the MPA (with emphasis on the distinction between no-take zone and part of the MPA which is open to fishing); outside the MPA, distinction between "vicinity" and "rest of the world" (the first zone should correspond to the area where spillover effects from the MPA – fish biomass export and, possibly, larval exports – may be considered as significant for fishers)
  - Inland zoning: definition of the category of "neighbouring coastal zone" (for the definition of "resident users", and of "local economic effects" of the MPA)

50. It is necessary to get a clear and regularly updated view of the MPA frequentation

This implies monitoring (making use of the above-mentioned definitions), for each type of use and zone:

- The yearly number of persons or boats frequenting the MPA, and the seasonality of this frequentation. Particular attention should be paid to informal and unregistered uses such as (in most cases) recreational fishing.
- The profile of these users (e.g. main home place, boat characteristics…)
- Their MPA-related activity (for recreational users: number of visits per year, duration of stay, local expenditure…; for commercial fishers: proportion of total activity within the fishing zone of the MPA or its vicinity…)
- Their perceptions concerning the MPA (impact of the MPA on ecosystem, on local economy, on personal activity, on cohabitation between users…; degree of implication in the MPA management; opinions concerning the MPA regulations and the effectiveness of their enforcement).

This monitoring system should partly rely on sample surveys, designed to be operated routinely by MPA management authorities. This implies the following constraints:

- reasonable cost
- technically easy implementation and processing

- socially acceptable type of investigation
- providing information that is directly useful for managers (i.e not requiring the permanent intermediation of scientists)
- a good compromise between i) taking into account specific local features, and ii) providing information that is comparable to other MPAs

51. It is essential that the ecological, socio-cultural and economic value of marine landscapes ("seascapes") be properly assessed to reconcile seascape conservation with human demands on natural resource utilization

One reason for the continuing misuse of marine "natural capital" is the under-valuation of the benefits of natural and semi-natural seascapes (Balmford *et al*. 2002; de Groot 2006). By taking into consideration quantitatively the ecological, fisheries and socio-economic effects of Marine Protected Areas a proper bio-economic valuation of their benefits can be made.

5.8 MPA research

52. Ecological causes and consequences of MPA effects need to be studied; particular research subjects should be addressed

In order to better understand the way MPAs work, we need more studies on the following aspects (see also Sale *et al*. 2005):

- Interactions among species (predation, competition, indirect effects, positive interactions, etc.), and their effects on the response of ecosystems to MPAs
- Source-sink dynamics; larval production inside MPAs and export from them through pelagic dispersal (and linked to that, hydrodynamics of coastal water masses)
- Spatial and temporal dynamics of fish colonisation, settlement and recruitment
- Mobility of target species (tagging and tracking studies)
- Connectivity amongst populations (based on genetics, otoliths, stable isotopes, etc.)

53. Fisheries-specific questions need to be addressed if we continue to hope that MPAs can play a role in sustainable exploitation of stocks

In particular, the following fisheries-related research goals need to be tackled:

1. The EMPAFISH project detected a tendency towards lower CPUEs near protected areas compared with more distant regions. It is likely that these lower

CPUEs are due to increased fishing effort in adjacent waters, as was demonstrated by the analysis of modelled spatial distribution within WP2. However, without information on the evolution of total effort and catches, traceable back to points in space (via GIS or box reference), this is a hypothesis that needs to be investigated further.

2. Dedicated research into the effects of MPAs on adjacent fisheries could establish a common baseline upon which disparate sites could be more readily compared. A considerable limitation of EMPAFISH was the shortage of sites with usable data. The total number of sites providing data to the project was moderate, and since not all sites could provide data that could be analysed in a comparable way, this led to an overall shortage of workable case studies within WP2. In EMPAFISH, many of the Mediterranean sites were similar in terms of age, size and protection regime. Better representation of sites in terms of age and size is more likely to provide more consistent results.

54. Empirical research on the economics of MPAs is scant and there are several issues that merit further investigation

Most economic research on MPAs has focused on consumptive (or extractive) values, particularly on the assessment of net effects of MPAs on adjacent commercial fisheries (Carter 2003). Some economic research areas identified are:

- Fisher's behaviour in the presence of an MPA. Relocation of effort. But also assessing and mitigating social conflict between fishers and other uses.
- Role of recreational fishing, both in ecological and economic terms.
- Assessing non-use values of MPAs (SCUBA diving or other recreational, non-extractive uses). Also the detrimental effect of excessive frequentation on habitat quality needs to be addressed, as well as the negative effect of congestion ("crowding") on the economic activity itself.
- Improve the socio-economic database to conduct complete analyses of costs and benefits of the type "before-after and control-impact".
- Quantifying existence and option values of marine resources.
- Investigating on economic techniques of valuation.

5.9 Communication and exchange

55. Need to set up programs for improving key variables of governability linked to communication and exchange

Some governance principles like transparency and information (Bavinck and Chuenpagdee 2005) are key elements that should be considered in relation to

communication and exchange policies in the MPAs (Ehler 2005). Transparency is a key (although rarely considered) element in the governability of these institutions. Frequently the institutional arrangements are prone to opaqueness, and this may severely compromise their public image. In the same sense, providing information to the public is a key element for improving the image of the institution in the society but also for changing attitudes in the general public in order to improve compliance with the conservation measures inside the MPA and in general terms. Planning educational programs for children constitute also a key element in this area.

56. There is a need for greater communication between scientists, managers, fishers and other users to improve the disparity in understanding the fisheries benefits of marine protection

There is often a low awareness, as well as a poor understanding of conservation and resource management issues among coastal communities. Ways to change the attitudes of fishers by means of education and publicity campaigns should be pursued. Our study showed that the views shared by fishers and managers on area management were polarised, and this is expected to make management of MPAs difficult to enforce. It is expected that fishers will have a low support for fully protected marine areas as closed areas limit their fishing grounds. Until good evidence is provided which shows that fishers benefit from having such protected areas their attitudes towards area management will remain low. Nevertheless, the protected areas used in our research have been successful in increasing fish biomass and contributing to the export of fish biomass of some commercial species. On the other hand, the importance of MPAs to fisheries management should not be oversold, as this leads to disappointment and mistrust.

57. Dissemination of MPA functioning and results should be a priority

MPAs should be well publicised and new results from research made available to the general public. Availability of educational courses and activities, on-site information panels, booklets and fliers, and videos would greatly help the stakeholders and general public to appreciate and acknowledge the importance of conserving natural resources within MPAs and implementing protection measures. However, programs for results spreading and education, although existing, are insufficient. This could be achieved through a variety of ways, such as for example:

- Visitor centres and new technologies
- Periodic meetings for open discussion
- Web pages
- Awareness campaigns

- Environmental education campaigns (in both formal and informal educational levels)
- Etc.

58. If necessary, assign persons specifically serving as links among scientific fields of expertise, between scientists and other MPA practitioners (managers, stakeholders, etc.), and/or among sectorial economical activities converging in the coastal zone, in order to improve multi-disciplinarity and communication / exchange

5.10 Capacity building

59. Enhance opportunities for training and exchange among MPA managers

5.11 Financial durability

60. Financing of the running costs and management of MPAs should be warranted, in view of their financial durability in the long term

61. New ways of generating complementary revenues with MPAs should be considered

5.12 MPAs and other management tools

62. Activity management inside and outside MPA should be coordinated

In the case of fishing, a large part of expected MPA benefits are likely to disappear if effort is left uncontrolled outside the MPA, especially if fishing fleets of high power, such as trawl, have access to these areas. This is particularly the case with fishery rent, since increase in biomass exports will normally generate an increase in the vicinity of the MPA, up to the point were the potential rent generated by the MPA is totally dissipated.

63. Conservation measures should be combined with access regulation measures

In the case of fishing, this implies the setting up of an effective system of limited entry licences and / or catch quotas in the MPA and its vicinity. This system should encompass both commercial and recreational fishing. In the case of other recreational activities (e.g. scuba diving), a system of access regulation may also be instituted, to prevent congestion and limit harmful environmental consequences. Both economic and financial considerations plead for a system based on entry fees. As another example, regulation of fishing practices with seasonal bans of certain types of fishing gear can be useful for restricting fishing at key periods (e.g. reproduction). Even, legislation to ban certain damaging fishing activities on a national or international scale may have more impact than the designation of MPAs. In particular, changes to international law need to be considered if oceanic areas are to be protected effectively.

5.13 From MPAs through IMCAM to Maritime Policy

64. Networks of MPAs at proper ecological spatial scales instead of isolated MPAs should be the main focus of planners for the (re)design of future and existing MPAs

The EMPAFISH project demonstrated that there is a clear gap between the proposed guidelines for the design of optimized MPA networks, as recognized the current state-of-the art science of MPAs, and the design of existing MPAs in South European MPAs. Noticeably, these have generally been put in pace to address conservation or fisheries goals at the local scale, but lacking a regional network perspective. However, the spatial scale of the ecological dynamics subjacent to such goals typically outscales that of the existing MPA (as clearly evidenced by the study of EMPAFISH MPAs). Such lack of ecological networking seriously hampers the capacity of existing MPAs to provide ecological and, especially, fisheries benefits.

65. MPAs should serve as small-scale laboratories, on which testing management goals and objectives, decisions and options, and assessment techniques, in order to be implemented in a true IMCAM approach

66. The "Ecosystem Approach" and Marine Spatial Planning within the framework of the Maritime Policy should be implemented by combining ecosystem structure and process, environmental, and socio-economic (including governability issues) research findings, such as that applied in EMPAFISH project

The EMPAFISH approach (as applied before in the COST-IMPACT project) combines ecosystem structure and process, environmental and socio-economic research findings, and has potential for use in the wider management of man's impacts on the marine environment within an Ecosystem Approach. For example the approach can be used to predict the environmental and social costs and benefits of multiple impacts including climate change, aggregate extraction, wind farms, oil extraction and navigation lanes as well as fishing. Research is now required to explore the wider scope and applicability of this approach, particularly for spatial and temporal management of man's activities and impacts upon marine biodiversity and goods and services in a manner that is acceptable to societal needs.

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