PART 2: DISCUSSION PAPERS

BACKGROUND PAPER 1

EXPERIENCES IN THE USE OF MARINE PROTECTED AREAS WITH FISHERIES MANAGEMENT OBJECTIVES – A REVIEW OF CASE STUDIES[1]

by

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Summary

Global fish stocks are in decline and associated habitats are being damaged at an alarming rate, both within Exclusive Economic Zones (EEZs) of states and increasingly also in areas beyond national jurisdiction. To date, conventional fisheries management approaches have typically focused on managing single species rather than maintaining the health of marine ecosystems – the basis for current and future production. However, current management theory and practice clearly point towards implementation of "an ecosystem approach to fisheries that strives to balance diverse societal objectives by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions..."(Garcia and Cochrane 2005). The concept of an ecosystem approach to fisheries management has gained ground in a number of international fora and its elements are now engrained in several international agreements and guidelines (e.g. the United Nations Fish Stocks Agreement, FAO Code of Conduct for Responsible Fisheries). Similarly, several global commitments have been made to establish marine protected areas (MPAs) and representative networks. In recent years, MPAs are increasingly being considered as an important tool for achieving an ecosystem approach to fisheries management.

MPAs are a flexible tool encompassing a range of management options, from smaller, strictly protected no-take reserves to larger, zoned multiple use areas where different activities are carefully managed. Their objectives and characteristics may vary but should, importantly, be clearly defined. MPAs may be viewed as a complement to other fisheries management tools and integrated with sustainable management practices over the wider marine environment. They must be carefully planned and designed in order to achieve realistically defined goals.

Worldwide experience with MPAs provides a number of useful lessons and case studies. The seven case studies described in this paper illustrate different success features with which MPAs can support fisheries management objectives, and they point out challenges and limitations of this potential according to the respective setting. Some key 'ingredients' are extracted from their lessons learnt. They broadly refer to MPA designation and stakeholder processes, to the legal and institutional frameworks, and to management aspects for sustaining MPA benefits.

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Overall, a thorough case-to-case assessment and further empirical evidence is needed to define MPA benefits and limitations for managing the diverse array of fisheries around the world. There is broad international consensus of recognizing the potential of MPAs as a fisheries management tool for some tropical demersal fisheries, while MPA benefits for sub-tropical/cold water and pelagic fisheries are still less understood and need to be fully explored. The aim of this paper is to move one step closer towards the identification of the role of MPAs for fisheries management, through a desk review of MPA case studies from a range of different scenarios, as well as a brief analysis of the literature.

1. INTRODUCTION

A rapid and often persisting decline in many key commercial fish stocks, together with a global increase in fishing pressure have resulted in a historical collapse of many fisheries (Halpern 2003; Hutchings 2000; Rowe and Hutchings 2003). This has led marine conservationists and fisheries managers to re-assess the exclusive value of conventional management measures such as gear regulations and catch quota adjustments for sustaining fish stocks (Carr and Raimondi 1999). Indeed, "the scientific literature contains numerous diagnoses of the widespread [fisheries] management failures [...]" (Garcia and Grainger 2005). Carr and Raimondi (1999) note that "taken together, the natural, analytical, and social causes of uncertainty in projecting stock trends and adjusting fishery yields have prompted great concern and a more conservative approach to ensuring sustainability of marine resources."

With the emphasis on ecosystem-based management policies, fisheries managers are reviewing conventional, target-resource oriented management and considering a more integrated, area-based management in which Marine Protected Areas (MPAs) are seen as an important tool.

MPAs hold promise as a rational and practical way of managing ocean resources to achieve fishery ecosystem objectives, and they are seen to provide one of the most tangible means for achieving broad protection across the biota and habitats of an ecosystem (Sainsbury and Sumaila 2003). MPAs are also being increasingly promoted as a tool to fulfil both broader conservation goals and fisheries management objectives (COMPASS 2004; Salm *et al*. 2000; Allison *et al.* 1998), and these goals are not necessarily mutually exclusive.

However, opinions still differ widely between conservationists, scientists, fishing sectors and other stakeholders over the effectiveness of MPAs for fisheries management compared to other fisheries management tools (Martin 2005; Hilborn *et al.* 2004; Agardy *et al.* 2003), when applied in a variety of different contexts.

A clear trend in the peer-reviewed literature is, that MPAs are increasingly being considered to be an important complement to existing fisheries management regimes (e.g. Bohnsack 1998; Guénette *et al.* 1998; Russ 2002; Gell and Roberts 2003; Halpern and Warner 2003; COMPASS 2004). Assessments based on existing case studies and the literature have confirmed this potential of MPAs to complement, although not to supplant, the range of existing fisheries management practices (e.g. FAO 2005; FAO Code of Conduct 1995; Sainsbury and Sumaila 2003; Russ 2002; Carr 2000; Allison *et al.* 1998; Lauck *et al.* 1998). "Their [MPA] performance in relation to fisheries resources and livelihoods thus depends greatly on the type of resource requiring protection and the situation of the fisheries exploiting them." (FAO (a) COFI/2005/8). A thorough case-by-case assessment and further empirical evidence is needed to define MPA benefits and limitations for managing the diverse array of fisheries around the world (e.g. Hilborn 2004; Martin 2005). MPAs should therefore not be considered as a one-way street to success by themselves, but rather as an important tool in the fisheries management 'toolbox' that simultaneously addresses ecosystem conservation.

Initiatives to design, implement and test MPAs as a tool for fisheries management and marine conservation have been under consideration internationally (e.g. World Summit on Sustainable Development [WSSD], Convention on Biological Diversity [CBD], United Nations General Assembly [UNGA], United Nations Fish Stock Agreement [UNFSA] and related international agreements) and are starting to be pursued within a regional fisheries management context. The ecosystem approach to fisheries management set forth by the Food and Agriculture Organization of the United Nations (FAO) (Code of Conduct 1995) creates opportunities to integrate MPAs as a management tool, and to assist states in achieving their recent international commitments. At its 26^{th} session in March 2005, FAO's Committee of Fisheries (COFI) recommended that FAO develop technical guidelines on the design, implementation and testing of MPAs and agreed that FAO should assist its members to achieve the World Summit on Sustainable Development (WSSD) goal with respect to representative networks of MPAs by 2012 (COFI Report, para. 103, 2005).

Section 2 of this paper provides a brief overview of MPA definitions, their main characteristics and potential roles for both biodiversity conservation and fisheries management. This sets the stage for a case-by-case exploration of MPAs in a fisheries management context, described in Section 3. Seven case studies have been highlighted as examples of a range of ecosystems and social, economic, institutional and governance contexts: high seas MPAs development in Antarctica; the Channel Islands stakeholder process in California; community-based management in the Philippines (Bohol) and Tanzania (Tanga); the Great Barrier Reef Marine Park adaptive zoning; resident indigenous fishing communities in Banc d'Arguin National Park in Mauritania; and territorial use rights in MPAs (in its wider sense) along the Chilean coastline. The case studies consider a variety of area-based management measures (strict protection zones, multiple-use areas, and management and exploitation areas) and institutional settings, which have been or have further potential to be integrated with other fisheries management measures by using different approaches. Successes and challenges encountered by each MPA in contributing to fisheries management objectives and the distilled lessons learnt are discussed within the context of a progressing international commitment to applying an ecosystem approach in fisheries management, and the increased interest expressed by COFI 2005 in integrating MPAs in the set of existing fisheries management tools. Section 4 then gives some key elements for consideration when designing, developing or revising MPAs in a fisheries management context, as they emerge from the case studies. It also highlights needs for research and management if MPAs are to be efficiently applied as a fisheries management tool. Both the elements and the needs are not complete, but compiled as a basis for further consideration and discussion in the context of the preparation of technical guidelines by FAO.

2. OVERVIEW OF MPAs

2.1 What is an MPA?

There is no consistently applied definition for an MPA. IUCN in 1994 defined a marine protected area as "*any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment"*. An analogous definition has been adopted by the 188 parties to the Convention on Biological Diversity[3].

The MPA is a tool, which encompasses application of a whole range of management options. Strictly protected, no-take reserves lie at one end of the spectrum (see the Channel Islands case study of this paper). Zoned, multiple use areas form the other end, with various combinations and options in between (e.g. the establishment of buffer areas). The Great Barrier Reef Marine Park shows that within a single multiple-use MPA strictly protected no–take zones may occur. Different management strategies can be developed through zoning and networks of smaller management areas. Small collaboratively managed areas by user communities in Tanzania, Chile and the Philippines show that the particular focus of the MPA may vary from protection of one key species or species group to

[3] CBD COP7, 2004, Decision VII/5 reflects the MPA definition to be: *"any defined area within or adjacent to the marine environment, together with its overlaying waters and associated flora, fauna and historical and cultures features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings"*.

targeted resource maintenance. The actual choice, size, and spacing of these areas depend on the characteristics of the specific ecosystem targeted as well as management and conservation objectives.

The term MPA is increasingly used in a context of fisheries management (e.g. FAO 2005), and it is important to clearly define it when assessing the role of a given MPA or network of MPAs for fisheries management. To identify what role MPAs may play in a fisheries management context, it is important to be clear about the type of MPA that can be designed and the grade of protection necessary to meet the key goal of the MPA: see Table 1 (IUCN 1994; IUCN 1998; Kelleher 1999).

Table 1. Overview of the IUCN Protected Area category system, their principle purpose of protection and an example from United States waters.

Category	Protected area managed mainly for . . .	Examples. . .
I	science or wilderness protection	Strict Nature Reserve/Wilderness Area, e.g. Fisheries Reserve
II	ecosystem protection and recreation	National Park
III	conservation of specific natural features	Natural Monument
IV	conservation through management intervention	Habitat/Species Management Area
V	landscape/seascape conservation and recreation;	Protected Landscape/Seascape
VI	the sustainable use of natural ecosystems	Managed Resource Protected Area, e.g. Area for Management and Exploitation of (benthic) Resources (Chile)

It should be noted that a discussion about the application of the Protected Area (PA) categories to a marine context (MPAs) has been ongoing since 2005.

The following list identifies some characteristics of MPAs, based on the presented case studies.

- An MPA has some form of protection, which is usually legally established but can also be established by custom or tradition. MPA have existed in some form among traditional fishing cultures for centuries. In the Pacific region, "*Tabu*" or "*Kapu*" areas, were no-take zones controlled by clans or chiefs. Case studies from California, where no-take MPAs are established in state waters under state law but not federal law, and from Mauritania, where the MPA has its own law established through direct support from the prime minister, provide examples for differing legal frameworks within which MPAs are established.
- The degree of protection is not necessarily the same throughout the area; indeed most large MPAs are zoned into areas of different usage and ecosystem impact, such as shown by the Great Barrier Reef and the Antarctic case studies.
- The MPA (and its various management provisions) often covers not only the seabed but also at least some of the water column with its flora and fauna. An example from a Tasmanian seamount reserve shows that vertical zoning is also possible (e.g. as a vertical buffer zone; Figure 1). Although still a rarely implemented tool, these MPAs show potential for offshore MPAs, and those which cover areas deeper than 100 meters (Simard, pers. com.).

- MPAs are not just relevant for natural features but also for protecting cultural features (such as wrecks, archaeological sites, lighthouses, jetties), and *traditional use/cultural practices*. The Mauritanian case study describes an approach to protect traditional fishing activities of a local community indigenous to the park area, further to biodiversity protection *per se*.
- MPAs, as their terrestrial counterpart, may be permanent as their terrestrial counterparts, their boundaries or management plans should be adaptive and subject to review and modification in order to encompass new knowledge, monitoring results and acquired experiences. Flexible handling of MPAs may permit uses to be further restricted or expanded, with appropriate safeguards to ensure sustainable use with minimal habitat impact. In the case of the Great Barrier Reef Marine Park, re-zoning and boundary adjustment on the basis of the management plan is done every five years. This leaves significant room for integration of fisheries objectives into MPAs with an existing/exclusive focus on biodiversity conservation. It is important to define the degree of MPA flexibility from the beginning, e.g. if an area is permanently or temporarily closed to fishing (depending on species distribution and factors such as the 'life span' of a particular ecosystem feature like e.g. a hydrothermal vent).
- MPAs work at, and across, different scales. For example, the Tanga MPA (United Republic of Tanzania) includes a network of fishing grounds spread over a wider area, while the Philippines case study describes very small no-take zones aiming to protect representative areas of habitat and their associated fishes. The Antarctic and Great Barrier Reef examples work at a large marine ecosystem scale, whereby a variety of MPA tools and other conservation and management mechanisms complement one another under a broad management framework.

There is growing potential for establishing MPAs which would focus on oceanographic features such as fronts, convergence zones or eddies. Where these features are relatively fixed, they could be demarcated as a permanent MPA with traditional boundaries. Where features are temporary and dynamic, area-based protection (such as through closures) would be temporary or follow the natural shift of these features. Satellite tracking and remote sensing enable such features to be monitored on a close to real time basis (Norse *et al.* 2005).

Closing areas of ocean to specific human activities for a defined period of time is commonly used for both nature conservation and for fisheries management. However, the terms used to designate such closures have sometimes been used in a confusing way.

Area Closures are fisheries management tools, often used in combination with other measures within a target-species based management, to support the management of a fisheries resource, or as a restoration tool for a fishery that has been over-exploited. They can encompass areas closed to all fishing activities, areas closed to fishing for single species, or areas with gear or vessel restrictions - both as temporal or permanent measures to manage fishing effort. Area closures usually aim at stock enhancement or recovery, but also include recovery for sensitive habitats and avoidance of specific vulnerable species. Broader ecosystem objectives are increasingly taken into account. Although generally aiming at enhancing the stock of a particular fisheries resource, area closures can also yield positive results for several other associated or dependent species. Traditionally MPAs were established with a conservation and protection focus; however, since they are increasingly being used as a fisheries management tool they could also be termed a form of area closure.

2.2 Potential roles of MPAs

The overall goal of MPAs is to contribute to the conservation of the biological diversity and productivity of the oceans, including ecosystem processes. The Convention on Biological Diversity (CBD), for example, states MPAs have an "effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings". However, a range of existing MPAs developed with biodiversity conservation objectives provide significant benefits for certain fisheries (e.g. Russ *et al.* 2004; McClanahan and Mangi 2000), however the extent and expected incidence of benefits to fisheries is still an open question (Halpern and Warner 2003; COMPASS 2004). Conserving an area of relatively low diversity but high productivity, such as a seagrass bed, may be equally vital for maintaining viable populations of threatened or endangered species as maintaining biological productivity to contribute to human welfare and food security (Kelleher 1999). The Mauritania and Philippines case studies provide good illustrations for this. Conserving an area of high diversity like the Tanzanian coral reefs can safeguard species and genetic diversity for the future, and help to secure the livelihoods of the local communities. By protecting critical breeding, nursery and feeding habitats of fish populations, MPAs can make a contribution to healthy fisheries beyond MPA boundaries. MPAs can protect the spatial complexity of benthic habitats like seamounts, coral and sponge communities, seagrass beds and mangroves, which are particularly important in sustaining biodiversity as well as species of commercial and socio-economic importance. Some of these habitats might also serve to mitigate the effects of coastal storms and tsunamis (see e.g. Kathiresan and Rajendran 2005; Kerr *et al.* 2006 for differing views on the mitigating potential of mangrove habitats).

As a tool within an integrated and ecosystem-based approach to marine conservation, appropriately designed and effectively managed MPAs provide significant benefits for biodiversity and also contribute in achieving fisheries management objectives (Halpern and Warner 2003; Willis *et al.* 2003).

Another way of looking at the role of MPAs is to consider how they help sustain a marine ecosystem's ability to provide essential goods and services. These can include fish and fish products, habitat provision, maintenance of biodiversity and biological resilience, products like medicinal or chemical compounds from marine genetic resources, tourism potential and revenue, nutrient cycling, carbon sequestration and waste assimilation.

MPAs can provide widespread benefits as reference sites or control sites for long-term scientific research and monitoring, including contributing to improving the understanding of a species' population demography, and species interactions within an ecosystem (e.g. Castilla 1999, 2000). As in exploratory fisheries, MPAs may be used to test both conservation and management techniques (Kenchington *et al.* 2003). The still largely unknown Antarctic ecosystem is a good example for the importance of scientific reference areas to complement area-based measures for fisheries management.

The role of MPAs in fisheries management has been extensively discussed in the scientific literature. A range of theoretical assessments have concluded that MPAs have great potential to complement other commonly used fisheries management practices (Sainsbury and Sumaila 2003; Carr 2000; Allison *et al.* 1998; Lauck *et al.* 1998), and that they have positive effects for fisheries (Russ *et al.* 2004; Gerber *et al.* 2003; NFCC 2004; Halpern 2003; McClanahan and Mangi 2000). MPAs are, however, not a panacea for fisheries management problems (Hilborn *et al.* 2004; FAO (a) COFI/2005/8; Murawski *et al.* 2004; Kaiser 2004).

A very limited number of long-term empirical studies exist which are able to demonstrate either MPA benefits, costs or shortcomings (Halpern and Warner 2003; COMPASS 2004), but documented evidence from single MPA sites is growing (e.g. Russ *et al.* 2004; McClanahan and Mangi 2000; McClanahan and Kaunda-Arara 1996). The case studies in this paper summarize some of the benefits and limitations encountered for MPAs in a fisheries management context.

For polar marine ecosystems and especially pelagic fish stocks, the effects of MPAs are still largely unknown (e.g. Kaiser 2004; Hilborn *et al.* 2004). This is partly because most pelagic stocks of commercial importance are more mobile during their life cycle, spawning and nursery areas are often unknown, and exploitation patterns can be widely dispersed. However, a number of studies are emerging that review the effects of various MPAs and closed areas for selected species (e.g. Pascoe and Mardle 2006; Cefas 2005; Sweeting and Polunin 2005; studies for Defra, in 2006). Recent research is also helping to identify distribution patterns such as migratory corridors and open ocean hotspots where pelagic species may congregate to feed, breed, spawn, and possibly also spend their juvenile stages (Hyrenbach 2000; Norse *et al.* 2005; Worm *et al.* 2005). Since many deep sea species, may have defined restricted ranges due to hydrographic or topographic barriers (ICES 2005), similar benefits as seen in nearshore reef areas could possibly apply. More long-term and empirical studies are however needed (Sale *et al*. 2005; Willis *et al.* 2003).

MPAs are seen as important tools for achieving an ecosystem approach to fisheries management (Murawski 2000), and as one of the most tangible means to date for conserving habitats and a broad band of the biota within an ecosystem, thus benefiting both fisheries and marine biodiversity as a whole (Bohnsack 1998; Murray *et al.* 1999; Pinnegar *et al*. 2000 in Carr 2000). At the same time, while most efforts have been directed towards detecting their effects on single species comparatively little is still known to date about MPA effects on community or ecosystem-wide levels (COMPASS 2004; NRC 1999, 2001).

3. CASE STUDY REVIEW: SELECTED EXPERIENCES

This chapter describes certain management aspects from seven MPAs, or sets of MPAs across the globe, which are in one way or another of relevance to fisheries management. The cases span a range of ecosystem types and social, economic, institutional and governance contexts. They also vary in MPA type and degree of protection. See Table 2 for an overview.

For each case study, a couple of key characteristics from planning and designation, implementation or assessment processes are highlighted. The main characteristics are then discussed on the basis of the key lessons learnt for each MPA.

The fourth chapter will then build on the cases and suggest a list of key elements or ‘ingredients’ for further discussion of the FAO technical guidelines, and for consideration when designing, developing or revising MPAs in a fisheries management context.

3.1 Case study A: Lessons from the stakeholder process of the Channel Islands Marine Reserves, California, United States

This case study describes the stakeholder process to designating no-take MPAs (reserves of IUCN category I) in a developed country setting, characterised by a multitude of uses such as tourism, transport and fishing, by a large array of user groups. The site designation process with stakeholders is known for its high potential for conflict during the consensus negotiations and the way in which science advice guided the conditions for these negotiations. The case study also stresses the importance of integrating participatory reserve design with the fisheries management system. The summary below largely references a United States-based MPA assessment report by Bernstein, Iudicello and Stringer (2004).

3.1.1 Background

The reserves are part of the Channel Islands National Park and the Channel Islands National Marine Sanctuary, covering about 4 350 km^2 of coastal waters. The islands are fished commercially and also provide extensive recreational activities such as sport fishing. They are situated close to a major shipping lane and regular United States military training activities. The main marine habitat features are kelp forests and rocky inter-tidal habitats (Figure 2).

In 1978 the U.S. Supreme Court recognized the state’s authority to manage the seabed out to three nautical miles. The marine resources of the islands are managed by a variety of state and federal jurisdictions of which many are overlapping. They include the Californian Fish and Game Department, the California State Lands Commission, the National Parks Service, the National Marine Sanctuary Program, the National Marine Fisheries Service, and the United States Coast Guard.

The Channel Islands Reserve designation followed three principle objectives: to protect ecosystem biodiversity, achieve sustainable fisheries, and to maintain long-term socio-economic viability. The designation process is characterised by a search for consensus amongst stakeholders on the basis of a long-term monitoring programme, running in parallel for California state waters and for the United States federal waters. It was initiated in 1998 by a group of recreational fishermen who were concerned about the potential over utilization of fish stocks around the islands, and who proposed a no-take reserve for 20 percent of the first (one) nautical mile off the shore. The development of reserves in state waters and federal waters was soon split into two separate processes because of differences in jurisdiction. It should be noted that the fishery resources of the reserves span a wider area and are subjected to a comprehensive fishery management plan.

A long-term research and monitoring programme involved regular, intensive and often confrontational discussions on all aspects of MPA designation with a stakeholder working group. The concentration of resource use in the small Channel Islands area, the variety of resource users, and a complex institutional setting for consultation and decision-making complicated the consensus-finding.

The highly participatory approach for site designation included a multi-stakeholder public working group, supported by a science advisory panel and a socio-economic advisory panel (NOAA 2003). The science panel, as a separate entity from the stakeholder group, was tasked with developing overall guidelines that framed the design work of the stakeholder group.

The stakeholder process in the Channel Islands is considered both a success and a failure, depending on the individual or group one talks to and on the criteria used in the evaluation. While a network of reserves was successfully designated for state waters in 2002, the process for a complementary set of reserves in federal waters is not yet complete. The designation process furthermore led to valuable lessons learnt, some of which are documented here. The following lists some of the perceived successes and challenges.

3.1.2 Key successes of the process

The process ultimately led to the implementation of a network of reserves in state waters that considers fisheries issues.

- Despite not finding consensus for site designation in federal waters, the stakeholder working group developed alternative scenarios that were formed into recommendations to the Fish and Game Commission for a network of reserves in state waters.
- A new approach was developed for applying reserve theory to reserve design: as a prominent example, an interactive mapping tool was created that helped stakeholders evaluate the biological and economic implications of multiple design scenarios. (see Robinson *et al.* 2005 for a description and future recommendations).
- Scientific advice was used as the basis for the stakeholder group's design negotiations.
- Concrete economic data from stakeholders was used to estimate the economic effects of alternative reserve designs.

3.1.3 Challenges of the process

The stakeholder working group did not reach consensus on a single reserve design that could be applied for state and federal waters, due to several constraints:

- The complexity of roles and relationships involved in the process were not adequately considered [e.g. separation of science advice from stakeholders resulted in perception of an elitist process, one that potentially undermines collaboration].
- Reserve goals were adaptively changed, but without the full agreement of all stakeholders.
- High potential benefits for fisheries were stated while the full range of fisheries science issues had not been explored [e.g. analyses underlying the reserve design did not account for existing

fisheries management regulations outside the reserves, including other extensive closures]. This ended up amplifying resistance and undermining the credibility of the reserve design with fishermen, the Pacific Fisheries Management Council, and the state and federal fisheries agencies. There was no long-term progress monitoring towards the sustainable fisheries goal.

- Reserve design did not plan for experimental situations that would allow for scientifically testing key expectations about reserve performance on both conservation and fisheries goals.
- Limited communication between the stakeholder working group and the science panel.
- No effective monitoring program was implemented (no long-term fisheries or fish stocks monitoring).
- A local commercial fishermen's association and the California Fish and Game Commission still challenge the legitimacy of the reserve, and filed a suit against the Commission in charge. The fishermen's arguments are: failure to adequately address mitigation of negative reserve consequences; procedural failures; and lack of authority by the agency to enforce fishing regulations.

3.1.4 Lessons learnt from the designation process with stakeholders

- It is a common phenomenon that the goals of an MPA shift over time. It is important to periodically re-assess the goal and objectives, and equally important to inform and adapt the process to it. For the Channel Islands, efforts should be made to inform stakeholders of planned and eventual shifts in MPA objectives, and to jointly reformulate new goals through consultations. A long-term management plan should describe implementation of an adaptive management process for the MPA. There also needs to be clear but not overly simplified communication of the rationale for protection and reserve design, as well as other key assumptions provided by scientific recommendations. Roles of working groups and panels need to be clearly defined, regularly evaluated and adapted. Communication and exchange opportunities between panels and working groups are essential to prevent misconceptions and concerns amongst stakeholders.

- The Channel Islands process emphasises the importance of integrating reserve design with the fisheries management system. Especially where a key goal is to promote sustainable fisheries, it is vitally important to include fisheries management and stock assessment expertise in the relevant working groups and to ensure that fisheries management agencies, who will be responsible in whole or in part for implementing policies regarding fishing, are fully involved and committed to the process (Bernstein *et al.* 2004) to prevent conflicts. It is of special importance for the Channel Islands where there were parallel designation processed for state and federal waters.

- Monitoring is a crucial tool to determine the role of the Park for fisheries resource conservation. Although the Channel Islands national Park has a long-term monitoring programme, it did not include the fish stocks that were fished commercially or recreationally (this has been modified and they are now included). More broadly, it is important to incorporate experimental monitoring and evaluation into the reserve design, to be able to draw comparisons and controls, to measure outcomes and adapt. Monitoring is an important tool to document that stakeholder 'sacrifices' and behaviour modifications are worthwhile.

- Identifying consensus as the single criterion of a successful process can promote unrealistic expectations, be difficult to achieve and provide an opportunity for political lobbying and other gaming behaviour that might undermine the decision-making process. A variety of measures for decision-making should be considered (for example majority or super-majority votes).

- The role of science against economic and social aspects of reserve designation remains a balancing act. In hindsight, some of the stakeholders involved stated that potential benefits of the reserve were probably oversold in the process, while financial costs for planning and consultations were underestimated. While the designation of reserves in state waters is a significant event, it remains a solution in flux in a dynamic scientific, social, and policy context. Events have continued to move forward since the designation of reserves in state waters in 2002. There are ongoing efforts to find funding for monitoring and a continued planning process of reserves in federal waters. Local fishermen have meanwhile filed suit against the Fish and Game Commission and organized collaborative and community-based data gathering and management initiatives. New efforts are being made for integrating conservation (reserve) science and fisheries management.

3.2 Case study B: User-driven fisheries monitoring and management in the Tanga Collaborative Management Areas, Tanzania

In Tanga region, on the northern coast of Tanzania, six contiguous collaborative management areas (CMAs) have been established, two being gazetted, with the primary objective of sustainable fisheries and marine resource extraction. Their main characteristic is full participation and ownership by local stakeholder groups, including a user-based monitoring programme.

3.2.1 Background

Taken together the areas span 1 600 km^2 of marine and coastal habitats comprising coral reefs, mangrove forests and some seagrass beds (Figure 3). Around 500 000 people live scattered along the coast neighbouring these CMAs, in 49 main villages and two principal towns, Tanga (pop. ~246 200) and Pangani (pop. 6 000).

The force behind the establishment of the CMAs was concern from local government officers and local communities in the mid 1980s about the degradation of the coral reefs from dynamite fishing and other illegal and destructive fishing techniques, and uncontrolled cutting of mangroves.

After a long phase of consultations, the Tanga Coastal Zone Conservation and Development Programme (TCZCDP) was formed in 1994 in response to this concern, with funding from Ireland and technical support from IUCN. The TCZCDP aims to improve the integrity of the Tanga coastal zone ecosystem so that its resources support sustainable development. This is being achieved by improving collaborative coastal and marine resource management by district administration, resource users and other stakeholders. The primary tool developed to achieve these objectives are the collaboratively managed multiple-use MPAs– the CMAs– the first of which were established in 1998.

The selection process for the collaborative management areas was based on common natural resource use, primarily fishing, by neighbouring villages, and did not necessarily overlap with political boundaries of villages or districts. This was innovative for its time and was a result of a lengthy and thorough consultation phase in the TCZCDP (Makoloweka and Shurcliff 1997).

A significant element of the CMAs is that one or two reefs were fully closed to fishing in five of the six CMAs. After monitoring and assessing the impacts of these fisheries closures (see below), the villagers voted to maintain them as permanently closed reefs in recognition of their benefits to local fisheries (Table 3a,b).

On an institutional basis, Central Coordinating Committees (CCCs) comprised of village and district government representatives, have been formed to manage each CMA and to develop a management plan, with the assistance of regional government officers. Regular patrolling of the CMAs is carried out by joint community and government patrol teams, and this was for many years done in partnership with the Navy. TCZCDP from the onset has placed a strong emphasis on female participation and has increased the involvement of women in the CCCs and overall management of the CMAs with 30-40 percent representation of women in key decision making positions, a marked increase from the beginning of the Programme.

The main fisheries management activities carried out within the CMA frameworks are patrolling and monitoring, subsequent review and analysis by the CCCs, and the review of the CMA plans in an adaptive management cycle.

A monitoring and evaluation programme was established in 1998 to monitor the coral reefs, fisheries, mangrove forests, patrols and socio-economic status of the villagers. The CMA management plans are reviewed every three to five years and the analysis of monitoring data is used to inform and adapt the plans (Pabari *et al.* 2005). However, analysis of monitoring data has been infrequent and not very thorough, though has indicated that the CMAs have had a positive impact on habitats and neighbouring fisheries (Verheij *et al.* 2004). A recent thorough analysis of the long-term data sets has revealed that the impacts of the CMAs on the surrounding fisheries are not immediately obvious. Nevertheless analysis of trends in catch rates (catch per unit effort, CPUE) over six years are encouraging for two of the primary artisanal fisheries of the region: the basket trap fishery for rabbitfish and the hook and line fishery for snapper and emperors.

The hook and line fishery for snapper and emperor remained stable and CPUE increased in 2004 (Figure 4a); in contrast the basket trap fishery for rabbit fish declined initially but CPUE has increased since 2003 (Figure 4b). Both recent increases may be interpreted cautiously to be an improvement of the fishery as a result of the CMAs which had almost eliminated destructive fishing methods and contain fully protected reefs. A recently increasing CPUE in these two fisheries when the coastal population increased by 60 percent from 1994 to 2005, can be seen as a positive outcome of the CMAs. Another monitoring study (McClanahan *et al.* 2006) found that overall fish biomass on the Tanga reefs has increased from 260 kg/ha in 1996 to 457 kg/ha in 2004, indicating that the CMAs are successfully increasing fish stocks within the managed area. The increase was most noticeable in the herbivorous group of species, which included parrotfish (Scaridae) and rabbitfish (Siganidae), but there was a significant decline in the carnivorous group comprising snappers, emperors, and grunts. These results differ somewhat from the catch rate analyses by the TCZCDP, but do provide some support for positive fisheries impacts from the CMAs.

The CMAs are managed by three district government offices in Tanga region, with advice, facilitation and funding from the regional government office. The CCC is the actual management body which manages each CMA, develops and maintains the existing management plan with the assistance of regional government officers. Regular patrolling of the CMAs is carried out by joint community and government patrol teams. CMA Plans have been enacted through village by-laws, but have now been approved nationally by the Director of Fisheries. These are reviewed every two years. The Director has suggested that the CMAs and their management bodies change their terminology to Beach Management Unit to comply with the new Fisheries Act (2003), which would give the CMAs legal backing.

3.2.2 Key successes to date

- The main success of the TCZCDP has been the development of a collaborative system that is broadly satisfactory to both communities and the government for preparing fisheries management plans based on multiple use MPAs, the CMAs. Management plans are key tools for sustainable fisheries, recommended by the FAO Code for Responsible Fisheries (FAO 1995) and are described in Tanzania's national 2003 Fisheries Act as 'management agreements'.
- A second key success is that the TCZCDP has explored structures for collaborative management within Tanzania's political and institutional framework, developed a collective natural resource management system within communities, and in so doing has introduced a strong sense of ownership of resources in the face of what was has been largely open access.

Of particular note is the establishment of management units (the CCCs) which span villages and correspond to fishing grounds rather than political boundaries.

- The fact that reef closures are included in all the CMAs, that these are being established for increasingly long periods or permanently, and that most communities see them as an acceptable fisheries management tool, is also a key success.

3.2.3 Challenges encountered

- One of the key challenges for Tanga is that there is no specific legal framework for the CMAs as established at present. The Fisheries Division approvals of the most recent plans have included the recommendation that once the by-laws have been approved, they should be considered as operational beach management units (BMUs). This will give them legal backing because BMUs can be established under the 2003 Fisheries Act. However, unlike the CMAs, BMUs are based around individual landing sites and operate at village level (Ogwang *et al.* 2004), which the TCZCDP has demonstrated is not a suitable management unit for coastal fisheries. This advice was provided by the TCZCDP who had significant input to consultations during the development of the Fisheries Act.
- Other challenges include difficulties in demonstrating a clear increase in catch rates as a result of closed areas, and the difficulty in completely eliminating destructive fishing methods, especially the use of dynamite (e.g. *Latimeria* fishing has been repeatedly reported).
- Tropical multi-species fishery monitoring is difficult – the data are highly variable and indicator species are still poorly understood, thus demonstrating a casual link between the closed zones and improved fisheries is difficult. Analysis of indicator species from datasets around the world could provide interesting insights.
- Empirical data on the link between improved fish resource management through MPAs and improved livelihoods or alleviation of poverty is not really available – the socio-economic monitoring and analysis lags behind the bio-physical – this gap needs to be filled.
- Understanding the suitability of the governance model of the MPA for the socio-economic, cultural and political context is lacking and would provide an interesting analysis to assist in the establishment or improved management of MPAs.

3.2.4 Lessons learnt

Several lessons can be drawn from the Tanga collaborative management experience.

- Collaborative co-management between local communities and local government were a crucial factor for success in Tanga. It led to the conclusion that local fisher participation and consultation is extremely important from the onset, and that government participation in MPA designation and management is essential at all levels (local to national).
- The long consultative phase and local community involvement in all aspects of the programme, as well as monitoring of resources and their distribution by the local fisher groups themselves created a sense of resource ownership by the local communities. Accurate and regular monitoring of key fishery indicators (based on sound science) is vital to demonstrate causal relationships between MPAs and improved fisheries. In this particular case, monitoring of important socio-economic factors started only late in 2004.
- Management area fisheries plans based on resource use (fishing grounds) have proven to be more relevant than village-based management plans, leading to the establishment of resource-based management units.
- Enforcement by village teams in collaboration with government and police, with financial support from government is one key aspect of the co-management principle put into practice. Importantly, dynamite fishing has resurfaced in 2005 indicating that current enforcement and compliance have not fully succeeded to address the problem.

- A weakness of the Tanga Collaborative Management Areas is inadequate recognition of the management programme at the national level and a resulting lack of legislative support and backing.

3.4 Case study C: Establishment of a spectrum of fisheries management activities in Banc d'Arguin National Park, Islamic Republic of Mauritania

The case study from Banc d'Arguin National Park showcases how fisheries management objectives may be added to existing MPAs with conservation objectives. It highlights the need for full integration of needs of residential communities and their traditional resource use patterns inside an MPA, as well as the utility of an efficient enforcement and compliance scheme for new and existing regulations.

3.4.1 Background

The Banc d'Arguin National Park (PNBA) covers an area of approximately 12 000 km^2, of which 6 300 km^2 are marine and 5 700 km^2 are terrestrial. It stretches along ca. one third of the Mauritanian coastline. Its shallow but steadily nutrient-rich waters provide a habitat for hundreds of fish species, crustaceans, molluscs, marine mammals, turtles, birds and other marine organisms. The main ecological habitat features are seagrass beds (important role as nursery grounds for fish), sand islands and islets, mudflats and sand dunes (Figure 5).

The Park also houses ca. 1 500 people, the Imraguen, in nine traditional fishing communities, on the sandbanks and the adjacent desert area.

Declared as National Park in 1976 by the Mauritanian government, the PNBA became a Ramsar site in 1982 and listed as a World Heritage site in 1989 (together with Satellite Reserve Cap Blanc to its north). The PNBA is commonly known as the oldest and most extensive MPA in West Africa.

The Park is managed by a government-associated institution (tutored by the prime minister) and technically, as well as financially, supported by international partnering institutions. A special law for the Banc d'Arguin National Park (2000/024) was passed in 2000, which takes into consideration habitat and species conservation objectives and for the first time legally recognizes the Imraguen people as resource users.

The initial objective of the Park was to conserve the Park's landscapes, and an important ornithological site in the region. Its potential as an equally essential tool for fisheries management has been revealed successively over the last ten years. Due to its large size, the Park has a significant impact on the national fisheries of Mauritania.

The main activities of the Park (described in detail below) with relevance for fisheries management include (1) surveillance, (2) research and (3) supporting the traditional fishing of the local Imraguen population, including rehabilitation of the 'lanche' (these are sailing boats used by the Imraguen since the middle of the 20th century for the meagre fishery, originating from the Canary Islands).

1) Due to constantly rising external fishing pressure and illegal fishing, surveillance is the most important management activity inside the Park. A surveillance system has been active since 1998, and comprises three small motorized boats stationed at control points, and three radar stations. Current resources permit ten to twelve surveillance trips per month per boat. The Park works in collaboration with the Delegation for Fisheries Surveillance and Maritime Control (DSPCM, which forms part of the Mauritanian military), and the Mauritanian Oceanographic and Research Institute (IMROP). The DSPCM runs the three radar control stations and reinforces the surveillance system with its own surveillance boats. The radars efficiently localize and track motorized boats entering the Park. Each surveillance boat in the Park includes a team of DSPCM staff, a Park guard and a member of the Imraguen community.

Illegal boats entering Park waters are fined up to Mauritanian ouguiya (~UM) 35 million (100 000 Euros) for industrial trawlers, and UM 2–10 million for freezer vessels. Most illegal fishing in the Park now comes from motorized pirogues, which are fined between UM 50 000 and UM 200 000 (140 – 570 Euros) if caught.

The system of surveillance and the follow-up to ensure the conviction of those caught illegally fishing within the Park is implemented successfully. The Park administration reported that the system was able to significantly decrease illegal activities since put in place in 1998. The threat particularly from large commercial trawlers entering the Park's waters seems to have been effectively minimized.

However, local Imraguen fishermen state that a threat from illegal fishing persists and that more surveillance is needed. Full coverage and enforcement of the 6 300 km^2 of marine area in the Park is limited by the capacity of the operating surveillance vessels. The surveillance boats and radar stations also need repair and replacement. A major drawback in this context is that money raised through fines via the State Treasury does not come back to the Park authority for covering the costs of surveillance. There is room to enhance the collaboration and regular communication flow between the partners (on technical and material aspects between Park Authority and DSPCM, and including relevant capacity development with the local communities).

2) Research and monitoring of fish populations in the Park area is steadily increasing. Since the very beginning the Park area has been considered a nursery ground for juvenile fishes, given that they are the source for feeding the populations of over two million waders, ~40 000 nesting birds and a huge quantity of migrating birds. Active research and monitoring of fish species however began only in the late 1990s with a project on the conservation and ecosystem-based management of the Banc d'Arguin ('ACGEBA', supported by the French Cooperation and led by the Mauritanian Oceanographic and Fisheries Research Institute 'IMROP'). Local fish capture data have been collected in the Park since 1997 with the aim to study the Imraguen fishery in the PNBA. Special efforts have been undertaken to monitor cartilaginous fish, mullets (*Mugil cephalus*, *Liza amata*) and meagre (*Argyrosomus regius)* since 2000, with implementation of three projects that supported the fisheries monitoring system in PNBA until 2005: sharks and rays; support of the re-orientation of the Imraguen fishery – Project ARPI; and conservation and sustainable use of the mullet in Mauritania. Since 2006, they have formed an integral part of the 'monitoring system for artisanal and coastal fisheries' which is executed by IMROP along the entire coast of Mauritania.

The fisheries monitoring system for PNBA will allow for a more regular and representative track record of monitoring data, encompassing oceanography, fish biology, ecology, fisheries technology and a socio-economic survey.

The findings of the monitoring efforts seem to confirm an important role of the park area as reproduction and nursery ground for a number of fish species. All outcomes (scientific data collected, development of management measures) are discussed at annual inter-institutional stakeholder meetings, which were established in 2001. Unfortunately, most of the information and results are not publicly accessible, complicating a quantitative estimation of the stated success to outsiders.

An important sub-region wide role of the PNBA is the protection of several shark species such as scalloped hammerhead (*Sphyrna lewini)*, nurse shark (*Ginglymostoma cirratum)* and spinner shark (*Carcharhinus brevepinna)*. One previously undiscovered species of guitar fish, *Rhinobatos cemiculus*, was found in 1998 and described in 2006 by the French Natural History Museum.

Practical and strategic application of the monitoring data is still limited. The main problem at this point stems from the isolation of the Park administration from other institutions, including from the Ministry of Fisheries.

Recommendations that can be formulated in this context are that:

- analysis of the collected monitoring data should be done in close collaboration with and between partners and relevant institutions in Mauritania;
- the results from the analysis should feed into strategic planning of the Park area, i.e. to develop a long-term strategy that specifically addresses fisheries issues; and
- additional efforts should strengthen institutional collaboration with the aim of harmonizing and integrating the fisheries management strategy of PNBA with the national management plan for artisanal and coastal fisheries in Mauritania (PADPAC).

3) The Park successfully supports traditional fishing practices of the local Imraguen population. However, efforts need to be made to improve the living conditions of local residents of the Park.

The Imraguen have a centuries-old tradition of subsistence fishing in the Park area. Formerly, their mainstay was fishing for grey mullet. The original tradition shifted however, as huge quantities of mullet were harvested south of the Park in association with external operators and merchants in the 1980s. Today, the Imraguen fisheries have moved from subsistence to small-scale artisanal fishing. While motorized 'pirogues' are being used for artisanal fishing activities outside the park boundaries, motorized fishing is prohibited inside the Park and local fishermen use sail boats instead.

Ray and shark fishing developed in the park through economic incentives provided by wholesale fish merchants: the Imraguen received fishing equipment on loan and attractive prices for their elasmobranch captures for shipping to the Southeast Asian fin market. Declines in captures of sharks and rays appeared rapidly, but were compensated for by increased fishing effort with new fishing nets. This accelerated overexploitation in the Park finally resulted in increased fishers' debts towards the merchants.

Over the past seven years, more environmentally friendly fishing activities have been developed inside the Park, such as abandoning of certain fishing gear, financial incentives, and increased valuation of local fish products. Buy back of unsustainable fishing gear and stakeholder consultations have ultimately led to a ban on ray and shark fishing inside the Park in 2003, based on an agreement with local fishermen.

Up to 110 traditional fishing boats are authorized to operate within the Park today and there is international support for the restoration of these boats. The local annual fish catch inside the PNBA is around 2 000 tons, of which (very roughly) one third are mullets, one third are meagre and one third remain smaller species of sharks and rays. Sharks and rays are still caught as bycatch in the meagre fishery, or through uncontrolled Imraguen fishing practices, while illegal fishing for sharks is controlled.

Despite these successes in supporting traditional fishing, the social and economic well-being (i.e. health, access to water, education) of the resident Imraguen population remains unsatisfactory.

There is plenty of movement between the village communities inside, and the villages outside the Park. Management action to improve the socio-economic conditions of the Imraguen population as well as regulations should be applied for all villages, inside and outside the Park. In regard to the application of Park rules and regulations, 'the Park resident' status needs to be clearly defined. Supporting the living conditions (e.g. funding partnerships; alternative income opportunities other than tourism; capacity development) is urgently recommended.

There is a feeling of discontent among some villagers over recreational fishing activity by Park visitors, although this activity is unlikely to have any significant impact on the fish stocks if properly regulated. The PNBA very recently produced a sport fishing 'chart' with the aim of regulating this activity.

3.4.2 Successes of the Park

The Park has provided a concrete (legal and administrative) framework for:

- A Park surveillance system and enforcement of specific fisheries regulations.
- Involvement of the residential Imraguen community in Park activities from the very beginning, and the establishment of a community cooperation scheme with stakeholders.
- A range of successfully implemented projects through international cooperation, and funding support dedicated to Park management resulted in a first track record of monitoring data, and finally supported establishment of a national fisheries monitoring system. A participatory research and monitoring programme on fish captures now exists, and is advised by a scientific committee.
- New fisheries management measures were established within the Park's boundaries, based on stakeholder agreement. They led to the protection of certain fish species and all species of sharks and rays.
- The large size of the PNBA management area can be seen as an advantage for extending the application of management measures to a national level. It also enables conservation of Park-endemic species, including species that may produce fisheries benefits beyond the Park's boundaries.

3.4.3 Challenges

- Tough, unsatisfying living conditions of the local Imraguen residents (health, access to water, etc.), and high poverty levels due to lack of alternative income opportunities and changes in fishing activities are a significant challenge that needs to be tackled.
- Involvement of the full range of stakeholders can be improved through ongoing communication between actors and institutions involved in shared activities, and regular consultations with fisheries managers. For example, the PNBA regulates merchandizing and trading of fisheries catches inside the Park. Integration of all actors involved in the fishery into the stakeholder consultation system and thus in fisheries management, including the merchants and other fisheries stakeholders from outside the Park boundaries can be optimized. Ownership from residential communities of the management issues inside the Park may be difficult due to the deficient living conditions and a lack of local managing capacity, but can be further promoted. Lastly, monitoring data collected should be publicly available to all stakeholders, to prevent time delays in consultations and potential distrust.
- An effective legal and governance scheme needs to be put in place. Currently there is a lack of implementation schemes for existing Park legislation (i.e. there is no decree to apply the Park law 2000/024), and unclear legal formulations that may lead to illegal activities (e.g. for people moving between the Park and its surroundings). A formalized residential status has not been established for the Imraguen, which makes it difficult to apply existing regulations. Changes in the national support system for the Park and leadership issues may pose a challenge for the overall Park management, stressing the need for collective and concerted support from the Ministries for Fisheries and Environment.
- There is a lack of long-term financial sustainability to maintain and extend surveillance measures, as well as to implement research and communication strategies. The current system is highly dependent on foreign financial support.

3.4.4 Lessons learnt for fisheries management

- The Park serves as a tool for habitat and species conservation which, through protecting the ecosystem on which fisheries depend, also enhances the local fisheries. It serves as a refuge for critical stages in the life cycles (e.g. breeding, juvenile) of fish species which migrate or whose ecological range exceeds the Park boundaries during other phases of their life cycle. This is the case for the commercially important mullet, meagre and some shark species.
- The PNBA constitutes an important shark sanctuary within the sub-region and as such may serve as a pilot site for using a participatory approach and joint research programme towards implementing a shark fishing ban.
- Fisheries scientists recognise the protective value of the Banc d'Arguin National Park but also recommend that other measures should urgently be implemented to ensure protection at a national or regional level for economically and ecologically important fish species.
- The Park was originally established for conservation purposes, but has also demonstrated significant benefits for fisheries. Where fisheries rules and regulations on national/regional levels did not exist, the Park provided an opportunity to apply other measures, while existing legislation could be more easily enforced in the context of the National Park.

3.5 Case study D: Integrated, multiple use perspectives for the Great Barrier Reef Marine Park, Australia

The Great Barrier Reef Marine Park provides an example of a large multiple-use MPA which is zoned to allow for different uses and human activities by sub-area, to an extent that ensures a healthy condition of the overall ecosystem. Zones include fishing limitations as well as no-take areas or closures where no extraction of any sort is permitted (Figure 6). Development and adaptation of a zoned management plan with stakeholders has recently increased the area closed to fishing from 4.5 percent to an overall 33 percent of the Park area.

3.5.1 Background

The Great Barrier Reef Marine Park, encompassing an area of 344 400 km^2, was authorised to be established in 1975 through the Great Barrier Reef Marine Park Act by the Australian Commonwealth Government. The Marine Park covers the entire Great Barrier Reef (GBR) of eastern Australia with the outer boundaries extending to straight lines approximating the 200m depth contour. The GBR is also a World Heritage Area and the largest barrier reef system in the world stretching for over 2 300km along the Queensland coast. Consequently there was little doubt as to its significance, bio-physical uniqueness and need for conservation, protection and wise management.

A wide number of fisheries occur in this multiple use Marine Park, ranging from bottom trawling for prawns and scallops, to line fishing for demersal reef fish and pelagic species. The fisheries focus in this case study will be the coral reef fin fish fishery taken by hook and line, which is almost wholly contained within the Marine Park, operating around the ~2 500 individual coral reefs.

The Great Barrier Reef Marine Park Act (1975) constitutes the legislative framework for the GBR and this is administered by the Commonwealth Great Barrier Reef Marine Park Authority (GBRMPA), a statutory authority within the Ministry of Environment and Heritage. GBRMPA acts as the principle adviser to the Commonwealth Government on the management of the GBR.

There is no specific mention in the GBRMP policies and legislation that the no-take zones have a fisheries management function. Their function is described as biodiversity protection and conservation. However, the Great Barrier Reef Marine Park Act (1975) does require that ecological sustainability is ensured, so all uses, including fishing, must be ecologically sustainable within the GBR Marine Park. Consequently, GBRMPA works with the Queensland State Fisheries Agency, the

Department of Primary Industries and Fisheries (DPI&F) to ensure that fisheries in the GBR Marine Park are ecologically sustainable. Through the legislation the GBRMPA can request DPI&F to take action if a fishery is deemed unsustainable or has unacceptable impacts on other species, habitats and other users. As federal legislation the GBRMP Act overrides conflicting State legislation including fisheries legislation.

Contrary to the GBRMP under federal law, the primary legislation for the coral reef fin fish fishery is the Queensland State Government's Fisheries (Coral Reef Fin Fish) Management Plan (2003) through the Fisheries Act (1994). The Plan invokes many standard fisheries input and output controls such as minimum and maximum size limits, limited entry (licenses), gear restriction, vessel restrictions, etc. and DPI&F manages all fisheries in accordance with the principles of ecologically sustainable development. The Coral Reef Fin Fish Management Plan makes no mention of the GBRMP closures with which the fishery must comply; however, the zoning plans of the GBRMP do identify reef line fishing as a reasonable use within certain zones of the Park.

Further relevant legislation is contained in the Commonwealth Government's Environment Protection and Biodiversity Conservation Act (EPBC) 1999. All fisheries that export products from, or that occur in a World Heritage Area, or that interact with endangered or protected species must comply with the EPBC Act and demonstrate that they are sustainably managed before they can operate. In 2004 the coral reef fin fish fishery was approved as a Wildlife Trade Operation (WTO) which allows for the continued export of reef fish. This approval acknowledged that 33 percent of the GBR (up to 30 percent of reef habitat) is protected through no-take zones and that this contributes to ensuring the fishery is being managed in an ecologically sustainable manner.

Since inception the GBRMPA has focused on strong participatory input from all users and other stakeholders of the GBR in managing the GBRMP, particularly in the formulation and review of the zoning and management plans. To engage stakeholders the GBRMPA employs different communication and consultation methods for four target groups: i) users of the GBR (e.g. fishers); ii) local communities that live adjacent to the Marine Park; iii) the broader Australian public who view the GBRMP as a national heritage; and iv) the global community.

The first zoning plan for the GBRMP was developed in the 1970s for the southern Capricorn-Bunker section of the Park which covered 12 000 km^2. Subsequently, additional sections were added over several years and zoning plans were developed for each section in which permanent no-take zones or closures were established with the primary objective of biodiversity conservation (Lawrence *et al.* 2002, FIGURE 6). Adaptive re-zoning of the Park generally every five years has been an ongoing periodic process.

In the early 1990s GBRMPA's management plan review process identified that there were several problems with the zoning, and that the increasing pressures on the GBR, from, among others, tourists/recreational users, fishing and pollution, were inadequately addressed through the number and size of no-take areas within the Park. In addition, the closures were focused on coral reefs with little regard to the other major habitats in the Park (Fernandes *et al.* 2005). The latest rezoning of the GBR, completed in 2004, was a massive undertaking and has increased the number of fully protected no-take areas for biodiversity conservation from 4.5 percent to 33 percent of the Park (Fernandes *et al.* 2005).

Compliance and enforcement of the closures (and all other regulations of the GBR Marine Park Act) is delegated to the Queensland Environment and Protection Agency – the Queensland Parks and Wildlife Service. This is primarily done through boat patrols and plane surveillance conducted by a number of agencies (Queensland Parks and Wildlife Service; Queensland Boating and Fisheries Patrol (DPI&F); Customs; Coastwatch; and State and Federal Police). These agencies are coordinated on a risk-based intelligence assessment. Thus, the likelihood of a particular infringement in a particular area/time causing environmental harm is assessed and patrols target those areas and times. At the same time the Queensland DPI&F conduct boat patrols to enforce the Coral Reef Fin Fish management plan within the GBR Marine Park.

The Minister of Environment offered a compensation package for fishers rather late in the recent re-zoning process, after strong lobbying from the fishing industry. (The package was offered by the Ministry of Environment to compensate for restricted access to fishing areas and potential loss of revenue from fishing, given that the main aim of the closures was biodiversity conservation rather than effort control or yield management.) Commercial fishers can now have their licenses bought out (a total package of around AUD 30 million), while they do not have to demonstrate a direct impact from the re-zoning. However, DPI&F provided information on the potential level of impact and the level of fishing effort for each fisher who applied for compensation. Licences were selected by the Department of Environment & Heritage (DEH) in part on this basis so that those licences that applied significant fishing effort in the Marine Park would be removed and compensated. Contrasting to this, people requesting compensation from fishing related business impact due to closures had to demonstrate the impact. The total package available for restructure package is about AUD 80 million to cover all fisheries in the GBR Marine Park (trawl and line fisheries, i.e. prawn, scallops, coral reef fin fish, crab, pelagics, etc). Clearly the DEH have demonstrated a commitment to compensating the fishing industry for the increase in closed areas in the Park.

3.5.2 Successes of the Park

- One of the key successes of the GBR Marine Park is the recent re-zoning that has resulted in 33 percent of the Park now closed to fishing and other extractive uses, a substantial increase from 4.5 percent. This increase was promoted on the basis that it is generally accepted that at least 20 percent of a multiple use MPA should be closed to conserve biodiversity (Fernandes *et al*. 2005). Modelling studies have suggested that the percentage should be as high as 40-50 percent to maintain sustainable coral reef fisheries (Russ 2002).
- Education campaigns on the new zoning plan ensured that 78 percent of the Queensland population knew about the plan when it became effective and consequently the incidence of infringement was significantly lower than during previous re-zoning times.
- A better understanding of the Park's potential and value by local authorities enabled effective coordination of enforcement and compliance between various agencies and the risk based approach to surveillance. This has increased the number of infringements reported and increased the number of prosecutions. In 1999 the Minister for Environment increased the level of fines significantly, up to AUD 220 000 to an individual fisher for illegal fishing and up to AUD 1 million to a company. In addition, investigators are now able to build cases against environmental crimes. This has been accompanied by training of the judiciary and strong awareness campaigns in the media. The recognition by the EPBC Act assessments of ecologically sustainable management by GBRMP through closures is also seen as a success.
- A strong scientific information basis justifying closures, their location, size and number, added significantly to the stakeholders' recognition of the Park's benefits (with exception of the fishing industry). Despite the fact that the two authorities responsible for the sustainable management of exploited coral reef fishes of the GBR employ different legislative approaches, and do not formally acknowledge each other's legislation, collaborative research between these authorities and others (e.g. James Cook University) has demonstrated benefits of the closures by showing increases in the biomass of fishery target species within the closed areas. Although likely, benefits through spillover effects for the surrounding fishery were however not evidenced.
- This research, on the effects of line fishing by the Cooperative Research Centre for the GBR World Heritage Area, has shown that two main target species of the reef fin fish fishery, the common coral trout and the red throat emperor, were significantly more abundant, larger and older in areas zoned closed to fishing than in adjacent areas that have always been open to fishing (Mapstone *et al.* 2004). The magnitude of these differences varied in relation to levels of fishing effort and natural patterns in abundance of these two species. Thus where fishing effort is high and population abundance is naturally high the difference between closed and

open reefs was greater - closures were more effective. Experimental manipulations of reef zoning status and fishing effort provide further evidence that the Marine Park zoning strategies have been effective in protecting sub-populations of the reef fin fish fishery resource from the impacts of harvest. The impacts of fishing effort were felt within a year of opening previously closed reefs indicating rapid decline in densities and size from fishing on these target species.

- Lessons learnt from over 40 years of engaging with stakeholders have recently led to a new approach of building relationships between individuals within local communities and Authority staff, to strengthen trust between the two and hence engage in collaborative management. Strong community links have been developed via the establishment of Local Marine Advisory Committees and Regional offices. Encouraging signs can be seen in the Keppell Islands, southern GBR, where a community group called "Capreef" (Capricorn Reef monitoring group) representing the recreational fishery, are supportive of the reef closures and want to monitor them with GBRMPA. They supported a total closure of >20 percent of their area and helped GBRMPA select areas that represented both healthy and depleted fish populations and habitats. They recommended closed zones for both replenishment (depleted fish stocks) and conservation (healthy fish stocks).

3.5.3 Challenges

- A critical challenge to the GBR Marine Park is poor acceptance of closed areas by the fishing industry. This is compounded by the fact that despite extensive research, conclusive evidence that high biomass of target species in closed areas will benefit the surrounding fishery is not readily apparent. The commercial and recreational coral reef line fishers are already regulated through the Queensland state's fisheries management plan, and therefore they are understandably unsympathetic to further regulation through closures which are primarily established for the purposes of conservation of biodiversity.
- The real benefits of closures as a fisheries management approach have not yet been well-enough demonstrated on the GBR. Research to demonstrate benefits of closures to surrounding fisheries needs to be carefully designed to tackle this issue. It would be important to look at spillover (larval supply and adult movement of fish) and catch rates in surrounding areas open to fishing. Information is equally needed on fisher behaviour in relation to closures. Monitoring of key indicators in the reef fin fish fishery (e.g. population density and biomass) in response to closures before and after is essential for measuring impacts.
- Clear and synthesised publication of research results is needed, e.g. on the effects of line fishing experiments, to help fishers understand the benefits of closures to the reef fin fish fishery. Awareness raising through educational materials such as videos is an option.
- It is clear that the results of the Effects of Line Fishing experiment need to be communicated carefully back to the fishing industry so that the results are clearly understood. It appears that there is still a large gap between researchers/managers and fishers in terms of trust and understanding. The informal understanding between GBRMPA and DPI&F staff regarding the merits of closures for fisheries management could be made more public to improve fishers' understanding of the positive impacts of closures. Further, the lack of recognition in the two legislations (GBRMPA and DPI&F) of each other's regulations does not foster a cohesive approach to the management of the reef fin fish fishery on the GBR.

3.5.4 Lessons learnt

- Legislation and other management measures for closures (no-take zones) within a large multiple-use MPA such as the GBR should specify to address both sustainable (reef) fisheries management as well as biodiversity conservation. Combining the dual benefits of biodiversity conservation and sustainable reef fisheries as objectives in an MPA management plan adds value and benefits and reaches a wider stakeholder base.

- Adaptive re-zoning as an ongoing periodic process is a key requirement for successful management of a large multiple-use MPA. For example, the GBRMPA Fisheries Issues Group worked closely with DPI&F during the re-zoning of the GBRMP and it was recognised informally that closures were working for fisheries management and therefore more stringent fisheries management measures by DPI&F would not be needed.
- Monitoring the effects of closures (before and after) should combine both biodiversity monitoring and fisheries monitoring to measure impacts.
- Education and awareness material especially video should be produced to illustrate the concept of closed areas as a fisheries management tool for demersal reef fisheries, with the reef fin fish fishery operators on the GBR as the target audience.
- A fully participatory and consultative process is essential to get support from stakeholders. Users, especially fishers, should be part of the monitoring programmes so that they can directly see the effects of the GBR closures.
- The protection of sub-populations of reef fish through closures (with sufficient compliance) was seen as the most effective way to increase total spawning biomass of harvested species over the GBR (Mapstone *et al.* 2004). However, this research cannot demonstrate, though it is implied, that the high biomass within closed zones will in turn benefit the surrounding areas open to fishing through larval flow and adult spillover.
- Enforcement of closures remains essential. A focus on compliance is necessary because of the large scale of the GBR, and this is best achieved by fishers believing in the net benefits of the closures to their fishery.

3.6 Case study E: Territorial use rights in coastal fisheries through Areas for Management and Exploitation of Benthic Resources (*Áreas de Manejo y Explotación de Recursos Bentónicos*), Chile

The number of Areas for Management and Exploitation of Benthic Resources (AMEBR) has rapidly expanded in Chile over the last decade in an effort to reduce the overall fishing effort in Chilean near shore fisheries and to improve compliance with coastal fisheries regulations. The AMEBR provide an important tool for transferring management responsibilities from a central authority to artisanal fishing communities. This case represents an important and ambitious initiative of introducing territorial use rights in a coastal fishery where property rights had never been in place.

3.6.1 Background

The Chilean Fisheries and Aquaculture General Law, enacted in 1991, provides for the establishment of MPAs as fisheries management tools. It lists three categories of MPAs: areas for management and exploitation of benthic resources, marine reserves, and marine parks, with different sets of objectives, management and conservation actions. Marine reserves and marine parks are scarcely applied in Chile; however, the Areas for Management and Exploitation of Benthic Resources (AMEBR) have rapidly expanded over the last decade.

The AMEBR areas aim to ensure sustainable use of marine resources by assigning exclusive territorial use rights to legally recognise artisanal fisheries organisations. Initially developed in the early 1990s as pilot experiments, AMEBRs are now a common management tool and adopted by most artisanal fisheries organisations in Chile.

The main objectives of the management area regime are:

- conservation of benthic resources (invertebrates and macroalgae)
- sustaining artisanal economic activities
- maintaining or increasing biological productivity of benthic resources

- increasing knowledge on the functioning of the benthic ecosystem
- promoting and encouraging participative management

The AMEBR areas fall into Category VI of IUCN's protected areas management categories. They can only be established within five nautical miles from the shore and in inshore areas (rivers and lakes). Over 430 declared AMEBRs with a management plan exist, and ca. 1 200 have been requested (see Figure 7 for region IV of Chile). The average surface extent is 190 ha; the number of fishers involved is around 16 500 out of a total number of ca. 52 000 artisanal fishers in Chile.

The legal provision for the establishment of the AMEBR is set out in article 48 of the Fisheries and Aquaculture General Law Nº 18.892. A specific regulation for management areas is set out in the Supreme Decree Nº 355/95 and outlines the rules and criteria for establishing and managing such areas.

In order to be granted an AMEBR, a community must constitute a legal organization (e.g. artisanal fishers' associations or fishers' cooperatives). There are two main steps for the establishment and implementation of an AMEBR: the first, administrative, aims to delineate the geographic area in which a management project would be undertaken. It involves extensive consultation with several governmental organizations and local communities that need to analyse the feasibility of establishing a management area and ensure compliance with existing uses in order to grant the exclusive use right to the fishers association.

After such consultation and if there are no major conflicts with other uses, the area is declared available and the implementation of a management project can start. This requires the development and execution of a proposal for a base line benthic resources assessment, and the presentation and results delivery of a management and exploitation proposal. The technical requirements for these steps are set out in the management area regulation.

Once the management and exploitation plan (hereafter management plan) of an area is approved by the Under-Secretariat for Fisheries (Subpesca), the second process involves the National Fisheries Service (SERNAPesca) establishing an "agreement of use" for a period of four years with the fisheries organization in order to transmit the obligations and privileges that the management of benthic resources of the declared area implies. Annual monitoring studies are mandatory to evaluate implementation of the proposed management objectives by Subpesca.

In addition to the provisions of the Fisheries and Aquaculture General Law, the management plan of an AMEBR specifies a set of actions to ensure the sustainable management of the fishery. Based on the baseline assessment of the area, the management plan identifies, on an annual basis, target species, harvest periods and techniques, as well as the criteria applied to determine allowable catch rates. The most commonly targeted benthic species within the Chilean management areas are "locos" (*Concholepas concholepas)*, limpets (*Fissurella* spp.), sea urchins (*Loxechinus albus*) and macha clams (*Mesodesma donacium*). The management plan can also include aquaculture activities provided that they have no impact on natural resources and are in compliance with the national fishing regulations.

For every AMEBR, a norm for enforcement of the management plan is established, which defines individual extraction levels, rights and obligations for each member of the fishing community. By this norm a code of conduct among fishers is set independently of the external regulatory authority. The control of the fishing area is done by the fisher's organization themselves, generally through the establishment of a control committee (of often rotating responsibility). Typically, the executive board of the fishers association identifies potential violations of the norm and establishes the appropriate sanctions (Palma and Chávez 2004).

The implementation of the management plan is controlled indirectly through the evaluation reports by Subpesca. SERNAPesca has the mandate to undertake inspections and sanctions. The presence of SERNAPesca during the fishing operations is necessary to certify that the resource was extracted from the management area in accordance with the management measures in place. The fishers' organization might lose the exclusive right to manage the area if the exploitation is in infringement of the management plan.

In Chile, there are several local studies on the effectiveness of the management area as a fisheries management tool, particularly on positive effects such as increase of size and abundance on the target species *Concholepas concholepas* (Castilla 1996, 1999; Castilla and Fernandez 1999; Orensanz *et al.* 2001; Stotz 1997), and on some economic and social improvements to artisanal fishers (Barros and Aranguez 1993; Subsecretaría de Pesca 2004).

3.6.2 Key successes

- The increase in numbers of management areas requested by fishers organizations demonstrates that acceptance of the system within the artisanal fishers communities has been highly successful.
- The Chilean Management Area system emerged in response to the need for alternative solutions that would ensure sustainability of benthic fisheries resources after their severe overexploitation by the end of the 1980s. Artisanal fishers themselves realised the need to change exploitation practices and introduce access regulations for optimized resource use. The results and effects of these access regulations and exclusion of human impact on coastal ecosystems have influenced artisanal fishers in Chile and strengthened their acceptance of the AMEBR concept.
- Shifting from common property fisheries (characterized by a lack of property rights and economic over-exploitation) to exclusive use right in the Chilean coastal fisheries has created a sense of ownership and responsibility for the management of the resource.
- During this process fishers learnt to acquire new skills for managing the fisheries resources, while the authorities delegated certain responsibilities and found new collaborative ways of working with the resource users.
- The management areas allow for improved interaction between the fishers, the management authorities and the scientific community. The system is participatory and transparent enough to build and reinforce trust between the different stakeholders.

3.6.3 Challenges

- The main challenge of the system is to ensure enforcement of the management regulations. Involving the fishers in managing the resource aims at reducing the need for external control, implying the commitment of fishers to control illegal practices themselves in order to increase their benefits.
- Current regulations, however, focus only on the biological and technical aspects of the fishery exploitation, while economic considerations, which are crucial to understanding the fishers' strategic behaviour, are largely ignored. The Chilean Fisheries and Aquaculture Law, for example, do not inquire about norms and internal regulations used by the community to guarantee the compliance of the management plan. Fishing associations need to take into account the potential problems associated with self-regulation prior to being granted full user rights (Villena and Chavez 2005).
- The new co-management regime of the fishery did not empower fishers in advance to enable them to manage the resource effectively. Today there is a clear need for capacity building in the implementation of the management and exploitation plans, equipping the fishers with better tools for the management of the resources.

- Research, and especially studies that relate these areas to broader conservation objectives or to the status of the resources at the national scale are lacking. There is also a need for interdisciplinary research, considering biological, social and economic factors to develop an improved understanding of the various determinants of success in use rights arrangements.

3.6.4 Lessons learnt

- Establishment and administration of the AMEBRs promote and strengthen the development of fishers unions that are then linked with both government institutions in charge, and with the scientific community.
- AMEBRs can have a high educational value, as they allow for direct interaction between scientists, managers and users. Targeted capacity building, however, still needs to be made (see above).
- The AMEBRs provide an interesting opportunity for implementing different fishery management experiments. A synthesis of lessons learnt and comparison of effectiveness of the different management schemes would be needed to provide a basis for structural improvement of the system. A comprehensive evaluation of the system at a broader scale needs to be conducted.
- Surveillance, sanction and control are key elements for AMEBRs to work effectively, and need to be enforced by strengthening the control capacity of the relevant authorities.
- There is a need to conduct studies that relate these areas to broader conservation objectives or to the status of the resources at the national scale. There is a particular need for interdisciplinary research, considering biological, social and economic factors to develop an improved understanding of the various determinants of success in use rights arrangements.

3.7 Case study F: Community-managed coral reef sanctuaries in Bohol, central Philippines

This case study provides an illustration of nineteen no-take MPAs that are fully implemented, managed and enforced by local subsistence fishing communities across Danajon Bank in Bohol, in the central Visayas of the Philippines.

The no-take MPAs have been established, by the communities with the support of a non-government organisation and its local counterpart foundation. The first sanctuary, Handumon, was proposed in 1995 and enforcement commenced the same year. Reports of good experiences elsewhere in the country, and increasingly good reports in Bohol have prompted subsistence fishing communities to support the development of these areas.

3.7.1 Background

All MPAs are small in size and function as no-take marine sanctuaries, primarily protecting shallow, fringing reefs, seagrass beds and mangroves within the inshore coast of the Danajon Bank reef complex (FIGURE 8). At the periphery of the Camotes Sea, the Danajon Bank is a distinctive double barrier reef complex of reefs, inshore islands, seagrass beds and mangroves. The Danajon Bank reef complex comprises of a total area of 2 476 km^2 and is historically reported as the most habitat-rich fisheries ecosystem of the Central Visayas (Green *et al.* 2004). The Danajon Bank is suffering from declining fish stocks primarily because of overfishing, and increasingly critical habitat status due primarily to destructive fishing methods notably the use of trawls and dynamite. Reef conditions span the entire spectrum of high to low quality due to both environmental and human impacts. In addition, this region presently contains one of the highest recorded fisher numbers in the Central Visayas and the majority of these fishers are dependent on the fisheries for their livelihood and direct consumption. The fisheries of the region have changed drastically over the last several decades with CPUE declines associated with all fishing grounds (Green *et al.* 2004).

The reasons for the establishment of these sanctuaries were to promote rebuilding of marine life, for both conservation and economic purposes; to manage important local artisanal fisheries, such as the seahorse fishery (Martin-Smith *et al.* 2004), but also fisheries for demersal reef fish particularly rabbitfish and parrotfish; and to comply with national legislation that stipulates Municipalities must establish marine protected areas (MPAs).

The impacts of five of these small coral reef sanctuaries have been analysed in some detail. All five sanctuaries are small (< 1 km^2) spread through three municipalities, over a distance of approximately 40 km (see FIGURE 8), and comprise shallow coral reef habitat, but some include dense beds of the brown algae *Sargassum,* which may have been promoted by extensive coral destruction from dynamite fishing (Marcus *et al.* in press).

Legislation for the protection of coastal waters is very progressive in the Philippines. The National Integrated Protected Area System (NIPAS) Act (RA 7586), was enacted by Congress in 1992 to respond to the profound impact of human activities on all components of the natural environment in the Philippines (DENR, BFAR and DILG, 2001). Of greater relevance to the Bohol sanctuaries are the complementary Local Government Code 1991 (RA 1760) and the Philippines Fisheries Code 1998 (RA 8550), which provide municipalities, termed local government units (LGUs), with legal frameworks and mandates to manage their 15 km municipal waters and to establish MPAs. This is a relatively quick process requiring the passing of a municipal ordinance. To get an area protected under the NIPAS act requires either an executive action (Presidential Proclamation) or congressional action (house and senate bill). Under RA 7160, the LGUs can use their internal revenues to support coastal resource management initiatives including MPAs. They may even use these resources to build up their own capacities in Coastal Resource Management. These LGU-codified MPAs are fully protected no-take MPAs, locally referred to as *sanktwaryo (*sanctuaries). Under Philippine law, taking of any sort is not allowed in these sanctuaries.

The Bohol marine sanctuaries are legally gazetted through municipal ordinances and resolutions. Management plans for the five sanctuaries are included in coastal resource management plans produced by the Municipality in consultation with village management teams. Village natural resource management (NRM) plans may also include management plans for the sanctuary. The majority of the MPA management plans include goals that focus on the improvement of fisheries yields outside the sanctuary for food security and income. Activities have included participatory coastal resource assessment, on-site consultations, fulfilment of legal requirements, management council establishment, management plan formulation and community-based monitoring.

Encouraging compliance of sanctuaries involves a number of different steps: placing marker buoys and posts so that the sanctuary is clearly delineated; the building of a guard house in the sanctuary; and a patrol team established with a daily guard assigned to guard the sanctuary from the guard house, and this may be 24hr or at night only depending on the fishery. Finally, where there is good enforcement, patrols by boat are also conducted.

Legally, enforcement can commence as soon as a municipal ordinance or resolution is passed as it is the municipality who owns the municipal water (Fisheries Code of 1998). In reality local communities often take enforcement into their own hands before the ordinance is passed, and have some powers through formally delegated village police and fish wardens.

Starting in 1998, teams comprised of biologists, local fishers and volunteers have developed and conducted bi-annual surveys that now include visual census of fish abundance, seahorse surveys and quantitative benthic assessment. The long term monitoring programme tracks the effectiveness of MPAs in providing protection to coastal habitat, enhancing fish abundance and biomass, and conserving seahorse populations. Changes in eight MPAs are now surveyed using permanent transects inside and outside the MPAs, and at five distant control sites. The biophysical monitoring is reported to local MPA communities and municipal governments on an annual basis for their assessment of MPA success.

3.7.2 *Key successes*

- Strong and active community and fisher participation in all aspects from sanctuary site selection, management planning and monitoring has been a feature of most of the Bohol sanctuaries (Meeuwig *et al.* 2003) and this has meant communities feel a strong sense of ownership, responsibility and therefore generally comply with sanctuaries. Each of the villages associated with the five Bohol sanctuaries has a Peoples' Organisation (PO) which is involved in all aspects of sanctuary management. Community participation has and will continue to provide important insights with regard to interpretation of the monitoring data for adaptive management.
- Activities focused more on people than marine life in designing and planning MPAs, using community development specialists called Community Organisers (COs) to facilitate strong Peoples' Organisations, in partnership and with support from biologists.
- Technical and financial support with a strong presence on the ground has provided communities and local governments with help, encouragement and guidance, as well as technical input, training and funds (Project Seahorse).
- Analysis of monitoring data of reef fishes over seven years provides some convincing evidence of positive impacts of the sanctuaries though the results are complicated by natural variation. Positive impacts were, not surprisingly, primarily seen in the three sanctuaries (Handumon, Batasan and Asinan) that are well enforced. In these, the densities of groupers (Serranidae) and breams (Nemipteridae), key target species in the local fisheries, increased significantly in the sanctuaries compared to distant unprotected (control) sites. These density increases in the sanctuaries over time were also seen just outside the sanctuary boundary though at lower densities, providing some suggestion of spillover of these two fish groups. These positive impacts no doubt contribute to community acceptance of MPAs. A further point for acceptance might be the small size of the sanctuaries, so that spatial reduction in the overall fishing area is less significant, and easier to manage in logistical terms (Samoilys *et al.* 2006).
- A strong legislative framework to complement community management activities, with increasing financial allocation to MPAs was essential for the success of MPA implementation.
- Extensive awareness campaigns on the benefits of sanctuaries for improved fisheries and hence improved livelihoods, and activities such as cross-visits to well-established sanctuaries (e.g. Apo Island) have been an effective tool for building awareness and understanding.

3.7.3 *Challenges*

- Long-term financial sustainability is one of the key challenges that the Bohol sanctuaries face, because many of the sanctuaries have relied on external aid for financial support. To address this issue, recently drafted MPA ordinances now specify that the LGU should allocate funds from its annual budget for MPA management. With the codification of budget allocation, communities can now claim a yearly allocation from municipal governments.
- Technical capacity is still lacking at the village level and to some extent at the municipal level, given that guidance has largely been provided by outside partners in the past. Development of a local technical resource institution would be recommended.
- Another key challenge for the Bohol sanctuaries is compliance. Three of the five focal sanctuaries were found to be well enforced. Illegal fishing in the sanctuaries continues to be a problem: poor or non-existent enforcement in the other two may reflect a lack of resources by villagers to keep outside offenders out since village management teams often state that poachers are fishers from neighbouring villages. It may also reflect local social infrastructure – those MPAs that were well enforced are those with relatively strong POs.

- Monitoring of CPUE in the fisheries surrounding the MPAs started late in 2003 – well after sanctuaries were established, and therefore direct improvement in neighbouring fisheries cannot yet be empirically demonstrated.
- Government participation has been weak.
- Rapidly increasing local human populations negate many of the MPA benefits.

3.7.4 Lessons learnt

- Local fisher participation and consultation is important from the onset. It should continue during all stages of planning and implementation, with an emphasis on capacity building.
- Building capacity should target local communities, MPA managers, municipal government units, and MPA technical resource institutions.
- Accurate and regular monitoring of key fishery indicators (bio-physical, socio-economic and fisheries) is essential to demonstrate causal relationships between sanctuaries and fisheries. Local communities must be involved in this including the interpretation of monitoring data. A global analysis of key indicators relevant to these sanctuaries would be very helpful.
- The impacts of MPAs on different sectors of the community (poorest, inshore, women, children) need to be assessed and disproportionate efforts adapted.
- Adequate funding, logistics, and institutional support must be provided for ongoing enforcement by local communities and fisheries management agencies. Detailed measures of enforcement, compliance and community participation in sanctuaries are important to fully understand the factors that contribute to successful sanctuary management.
- Strengthen other fishery legislation such as gear restrictions and licensing needs to be put in place to complement, and be integrated with MPAs.
- The adaptive management cycle in which sanctuary plans are reviewed and revised based on analysis of monitoring data (bio-physical and socio-economic) needs to be put in place and supported (financially and technically).

3.8 Case study G: Incorporating MPAs into a set of existing fisheries management measures in Antarctic high seas areas

Experience in Antarctica provides a useful case study on recent progress and remaining challenges of developing marine protected area (MPA) systems within an existing regional fisheries management framework. At the same time it provides one of the very few concrete examples for establishing area-based measures in waters beyond national jurisdiction (i.e. on the high seas). This case study highlights the recent recognition by a regional fisheries management body that MPAs have considerable potential as a tool for use towards the implementation of an ecosystem-based approach to marine conservation and fisheries management, in an area that is characterized by a highly industrialized commercial fishery. This article largely references a recent article by Susie Grant (PARKS 2005).

3.8.1 Background

The Southern Ocean, bounded by the Antarctic Continent to the south and the Antarctic Polar Front to the north, comprises around 10 percent of the world's oceans. It is characterized by highly seasonal primary productivity leading to huge quantities of herbivore species such as copepods, salps, and euphausiids (especially the Antarctic krill). Their predators have been major target species for human exploitation historically and until today. The benthic fauna of Antarctica is highly adapted and species rich, with exceptional levels of endemism.

The Antarctic Treaty System (ATS) provides the basis for the protection of the marine ecosystem. Development of MPAs falls under the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), and the Antarctic Treaty and Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol) (FIGURE 9). Both instruments have developed area-based measures for protection and management in marine areas.

The two main tools for area protection and management under the Madrid Protocol are: Antarctic Specially Protected Areas (ASPAs) and Antarctic Specially Managed Areas (ASMAs).

ASPAs correspond to IUCN Category I protected areas (Strict Nature Reserve), and require a permit for entry and other activities such as scientific study. There are currently six marine ASPAs (as well as nine terrestrial areas with small marine components), covering a total marine area of approximately 1 800 km^2, or 0.012 percent of the marine area south of 60° S. These are some of the few high seas MPAs currently in existence worldwide, however the majority are *ad hoc*, coastal areas of limited extent. None are located in areas in which there is any fishing activity, and none have been designated as "representative examples of major marine ecosystems" as required by the Madrid Protocol (Annex V, Article 3.2).

ASMAs correspond to IUCN Category IV protected areas (Habitat/Species Management). They are designed to help manage and co-ordinate activities based on a non-mandatory code of conduct for multiple uses. Three current ASMAs include marine components (although one of these has not yet been formally adopted), but this tool has the potential for much wider use to strengthen management and provide codes of conduct in areas of intensive use. These areas do not require a permit for entry.

CCAMLR is a pioneer of the ecosystem approach to fisheries management, aiming at the conservation and rational use of Antarctic marine living resources. These include populations of fin fish, molluscs, crustaceans and all other species of living organisms found south of the Antarctic Convergence (CCAMLR 2004, Article I, II). It has a wider conservation mandate than any other Regional Fisheries Management Organization (RFMO). A Commission and a Scientific Committee oversee implementation of the Convention.

The entire area covered by the Convention can be classified theoretically as an IUCN Category IV protected area (Habitat/Species Management), because of the level of overall management it provides: Conservation measures defined by CCAMLR include closed seasons, catch and effort limits for particular species, restrictions on the number of vessels permitted to fish in each season, gear restrictions, limits on by-catch of other fish species, and measures to mitigate the effects of fishing on associated and dependent species. CCAMLR also has a variety of area-based management tools that provide protection.

Amongst these area-based tools are Closed Areas for the purposes of scientific study or conservation, including special areas for protection and scientific study. Closed Areas have to date been implemented only on a species-specific basis, although two areas off the Antarctic Peninsula remain closed to all fin-fishing to allow stock recovery. Other Closed Areas include regions closed to fishing by species and season, and areas for protection of benthic habitats where fishing is prohibited in depths of less than 550 m. Areas may also be closed immediately once catch limits or by-catch limits for fish or seabirds have been reached (Figure 10).

Additional tools include geographically defined units used to assist with the implementation of fisheries management measures. Small Scale Research Units (SSRUs) are used to apply catch restrictions and research requirements for new and exploratory fisheries for toothfish (*Dissostichus* spp.), defining catch limits of zero (thus effectively closing the area to fishing for these species) in several locations. Small Scale Management Units (SSMUs) are used to facilitate management of the krill fishery, and aim to distribute fishing effort and reduce the potential for localized depletion of krill populations and impacts on land-based predators. No areas of fishing activity have been permanently closed to all types of living resource extraction.

The provisions and restrictions of individual area-based management measures applied here build a useful starting point for the development of MPA tools and implementation systems, whereas no MPA as such has been officially declared in Antarctic waters yet (areas have been declared due to their importance for science rather than conservation). The following describes recent progress towards rather than results from MPA effectiveness assessments.

3.8.2 Recent progress

Discussions on the development of MPAs within the CCAMLR context have recently advanced acceptance of conservation objectives into the fisheries management regime, and of fisheries no-take reserves: a workshop held in September 2005 identified specific conservation objectives for potential Antarctic MPAs, priorities for the types of areas to be considered for protection, and the types of scientific information required for the development of representative MPAs. The potential benefits of MPAs for biodiversity conservation, minimization of impacts of harvesting on non-target species, and protection (including restoration) of stocks and life history stages of target species were noted by CCAMLR Members. The positive workshop outcomes furthermore indicate an increasing willingness by CCAMLR Members to take action towards developing and testing new approaches for establishing MPAs that further the objectives of CCAMLR.

3.8.3 Challenges and lessons learnt

- There is a need for interaction and coordination between the two ATS instruments on the development of marine protected area strategies. Parties to the Antarctic Treaty and the Madrid Protocol do not have the authority to manage harvesting of marine living resources however with CCAMLR's approval it can designate ASPAs that would restrict marine living resource harvesting (no ASPAs have yet been designated where this is the case). Further interaction and coordination between the two instruments could include the development of networks of protected areas to achieve both fisheries and biodiversity conservation objectives, and the designation of representative MPAs throughout the Southern Ocean.
- The CCAMLR area extends north of 60°S, thus covering a much larger area than the Antarctic Treaty and the Madrid Protocol. ASPAs and ASMAs cannot be applied in the entire area north of 60°S. There is a need to develop a strategic approach to MPA design and implementation throughout the CCAMLR area, and any regime for protection of the marine environment should be harmonized with measures already taken under the Antarctic Treaty and the Madrid Protocol.
- Although progress is being made, long-term biological data on the ecosystem and its functions is still very sparse. More information is needed with which to identify areas for protection.
- Year-round enforcement of the regulations established remains a challenge in the Antarctic environment.
- Although CCAMLR has designated Closed Areas to support its precautionary approach to managing fin-fisheries, these have not been established for broader purposes relating to MPAs.
- Recent CCAMLR discussions and decisions also have relevance for high seas marine protected area development worldwide: there is potential for concepts and models currently developed by CCAMLR to be used for high seas development elsewhere, and to appropriately apply them in relation to other management measures, particularly for fisheries. The concept of MPAs established under fisheries management frameworks (such as CCAMLR) but within a wider conservation context (such as that provided by the Antarctic Treaty with the Madrid Protocol) may be particularly applicable for high seas MPAs worldwide.

- Priorities for future work on MPA development within the CCAMLR context include wide consultation with appropriate interest groups and stakeholders, and the development of flexible decision-making and review procedures. To achieve maximum benefits, MPAs must be implemented within, and contribute to, the wider framework of sustainable fisheries management.

3.9 Discussion of the case studies

The case studies described throughout this paper illustrate different success features which MPAs can provide for achieving fisheries management objectives, as well as their challenges and limitations. Given the variety in scope, ecosystems, social, economic, ecological and governance context of the MPAs covered, and not least availability of supporting data and information, the first point they make is that there is no standard recipe for identifying their individual role and determining their set up.

A common feature that reappears throughout is the idea of developing MPAs that complement existing fisheries management regimes, and vice versa, and towards implementation of an ecosystem-based approach to both conservation and fisheries management. Recent advances have been made in Antarctica of developing MPAs in high seas areas where multiple-state industrial fisheries are regulated through existing fisheries management regimes.

The stakeholder process of designating no-take MPAs in the Channel Islands emphasises the importance of integrating reserve design and science with the fisheries management system. A cost-intensive process that included a large array of user groups from different sectors has been put in place for this reason. Given the wealth of lessons learnt, this case study focuses entirely on stakeholder processes.

Several of the other case studies also highlight the need for full participation and ownership by local stakeholder groups to make MPAs work and achieve sustainable fisheries objectives. While the Philippines case study provides an illustration of nineteen small-scale no-take MPAs that are fully implemented, managed and enforced by local subsistence fishing communities (villages), a series of collaborative management areas are established by user-groups in Tanzania in combination with a long-term fisheries monitoring programme.

Careful monitoring of the fisheries and their associated bio-physical and socio-economic context in and around MPAs is also documented in other cases, and should ideally lead to adaptations in MPA management if changing states are documented. The Great Barrier Reef Marine Park provides an example of where such adaptive management is practiced at the scale of a large multiple-use MPA. It is zoned to allow for differing human activities, including limited fishing and no-take areas, to an extent that ensures a healthy condition of the overall ecosystem.

The case study from Banc d'Arguin National Park shows how fisheries management objectives may be successively integrated into MPAs with primary conservation objectives, even if conservation objectives have been long established and conditions for efficient monitoring and enforcement are difficult. Full integration of the residential communities and their traditional resource use patterns inside an MPA is a key characteristic of this case, as is the role of the large-scale MPA for protecting critical life stages of commercially important fish species.

A crucial issue for all the case studies presented is that legal tools for MPA management be embedded within existing legal frameworks, and that new tools also be developed. Granting territorial use rights to local fisher communities in Chilean near shore zones has led to a rapidly increasing number of management areas for sustainable exploitation of benthic resources in Chile. A clear sense of local ownership could thus be established that led to overall improved conditions for fisheries management.

MPAs are emerging as a significant tool in the toolbox of fisheries management options (e.g. Martin-Smith *et al.* 2004). They can complement other fisheries management options and provide an additional safety net or insurance policy in case other options fail (Guénette *et al.* 1998; Russ 2002), or even an opportunity for other restrictions to be less severe.

The following section will present key elements, or 'messages', that have been extracted from the presented case studies for consideration and further discussion during this workshop.

4. RECOMMENDATIONS FOR TECHNICAL GUIDELINES AND FUTURE DIRECTIONS IN MPAs FOR FISHERIES MANAGEMENT

4.1 Key elements for consideration and recommendations

This section provides a set of recommendations and 'ingredients' for consideration when developing technical guidelines focused on MPAs as a tool for fisheries management. Given the wealth of lessons and recommendations resulting from MPA experiences globally, this listing does not seek to be exhaustive. It rather provides a set of 'conventional' experiences that can be complemented with more innovative approaches, such as vertically zoned, migrating or rotating MPAs, for example. It is recommended that the FAO consultative workshop improves, expands and agrees on this list on the basis of further information and reviews available (e.g. DEFRA 2006 for North Sea and Northeast Atlantic; Bernstein *et al*. 2004 for MPAs in United States waters; e.g. Simard and Lundin 2005). Further research and testing is needed, and the paper concludes with a brief discussion of the most pressing needs.

4.2 The MPA planning and designation process

As fisheries management agencies are moving towards applying the ecosystem approach to fisheries, classical fisheries management tools need to be adapted to take a more holistic approach and consider the ecosystem as a whole. The use of MPAs as a spatial management tool is becoming more common, but such use need to be integrated in an array of measures to ensure the sustainable use of marine resources and biodiversity (IUCN 2004).

As stated before, Marine Protected Areas can have different levels of protections, they can be no-take areas, or multiple use MPA where regulations are stricter than in the surrounding environment. The MPA can also be a combination of several zones.

4.2.1 Well defined goals and objectives

MPA goals and objectives need to be clearly defined when the MPA is in the planning stage. The specific role of the MPA in fisheries management needs to be captured in these objectives. The goals and objectives identified for an MPA determine criteria for its design as well as approaches for evaluating its effectiveness in achieving its goals and objectives.

Many MPAs are established with primary biodiversity conservation objectives, but they can also have significant benefits to fisheries, which are often not recognized or articulated by the conservation community.

Fisheries managers as well as conservation managers should take advantage of such MPAs and, where relevant, strive to ensure that they do also capture defined fisheries management objectives in their plans and design. On the other hand, MPA management should be realistic and critical to what stock enhancement can be achieved by the MPA, and where other, complementary fisheries management measures are likely to be more effective. There is abundant evidence that area closures for fisheries can also benefit benthic biodiversity and enhance habitat complexity (e.g. Sweeting and Polunin 2005). An individually adapted combination of tools seems thus to be the most practical way to go.

MPAs that have fisheries management objectives in addition to conservation objectives can help to bridge the gap between conservation and fisheries and in some cases address conflicts between competing users. They may also provide opportunities to create synergies and interactions between the practitioners, users and management authorities.

4.2.2 Full stakeholder involvement

Successful performance of MPAs in fisheries management requires that stakeholders recognize and agree to the need for this more inclusive approach to fisheries management. The engagement of stakeholders in MPA design and management is critical and needs to start from the very beginning at the conceptual/design phase of the MPA and continue throughout the review, evaluation and adaptive management cycle.

Representatives from all stakeholder groups need to be involved regardless of who is the driving force behind the MPA, whether government, community group, or other. All stakeholders likely to be affected by the MPA setting need to be consulted, and engaged into the MPA planning, implementation, monitoring and assessment process. Special attention must be given to address conflicts between competing users.

The mechanisms for consulting and engaging stakeholders will vary greatly from one situation to another, and need to be considered on a case-by-case basis. Advisory committees or coordination committees are common mechanisms and can comprise representatives from as broad a base of stakeholders as is relevant. If this step is ignored, or only partially considered due to financial or management constraints, the chances of opposition and resistance are greater. For an MPA to be successful local stakeholder support must be guaranteed, otherwise they are likely to undermine the whole process. Experiences also show that when the stakeholders, particularly fishers, are involved in the design and management of the MPA, they are more likely to comply with the MPA regulations, consequently reducing enforcement challenges.

Direct interaction between scientists, managers and users is particularly important in the monitoring, evaluation and adaptive management cycle (see below), but also more broadly to ensure stakeholder relations are cordial and that trust is built and maintained. This takes time and effort, trial and error, but will be important to prevent a breakdown of relations between stakeholders which can undo all the management on the ground. It is of key importance that stakeholders both within and beyond MPA boundaries are included. A fully open debate on the appropriate application of MPAs is often necessary to avoid public distrust and political manipulation that has recently dogged fisheries scientists and managers (Kaiser 2004).

4.2.3 Building capacity, education and communication

As governance concerns and financial constraints encourage the use of co-management models for MPA, there are new needs to build capacity in other stakeholders such as fishers and local communities.

Stakeholders' interactions are improved when each can appreciate each other's use of the MPA, and understand the ecosystem, the fisheries, the socio-economic constraints, etc. With the increasing number and broadening range of stakeholders, the potential differences in ability to participate in management also increase. Management agencies need to facilitate capacity building to empower all stakeholders to effectively play their role in the management of the MPA.

The Implementation of an ecosystem approach to fisheries and the use of MPAs as a fisheries management tool may involve changes in the responsibilities and priorities of management agencies and this might require appropriate training to staff affected by these changes. This might include enhancing knowledge and understanding of fisheries measures and objectives by MPA managers, and conservation and biodiversity considerations for fisheries officials.

Technical training in monitoring, evaluation and adaptive management is particularly helpful to local resource users and managers in developing countries and needs to be done on a regular basis. Training programmes and long term funding support need to be generated so that capacity can continue to be built in an inter-disciplinary way.

4.3 The legal and institutional frameworks

4.3.1 Enforcement

Illegal, unreported and unregulated (IUU) fishing is one of the most significant challenges to fisheries managers.

The experiences illustrated in the case studies above show that MPA offer an opportunity to reduce enforcement challenges, in cases where the stakeholder engagement is strong and particularly when enforcement is done by the local communities that benefit from the MPA.

Most large scale MPAs have particular challenges when it comes to control and surveillance functions to ensure compliance with the MPA regulations. This problem might require the use (and in certain cases development) of new and appropriate technologies such as vessel monitoring systems. The costs of such investment can be reduced when such measures are integrated in wider fisheries management tools required at a national/regional scale.

4.3.2 Harmonizing MPAs with other fisheries management legislation and existing legal frameworks

The choice of the legislation that would regulate the management of the future MPA is of crucial importance. The creation and management of an MPA, however, sometimes uses various existing pieces of legislation, each regulating one activity or use. In such cases, it is important to consider harmonization of these overlapping regulations.

The legislation(s) governing MPA management should also be easily amendable by additional arrangements without the involvement of too complex a legislative procedure in order to integrate the evolving management of existing and future human activities.

4.3.3 Institutional frameworks

The application of an ecosystem approach to fisheries implies a need for institutions to ensure coordination, consultation and cooperation, including joint decision-making, between fisheries management agencies and agencies managing other activities that might have interaction with Fisheries (FAO 2003).

One of the challenges will be promoting and strengthening synergies between fishery legislation and environment/conservation legislation. In many countries fisheries management responsibility is within one Ministry (e.g. of Agriculture) whereas environmental management with a more conservation/protection focus comes under another Ministry (e.g. Environment), although institutional responsibilities vary and sometimes overlap.

Ensuring coordination and consultative mechanisms between different agencies with relevant interests is essential and should be made in a formal manner. Ensuring transparency and dissemination of the information is also another important point that needs to be considered when establishing institutional frameworks.

Research that assesses the relative merits of different governance systems for MPAs in different cultural, political and socio-economic situations would be very useful for developing guidelines for legal frameworks for MPAs. On a regional scale, this could, for example, include examining the potential of inter-governmental commissions and similar governance units. The guidance proposed by FAO (2003) is a very useful first step that could be built upon to develop guidelines for legal frameworks for MPAs.

4.4 Sustaining MPA benefits

4.4.1 Monitoring and evaluation

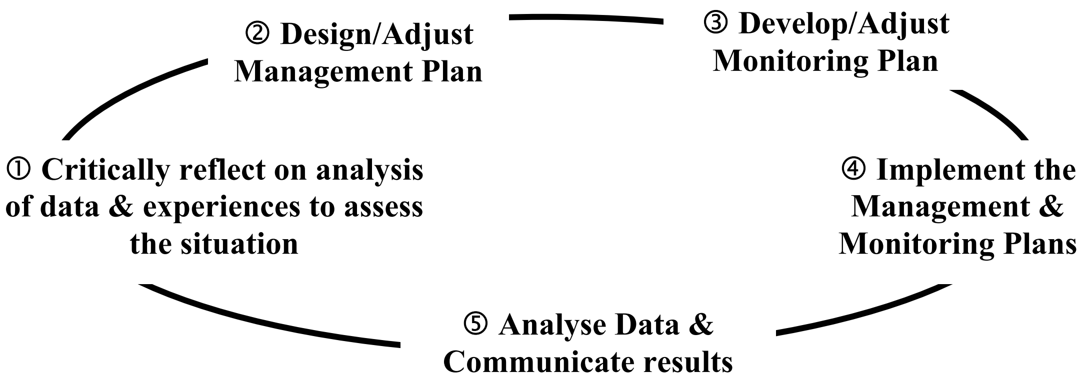
Careful monitoring of the fisheries and their associated bio-physical and socio-economic context in and around the MPA must be put in place. This needs to be done before and after MPA establishment if MPA effects are to be assessed, and the predominating gap in before-and-after change impact analysis (BACI) needs to be addressed (see Sweeting and Polunin 2005). The importance of monitoring and assessment is generally well recognized, although MPA managers often fail to seek suitable advice and expertise to put the right monitoring programme in place. A number of factors must be considered including resources, technical capacity and the long term sustainability of the programme, since the latter is crucial. For example, an MPA might be established with financial support from a particular donor. However, donors rarely want to fund long term monitoring programmes. Therefore such programmes need to be considered during financial sustainability assessments and built into local MPA budgets (often government funds), or supported through engaging with long-term partners, such as universities.

Choosing suitable indicators is integral to an effective monitoring programme. Indicators need to be specific to the objectives of the MPA, relevant to the resource managers, measurable (in terms of cost, logistics and replication), sensitive to change, and responsive within a reasonable time period (Pabari *et al.* 2005). Deciding on suitable indicators may require research (see Future Research section below), and certainly requires input from relevant experts.

4.4.2 Adaptive management

Although the concept of adaptive management is now well documented, it is regrettably still rare to find it being used properly. Adaptive management "*incorporates research into conservation action*. Specifically, *it is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn"* (Salafsky *et al.* 2002).

Effective adaptive management requires managers to complete all steps in the cycle illustrated below (taken from Pabari *et al.* 2005):



This adaptive management cycle needs to be incorporated into the MPA management plan, supported by monitoring and data analysis. One of the steps that is often not given due consideration is critical reflection on the results of the data analysis. This should also involve consultation with stakeholders to verify interpretations of the results are plausible and practically applicable in the respective socio-economic context. In this way recommendations for management changes, where needed, are based on critical assessment and collaboration. Options for management change need to be a formal part of the MPA's management plan – e.g. to be reviewed every three years.

There is a need and demand for new innovative approaches to fisheries management and appropriate combinations of established tools and new approaches (FAO Code of Conduct 1995; FAO 2005). Continuously adaptive and participatory management processes with the broadest possible array of stakeholders will be needed to best assess and validate such approaches (Agardy *et al.* 2003; Carr and Raimondi 1999). This is even more important in the face of rapidly changing climate conditions that affect species compositions and habitats as well as fish stocks.

4.4.3 Financial sustainability

One of the major limitations in effective MPA implementation is sustaining funding in time. Funding mechanisms need to be set in place early in the design of an MPA, with long term sustainability in mind. Often, MPA plans are over-ambitious and consequently not realized due to inadequate funding. Priorities, for example for enforcement and monitoring, need to be considered and a regular source of funds identified. If this is through local or national government, the merits of the MPA often need to be justified. Management of fisheries and the link with peoples' livelihoods may be a better message to send to the government than biodiversity conservation alone.

Revenue generation, e.g. from fishing levies, cost sharing among stakeholders and other fund generating ideas, needs to be put in place at the start of the MPA. A wide range of funding options exists, and they will vary widely from country to country and between fisheries. Generally, three sources of funding are available: government, donors, and self-generating activities. The following mechanisms for financial sustainability can be considered: (i) cost effective implementation; (ii) revenue collection from use of the MPA and the ecosystem services it provides (fisheries, tourism, etc); (iii) equitable revenue sharing that reinforces local management efforts; (iv) precautionary instruments that provide safety nets; and (v) sharing of revenue between MPAs (Ruitenbeek *et al.* 2005).

4.5 Ecological considerations – some aspects

4.5.1 Habitat protection and restoration

It is logically evident, but often difficult to quantify the benefits that healthy (protected) habitats have for certain fisheries (Sweeting and Polunin 2005). MPAs which ban fishing gear with high impact on benthic features (such as towed gears) clearly protect seafloor habitats. A recent series of case study reviews from Northeast Atlantic temperate waters (DEFRA 2006) describe that area closures, if combined with effort removal, generally lead to increases in associated fauna, habitat complexity and increased survival in fish species. MPAs thus play a role in preventing damage by fishing gear especially to biogenic, slow growth-recovery habitats (as e.g. maerl beds, deepwater corals, sponge communities). In contrast, habitats subject to frequent natural disturbance are unlikely to benefit to the same extent.

4.5.2 Spawning and nursery site protection

MPAs can provide protection to vital breeding and nursery areas of important fishery species, and although these species may range well beyond the MPA boundaries, these critical life history stages remain protected at a time when they are particularly vulnerable and easy to exploit. The Mauritania and Australia case studies illustrate these benefits. Other examples include the protection of spawning aggregation sites. Many species migrate predictably to certain sites where they congregate in large numbers to spawn. Protection of these sites is vital, particularly if the species is subjected to heavy commercial fishing pressure (Sadovy and Domeier 2005). The Nassau grouper, *Epinephelus striatus,* in the Caribbean provides a clear example of this. The species was fished to the brink of extinction because spawning aggregations were specifically targeted by commercial fisheries (Sadovy 1993). Eventually several fisheries collapsed. Some have never recovered, such as those in Cuba and Bermuda, while others have only very recently been protected, such as in Belize. In the Cayman Islands, management has been in place for a number of years and the aggregations although reduced, still exist (Sadovy 1999). The existence of spawning aggregation sites needs to be determined early in the establishment of the MPA so that zoning of the MPA can take these sites into consideration.

4.5.3 Impact on biodiversity and fisheries

In general, several studies confirm that the establishment of Marine Protected Areas has led to increases in density, biomass, individual size, and diversity in nearly all fish functional groups (Halpern 2003). Various studies in Mediterranean MPAs attest to higher abundances of the most vulnerable fished species in comparison with adjacent fished areas, a greater total number of individual fishes in general, and fish of greater average sizes in the MPA than outside it (Francour *et al.* 2001).

MPA establishment can also lead to a “cascade effect”, as the protection regulations can lead to increases in top-predator populations (often target fisheries resources) provoking changes in predation interactions involving species at different trophic levels (Steneck 1998). The cascade effect as a direct consequence of protection was first proposed for a Chilean MPA (Moreno *et al.* 1984).

Marine reserves or MPAs generally aim to increase biodiversity or enhance a fisheries resource by removing or reducing exploitation pressure. One should not expect increases in all species following reserve designation, as each species’ response depends on various factors such as the level of exploitation, life-history characteristics, potential for replenishment from surrounding areas, and abundance of predators and prey. Pinnegard *et al.* (2000) reviewed research at 21 MPAs, and documented 39 cases of “trophic cascades”, in which the presence of primary carnivores had suppressed herbivores, and so increasing plant abundance.

The ecological interactions that play out within an MPA (and in relation with its surroundings) can yield unexpected results, and need to be taken into account when designing the MPA and setting its management options.

In summary, it is recommended that these technical guidelines for using MPAs are combined with the information gained from tracking the benefits of MPAs for different fisheries (see below) into a Toolkit for using MPAs for fisheries management. Such a Toolkit would provide fisheries managers with a hands-on reference tool with clear steps, guidelines, reference sources and contacts. A similar Toolkit has been developed for MPA managers in the Western Indian Ocean (IUCN 2004), but this encompasses all aspects of MPAs. Having a Toolkit that addresses fisheries specifically could be a very useful tool.

4.6 Future directions in MPA research

4.6.1 Indicators for MPA success

It is critical that indicators for measuring the effectiveness of MPAs as a fishery management tool are developed, and these have to be based on empirical assessment. Criteria for selecting suitable indicators are discussed in the section above. All too frequently inappropriate indicators are selected and the opportunity to monitor MPA impacts will be lost. Small scale, multi-species fisheries with multiple gear/vessel types and landing sites, typical of tropical coastal waters in developing countries (Munro and Williams 1985; Wright and Hill 1993), are particularly hard to measure precisely and therefore need to be very carefully tested to detect MPA effects for these types of fisheries. It is highly recommended as a first step that a global meta-analysis of datasets around the world on priority fisheries be conducted to determine suitable indicators. These can then be tested as new MPAs are established and trialed for particular fisheries.

In addition to developing suitable indicators based on sound science, monitoring design and data analysis protocols need to be defined for MPAs and associated fisheries. Often monitoring occurs, but data analysis is limited or absent. Analysis, evaluation and adaptive management cycles need to be put in place and this can be challenging where resources and capacity are limited (but see Pabari *et al.* 2005). Research that addresses these gaps would be extremely useful and the protocols developed could be incorporated in a Toolkit for MPA fisheries management (see section above on guidelines).

4.6.2 Track the benefits of MPAs for different species/fisheries worldwide

It would be hugely beneficial if an organization such as FAO were to track and analyze fisheries management successes over a period of time, say for the next five years, and to record where MPAs have been used, and to what extent, in conjunction with other fisheries management tools. This could be assimilated into a database of information from which fishery or species specific recommendations could be derived. For example, if demersal coral reef fisheries around the world are seen to be more sustainable when MPAs are involved, then one can recommend MPAs as one key tool for the management of such fisheries. Where MPAs show no benefits to a specific fishery after thorough checking, emphasis needs to be put on more suitable fisheries management tools instead. The database would enable the relative merits of MPAs for managing pelagic fisheries to be assessed, and ultimately could determine criteria for fisheries that are best suited to be covered by area-based management.

4.6.3 Fisheries models

Incorporating area-based input controls (MPAs) into fisheries models will give fisheries researchers the opportunity to assess the relative merits of MPAs among the suite of tools employed in managing a fishery. This approach has started (CEFAS 2005; Guénette *et al.* 1998; Stefansson and Rosenberg 2005) but needs to expand to cover the wide range of fisheries being managed by MPAs. Such models can quantify the merits of different fishery management options and these can then be presented to fishers and the options discussed. For example, it may transpire that for a particular fishery, an area restriction or closure is in fact less restrictive to a fisher than an effort or gear control throughout the fisher's range of operation. Although either option may be sufficient for sound fishery management, the area restriction may suit the fisher better, and without the model such scenarios may not have been apparent.

Scientific uncertainty and a persisting lack of empirical data on larger, mobile marine organisms in the open ocean is another constraint. Some fish stocks may be too mobile for site-specific approaches (Kenchington *et al.* 2003). Yet the applicability of area-based ecosystem management in the open ocean context is beginning to take hold, particularly as scientists are learning more about the importance of ocean 'hotspots' such as convergence zones and above benthic features like seamounts. Norse *et al.* (2005) note that a modelling study of Mediterranean hake (*Merluccius merluccius*) led Apostolaki *et al.* (2002) to conclude that "yield and spawning stock biomass benefits can be obtained through the use of a marine reserve even for highly mobile fish and underexploited fisheries." Wherever the mobility of adults is high, reserves have often been discounted as an effective management tool in the past. But even for highly migratory species such as swordfish or tunas, MPAs that protect nursery areas or vulnerable population bottlenecks may be effective management tools (NRC 2001). Such modelling approaches need to be continued to assess the applicability of MPAs for highly mobile species.

Models can furthermore usefully assess the case-to-case applicability of new MPA approaches such as vertical zoning schemes of an MPA, and the benthic-pelagic coupling to determine the most suitable form of zoning. So far, there are MPAs which only cover the seabed (determined useful for e.g. hot vents and cold seeps), while other MPAs apply a vertical 'buffer zone' to include the above water column in the protection scheme. Designating vertical MPA categories, such as applied in Tasmanian seamount reserves (FIGURE 1; AXYS 2003), thus needs to consider not only the seamount habitat itself, but also some migratory pelagic species of commercial value that tend to congregate above them. Given the likeliness that more vertically zoned MPAs may be established within the coming years, it is thus necessary that the benthic-pelagic coupling of the specific feature is studied in detail and that the zoning structure be adapted to the results from these studies.

4.6.4 Assessing suitability of MPAs for different fisheries

The effectiveness of MPAs for the large number of fisheries that have not yet employed area based controls such as various cold water/deep water demersal fisheries, open water pelagic fisheries, fisheries based on highly migratory species and others, needs to be properly assessed (FAO 2005; Hilborn *et al.* 2003; Kaiser 2004; McManus 2004; Agardy *et al.* 2003; Lubchenco *et al.* 2003; Jones 2002).

Research directed at assessing MPA effectiveness for fisheries management requires (i) suitable designs before and after MPA implementation; (ii) adequate replication and controls, (iii) suitably sensitive indicators defined and tested; (iv) criteria for MPA success defined; and (v) long-term evaluations and monitoring. Practically, such research tends to use a suite of fishery variables as the MPA is implemented, and through analysis suitable indicators among the variables become apparent. Such indicators may range from female spawning biomass, average fish size, egg production, yield per recruit, etc. Indicators can inform researchers and managers whether the MPA is equally effective, less effective, or more effective than other conventional management options, and analyses will quantify the relative merits of different management options. It is only through this sort of rigorous research and analysis that we will know how useful MPAs are across the broad spectrum of fisheries. Models are particularly useful for examining various scenarios, and varying the different management options including MPA type and size (e.g. Atlantic cod, Polachek 1990; prawns, Die and Watson 1992; reef fishes, DeMartini 1993; surf zone South African Fishes, Attwood and Bennett 1995).

For those fisheries that are relatively well understood in an MPA context, such as coral reef fisheries, there are still several gaps. The link between MPAs and improved livelihoods of coastal people dependent on marine resources is an area that requires quantification. Research is also needed to assess MPAs for tropical fisheries of other ecosystems such as seagrass beds and sand/mud substrates.

An ecosystem based research approach is also needed to understand the broader ecological impacts of fishing (see COMPASS 2004; Murawski 2000) in order to assess if and how various MPA types can be used to control negative habitat impacts from fishing. Another area that requires research is MPA size. Several modelling and fish movement studies have asked this question, though certainly not across the spectrum of fisheries, and the answers are likely to be fishery or species specific. This research should not only consider ecological factors but also social factors and the behaviour of fishers or the dynamics of the fleet.

4.6.5 Legal frameworks

It would be very useful to assess the relative merits of different governance systems for MPAs in different cultural, political and socio-economic situations. A global analysis might reveal interesting models from which guidelines for suitable, integrated legal frameworks for MPAs and fisheries management tools could be developed in particular contexts.

4.6.6 Addressing financial constraints

Availability of financial resources also remains a constraint for inventorying, managing and monitoring the effectiveness of MPAs to meet fisheries objectives. Some argue that the amounts needed to achieve major marine conservation goals worldwide are less than what is spent on fishing subsidies and would have profitable returns (Balmford *et al.* 2004). Economic valuation of marine ecosystems to date has focused almost entirely on easily quantifiable terms such as commercial fisheries and tourism. It is increasingly recognized that additional aspects need to be considered, such as exploitation of corals, mangroves and shells, ‘ecosystem services’, possible future uses, and values irrespective of use (cultural, aesthetic, scientific, bequest and heritage significance) (Salm *et al.* 2000). Further research along these lines could support identification and definition of the role of MPAs, and in turn identify sources of funding for MPAs.

4.6.7 Socio-economic impacts

Socio-economic studies of MPAs lag behind the biological and natural resource studies. MPAs, particularly as a fisheries management tool, would be more robust and effectively managed if their design could address in some ways the driving forces for over-exploitation of the resources. More studies on the socio-economic aspects of MPA could also help set incentives for their establishment and compliance with the regulations.

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ANNEX I: TABLES AND FIGURES

Table 2. Overview of the selected case studies and their key characteristics. Cases were selected to cover a wide range of different ecosystems, fisheries and reserve types, and come from varying socio-economic and institutional contexts.

Case Study	Location	Region	Ecosystem Type	Fisheries Type	Reserve Type	IUCN Category	Socio-econ Context'	Instit. Responsibility
A	**Channel Islands, California, USA**	North America	Temperate Coastal and Deeper Waters	Commercial, Recreational	Marine Reserves in State Waters	I	Multiple users across scales, science-based consensus-finding	Variety of state and federal jurisdictions, U.S. Coast Guard
B	**Tanga, Tanzania**	Eastern Africa	Tropical Coral Reef	Small-scale artisanal subsistence	Collaborative Management Areas	/=	Development from village-owned to user-based approach	Govt, Local Communities
C	**Banc d'Arguin, Mauritania**	West Africa	Coastal waters near upwelling area	Small-scale artisanal (formerly subsistence), Industrial	National Park, Ramsar and World Heritage Site	II	Resident population of trad. fishers, external fishing pressures	Park authority, Government (PM), (national research institute)
D	**Great Barrier Reef, Australia**	Oceania	Tropical to Temperate Coastal Waters	Recreational + Commercial	Large-scale, Zoned Multiple-use MPA	I - VI	Public, multiple user based approach	Government
E	**Nearshore Coastline, Chile**	Latin America	Upwelling Continental Shelf	Artisanal + Commercial	Areas for Management and Exploitation of Benthic Resources	VI	User-based exploitation system, govt supported	Fisher's associations, Govt, CPPS
F	**Bohol, Philippines**	Southeast Asia	Tropical Coral Reef	Subsistence	Small Scale Community-based MPAs	VI	Village-owned (monitoring) approach	Local Communities
G	**Antarctica, incl. high seas**	Antarctica	Polar Ocean	Commercial, Industrial	ASPA, ASMA, CCAMLR Closed Areas, Small-scale Research and Mgt. Units	I - IV	High seas areas of international use	Reg. Fish. Mgt. Organisation, Antarctic Treaty & Env. Protection Protocol

Table 3a. Main features of closed reefs in Tanga region. *Italics = reefs that are no longer closed*

Collaborative Management Area Name	Closure Area Name	Area km^2	Percentage of total CMA	Date closed	Date opened	Length of closure	Planned length of closure
Boma-Mahandakini	Bunju	2.0	1.4%	2001		4y	8y
Deep Sea Boma	Chundo/ Kiroba	10.0	2.7%	2000		5y	5y, but reviewed every 2y
Mwarongo-Sahare	Kipwani	1.5	0.8%	2000		5y	Reviewed every 2y
Mtang'ata	*Kitanga*	1.0		*1997*	*1998*	1yr	
	Upangu	4.25		*1997*	*1998*	1 yr	
	Makome (Kigombe)	2.5	4.7%	2001		4y	5y, but reviewed every 2y
	Shenguwe	2.0		2001		4y	5y, but reviewed every 2y
Boza-Sange	Dambwe	5.5	2.5%	1998		7y	Permanent, but reviewed at intervals
Mkwaja	Maziwe	4.5		1975		20y	Permanent
	Fungu Buyuni			2005			Permanent

Table 3b. Annual Estimates of Catch/Value by District in Tanga region, 2002-2004 (*source: Anderson 2004*).

District	Year	Annual Estimate of Catch (MT)	Annual Estimate of Value (Tsh)	Annual Estimate of Value (USD*)
Muheza	2002	1 016	527 192 239	483 663
Muheza	2003	639	377 365 104	346 207
Muheza	2004	676	481 237 536	441 502
Pangani	2002	1 760	579 271 330	531 442
Pangani	2003	1 329	426 303 171	391 104
Pangani	2004	941	344 601 172	316 148
Tanga	2002	4 190	2 365 675 317	2 170 344
Tanga	2003	5 912	2 514 534 532	2 306 912
Tanga	2004	4 571	1 767 872 393	1 612 901
Total	2002	6 966	3 472 138 886	3 185 448
Total	2003	7 880	3 318 202 807	3 044 222
Total	2004	6 188	2 593 711 101	2 379 551

*Tsh1090:1USD

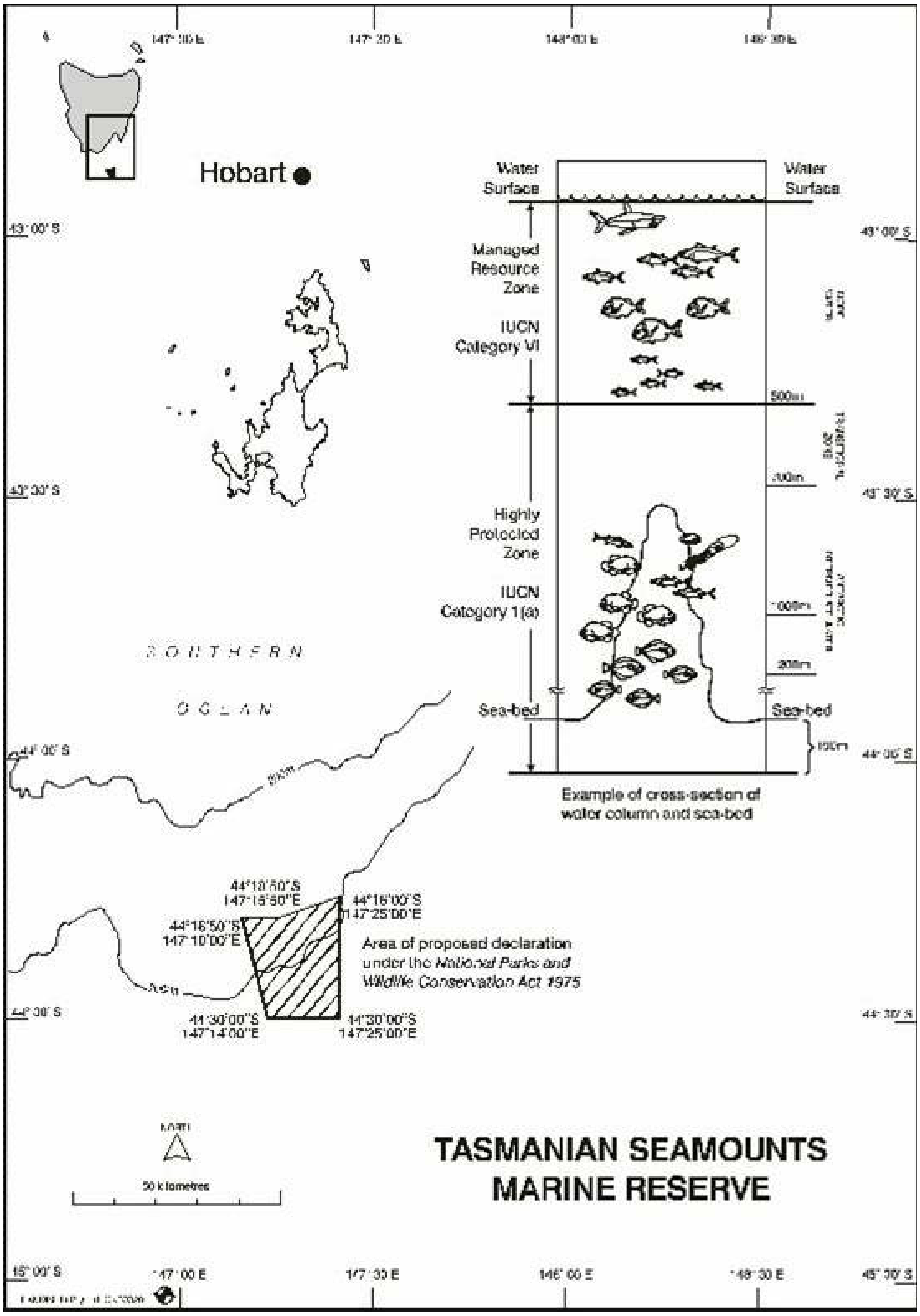


Figure 1. Tasmanian Seamounts Marine Reserve showing reserve location and vertical zoning by IUCN category.

Source: Environment Australia – Department of Environment and Heritage (http://www.pac.dfo-mpo.gc.ca/oceans/Bowie/bowie_appx_m%20(tasmn)_e.htm)

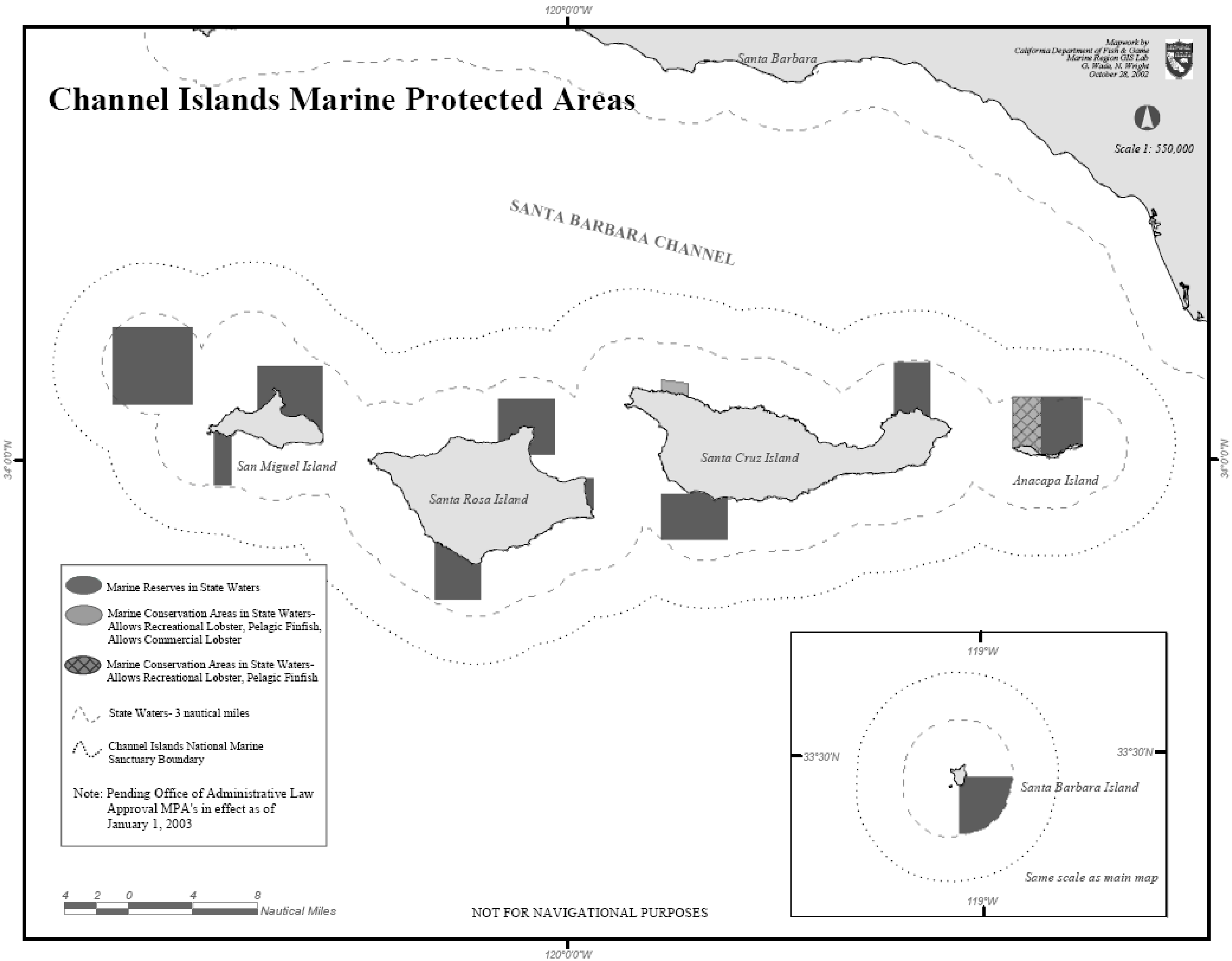


Figure 2. Map of the Channel Islands Marine Protected Areas.
Source: California Department for Fish and Game, Marine Region(http://www.dfg.ca.gov/mrd/channel_islands/index.html

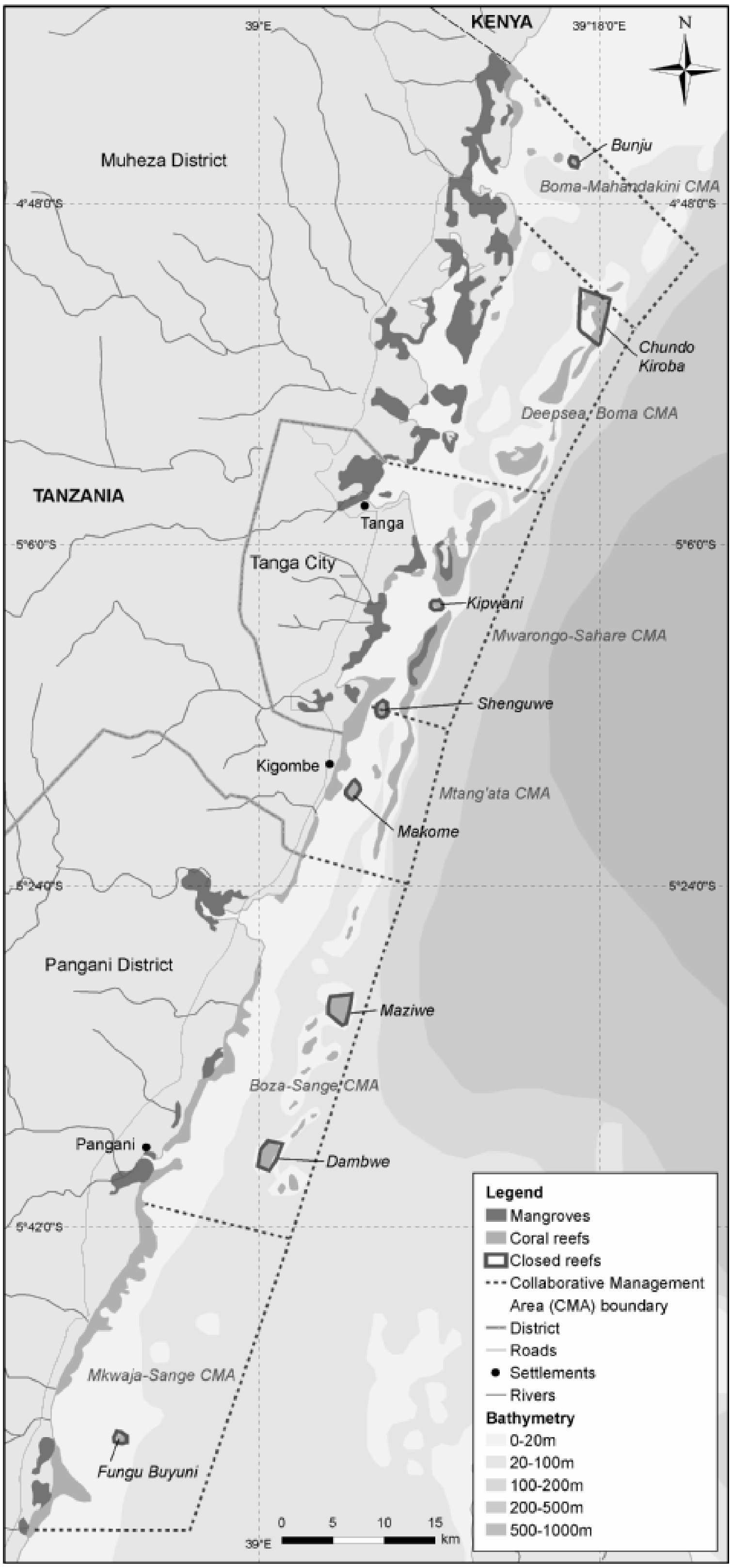
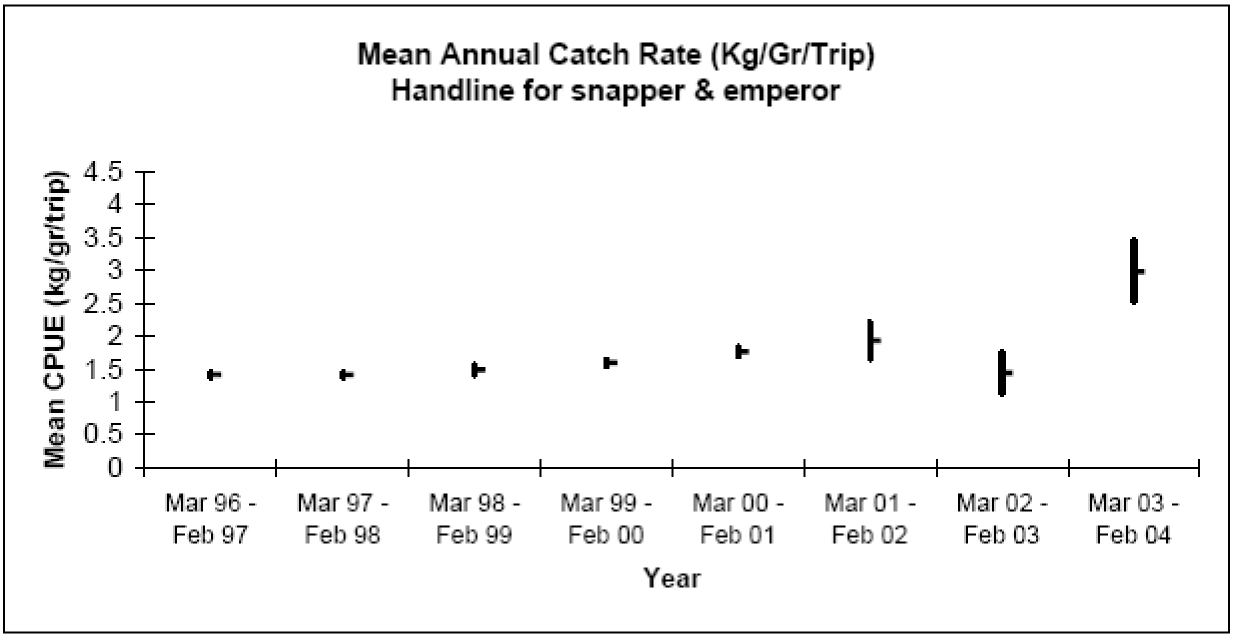


Figure 3. Map of the Tanga Collaborative Management Areas and key ecosystem and socio-economic features.



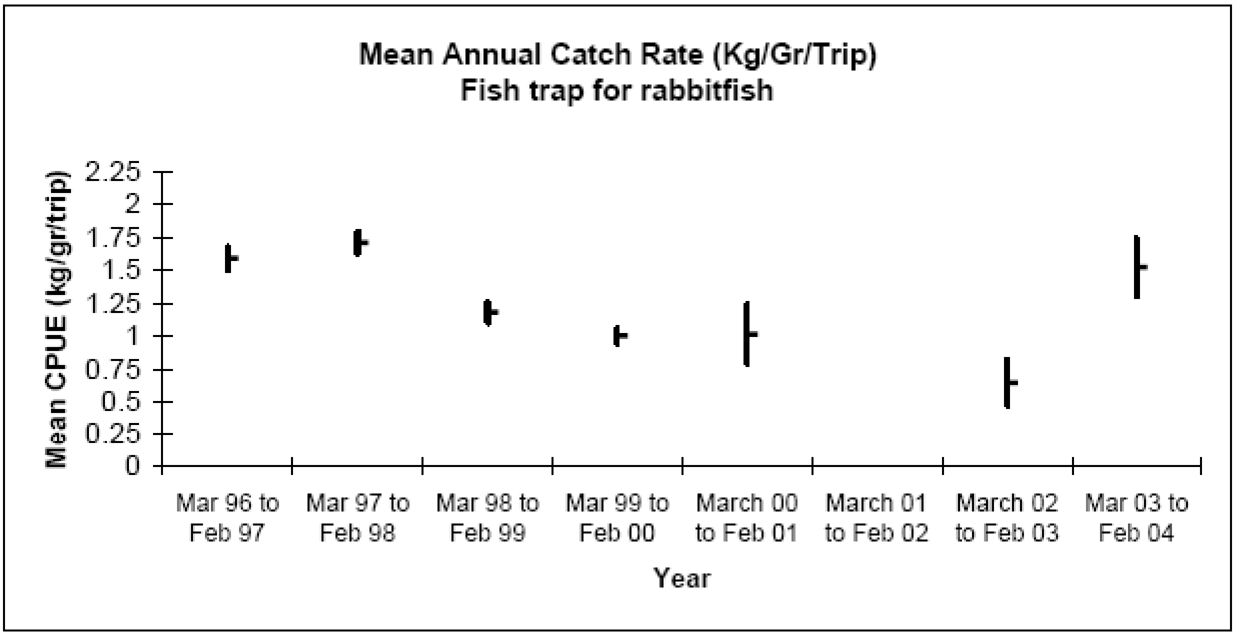


Figure 4a/b. Annual catch rates of the hook and line fishery for snapper and emperor and mean annual catch rate (CPUE) for rabbitfish trap fishery in Tanga.

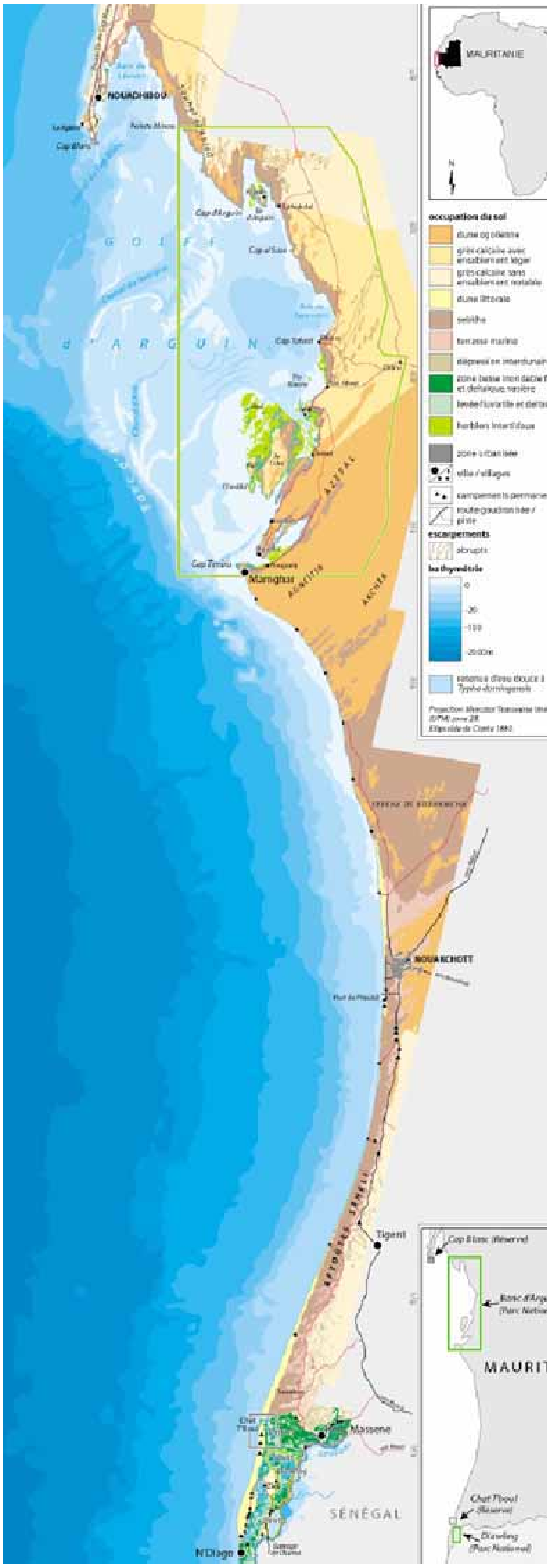


Figure 5. **Mauritanian coastline with the main ecological habitat and socio-economic features. The boundaries of the Park National du Banc d'Arguin are indicated by the fine green line.**

Source: Projet PALM, Programme Régional Côtier et Marin de l'Afrique de l'Ouest.

Figure 6. Great Barrier Reef Marine Park zoned management areas, in 2005.

Source: Great Barrier Reef Marine Park Authority

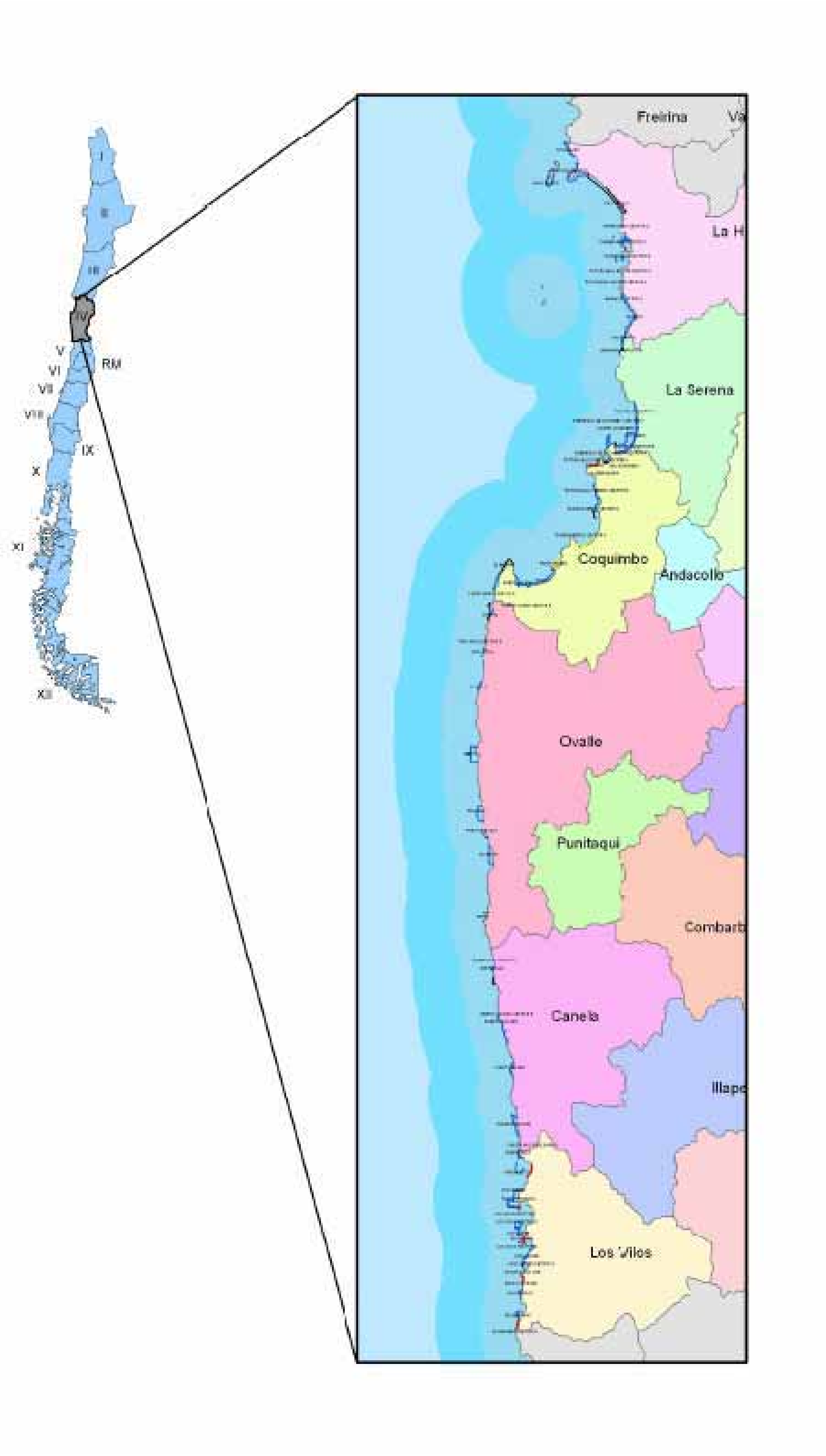


Figure 7. Location of AMEBR management areas in the IV region off the Chilean coastline, as per June 2005.

Source: Subpesca

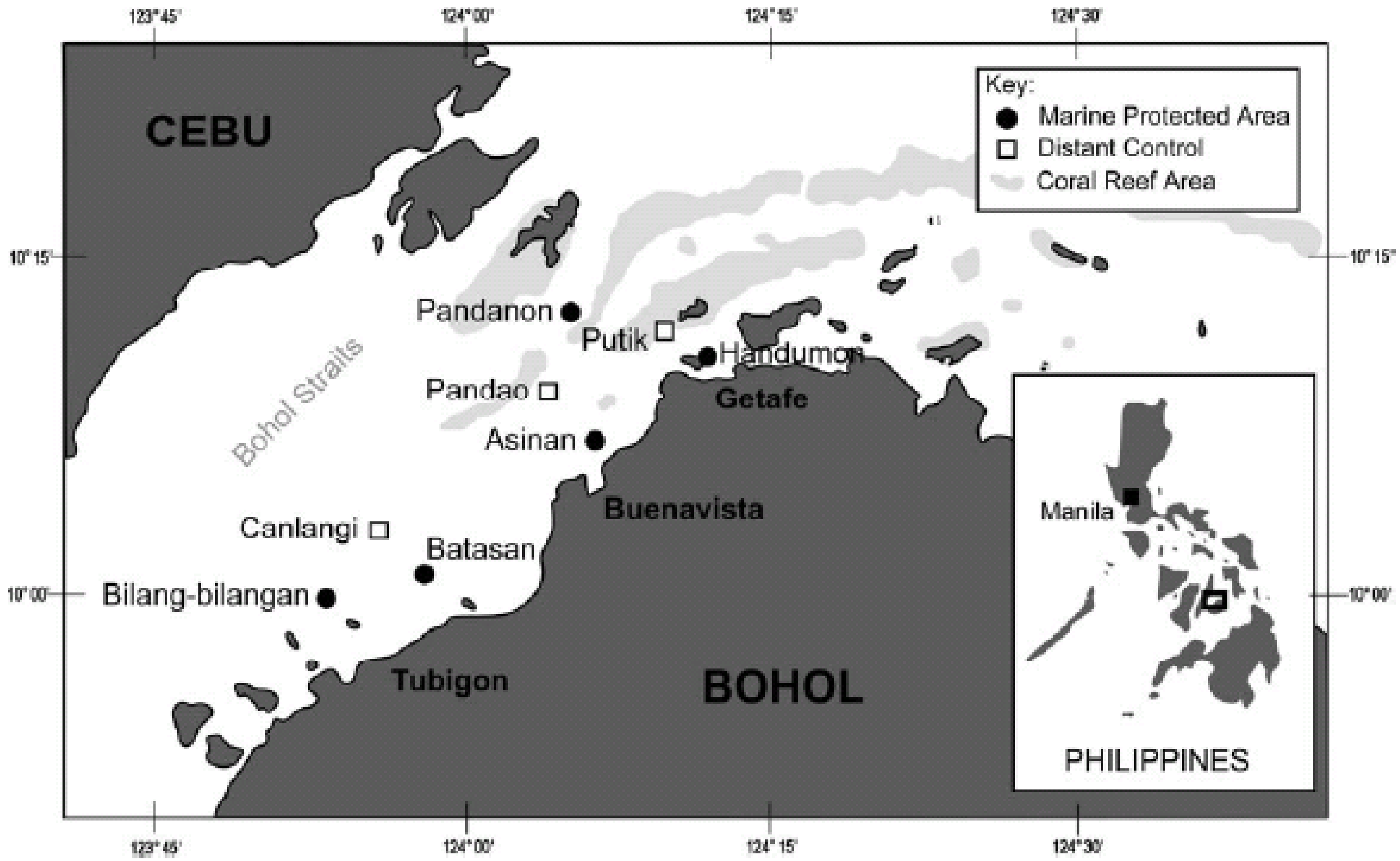


Figure 8. Map of Bohol, central Philippines, indicating location of reserve sites and municipalities.

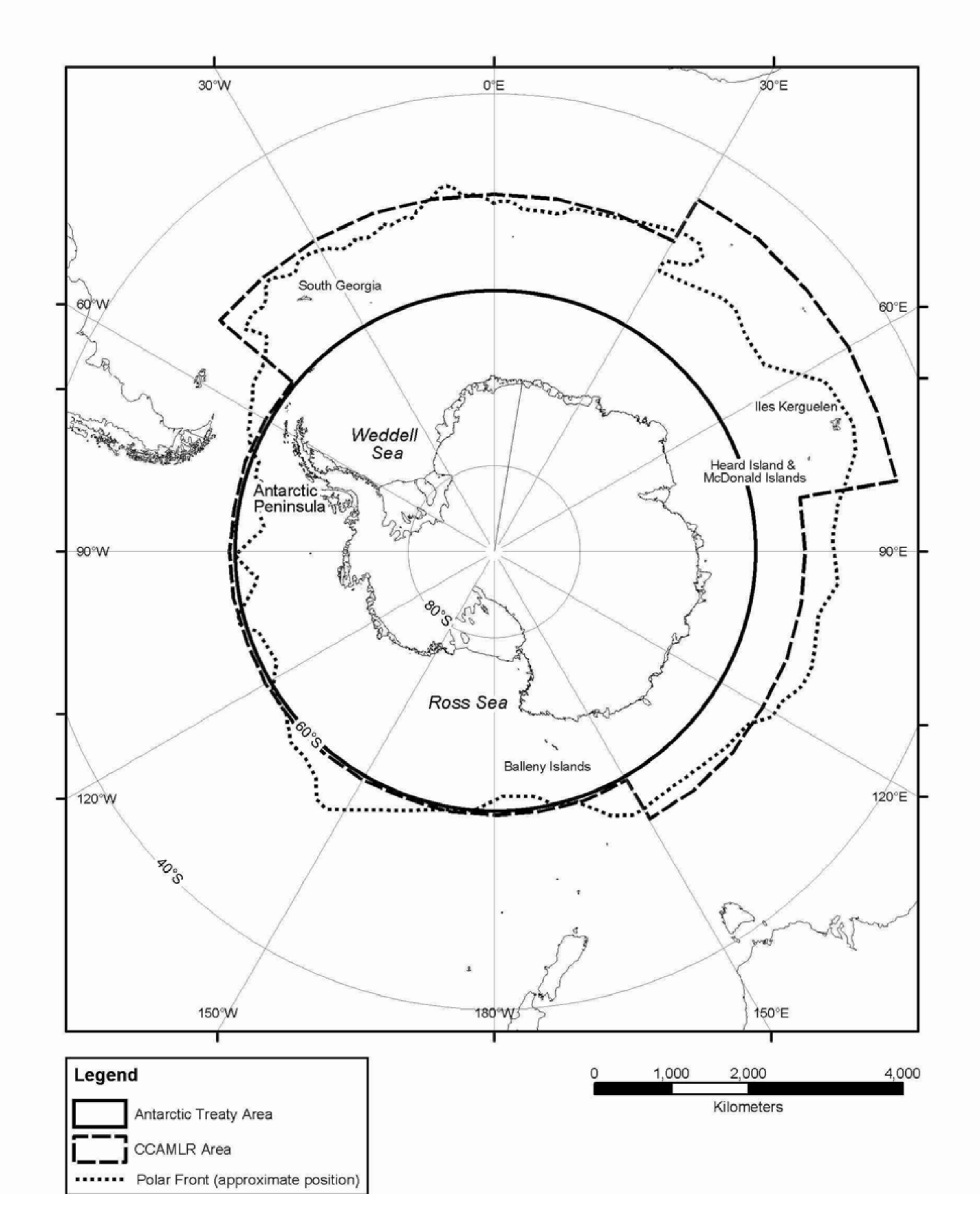


Figure 9. Map of Antarctica and the Southern Ocean showing the boundaries of the Antarctic Treaty Area and the CCAMLR Area, and the approximate position of the Polar Front.

Source: Susie Grant

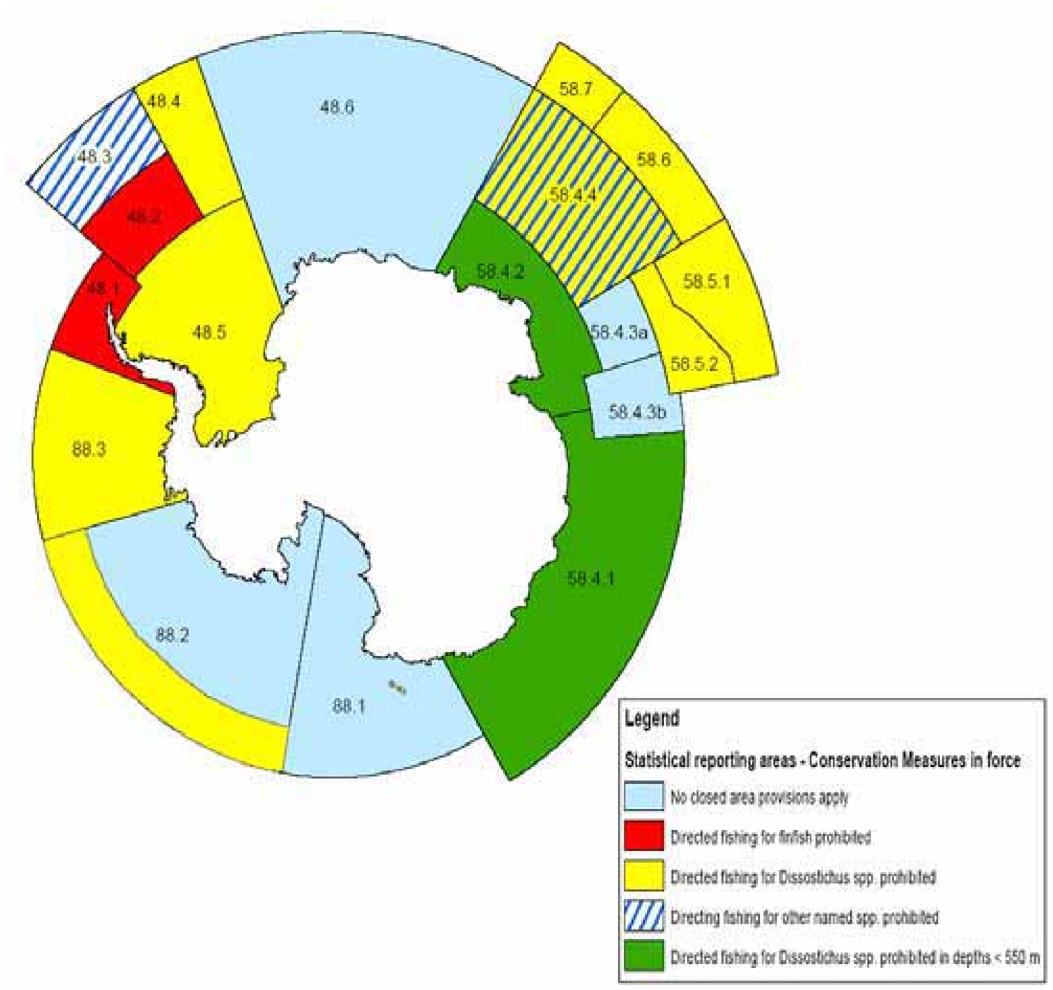


Figure 10. **Map of the Antarctic area-based conservation measures in place (statistical reporting areas).**

Source: Susie Grant

ANNEX 2: ABSTRACTS FROM REFERENCES LITERATURE

Agardy, T., Bridgewater, P., Crosby, MP., Day, J., Dayton, PK., Kenchington, R., Laffoley, D., McConney, P., Murray, PA., Parks, JE. & Peau, L. (2003) Dangerous targets? Unresolved issues and ideological clashes around marine protected areas. *Aquatic Conservation: Marine & Freshwater Ecosystems* 13, 353-367.

1. While conservationists, resource managers, scientists and coastal planners have recognized the broad applicability of marine protected areas (MPAs), they are often implemented without a firm understanding of the conservation science} both ecological and socio-economic} underlying marine protection. The rush to implement MPAs has set the stage for paradoxical differences of opinions in the marine conservation community.
2. The enthusiastic prescription of simplistic solutions to marine conservation problems risks polarization of interests and ultimately threatens bona fide progress in marine conservation. The blanket assignment and advocacy of empirically unsubstantiated rules of thumb in marine protection creates potentially dangerous targets for conservation science.
3. Clarity of definition, systematic testing of assumptions, and adaptive application of diverse MPA management approaches are needed so that the appropriate mix of various management tools can be utilized, depending upon specific goals and conditions. Scientists have a professional and ethical duty to map out those paths that are most likely to lead to improved resource management and understanding of the natural world, including the human element, whether or not they are convenient, politically correct or publicly magnetic.
4. The use of MPAs as a vehicle for promoting long-term conservation and sustainable use of marine biodiversity is in need of focus, and both philosophical and applied tune ups. A new paradigm arising out of integrated, multi-disciplinary science, management and education/outreach efforts must be adopted to help promote flexible, diverse and effective MPA management strategies. Given scientific uncertainties, MPAs should be designed so one can learn from their application and adjust their management strategies as needed, in the true spirit of adaptive management.
5. It is critical for the conservation community to examine why honest differences of opinion regarding MPAs have emerged, and recognize that inflexible attitudes and positions are potentially dangerous. We therefore discuss several questions } heretofore taken as implicit assumptions: (a) what are MPAs, (b) what purpose do MPAs serve, (c) are no-take MPAs the only legitimate MPAs, (d) should a single closed area target be set for all MPAs, and (e) how should policymakers and conservation communities deal with scientific uncertainty?

Allison, G.W.; Lubchenco, J. & Carr, MH. (1998) Marine reserves are necessary but not sufficient for marine conservation. *Ecological Applications* 8, S879-S892.

The intensity of human pressure on marine systems has lead to the push for stronger marine conservation efforts. Recently, marine reserves have become one highly advocated form of marine conservation and the number of newly designated reserves has increased dramatically. Reserves will be essential for conservation efforts because they can provide unique protection for critical areas, they can provide a spatial escape for intensely exploited species, and they can potentially act as buffers against some management miscalculations and unforeseen or unusual conditions. Reserve design and effectiveness can be dramatically improved by better use of existing scientific understanding. Reserves are insufficient protection alone, however, because they are not isolated from all critical impacts. Communities residing within marine reserves are strongly influenced by the highly variable conditions of the water masses that continuously flow through them. To a much greater degree than in terrestrial systems, the scales of fundamental processes, such as population replenishment, are often much larger than reserves can encompass. Further, for some important threats, such as contamination by chemicals, they offer no protection. Therefore, without adequate protection of species and ecosystems outside reserves, effectiveness of reserves will be severely compromised. We outline conditions under which reserves are likely to be effective, provide some guidelines to increase their conservation potential, and suggest some research priorities to fill critical information gaps. We strongly support vastly increasing the number and size of marine reserves; at the same time, strong conservation efforts outside reserves must complement this effort. To date, most reserve design and site selection has involved little scientific justification. It must begin to do so to increase the likelihood of attaining their conservation objectives.

Attwood, C.G. & Bennett, B.A. (1995) Modelling the effect of marine reserves on the recreational shore-fishery of the south-western Cape, South Africa. *S. Afr. J. Mar. Sci.* 16, 227-240.
Abstract not available

AXYS Environmental Consulting Ltd. (2003) Management direction for the Bowie seamount MPA: links between conservation, research, and fishing. Report prepared for WWF Canada, Pacific Region, 72 pp.
Abstract not available

Balmford, B.; Gravestock, P; Hockley, N.; McClean, C. & Roberts, C.M. (2004) The worldwide costs of marine protected areas. *Proceedings of the National Academy of Sciences* 101, 9694-9697.
Declines in marine harvests, wildlife, and habitats have prompted calls at both the 2002 World Summit on Sustainable Development and the 2003 World Parks Congress for the establishment of a global system of marine protected areas (MPAs). MPAs that restrict fishing and other human activities conserve habitats and populations and, by exporting biomass, may sustain or increase yields of nearby fisheries. Here we provide an estimate of the costs of a global MPA network, based on a survey of the running costs of 83 MPAs worldwide. Annual running costs per unit area spanned six orders of magnitude, and were higher in MPAs that were smaller, closer to coasts, and in high-cost, developed countries. Models extrapolating these findings suggest that a global MPA network meeting the World Parks Congress target of conserving 20–30% of the world's seas might cost between $5 billion and $19 billion annually to run and would probably create around one million jobs. Although substantial, gross network costs are less than current government expenditures on harmful subsidies to industrial fisheries. They also ignore potential private gains from improved fisheries and tourism and are dwarfed by likely social gains from increasing the sustainability of fisheries and securing vital ecosystem services.

Barros, R. & Aranguez, R. (1993) La Experiencia de los Pescadores Artesanales de Caleta Quintay en el Manejo de Recurso Bentónicos, in Escuela de Ciencias del Mar, Universidad Católica de Valparaíso y Servicio Nacional de Pesca (eds) Taller Áreas de Manejo, Valparaíso, Chile.
Abstract not available

Bernstein, B.; Iudicello, S.; & Stringer, C. (2004) Lessons learned from recent marine protected area designations in the United States. A Report to the National Marine Protected Areas Center NOAA by the National Fisheries Conservation Center. http://www.mpa.gov/information_tools/lessons_learned_table.html
In the United States and around the globe, governmental agencies use marine protected areas (MPAs) as a tool to manage human impacts in ecologically and culturally sensitive areas. Defined in the U.S. as "any area of the marine environment that has been reserved by Federal, State, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (E.O. 13158, Federal Register, 2000), MPAs are designated through various processes that attempt – some more successfully than others – to merge the prerogatives of often disparate stakeholder groups with the physical needs of complex ecological systems.
This report is a study of six separate and distinct efforts to designate MPAs in the United States. Based on the assumption that within their unique details lie lessons that can be broadly applied to other efforts, the case studies were carefully selected to represent diverse geographic areas and a spectrum of social, political, and ecological complexity. The assumption was correct. Through review of the written record and numerous interviews with those intimately involved in and affected by the six MPA designation processes, patterns emerged that formed the basis for important, broadly applicable lessons.

The six case studies that form the analytical basis of this report, illustrated in Figure 1, are:

- •The attempt to designate a National Marine Sanctuary in the Northwest Straits and the related establishment of Bottomfish Recovery Zones in San Juan County, Washington
- • The designation of the Channel Islands Marine Reserves off the Coast of Santa Barbara, California
- • Phase I of the establishment of marine reserves under California's state-wide Marine Life Protection Act:
- • The creation of the Tortugas Ecological Reserve in the Florida Keys
- • Grouper Closures off the coast of Florida in the Gulf of Mexico
- • The establishment of the Carl N. Schuster Horseshoe Crab Reserve in Delaware Bay.

Bohnsack, JA. (1998) Application of marine reserves to reef fisheries management. *Australian Journal of Ecology* 23, 298-304.

Establishing permanent 'no-take' marine reserves, areas where fishing and all other extractive activities are prohibited, is an attractive but under-utilized tool for fisheries management. Marine reserves could potentially deal with many fishery problems that are not effectively addressed by other traditional management measures; they also offer numerous social, economic, and scientific benefits not directly related to fisheries. Limited but growing research has shown beneficial biological and economic effects of marine reserves on fisheries. More research is needed, especially at larger scales, to determine the ideal marine reserve size, number and location necessary to optimize fisheries productivity and resource conservation. Sufficient evidence is available to justify the expanded use of marine reserves in an adaptive approach to fisheries management.

Castilla, J.C. (1996) The Chilean dived-invertebrate resources: Fishery, Collapses, Stock Rebuilding and the Role of Coastal Management Areas and National Parks. Second World Fisheries Congress, 28 July-2 August, Brisbaine, Australia.

Abstract not available

Castilla, J.C. (1999) Coastal marine communities: trends and perspectives from human exclusion experiments, *Trends in Ecology and Evolution* 14: 280-28.

Abstract not available

Castilla, J. C. & Fernández, M. (1999) Coastal marine community-ecosystem approaches in invertebrate multispecies management: "take" and "no-take" areas network and territorial use rights in fisheries (TURFs). In Proceedings of the "Norway/UN conference on the Ecosystem approach for sustainable use of biological diversity". Trondheim, Norway, 6-10 Sep. 1999. Pp.137-142.

Abstract not available

Carr, MH. & Raimondi, PT. (1999) Marine Protected Areas as a precautionary approach to management. *CalCOFI Rep* 40, 71-76.

Various sources of uncertainty have greatly impeded the effectiveness of traditional fisheries management to assure acceptable levels of sustainability of fisheries and species populations. Marine protected areas are receiving increasing consideration and show potential as a means of contributing to the sustainability of populations and guarding against fishery failures. Marine protected areas take advantage of the open population structure that characterizes most exploited benthic marine species by considering the pelagic dispersal of propagules and the patchy distribution of benthic habitat. Because protected areas have only recently been considered for west coast fisheries, because poorly designed reserves may be useless and possibly detrimental, and because optimal design criteria are not yet understood, incorporating the evaluation of empirically derived design criteria into the final implementation of protected area networks (i.e., adaptive management) is the only prudent approach.

Carr, MH. (2000) MPAs: challenges and opportunities for understanding and conserving coastal marine ecosystems. *Environmental conservation* 27, 106-109.

The term 'marine protected area' (MPA) refers to areas in which human activities that cause reductions in populations either directly through exploitation or indirectly through habitat alteration are eliminated or greatly reduced. This spatially explicit approach to managing human impacts has many potential ecological and socio-economic benefits that can alleviate some of the problems fundamental to conventional management practices and can therefore complement, but is unlikely to supplant, the conventional practices (Allison *et al*. 1998; Bohnsack 1998, Lauck *et al*. 1998; Hastings & Botsford 1999; Murray *et al*. 1999). Five reviews in this number of *Environmental Conservation* summarize the main issues relevant to MPAs in the Western Mediterranean, our understanding of their ecological and management consequences, and our knowledge of the ecological and socio-economic processes that determine their effectiveness for fisheries management and conservation (Badalamenti *et al*. 2000; García Charton *et al*. 2000; Pinnegar *et al*. 2000; Planes *et al*. 2000; Sánchez Lizaso *et al*. 2000). The reviews identify three issues of key importance to the development and success of MPAs for conservation and management. First, MPAs hold strong promise for management and conservation objectives, but the historical pattern of haphazard design, implementation, enforcement and evaluation has often produced equivocal and sometimes contradicting evidence for both their ecological effects and their effectiveness at achieving their intended objectives. Second, our understanding of many of the critical population and community processes that bear greatly on the consequences of this approach (e.g. dispersal, recruitment, direct and indirect effects of competition and predation) suffers from a lack of strong empirical studies and a comprehensive theoretical framework. Third, the global growth of interest in MPAs and concern for rapid development of organized systems of MPAs is great. Taken together, these three issues identify an urgent need for a well-developed theoretical framework, more rigorous empirical studies motivated and directed by theory, and actual implementation of systems of MPAs that will allow for proper evaluation and an evolution toward optimal design.

Centre for Environment, Fisheries & Aquaculture Science (CEFAS). 2005. *Investigations into closed area management of the North Sea cod*. Report for United Kingdom Department for Environment, Food and Rural Affairs SFCD15. 98 pp.

Executive summary see http://www.defra.gov.uk/fish/science/index.htm

Convention for the Conservation of Antarctic Marine Living Resources (CAMLR) (2004) SC-CAMLR-XXIII Report. CCAMLR: Hobart Australia, 680 pp.

Abstract not available

Communication Partnership for Science and Sea (COMPASS) (2004) Synthesis of marine reserve science as it relates to fisheries management. COMPASS, USA, 27 pp.

Marine reserves are being widely considered around the world as a tool to fulfil both conservation and fisheries management objectives. Although the use of reserves to achieve biodiversity and ecosystem conservation goals is widely accepted, their potential role in fisheries management is controversial. This controversy is embedded in and complicated by an emerging shift within fisheries management from a focus on single species and optimum yield to a more holistic, ecosystem-based approach to fisheries management (Botsford et al. 1997, NMFS 1999, NRC 1999, Link 2002).

This paper synthesizes existing information from the natural sciences about marine reserves to inform a discussion about whether and how marine reserve science can be incorporated into fisheries management. It is intended solely to provide background data for this conference, without drawing conclusions about any areas of scientific disagreement. Thus, this paper narrowly focuses on scientific aspects of the possible roles of marine reserves in fisheries management by reviewing the following topics:

1. Definitions – What are marine reserves and how do they differ from other forms of area-based management?
2. Empirical evidence – What is known about marine reserve performance?
3. Theoretical insights – What can be inferred about marine reserve performance, especially in contrast with conventional methods of effort control, based on modelling studies?

4. Design considerations – Generally, what is known regarding design criteria for marine reserves?
5. Scientific uncertainties – What types of uncertainty can be addressed by new research and what are some additional, inevitable uncertainties?
The information contained in this document summarizes key findings and the kinds of evidence that are available for assessing or predicting the effects of reserves on fisheries. The evidence is necessarily global in scope because the use of marine reserves and marine protected areas for fisheries management in US waters has been limited. For recent comprehensive reviews of the use of marine reserves and/or marine protected areas for fisheries, see Ward et al. 2001, Russ 2002, and Gell and Roberts 2003 (empirical studies) as well as Gerber et al. 2003 (theoretical studies).

7th Conference of Parties on the Convention of Biological Diversity (CBD COP 7) (2004) Thematic problems of work: Review, further elaboration and refinement of the elaborated programme of work on marine and coastal biodiversity. CBD COP 7, Kuala Lumpur, Malaysia, 44 pp.
1. The present document contains the elaborated programme of work on marine and coastal biological diversity, which has been produced in response to recommendations VIII/3 A-D of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). In recommendation VIII/3 A, SBSTTA stressed that the programme elements of the programme of work still corresponds to global priorities, and although much progress has been made, the programme of work has not yet been fully implemented. Therefore, SBSTTA recommended that the Conference of the Parties extend the time period of the programme of work by an additional six years, and that an elaboration of the programme of work be undertaken by the Executive Secretary in accordance with paragraph 2 of recommendation VIII/3 A for the consideration of the Conference of the Parties at its seventh meeting.

Department for Environment Food and Rural Affairs (2006) The potential role of Marine Protected Areas (MPAs) for fisheries management purposes: Fisheries Directorate's summary of the main conclusions emerging from three desk studies. 5 pp.
Abstract not available

DeMartini, E.E. 1993. Modeling the potential of fishery reserves for managing Pacific coral reef fishes. *Fish. Bull.* 91, 414-427.
Abstract not available

Die, D.J. & Watson, R.A. 1992. A per-recruit simulation model for evaluating spatial closures in an Australian penaeid fishery. *Aquat. Living Resour.* 5, 145-153.
Abstract not available

Fernandes, L. Day, J., Lewis, A., Slegers, S., Kerrigan, B., Breen, D., Cameron, D., Jago, B., Hall, J., Lowe, D., Innes, J., Tanzer, J., Chadwick, V., Thompson, L., Gorman, K., Simmons, M., Barnett, B., Sampson, K., De'ath, G., Mapstone, B., Marsh, H., Possingham, H., Ball, I., Ward, T., Dobbs, K., Aumend, J., Slater, D. and K. Stapleton (2005) Establishing representative no-take areas in the Great Barrier Reef: large-scale implementation of theory on marine protected areas. *Conservation Biology,* 1733–1744.
The Great Barrier Reef Marine Park, an area almost the size of Japan, has a new network of no-take areas that significantly improves the protection of biodiversity. The new marine park zoning implements, in a quantitative manner, many of the theoretical design principles discussed in the literature. For example, the new network of no-take areas has at least 20% protection per "bioregion," minimum levels of protection for all known habitats and special or unique features, and minimum sizes for no-take areas of at least 10 or 20 km across at the smallest diameter. Overall, more than 33% of the Great Barrier Reef Marine Park is now in no-take areas (previously 4.5%). The steps taken leading to this outcome were to clarify to the interested public why the existing level of protection was inadequate; detail the conservation objectives of establishing new notake areas; work with relevant and independent experts to define, and contribute to, the best scientific process to deliver on the objectives; describe the biodiversity (e.g., map bioregions); define operational principles needed to achieve the objectives; invite community input on all of the above; gather and layer the data gathered in round-

table discussions; report the degree of achievement of principles for various options of no-take areas; and determine how to address negative impacts. Some of the key success factors in this case have global relevance and include focusing initial communication on the problem to be addressed; applying the precautionary principle; using independent experts; facilitating input to decision making; conducting extensive and participatory consultation; having an existing marine park that encompassed much of the ecosystem; having legislative power under federal law; developing high-level support; ensuring agency priority and ownership; and being able to address the issue of displaced fishers.

FAO (1995) Code of conduct for responsible fisheries. FAO Fisheries Department. Rome, Italy, 41 pp.

Fisheries, including aquaculture, provide a vital source of food, employment, recreation, trade and economic well being for people throughout the world, both for present and future generations and should therefore be conducted in a responsible manner. This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The Code recognises the nutritional, economic, social, environmental and cultural importance of fisheries, and the interests of all those concerned with the fishery sector. The Code takes into account the biological characteristics of the resources and their environment and the interests of consumers and other users. States and all those involved in fisheries are encouraged to apply the Code and give effect to it.

FAO (1997) Technical guidelines for responsible fisheries. FAO, Rome, Italy, 82 pp.

These Guidelines have been produced to support the implementation of Article 7 of the Code of Conduct for Responsible Fisheries, with some reference to Article 12. They are addressed primarily to the decision-makers within fisheries management authorities and other interest groups, including fishing companies, fishers' organizations, concerned non-governmental organizations and others. The Guidelines provide a background to the need for fisheries management and an introduction to the activities encompassed by fisheries management. They introduce the major constraints experienced in fisheries and fisheries management and some of the fundamental concepts related to these. Biological, environmental, technological, socio-cultural and economic constraints and concepts are examined. Information is fundamental to responsible fisheries management and these Guidelines put emphasis on the range of data required for informed decision-making and examine aspects of the collection and interpretation of these data. Data are discussed in terms of three suggested scales in fisheries management: fisheries policy and development planning, formulation of management plans and implementation of management action. The range of possible management actions is outlined. This includes technical measures, such as gear restrictions, and more direct approaches in the form of direct catch limitation or effort limitation. The problems associated with open access fisheries are explained and comments made on the means to limit access and obstacles which may be encountered in this process. Finally, the Guidelines examine the management process. This section covers the process of agreeing on a management plan for a fishery, including the need for consultation and, where appropriate, cooperative decision-making. The need for periodic review of management plans is stressed. The importance of an effective legal framework, institutional and administrative structures and monitoring control and surveillance are described.

FAO (2003) Fisheries Report No. 699. FAO, Rome, Italy, 27 pp.

The Advisory Committee on Fisheries Research (ACFR) held its fourth session in Rome from 10 to 13 December 2002.

The Committee reviewed its achievements during its last three sessions; provided guidance for operationalizing the time-bound fisheries goals in the Plan of Implementation of the World Summit on Sustainable Development (WSSD) 2002; identified priority emerging issues of international character in fisheries and aquaculture; and elaborated the plan of work for the Committee (2003 - 2004).

As in the past, the Committee extended its deliberation to include the manner in which scientific research could contribute to the development of fisheries policies with particular emphasis on questions of food security and poverty alleviation. In this regard the Committee, *inter alia:*

Welcomed the attention and prominence given by WSSD 2002 to fisheries issues;

Provided detailed guidance on how to operationalize the time-bound goals in fisheries of WSSD 2002 in the context of responsible fisheries;
Recommended that FAO play a key facilitating role in support of national, regional and international efforts towards implementation of the planned targets of WSSD 2002 and indicated how this could be done;
Reiterated that small-scale fisheries had generally received less research attention relative to other sectors than merited by their relative contribution to nutrition, food security, sustainable livelihoods and poverty alleviation;
Welcomed the inclusion of small-scale fisheries as a stand-alone agenda item of the Twenty-fifth Session of COFI;
Recommended the establishment of an ACFR Working Party on Small-scale Marine Fisheries to elaborate a draft research agenda and undertake an evaluation of the role and importance of these fisheries and also outline ways in which the transition to responsible fisheries can be facilitated, bearing in mind the developing paradigm of the Ecosystem Approach to Fisheries (EAF);
Recommended that priority be given to case studies to determine the impacts of trade and trade measures (either liberation on trade barriers) on conservation and livelihoods, particularly for small-scale fisheries in developing countries;
Recognized that the goals of WSSD 2002 and the promotion of responsible fisheries management and sound aquaculture development were constrained by lack of appropriate human capacity to accommodate the new approaches to fisheries issues and fisheries management, and therefore designated the building of human capacity as its next "mega-priority cross-cutting issue";
Recommended that the idea for the development of a human capacity building strategy for fisheries should be highlighted by the Fisheries Department at the Twenty-fifth Session of COFI and indicated the process by which such a strategy could be established.

FAO (a) Committee on Fisheries (FAO COFI) (2005) Marine Protected Areas and Fisheries. COFI/2005/8. FAO, Rome, Italy, 4 pp.

Protected areas (and reserves) in which extractive activities are strictly controlled (or banned) have been conventionally used for the protection of aquatic biodiversity, critical habitats, or endangered species. An increase of their use is foreseen as a consequence of their establishment and development being called for in the Convention for Biological Diversity and the World Summit on Sustainable Development (WSSD) plan of Implementation. Marine Protected Areas (MPAs) and reserves are also being advocated as a fisheries management instrument. MPAs have a number of potentially useful properties for fisheries but a number of limitations too have drawbacks if not properly designed. Experience on the impacts of MPAs in fisheries is still scarce but slowly building up. Their performance in relation to fisheries resources and livelihoods depends greatly on the type of resources requiring protection and the situation of the fisheries exploiting them. More experimentation is needed before definitive statements can be made about the potential role of MPAs in fisheries management under different circumstances. Experimental MPAs need to be established through a strongly participatory process involving the main stakeholders.

Garcia, SM. & Grainger, RJR. (2005) Gloom and doom? The future of marine capture fisheries. *Philosophical Transactions of the Royal Society* 360, 21-46.

Predicting global fisheries is a high-order challenge but predictions have been made and updates are needed. Past forecasts, present trends and perspectives of key parameters of the fisheries—including potential harvest, state of stocks, supply and demand, trade, fishing technology and governance—are reviewed in detail, as the basis for new forecasts and forecasting performance assessment. The future of marine capture fisheries will be conditioned by the political, social and economic evolution of the world within which they operate. Consequently, recent global scenarios for the future world are reviewed, with the emphasis on fisheries. The main driving forces (e.g. global economic development, demography, environment, public awareness, information technology, energy, ethics) including aquaculture are described. Outlooks are provided for each aspect of the fishery sector. The conclusion puts these elements in perspective and offers the authors' personal interpretation of the possible future pathway of fisheries, the uncertainty about it and the still unanswered questions of direct relevance in shaping that future.

Garcia, SM. & Cochrane KL. (2005) The ecosystem approach to fisheries management. In: World Fisheries and Aquaculture Atlas, 3rd edition. FAO, Rome, Italy, 2005. [Z:\html\govern\capture\ecosysmng\default.htm]

Abstract not available

Gell, FR. & Roberts, CM. (2003) The fishery effects of marine reserves and fishery closures. WWF, Washington DC, USA, 90 pp.

Marine reserves, areas permanently closed to all fishing, are frequently proposed as a tool for managing fisheries. Fishery benefits claimed for reserves include increases in spawning stock size, animal body size, and reproductive output of exploited species. Reserves are predicted to augment catches through export of offspring to fishing grounds, and spillover of juveniles and adults from reserves to fisheries. Protection of stocks and development of extended age structures of populations in reserves are argued to offer insurance against environmental variability and management failure. Models also suggest reserves will reduce year-to-year variability in catches, and offer greater simplicity of management and enforcement. Reserves are predicted to lead to habitat recovery from fishing disturbance which can also enhance benefits to fisheries. Extensive field research confirms many of these predictions. Reserves worldwide have led to increases in abundance, body size, biomass and reproductive output of exploited species. Such measures often increase many times over, sometimes by an order of magnitude or more. Population build up is usually rapid with effects detectable within 2-3 years of protection. Increases are often sustained over extended periods, particularly for longer-lived species and for measures of habitat recovery. Reserves have benefited species from a wide taxonomic spectrum that covers most economically important taxa, including many species of fish, crustaceans, molluscs and echinoderms.

Encouraged by these results, many countries and states have embarked upon initiatives to establish networks of marine reserves. However, reserves remain highly controversial among fishers and fishing industry bodies who argue that fishery benefits remain unproven. In the last three years there has been rapid growth in the number of cases where fisheries have been shown to benefit from reserves. In this report, we critically analyze this body of evidence, drawing upon studies of reserves and fishery closures. Fishery managers have long used fishery closures, areas temporarily closed to fishing for one or more species or to specific fishing gears. They are employed to help rebuild depleted stocks, reduce gear conflicts, protect vulnerable life stages of exploited species or protect sensitive habitats from damaging gears. Such areas can tell us much about the potential effects of marine reserves.

Fishery benefits from reserves and fishery closures typically develop quickly, in most cases within five years of their creation. Perhaps the most persuasive evidence of fishery effects of reserves comes from changing fishing patterns. In most places where well-respected reserves or fishery closures exist, fishers tend to move their fishing activities closer to their boundaries. Fishing-the-line, as it is called, allows fishers to benefit from spillover of animals from reserves to fishing grounds. There are now well-documented cases of spillover from more than a dozen countries and including a wide range of species. It is more technically demanding to prove fishery enhancement through export of offspring on ocean currents. Existing reserves are generally small, making it hard to detect increased recruitment to fisheries at a regional scale. However, there are now several cases in which export of eggs and larvae have been confirmed, including dramatic enhancement of scallop fisheries in Georges Bank and clam fisheries in Fiji. Small reserves have worked well and repeatedly produce local benefits. However, regional fisheries enhancement will require more extensive networks of reserves. Some of the most convincing success stories come from places in which between 10 and 35% of fishing grounds have been protected. In several cases there is evidence that yields with reserves have risen to higher levels than prior to protection, despite a reduction in the area of fishing grounds. In other cases, smaller reserves have stabilized catches from intensively exploited fisheries or slowed existing rates of decline.

We describe experiences that prove that success of marine reserves is not contingent on habitat type, geographical location, the kind of fishery involved, or the technological sophistication of management. Reserve benefits are not restricted to habitats like coral reefs, or to artisanal fisheries, as some critics claim. Fishery benefits have been demonstrated from reserves established in tropical, warm- and cold-temperate waters, and in many habitats, including coral reefs, rocky reefs, kelp forests, seagrass beds,

mangroves, estuaries, soft sediments, continental shelves and deep sea. Reserves and fishery closures have worked well for a wide range of fisheries, spanning recreational fisheries, artisanal fisheries like those of coral reefs, through small-scale nearshore fisheries for species like lobsters, up to industrial-scale fisheries for animals like flatfish and scallops.
They have worked across a similarly broad spectrum of management sophistication, from self-policing by committed fishers, through warden patrols to satellite monitoring of distant fishing activities. We now have strong evidence that with the support of local communities, marine reserves offer a highly effective management tool. However, reserves will only rarely be adequate as a stand-alone management approach, although we describe cases where they have worked in the absence of other measures. They will be most effective when implemented as part of a package of limits on fishing effort, designed to protect exploited species and their habitats

Gerber, LR. Botsford, LW., Hastings, A., Possingham, HP., Gaines, SD., Palumbi, SR. & Andelman, S. (2003) Population models for marine reserve design: A retrospective and prospective synthesis. *Ecological Applications* 13, S47-S64.

We synthesize results from existing models of marine reserves to identify key theoretical issues that appear to be well understood as well as issues in need of further exploration. Models of marine reserves are relatively new in the scientific literature; 31 of the 33 modelling papers we reviewed were published after 1990. These models have focused primarily on questions concerning fishery management at the expense of other objectives such as conservation, scientific understanding, recreation, and education and tourism. Roughly one third of the models analyze effects on cohorts while the remaining models have some form of complete population dynamics. Few models explicitly include larval dispersal. In a fisheries context, the primary conclusion drawn by many of the complete population models is that reserves increase yield when populations would otherwise be overfished. A second conclusion, resulting primarily from single cohort models is that reserves will provide fewer benefits for species with greater adult rates of movement. An important aspect of reserve design in need of further analysis and greater understanding is the interaction between dispersal and the spatial configuration of reserves. Other outstanding issues include the effects of: (1) particular forms of density-dependence, (2) multispecies interactions, (3) fisher behaviour and (4) effects of concentrated fishing on habitat. Model results indicate that marine reserves could play a beneficial role in the protection of marine systems against overfishing. However, additional modelling and analysis will greatly improve prospects for a better understanding of the potential of marine reserves for conserving biodiversity.

Grant, S.M. (in print) Challenges of Marine Protected Area Development in Antarctica. In: *PARKS*, Vol 15.3: High Seas Marine Protected Areas. IUCN, Gland, Switzerland. X pp.

Recent experience in Antarctica provides a useful case study on the challenges of developing marine protected area (MPA) systems on the high seas. This article provides an overview of the legal framework in which Antarctic MPAs can be designated, the protected areas existing within that framework, and the shortcomings of the current designations. The challenges facing MPA development in Antarctica include the sparseness of biological data with which to identify areas for protection, the need for decisions to be made within a consensus-based system of international governance, and the problem of enforcement. Further challenges include the need for co-ordination of protected area strategies between the different instruments of the Antarctic Treaty System, and with global recommendations on the development of high seas MPAs. Approaches being taken to address these challenges include recent work by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to identify specific conservation objectives for MPAs, priorities for the types of areas to be considered for protection, and the types of scientific information required. Finally, this paper offers some recommendations on how lessons learned in Antarctica might be applied in the establishment of high seas marine protected areas elsewhere.

Green, S.J.; Flores, J.O.; Dizon-Corrales, J.Q.; Martinez, R.T.; Nunal, D.R.M.; Armada, N.B. & White, A.T.. (2004) The fisheries of Central Visayas, Philippines: Status and trends. Coastal Resource Management Project of the Department of Environment and Natural Resources and the Bureau of Fisheries and Aquatic Resources of the Department of Agriculture, Cebu City, Philippines, 159pp.
Abstract not available

Guénette, S., Lauck, T. & Clark, C. (1998) Marine reserves : From Beverton and Holt to the present. *Reviews Fish Biology & Fisheries*, 8, 251-272.
Abstract not available

Halpern, BS. (2002) The impact of marine reserves: Do reserves work and does reserve size matter? *Ecological Applications* 13, S117-S137.
Marine reserves are becoming a popular tool for marine conservation and resource management worldwide. In the past, reserves have been created with little understanding of how they actually affect the areas they are intended to protect. A few recent reviews have evaluated how reserves in general affect the density and biomass of organisms within them, but little work has been done to assess temporal patterns of these impacts. Here we review 112 independent measurements of 80 reserves to show that the higher average values of density, biomass, average organism size, and diversity inside reserves (relative to controls) reach mean levels within a short (1–3 y) period of time and that the values are subsequently consistent across reserves of all ages (up to 40 y). Therefore, biological responses inside marine reserves appear to develop quickly and last through time. This result should facilitate their use in the management of marine resources.

Halpern, BS. & Warner, RR. (2003) Marine reserves have rapid and lasting effects. *Ecology Letters* 5, 361-366.
Marine reserves are quickly gaining popularity as a management option for marine conservation, fisheries, and other human uses of the oceans. Despite the popularity of marine reserves as a management tool, few reserves appear to have been created or designed with an understanding of how reserves affect biological factors or how reserves can be designed to meet biological goals more effectively (e.g., attaining sustainable fish populations). This shortcoming occurs in part because the many studies that have examined the impacts of reserves on marine organisms remain isolated examples or anecdotes; the results of these many studies have not yet been synthesized. Here, I review the empirical work and discuss the theoretical literature to assess the impacts of marine reserves on several biological measures (density, biomass, size of organisms, and diversity), paying particular attention to the role reserve size has in determining those impacts. The results of 89 separate studies show that, on average, with the exception of invertebrate biomass and size, values for all four biological measures are significantly higher inside reserves compared to outside (or after reserve establishment vs. before) when evaluated for both the overall communities and by each functional group within these communities (carnivorous fishes, herbivorous fishes, planktivorous fishes/invertebrate eaters, and invertebrates). Surprisingly, results also show that the relative impacts of reserves, such as the proportional differences in density or biomass, are independent of reserve size, suggesting that the effects of marine reserves increase directly rather than proportionally with the size of a reserve. However, equal relative differences in biological measures between small and large reserves nearly always translate into greater absolute differences for larger reserves, and so larger reserves may be necessary to meet the goals set for marine reserves. The quality of the data in the reviewed studies varied greatly. To improve data quality in the future, whenever possible, studies should take measurements before and after the creation of a reserve, replicate sampling, and include a suite of representative species. Despite the variable quality of the data, the results from this review suggest that nearly any marine habitat can benefit from the implementation of a reserve. Success of a marine reserve, however, will always be judged against the expectations for that reserve, and so we must keep in mind the goals of a reserve in its design, management, and evaluation.

Hilborn, R., Branch, TA., Ernst, B., Magnusson, A., Minte-Vera, CV., Scheuerell, MD. & Valero, JL. (2003) State of the world's fisheries. *Annual Review of Environmental Resources* 28, 359–399.

The total world catch from marine and freshwater wild stocks has peaked and may be slightly declining. There appear to be few significant resources to be developed, and the majority of the world's fish stocks are intensively exploited. Many marine ecosystems have been profoundly changed by fishing and other human activities. Although most of the world's major fisheries continue to produce substantial sustainable yield, a number have been severely overfished, and many more stocks appear to be heading toward depletion. The world's fisheries continue to be heavily subsidized, which encourages overfishing and provides society with a small fraction of the potential economic benefits. In most of the world's fisheries there is a "race for fish" in which boats compete to catch the fish before a quota is achieved or the fish are caught by someone else. The race for fish leads to economic inefficiency, poor quality product, and pressure to extract every fish for short-term gain. A number of countries have instituted alternative management practices that eliminate the race for fish and encourage economic efficiency, use lower exploitation rates that deliberately do not attempt to maximize biological yield, and encourage reduced fishing costs and increased value of products. In fisheries where this transition has taken place, we see the potential for future sustainability, but in those fisheries where the race for fish continues, we anticipate further declines in abundance, further loss of jobs and fishing communities, and potential structural change to marine ecosystems.

Hilborn, R., Stokes, K., Maguire, J-J., Smith, T., Botsford, LW., Mangel, M., Orensanz, J., Parma, A., Rice, J., Bell, J., Cochrane, KL., Garcia, S., Hall, SJ., Kirkwood, GP., Sainsbury, K., Stefansson, G. & Walters, C. (2004) When can marine reserves improve fisheries management? *Ocean & Coastal Management* 47, 197-205.

Marine reserves are a promising tool for fisheries management and conservation of biodiversity, but they are not a panacea for fisheries management problems. For fisheries that target highly mobile single species with little or no by-catch or habitat impact, marine reserves provide few benefits compared to conventional fishery management tools. For fisheries that are multi-species or on more sedentary stocks, or for which broader ecological impacts of fishing are an issue, marine reserves have some potential advantages. Their successful use requires a case-by-case understanding of the spatial structure of impacted fisheries, ecosystems and human communities. Marine reserves, together with other fishery management tools, can help achieve broad fishery and biodiversity objectives, but their use will require careful planning and evaluation. Mistakes will be made, and without planning, monitoring and evaluation, we will not learn what worked, what did not, and why. If marine reserves are implemented without case by case evaluation and appropriate monitoring programs, there is a risk of unfulfilled expectations, the creation of disincentives, and a loss of credibility of what potentially is a valuable management tool.

Hutchings, JA. (2000) Collapse and recovery of marine fishes. *Nature* 406, 882-885.

Over-exploitation and subsequent collapse of marine fishes has focused attention on the ability of affected populations to recover to former abundance levels and on the degree to which their persistence is threatened by extinction. Although potential for recovery has been assessed indirectly, actual changes in population size following long-term declines have not been examined empirically. Here I show that there is very little evidence for rapid recovery from prolonged declines, in contrast to the perception that marine fishes are highly resilient to large population reductions. With the possible exception of herring and related species that mature early in life and are fished with highly selective equipment, my analysis of 90 stocks reveals that many gadids (for example, cod, haddock) and other non-clupeids (for example, flatfishes) have experienced little, if any, recovery as much as 15 years after 45?99% reductions in reproductive biomass. Although the effects of overfishing on single species may generally be reversible, the actual time required for recovery appears to be considerable. To exempt marine fishes from existing criteria used to assign extinction risk would be inconsistent with precautionary approaches to fisheries management and the conservation of marine biodiversity.

Hutchings, JA. (2001) Influence of population decline, fishing and spawner variability on the recovery of marine fishes. ***Journal of Fish Biology*** **59, 306-322.**
Abstract not available.

Hyrenbach, K.D; Forney, K.A. & Dayton, P.K. (2000) Marine protected areas and ocean basin management. ***Aquatic conservation: Marine and Freshwater Ecosystems*****. 10: 437 – 458.**
1. All reserve designs must be guided by an understanding of natural history and habitat variability.
2. Differences in scale and predictability set aside highly dynamic pelagic systems from terrestrial and nearshore ecosystems, where wildlife reserves were first implemented. Yet, as in static systems, many pelagic species use predictable habitats to breed and forage. Marine protected areas (MPAs) could be designed to protect these foraging and breeding aggregations.
3. Understanding the physical mechanisms that influence the formation and persistence of these aggregations is essential in order to define and implement pelagic protected areas. We classify pelagic habitats according to their dynamics and predictability into three categories: static, persistent and ephemeral features.
4. While traditional designs are effective in static habitats, many important pelagic habitats are neither fixed nor predictable. Thus, pelagic protected areas will require dynamic boundaries and extensive buffers.
5. In addition, the protection of far-ranging pelagic vertebrates will require dynamic MPAs defined by the extent and location of large-scale oceanographic features.
6. Recent technological advances and our ability to implement large-scale conservation actions will facilitate the implementation of pelagic protected areas.
7. The establishment of pelagic MPAs should include enforcement, research and monitoring programmes to evaluate design effectiveness.
8. Ultimately, society will need a holistic management scheme for entire ocean basins. Such overarching management will rely on many innovative tools, including the judicious use of pelagic MPAs.
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IUCN – The World Conservation Union (2004) Managing marine protected areas: A Toolkit for the Western Indian Ocean. IUCN Eastern African Regional Programme, Nairobi, Kenya. xii+172 pp.
Abstract not available.

Jones, PJS. (2002) Marine protected area strategies: issues, divergences and the search for middle ground. ***Reviews in Fish Biology & Fisheries*** **11, 197-216.**
There has been a dramatic increase in recent years in the number of papers, reports, etc., which have been published concerning Marine Protected Areas (MPAs). This overview of the objectives, selection, design and management of MPAs aims to provide a basis for discussion regarding possible ways forward by identifying emerging issues, convergences and divergences. Whilst the attributes of the marine environment may limit the effectiveness of site-specific initiatives such as MPAs, it is argued that it would be defeatist in the extreme to abandon MPAs in the face of these limitations. Ten key objectives for MPAs are discussed, including that of harvest refugia, and it is argued that whilst these objectives may be justifiable from a preservationist perspective, they may be objected to from a resource exploitation perspective. MPAs generate both internal (between uses) and basic (between use and conservation) conflicts, and it is argued that these conflicts may be exacerbated when scientific arguments for MPAs are motivated by preservationist concerns. It is reported that a minority of MPAs are achieving their management objectives, and that for the majority insufficient information was available for such effectiveness evaluations. Structure and process-oriented perspectives on marine conservation are discussed. It is argued that there are two divergent stances concerning optimal MPA management approaches: top-down, characterized as being government-led and science-based, with a greater emphasis on set-aside; and bottom-up, characterized as being community-based and science-guided, with a greater emphasis on multiple-use. Given the divergent values of different stakeholders, the high degree of scientific uncertainty, and the high marine resource management decision stakes, it

is concluded that a key challenge is to adopt a "middle-ground" approach which combines top-down and bottom-up approaches, and which is consistent with the post-normal scientific approach.

Kaiser, MJ. (2004) Marine Protected Areas: The importance of being earnest. *Aquatic Conservation: Marine & Freshwater Ecosystems* 14, 635-638.

Abstract not available

Kathiresan, K. & Rajendran N. 2005. Coastal mangrove forests mitigated tsunami. *Estuarine Coastal and Shelf Science* 65: 601-606.

A study conducted after the 26th of December 2004 tsunami in 18 coastal hamlets along the south-east coast of India reiterates the importance of coastal mangrove vegetations and location characteristics of human inhabitation to protect lives and wealth from the fury of tsunami. The tsunami caused human death and loss of wealth and these decreased with the area of coastal vegetation, distance and elevation of human inhabitation from the sea. Human inhabitation should be encouraged more than 1 km from the shoreline in elevated places, behind dense mangroves and or other coastal vegetation. Some plant species, suitable to grow in between human inhabitation and the sea for coastal protection, are suggested.

Kelleher, G. (1999) Guidelines for Marine Protected Areas. IUCN, Gland, Switzerland, 107 pp.

Marine Protected Areas (MPAs) are essential to conserve the biodiversity of the oceans and to maintain productivity, especially of fish stocks. Yet at present there are too few MPAs and not many of them are effectively managed. These guidelines set out the various steps a country should take to establish an effective network of MPAs. IUCN has defined an MPA as "any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment". There are two ways of establishing MPA systems: either as many relatively small sites, each strictly protected, or as a few large multiple-use areas which contain strictly protected areas within them. To conserve biodiversity, both approaches should occur within an effective programme of ecosystem management covering the marine ecosystem and the land areas that affect it. From the accumulated technical experience in this field, there is one general lesson which can be drawn. A crucial attribute of an MPA manager is integrity. Some managers have made the mistake of believing that they can fool some of the people some, or even all, of the time. The result is a breakdown in trust. The manager may appear to win a series of battles but in fact the eventual outcome is failure. Another key lesson is that time spent in preparation is an essential investment that will be repaid many times over. Proponents of MPAs have to show demonstrable benefits for stakeholders, and this takes time and diplomacy. Box 1 lists other lessons from experience in establishing and managing MPAs in various situations around the world. The Guidelines set out the following steps, each being the subject of a separate chapter:

***1. Placing MPAs in their wider context*.** The high degree of linkage between land and adjoining sea, and the inter-connectivity of the oceans, require that MPAs be integrated into management regimes that deal with all human activities that affect marine life. Thus MPAs should be integrated with other policies for land use and use of the sea. It is also desirable for countries to make use of international agreements, notably UNCLOS and CBD. More international support is needed for MPAs and more attempts should be made to establish MPAs on the High Seas.

***2. Developing the legal framework*.** In most countries, a key step will be to establish the legislation needed. This may either be enabling legislation, which allows the administration or communities to establish individual MPAs, or specific legislation establishing an MPA, usually as a large multiple-use area. The various requirements for the legislation are outlined, though the needs and context will differ from one country to another.

***3. Working with relevant sectors*.** Many sectors of human activity affect the coast and the sea, and it is vital for those planning an MPA to work with these sectors from the earliest opportunity. Tourism often has most to gain from an MPA and can generate the greatest economic activity from it. Fisheries is the other key sector, and one with which it is most important to cooperate. Other relevant sectors include aquaculture, coastal development, agriculture, forestry, industry, defence and science.

4. Making partnerships with communities and other stakeholders. MPA management should understand the local communities that will be affected by the MPA and identify potential partners. It must listen to the many interests and seek ways to involve them as participants in resource management. It is recommended to build management partnerships using the collaborative management model, which is outlined in greater detail in Annex 1.
5. Selecting the sites for MPAs. Choosing the location and extent of MPAs involves a different emphasis to that of terrestrial protected areas. In many parts of the world, local people depend greatly on the services and resources provided by natural terrestrial areas. However, the dependence on marine areas tends to be even greater. Some forms of fishing can occur in large areas without threatening the conservation objectives of the MPA because they do not involve habitat modification. This makes it feasible to balance conservation and the needs of local people. Weight needs to be given to events outside the MPA that might affect it, such as pollution. Following these principles, the guidelines propose a rigorous set of criteria for site selection that have been applied in many countries over the past few years.
6. Planning and managing the MPA. Management should be responsive and adaptive, working with local interests in a way that builds support for the conservation objectives. To achieve this, managers should adopt a systems approach, use interdisciplinary teams and follow a clear sequence of decision-making. Most MPA management is about managing human activities, so this must be at the heart of the approach. Suggested contents for a management plan are provided in Annex 2.
7. Zoning, in which various areas are allocated for various uses. This is usually the best way of ensuring strict protection of a core zone as part of a larger, multiple-use area. The stages involved in preparing a zoning plan are outlined in Annex 3.
8. Planning for financial sustainability. Lack of funds is a critical problem for many MPAs. Managers therefore need the freedom to raise funds in as many ways as possible, such as user fees, donations and environment funds, and to retain those funds for management of the MPA. External donors are advised to extend the aid period for protected area projects, so as to help achieve financial sustainability.
9. Ensuring research, monitoring, evaluation and review. Research and monitoring should be firmly orientated to solving management issues. Guidance is given on the planning and development of a monitoring and research programme, with its different emphases in the planning and the implementation phase of the MPA. Most important of all is to use the results of research and monitoring to evaluate and if necessary reorient management.

Kenchington, R., Ward, T. & Hergerl, E. (2003) The benefits of Marine Protected Areas. Australian Government Department of Environment & Heritage. Australia, 20 pp.
http://www.deh.gov.au/coasts/mpa/wpc/benefits/pubs/benefits-mpas.pdf

Kerr, AM.; Baird, AH.; Campbell, SJ. 2006. Comments on „Coastal mangrove forests mitigated“ by K. Kathiresan and N. Rajendran [Estuar. Coast. Shelf Sci. 65 (2005) 601-606]. *Estuarine Coastal and Shelf Science* 67: 539-541.
Abstract not available

Lauck, T., Clark, CW., Mangel, M. & Munro, GR. (1998) Implementing the precautionary principle in fisheries management through marine reserves. *Ecological Applications* 8, S72-S78.
Abstract not available

Lubchenco, J., Palumbi, SR., Gaines, SD. & Andelman, S. (2003) Plugging a hole in the ocean: The emerging science of marine reserves. *Ecological Applications* 13, S3-S7.
Rapid and radical degradation of the world's oceans is triggering increasing calls for more effective approaches to protect, maintain, and restore marine ecosystems (Allison et al. 1998, Murray et al. 1999, NRC 1999a, 2000a). A broad spectrum of land and ocean-based activities, coupled with continued growth of the human population and migration to coastal areas, is driving unanticipated, unprecedented, and complex changes in the chemistry (Committee on Environment and Natural Resources 2000, NRC 2000b, Boesch et al. 2001), physical structure (Lubchenco et al. 1995, Watling

and Norse 1998), biology and ecological functioning (Lubchenco et al. 1995, Vitousek et al. 1997, Botsford et al. 1997, Watling and Norse 1998, NRC 1999b, NMFS 1999, FAO 2000, Hutchings 2000, Carlton 2001, Jackson et al. 2001) of oceans worldwide. Symptoms of complex and fundamental alterations to marine ecosystems abound, including increases in: coral bleaching, zones of hypoxic or anoxic water, abrupt changes in species composition, habitat degradation, invasive species, harmful algal blooms, marine epidemics, mass mortalities, and fisheries collapses (Botsford et al. 1997, Vitousek et al. 1997, Harvell et al. 1999, NRC 1999b, 2000a). Fishing practices, coastal development, land-based chemical and nutrient pollution, energy practices, aquaculture, land use and land transformation, water use and shipping practices combine to alter the structure and functioning of marine ecosystems globally (Lubchenco et al. 1995). Fundamental alterations to ecosystem structure include changes in species diversity; population abundance, size structure, sex ratios, and behaviour; habitat structure; trophic dynamics; biogeochemistry; biological interactions; and more. These changes in turn affect the functioning of marine ecosystems and the consequent provision of goods and services (Lubchenco et al. 1995, Peterson and Lubchenco 1997). As both the value and vulnerability of marine ecosystems become more broadly recognized, there is an urgent search for effective mechanisms to prevent or reverse widespread declines and to protect, maintain, and restore ocean ecosystems. Fully protected marine reserves are an emerging tool for marine conservation and management. Defined as ''areas of the ocean completely protected from all extractive and destructive activities,'' fully protected marine reserves (hereafter, simply ''marine reserves'') have explicit prohibitions against fishing and the removal or disturbance of any living or nonliving marine resource, except as necessary for monitoring or research to evaluate reserve effectiveness.

Makoloweka, S. & Shurcliff, K. 1997. Coastal management in Tanga, Tanzania: a decentralized, community-based approach. *Ocean and Coastal Management* 37: 349-357.
Abstract not available

Mapstone, B.D.; Davies, C.R.; Little, L.R.; Punt, A.E.; Smith, A.D.M; Pantus, F.; Lou, D.C.; Williams, A.J.; Jones, A.; Ayling, A.M.; Russ, G.R. & McDonald, A.D. 2004. The Effects of Line Fishing on the Great Barrier Reef and Evaluations of Alternative Potential Management Strategies. *CRC Reef Research Centre, Technical Report No 52.* CRC Reef Research Centre, Townsville, Australia.
The effects of reef line fishing on the productivity of targeted species and its impacts on other reef species on the Great Barrier Reef (GBR) have been poorly understood. Understanding the distribution, intensity, and effects of reef line fishing is essential for successful management of both fishing and other recreational and commercial activities in the GBR region, as well as for conservation of the GBR ecosystem.
The GBR Reef Line Fishery (RLF) comprises socially and economically important commercial, charter, and recreational fishing sectors. The fishery has been undergoing some change over the last decade, particularly manifest as considerable increases in effort and catch in the commercial fishery since 1995. These changes probably arise from several events, including changing management arrangements in other fisheries, the introduction of Dugong Protection Areas in in-shore areas, the process of reviewing management arrangements for the Reef Line Fishery and the development of lucrative export markets for live reef fish for consumption. Collectively, these influences have resulted in nearly 50% increase in commercial effort and 40% increase in catch since 1996. There also is potential for increased recreational fishing pressure along the GBR coast simply because of population growth and increased tourism. Management arrangements for the Coral Reef Fin Fish Fishery are now under review, with new management arrangements likely to regulate commercial effort in the fishery explicitly.
Conservation management of the GBR Marine Park also is undergoing significant change. The current zoning system is being substantially upgraded with the development of a comprehensive, adequate and representative system of no-take areas for biodiversity conservation of the GBR ecosystem – the Representative Areas Program. This revision is likely to increase the area of the GBR closed to reef line fishing. Realising the minimum regime of 20% of all GBR bioregions being 'no-take' will inevitably result in significant increases in the amount of coral reef habitat closed to the Reef Line Fishery in some areas. These factors, combined with limited historical information about the fishery or

its main target species, present significant problems for planning appropriate management strategies of the fishery and the GBR World Heritage Area.

These factors, combined with limited historical information about the fishery or its main target species, present significant problems for the development of appropriate management strategies for the fishery and the GBR World Heritage Area. In this research, we have quantified some of the primary impacts of the RLF on targeted stocks and assessed secondary impacts on other components of the GBR ecosystem. We have assessed experimentally the degree to which area closure strategies are likely to have ameliorated those impacts. Finally, we evaluated the prospects for alternative mixes of strategies for conservation and fishery management in the region to realise the objectives of diverse stakeholders.

Surveys of areas that had been open and closed to fishing for over a decade showed that the two main target species of the RLF, the common coral trout and the red throat emperor, were significantly more abundant, larger and older in areas zoned Marine National Park 'B' (and so closed to fishing) than in adjacent General Use areas that have always been open to fishing. The magnitude of these differences varied regionally, from near-zero around Lizard Island to several-fold for some population characteristics in the southern regions of the GBR. The pattern in apparent 'effectiveness' of past closures matched closely patterns in the amount of fishing effort and catch and underlying patterns in the abundances of several harvest and non-harvest species. We present circumstantial arguments that this regional variation in the apparent 'effectiveness' of Marine Protected Areas is likely to reflect long-standing regional variations in the amounts of fishing and its impacts outside closed areas, rather than wholesale subversion of zoning strategies by high levels of poaching. That is, the lack of contrast between open and closed areas in the Lizard Region probably arises because the open areas are lightly fished, whereas the strong contrasts in the other regions arises because of relatively heavy fishing in the open areas in those regions.

Experimental manipulations of reef zoning status and fishing effort verified that fishing on reefs that had been closed historically reduced the abundances of target species on those reefs to levels similar to surrounding open reefs. In the absence of prior data with which to compare open and closed reefs before zoning was implemented, these manipulations provide the most convincing evidence that the Marine Park zoning strategies have been effective in protecting sub-populations of the fishery resource from the impacts of harvest. The protection of such refuges, with sufficient compliance, thus has the potential to sustain high biomass of reproductively mature populations of harvested species in spite of an active fishery on the GBR.

Indirect effects of line fishing on non-harvest fish were less conspicuous. Whilst differences existed between open and closed reefs in abundances of the prey of targeted species, the nature of the patterns varied regionally, through time and with species or species group. In some situations the patterns in abundance suggested that removal of a key predator (coral trout) by fishing might have allowed populations of some prey to grow on fished reefs, but the evidence was neither uniform nor convincing.

We have evaluated prospectively the relative merits for managers and stakeholders of alternative strategies for effort management and area closure on the GBR. We based these evaluations on a set of simulation models ('ELFSim') for the population dynamics and harvest of common coral trout on the GBR. The population dynamics model is spatially structured, depicting nearly 4000 reef-associated populations of coral trout inter-connected via larval dispersal. The reef-associated, post-settlement populations are age, size and sex structured and we allow for variation in most of the key demographic parameters, such as natural mortality, growth, recruitment, etc. The harvest model predicts the allocation of fishing effort over the GBR by three fishing fleets, parameterised with historical catch and effort data to represent the commercial, charter and recreational sectors of the RLF.

Objectives for the future status of coral trout populations and for the RLF were developed by a diverse set of stakeholders in the fishery and the GBR World Heritage Area, in association with the Reef Line Fishery Management Advisory Committee (ReefMAC). Contributing stakeholders included state and federal managers, commercial, charter and recreational fishers, conservation organisations, and researchers. Stakeholder objectives included preserving near-virgin biomass of coral trout on reefs closed to fishing, ensuring satisfactory levels of populations available for harvest, maintaining economically viable commercial catch rates and recreationally rewarding recreational catches of coral trout, and minimising variation in harvests from year to year. Quantitative articulations of these and other objectives were derived and agreed with stakeholders, together with associated performance indicators.

The same set of stakeholders advised on the mix of potential strategies to be considered for achieving their respective objectives. We were asked to compare the efficacy of three levels of fishing effort, ranging from half of 1996 levels to 1½ times 1996 levels, and three levels of area closure, ranging from current closures to nearly three times current closures. The outputs from these Management Strategy Evaluations provide comparative assessments of the likelihood that each of the stakeholder objectives will be met by each combination of effort control and area closure strategy. The results are not intended to prescribe which strategy mix should be adopted, but to provide a basis for stakeholders to negotiate such an outcome based on the degree to which different combinations of strategies meet their needs.

Harvest-related objectives (e.g., maintaining CPUE, increased chance of catching a large fish, preserving biomass available for harvest) were most likely to be achieved when effort was lowest under any area closure strategy, but were less likely to be achieved as increasing amounts of area were closed to fishing. The principle stock-conservation objective, represented by preserving the spawning biomass of the whole population, was most likely to be achieved by increasing the amount of area closure and was only relatively slightly impacted by increasing fishing effort within each area closure strategy.

Importantly, the observed increase in fishing effort in recent years is most likely to impact most negatively on the performance indicators for areas open to fishing, especially those reflecting what fishers would consider satisfactory performance of the fishery (e.g., catch rates and sizes of fish). The increase in area closures under the Representative Areas Program is likely to exacerbate the depreciation of fishery performance, but our results suggest that growth in fishing effort will be considerably more influential than changes in areas available to the fishery. Our results suggest that the currently elevated levels of effort (~1.5 time 1996 levels) will reduce significantly the prospects of fishers in all sectors realising their objectives in future years, irrespective of the inevitable increases in protected areas under the Representative Areas Program.

Reducing effort, conversely, is the strategy of those considered in our evaluations most likely to realise direct fisheries-related objectives. The conundrum in these results, however, is that the improved prospects from effort reduction would apply only to those fishers remaining in the fishery. We are unable to assess the magnitude of financial costs likely to be incurred by those fishers excluded through the effort reductions that would now be necessary to achieve the two lower effort scenarios we considered. Changing effort had relatively little impact on most performance indicators for closed areas, especially conservation of spawning biomass of coral trout within Marine Protected Areas, even allowing for low levels of infringement of closed areas. The most effective mechanism by which to increase total spawning stock biomass over the GBR domain, therefore, was increasing the area closed to fishing, presuming that compliance with those closures was relatively high.

It is important to note that the status of coral trout populations in areas open to fishing remained relatively robust under all strategies we considered. For example, even under the most 'adverse' scenario of maximum effort constrained to the smallest fishable area, spawning biomass (in the open areas) remained above 50% of virgin spawning biomass and biomass available for harvest (i.e., above the minimum legal size limit) remained above 30% of virgin available biomass. These statistics generally would be considered acceptable for a harvested stock. In large part, this is likely to be the consequence of the biologically precautionary minimum legal size limit on harvest of common coral trout, which ensures that most fish can spawn in at least one year before reaching harvestable size.

Sensitivity analyses for the simulations showed that the qualitative relationships among scenarios were robust to changes in model parameters. Accordingly, the conclusions about the relative merits of increasing or decreasing fishing effort or area closures are robust to most changes in model assumptions. It should be noted, however, that our evaluations relate only to the populations and harvest of common coral trout (*P. leopardus*). Though several other species harvested in the Reef Line Fishery are taxonomically close to *P. leopardus*, they are generally considered to be less abundant and longer lived than *P. leopardus* and their populations dynamics are perhaps less resilient to harvest than that of *P. leopardus*. Accordingly, conservative regulations for the harvest of these other species would be prudent at this stage.

This research has laid bare some of the inevitable trade-offs among different scenarios for managing the harvest of common coral trout by the RLF in the GBR World Heritage Area. Most importantly, the trade-offs have been assessed in relation to objectives and performance indicators specified by diverse stakeholders in the fishery and the World Heritage Area. We present the tradeoffs in ways that allow direct comparisons among disparate objectives, essentially providing a common currency for comparing performance across fundamentally different types of objectives. In so doing, we hope that the costs and benefits of different management options are more transparent to all stakeholders than might otherwise have been the case. We hope that such transparency aids in the negotiation of acceptable and effective future management arrangements for the Great Barrier Reef World Heritage Area and the Reef Line Fishery.

Marcus, J.E; Samoilys M.A.; Meeuwig, J.J.; Villongco, Z.A.D. & Vincent, A.C.J. (in press) Benthic status of near-shore fishing grounds in the central Philippines and associated seahorse densities. *Marine Pollution Bulletin*.
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Abstract not available

Martin-Smith, K.M.; Samoilys, M.A.; Meeuwig, J.J. & Vincent, A.C.J. (2004) Collaborative development of management options for an artisanal fishery for seahorses in the central Philippines. *Ocean Coast. Manage*. 47:165-193.
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Abstract not available

McClanahan, T. R. & Mangi, S. (2000) Spillover of exploitable fishes from a marine park and its effect on the adjacent fishery. *Ecological Applications* 10:1792-1805.
Abstract not available

McClanahan, T.R.; Verheij, E. & Maina, J. (2006) Comparing the management effectiveness of a marine park and a multiple use collaborative management area in East Africa. *Aquatic Conservation: Marine and Freshwater Ecosystem* 16: 147-165.
Abstract not available

McManus, RE. (2004) Protecting some fish with no-take reserves is common sense. National Fisheries Conservation Center (NFCC): Ojai (USA), 1 p.
One evening you go to dinner with several people, including a local wildlife manager. During dinner the manager tells you that she is setting up a new protected area where no wildlife will be killed. She explains that where people kill wild animals, their numbers and sizes have decreased. Moreover, where there has been heavy hunting and other types of human activities, wild places have fewer kinds of animals and plants. To help remedy these problems, the manager explains, her agency will fully protect wildlife in a few carefully chosen areas administered by the government. Where this has been done elsewhere she notes, the animals and plants are more abundant and larger, and their habitats look more like they have in the past before they were disturbed by humans. One of your reactions might be to say, "this doesn't sound like rocket science to me, it would be logical to assume that when you protect wildlife, they do better." Most people agree with that conclusion. All of the scientists that I know who study protected areas have concluded the same thing, for both terrestrial ecosystems and marine ecosystems. Of course, the degree such management regimes are successful depends on a variety of factors regarding how they are designed and implemented, and how well external threats to the species are controlled. Nevertheless, the basic hypothesis that if you protect them they do better seems to be common sense and it is supported by scientific evidence.

Micheli, F. & Halpern, BS. (2005) Low functional redundancy in coastal marine assemblages. *Ecology Letters* 8, 391-400.

The relationship between species and functional diversity remains poorly understood for nearly all ecosystem types, yet determining this relationship is critically important for developing both a mechanistic understanding of community assembly and appropriate expectations and approaches to protecting and restoring biological communities. Here we use two distinct data sets, one from kelp forests in the Channel Islands, California, and one from a global synthesis of marine reserves, to directly test how variation in species diversity translates into changes in functional diversity. We find strong positive relationships between species and functional diversity, and increased functional diversity of fish assemblages coinciding with recovery of species diversity in marine reserves, independent of the method used for classifying species in functional groups. These results indicate that low levels of redundancy in functional species traits exist across a suite of marine systems, and that fishing tends to remove whole functional groups from coastal marine ecosystems.

Murawski, SA. (2000) Definitions of overfishing from an ecosystem perspective. *ICES Journal of Marine Science* 57, 649-658.

Ecosystem considerations may be incorporated into fisheries management by modifying existing overfishing paradigms or by developing new approaches to account for ecosystem structure and function in relation to harvesting. Although existing concepts of overfishing have a strong theoretical basis for evaluating policy choices and much practical use, they do not provide direct guidance on issues such as biodiversity, serial depletion, habitat degradation, and changes in the food web caused by fishing. There is, however, little basis for defining optimum fishing by using related metrics such as diversity indices, slopes of size or diversity spectra, or average trophic level of the catch, and these may produce ambiguous results. If ecosystem-based overfishing concepts are to assume a greater role in management, unambiguous, quantifiable, and predictive measures of ecosystem state and flux must be developed to index: (1) biomass and production by the ecosystem and relationships among its parts, (2) diversity at different levels of organization, (3) patterns of resource variability, and (4) social and economic benefits. Ecosystem considerations do not need to substitute for existing overfishing concepts. Instead, they should be used to evaluate and modify primary management guidance for important fisheries and species. In practice, they emphasize the need to manage fishing capacity, supported by broader use of technical measures such as marine protected areas and gear restrictions.

Murawski, S.; Rago, P. and Fogarty, M. (2004) Spillover Effects from Temperate Marine Protected Areas. In: Shipley, J. B. (ed) Aquatic protected areas as fisheries management tools. American Fisheries Society, 301 pp.

Abstract not available

National Fisheries Conservation Centre (NFCC) (2004) Integrating marine reserve science and fisheries management: NFCC consensus conference. NFCC: Long Beach (USA), 33 pp.

Objective

The objective of this Consensus Statement is to inform the fishery management, ecological research, and marine protected area management communities of the results of the NFCC Consensus Conference on Integrating Marine Reserve Science and Fisheries Management. The statement provides an objective examination and assessment of the information regarding potential biological, social, and economic consequences of marine reserves, their potential effectiveness as a fishery management tool in the U.S., the methods for integrating their application with existing U.S. fisheries management and how marine reserves might be designed, monitored and evaluated. In addition, the statement addresses sources and magnitudes of uncertainty associated with marine reserves and conventional management approaches, and recommends areas for further study.

Participants

The conference included scientists and policy experts representing the fields of biological oceanography, marine ecology, fish biology, population dynamics, stock assessment, fishery management, fishery economics, and marine environmental law. The conference's seven-member review panel was made up of scientists and policy experts not currently engaged in research or advocacy in the field of marine reserves. The conference's ten-member presentation panel was made up of scientists and policy experts that are currently engaged in research or advocacy in the field of marine reserves. In addition to conference panelists, an audience of about 100 fishers, scientists, and policy makers was observed and contributed comments.

Evidence

The Communication Partnership for Science and the Sea (COMPASS) at Oregon State University conducted the literature search for the planning committee and the consensus conference and prepared an extensive bibliography for the panel and conference audience. COMPASS staff also prepared abstracts and topic synthesesfor the panel with relevant citations from the literature.

Consensus Process

The panel, answering predefined questions, developed their conclusions based on the scientific evidence presented in open forum and the scientific literature. The panel composed a draft statement that was summarized and presented to the experts and the audience for comment. Thereafter, the panel resolved conflicting recommendations and released a summary of its revised statement at the end of the conference. The panel finalized the revisions after the conference. The draft statement was made available on the World Wide Web after panel revisions.

Conclusions

Marine reserves should be considered in the broader context of the development of ecosystem-based management in the U.S. From that perspective, marine reserves have clear application for meeting objectives for ecosystem conservation and protection of marine biodiversity in addition to whatever benefits they may have for achieving fishery management objectives. Furthermore, marine reserves are a category of area management options—including less restrictive and less permanent alternatives -that may be used in order to achieve ecosystem- or species based management objectives. With regard to fishery effects, studies of marine reserves and other area closures, most of which are from lower latitudes, have now shown that fishery target species have increased in abundance and expanded age structure within the closed area in a preponderance of cases (the so-called "reserve effect."). This is particularly the case where the resource species are significantly overfished. Evidence for effects outside closed areas, either by movement of adults across the reserve boundaries ("spillover") or larval "export" is more limited and effects on stocks within larger regions can only be deduced by models at this point. This is because of the limited size of existing reserves and inherent difficulties in measuring and interpreting such broader effects. In general, knowledge is sufficient to proceed with the design and evaluation of marine reserves and other marine protected areas and their incorporation into regional ecosystem-based management. More sophisticated modelling and analysis is required for better understanding of spatial movement rates, export of reproductive products, and adaptations by fishers. Marine reserves clearly offer some advantages for simultaneously incorporating habitat protection and maintenance of ecosystem structure and function within the protected area. They may offer some advantages for multi-species management and as a hedge against environmental surprise or management failure. Marine reserves are most likely to be an effective management tool for relatively sedentary species with broad larval dispersal, which are recruitment limited, and for mobile species with high site fidelity. They may also be effective for protecting rare habitats vulnerable to human disruption or in protecting aggregations of animals (e.g., when spawning), when exploited populations have been severely depleted, or where bycatch is high. Closed areas may also be useful in achieving broad demographic representation in spawning populations if large animals have limited movement potential relative to reserve boundaries, and when they can maintain populations of highly fecund, older females with strong reproductive potential. They may be more feasible to implement either when reduced yields have already restricted fishing activities and other management measures have been ineffective or when they address special needs within otherwise productive regions. Marine reserves and other protected areas should be integrated with existing and emerging management measures as part of a coherent ecosystem-based approach to management of commercial and recreational fisheries and should not be simply layered over existing regulations. Careful consideration of the effects on allocation of resources among users, displacement of fishing activity, the requirements for surveys and stock assessment, and the costs of monitoring and enforcement should be made in considering protected area options and design. The Panel found it difficult to limit its considerations to marine reserves as strictly defined, i.e. areas permanently protected from all extractive activities. We found that management actions need to be openly evaluated against stated goals and where goals are not being met changes in management must at least be considered. The design requirements for marine reserves depend heavily on the environmental context and specific management goals, including the overriding goal of sustainability and high yields of economically important species. Robust experimental design will be critical in order to determine the effects of displaced fishing pressures and enhancement effects on populations outside of reserves in before-after-control-impact assessments. We have been hampered in evaluating the use of marine reserves as a tool for fishery management by the lack of experiments explicitly designed to address reserve effects on fisheries. These explicit experiments are urgently needed. There are numerous uncertainties associated with our understanding both of important biological and socioeconomic processes and with monitoring, analysis, prediction, and implementation. Some important uncertainties for marine reserves include the degree of effective dispersion and reproductive seeding and the ability to resolve spatial and temporal interactions in monitoring and modelling. Further study is required on several key issues if closed areas are to assume a more important role in ecosystem approaches to fisheries management and biodiversity protection. These include high quality, synthetic bottom mapping with which to define vulnerable habitats that closed areas might best protect; study of dispersal rates; synthesis of effects of closures in northern temperate and boreal systems. Many authors have speculated that marine reserves offer more precaution against management and scientific uncertainty than traditional measures. At this point, this is an assertion, and no studies using common definitions and metrics of precaution have been conducted. Given the importance of this issue, there is a need to conduct such work, applying biology and social science, particularly as it relates to findings from existing marine closures.

National Research Council Committee on Ecosystem Management for Sustainable Marine Fisheries (NRC) (1999) Sustaining marine fisheries. NRC, USA, 184 pp.

Marine ecosystems are being perturbed by fishing and other human activities. Many marine fisheries are in decline, and the effects of fishing on other ecosystem goods and services are beginning to be understood and recognized. In recent years, global marine catches appear to have reached a plateau of about 84 million metric tons per year, although total fish production, which includes aquaculture, has continued to increase. In some cases, fisheries have been entirely closed, and in many others it takes increasing effort to maintain catch rates. Fishing is also an economically important international industry, with first-sale revenues of approximately $US 100 billion per year for all fishery products. (Farm-raised and freshwater fisheries account for approximately 25 percent by weight of all fishery products.) Globally, fishery products directly provided approximately 14 kg of food per person in 1996; approximately 28 percent of global fishery products was used for animal feed and other products that do not contribute directly to human food. Although in recent years total fish production has increased faster than the human population, the total from marine-capture fisheries has increased little if at all. To evaluate whether current marine-capture fisheries are sustainable, to determine to what degree marine ecosystems are affected by fishing, and to assess whether an ecosystem approach to fishery management can help achieve sustainability, the National Research Council's Ocean Studies Board established the Committee on Ecosystem Management for Sustainable Marine Fisheries. The committee was directed to "assess the current state of fisheries resources; the basis for success and failure in marine fisheries management (including the role of science); and the implications of fishery activities to ecosystem structure and function. Each activity [was to] be considered relative to sustaining populations of fish and other marine resources" (Statement of Task). This report is the product of the committee's study.

National Research Council Committee on Ecosystem Management for Sustainable Marine Fisheries (NRC) (2001) Marine Protected Areas: Tool for sustaining ocean ecosystem. NRC, USA, 288 pp.

Declining yields in many fisheries and the decay of treasured marine habitats such as coral reefs have heightened interest in establishing a comprehensive system of marine protected areas (MPAs) in the United States. MPAs, areas designated for special protection to enhance the management of marine resources, show promise as components of an ecosystem-based approach for conserving the ocean's living assets. However, MPA proposals often raise significant controversy, especially the provisions for marine reserves—zones within an MPA where removal or disturbance of resources is prohibited, sometimes referred to as closed or “no-take” areas. Some of the opposition to MPAs lies in resistance to “fencing the sea,” reflecting a long tradition of open access. This opposition continues despite compelling empirical evidence and strong theoretical arguments indicating the value of using reserves as a tool to improve fisheries management, to preserve habitat and biodiversity, and to enhance the esthetic and recreational value of marine areas. The controversy persists because we lack a scientific consensus on the optimal design and use of reserves and we have only limited experience in determining the costs and benefits relative to more conventional management approaches. The current decline in the health of the ocean’s living resources, an indication of the inadequacy of conventional approaches, and the increasing level of threat have made it more urgent to evaluate how MPAs and reserves can be employed in the United States to solve some of the pressing problems in marine management.

Norse, E.A.; Crowder, L.B.; Gjerde, K.; Hyrenbach, D.; Roberts, C.; Safina, C. & Soulé, M.E. (2005) ‘Place-based ecosystem management in the open ocean’ in EA. Norse & LB. Crowder (eds) *Marine Conservation Biology: The science of maintaining the sea’s biodiversity*. Island Press: Washington

Abstract not available

Ogwang, V.; Medard, M. & Nyeko, J.I. (2004) Harmonised Beach Management Unit (BMU) Operational Guidelines for Fishing Communities of East African States. Lake Victoria Fisheries Organisation. Implementation of the Fisheries Management Plan for Lake Victoria.

Abstract not available

Orensanz, J.M., Parma, A.M., Jerez, G., Barahona, N., Montecinos, M. y Elías, I. (in press) What are the key elements for the sustainability of "S-fisheries"? Insights from South America. In N. Erhardt, ed., *Proceedings of the Conference on the Scientific Bases for the Sustainability of Fisheries*, Miami, November 26-30, 2001.

Abstract not available

Pabari, M.; Samoilys M.; Muniu, H.; Othina, A.; Thande, G.; Mijifha, P. & Matiru, V. (2005) Using Monitoring and Assessment for Adaptive Management: A Guide to the TCZCDP Information Management System. IUCN Eastern Africa Regional Office, Nairobi, Kenya.

Abstract not available

Palma, M. & Chávez, C. (2004) Normas y Cumplimiento en Áreas de Manejo de Recursos Bentónicos: Estudio de Casos en la Región del Bío-Bío, mimeo, Department of Economics, Concepción University, Chile.

Abstract not available

Pascoe, S. & Mardle, S. 2006. Economic impact of area closures and effort reduction measures in the North Sea. CEMARE Report to the United Kingdom Department for Environment, Food and Rural Affairs. 38 pp.

Executive summary see http://www.defra.gov.uk/fish/science/index.htm

PARKS (1998) Marine Protected Areas. Vol 8. IUCN, Gland, Switzerland, 64 pp.

http://www.iucn.org/themes/wcpa/pubs/pdfs/PARKS/Parks_Jun98.pdf

Abstract not available.

PARKS (in print) High Seas Marine Protected Areas. Vol 15.3. IUCN, Gland, Switzerland.

http://www.iucn.org/themes/wcpa/pubs/pdfs/PARKS/Parks_Jun98.pdf

Abstract not available.

Pinnegar, JK., Polunin, NVC., Francour, P., Badalamenti, F., Chemello, R., Harmelin-Viviens, M-L., Hereu, B., Milazzo, M., Zabala, M., D'Anna, G. & Pipitone, C. (2000) Trophic cascades in benthic marine ecosystems: lessons for fisheries and protected-area management. ***Environmental Conservation*** **27, 179-200.**

An important principle of environmental science is that changes in single components of systems are likely to have consequences elsewhere in the same systems. In the sea, food web data are one of the few foundations for predicting such indirect effects, whether of fishery exploitation or following recovery in marine protected areas (MPAs). We review the available literature on one type of indirect interaction in benthic marine ecosystems, namely trophic cascades, which involve three or more trophic levels connected by predation. Because many indirect effects have been revealed through fishery exploitation, in some cases we include humans as trophic levels. Our purpose is to establish how widespread cascades might be, and infer how likely they are to affect the properties of communities following the implementation of MPAs or intensive resource exploitation. We review 39 documented cascades (eight of which include humans as a trophic level) from 21 locations around the world; all but two of the cascades are from shallow systems underlain by hard substrata (kelp forests, rocky subtidal, coral reefs and rocky intertidal). We argue that these systems are well represented because they are accessible and also amenable to the type of work that is necessary. Nineteen examples come from the central-eastern and north-eastern Pacific, while no well-substantiated benthic cascades have been reported from the NE, CE or SW Atlantic, the Southern Oceans, E Indian Ocean or NW Pacific. The absence of examples from those zones is probably due to lack of study. Sea urchins are very prominent in the subtidal examples, and gastropods, especially limpets, in the intertidal examples; we suggest that this may reflect their predation by fewer specialist predators than is the case with fishes, but also their conspicuousness to investigators. The variation in ecological resolution amongst studies, and in intensity of study amongst systems and regions, indicates that more cascades will likely be identified in due course. Broadening the concept of cascades to include pathogenic interactions would immediately increase the number of examples. The existing evidence is that cascade effects are to be expected when hard-substratum systems are subject to artisanal resource exploitation, but that the particular problems of macroalgal overgrowth on Caribbean reefs and the expansion of coralline barrens in the Mediterranean rocky-sublittoral will not be readily reversed in MPAs, probably because factors other than predation-based cascades have contributed to them in the first place. More cascade effects are likely to be found in the soft-substratum systems that are crucial to so many large-scale fisheries, when opportunities such as those of MPAs and fishing gradients become available for study of such systems, and the search is widened to less conspicuous focal organisms such as polychaetes and crustaceans.

Polacheck, T. (1990) Year around closed areas as a management tool. ***Nat. Resour. Model.*** **4, 327-354.**

Abstract not available

République islamique de Mauritanie, Secrétariat général du Gouvernement. (2004) Document de synthèse du Plan d'aménagement et de gestion du Parc national du Banc d'Arguin. 2005-2009. 52 pp.

Abstract not available

Robinson, M.; Miller, C.; Hoeflinger, C.; & Walker, B. Problems and recommendations for using GIS to improve decision-making in California's Channel Islands marine reserves. ***MPA News*****, 7(5):4-5.**

Abstract not available

Rowe, S. & Hutchings, JA. (2003) Mating systems and the conservation of commercially exploited marine fish. ***Trends in Ecology & Evolution*** **18, 567-572.**

Unprecedented declines of marine fish have revealed our inability to predict the susceptibility of populations to collapse and their capacity for subsequent recovery. Lack of knowledge about the behaviour and ecology of exploited species has hindered our understanding of how exploitation influences the resistance of marine fish to catastrophic decline and their resilience thereafter. Based on available data, particularly on the Atlantic cod *Gadus morhua*, we argue that the breeding behaviour of marine fish is considerably more complex than was believed previously. Mate competition, mate choice and other components of mating systems can affect population growth rate deleteriously during and after periods of intense exploitation. There is a pressing need to incorporate knowledge of mating systems in population assessments, to undertake field research on spatial and temporal scales of reproduction, and to initiate laboratory manipulation experiments to test hypotheses about marine fish mating systems, Allee effects and correlates of individual reproductive success.

Ruitenbeek, J.; Hewawasam, I. & Ngoile, M. (2004) Blueprint 2050: Sustaining the Marine Environment in Mainland Tanzania and Zanzibar. The World Bank, Washington D.C., USA.
Abstract not available

Russ, G.R. (2002) Yet another review of marine reserves as reef fishery management tools. In*:* Sale, P.F. (ed) Coral reef fishes: dynamics and diversity in a complex ecosystem. Academic Press, New York, p 421-444.
Abstract not available

Russ GR. & Alcala AC. (2004) Marine reserve benefits local fisheries. *Ecological Applications* 14, 597-606.
The utility of no-take marine reserves as fisheries-management tools is controversial. It is hypothesized that marine reserves will help to sustain fisheries external to them by becoming net exporters of adults (the "spillover effect") and net exporters of propagules (the "recruitment effect"). Local fishery benefits from spillover will likely generate support from fishing communities for marine reserves. We used underwater visual census to show that biomass of Acanthuridae (surgeonfish) and Carangidae (jacks), two families of reef fish that account for 40–75% of the fishery yield from Apo Island, Philippines, tripled in a well-protected no-take reserve over 18 years (1983–2001). Biomass of these families did not change significantly over the same period at a site open to fishing. The reserve protected 10% of the total reef fishing area at the island. Outside the reserve, biomass of these families increased significantly closer to (200–250 m) than farther away from (250–500 m) the reserve boundary over time. We used published estimates of fishery catch and effort, and fisher interviews (creel surveys) to show that the total catch of Carangidae and Acanthuridae combined at Apo Island was significantly higher after (1985–2001) than before (1981) reserve establishment. Hook-and-line catch per unit effort (CPUE) at the island was 50% higher during 1998–2001 (reserve protected 16–19 years) than during 1981–1986 (pre-reserve and early phases of reserve protection). Total hook-and-line effort declined by 46% between 1986 and 1998–2001. Hook-and-line CPUE of Acanthuridae was significantly higher close to (within 200 m) than far from the reserve. CPUE of Carangidae was significantly higher away from the reserve, possibly reflecting a local oceanographic effect. The benefits of the reserve to local fisheries at the island were higher catch, increased catch rate, and a reduction in fishing effort. The fishery and tourism benefits generated by the reserve have enhanced the living standard of the fishing community.

Sadovy, Y. (1993) The Nassau grouper, endangered or just unlucky? *Reef Encounter* 13: 10-12.
Abstract not available

Sadovy, Y. (1999) The case of the disappearing grouper: Epinephelus striatus, the Nassau grouper, in the Caribbean and western Atlantic. Proc. 45th Gulf. Carib. Fish. Inst. Mexico, November 1992. 22 pp.
Abstract not available

Sadovy, Y.J. & Domeier, M.L. (2005) Are aggregation fisheries sustainable: reef fish fisheries as a case study? *Coral Reefs* 24, 254–262.
Abstract not available

Sainsbury, K. & Sumaila, UR. (2003) 'Incorporating ecosystem objectives into management of sustainable marine fisheries, including "best practice" reference points and use of marine protected areas' in M. Sinclair & G. Valdimarsson (eds) *Responsible fisheries in the marine ecosystem*. FAO: Rome (Italy), 343-361.

The broadening of fisheries management to include ecosystem-related objectives raises a potentially confusing range of possible issues for consideration in management decisions, in reporting and in assessing management performance. However, there are methods available and approaches to addressing the issues that are practical, accessible to stakeholder participation and scientifically assessable. Three broad and interrelated elements are described that allow ecosystem objectives to be practically and operationally incorporated into marine fisheries management systems.

Reporting and assessment of the whole management system against sustainability objectives

Three major points are developed and emphasized:

1. Indicators and reference points - and consequently performance measures – must relate explicitly to the high-level objectives of management.

2. The structure and focus of reports on sustainability must be derived transparently from the high-level objectives. A methodology for this is described that can be used in meetings with stakeholders to elucidate the issues, indicators and reference points, management response and the justification for decisions. It can include risk-based methods to help identify the relative importance of different issues.

3. Performance assessments must be of the management system as a whole, rather than solely on the merits of particular parts in isolation. An established methodology (management strategy evolution) is described that can be used to test quantitatively the likely performance of different management strategies in achieving ecosystem objectives. A management strategy in this context is a combination of monitoring, use of the monitoring data for assessment against reference points, identification of appropriate management measures and implementation of these measures. This methodology can be used to test any aspect of the strategy in the 'common currency' of the management objectives, and to identify the circumstances in which particular strategies are likely to perform well or fail. It has already been used in fisheries in relation to target species, important by-catch species, predator-prey dependencies and seabed habitats.

Indicators, reference points and performance measures for fisheries ecosystem objectives

There are many options available, and some recent summaries are identified. A set of target and limit reference points for fisheries ecosystem objectives are provided. These are based broadly on experience to date, and could be practically implemented in the short term. It is not claimed that these reference points are necessary or adequate to achieve sustainability for fisheries and marine ecosystems. Rather, they represent a practical and emerging 'best practice' means of operationally accommodating ecosystem-related objectives in fisheries management.

Use of marine protected areas to achieve ecosystem objectives in fisheries management

Fisheries have long used some forms of spatial management, such as closure of nursery areas to protect juvenile fish, but more recently there has been a focus on use of marine protected areas (MPASs) to achieve fishery objectives for the target species and the for the ecosystem generally.

MPAs hold promise as a rational and practical way of managing ocean resources to achieve fishery ecosystem objectives, although this promise should not be overstated. MPAs are best seen as part of a collection of management tools and measures, with a combination of on-reserve and off-reserve measures being used together to achieve sustainable fisheries and marine ecosystems. Several new technological developments are making their design and management more practical. These recent development are reviewed.

Salafsky, N.; Margoluis, R. & Redford, K. (2002) Adaptive Management: A Tool for Conservation Practitioners. Washington, D.C.: Biodiversity Support Program.

Abstract not available

Sale, PF., Cowen, RK., Danilowicz, BS., Jones, GP., Kritzer, JP., Lindeman, KC., Planes, S., Polunin, NVC., Russ, GR., Sadovy, YJ. & Steneck, S. (2005) Critical science gaps impede use of no-take fishery reserves. *Trends in Ecology and Evolution* 20, 74-80.

As well as serving valuable biodiversity conservation roles, functioning no-take fishery reserves protect a portion of the fishery stock as insurance against future overfishing. So long as there is adequate compliance by the fishing community, it is likely that they will also sustain and even enhance fishery yields in the surrounding area. However, there are significant gaps in scientific knowledge that must be filled if no-take reserves are to be used effectively as fishery management tools. Unfortunately, these gaps are being glossed over by some uncritical advocacy. Here, we review the science, identify the most crucial gaps, and suggest ways to fill them, so that a promising management tool can help meet the growing challenges faced by coastal marine fisheries.

Salm, RV., Clark, JR. & Siirila, E. (2000) Marine and coastal protected areas: a Guide for Planners and Managers. IUCN, Gland, Switzerland, 370 pp.

Approaches to planning and managing marine protected areas (MPAs) have evolved considerably since the first edition of this book was published in 1984. The original version arose from the Workshop on Managing Coastal and Marine Protected Areas, held in October 1982 during the World Congress on National Parks in Bali, Indonesia. A second edition was printed in 1989, with minor revisions. This second edition was exhausted several years ago, but demand for the book remained high. However, as so much has changed over the past 15 years, and so many new lessons have been learned, there is evident need for a major update. This Third Edition answers that demand. Even today, some 15 years later, the feedback we have received is that the book is a practical tool with an applied, "hands-on," viewpoint. This was the book's original intention and remains the main goal of this revision. It is still intended as a guide for people who find themselves with mandates to plan individual or national systems of marine protected areas (MPAs), or both, and need a philosophical context for marine protected areas along with some basic principles and approaches to establish them. Wherever possible, case studies are used to illustrate points or processes by "real world" examples. We would like to think that practitioners today will find this version as useful as our counterparts and colleagues did the original "Orange Book" during the past many years.

The book derives from many sources, including the 1982 Bali Workshop papers and summary reports of session chairs and rapporteurs. The participants of the workshop remain contributors to this version of the book. It is heartening to find how relevant these original outputs are today. But the field of conservation science and theory have evolved enormously over the past two decades, which has been a period of catch-up for marine protected areas with those on land. We have reached the point where one book can only introduce the huge body of thought and publications on theory, science and policy surrounding MPAs and the vast quantity of new practical experience (largely embodied in the gray literature). In revising this book, we have accessed some of the least accessible techniques and practices, many of which remain unpublished.

One new trend is important - the emphasis on community participation mechanisms. Also, there have been major advances in the last two decades on the challenge of sustainability of MPAs through innovative financing mechanisms, partnerships with the private sector and NGOs, and collaborative management between government and coastal communities. These advances have brought along with them new approaches for MPA establishment and management that are more participatory, involving communities through interaction and collaboration rather than prescription. While it has become popular to write about participatory and collaborative management, we are still testing and refining different approaches. We may need ten more years in most cases before we can separate reality from easy optimism and say that one or another approach is a real success. This applies especially to the emerging field of collaborative management—partnership between government and communities, NGOs and/or the private sector (especially those concerned with tourism). In the search for published material to use in the first edition of this book, it soon became apparent that relevant publications on planning and managing marine and coastal protected areas were scarce. There are more today. In the early 1980's, the MPA creation and management field was new and evolving with few tested practical tools and little to publish. As a result, the book drew heavily on personal experience and displayed a strong bias toward personal styles of approach. These days we are blessed with a wider variety of published materials and tools, but there still exists a deficit of tested, proven, practical results, particularly in collaborative management. So again, the personal experiences of the authors tend to influence the book.

This is a book for practitioners in tropical countries. It is meant to complement modern texts covering policy aspects of MPA selection and design by providing approaches and tools for everyday application at field sites. Until the modern theories are tried, tested, refined, proven, and generally absorbed into everyday practice, there will always be the need for approaches that get results on the ground. Given the urgency to act now and safeguard what we have before it is lost, we need to lock up what we can in conservation and to strive over the longer term for perfection. Practitioners who see their reefs being blasted apart, their mangroves being cut, their beaches and dunes eroding, their coastal wetlands being clogged with silt, or their MPA boundaries being ignored or encroached upon often make the same remark: "We need to do something now to safeguard what we have, based on the best available information." That "something" often means "We need to engage the stakeholders (communities, private sector, tourism industry, government) and work with them to achieve compliance with our programme and its objectives, and we need to do it fast." It is to this audience that we are attempting to cater: to give the practitioner in a tropical country some very basic approaches and tools to take those immediate first steps.

Samoilys, M.A.; Martin-Smith, K.M.; Giles, B.; Cabrera, B.; Anticamara, J.; Brunio, E.O. & Vincent, A.C.J. (2006) Fish responses over seven years in five coral reef sanctuaries in the central Philippines. Fisheries Centre Working Paper #2006-10. The University of British Columbia, Vancouver, Canada.

No-take marine reserves are increasingly promoted as a simple, precautionary measure to conserve biodiversity and sustain coral reef fisheries. However, rigorous empirical assessment of their effects has lagged behind theoretical studies. We surveyed changes in fish communities for seven years. Our transects were located within (Inside) five small reserves in the central Philippines, within a kilometre of their boundaries (Outside) and at three distant Control sites. We found significant differences between fish communities Inside and Outside the reserve only at the two sites with strictest compliance with fishing prohibition, while there were significant differences to distant Control sites in all cases. The strongest responses to reserve protection were found in predatory fishes (groupers and breams) and in butterflyfish. Other abundant fish families showed weak effects of protection. For all taxa analysed, we found significant effects of reserve Site and Site x Treatment interactions. The detection of fish responses to reserves is complicated by potential spillover effects, site-specific factors, particularly compliance, and the difficulty of identifying appropriate control areas.

Simard, F. & Lundin, C.G. (2005) Japanese fishing rights and biodiversity conservation. Summary paper submitted to the First International Marine Protected Areas Congress, Geelong, Australia, October 2005, 5 pp.

There exist many examples of fishing customary rights and tenures all around the world. The Japanese system is interesting mainly for two reasons: 1. it concerns a huge number of fishers grouped in fisheries cooperatives; 2. it is ancient and traditional however institutionalized during the reform of the Constitution in 1948. The system includes several management tools for the coastal zone around Japan, e.g. temporary and permanent closures, no-take zones, and other fisheries regulations. It is an example of strong local governance within a fairly centralized country. This paper looks into this fishing right as a management tool for local communities on a large scale and discusses the values of such systems for both biodiversity conservation and sustainable development.

Stefansson, G. and A.A. Rosenberg (2005) Combining control measures for managing fisheries under uncertainty: quotas, effort limitation and protected areas. Proceedings of the Royal Society: B. 360:133-146.

We consider combinations of three types of control measures for the management of fisheries when the input information for policy decisions is uncertain. The methods considered include effort controls, catch quotas and area closures. We simulated a hypothetical fishery loosely based on the Icelandic cod fishery, using a simple spatially explicit dynamic model. We compared the performance with respect to conserving the resource and economic return for each type of control measure alone and in combination. In general, combining more than one type of primary direct control on fishing provides a greater buffer to uncertainty than any single form of fishery control alone. Combining catch quota control with a large closed area is a most effective system for reducing the risk of stock collapse and maintaining both short and long-term economic performance. Effort controls can also be improved by adding closed areas to the management scheme. We recommend that multiple control methods be used wherever possible and that closed areas should be used to buffer uncertainty. To be effective, these closed areas must be large and exclude all principal gears to provide real protection from fishing mortality.

Stotz, W. (1997) Las áreas de manejo en la ley de pesca y acuicultura: primeras experiencias y evaluación de la utilidad de esta herramienta para el recurso loco. Estud. Oceanol. 16: 67-86 1997.

In north-central Chile the fisherfolk unions began to protect coastal areas at the end of 1990, one year before the management areas appeared in the Chilean fishery law as a new management tool. The areas were selected for the protection of the snail *Concholepas concholepas (`loco'),* whose fishery had been closed for several years, but nevertheless, was suffering an important illegal capture. The only management decision was to prohibit fishing in the areas. As a result, a rapid increase of the abundance of the "loco" was observed in the areas. Nevertheless, in the area that was first established, the abundance exceeded the carrying capacity before legal extraction was authorized. The "loco" population overexploited his prey species, and then emigrated from the area. The present general low abundance of 'locos", in the management areas, as well as in the historical fishing areas, are frustrating the expectations the fisherfolk unions had in this new management tool. Many of them are abandoning the care of their areas. The present paper analyses this experience and evaluates, in view of the characteristics of the life history of the species, the possibilities or utility of the areas as a management tool to favour fishery production of this resource. The basic conclusion is that production of *Concholepas concholepas* in the management areas depends largely on oceanographic processes, which occur at scales which are not controllable in restricted coastal areas. Thus, little can be done to improve production in management areas, but proper management would help to make an efficient and sustainable use of the natural production of the resource. Restricting the fishery exclusively to management areas, and protecting the rest of the coast, could be beneficial. General management of the resource has to take account of the natural spatial and temporal variability of the abundance and production of the snail and his prey species. Nevertheless, the importance of management areas goes beyond its only objective to improve or maintain production of the resource. Its establishment offers the unique opportunity to perform management experiments, with different treatments and proper controls, using the different areas. Thus, the areas will help to improve knowledge and experience on fishery management. Furthermore, the establishment and administration of the areas strengthen the organization of fisherfolk unions, and include an important educational value, for all the people involved: academics, administrators and fisherfolk. Finally, the development of management strategies, which not only include biological, but also legal, social and economic aspects, will be favoured.

Subsecretaría de Pesca. (2004) Análisis del desempeño económico de las áreas de manejo 2000–2002.

1. Introducción

En los inicios de la implementación del Régimen de Áreas de Manejo y
Explotación de Recursos Bentónicos (AMERB), muchas hipótesis se plantearon sobre las posibles fortalezas de tal medida, que afectarían en el tiempo, tanto al recurso como a los agentes directamente involucrados, los pescadores. Dentro de estas presunciones, se planteó: un aumento de los precios promedios de venta; aumento de la biomasa, tanto del recurso principal como del secundario; esto aparejado de un aumento de los ingresos del pescador; mayor capacidad de gestión de las organizaciones y aumento de las tallas de los recursos, entre otras. Ya hace más de diez años, que las áreas de manejo han venido desarrollándose, inicialmente, como pruebas pilotos o experimentales en algunas regiones, y a la fecha, como una medida adoptada por casi todas las organizaciones de pescadores artesanales a nivel nacional. Aunque la mayoría de las fortalezas planteadas en aquellos años, son reconocidas por los involucrados hoy en día y evaluadas a nivel organizacional, difícilmente se ha podido cuantificar algunas de éstas, desde un punto de vista de su aplicación a nivel nacional. Si bien aún es difícil evaluar dichas fortalezas, por la falta de información, se puede rescatar ciertos resultados de algunas de éstas, como el precio, la captura y por ende, del ingreso percibido. Por cuanto y tomando la información de los estudios de seguimiento, se tratará de determinar si tales fortalezas se han cumplido actualmente, al menos para el período de evaluación.

Sweeting, C.J. & Polunin, N.V.C. (2005) Marine Protected Areas for management of temperate North Atlantic Fisheries – lessons learned in MPA use for sustainable fisheries exploitation and stock recovery. A report to Defra. 64 pages.

http://www.defra.gov.uk/fish/science/index.htm

With most fish stocks in the NE Atlantic at historically low levels there is pressure for more effective fishery management practices. One approach involves marine protected areas (MPAs), spatially defined areas of sea or estuary, where populations are protected from human extractive impacts (particularly fishing and contingent habitat damage).

Exhaustive lists of potential benefits of MPAs are largely derived from small conservation-oriented MPAs in tropical coastal waters. Use of MPAs for sustainable exploitation of temperate fisheries however, requires knowledge of how MPAs function in a radically different setting. This report reviews scientific information on existing well-studied MPAs in the North Atlantic and draws the following conclusions.

A CRITICAL INFORMATION SHORTAGE EXISTS.

(1) The design of MPAs (e.g. size, shape, management and objectives) varies greatly, however the science is biased towards small inshore MPAs. Very few MPAs in the temperate North Atlantic are well-studied and for fewer still have fishery effects been considered, severely limiting detailed lessons that may be drawn, especially regarding effects of strong protection at the large scales (100s-10,000s km^2) required for temperate fisheries management.

THERE ARE POTENTIAL BENEFITS OF MPAS BUT NONE ARE GUARANTEED.

(2) Establishment of even small MPAs (<$10km^2$) can lead to increased habitat quality in most habitat types, (particularly greater structural complexity) where fishing methods that interact with the seabed are excluded. There are positive links between such quality and growth and survival of some juvenile fishes, however such fisheries benefits are unquantified. Many critical fish habitats (e.g. maerl, sea grass beds, salt marsh and rocky and Sabellaria reefs) have inherent conservation value, thus an opportunity exists for conservation-oriented MPAs, some of which may benefit local fisheries.

(3) Enhancement of shellfish populations (e.g. scallop and lobster) inside MPAs often occurs because adult mobility is limited and the MPA effectively protects a component of the stock. There is some evidence that such increases benefit surrounding fisheries through net export of juveniles and adults [‘spillover’] and of eggs/ larvae. MPAs can contribute to management of shellfish stocks.

(4) Evidence for benefits to temperate finfish inside MPAs is inconsistent. Strongly protected MPAs can benefit site-attached species (e.g. wrasse, rockfish on rocky reefs) and mobile finfish stocks (e.g. cod, mackerel, plaice) will benefit where hydrodynamic or topographic isolation effectively increase larval return and reduced adult emigration, or where strong management significantly reduces fishing mortality. But these conditions look to be rare, and light protection in very large MPAs (10,000s km^2) is inadequate to accumulate biomass within.

(5) Spillover and larval export depend especially on biomass build-up inside MPAs which is not guaranteed. Spillover relies also on animal mobility, which in turn influences biomass build-up in MPAs. In virtually all cases where spillover occurred, effects were localised (invertebrates – scale of 10-100s m, finfish – 100s m to km). In no case examined has spillover compensated for loss of fishing area. Larval export depends also on current dispersal and data on it are rare, even for the well-studied tropical reef MPAs. The magnitude of the larval export role of MPAs can therefore scarcely be predicted, and finfish (e.g. cod, haddock) represent a stumbling block to uncritical MPA application.

MANY FACTORS MITIGATE MPA BENEFITS.

(6) The argument that MPAs are more politically robust than other forms of fisheries management is rejected. The notion that MPAs reduce conflicts among users is valid in some cases but not others. Many supposed MPA benefits (e.g. maintenance of diversity of fishing opportunities, reduced variation in fisheries yield) remain inadequately tested even for reefs, thus there is no sound basis for planning MPAs for them.

(7) With few exceptions, highly mobile species benefit only from MPAs of very large size. Yet protecting such areas is manifestly extremely difficult for economic and social reasons and extension of existing fisheries management measures may prove the most effective approach.

(8) MPAs are not isolated from wider conditions. As spatially defined static entities, MPAs are vulnerable to environmental changes, including altered spatial and temporal distributions of fish and

habitat, pollutants and eutrophication. MPAs are not the hedge against fisheries management failures that advocates suggest.
(9) Effects of fishing are assumed to be reversible, yet marine ecosystems can be fundamentally altered in structure by fishing such that return to pre-closure conditions is impossible. Recovery of stocks inside MPAs or enhancement outside MPAs can be influenced by the complex population structure ('metapopulation') of the species involved. Thus interruption of larval dispersal by hydrographical isolation or reduction of supply will mean some MPA objectives become unachievable. Additionally, where stocks have fallen below critical densities required for successful reproduction (ie. 'depensation'), recovery may be negligible.
(10) MPA success should be based on benefit/cost assessments of whole areas, both inside and out of the MPA. For strongly-protected MPAs, other additional fisheries management measures are essential (e.g. large fleet or quota reductions) to mitigate effects of displaced effort which unless reduced decrease MPA benefit and in extreme cases the MPA becomes detrimental overall. Other socio-economic considerations including the extent of compliance with MPA regulations and direct economic costs (e.g. fuel) compared to benefits (i.e. catch) must also be considered.
(11) No-take MPAs are not the only way forward for MPA-based management and strict adherence to rules of thumb (e.g. percentage of habitat to be protected) may be misguided. MPAs require tailoring to specific objectives and local biological, social and physical conditions. MPAs need to be designed on a case by case basis.
(12) Fishery science has been blamed for failures of fisheries management, but gaps in MPA science mean that for MPA management to avoid the perceived pitfalls of fisheries science, more research of a new kind is needed.
CONCLUSIONS
This report suggests that MPAs are not a cure-all of fisheries management, but, under the right conditions, MPAs are valuable tools for the preservation and enhancement of certain critical habitats and management of site-attached shellfish and finfish populations. In very specific situations, MPAs may benefit the mobile species which are socio-economically the most important, however all MPAs should be assessed for their merit on a case by case basis that accounts for both internal and external effects of MPA establishment. The strict closure of large open sea areas is unlikely to be a good management measure, and the fundamental shift in policy which this would require should encourage renewed consideration of other management measures which may provide a more optimal cost/benefit distribution, although this might be in combination with light or small MPAs. However, many of the costs and benefits of MPAs remain speculative due to a lack of research on what is a comparatively new tool for fisheries management. There is a critical need to remedy this information deficit if MPAs are to fulfil their full potential in the areas indicated with confidence.

Verheij, E.; Makoloweka, S. & Kalombo, H. (2004) Collaborative coastal management improves coral reefs and fisheries in Tanga, Tanzania. *Ocean and Coastal Management* 47: 309-320.
Abstract not available

Villena, M. G. & Chávez, C. A. (2005) On the enforcement of territorial use rights regulations: a game theoretic approach. *Economia*, Brasilia (DF), v.6, n.1, p.1–44, Jan / July 2005.
Territorial Use Rights (commonly known as TURFs in the literature) consists in the allocation of fishing rights to individuals and/or groups to fish in certain geographical locations. A requisite for these communities to be granted fishing rights is the formulation of a management and exploitation plan (MEP). While thus far the literature on TURFs has been centred on the biological and technical aspects of it, to our knowledge there is no work squarely dealing with the issue of enforcement of the MEP that the community, once granted the fishing use rights, have to comply with. We formally explore this issue from an economic perspective by formulating a static game of norm compliance in a regime of common property resource exploitation. The key characteristic of this game is a monitoring and sanctioning mechanism, where fishermen monitor and sanction one another. We found that in the absence of any endogenous regulation from the part of the fishing community, TURFs can not avoid the economic overexploitation of the fishery. We discuss the importance of economic incentives (and disincentives) in the formulation of endogenous regulations aimed at ensuring compliance of the MEP.

Our results on the Revista EconomiA July 2005 relevance of economic incentives in the context of a TURF regulation can also be used to highlight the importance of less conventional enforcement tools.

Willis, TJ., Millar, RB., Babcock, RC. & Tolimieri, N. (2003) Burdens of evidence and the benefits of marine reserves: putting Descartes before des horse? *Environmental Conservation* 30, 97-103.

An extensive literature has appeared since 1990 on the study of 'no-take' marine reserves and their potential to make significant contributions to the conservation and management of fisheries, especially in tropical environments (see Polunin 1990; Roberts & Polunin 1991; DeMartini 1993; Roberts 1997; Allison *et al.* 1998; Guénette *et al.* 1998). The literature describes many potential benefits of marine reserves to fisheries, including increases in spawner-biomass-per-recruit and increases in larval supply from protecting 'source' populations (Jennings 2000). The important word here is 'potential'. Some claims made by advocates of marine reserves might be regarded as optimistic, whereas critics of reserves might sometimes have been unduly harsh. Conservation goals for marine reserves are often poorly defined, and differences of opinion regarding the efficacy of reserves for fulfilling any of their stated goals can frequently be attributed to a lack of good information with which to predict their effects. Here, we critically examine the literature from 1990–2001 to determine (1) the relative effort put into empirical and theoretical approaches to predict reserve effects, and (2) the quality of empirical evidence available to support theoretical predictions. It is not the purpose of this article to single out particular studies for criticism (although this is sometimes inevitable to provide examples), nor to draw conclusions concerning the efficacy of marine reserves. Our purpose is to examine the science, rather than politics, of the field of 'marine reserves'. We examined the relevant peer-reviewed primary literature from 1990–2001 by searching the Current Contents and Science Citation Index (ISI) databases using the keywords 'marine reserve' found anywhere in a paper. Also included were papers that were not in the search databases but were cited in papers that were (these included refereed proceedings of symposia, but excluded book chapters and unpublished reports). Only studies that directly investigated the effects of reserves were included. Many articles that explored specific biological issues mentioned marine reserves incidentally in the discussion. These were removed from the analysis, as were those concerned solely with policy, management or advocacy. The remaining papers (*n* _ 205) were classified into three groups, namely empirical (presenting field data from existing reserves), theoretical (conceptual or numerical modelling studies) and review (including notes and ideas papers based on other literature). With few exceptions, empirical papers reported some positive impact of the marine reserve or reserves under study, so these were carefully examined to determine (1) the robustness of the survey design, and (2) the effect size.

Worm, B.; Sandow, M.; Oschlies, A.; Lotze, H.K. & Myers, R.A. (2005) Global Patterns of Predator Diversity in the Open Oceans, *Science*, Vol 309:1365-1369.

The open oceans comprise most of the biosphere, yet patterns and trends of species diversity there are enigmatic. Here, we derive worldwide patterns of tuna and billfish diversity over the past 50 years, revealing distinct subtropical ''hotspots'' that appeared to hold generally for other predators and zooplankton. Diversity was positively correlated with thermal fronts and dissolved oxygen and a nonlinear function of temperature (È25-C optimum). Diversity declined between 10 and 50% in all oceans, a trend that coincided with increased fishing pressure, superimposed on strong El Nin˜o–Southern Oscillation–driven variability across the Pacific. We conclude that predator diversity shows a predictable yet eroding pattern signaling ecosystem-wide changes linked to climate and fishing.

Wright, A. & Hill, L. (1993) Nearshore Marine Resources of the South Pacific. Forum Fisheries Agency, Honiara, Solomon Islands. XVI.

Abstract not available