Marine Protected Areas as a Mediterranean fisheries management tool[1]

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Let us look to the long-term, and use this present generation of marine reserves to gain the knowledge we will need as we seek to make our fisheries sustainable and manage our coastal environments (Rowley, 1994).

Abstract

As a consequence of the high variety of the bio-ecological and socio-economic factors that are intrinsic to fishery, the traditional management methods of the fisheries (minimum size, effort and catch limitations, closed seasons…) that often do not give the results required for a sustainable fishery and the preservation of marine biodiversity, marine protected areas (MPAs) have been suggested as a complementary management tool in the preservation of the marine living resources and biodiversity. In multi-specific fisheries, as the Mediterranean bottom fisheries, where the existence of numerous species prevents managers from applying single-species stock assessment techniques, MPAs may be only the available tool. By the other hand, MPAs, as an ecosystem management strategy, should aim at contributing to the maintenance of biodiversity, ecological processes, and sustainable resource usage. The adequate (*ad hoc*) planning, design, management and long term perspective represent important items for the MPA success, taking into account the collaboration of the fishery community.

1. Introduction

Although there are signs of overexploitation in most of the world's fisheries (Ludwig *et al*., 1993; Goñi, 1998; Agardy, 2000), we still have to formally address the effects of fishing on entire ecosystems. Dependence on accurate estimates of single-species stocks, as well as on efficient control of effort and catch, raises serious concerns about the efficacy of current fisheries management strategies in ensuring sustainable fisheries (Ludwig *et al*., 1993; Bohnsack & Ault, 1996; Roberts, 1997; Sumaila *et al*., 2000). In addition, reducing the effective fishing effort is almost impossible to achieve in the face of gear efficiency through technological improvements. Focusing on only one stock at a time, we fail to realise the significance of serial depletion of individual stocks and fishing grounds, as illustrated by fisheries in all parts of the world (Dugan & Davis, 1993; Lindholm *et al.,* 2001).

On the other hand, fishing down an ecosystem renders the latter vulnerable to random processes (Lauck *et al*., 1998), and fishing may even eliminate trophic groups or keystone species and result in a complete change to the overall community structure (Botsford *et al*., 1997; Hall, 1999).

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Moreover, as a consequence of the high variety of the bio-ecological and socio-economic factors that are intrinsic to a fishery, traditional methods of managing fisheries (minimum size, effort and catch limitations, closed seasons…) often do not give the results required for a sustainable fishery and the preservation of marine biodiversity (Bohnsack & Ault, 1996; Roberts, 1997). Marine Protected Areas (MPAs) have been suggested as complementary management tools for the preservation of the marine living resources and biodiversity (Plan Development Team, 1990; Ballantine, 1991; Bohnsack, 1996; Agardy, 2000). In multi-specific fisheries, like Mediterranean bottom fisheries, where the existence of numerous species prevents managers from applying single-species stock assessment techniques, MPAs may be the only available tool (Roberts & Polunin, 1993; Badalamenti *et al*., 2000). By the other hand, MPAs, as an ecosystem management strategy, should aim at contributing to the maintenance of biodiversity, ecological processes, and sustainable use of resources (Ballantine, 1991; Bohnsack & Ault, 1996; Sumaila *et al.,* 2000).

Interest in fishery reserves, marine harvest refugia, and MPAs as fishery management tools has grown quickly over the last decade. Most of the early experiments have been characterised by: i) initial resistance by fishers who were excluded from traditional fishing areas; ii) significant, and often dramatic, increases in numbers and size of fish or other harvested resources within refugia; iii) often anecdotal increases in harvests outside refugia; iv) poor documentation of baselines and changes in biological assemblages and fishery catches.

Despite this lack of documentation, results have been perceived as sufficiently positive to result in (Hourigan, 1998): i) local community support for refugia; ii) inclusion of refuges in fishery 'best practices' (e.g. FAO Code of Conduct for Responsible Fisheries), especially for new or still-developing fisheries and artisanal fisheries; and iii) the beginning of a much more ambitious dialogue about the next generation of MPAs. Furthermore, the UNCLOS (United Nations Convention on the Law of the Sea) has proposed the adoption of emerging concepts that would enforce the legal regime of the oceans (Bliss, 2003): the integrated management of oceans, the ecosystem-based approach, and marine protected areas.

2. Marine Protected Areas: Justification and needs

The global biodiversity conservation movement has accelerated interest in marine protected areas and harvest refuges (Norse, 1993). This stems from the view that such areas are the fishery management tool most likely to conserve biological communities and their processes in addition to target fishery species (Hourigan, 1998). The Conference of Parties to the Convention on Biological Diversity specifically identified the need for Parties to establish MPAs, and in May 1998, urged both Parties and the Secretariat of the Convention to facilitate research and monitoring activities related to the value and the effects of marine and coastal protected areas or similarly restricted management areas (as no-take harvest refuges) on the sustainable use of marine and coastal living resources. This issue will form part of the Convention's program of work on marine and coastal biodiversity. It is reflected in several IUCN resolutions and the conclusions of the International Group of Experts on Marine and Coastal Protected Areas (1995). The First Symposium on Marine Conservation Biology issued this call: *'Increase the number and effectiveness of marine protected areas so that 20% of Exclusive Economic Zones and High Seas are protected from threats by the year 2020'* (Hourigan, 1998).

One of these important recommendations is: *'to ensure a sustainable exploitation of the species and the ecosystems'*. In this sense, the FAO Code of Conduct for Responsible Fisheries in Article 6.8 requires that the States provide adequate protection for critical fisheries habitats so as to ensure the health and viability of the fishery resources, through the establishment of MPAs (Hourigan, 1998). In this regard, COPEMED (Co-operation across Mediterranean Fisheries Project of the FAO) aims to foster fisheries co-ordination and information exchange among Mediterranean countries and highlight the importance of local support for the preservation of nature. In accordance with these principles, COPEMED organizes activities related to the conservation and protection of living marine resources (research, training) to maintain the small-scale fisheries, and to promote the fishermen participation in MPA management.

Some problems are generated by the confluence of various uses on the same area. This leads to a variety of conflicts, for example:

- i) Small-scale fisheries *vs.* industrial fishing (trawling, purse seine): loss of the nursery areas caused by non selective methods (juvenile fishing); sea bed degradation; loss of artisanal gear (trammel nets, long-lines)
- ii) Sports fishing *vs.* small-scale fishing: spearfishing (impact on large hermaphrodite individuals); illegal use of professional methods (nets, long-lines) by sports fishermen
- iii) Leisure and tourism *vs.* small-scale fisheries: Loss of nursery areas (e.g. seagrass meadow destruction) by beach replenishment, harbour sediment extraction and dumping, and mooring of boats
- iv) Exploitation vs. conservation: e.g. fishermen and conservationists.

These conflicts are more pronounced in the Mediterranean, where tourism and fisheries are developed almost everywhere. To avoid these conflicts, MPAs represent one of the most important tools for preserving marine biodiversity and ensuring sustainable development of marine resources. In those areas, it is possible to reconcile protection of marine life with rational use of marine resources (selective fishing, ecotourism). The approach combining nature conservation and sustainable exploitation has been supported by several international programs and forums (like Man and Biosphere Program, UNESCO, 1976; World Conservation Union, 1978; Bali Declaration, 1982; Rio Summit 1992; Barcelona Convention, 1995). Some basic recommendations have been proposed: i) to preserve the biodiversity and the most essential ecological processes; ii) to protect environmental quality and to prevent any danger to the biological equilibrium of the marine and coastal communities; iii) to ensure sustainable exploitation of species and ecosystems; and, iv) to keep pristine areas for research, training and educational purposes.

Among the objectives and needs of the MPAs figure, apart from the conservation and social needs, and from the fisheries point of view (modified from Kingsford & Battershill, 1998):

- Reservoir for commercial and non-commercial species
- Refuge for different life history stages (e.g. juveniles, change of sex) and for fishes of highest fecundity (e.g. large individuals)
- Protect a portion of spawning stock
- Conserve genetic diversity of populations (especially with respect to max. size)
- Recover size-class structure of the exploited species

- Increase in abundance, size and age of vulnerable species
- Recovery of depleted stocks (fishes, invertebrates)
- Enhanced fishing in adjacent grounds by restocking (biomass exportation)
- Protect spawning/mating and nursery areas of commercial species
- Increase yield per recruit (when nursery grounds are protected)
- Increase reproductive output (larval supply) and recruitment to external areas
- Protect migration stop over points and bottlenecks
- Reduce conflicts between user groups on areas of coast (artisanal vs. trawl fishing, sports vs. professional fishing…).

3. Fisheries angle

The establishment of an MPA supposes, up to a point, a return to an initial situation of the fishery where the exploitation has only affected some parts of the target population distribution. So, the non-exploited or inaccessible sites should be *de facto* restocking areas (Boudouresque, 1990). On the other hand, the MPAs represent measures focused to the uncertainty of the fisheries management and the variable conditions of the marine ecosystems, and to try to mitigate possible mistakes in the fisheries management or environmental imbalances and marine production (Dayton *et al.*, 2000).

a) Single species

From the single-species point of view, a MPA is expected to help control fishing mortality and, by so doing, restore, at least partially, pre-industrial exploitation patterns, when less efficient fishing techniques and lower boat power prevented the exploitation of portions of the fishing grounds (Boudouresque, 1990). An increase in the mean body size, density and biomass of various species, and especially those targeted by the fishery, has been reported in several reserves (Roberts & Polunin, 1991,1993; Dugan & Davies, 1993; Jones *et al.*1993; Rowley, 1994). As a result, reproduction potential would increase within and perhaps outside the reserve.

Although MPAs have not been shown to swell the fish population in the unprotected parts of the habitat, in some cases they sustain yield by adult migration into the neighbouring fishing grounds (Ramos *et al.*, 1992; Bohnsack, 1996; Russ & Alcala, 1996). Closed areas used as part of fisheries management regimes (for single species or gear) have produced positive results for several species (Davis & Dodrill, 1989; Pipitone *et al.*, 1996).

b) Reduce fishery mortality and by-catch

An important aspect of the MPA's potential benefits is the fishing mortality decrease for a target population part in a certain area (e.g. recover of the demographic structure; increase of the spawning biomass). Moreover, the MPAs present other positive effects, prohibiting the trawling, and/or reducing the conflicts between fishers (Bohnsack & Ault, 1996). For example, the trawls and dredges may modify or destroy the habitat, reduce seabed complexity and remove macrobenthic organisms that provide shelter and food for target species (Hutchings, 1990; Jones, 1992). From a formal point of view, the MPAs are of different kinds, created for biodiversity preservation (nature reserves and parks) or to manage fisheries (closed areas, 'no-take zones', harvesting refuges, fisheries reserves…). However, in spite of the

primary objectives (biodiversity, fisheries), the management of MPAs should be convergent and share, in the same time, the conservation and exploitation objectives, directed to the sustainable use of resources.

MPAs may also be a suitable tool for reducing bycatch, when critical habitats of the species or age group at risk are protected. Such reserves would be more efficient than size limits, as well as easier to regulate and enforce than single-species oriented regulations.

c) Habitat protection

The observed effects of fishing on benthic-community structure underline the importance of creating permanent reserves. By eliminating fishing by trawling gears, bottom complexity as well as benthos and fish species composition is likely to change from disturbed to mature ecosystems (see references in Hutchings, 1990; Jones, 1992; Hall, 1999; Lindholm *et al*., 2001). Evidence that closed areas may result in community structure modification has been found in *Posidonia* meadows (Ramos-Esplá *et al*., 1997) and maërl beds (Bordehore *et al*., 2003). However, because of some epibenthic species (like *Posidonia* and maërl rhodoliths) are slow-growing and long-lived (up to 100 years), rebuilding the habitat structure may be a long process.

4. Types and figures of MPAs

There is no standard model of marine protection; most of the existing models have been taken from regulations based on protected land areas. It is necessary to know what is the main aim at establishing each MPA (species and/or community protection?, to promote fishing development?, educational or cultural purposes?…) and what means and infrastructure are available to attain the objectives of each area. MPAs have been established under different legislation and with diverse objectives/criteria:

- 1) A variety of nomenclature has been used, and established under different national and regional legislation (fisheries, hunting, environment…): fishery preserved zone, prolongation of terrestrial parks, hunting refuges, marine reserves, marine-terrestrial parks.
- 2) Objectives are diverse:
    - Restricting fishery activity (number of boats, methods, periods, species)
    - Marine protection of terrestrial parks (marine buffer zone)
    - Preservation of the flag species (sanctuaries for monk seal, marine turtles, cetaceans)
    - Restocking areas (marine reserves, ‘cantonnements de pêche’, ‘aree di tutela biologica’)
    - Preservation of the marine and/or terrestrial coastal environment (e.g. National Parks, natural marine reserves)

5. Legal aspects

For the conservation and management of the Mediterranean fisheries through MPAs in the COPEMED countries (Algeria, France, Italy, Libya, Malta, Morocco, Spain and Tunisia), the States have promulgated specific legislation (Cacaud, 2000) and there are some regional organizations which coordinate the management and conservation of the living resources in the Mediterranean Sea.

a) State level

All the countries in the COPEMED zone have adopted a legal framework to minimize the impact of fishing activities on the living resources (Cacaud, 2000). These management measures mainly concern the fishing effort (fishing gear and methods, licensing of fishing activities, time and area restrictions, mesh size), prohibition methods and minimum fish size. Besides, with regard to MPAs, all of them contemplate in their environmental legislation extended protection inside the territorial waters. Nevertheless, only some of them (e.g: France, Italy, Malta, Spain) have legislated fisheries MPAs.

b) Regional cooperation

Under the UNCLOS, the Mediterranean Sea falls in the category of enclosed or semi-enclosed seas without economic exclusive zone (EEZ). In this case, the UNCLOS requires that States bordering this sea cooperate directly or through an appropriate regional organisation to: 'coordinate the management, conservation, exploration and exploitation of the living resources of the sea' (article 123).

At present, three regional organisations dealing with the conservation of the living marine resources in the Mediterranean have been established: FAO General Fisheries Commission for the Mediterranean (GFCM), the International Commission for the Conservation of Atlantic Tuna (ICCAT), and the Mediterranean Action Plan of the United Nations Environment Programme, with its Regional Activity Centre for Specially Protected Areas (RAC/SPA). The first two organisations (GFCM and ICCAT) dealing with fisheries issues, and the third one (RAC/SPA) dealing with Special Protected Areas of Mediterranean Interest (SPAMI) and Biological Diversity (Barcelona Convention, 1995).

6. Design

Costs associated with any management strategy can be magnified by poor design and inadequate or inaccurate evaluation. The reserves may contribute to, but may not be sufficient protection for, some marine resources (Allison *et al*., 1998). Because of reserves have argued mainly to strengthen rather than replace other management strategies (Carr & Reed, 1993; Roberts, 1997; Allison *et al.,* 1998), the cost of implementing reserves may detract from the efforts and finances required for other strategies (e.g. enforcement). The main problems are:

- Poorly designed fishery reserves could provide minimal benefits while giving a false sense of security to managers and fishers (Carr & Raimondi, 1998). In this case, the reserves could be used to justify relaxed restrictions in the remaining fishing grounds and exploited populations could be subjected to a combination of concentrated effort and less restrictive regulations

- Like poor design, improper evaluation could jeopardise the future of a reserve program. Well designed reserves may be highly effective at sustaining and enhancing fisheries, but flawed methods of evaluation can fail to demonstrate their positive effects. Again, it may be difficult to justify the future of a reserve program because of a lack of demonstrable benefit

The effectiveness of any MPA depends on its location, size and shape in relation to the life history characteristics and habitat requirements of the species to be protected (Rowley, 1994). The great differences between terrestrial and marine systems require that care should be taken in applying to marine reserves conclusions based on terrestrial systems. However, many useful ideas have been generated which are applicable to marine reserves.

a) Location

Poor results have been shown when the protected area is located in unfavourable habitats, or is not protecting a sufficient portion of critical habitats (Armstrong *et al*., 1993; Tegner & Dayton, 2000). To prevent this situation and to enhance local fishing, a MPA should (Rowley, 1994): i) be within reach of fisheries; ii) include relevant recruitment and nursery habitats, or be close enough to receive recruits from separate nursery grounds (which may require protection as well); iii) have juveniles in many size/age classes which tend to indicate a recent history of consistent recruitment; iv) be subject to long-term regional control to protect the reserve, its nursery areas, and the routes of migration from nursery to reserve; and v) for species reluctant to disperse across 'foreign' habitats, a reserve should be located within a larger patch of similar habitat such that the reserve perimeters have high 'permeability'.

b) Size

Lacking a conservation objective to start with, scientists have tried to devise a minimum proportion of the habitat that should be protected. Based on the minimum spawning biomass that should be preserved in exploited stocks, the Plan Development Team (1990) suggested that 20% of the total habitat should be protected. The appropriate proportion, although unknown, is likely to be larger. Modelling based on species with different life histories suggests that a large proportion of the local habitat (up to 50%) should be included in reserves to efficiently protect both the habitat and the animals contained therein from the negative impacts of exploiting the resources. Based on observed dispersion rates for commercial North Sea fish stocks, Daan (1993) showed that if a contiguous area of 25% was closed, the reduction in mortality would only be in the order of 12%.

Both larval dispersal and adult migration patterns (Table 1) are important for determining the location, size and number of reserves necessary to protect a particular species (Allison *et al*., 1998). A high rate of adult migration out of the reserve is likely to decrease the efficiency of the reserve since a large proportion of individuals would still be vulnerable to exploitation (Sumaila *et al*., 2000). In consequence, the need for knowledge of the home range and migration patterns becomes crucial (Bennett & Attwood, 1991; Zeller, 1997)

Table 1. Relationship between spatial scale of the attached or site-dependent phases of the adult and the embryonic stage with regard to minimum size of MPAs (modified from Kenchington, 1990).

Type	Adult phase	Embryonic phase and/or juvenile	Examples	MPA size (ha)
A	fixed or territorial	direct development	Syngnathidae	<1000
B	fixed or site dependent	planktonic larvae	Serranidae, lobsters	10^3-10^4
C	adult territory ± diffused (demersal or pelagic spp.)	direct development (egg-laying zones)	Cephalopoda	10^3-10^4
D	adult territory ± diffused (gregarious demersal spp.)	planktonic larvae	Merluccidae, Mullidae	10^4-10^5
E	large adult territory (gregarious pelagic spp.)	nursery and/or spawning areas	Thunnidae	10^5-10^6
F	large adult territory (solitary pelagic spp)	planktonic larvae or direct development	Xiphiidae, pelagic sharks	> 10^6

From a pragmatic point of view, Tisdell and Broadus (1989) consider a minimum area of 1000 ha (see paragraph 6. e) Socio-economic factors), mainly for enforcement reasons. Figure 1 shows the percentage of MPAs (Nº= 60 at 2003) in the COPEMED countries with regards to the protected area.

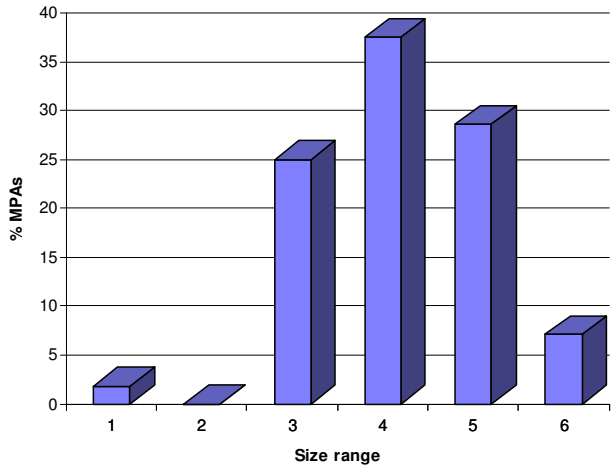

Figure 1. Percentage of the MPAs (Nº = 60) in the COPEMED region (Algeria, France, Italy, Libya, Malta, Morocco, Spain, Tunisia) related to the protected surface area (in ha). Surface ranges: (1) ≥ 10^6 ha; (2) 10^6 - 10^5 ha; (3) 10^5 - 10^4 ha; (4) 10^4 - 10^3 ha; (5) 10^3 - 10^2 ha; (6) < 100 ha.

c) Reserve shape

- Perimeter/area ratio: This could influence the movement of animals across reserve borders. For two reserves of equal area that are equivalent in terms of habitat, productivity and other factors, we can expect more spillover from the reserve with the longer border. In terms of spillover supporting local fishing, however, we must remember that a long perimeter also spreads any potential increase in catch due to the reserve across a larger area and so decreases the likelihood of increases being substantial or easily caught (Rowley, 1994).
- Variety of habitats: Increased habitat diversity within a reserve will both increase the diversity of species protected, and be more likely to protect both adult populations and

the nursery habitats required by some species. Many important fishery species require specific habitats or substrates for larval settlement and/or juvenile 'nursery grounds' e.g.: seagrasses are required as settlement and juvenile habitat for Labridae, Sparidae and Scorpaenidae (Jiménez *et al.,* 1996); maërl bottoms as recruitment grounds for *Pecten* and *Octopus* (BIOMAERL team, 2003); spiny lobsters (*Palunirus argus*) recruit into specific juvenile or nursery habitats, and successful recruitment of stocks may be limited by the availability of such habitats (Davis & Dodrill, 1989).

- 'Corridors': The permeability of a reserve edge may be increased by placing reserves within large patches of similar habitats or within a habitat strip (such as rocky shore lines, hard bottoms, seagrass meadows, maërl beds). These habitats could act as 'corridors' that 'spill' the individuals into local fisheries. Alternatively, spillover may be limited from reserves that protect disjoint patches of habitat separated from similar habitats by expanses of 'foreign' habitat or deep water.

Protection of species with separate juvenile and adult habitats may require that both habitats are included within one reserve, or that there is protection of separate nursery and adult reserves and the dispersal corridors between them (Rowley, 1994).

d) SLOSS debate

'Single large or several small reserves of similar total area' (SLOSS debate). A single reserve could be self-replenishing and therefore potentially self-sustaining only if it is sufficiently large to encompass the range of dispersal of many larvae produced by its local populations.. But it seems unlikely that any single reserve will be of sufficient spatial extent to be largely self-sustaining (because of the long planktonic duration and tremendous dispersal potential of many exploited species: e.g. 1-2 months)

Therefore, a collection or network of reserves seems necessary in order to ensure that reserve populations are both self-replenishing and self-sustaining. The spatial design (distribution and number) of a network should aim for a high likelihood of connectivity (via larval dispersal) among reserves, while replenishing exploited populations outside the reserves (Carr & Raimondi, 1998). Several authors (Ballantine, 1991; Carr & Reed, 1993; Roberts, 1997) have pointed the advantages of a network of reserves, each lying within the 'replenishment area' of the others, so that larvae produced within one reserve are likely to recruit to other reserves. This design allows local extinctions within a reserve to be replenished from distant reserves and buffers the entire system against the effects of local recruitment failure.

Compared with one single large reserve, a network of small ones would provide greater protection against environmental variations and local catastrophes (Ballantine, 1991; Carr & Reed, 1993; Rowley, 1994). Multiple reserves would also allow the replication of study sites needed to provide scientifically conclusive answers to many of the questions about reserve function (Ballantine, 1991).

From a practical point of view, a system or a network of small MPAs is sometimes the only possible choice along an urbanised coastline where the marine environment is exposed to a multitude of uses. In this context, Francour *et al.* (2001) stated that the establishment of several small MPAs rather than a few of larger size in Mediterranean countries is the result of independent local decisions rather than instructions in national management plans. Siting and size of MPAs are generally chosen more for human reasons than for ones of ecology, e.g.: i)

maintenance of traditional small-scale fisheries, or ii) marine leisure activities, potential conflicts, effective surveillance.

e) Socio-economic factors

Apart from resource conservation and food supply, ecosystem management goals include wealth and the maintenance of viable fishing communities. The long-term effects of fishing on the economic and social well-being of fishing communities may be positive if the interaction between the community and the fish is such that the ecological base of the resources remains intact through time. However, economic factors are generally not taken into account in the planning of MPAs (Tisdell & Broadus, 1989), probably because MPAs are usually created either in anticipation of biological and ecological benefits or in response to public pressure, in particular from conservationist groups.

The economic justification for establishing MPAs usually takes two broad forms (Sumaila *et al.,* 2000): i) it is argued that economic benefits may follow the establishment in the form of creating employment through non-consumptive activities such as tourism and recreation; ii) it is expected that MPAs may protect future jobs by increasing the chances of managing stock sustainability.

7. Management and Zoning

Generally, conflicting interests, such as those between conservation and exploitation, represent a major issue in resource-allocation exercises. There are many different approaches to marine protected area planning, management and zoning. The choice of approach should be influenced by the prevailing resources as well as the environmental, social, political and economic parameters (Salm & Dobbin, 1993). Thus, we should consider in MPAs (Figure 2):

- the ecological component: linked environments and component species (scientific support)
- the socio-economic component: pressures on the ecological component from human activities and needs (socioeconomic support)
- the political component: the political, administrative and institutional influences and constraints (legal support).

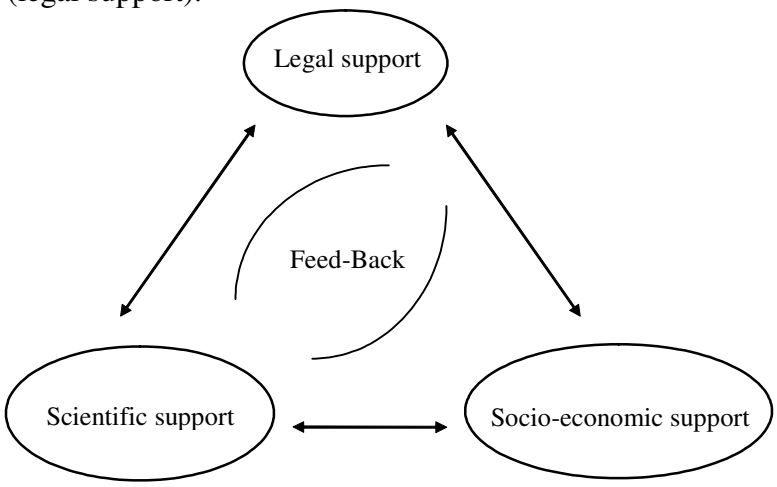

Figure 2. Three main components in the establishment of MPAs.

To avoid as far as possible human impacts, it is necessary to consider the zoning of the MPA planning. Moreover, the zoning may resolve some conflicts between users of the coastal zone (selective/non selective fishing methods, professional/sports fishing, Scuba diving/spear-fishing). The principle objectives of zoning reflect the objectives for the management of the MPA and are usually (Kelleher & Kenchington, 1992; Laffoley, 1995):

- To provide protection for critical or representative habitats, ecosystems and ecological processes
- To preserve some areas of the MPA in their natural state undisturbed by humans except for the purposes of scientific research or education
- To separate conflicting human activities
- To protect the natural and/or cultural qualities of the MPA whilst allowing a spectrum of reasonable human uses
- Traditional users of the managed area should be consulted and involved in the development and implementation of management plans
- To reserve suitable areas for particular human uses, whilst minimising the effects of those uses on the MPA.

An MPA refers to a management area in which use is regulated by zoning for different activities. It includes marine reserves, which are strictly no-take areas. In this sense, the philosophy and zoning (Figure 3) of the Biosphere Reserves (Man and Biosphere Program, UNESCO, 1976) may be useful for integrating the conservation and exploitation in MPAs, according to three basic functions of the Biosphere Reserves:

- ***Conservation function***: preservation of the different levels of biological biodiversity (genetic, taxonomic, habitats, ecosystems)
- ***Logistic function***: focused to research and monitoring from inside and outside the MPAs, as well as supplying services for education and information
- ***Development function***: to allow traditional uses (artisanal fishing) and low impact activities ('soft-tourism') that sustain a rational and continuous exploitation of natural resources and cooperation with local populations.

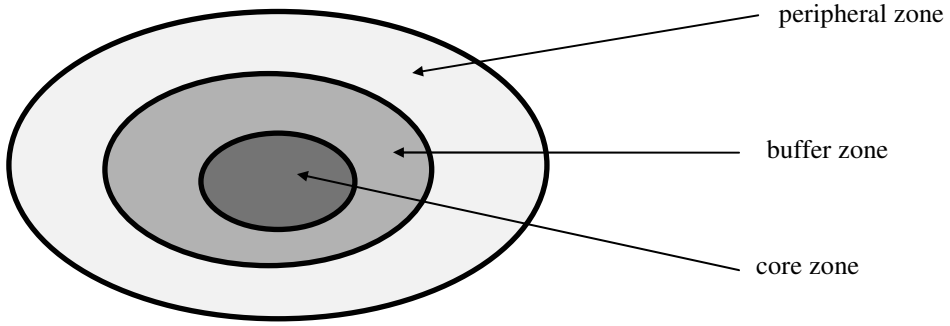

Figure 3: Zoning in the Biosphere Reserves (MaB, UNESCO, 1976): core zone or integral reserve (≥10% of the protected area); buffer zone or protection of the core zone; peripheral or multi-use zone, development area.

The table 2 shows the zoning of the Marine Reserve of the Tabarca Island in these three areas, with integral protection (core area), and fisheries and tourism uses (buffer and peripheral areas).

Table 2. Zoning of the Marine Reserve of Tabarca 1400 ha in Alicante, Spain): (I) core zone (integral reserve: 100 ha); (II) buffer zone (core zone protection: 630 ha); (III) peripheral zone (multi-use zone: 670 ha); (a,b) sub-zones. Spear fishing prohibited (Ramos-Esplá, 1990)

USES	**I**	**IIa**	**IIb**	**IIIa**	**IIIb**
Conservation	♦	♦	♦	♦	♦
Scientific research (monitoring, evaluation)	♦	♦	♦	♦	♦
Trawl-line (professionals)	·	♦	·	·	♦
Hand-line (squids by professionals)	·	♦	·	·	♦
2 Large trap nets (amberjack, April-June) (professionals)	·	·	♦	·	·
10 Small trap nets (Atherinids, October-December) (professionals)	·	·	·	♦	♦
SCUBA diving (30 divers with permission)	·	♦	♦	♦	♦
Education (nature trips)	·	·	·	♦	♦
Snorkelling	·	·	·	♦	♦
Sun-bathing	·	·	·	♦	♦
Hand-line (amateurs)	·	·	·	·	♦
Anchoring (beach and harbour sectors)	·	·	·	·	♦
Glass-bottomed boat	·	·	·	·	♦

8. Involving the fishermen community

It is important that local communities participate in marine conservation and the rational management of marine resources. Socio-economic activities (like fisheries and tourism) must be compatible with the environment preservation, by establishing limits to the development. Trying a balanced tourism development generates benefits to the local population, by creating new professional activities (sea-watching, Scuba-diving, bottom-glass boats, guides, guardians), where the fishermen participate. The general principles to apply to community involvement are(Wells & White, 1995):

- i) the concept of a new protected area should be introduced very carefully to the community
- ii) the benefits of protected areas must be made clear to the people and their needs should be addressed
- iii) in many cases, the appointment of a community worker, trained in both resource management and community skills, may be enormously beneficial and sometimes essential
- iv) the establishment of a committee to oversee the development and management of the protected area; and
- v) where possible, the community should be responsible for enforcement, allowing traditional disincentives and peer pressure to operate
- vi) a protected area needs to be managed in such a way that its future survival is guaranteed beyond the early stages, when community support may mainly reflect the novelty value of the project.

It has been widely recognised that public participation and local community involvement is an essential factor that contributes to the success of a MPA (Fiske, 1992; Wells & White, 1995). In the absence of strong community support, the integrity of MPAs relies more heavily on efficient enforcement, which is costly and not easily achieved.

However, co-management and community involvement require a great deal of commitment and energy from all parties. Fishermen must be involved early in the decision-making process to ensure support and ultimately to reap the expected benefits (Alder *et al*., 1994), because they possess detailed knowledge of their fishing grounds, which is essential for the design of efficient reserves (Neis, 1995).

9. Discussion

Considered the limitations in fully understanding the ecosystem, the precautionary approach could be attempted when creating a network of MPAs. MPAs can be used, in combination with other management measures, as part of an adaptive management scheme. Rather than solely controlling fishing mortality for targeted species, MPAs should be designed to allow permanent and/or temporal closures to cover critical habitats such as nurseries, spawning and feeding grounds or to protect stocks during crucial life-history events such as migrations and spawning aggregations. MPAs should be seen as tools for learning and experimentation with target and non-target species recovery and ecosystem management.

However, the reserves may be contributory, but not sufficient protection for some marine resources (Allison *et al*., 1998; Carr & Raimondi, 1998). Because reserves are designed to effectively augment rather than replace other management strategies (Carr & Reed, 1993); Roberts, 1997; Allison *et al*., 1998), the cost of implementing reserves may then detract from the effort and finances required of other strategies (e.g. enforcement).

Perhaps the most robust purpose of a MPA designed primarily as a fisheries management tool is to provide insurance against fishery management failures. Thus, fishery management protects fish projected to exist, based on uncertain data and models. Well-designed and managed marine reserves would protect real fish and real ecosystems even if fishery management completely fails, or results in fishing mortality that is greater than projected (Fujita, 1998).

Research should be directed towards the evaluation of existing MPAs to determine their success and potential benefits. Well-designed long-term monitoring programmes will be necessary to gather data about the processes of population and ecosystem rebuilding, to assess benefits, to increase knowledge of both fishers and scientists, and to improve the level of protection.

In conclusion, when properly established, MPAs offer a viable additional management tool to help stem the decline of fisheries at risk, rehabilitate those that have collapsed, and contribute to the sustainability of future fisheries. Not only MPAs can help to address the ecological problems of poorly managed fisheries, but they can also assist in improving the long-term socio-economic welfare of coastal communities that often rely on very resource they are depleting.

10. Recommendations

To attain the objectives for an adequate and effective protection, management and monitoring it is necessary to consider some recommendations (Ramos-Esplá & Mas, 1995; Francour *et al*., 2001):

a) Design: the importance of the initial choice

- Ecological parameters: i) apart from the living resources, it is necessary to consider the variety and complexity of habitats (e.g. seabed with heterogeneous topography, seagrass meadows) and availability of corridors; ii) the possibilities for recruitment of the biota (e.g. suitable nursery areas in the MPA or nearby, and a good influx of currents carrying fish larvae) are adequate (shape, perimeter, …)
- Site selection (ecological and socio-economic studies) with some preliminary studies on the living marine resources and habitats mapping of the possible protected area. The size (> 1000 has) and shape of the area could be a compromise between: habitats/species preservation, management objectives (protection, socio-economic and cultural components), and easy delimitation and enforcement
- In the case of the Mediterranean, several MPAs of relative limited size (1000-10000 has) may be preferable to the option of one single large protected area, as much for ecological reasons as socio-economic ones. The distance between these MPAs should be not more than 100 km.

b) Legislation

- The initial choice of legislation regulating the management of the future MPA is of prime importance. However, the creation and management of a protected area, generally depends on the use of various existing pieces of legislation, but to be effective this legislation must be able to be amended by additional arrangements without involving too complex a legislative procedure.
- To bear in mind: The greatest flexibility in the regulatory arrangements and a certain amount of decision-making autonomy for the managers is necessary and appropriate.

c) Management and zoning

- Realistic management planning and zoning, bearing in mind some areas with different protection levels, at least two zones: a core zone of integral protection(about 10-20% of the MPA); and a buffer zone to protect the core area with selective fishing methods (e.g. hand-lines, long-lines, trap-nets). The management plan should be flexible to allow later improvement as result of experience
- Integration and participation in the management committee of representatives from the local communities and socio-economic activities (fisheries, tourism)
- Effective enforcement by land and sea (rangers with a boat) and well-trained personnel
- Public and administrative awareness is very important for the acceptance of the marine protected area
- Suitable funding support is necessary for the scientific monitoring, infrastructure, maintenance, enforcement and educational activities that guarantee the long-term continuity of the MPA. It is important to consider possible self-funding sources (eco-taxes, visits, sea-watching…)

- Logistic parameter: related to the effectiveness of surveillance (the site chosen should be accessible throughout its extent from a terrestrial base).

As Fancour *et al.* (2001) state: '… the results of the past and present experiences indicate that the significance of management conflicts within any future MPA will be inversely proportional to the extent of preliminary consultations with all of the users (both professional and amateur) of the area to be protected'.

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