C I E S M W o r k s h o p S e r i e s

Scientific design and monitoring of Mediterranean marine protected areas

Porto Cesareo (Italy), 23-26 October 1999

This is volume n° 8 in the *CIESM Workshop Series*.

The collection offers a broad range of titles in the marine sciences, with a particular focus on emerging issues. The reports do not aim to present state-of-the-art reviews; they reflect the latest thinking of researchers gathered during four days at CIESM invitation to assess existing knowledge, confront their hypotheses and perspectives, and to identify the most interesting paths for future action.

A collection edited by Frédéric Briand.

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I - EXECUTIVE SUMMARY

1. INTRODUCTION

The workshop was held on the coast of the Gulf of Taranto, in Porto Cesareo, from 21 to 24 October 1999. Fourteen scientists, managers and legal experts on coastal conservation (see list at the end of volume) did participate at the invitation of CIESM. The Director General of CIESM, Professor Frédéric Briand, opened the meeting by welcoming all participants. He expressed his gratitude to Professor Boero, to the University of Lecce – in particular, to the Technical Office and to the staff of the Marine Biological Station –, to the Province of Lecce and the Municipality of Porto Cesareo for the organization of this event. Thanks to their efforts, the participants were able to work in a magnificent, newly-restored medieval tower overlooking the coast and graciously placed at their disposal.

1.1. Aims and objectives

Frédéric Briand then explained the origin and context of the current workshop. Considering the renewed emphasis placed on littoral environments by CIESM Member States – with the recent creation of a committee on the subject – and the orientations provided at the latest (June 1998) CIESM Congress, it was decided to review recent scientific advances which could be of potential benefit in designing, monitoring and managing Marine Protected Areas (MPAs) in the Mediterranean region. The Director General expressed his concern that biogeographic theory applied to MPAs was still very much influenced by concepts derived from terrestrial ecosystems, and he encouraged the participants to develop marine-centered concepts where hydrological fronts, currents and rates of larval dispersal would play a more explicit role. In this region of the globe where small-scale artisanal fisheries remain of critical socio-economic importance, it seemed urgent (a) to highlight the potential of MPAs for the enhancement of marine stocks, with a view to develop a more harmonious relation between conservation and exploitation of resources, and (b) to identify a small set of indicators of change, success (or trouble) where MPAs would provide early warning signals.

Professor Ferdinando Boero, Chairman of the CIESM Committee on Littoral Environments, followed. He started with a reminder that the mode of selection and design of marine protected areas, the central subject of the workshop, was likely to draw different approaches and thus different responses from the main actors involved in coastal management, even among those advocating coastal conservation.

Indeed environmentalist movements, which have been the most effective so far in promoting environmental protection, tend to center their action on a few, highly popular, target species (*e.g.* whales, turtles, seals). This approach has clearly been successful : if there is an environmental policy or framework in most countries, it is due, largely, to the original impulse and pressure of the green movement and environmental NGOs. Scientists, for their part, usually propose protected areas for different reasons, privileging the integrity of communities and biotopes rather than that of single species. The impact of this group is much lower, due to scarce public visibility. As a result, scientific arguments are often simply neglected … when they are not heard long after the decisions have already been taken. Finally socio-economists are seldom consulted when it comes to evaluate the opportunity of creating marine protected areas.

This lack of concertation only adds fuel to the lasting and damaging conflict between those who use the coastal-marine environment as a source of income (fishermen, urban or touristic developers, etc.) and those who want to preserve it as much as possible from human interference. It is desirable that a compromise be reached among all parties so as to provide a secure basis for the lasting protection and integrated management of coastal resources for the benefit of all concerned.

A primary aim of the workshop, therefore, was to confront, from a scientific angle, theory and practice accumulated in MPAs over the last decade, both within and outside the Mediterranean Basin. Hopefully the resulting recommendations, while mostly based on science at their core, will be helpful to decision-makers in the choice and management of marine protected areas.

1.2. Relevant considerations

The various professional sectors involved with coastal areas all apply pressure on policy-makers and administrators, in the development of legislation and regulation compatible with local situations. A marine reserve, thus, is a very complicated object to design and to deal with, requiring a multidisciplinary approach at all stages of its conception and development.

Mediterranean shores today constitute the number one touristic destination in the world. More attention should be given to the promotion of eco-tourism, a growing branch of the tourism industry, as tourists from rich – and often environmentally degraded – countries are willing to invest more time and money to travel to less contaminated, more pristine parts of the world. This results in a huge and growing transfer of resources towards areas that are less favoured from the point of view of economic development but, certainly, more favoured in terms of environmental integrity and beauty.

Tour operators find it increasingly easier to sell “holiday packages” for regions where a policy of environmental protection is in place, proof that clients are fast becoming ecologically-sensitive. The establishment of MPAs could benefit from such a trend : local interests will be certainly sensitive to the fact that stretches of coast including marine reserves will attract eco-tourism, while keeping environmental quality high.

An easy way to design a MPA is to take a map, draw some lines parallel and perpendicular to the shore and declare that, within a given area, human activities are forbidden. Usually the choice of the area is based essentially on a single criterion : the presence of a rare emblematic, “likable” species (*e.g.* sea turtles, monk seals, etc.), or of particularly valuable seascapes (the marine counterpart of landscapes) such as rocky cliffs or coral reefs. Such choices also aim to enhance the yield of artisanal fisheries, since it has been long assumed that protected areas comprise the spawning grounds of commercially important species. A further, direct economic advantage consists in the attraction of eco-tourists who will enjoy the seascape by SCUBA diving.

This mode of selection has been operating for several years in Mediterranean areas and it is now time to question its efficiency and to correct the mistakes, if any, of the past. This should ultimately lead to a better design and management of existing and future MPAs.

MPAs have often been designed with the paradigms of terrestrial ecology in mind, although it is evident that marine communities work in a different way. The need for conservation corridors, for instance, is paramount in connecting terrestrial reserves, whereas a well-designed network of marine reserves could take advantage of existing currents which provide a very efficient mean of propagule dispersal. Currents, however, also bring contaminants and alien species at a faster pace than on land, which must be incorporated in MPAs management.

The workshop provided several points of view, represented in the individual contributions of the participants (see chapter II of this volume). Discussions were usually longer than presentations and the last day was largely devoted to “squeeze” the most important outcomes of the meeting. These, plus a technical section on monitoring procedure (by Simonetta Fraschetti and Antonio Terlizzi, see below), are sketched in this executive summary.

2. SELECTION AND DESIGN OF MPAS

2.1. Zonation

The objectives of a given MPA must be made clearly explicit at the onset so as to monitor its effectiveness over time and make proper adjustments if necessary.

Traditional objectives are :

a - the protection of unique communities and habitats;
b - the protection of rare and endemic species;
c - the protection of pristine areas;
d - the protection of nursery areas;
e - the representation of a vast range of species and habitats;
f - the restoration of degraded habitats that still have some chances of recovery, a particular case especially relevant to the Mediterranean Sea.

Once the objectives are established, zonation can be planned. While the perception is growing that MPAs can be a source of income for local communities, often zonation remains heavily constrained by tourist operators, developers, and fishermen. It is obvious that the success of a MPA is directly correlated to the degree of acceptance by locals and it is tenuous to expect positive results without their support. Zonation, thus, must be planned very carefully, case by case, finding compromises between development of economic activities, research, and environmental protection.

2.2. Where and how many?

A traditional criterion for choosing a MPA is the preservation of biodiversity. Biodiversity "hotspots" might be important source areas for the surrounding populations. This principle is well known for fish populations but did not concern benthic ecology for a long time. In recent years, with the emergence of supply-side ecology (Gaines and Rougharden, 1985), the recruitment paradigm of fisheries has been transferred to marine benthic communities. Application of supply-side ecology to the design of MPAs requires the possibility to evaluate the output and input of propagules through the reserve. The future of a given community, in fact, depends on the turnover of the individuals that make it up. Individuals die and are to be replaced. In the long term, thus, it is the supply of propagules that determines the features of a community. In the sea, propagules are easily displaced by currents and a given local population is not usually self-sufficient. It is instead is both a source – exporting propagules that are carried away by currents – and a sink – importing propagules that are brought in by currents – (Pulliam, 1988) (Fig. 1).

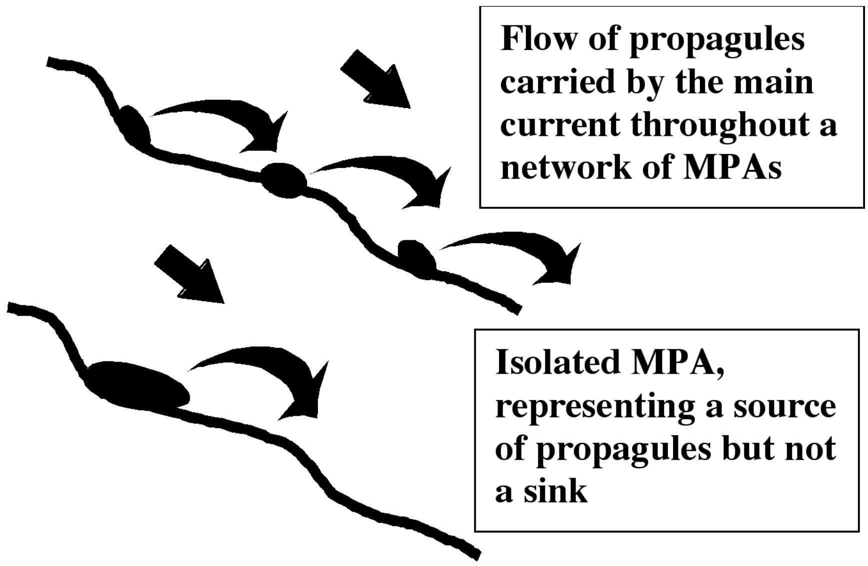

Fig. 1. Alternative scenarios deriving from different modes of MPA design.

Marine Protected Areas are nowadays largely chosen because of their species richness, taking for granted that they supply propagules to nearby areas. Yet a given MPA, instead of being a source, might represent a sink of biodiversity. Maurer (1999) argued, within the framework of macroecology, that a given area inhabited by a very high number of species might be some sort of epiphenomenon summarising situations that are well-established elsewhere. In other words, each species should be very abundant in a low-diversity habitat, where it dominates, and rare in many others. A biodiversity hot-spot, in this framework, is the point of convergence of a series of wider areas, each dominated by few species. The high biodiversity of a single place, thus, should be the outcome of immigration fluxes from nearby populations (Fig. 2).

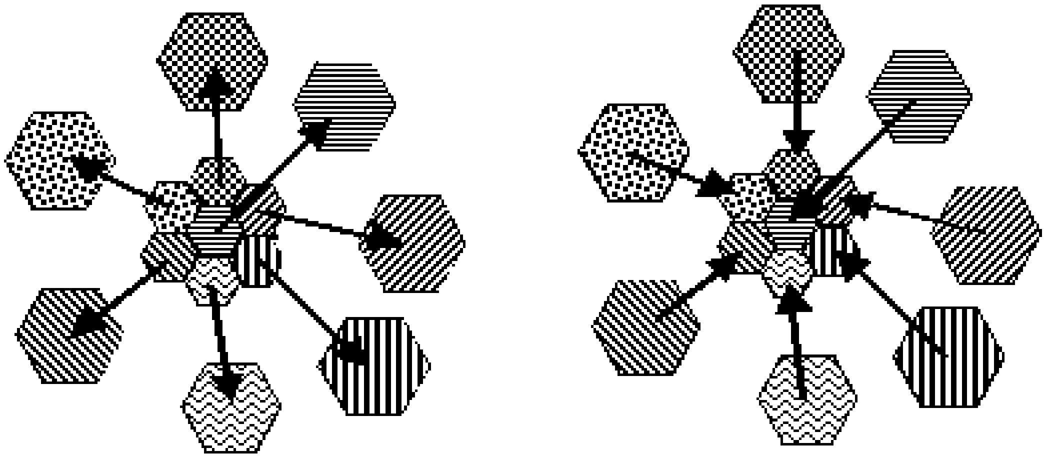

Fig. 2. Alternative views of the properties of a high-diversity spot (hexagons represent distinct populations). Left : source of biodiversity for less diverse, nearby areas. Right : sink of biodiversity from less diverse, but self-sufficient, nearby areas.

Preserving the high-diversity spot without managing its sources will lead to serious dysfunctioning since the non preserved source-sites will soon cease to provide propagule supplies, leading to the extinction of the local populations which make up the high-diversity spot. In this framework, a high diversity spot is a black-hole of biodiversity. A reverse way to look at this picture is to consider the hot-spot as a sensor of the health of the nearby systems which, due to their spatial extension, are much more difficult to monitor. If some stress is identified in the hot-spot, this might be a signal of stress in a much wider area, calling for proper action. This aspect, however, needs more theoretical and field work before contributing to general guidelines of reserve design and monitoring, since a biodiversity hot-spot can be interpreted either as a source or as a sink of biological diversity.

This, of course, should be ascertained during the design phase, but these features have been considered only rarely, if ever. The importance of larval supply for future populations, the very basis of supply-side ecology, is usually considered for commercially exploited species and the protection of nursery areas is one of the main goals of MPAs. Nursery areas are both sinks and sources of biodiversity. Some species, in fact, gather at particular sites to spawn and, thus, these areas are sinks of reproductive efforts for populations inhabiting much wider areas than the nursery site. This, in its turn, becomes a source of biodiversity because, from it, specimens will colonise the area originally inhabited by the population. This situation is well-known for commercial species but is an unexplored ground for all other species. Nursery areas may be indicators of other characteristics of these locations. Giuseppe Lembo showed a very convincing case of "fidelity" to a single, small nursery area around the island of Ustica for the fish species *Epinephelus marginatus*. The fish might have elected that area as nursery ground due to very particular environmental characteristics, thus indicating features worthy of protection. But what are those features? Clearly further studies on fisheries biology – particularly on homing behaviour – will be conducive to the identification of proper sites for MPAs.

Marine reserves of the globe are usually rather large and distant from each other. The "typical" Mediterranean MPA is small, isolated, unlikely to provide long distance dispersal. Such a "design" does not respect the principles of both supply-side ecology and macroecology, and does require a change of attitude. A major question is : how to develop, expand, the current collection of Mediterranean marine reserves into a biologically sound network, which will protect the fullest range of species ? Models like those of Botsford (this volume) do suggest some elements of response, but too little is known about the dispersal of marine species to have a ready answer.

Supply-side ecology, for instance, was developed from studies on barnacles, i.e. individual, intertidal organisms. Most MPAs, however, comprise subtidal rocky coasts dominated by clonal organisms. Individual organisms reproduce just by larvae, whereas clonal ones disperse also by asexual propagules, both in form of fragments or of specialised morphs. These parameters have not only been ignored by ecological modellers with mathematical tools, they are even ignored by field ecologists ! This issue, thus, requires massive inputs of new theoretical and experimental work and might become a key topic of research in MPAs, with a wider bearing on coastal management. The available evidence suggests that networks of many small reserves are better than larger but isolated ones. This issue, however, is far from being settled and recalls the never-ending debate among wildlife managers about the optimal design of terrestrial protected areas (see for instance Channel and Lomolino, 2000). Marine habitats are much more interconnected than terrestrial ones, with propagules dispersing widely, reaching distant sites much easier than on land, a fact to take into account

3. MONITORING

3.1. Which indicators ?

A major difficulty in conservation management is to monitor the efficiency of protection. It is obvious that MPAs are chosen not for particular chemico-physical circumstances but for certain bio-ecological emergencies. Monitoring, therefore, should be mainly bio-ecological. Despite the enormous complexity of the biological world, there is a great need of standardisation and simplicity, as cumbersome procedures would lead to sure failure due to lack of expertise and variability. What are the "right" indicators then ? In the face of uncertainty, and given the multifaceted objectives of MPAs, can there be one basic, universal kit of indicators ? Possibly no, but there has to be a common theoretical framework. A possible approach to this problem is sketched in the section below.

RECOMMENDED MONITORING PROCEDURES

by Simonetta Fraschetti and Antonio Terlizzi, Università di Lecce, Italy

MPAs aim to preserve critical areas, offer spatial escape for overexploited species, and buffer some management miscalculation (Allison ***et al.***, 1998). Yet the design of MPAs, usually, involves little scientific justification. The degree of effective protection, furthermore, is rarely if at all monitored by rigorous sampling programmes (Lasiak, 1999; Garcia-Charton and Pérez-Ruzafa, 1999).

Evaluating the effect of MPAs on natural populations requires the development of rapid, reliable and cost-effective procedures. Whereas most monitoring programmes were developed to determine the putatively negative effect of certain human activities (marinas, sewage outflows, power plants) on target populations, it would be logical to use these procedures to assess also the presumably positive impact of MPAs on biota.

Reserve goals (***e.g.*** maximise reserve biodiversity and population density, sustain yield outside the reserve) have to be explicit : this will help define a target-oriented sampling strategy.

Rocky bottoms, due to their visual impact (as underwater landscapes) and to the high level of diversity of their communities, are usually comprised into MPAs. The sampling methods proposed here apply especially to hard-bottom subtidal marine communities, whose sessile organisms are good indicators of environmental quality. Similar procedures, however, should be applicable to communities associated with other types of substrates.

The choice of controls

A wide array of environmental impacts can be detected by a "beyond BACI'" (Before and After Control Impact) sampling design, using one putatively impacted site and several control sites. Such experimental design requires that data are collected with the same criterion before and after the putative impact (***e.g.***, MPA establishment). Rarely, however, are future MPAs monitored before protection.

The impact of a reserve can be detected by monitoring after MPA institution (ACI, After Control Impact) only if controls are numerous enough to allow an asymmetric comparison with the protected site (Glasby, 1997). With this procedure, the effect of protection will be distinguished from the range of natural variability among sites.

Controls must be chosen randomly from a set of similar locations, but environmental variability makes it almost impossible that any control site is identical to the impacted one. Furthermore, MPAs are chosen for their unique characteristics (***e.g.*** species composition). However, monitoring will provide direct causal evidence only if suitable controls are found.

Summarized from Underwood (1992) and Chapman ***et al.*** (1995), control locations must:

- be unaffected by impact (in this case, protection),
- have the same type of communities as the impacted area (MPA),
- have similar habitat features to those of the impacted area,
- be chosen over a spatial scale covering the dispersal of the sampled populations,
- range from local to regional distributions when protection efficiency is unknown.

Sampling frequency

Sampling design must consider organism turnover. Sampling frequency, however, is often arbitrary (i.e., monthly or seasonal), whereas it is important to detect within-season variability (Underwood, 1993). When such variability is high, in fact, a single seasonal sampling (although in many replicate sampling units) can lead to unrealistic trends, so that short-term variability blurs among-season differences. The best solution then is to choose randomly several sampling times (the same for all locations) for each season. This stresses that the observed trends are not due to short-term fluctuations.

The above-mentioned criteria integrate information derived by univariate analyses, allowing multivariate data analysis. Most multivariate methods, however, do not test for the presence of interactions and do not measure interaction magnitude between spatial differences and temporal change (Clarke, 1993; Underwood and Chapman, 1998). Multivariate analysis of variance requires assumptions about correlations between variable pairs that are rarely met in ecological data sets (Johnson and Field, 1993).

Sampling methods

SCUBA diving sampling is the main source of information on subtidal hard-bottom communities. Sampling, especially in MPAs, must be non-destructive, which will cause a decrease in taxonomic precision as the observer will focus on “conspicuous species” easily recognised ***in situ*** (Hiscock, 1987), and underestimate inconspicuous ones. When possible, data should be collected by quantifying taxa abundance (as percent covering of substrate) in a quadrat frame. For most hard-bottom Mediterranean communities, a 1 m^2 frame is an optimal solution (Gili and Ros, 1984; Bianchi, 1994). However, the sampling surface can vary, depending on community spatial distribution (***e.g.*** high patchiness requires many replicates of small size). Counting operations are facilitated by dividing the frame into 25 quadrats.

When depth prevents long periods on the bottom, and/or when taxonomic expertise is scant, a good solution is to sample by underwater video cameras. Both number and abundance (percentage cover) of species can be estimated from pictures taken on random quadrats by superimposing a grid of 100 regularly spaced points on each picture. The number of points intersecting each taxon is a measure of its abundance. Roberts ***et al.*** (1994), comparing photographic and direct sampling by visual inspection, found that the two methods have a similar efficacy. Photographic methods provide an objective sample (the picture) that can be analysed by many researchers and by computers. Furthermore, pictures can be taken also by non-specialists.

Most workshop participants agreed that, besides the basic abiotic variables such as temperature and water clarity, photographic monitoring of benthic communities is effective and simple, leading to maps of habitat heterogeneity. This should be completed by monitoring the conditions of some conspicuous species such as gorgonians, certain sponges or bryozoans. In the long term, detailed species lists should be compiled, promoting the development of taxonomic expertise. Vertebrates are the most “charismatic” members of the marine fauna and their populations should be monitored by visual censuses. Another issue is the record of exotic species. Sea-grass beds can be monitored by simple and low-cost techniques, for example by marking their edges and see if they move through time. A key issue is to keep track of activities on the shore (development, number of visitors, etc.).

Monitoring environmental conditions in MPAs will lead to long-term series, providing an ideal tool to evaluate, for instance, the impact of global change. If and when countries adopt a coordinated policy of protection of the marine environment, MPAs should consolidate their cooperation to form an essential and reliable network of sensors of environmental conditions. This will require planning basic monitoring activities that should be carried out with the same rationale in all reserves. In this way, besides the conservation and protection of local and neighbouring biodiversity, marine protected areas would acquire additional value for environmental management at a much wider scale. The called-for institution of a grid of smaller and interconnected MPAs (see section 2 above) would see its value reinforced by providing at the same time a precious tool for environmental monitoring which would be maintained within the budget of the reserves, without additional costs.

3.2 Monitoring and regulating tourism (*e.g.* diving)

Tourism usually provides the main source of income for MPAs and growing numbesr of visitors are seen as evidence of success. The experience of the Medes islands (see Zabala, this volume), calls however for caution in considering this activity as having no impact. When a particularly scenic seascape is visited by thousands of divers, trampling can lead to the destruction of hard bottom benthic communities. The extreme case is that of marine caves, where even the air bubbles of SCUBA divers are a cause of community destruction on cave roofs. A possible solution, which is now in use most effectively in the Ras Mohammed National Park, in the Red Sea, was detailed by Jeudi de Grissac (this volume) : before going into a protected zone, divers must follow a short course of environmental education, followed by a practical sub-marine test into an artificial environment mimicking the situation that they will encounter in the field. This offers further employment opportunities and enhances self-control and evaluation by divers, fulfilling one of the aims of MPAs : the increase of knowledge and respect for the environment by promoting ecologically-correct individual behaviours.

4. CONCLUSION

The complexity of marine protected areas is being perceived only gradually through the vast array of approaches that are necessary for their institution and management. The experience accumulated with terrestrial protected areas is only partly useful for MPAs, due to significant differences between terrestrial and marine environments. What we presently know is insufficient to outline a straightforward policy of protection of marine habitats. Ignorance, however, cannot become an excuse for delayed action. Ward *et al.* (1999) proposed, along the lines developed here in section by Simonetta Fraschetti and Antonio Terlizzi, the use of “surrogates” for biological diversity to identify proper sites for MPAs. This stems from a growing disregard and ignorance of taxonomy, making it impossible to identify all the species inhabiting a given habitat. In the short term, it is reasonable to select areas to protect by using “surrogates” for biological diversity. However, unless thorough explorations of biological diversity are undertaken within MPAs, this would soon result in gross errors in the long term. The compilation of detailed species lists, with a map of distribution for each species, should be one of the priorities of research within MPAs. The “surrogate”, in other words, can substitute the “original” only in cases of emergency (i.e., the need of rapid detection of sites to protect), but, once the emergency is over, a return to normality implies the search for “originals”. Another priority is to increase the number of marine protected areas along Mediterranean shores. Mistake detection and correction must derive from targeted research and monitoring carried out within the reserves.

In the absence of declared exclusive economic zones (EEZ) in the Mediterranean Sea, and the resulting vast expanses of water – beyond the 12-mile territorial limit – with the legal status of high seas, it is urgent to reinforce intergovernmental cooperation in marine environmental legislation. The ratification of the new Protocol of the Barcelona Convention, concerning specially protected areas in the Mediterranean will remedy critical gaps in this regard (see Scovazzi this volume). Particularly encouraging is the real prospect that the brand-new International Sanctuary for Cetaceans, established in the Ligurian Sea to protect the eight species of cetaceans common in the area, become the first SPAMI (Specially Protected Area of Mediterranean Interest) officially listed in the Protocol. This will make its protection binding on all parties to the Convention and not just on the three bordering countries (France, Italy and Monaco). This will further strengthen the links between countries with a rather long tradition in marine protection, like France, Spain and, to a lesser extent, Italy, and those that are developing policies in this direction.

This report calls for the development of a coherent, multi-targeted network of Mediterranean MPAs. In such a framework, CIESM will have naturally a role to play, offering its multi-lateral scientific assistance, and helping to analyse and make kniwn the early warning signals of environmental change detected in the system.

II – WORKSHOP COMMUNICATIONS

Global experiences in marine protected area planning and lessons learned

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Marine protected areas are increasingly being used worldwide to protect biologically rich habitats, resolve user conflicts, and help restore over-exploited stocks and degraded areas. The upsurge in the use of the tool is in part due to the fact that fisheries managers are now looking to reserves to complement conventional fisheries management techniques. Many of the newest marine protected areas are more ambitious than conventional marine protected areas, resulting in multiple use reserves that try to accommodate many different users groups, each with their own needs and objectives (Agardy, 1997). Administrators are finding different uses can indeed be fostered without adverse impacts on ecosystem function, as long as planning is based on ecological realities, relies on specific objectives from the outset, and balances established objectives. These protected areas can provide a footing for integrated coastal management and better ocean governance overall. Whatever the scope of protected area, the science of conservation biology has contributed important theories, perspectives, and tools, many of which have been critically tested (Allison *et al.*, 1998).

Marine protected area site selection or placement, design, and type of management all relate to the very specific goals being targeted by the protected area establishment. Therefore, the most crucial information that needs to be obtained is that concerning the specific objectives the protected area is designed to achieve. This information is ultimately societal, not scientific. Subsequent to the elaboration of specific objectives, conservation biology and other sciences can be harnessed to help identify what needs to be protected and in what manner, leading to optimally effective marine protected areas. We should keep in mind that there is no single “model” marine protected area that can be applied in any country, any biome, or any setting. The size, shape, and means of implementation in any single marine protected area will be a function of the primary objectives that protected area sets out to achieve (Table 1). If the goal of a protected area is, for instance, the protection of a single vulnerable habitat type from a specific type of use (*e.g.* protection of a fringing reef system from prospective shipping accidents), the resulting protected area can be simple in both design and management. If, however, the conservation goal targets a wide range of habitats/resources, the protected area will have to be necessarily more complex. Where a functional approach is adopted, in other words where the object of conservation is not a single stock of resources or a single species but the ecosystem and its processes, marine protected areas will tend to be large and encompass many types of linked habitats (Lauck *et al.*, 1998). These large multiple-use protected areas can be thought of as demonstrating the concept of ecosystem-based management, where the limits of protection in a geographical sense are based on the extent to which movements of organisms and physically-linked processes (Hatcher

Table 1. Relationship between marine protected area objectives, size, and design complexity.

SPECIFIC MPA OBJECTIVE	RELATIVE SIZE	COMPLEXITY
Protecting an endangered species	Small to medium	Simple
Protecting a migratory species	Large (or network)	Simple to Complex
Protecting habitat from single threat	Medium	Simple
Protecting habitat from multiple threats	Medium to large	Complex
Preventing overfishing	Small	Simple
Enhancing stocks	Small to medium	Simple
Protecting an area of historic or cultural interest	Small	Simple
Providing a CZM model or empowering local people	Small to medium	Somewhat complex
Promoting marine ecotourism	Small	Simple
Providing site(s) for scientific research	Small	Simple
Conserving Biodiversity	Large (or network)	Simple to complex

et al., 1989; Dayton *et al.*, 1995). The underlying ecology thus defines the outer boundaries for the area of protection, or management unit. In recognizing these linkages, marine protected area planners can work towards conserving ecosystem function, not just individual resources or ecosystem structure.

Marine protected areas are fundamentally different from terrestrial protected areas, though whether these differences are in kind or degree is debatable. An important factor underlying these differences is the nebulous nature of boundaries in the fluid environment of the sea (Steele, 1974; 1998), making it difficult to attach boundary conditions to marine ecological processes and threats to those processes. While this is also true for inland freshwater systems, these ecosystems usually have distinct horizontal layers and more discernable outer bounds. As on land but to a far greater extent, it is impossible to "fence in" living marine resources or the critical ecological processes that support them, just as it is impossible to "fence out" the degradation of ocean environments caused by land-based sources of pollution, changes in hydrology, or ecological disruptions occurring in areas adjacent or linked to a protected area. Long distance dispersal and the vastness of linkages between critical habitats in a coastal and marine ecosystems requires comprehensive management of all its parts (Caddy and Sharp, 1986; Costanza *et al.*, 1993; Mooney 1998).

What can we learn from various experiences worldwide as to the selection of sites for marine protected areas ? To start, a rationale for the protected areas must be elaborated. Strategic criteria for sitting marine protected areas fall under three approaches: 1) preservation of ocean or coastal "wilderness" areas that remain relatively pristine and are usually flagged for their high diversity, 2) resolution of conflicts among users (current or in the future), or 3) restoration of degraded or over-exploited areas. One might view these three categories according to the nature of the intervention through which they become established: 1) the first category is proactive, in that the protection strategy is adopted before degradation occurs, 2) the second category is interactive, as the protection strategy aims to resolve conflicts between users, and 3) the third is reactive, in that the protection strategy is designed to avert continued degradation.

Assuming the marine protected area is being used to protect marine resources and biodiversity, optimize management, and allow recovery of degraded areas, there are basic information needs that must be met in the process of designing, implementing, and maintaining marine protected areas. These data and resulting information must guide:

- where, in a broad geographic sense such as at the ecoregion scale, to establish multiple-use marine reserves and networks of reserves;

• how to design marine protected areas and locate specific sites within them that should be protected as core, no-take areas;

• how to establish regulations and effectively manage the protected area in order to meet objectives; and

• how to monitor and evaluate whether goals are being met, including benefit valuation.

Scientific information on biomass, dispersal patterns, recruitment dynamics, trophic interactions, and critical habitat are often used to design the size, shape, and management of marine protected areas. But what is needed first and foremost, and what is most often overlooked when the process of establishing a marine protected area is initiated, is information on what the protected area is being established to achieve. This goal-setting or objective elaboration is critical in order to determine expectations, effectively design the reserve, and have in place targets and benchmarks against which progress towards the objectives can be measured. Once objectives are elaborated, a management plan (often coupled to a zoning plan) must be developed and implemented. Part of this management plan should be a monitoring program that can shed light on whether objectives are truly being met.

For marine protected areas serving marine conservation generally, there are several essential steps that must be taken to increase the likelihood of success (Agardy, 1997). These steps include:

• clearly define specific objectives for the marine protected area at the onset;

• design zoning to maximize protection for ecologically critical areas and processes;

• design marine protected area boundaries so they reflect ecological reality and be prepared to alter the design as more ecosystem information is derived;

• design the marine protected area and develop its management plan with feasibility in mind;

• make the planning process truly participatory;

• develop monitoring and evaluation methodologies that are appropriate to the specific objectives of the protected area;

• use the marine protected area to raise awareness;

• form an independent, non-partisan or multi-user group body to manage the marine protected area;

• undertake valuation exercises periodically to ensure the full value of the protected area is being realized;

• use individual marine protected areas as a starting point for more effective marine policies overall.

In some cases, individual marine protected areas will not serve to meet the goals outlined, either because the geographic scope of the target area is too vast, or because the threats to the ecosystem are too varied. In such cases conservation and sustainable use is best served through a network of marine protected areas, designed to conserve the wider ecosystem through strategically placed and scientifically determined site protection.

Fishers, nations, and indeed the entire biosphere can benefit from the establishment of marine protected areas at all scales and in all coastal environments. As noted above, the rationale is for marine protected area establishment is no longer lacking – but the courage to go forward is often hard to summon. Despite incomplete knowledge and imprecise science, steps must be taken to establish protected areas now – and use the additional information we gain as time goes on to alter these reserves, remove superfluous ones, and add new reserves. By clearly defining objectives and using science to design the best possible plans for meeting those objectives, we can improve our management of marine activities before the health of the seas is compromised and with it the ability of marine systems to provide us with the resources and services upon which we increasingly depend

La protection côtière intégrée dans l'île de Djerba en Tunisie : réalités et perspectives

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PROBLÉMATIQUE GÉNÉRALE

Djerba est une île continentale séparée de la Tunisie méridionale par un détroit de 2,5 km. Elles est située à 33° 45'(37G50') latitude N et 10° 50'(9G50') longitude E. L'île s'étale sur 30,5 km de l'ouest à l'est et sur environ 30 km du sud au nord. Sa superficie est de 514 km^2; son périmètre est d'environ 125 km. L'écosystème terrestre est caractérisé par son hétérogénéité spatiale et l'aspect en mosaïque de ses milieux et de ses divers biotopes. L'anthropisation, les effets des techniques agricoles – aussi bien traditionnelles que modernes – ainsi que le tourisme et l'urbanisation sont très marqués.

Les éléments du diagnostic sur l'état de l'environnement dans l'île avec ses deux composantes terre et mer ont conclu que :

- au niveau de l'état de l'environnement naturel et humain, l'île de Djerba est passée d'un système de développement traditionnel, cohérent, en parfait équilibre avec l'environnement et résultant des expériences et de la mise en oeuvre de traditions séculaires, à un système dont les composantes sectorielles fonctionnent indépendamment les unes des autres, malgré l'apparente rationalité du fonctionnement de chacune d'entre elles;
- l'absence de coordination entre les composantes sectorielles a conduit à une perturbation des différents éléments du système et à une rupture de l'équilibre ancien sur terre et en mer;
- l'île est passée d'un système de développement intégré, né de l'action de l'homme en accord avec son milieu, ses besoins et ses ressources, à un système qui s'impose à l'homme.

De telles contraintes ont été à l'origine de la motivation à la base pour doter l'île de Djerba d'une stratégie de développement durable basée sur la protection intégrée de son écosystème. Les principales pressions exercées sur l'écosystème sont le fait de l'action de l'homme pour le développement urbain, le tourisme, l'industrie et l'agriculture. Ces pressions se sont traduites sous formes d'agressions à l'environnement.

Une ONG locale, l'ASSIDJE (Association de Sauvegarde de l'Ile de Djerba), a pris l'initiative d'élaborer l'Agenda 21 local de Djerba et de préparer le dossier administratif et juridique pour la création d'aires spécialement protégées sur les zones de Ras Rmell et de Bin El Ouidiane, et les îlots de Borj El Kastill et de Gataya El Kbira.

L'élaboration de l'Agenda 21 local de Djerba a constitué un processus qui a fait évoluer l'attitude habituellement admise pour la gestion du développement au niveau local :

• il a permis de s'éloigner de la politique curative;
• il a permis de s'éloigner au maximum de la politique réactive (connaître les risques pour être prêt à y répondre en cas de besoins);
• il a favorisé la politique proactive par l'anticipation des tendances futures, jugée comme la seule efficace pour un développement durable sur le territoire de l'île et sa gestion d'une façon intégrée.

L'élaboration de l'Agenda 21 de Djerba a constitué un forum de concertation et de mise en cohérence entre les différends acteurs et de planification stratégique. Il a permis de favoriser un type de développement:

• pris en charge par la population locale (les djerbiens);
• pluriel dans un cadre unitaire;
• qui préserve les atouts de l'île avec sa terre et ses mers;
• ouvert sur le monde extérieur.

L'élaboration de l'Agenda 21 local de Djerba a constitué une étape importante d'un processus de communication inter-acteurs au niveau de l'île qui n'a jamais existé auparavant. Le projet de création d'aires spécialement protégées a constitué un processus dynamique impliquant tous les acteurs à l'exception de ceux du secteur touristique qui jugent que de telles initiatives de protection sont susceptibles de geler les activités touristiques et, par là-même, de réduire leurs revenus.

La préparation du projet de création d'aires spécialement protégées a buté sur les indicateurs à prendre en considération pour le classement des territoires en zones protégées.

MESURES RECOMMANDÉES POUR UNE GESTION INTÉGRÉE DE DJERBA

1- Développer et promouvoir un tourisme diversifié, respectueux de l'environnement

Pour développer et promouvoir un tourisme diversifié, respectueux de l'environnement et des spécificités de l'île, il a été proposé:

• d'améliorer la localisation et la qualité des unités touristiques en:
  - œuvrant pour une meilleure intégration spatiale des unités hôtelières;
  - développant des règlements et des normes spécifiques d'urbanisme, de qualité des constructions concernant les consommations d'énergie et d'eau et de traitement des eaux usées;
  - imposant des études d'impact environnemental.
• d'améliorer les rendements environnementaux de l'activité touristique en:
  - contribuant plus directement à la protection de l'environnement, à l'amélioration de l'esthétique et à la réhabilitation des milieux écologiquement endommagés;
  - incitant les hôteliers à récupérer les eaux de pluie et les utiliser;
  - gérant convenablement l'eau utilisée en assurant l'épuration et le recyclage des eaux au niveau de chaque unité ou groupe d'unités hôtelières;
• de promouvoir un système touristique diversifié et respectueux de l'environnement en:
  - développant un tourisme culturel et tourisme de santé
  - déconcentrant le tourisme des zones balnéaires en l'ouvrant sur l'intérieur de l'île.

2- Développer des outils de gestion intégrée et des indicateurs de suivi du développement durable

2.1. Développer des outils de gestion du développement durable

Pour garantir le développement durable sur le territoire de l'île et sa gestion intégrée, il a été proposé de développer une série d'outils de gestion intégrée du développement dont principalement la préparation d'un Plan de sauvegarde et de mise en valeur couvrant la totalité du territoire de l'île.

Cet outil permettra , entre autres d'assurer:

- une meilleure organisation de la totalité du territoire de l'île par le biais d'une plus grande maîtrise de son devenir à moyen et long termes;
- la cohérence entre les différents documents de gestion de l'occupation des sols;
- la mise en valeur du savoir-faire populaire et l'intégration des activités;
- la valorisation de ses potentialités naturelles terrestres et marines, artistiques, culturelles et traditionnelles dans le processus de développement.

2.2 Développer des indicateurs de suivi du développement

La complexité de la problématique du développement intégré à Djerba nécessite la mise en place d'un système de suivi doté d'indicateurs précis. Pour y parvenir, il a été jugé nécessaire de:

- créer un observatoire de l'environnement insulaire de Djerba
- mettre en place un tableau de bord du développement, informatisé et mis à jour périodiquement.

3. Protéger la mer et revitaliser la pêche

3.1. Limiter la surexploitation des ressources marines

Pour rétablir l'équilibre dans le milieu marin, il a été proposé de prendre des mesures susceptibles de réduire les effets néfastes du chalutage et d'aboutir à une restructuration des ressources halieutiques dans les zones côtières. La revitalisation de la pêche côtière suppose une adaptation des prélèvements aux ressources existantes, l'incitation à la promotion des pêcheries fixes. Les petites unités pourront faire des prises sur le plateau continental en respectant des normes strictes de périodes de pêche, de territoires interdits à la pêche et de tailles des espèces à pêcher ou à récolter (poissons, poulpes, éponges, ...).

3.2. Lutter contre la pollution et les sources d'eutrophisation

Pour lutter contre la pollution d'origine chimique, il a été proposé d'intervenir à deux niveaux: à l'origine, par un arrêt total des rejets marins de phosphogypse dans le Golfe de Gabès, et à l'arrivée, dans la mer de Boughrara, par l'activation de la circulation vers la haute mer par les chenaux à aménager sous la chaussée.

3.3. Sensibiliser les acteurs

Il a été recommandé d'engager un programme de sensibilisation et d'éducation à la protection des ressources halieutiques destinée aux pêcheurs et aux exploitants de la mer.

4 - Adapter le cadre institutionnel pour le développement durable dans le cadre d'un partenariat entre les différents acteurs

L'île de Djerba qui forme un substrat solide et bien ancré d'un mode de vie traditionnel, et une plate-forme de civilisations millénaires renfermant un nombre impressionnant d'éléments de grande valeur historique, culturelle et naturelle, constitue la meilleure illustration de l'harmonieuse adaptation de l'homme à son milieu naturel. Cette harmonieuse adaptation s'est vue fragilisée et menacée par les pressions de l'urbanisation, les mouvements des populations, l'utilisation excessive des ressources naturelles terrestres et marines et la faiblesse du processus de conservation et de protection du patrimoine culturel, historique et naturel engagé sur le territoire de l'île de Djerba.

Les problèmes rencontrés sur le territoire de l'île en matière de gestion intégrée des ressources naturelles, et plus particulièrement la biodiversité terrestre et marine, sont le fruit de la non adaptation des modes de planification et de gestion du territoire, adoptés jusque-là, aux spécificités de l'île et aux exigences du développement durable. L'île de Djerba constitue aujourd'hui trois territoires municipaux qui coopèrent rarement ensemble et ne se concertent pratiquement pas sur les questions de développement sur l'île. Ces municipalités ont des préoccupations de gestion de leurs territoires et non de l'île.

L'objectif principal du développement d'outils de gestion intégrée et d'indicateurs de suivi de développement et de l'adaptation du cadre institutionnel, est l'engagement des opérateurs dans un processus de développement basé sur un partenariat impliquant tous les concernés par le développement sur le territoire de l'île et plus particulièrement la population avec ses jeunes et ses femmes, les collectivités publiques locales et ses partenaires économiques, sociaux et techniques.

Ce partenariat doit permettre de:

- identifier toutes les actions devant être menées en concertation effective entre les acteurs principaux;
- établir un code de partenariat et un pacte de solidarité et de complémentarité pour le développement durable de l'île qui tiennent compte des différentes sensibilités, tendances et intérêt sectoriels;
- initier un plan-programme de gestion intégrée de tout le territoire de l'île;
- développer la coopération et la concertation entre les intervenants;
- impliquer pleinement les djerbiens dans le processus de planification des actions de développement et de leur mise en oeuvre.

Structure *versus* organization and function: an approach for the evaluation of a site for marine protection

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The vast majority of past and current efforts to preserve biological diversity have focused on species, sub-species and populations (Primack, 1995). More recently larger-scale approaches, at the levels of ecosystem and landscape, have been considered the only way to conserve the overwhelming mass of biodiversity (Franklin, 1993).

Conservation at the ecosystem or landscape level can be pursued with one of the two following approaches: (a) the institution of natural reserves, or/and (b) the bio-monitoring and management of the ecosystem or landscape health. The two approaches require some degree of integration since the first is mainly based on the analysis of structures, while the second is largely based on the analysis of functions and processes, but is likely to be less effective at least on short time scales

The proposal of a reserve, in the particular case of a coastal marine reserve, is almost always based on structural properties of both the abiotic and the biotic components of coastal ecosystems and landscapes. The reason for proposing the reserve can be the conservation of a particular species or species group, or the conservation of the biological diversity in biodiversity hot spots. The conservation of biodiversity is widely accepted by people, in western countries, as a priority for aesthetic and ethic considerations, in addition to the scientific considerations more relevant within research centers. However, differently from the abiotic structural features of coastal and bottom landscapes, biodiversity and its aesthetic value are not expected to be maintained through time, despite the conservation effort, unless functionally consistent.

The functional consistence of biodiversity with the reserve characteristics and with the reserve management depends on how communities are organized, and which mechanism maintains biodiversity at the local scale. To this aim, ecologists attributed, since more than four decades, a key role to the mechanisms of interspecific coexistence among species of competitors. Here, I will emphasize the relationships between the coexistence mechanisms among species and the design and management of coastal reserves, accounting for the indirect, cascade, effects through food webs and energy flows of any perturbation of the coexistence interspecific relationships.

Interspecific competitive coexistence occurs when the energy input actually available for each population of competitors is only a fraction of the global energy input which potentially would be available, even restricting the field at the competitor guild or trophic level. Therefore, an analysis of the mechanisms of competitive coexistence requires accounting explicitly for the trade-off that constraint the energy monopolization by a single species. These trade-off will set both the conditions under which populations compete and the mechanisms that could allow coexistence (Fig. 1).

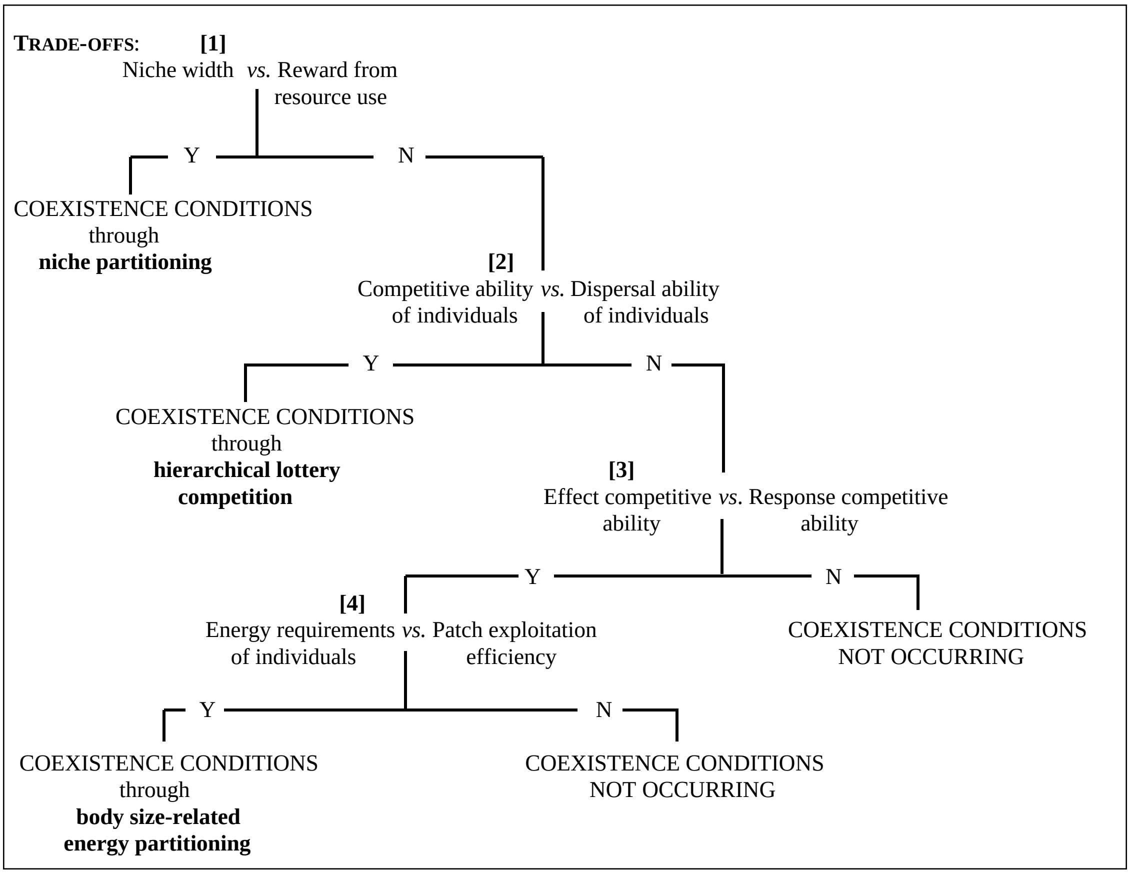

Fig. 1. Trade-offs underlying the mechanisms of competitive coexistence. Trade-offs are organized in a nested hierarchy; their occurrence (Y) or non occurrence (N) set the competitive conditions and their possible outcome.

Two main trade-offs constraining energy monopolization by a single species can be distinguished. The first one is the well-known trade-off expressing the costs of generalism. The second main trade-off is the body size-related trade-off between energy requirements of individuals and patch exploitation efficiency (Basset, 1995), which leads to stable coexistence at a local scale when some degree of interference competition occurs.

In a pure exploitation environment, stable coexistence among competitors can also be related to individual features other than resource use, such as the reproductive strategy, but only at a meta-population scale. Environmental stochasticity can fully release the limits of niche similarity allowing coexistence when a trade-off between competitive and dispersal ability of individuals prevents resource monopolization by a single species at a meta-population scale (Abrams, 1996), through what we can call hierarchical lottery competition as a coexistence mechanisms.

Competitive coexistence can, therefore, depend on three main mechanisms: niche partitioning and body size-related energy partitioning, occurring at the scale of population, and hierarchical lottery competition, occurring at the scale of meta-population.

When community organization within a reserve is based on resource partitioning or body size-related energy partitioning, biodiversity conservation mainly depends on processes occurring locally, within the reserve. All factors affecting the energy flow locally, from those regarding the relative boundaries of the natural reserve and of the ecosystem, to those regarding the stress pressures from the input environments and the management policy *(e.g.* fisheries regulation), are going to be very relevant for the maintenance of the biological diversity. Practical implications regard the reserve size and the fishery regulation. Reserves that are too small, established as subsets of coastal ecosystems, are expected to lose species, especially large species. Both the main features and the number of the species that are going to be lost can be predicted, with some stochasticity, by basic ecological theory. Similarly, wherever fishery had a keystone role, a complete prohibition – even of the traditional fishery – will have cascade effects through the food webs. Ecological cascading is expected to introduce some changes in the community structure, either leading to a global reduction or to a global increase of the biological diversity within the reserve, according to the niche of the previously harvested species; at least in some guilds a reduction of biodiversity is expected as a result of the conservation strategy selected.

In many coastal reserves, community organization is based on hierarchical lottery competition. It can be a common case at the guild level, especially as regards the guilds of sessile benthic invertebrates with complex life cycles (Roughgarden *et al.*, 1988). In these cases, biodiversity conservation is likely to depend on processes occurring outside the reserve. This should lead to network composed of a number of reserve patches, controlling the distance among reserves and the variance in reserve quality, in order to obtain asynchronous population dynamics allowing meta-population stability. However, relatively large reserve are easier to manage than a network of small reserves and relatively large reserves are also a better choice in case of a community organization based on resource partitioning or body size-related energy partitioning. Therefore, communities organized through hierarchical competitive lottery are generally far from equilibrium at the reserve spatial scale and largely depend on the management of the marine ecosystem health at a much larger spatial scale.

Coexistence relationships among species also regulate the propagation of perturbations within food webs and allow to evaluate the expected influence of potential agents of perturbation, which are likely to modify either the availability of limiting resources or the dispersal of individuals. Therefore, coexistence mechanism implications at the community level can supply useful tools for monitoring the ecosystem health within a marine reserve. In particular, in case of guilds structured by body size-related energy partitioning, body size spectra could be a useful tool for monitoring, since they are simple to detect and with an highinformation content. Evidence arising from different aquatic habitats shows that body size spectra tend to be relatively constant (Basset, 1994) but sensitive to different types of perturbation, from eutrophication (Sprules and Munawa, 1986; Bourassa and Morin, 1995) to metal pollution (Dadea *et al.*, 1996). To what extent community organization in marine habitat is actually related to body size related energy partitioning is still unknown. However, according to the knowledge acquired on freshwater habitats, body size-related constraints could play a relevant role in the organization of soft-bottom benthic guilds of decomposers, of invertebrate and vertebrate guilds of predators and of planktonic guilds. For such cases, I propose that variations of the body size spectra through time or space could be a simple indicator of changes in the health of the aquatic ecosystem.

In conclusion, the theoretical background of community ecology suggests that the choice of definite boundaries and management policy for a coastal reserve can either manage to maintain the biodiversity or fail, according to ecological functional constraints, which regulates the inter-specific competitive coexistence at the local site. Therefore, an understanding of the mechanisms underlying community organization may provide useful information both for the design of the coastal marine reserves and for their control and management.

Marine protected areas in the Mediterranean Sea : Croatian experiences

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In Croatian part of the Adriatic Sea marine environments are primarily protected under two categories: national parks and special reserves in the sea. Laws for national parks are proclaimed by Parliament, and special reserves in the sea by County's assembly.

National parks were originally designated for their terrestrial natural characteristics, mostly because of "nice landscapes". These include Brioni islands, Kornati islands and island of Mljet. There were no, or very limited, scientific data that would backup protective designations. Recently, national park boundaries were extended to include surrounding marine areas.

Special reserves in the sea, Limski canal and Mali Ston bay, are historical bivalve aquaculture areas that have been protected with the purpose of protecting present and future production of bivalves. Examples of island of Mljet and Mali Ston bay are presented in this paper.

Island of Mljet National Park

The island of Mljet is an offshore South Adriatic island extending 37 km in NW-SE direction. In 1960, northwestern part of the island has been proclaimed a National Park (NN 49/1960). Specific coastal line, rich terrestrial flora and valuable cultural heritage were primary reasons for the establishment of this national park (Braliç, 1991). Main feature of the park is two saltwater lakes: Malo jezero (Little lake) and Veliko jezero (Big lake). Comparing to world trends in marine protection, inclusion of Malo and Veliko jezero into national park boundaries is an example of early recognition of need to protect marine areas. Marine flora and fauna of Malo and Veliko jezero have been protected since 1976 under Law of nature protection (NN 54/1976).

Following intensive research of marine biodiversity in areas surrounding Mljet islands (Orepiç *et al*., 1997), recommendation has been made to extend park boundaries to marine environment. In 1997, marine area up to 500 m away from the most protruding coastal landmarks on Mljet island and accompanying little islands was included in Mljet Island National Park territory (NN 13/1997). This increase in National Park territory requires changes in management that are slowly taking place.

Some types of subsistence fishing by local people are allowed in Mljet National Park, except in saltwater lakes. Collection of bivalves and other marine organisms is forbidden. This is a compromise solution between need of local people and protection of biological resources. Main advantages to preservation of marine part of Mljet National Park are relative isolation of the island, small visitation and islands offshore position – far away from coastal pollution. Problems that it faces include unsolved question of private property, non-existence of modern infrastructure (*e.g*. sewage treatment for local households), inappropriate garbage disposal, and lack of educated staff in the authority of National Park.

Mali Ston Bay

Under current Croatian legislation there is no protection category for marine areas whose objective would be preservation of natural stocks used for human consumption. Mali Ston bay has been important bivalve aquaculture area since ancient Romans and medieval Republic of Dubrovnik. During 1970s and 1980s threats from pollution occurred, and in 1983 Mali Ston bay has been proclaimed a special reserve in the sea (NN 3/1983).

Special reserve is an area in which one or more undisturbed natural characteristics are evident, and are of special scientific importance and purpose. Actions that could jeopardize characteristics, for which reserve was designated, are not allowed on its territory and county administration is responsible for its management (NN 30/1994).

It is clearly evident that special reserve category is not appropriate one for the Mali Ston bay. Being aware that future environmental problems could appear because of new political facts (area is located between Croatia and Bosna and Hercegovina border), in 1998, Dubrovnik-Neretva County assembly considered protecting it under category of strict special reserve, but later gave up on the idea.

Conclusion

Future designations of protected areas and level of assigned protection need to be based on scientific proofs. Preservation objective and management plans need to be clearly evident, whether it is species (endem) oriented protection or protection of specific ecosystems or regions, including proves for that. Evaluation of potential marine protected areas and plan for their designation are included as one of the objectives in the “Strategy and action plan for protection of biological and landscape diversity of Republic Croatia” (NN 81/1999). Need for the establishment of zoological marine reserves, *e.g.* for dolphins, is contained in the same document.

Interests of local population, such as fishing rights, should not be put in front of preservation objectives, as has been done previously. Local people should be encouraged to actively participate in protection and to seek alternative jobs that are compatible with preservation objectives.

Other problems related to designation and management of marine protected areas include lack of proper legal tools, scarce knowledge on species distribution and environmental preservation/degradation, lack of interdisciplinary experts such as natural resource managers and financial costs involved in managing and monitoring marine protected areas.

A summary of theoretical results regarding the design of marine reserves

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Because there have been few opportunities to learn much about the effectiveness of marine reserves empirically, we have explored theoretical approaches as an initial basis for their design. Here I review what has been learned about the performance of marine reserves through modeling, primarily over the past decade.

Application of yield-per-recruit models to the problem of marine reserves began with Beverton and Holt (1957), and was continued recently by Polacheck (1990) and DeMartini (1993). The major result from those studies was that the benefits accrued directly from fishing juveniles and adults (i.e. ignoring larval dispersal) were greatest for species with intermediate rates of movement. A number of recent studies have explicitly included reproduction in addition to growth and mortality (Quinn *et al*., 1994; Holland and Brazee, 1998; Sladek Nowliss *et al.,* in press). The major result from these studies was that the addition of reserves increased fishery yield if fishing effort was high enough that the fishery would otherwise be overfished. Knowing whether reserves will benefit a specific fishery therefore depends on knowing how hard it is being fished relative to its sustainable level, which is often uncertain.

For the red sea urchin fishery in northern California, we have used a decision analysis approach to determine the fraction of coastline in reserves that will maximize yield, given this uncertainty (Botsford *et al*., 1999). Our recent finding that for the case of sedentary adults and post-dispersal density-dependence only, managing a fishery using classical effort control produces the same yield as managing using reserves is closely related to this result (Hastings and Botsford, 1999). That finding can serve as a benchmark to qualitatively judge other similar cases.

Almost all of these studies have focused on the benefits of reserves to fishery yield, with little attention to the effects of reserves on population persistence. For the most part they have not explicitly included the effects of dispersing larvae.

In a recent study we determined the effects of marine reserve sizes and spacing on population persistence using a model with an infinite coastline, periodically spaced reserves and dispersal exponentially decaying with distance (Botsford and Hastings, ms). The results indicate that for species dispersing long distances (relative to reserve size), the fraction of coastline that must be placed in reserves is equal to the fraction of natural lifetime reproduction required for population persistence. For species dispersing shorter distances however, smaller fractions of the coastline can be put in reserves, if they are made larger (i.e., on the order of one or two mean dispersal distances). This result highlights the consequence that reserves will generally provide better recruitment for shorter distance dispersers. We are currently exploring the community level consequences of this.

South Sinai protected areas network : from a vision to a success and the coming challenges and risks

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Recognising the close linkage between coral reefs, reef associated marine environments and its ambitious tourism development objectives for Southern Sinai, prompted the Government of the Arab Republic of Egypt to establish a network of marine and terrestrial protected areas to conserve critical natural resources and thereby supporting national economic development policies. Government objectives supported by the Commission of the European Union are being realised, coral reefs and associated marine ecosystems on the Gulf of Aqaba are now fully protected, zero discharge policies are strictly enforced, coastal alterations are prohibited, artisanal fisheries are regulated and consensus on management issues with resident communities has been achieved. The South Sinai Protectorates Development Programme owes its success to strong legislation, unwavering Government support and to the establishment of functional partnerships with the local community.

Background

The Ras Mohammed Marine Protected Area, declared in 1983 following the return of the Sinai Peninsula to Egypt, lay dormant as a paper park until 1988. The Marine Protected Area declared by Law 102 of 1983 set aside an area of 97 km^2 (0.6% of the Egyptian Gulf of Aqaba littoral) containing coral reefs of international significance at the southern tip of the Sinai Peninsula and the island of Tiran at the entrance to the Gulf of Aqaba. Tourism development was already planned for coastal areas immediately adjacent to the declared boundaries, commercial fisheries were practiced within the boundaries, and recreational pressure on reef resources was mounting. Faced with the prospect of losing economically valuable natural resources, the Government of the Arab Republic of Egypt instructed its Environmental Affairs Agency (EEAA) to secure technical assistance to develop and manage Ras Mohammed.

An ambitious project designed to manage the Ras Mohammed Protectorate was initiated in 1989 with assistance from the Commission of the European Union. Immediate actions identified by a project feasibility report (Pearson, 1988) resulted in:

- the re-definition of the Protectorates boundaries and increasing its area to 210 km^2;
- upgrading its status to Category II - National Park;
- establishing immediate management based on existing legal instruments pertaining to Protected Areas in Egypt; and
- initiating resource monitoring programmes to evaluate and if necessary modify management measures.

This initial development phase lasted 30 months and established the principles that were to define the development of Egypt's protectorates management policies for the 21st century.

Positive performance evaluations led to additional support from the Commission of the European Union to assist the EEAAin developing two newly declared Protectorates at Nabq and Abu Galum on the Gulf of Aqaba. These areas, declared in 1992 as Category VI Managed Resource Protected Areas permitted the EEAAto conserve and manage 52% of the Egyptian Gulf of Aqaba littoral as an integrated and linked network of distinct protectorates. Further declarations in 1996 added the remainder of Egypt's littoral on the Gulf of Aqaba to the Abu Galum Managed Resource Protected Area, expanded the boundaries of the St. Katherine Protected Area (Declared in 1987) and added the Taba Protected Area in 1997. At present, the South Sinai Protectorates network is complete and covers over 12,000 km^2 of land and sea or 40% of Southern Sinai. Declaration of the above mentioned areas followed an extensive appraisal of planned development activities in Southern Sinai. Coastal environments were surveyed and classified according to uniqueness and sensitivity. Terrestrial environments were subjected to similar appraisals given the linkages between marine and terrestrial environments. The studies led to the formulation of a plan that established Protected Areas adjacent to planned tourism development zones on the Gulf of Aqaba. In so doing, development areas would be sandwiched between large protected areas providing for space, undisturbed natural systems, economic opportunities in nature based tourism, and a mechanism to effectively regulate development activities on an equitable basis firmly rooted on the principles of common property resources.

South Sinai protectorates: driving forces and management objectives

With its rich history dating from Neolithic periods, the Sinai has witnessed some of the great events that have shaped our civilization. Today the Sinai has been targeted as a major tourism destination servicing European markets. Its wealth of both marine and terrestrial natural resources has become a catalyst for investors wishing to capitalize on the attributes of the destination and its proximity to Europe. The following elements are the reason of the on-going success of the network of protected areas and of the connected development zones.

Legislation

Law 4 of 1994 on the environment and Law 102 of 1983 on protected areas are the base of the protection. Penalties are applied by the courts according to these texts including a set of rules taking actual restoration and recovery costs into consideration, i.e. the so-called financial values of restoration.

Tourism development

The Egyptian Environmental Affairs Agency, conscious of the detrimental consequences of rapid, unplanned tourism development, realised that the resource based economic value of South Sinai would be lost if measures were not taken to strictly enforce protection measures to conserve its marine and terrestrial ecosystems. Expansion and development of a tourism based local economy is reflected by the number of beds available in the area (1030 in 1988, 14,000 end of 1997 and 60,000 expected in 2002) (World Bank 1997 and SSS/EEAA 1999).

Population and employment

In 1986, the local population of Bedouins represented about 5,000 inhabitants. This number has slightly increased up to 7,000. On the other side the resident and working population (hotels, tour operators, services) shared between Sharm El Sheikh, Dahab, Nuweiba and Taba has drastically changed from less than 1,500 in 1986 to about 60,000 inhabitants in 1999.

Land tenure and land management

Different institutions have jurisdiction in the land management in South Sinai and Egypt. The Governorate of South Sinai with its City Councils and the Tourist Development Agency (TDA) are the central government's principal local institutions. Other areas are under special jurisdiction of Egyptian Environmental Affairs Agency (EEAA) responsible for National Parks and Protected Areas.

There are four city councils along the Gulf of Aqaba: Sharm El Sheikh, Dahab, Nuweiba and Taba. They are urban areas, which take up approximately 33% of the coastline. These areas are under the management of the city council and the governorate. They have the responsibility for the public services, such as solid waste management, potable water, wastewater treatment, infrastructure such as roads, etc. Electricity is provided through the Ministry of Energy and health and education services through respective ministries.

TDA is responsible for selling land to tourist developers. Each investor is responsible to provide infrastructure, such as roads, wastewater treatment, solid waste management, desalination plants, etc. This creates a situation where there is no collective solution for public services, including the final disposal of solid waste.

Tourism

Most of the tourists visiting the South Sinai are of European origin. From about 160,000 in 1990, the number of tourists has reached 700,000 in 1996 and near 1,000,000 in 1998. The protected areas of Ras Mohammed and Nabq are presently subject to entrance fees. The number of visitors by land and by sea has grown from about 14,000 in 1990 to more than 120,000 in 1998.

Investment from the public sector

The central government, as well as the local government invests considerable funds in infrastructure and public services. The Governorate of South Sinai channelled approximately 5 millions Egyptian Pounds for infrastructure development to the Sharm El Sheikh city council in 1998. Furthermore, the Ministry of Energy funded investments within its sector and the New Urban Societies under the Ministry of Housing funded other investments.

Private sector involvement

The estimated value of the properties (hotels and shops) built by the private sector is estimated to 16 billions Egyptian pounds end of 1998 (Source City Council of Sharm El Sheikh). This represents about 5 billion US Dollars. The annual income corresponding to all operation (hotel, land and sea) is estimated to be 18 billions Egyptian Pounds or 6 billion US Dollars in 1998.

Government implication

During 1989, following request from the Government of Egypt, the European Union agreed to provide technical assistance to the Egyptian Environmental Affairs Agency to develop and manage Egypt’s first marine protected area at Ras Mohammed. This project was founded on the principle that coral reefs of outstanding quality and international importance should be afforded special treatment and legal protection to ensure their survival for future generations, thereby providing a guarantee to the government’s economic development programmes in South Sinai. This project achieved its objectives by developing Egypt’s first national park. It also was to become the driving force for an ambitious natural resource conservation and management programme over the following eight years.

Present evolution

The project has been in place during a period that has witnessed rapid expansion of the tourism sector in Southern Sinai. Preceding the development phases, the Ras Mohammed National Park Development Project and its subsequent phases has been instrumental in regulating and managing tourism development in Southern Sinai.

Its effect has been clearly demonstrated and as a result; the integrity of coastlines has been preserved; coral reefs have been protected; water quality has been maintained through a complete prohibition of either direct or indirect effluent discharges into coastal waters; the collection and sale of marine curios has been prohibited; inland desert areas are receiving increasing protection; aggregate and commercial stone quarrying is being regulated; targeted public awareness programmes are effectively reducing damage to economically important natural resources; and most importantly, functional partnerships with private sector interests in the region are being forged to assist our nature conservation efforts.

Egypt's Protectorates programmes in Southern Sinai have not only maintained the integrity of coastlines, coral reefs and desert ecosystems but have also provided services beyond our original expectations. These being:

- the provision of assistance to the South Sinai Governorate enabling it to plan and regulate development activities more effectively;
- the provision of assistance to the General Organization for Physical Planning to include environmental parameters into the planning of both urban and touristic development areas;
- the provision of assistance and support to the tourism sector through regulatory measures that have translated into higher occupancy and room rates and which have maintained the value of Gulf of Aqaba destinations;
- the provision of strong marketing tools enabling investors and resort management groups to tap into the rapidly expanding nature based tourism market;.
- the enhancement of the Government's credibility as regards its intention to support and sustain its environment programmes;
- the close relationship between environmental quality, natural resource conservation and economic development have been clearly demonstrated by the South Sinai Protectorates Development Programmes. These programmes can be replicated in Egypt, not only in terms of protectorates management, but in the environment sector in general.

The challenge

The Government of the Arab Republic of Egypt is committed to a programme of environmental management that will arrest environmental degradation and gradually improve environmental quality and hence the quality of life of its population. This objective is essential if Egypt is to achieve and sustain its economic targets. To this end, the Government is setting achievable short term objectives to protect and manage natural resources, regulate and gradually eliminate sources of water and air pollution, restore degraded habitats, improve and modernise waste disposal systems, improve water quality, reduce the use of persistent toxic pesticides, and in general prevent losses in social welfare of future generation by protecting intergenerational equity (resources and opportunities left by the present generation to future generations).

The vision

As noted previously, and in order to maximize the benefits accrued to Egypt from donor assisted projects, the Government favours a strategic sectoral approach to environmental programmes that will address all related issues. This position is based on the recognition that environmental issues are a common denominator to all development programmes be they targeting economic and industrial development, agriculture, joint venture initiatives, public health, tourism, etc.

The successful implementation of the Protectorates Development and Management Programmes in South Sinai have demonstrated that a single project having the correct objectives can generate consensus between different line Ministries and implementing Agencies thereby reinforcing and sometimes adjusting economic development objectives.

The role of MPAs for the sustainable use of marine resources : problems related to a cost-benefit analysis

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In recent years, several international fora did recognise the role of Marine Protected Areas (MPAs) as effective remedies against the modifications occurring at fish community level (the so-called fishing down marine food webs). Indeed, "fishing refugia" could guarantee the recovery of long-lived large species (predators) stocks contributing to the long-term sustainability of fisheries and biodiversity. Furthermore, MPAs, besides protecting marine species and habitat, may:

- ensure continued recruitment by maintaining a critical spawning stock biomass that acts as a propagule source for the surrounding areas (recruitment effect);
- serve as centres of dispersal of adults into the surrounding areas (spillover effect).

Thus, marine reserves may form a more effective management option for stock maintenance, particularly where conventional fisheries management strategies are difficult to apply. This condition often occurs in Mediterranean coastal areas as well as in coral reef ecosystems. In such situations, closed areas may be particularly effective, as fisheries are almost always multispecies and multigear, landing their catch at many sites over a wide area. These features make difficult the adoption of conventional management rules.

Fishing refugia may also play an important role as a buffer against management errors and recruitment failure. Modelling suggests that marine reserves can function as a hedge against inevitable management limitations, thus greatly enhancing the long-term sustainable exploitation of fishery resources (Lauck *et al.*, 1998). They would not only protect the long-term future stocks, but also yield higher average catches in the adjacent areas.

The evaluation of the effectiveness of a marine protected area, in terms of sustainable use of marine resources needs the development of a proper and standard methodology for a qualitative and quantitative cost-benefit analysis. In the designing phase, when the extent of the no-take areas has to be estimated, mathematical models assessing the effects of a marine reserve on the basis of the carrying capacity and the maximum per capita growth rate of the population (Lauck *et al.*, 1998) could represent suitable tools. Moreover, estimate of the spatial distribution and density level of recruits in the fishing ground, according to the Beverton and Holt concept, could give further useful elements.

The delimitation of nursery areas and the assessment of recruit abundance by geostatistics may provide suitable information for the appraisal of MPA spillover effects in the spatial dimension. The gathering of data on species behaviour and their movement dynamics is preliminary to all approaches. To this end the application of telemetry techniques may furnish a substantial input of information. Other aspects enhancing the cost-benefit analysis concern the evaluation of the diverse economic use of the resources, such as the role of ecotourism.

Marine reserves : US experience in a Mediterranean context

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The use of marine reserves for fishery enhancement and conservation of biodiversity is relatively new, compared to the long history of reserve establishment in terrestrial systems. The first Marine Protected Areas (MPAs) were established in 1964 in South Africa, 1975 in the USA, 1977 in New Zealand and 1986 in the U.K. (Attwood *et al.*, 1997). Recently, MPAs have received great attention and have been viewed as an alternate or additional means of managing fisheries. The proposal to set aside 20% of the US coastline as reserves by year 2020 (Schmidt, 1997) is an example of the attention recently placed on reserves.

Expected benefits provided by marine reserves include: (1) protection of spawning-stock biomass supplying fished areas via larval dispersal; (2) maintenance or enhancement of fish yields in areas adjacent to reserves through adult dispersal; (3) protection of whole communities, including non-target species; (4) protection of critical habitats; (5) opportunities for science, education and tourism. Presently, however, only a very small proportion of the US coastlines is protected from human disturbance and extractive uses. For example, only 0.2% of the California coastline has total protection from extractive resource use, while only one or few species are protected along an additional 5.3% of the coastline (McArdle, 1997).

In contrast to terrestrial ecosystems, where a great deal of data and theory are available to guide the design and management of conservation reserves, an ecological basis for the design of marine reserves is largely lacking. J. Lubchenco (Oregon State University), S. Palumbi (Harvard University) and S. Gaines (University of California, Santa Barbara) have convened a working group at the National Center for Ecological Analysis and Synthesis (NCEAS), Santa Barbara, California, with the objective of developing a theoretical and empirical basis for designing and managing marine reserves.

Although this effort is ongoing, some generalizations have emerged. A synthesis of the available data comparing marine fish and invertebrate communities before and after the establishment of reserves or between reserves and control, unprotected sites revealed that reserves contain greater abundances, biomass and diversity and larger organisms compared to fished areas (Halpern, 2000). Thus, reserves effectively protect at least a subset of the species in the community. Interestingly, even the smallest reserves (a few hectares) in the dataset host greater biological abundance and diversity than adjacent unprotected sites (Halpern, 2000). Estimated dispersal distances of species in coastal marine communities of the western US suggest that small (a few km long), isolated coastal reserves are likely to protect only a subset of the species present (Grantham *et al.*, 2000). Case studies and theoretical models examining effects of reserves on species interactions show that reserves may alter the structure and dynamics of marine food webs by affording differential protection to species linked through predator-prey and competitive interactions (Micheli *et al*., 2000). Thus, reserves are expected to affect the composition of marine communities both directly, through the differential responses of species to protection, and indirectly, through species interactions and "cascading" effects of protection.

Theoretical models suggest that managing a fishery using reserves can produce the same yield as managing using classical effort control (Hastings and Botsford, 1999; Botsford, this volume). Thus, reserves can maintain fish yields while providing additional benefits not provided by effort control, such as protection of habitat and of non-target species. Metapopulation models (Andelman *et al*., 2000), considerations based on the dispersal ability of marine species (Grantham *et al*,. 2000) and distribution of both natural and anthropogenic disturbances, such as hurricanes and oil spills (Allison *et al*., 2000) indicate that networks of reserves are needed for the long-term persistence of marine populations and communities. Moreover, networks of reserves are a prerequisite for implementing adaptive management of marine reserves and directly compare the effectiveness of alternative reserve designs and management strategies (Murray *et al*.,1999).

These results suggest that the small, isolated marine reserves typically found in the Mediterranean are effective in enhancing the abundance of some species, but are unlikely to allow the long-term persistence of Mediterranean marine communities in the face of increasing human impacts and environmental change. The need for establishing reserve networks protecting a range of representative Mediterranean habitats and species should guide future sitting of new reserves.

The international sanctuary for Mediterranean cetaceans : criteria for its origin and implementation

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The international sanctuary for Mediterranean cetaceans is a marine protected area, covering some 96.000 km^2 in the Ligurian Sea. Located between NW Italy, S. France and N. Sardinia, it encompasses Corsica and the Tuscan Archipelago (Fig. 1). The main goal of the sanctuary is to conserve and manage important pelagic habitats for Mediterranean populations of cetaceans, which include eight regular species (Notarbartolo di Sciara, in press). The agreement among France, Italy and Monaco, which will establish the sanctuary, was signed in Rome on

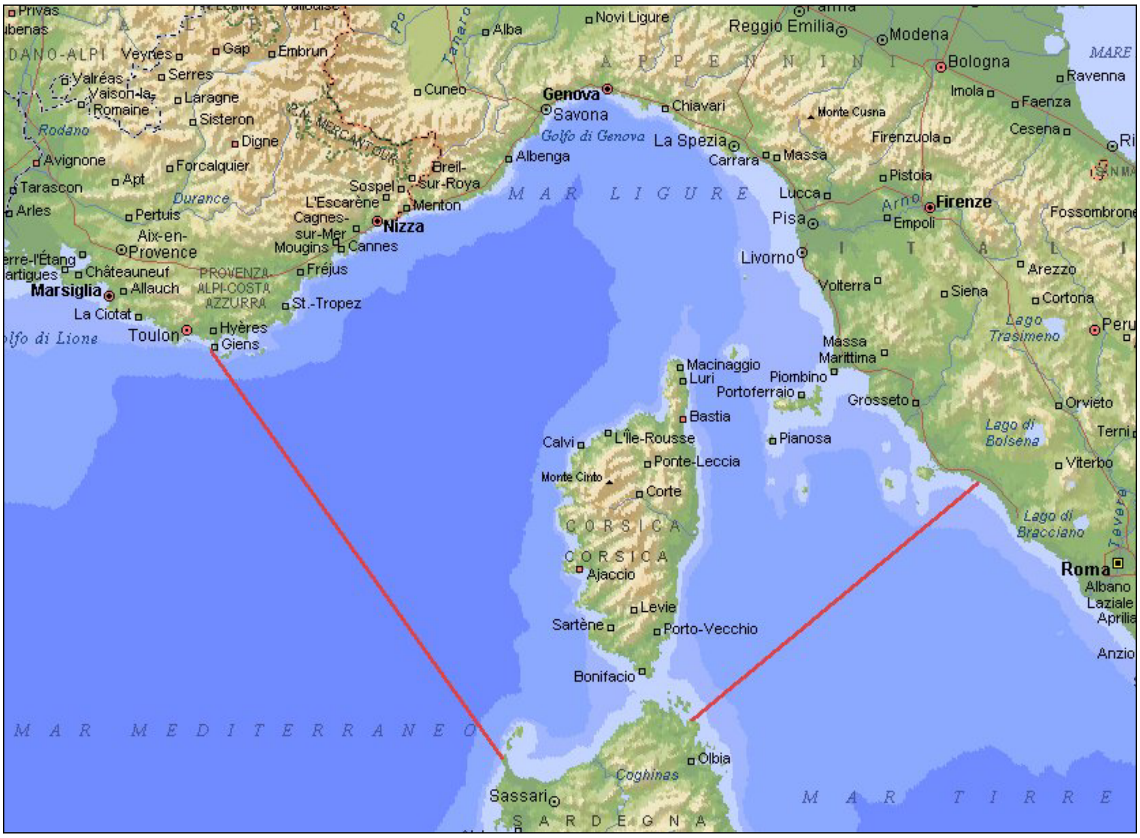

Fig. 1. The area of the Sanctuary

25 November 1999. To achieve the final goal of putting the sanctuary in place, criteria were needed for the definition of baseline conditions, necessary for the creation of the marine protected area:

- boundary conditions which provided the impetus for the proposal of the sanctuary: faunal richness due to conditions of exceptional primary productivity (Forcada *et al.*, 1996; Notarbartolo di Sciara *et al.*, 1993; Orsi Relini *et al*., 1992), and lack of an international legal framework which could afford adequate protection to such vulnerable richness;
- choice of location, centred around the upwelling zones and corresponding faunal hotspots;
- choice of boundaries, initially based on practical considerations, and later a result of political negotiations;
- finally, a cost-benefit balance concerning a multiplicity of user groups which leaned strongly on the benefits' side.

Now that the sanctuary is officially established, other criteria will be needed to ensure that the marine protected area is appropriately managed and functioning. These will include: the definition of a clear set of objectives, and, accordingly, criteria for the subdivision of the sanctuary in zones for different levels of use and types of human activities. To do this, basic knowledge will be needed on the distribution and natural variability of the major life-supporting processes within the pelagic ecosystem, on the distribution of the essential habitats of its major faunal components (*e.g.* krill, filter-feeders and top predators), and on the types and extent of the main human activities in the area.

Although a large amount of data is already available, a wide, international effort will be needed to identify knowledge gaps and to emphasise research priorities. Within such conceptual framework ICRAM is proposing a co-operative research programme at the national (Italian) level, which will then need to be harmonised within a wider, international scenario.

Marine protected areas : conservation of biodiversity and enhancement of fisheries

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BACKGROUND

Three main goals of protected areas are generally recognised (IUCN, 1978; UNEP, 1987):

- to preserve biological diversity, maintain essential ecological processes and life support systems;
- to ensure the sustainable use of species and ecosystems; and
- to protect environmental quality, the health and safety of coastal communities and of resource users.

In the marine sphere environmental protection is more complicated than in the terrestrial one:

- physical barriers, no defined limits;
- no precise ownership;
- complex (local, regional, national) administrations; confluence of various uses which generate conflicts.

This complexity and confluence of interests as well as administrative conflicts render integrated management difficult. Often, the strategy adoption of use optimisation (selection and regulation of activities) is very difficult to apply, since the pressure of the distinct sectors involved supposes the reorganisation of the activities, or else the administrations impose their authority in a restricted sense.

Marine Protected Areas (MPAs) must be situated in this context. However, and as pointed out in the background document of the present workshop: "... *a marine reserve is a very complicate object to design and to deal with, (...) and its implementation requires a multidisciplinary approach*".

PLANNING AND ZONING

To resolve these conflicts, a serious and objective planning is necessary, in search of the elusive equilibrium : conservation versus. exploitation. In this sense, MPAs represent an interesting tool for biodiversity preservation and sustainable development (as traditional fisheries activities).

There are many different approaches to marine protected area planning, management and administration. The choice of approach should be influenced by the prevailing resources as well as environmental, social, political, and economic parameters (Salm and Dobbin, 1993). Thus, we should be to consider in MPAs three interrelated components:

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

The participation of the local communities in the marine conservation and the management of the marine resources is indispensable (Wells and White, 1995). Socio-economic activities must be compatible with environmental preservation, by establishing limits to the development by zoning.

The main objectives of zoning reflect the objectives for managing marine protected areas and aim usually (Keller and Kenchington, 1992; Laffoley, 1995) to:
• provide protection for critical or representative habitats, ecosystems and ecological processes;
• preserve certain zones of the marine protected area in their natural state, undisturbed by humans except for the purposes of scientific research or education;
• separate conflicting human activities;
• protect the natural and/or cultural qualities of the MPA whilst allowing a spectrum of reasonable human uses;
• reserve suitable areas for particular human uses, whilst minimising the effects of those uses on the MPA.

In this regard, the philosophy of the Biosphere Reserves (MAB Program, UNESCO, 1987) may be of some value to MPAs, as they integrate three basic functions:
• conservation function: preservation of the different levels of biological biodiversity (genetic, taxonomic, habitats, ecosystems).
• logistic function: focused research and monitoring from inside and outside the protected area, as well as supplying services for education and information.
• development function: to allow traditional uses and low impact socio-economical activities, which sustain a rational and continuous exploitation of natural resources; and cooperation with local populations.

Several important aspects of zoning (Laffoley, 1995) must be kept in mind as well:
• large management areas are easier to zone than smaller areas;
• zones should encompass all acceptable uses;
• there should be a gradation from least through most heavily protected zones, to buffer and transition zones;
• simple zoning schemes are easier to understand by users than complex ones;
• traditional users of the managed area should be consulted and involved in the development and implementation of management plans.

3. AN EXAMPLE : THE MARINE RESERVE OF TABARCA (ALICANTE, SPAIN).

According to the objectives of the workshop, we will introduce the example of a small MPA (1400 ha) with a zonation that considers at least three zones:
• a core area or integral reserve zone with total protection (at least 10% of the MPA);
• a buffer zone, where some low impact activities may be located (trap-net and trawl-line fisheries, SCUBA diving ; at least 40% of the MPA); and
• multi-use or peripheral area, offering free access but with certain limitations to users (50% of the MPA).

Some examples of habitat protection and small-scale fisheries enhancement will be presented.

Marine protected areas in the Maltese Islands : status and problems

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At present there are no marine protected areas within Maltese territory. Fishing and/or diving and other marine activities are restricted in certain sea areas round the Maltese Islands. However, this is for reasons of safety, security and to preserve important wrecks and marine archaeological remains rather than for the protection of marine habitats and species, or for management of coastal fisheries. The closest to a marine protected area that the Maltese Islands have is the sea area round the island of Filfla, which is situated some 5km off the southern coast of the island of Malta (Fig.1).

The Filfla Nature Reserve Act, 1988, established the land area of Filfla as a nature reserve with the aim of protecting the flora and fauna on the island. Originally, berthing or navigation of any craft within an area of radius one nautical mile (1.852km) from Filfla, as well as swimming, underwater activities and any activity connected with fishing and trawling were prohibited (Local Notice to Mariners nº16 of 1987) and this sea area thus effectively functioned as a strict nature reserve. However, since 1990 fishing within one nautical mile off Filfla was once again permitted (Government Notice nº173 of 1990). No other sea area is protected, although a relatively large number of coastal sites are. Two minor islands have been declared nature reserves: Fungus Rock in Dwejra Bay, Gozo (established by Legal Notice nº22 of 1992), and Selmunett Islands, also known as St.Paul Islands, Malta (established by Legal Notice nº25 of 1993); however, on these, it is only terrestrial biota and habitats that are protected.

The Environment Protection Act, 1991, is one of the two main pieces of legislation concerned with nature protection in the Maltese Islands. This legislation empowers the Minister responsible for the environment to issue regulations declaring specified areas of the Maltese Islands and their territorial waters a "Nature Reserve" and to make regulations for the protection of such areas. To date, the saline marshland at Salina, the saline marshland and dunes at Ghadira in Mellieha Bay, the saline marshlands at is-Simar in St. Pauls Bay and at Il-Ballut in Marsaxlokk Bay, the rocky shore and the wetland at Il-Qawra in Gozo, the Ta' Cenc cliffs also in Gozo, and the whole land area of the island of Comino have been declared nature reserves under this Act (Legal Notice nº144 of 1993). It must be emphasised that "Nature Reserve" in the context of the Environment Protection Act does not describe a management category such as defined by the IUCN-The World Conservation Union (IUCN, 1994). Of the sites currently designated "Nature Reserves" most are in reality bird sanctuaries where the shooting and trapping of birds is prohibited. In terms of management, only the islands of Filfla and of Fungus Rock actually function as nature reserves since access is prohibited and the terrestrial biota is strictly protected (Schembri *et al.*, 1999).

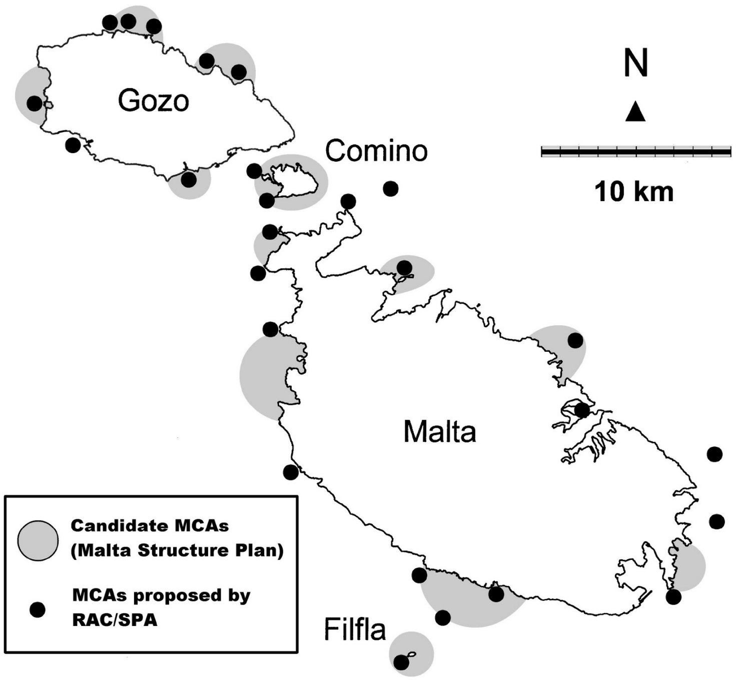

Fig. 1. Map of the Maltese Islands showing candidate Marine Conservation Areas (MCAs) identified in the Malta Structure Plan and those proposed by the Regional Activity Centre for Specially Protected Areas (RAC/SPA) of the United Nations Environment Programme's Mediterranean Action Plan.

In 1993, the Government of Malta requested the assistance of the Regional Activity Centre for Specially Protected Areas (RAC/SPA) of the United Nations Environment Programme's Mediterranean Action Plan in establishing marine protected areas in the Maltese Islands. In 1994 RAC/SPA presented its findings and proposals in two reports, one concerned with scientific aspects (Schembri, 1994) and the other with legal aspects (Scovazzi, 1994). The former report identified 27 separate marine areas as deserving protection because of their relatively pristine ecosystems and/or the representative habitats and biotic communities that they include (Fig.1). An attempt by the Environment Protection Department (the governmental agency concerned with implementing the Environment Protection Act) to start the process of declaring marine nature reserves was unsuccessful after a committee made up of stakeholders failed to agree on even basic principles. Most opposition was registered from the fishers associations, partly because fishers were concerned that declaring any form of marine protected areas would curtail their activities and partly because of internal disagreements amongst the different fishers associations.

The other piece of local legislation that has an important bearing on nature protection is the Development Planning Act, 1992. This act establishes a Planning Authority to promote and control development in accordance with approved policies and plans. One key responsibility of the Planning Authority is the preparation and periodic revision of a Structure Plan for the Maltese Islands and supplementary planning documents. The Malta Structure Plan formulates a national planning policy and puts forward general proposals in respect of the development and other use of national territory. It has as its basic objective the optimal physical use and development of national territory that respects the environ-ment and at the same time ensures that the basic social needs of the community are satisfied. To date some 29 coastal sites have been scheduled as Areas of Ecological Importance and/or Sites of Scientific Interest in terms of the Development Planning Act. These include saline marsh-lands and other types of coastal wetlands, sand dunes, and stretches of coastal cliffs and gently sloping rocky shores.

The Malta Structure Plan also contemplates the setting up of Marine Conservation Areas (MCAs) and lists 14 separate areas round the Maltese Islands as candidates for such status (Fig.1). However, the Structure Plan does not define Marine Conservation Areas, neither does it give protection to the candidate MCAs, but simply states that "*following further analysis, these and other possible areas will be categorised and given protection according to defined criteria*".

While a large number of coastal sites have been protected since the enactment of the Development Planning Act in 1992, not a single marine area has been scheduled. The reasons for this are many. One is simply that the Planning Authority has other more pressing priorities. This is understandable given that the Authority is concerned with development planning and the management of development for the whole of the Republic of Malta, a group of islands with a land area of some 316km^2, a submerged area (to a depth of 100m) of ca.1940km^2, a resident population of over 372,000 (giving one of the highest country population densities anywhere in the world), and a tourist population of more than a million arrivals every year.

Another problem is lack of information on the marine environment, and the related problem of lack of funds to enable this information to be gathered. There is a good general knowledge of local marine species and habitats, resulting partly from academic research mainly by the University of Malta, and partly from baseline surveys of marine biota, habitats and ecosystems commissioned in connection with coastal zone management issues, including the assessment of the environmental impact of coastal and marine development projects (Anderson and Schembri, 1989; Schembri and Lanfranco, 1989; Borg *et al.*, 1997; Schembri, 1995; Schembri *et al.*, 1999). Locally occurring marine habitats have been characterised using the widely used scheme of Pérès and Picard (1964) and mapped at a large scale. Inventories of marine biota have started being compiled. Rare, scientifically interesting and/or sensitive marine habitats and species have been documented and the key threats to their continued existence have been identified. Recently, key seascapes have also started to be mapped. In spite of this, with two exceptions (the Dwejra candidate MCA in Gozo, and that off St.Georges Bay, Malta), detailed studies and small-scale mapping such as are required to establish boundaries for MCAs, and within such areas, for different management zones, have still to be made.

Additional problems have to do with site management and enforcement of legislation. Most existing terrestrial protected areas do not have a management plan and either they are not managed at all or else are “managed” on an *ad hoc* basis by whoever is in charge of the site at the time (Schembri *et al*., 1999). In some cases this has led to a number of negative impacts on the habitats and biota within the protected area. Again, for terrestrial protected areas, enforcement of existing regulations is poor due to lack of manpower, training and bureaucratic problems. Under the circumstances, the local agencies concerned with nature protection are reluctant to declare marine conservation areas that would most likely be “paper reserves” in the absence of the proper infrastructure for management of these sites and for law enforcement.

This is well illustrated by the case of defunct vessels that have been sunk by local divers associations to become “wrecks” and serve as an attraction for sports divers. To date six such vessels have been sunk, two at the same site. Most have become colonised by a variety of benthic species and are frequented by demersal fish. However, since there are no restrictions on access and activities, fish and other biota are collected indiscriminately from the wrecks, degrading the biotic communities present, while passing marine traffic poses a danger to divers. The divers associations are now themselves requesting the authorities to establish traffic-free zones and no-fishing zones round the wrecks.

In conclusion, therefore, there are no legal problems in declaring marine conservation areas in Maltese waters. Sites with critical or representative habitats, ecosystems and ecological processes that deserve such status have already been identified. However, lack of finances is slowing down the process of gathering sufficient data upon which to base management of such MCAs, while the infrastructure to manage these areas in a manner that ensures that the objectives of the management plans are attained still has to be set up. Some of the problems discussed above are specific to Malta, and result mainly from scale: the Maltese Islands are an island nation with all the needs and concerns that statehood brings with it, with limited land area, few natural resources and a limited human resource base. Other problems are common to all Mediterranean Marine Protected Areas and in this respect Malta is a representative case study of the situation in the region.

Acknowledgements
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A new instrument on specially protected areas in the Mediterranean

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The so called "Barcelona system", consisting of the 1976 Convention on the protection of the Mediterranean sea against pollution and its related protocols, was recently updated by the adoption of new instruments and the amendment of the existing ones. This was also done in order to conform a regional system to the recent evolution of international law in the field of the protection of the environment, as embodied, on the world scale, in the documents adopted by the United Nations Conference on Environment and Development (Rio de Janeiro, 1992).

One of the new texts is the Protocol concerning specially protected areas and biological diversity in the Mediterranean, opened to signature in Barcelona on 10 June 1995. When the new protocol enters into force (six ratifications are needed), it will replace the previous Protocol concerning Mediterranean specially protected areas (Geneva, 1982). Substantial differences exist between the two protocols.

The new protocol is applicable to all the marine waters of the Mediterranean, irrespective of their legal condition, as well as to the seabed, its subsoil and to the terrestrial coastal areas designated by each parties, including wetlands. On the contrary, the application of the previous protocol was limited to the territorial sea of the parties and did not cover the high seas. An extension of the geographical coverage of the protocol was needed in order to protect also those highly migratory marine species (such as the marine mammals) which, by definition, do not respect the artificial boundaries drawn by the man on the sea.

The purpose to "go into the high seas" determined some difficult problems, which are peculiar of the present political and legal condition of the Mediterranean. Unlike other semi-enclosed seas, the Mediterranean coastal States have not yet established exclusive economic zones (EEZ) or given effect to EEZ claims. There are in the Mediterranean large extents of waters located beyond the 12-mile limit which still have the status of high seas. Furthermore, many maritime boundaries wait to be agreed upon by the interested countries, including several cases where the delimitation is particularly difficult because of the local geographic characteristics.

In order to overcome these difficulties, the new protocol includes two provisions whose precedents are to be found in the instruments drafted for a very different region of the world. While the Antarctic and the Mediterranean have hardly any similarity as regards their environment, from the legal point of view the two regions share some common aspects: the presence of large extents of high seas and the existence of difficult and unsettled issues on sovereignty over coastal zones. This explains why the new protocol includes a very elaborated disclaimer clause, which recall the legal devices used for the instruments of the Antarctic system. The idea behind such a display of juridical complications is simple. On the one hand, the establishment of intergovernmental cooperation in the field of the marine environment shall not prejudice all the legal questions which have a different nature; but, on the other hand, the very existence of such legal questions (whose settlement is not likely to be achieved in the short term) should not jeopardize or delay the adoption of measures necessary for the preservation of the ecological balance of the Mediterranean.

The new protocol provides for the establishment of an ad hoc list of specially protected areas of Mediterranean interest (SPAMI List). The SPAMI List may include sites which "*are of importance for conserving the components of biological diversity in the Mediterranean; contain ecosystems specific to the Mediterranean area or the habitats of endangered species; are of special interest at the scientific, aesthetic, cultural or educational levels*". The procedures for the establishment and listing of SPAMIs are described in detail. For instance, as regards the areas located partly or wholly on the high seas, the proposal must be made "*by two or more neighbouring parties concerned*" and the decision to include the area in the SPAMI List is taken by consensus by the contracting parties during their periodical meetings.

Once the areas are included in the SPAMI List, all the parties agree "*to recognize the particular importance of these areas for the Mediterranean*" and – what is even more important – "*to comply with the measures applicable to the SPAMIs and not to authorize nor undertake any activities that might be contrary to the objectives for which the SPAMIs were established*". This gives to the SPAMIs and to the measures adopted for their protection an *erga omnes* effect, as far as the parties to the protocol are concerned.

Recreation in Mediterranean marine parks : limits and perspectives

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Marine parks have proven to be useful tools for coastal management by meeting ecological and economic goals (Dixon *et al*., 1993). By allowing recovery of otherwise over-fished populations (García-Rubies and Zabala, 1990; Bohnsack, 1996, Russ and Alcala, 1998), MP become recreational attractors of overwhelming importance for competing tourism-based economies (*e.g.* most coastal Mediterranean countries). However, moving man from predator to visitor not totally frees MP ecosystems from ecological damages. Increasing evidences of negative effects of anchoring (Davis, 1977), intensive trampling (Kay and Liddle, 1989; Liddle, 1991; Povey and Keough, 1991; Brosnan and Crumrine, 1994), SCUBA diving (Hawkins and Roberts, 1992, 1993), or whale watching are coming from far seas (Tilmant, 1987; Rogers *et al*., 1988; Tilmant and Schmahl, 1981); Mediterranean MP have been poorly studied for this issue despite the importance of recreational activities in the area.

We here present clear evidences of erosive effects produced by intensive SCUBA diving on the Medes Islands MP (Spain; NW Mediterranean). In less than 8 ha and 8 diving sites around 70,000 dives occur a year (up to 450 dives d-1 during 200 d y-1, 10.000 dives ha-1 y-1 in some sites). Populations of two sessile erect invertebrates, *Pentapora fascialis* (bryozoan) and *Paramuricea clavata* (gorgonian), were compared at heavily and little (control) dived areas. *P. fascialis* colonies were studied for their density, size and exposition (Sala, *et al*., 1996). Since 1991 tagged *P. clavata* colonies were yearly monitored for size and mortality to both epibiose and wrenching (Coma and Zabala, 1994). An unplanned increase of diving activity on two controls (previously undived sites) provided a semi-controlled experiment which allowed us to discriminate SCUBA diving from other potential sources of damage (Garrabou *et al*., 1998).

Colonies of *P. fascialis* have significantly lower densities (5-10 times), were significantly smaller (2-5 times) and occupied more cryptic loci in areas heavily used by divers than in control areas (Sala *et al*., 1996). *P. clavata* mean interannual wrenching mortality (c. 8 % y-1) was three folds higher in heavily dived areas than in controls (c. 2.5 % y-1). Two years of intensive activity in new dive sites was enough to lower to the third the densities of *P. fascialis* (Garrabou *et al*., 1998); moreover, a step rise on wrenching mortality of *P. clavata* gorgonians was observed in control areas after they opened to diving activities (unpublished data). However, clear as they are, these results cannot be extrapolated to other communities, species or sites. Only 3D complex communities (*e.g.* coralligenous) mainly composed of demographically parsimonious, highly structured species (Garrabou, 1997), usually provided with rigid skeletons seem susceptible to great damages. Paradoxically, these communities constitute, due to the beauty of their seascapes, the most conspicuous attractor (besides fishes) for SCUBA divers. A gradient of increasing susceptibility to erosion by SCUBA diving with increasing depth (Garrabou, 1997) is proposed.

For management purposes, the results show that new dive sites can suffer damage very rapidly. As dramatic enhancing on recreational diving activity seems to be unavoidably tied to the creation of new MP, strict and effective policies of visitors control must be guaranteed before proceeding further in the creation of new MP in areas containing fragile communities/species.

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