THE BENEFITS OF MARINE PROTECTED AREAS

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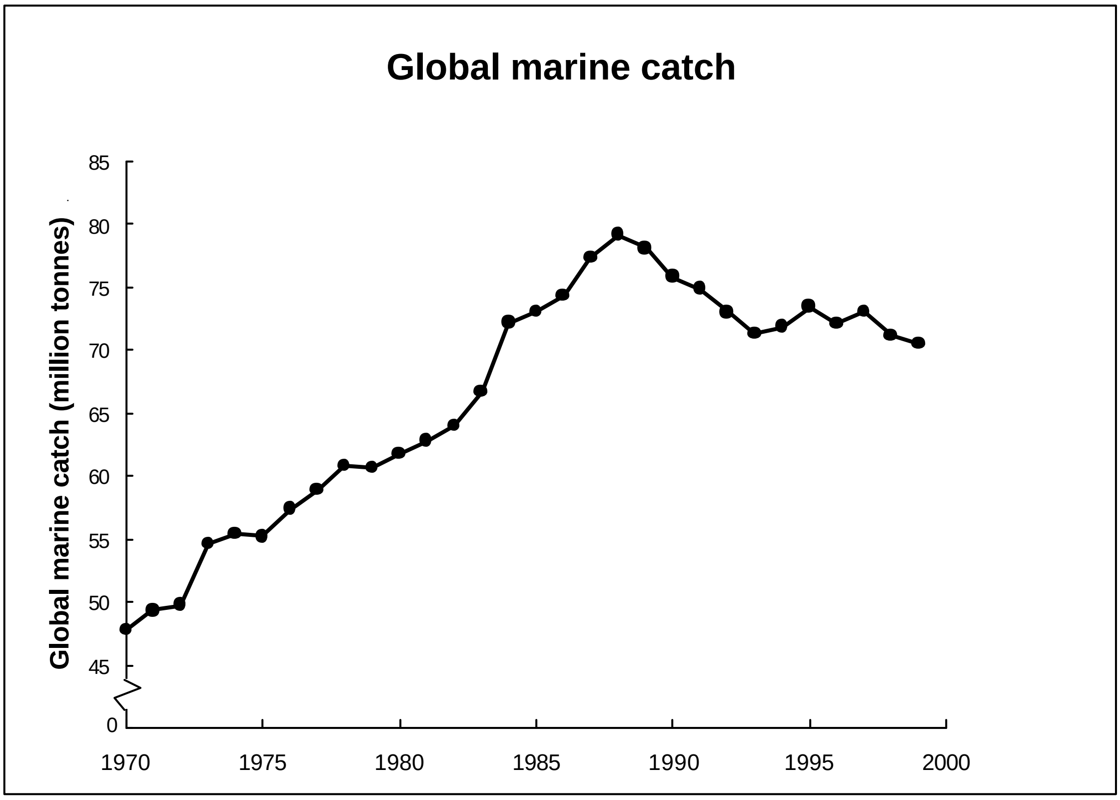
1. Why do we need Marine Protected Areas?

Overfishing, damaging pollution, habitat destruction and other impacts of human activities in the sea and from land are causing increasing damage to coastal and marine environments. Current management systems are failing to sustain the productivity, biological diversity and ecosystem services of marine ecosystems.

The consequences of this failure are serious and far-reaching. The most obvious effect is seen in impacts on the longstanding and widespread use of marine resources for sea food. While the global fish catch stabilised briefly in the 1980s (Watson & Pauly 2001) it has since then been in consistent decline (Pauly et al 2002.

Estimated global fish landings for the period 1950 to 1999, corrected for over-reporting of China catch and without the catch of Peruvian anchovetta (Watson et al 2001).



Compared to our knowledge of life on land, we know little of marine ecosystems or the effects of our impacts upon them. Nevertheless, recent analysis of fossils and archaeological data from middens shows that today's ecosystems appear to be very degraded since the start of human impacts. (Jackson et al. 2001)

Cod

"The Atlantic cod has been fished for 5,000 years in the Gulf of Maine, in the north-western Atlantic, and during this time has provided an immense source of food and wealth. The average size of these fish 2,000 years ago was about 1m in length, but this has now declined to less than 40cm, as a direct result of fishing.

"New mechanized fishing technology in the 1920s set off a rapid decline in numbers and body size of coastal cod in the Gulf of Maine that has extended offshore to Georges Bank. Formerly dominant predatory fish are now ecologically extinct and have been partially replaced by smaller and commercially less important species." (Jackson et al 2001).

The cod fishery collapsed in the late 1900's, and the use of protected areas in a carefully designed fisheries management regime is now considered the most likely way to recover the fishery and ensure that it stays sustainable in the future (Murawski et al 2000).

Modern technology has increased the current and potential range of uses of marine environments providing new industries such as tourism, aquaculture and the development of new forms of drugs from marine biodiversity. But, like fisheries, unless managed sustainably these uses can threaten, change and destroy the very processes that they depend on. Marine biodiversity, ecosystems and resources are also threatened by impacts reaching the sea from the land through pollution by chemicals and silt and through changed river flows.

Marine Protected Areas are critically important if we are to meet the needs of the increasing world population and demands for a reasonable quality of life. It is vital that we reverse the decline in marine ecosystems. This is essential to maintain, and ideally to increase, the sustainable supply of high quality protein from the sea and to realise the potential of other uses and values.

2. What is a Marine Protected Area?

A resolution of IUCN General Assembly in 1988 called upon national governments, international agencies and the non-governmental community to:

> "Provide for the protection, restoration, wise use, understanding and enjoyment of the marine heritage of the world through the creation of a global, representative system of marine protected areas and through management in accordance with the principles of the World Conservation Strategy of human activities that use or affect the marine environment."

IUCN defines a marine protected area as:

> "Any area of inter-tidal or sub-tidal terrain, together with its overlying water and associated flora, fauna, historical, or cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (Kelleher 1999).

There are two core but inextricably linked roles in the concept of Marine Protected Areas.

The first role is ecosystem-based management. The second role is provision of core "no-take" reserves free from fishing and collecting and as far as practicable buffered from other human impacts.

Ecosystem-based management

Most marine ecosystems are very large and linked with each other by currents and with events on land through river discharges. Ecosystem-based management addresses the effects of all uses and impacts at the large scale of marine ecosystems. The object is to achieve verifiably sustainable use and enjoyment of the marine heritage of the world by ensuring that the collective impacts of human activities do not exceed the resilience or self-repair capacity of marine ecosystems. Without it, the deterioration caused by the individual, combined and cumulative human impacts continues. There is clear evidence that deterioration is already causing complex and costly consequences for humanity.

“No-take” Reserves

“No-take” reserves free from fishing and collecting and as far as practicable buffered from other human impacts are an essential component of management for sustainability. The functions they serve include:

- Preservation of representative samples of biological diversity;
- Protection of critical sites for reproduction and growth of species;
- Protection of sites with minimal direct human stress to maximise their resilience or self-repair from other stresses such as increased ocean temperature;
- Settlement and growth areas providing spill-over recruitment to fished stocks in adjacent areas;
- Focal points for education about the nature of marine ecosystems and human interactions with them;
- Sites for nature-based recreation and tourism; and
- Undisturbed control or reference sites serving as a baseline for scientific research and for design and evaluation of management of other areas.

Ecosystem-based Marine Protected Areas incorporating core “no-take” reserves may require new approaches to management of marine environments, but there are many benefits.

3. What are the benefits of preserving biodiversity and ecosystem processes?

Some people regard preservation of biodiversity as a stewardship responsibility; that is, a duty of humankind to protect the full range of life forms (Norse 1994). Others may focus only on the immediately useful or interesting species. Preserving marine biodiversity is critically important if we are to achieve verifiably sustainable management of coastal and marine resources.

Well designed Marine Protected Areas with core "no-take" reserves are essential to preserve and protect representative examples of the biological diversity of the world's coasts and oceans.

Marine biodiversity

What is Biodiversity?

Biological diversity (usually shortened to biodiversity) is the variability of life in all its forms, levels and combinations, and the ecosystems within which it operates.

Biodiversity is the combination of a three-tiered structure and the operation of the dynamic processes that maintain the structure and the functional linkages within and between each tier:

Genetic diversity: the variety and frequency of different genes and/or genomes within each species.

The characteristics of genetic diversity in marine plants or animals that are valuable for human use, such as resistance to a pest or disease, or medicinal potency, may occur in only a few individuals of a species, or in a small sub-population. The basic unit of conservation of genetic diversity is therefore the plant or animal population.

Species diversity: the variety and frequency of different species.

The importance of species diversity is that it identifies and characterises the biological community and functional condition of a habitat and ecosystem.

Ecosystem diversity: the variety and frequency of different habitats or ecosystems and the processes that shape them.

The biological structure is maintained by dynamic processes: physical (including ocean currents, wind, waves and erosion), chemical (including salinity, sediment geochemistry and pH, and runoff from land masses) and biological (including migration, predation, reproduction and larval drift).

Understanding and managing change

We are living at a time of incremental change to ocean ecosystems that is happening on time scales that make it hard for us to realise their nature, extent or magnitude. All too often we come to appreciate the significance of biological diversity and ecosystem processes after they have been damaged.

Aquaculture management in Sri Lanka

In Sri Lanka, the need for some form of coastal resource and environmental management was recognised as early as the mid 1970's, mainly as a response to the destruction of coral for building purposes. The Coastal Environmental Management Plan (for the West Coast) was developed in 1984 with the objective of preventing the environmental degradation of coastal areas. It included setback standards; Environmental Impact Assessments (EIAs) for development activities; and the prohibition of activities that would degrade designated natural areas. Since 1987 a Coastal Resources Management Programme has resulted in a range of measures, including a Coastal Zone Management Plan. This seeks to promote sustainable yields from multiple uses of estuaries, lagoons and mangroves in the region. Under these initiatives and recent legislation, aquaculture operations must be registered, and EIAs, (assessed by a wide variety of government agencies and other interests) are normally required for farms over 4 ha in size. Despite these provisions, shrimp farming has developed rapidly and uncontrollably, resulting in self-pollution, disease, user conflict in some areas, and significant mangrove destruction. The failure of these coastal management initiatives relates largely to the difficulties of enforcing registration, and the inability of single enterprise EIA to cope with the problems associated with small incremental, but substantial cumulative impacts. In other words, despite its name, this Coastal Zone Management Plan lacked a strategic approach to planning for aquaculture development, and depended instead on a piecemeal and bureaucratic regulatory approach, which inevitably failed.
(source: GESAMP 2001).

Without MPAs and "no-take" reserves, we are likely to lose species, genetic diversity and biological communities before we are aware that they exist, or how important they are for humanity, or how they should be managed for long term sustainability.

The most immediate benefits of MPAs are that they provide islands of naturalness, low environmental stress and normal function. Most species and biological communities have evolved with a degree of resilience that provides some capacity to survive, regenerate from or recolonise after periodic stresses such as high or low salinities, temperatures, severe storms or tectonic events. Research into high temperature-induced coral bleaching suggests that corals from areas with low stress from human activities have higher resilience and are less likely to suffer or be killed by extreme coral bleaching.

Coral bleaching

A study (Done et al 2003) presented at the recent Second International Tropical Marine Ecosystems Management Symposium has confirmed that a combination of 5 factors can explain high resistance or post-bleaching survival.

These factors should be taken into account in selecting networks of protected areas that can contribute to recovery from coral bleaching and other high stress events. They are:

- Cooling – where geography and physical factors produce increased water exchange and mixing
- Flushing – in areas with strong current and high tidal range
- Shading - where structure reduces light stress on corals
- Acclimatisation – such as intertidal polls and shallow lagoons where high temperatures are frequent; and
- Biology – where the survival characteristics of coral communities and species are conditioned by their prior acclimatisation history.

Maintaining representative samples of the ocean ecosystems in intact condition, which can be self-sustaining and adapting to incremental changes in ocean climate, is a prudent investment in the future and enables us to avoid foreclosing on options for ocean uses that we, as yet, have not been able to foresee.

Maintaining a comprehensive gene pool in marine species, with natural ranges of populations and their functions, will ensure that we keep open the broadest possible range of biodiversity options.

Centres of dispersal

Where human uses damage biodiversity, MPAs can provide reservoirs of genetic material for the natural or assisted re-seeding of areas affected by pollution, or overfishing. Here, a reserve acts as a centre of dispersion, and can provide a continuous supply of new recruits to adjacent areas. This service - the *in-situ* reservoir of the genetic material, structure and functions of biodiversity - has long been provided by natural refuges in the ocean. These natural refuges were areas that were formerly too remote or too difficult to fish, but they are being rapidly lost with advances in marine technology. Now we must plan to incorporate carefully designed marine protected areas with "no-take" reserves to replace this mostly lost service and thus serve as an insurance policy by providing a basis for repairing or restoring damaged marine ecosystems and depleted stocks of fish.

Sinks and sources

The young life forms of coastal marine organisms have the potential to disperse from less than a metre up to hundreds, and in some species, thousands of km, but their effective dispersal distance may be much less that their maximum potential distance. This is because it takes more than a single new recruit to recolonise an area, and form a viable population. The effective dispersal distance of the young of a benthic marine species depends on the prevailing water currents, their local situation (in a rockpool, or behind a reef), the time of year when spawning occurs, their ability to live without feeding, and their behaviour in the water column (some sink to the bottom where currents are weak, while others swim to the surface where currents may be stronger).

Simulation models using observed and estimated dispersal distances suggest that, for the coasts of continents or large islands, reserves should be about 4-6 km in size and located about 20 km apart. Such reserves, it is suggested, would provide adequate insurance for populations of many common benthic marine species, although would not be adequate for larger mobile fish which may range across wider areas and need reserves of a different design (Shanks et al 2003). Reserves that provide insurance for fish stocks may require a larger area than those strictly for conservation purposes alone, because of the need for higher levels of recruitment of the harvested species needed into non-reserved areas to support the fishery (Hastings & Botsford 2003).

New uses

The most immediate examples of the economic value of maintaining biodiversity lie in the discovery of medical drugs and other valuable chemicals from marine plants and animals. Research in recent years has isolated and tested an increasing range of compounds that have proved to be active for purposes including treatment of viral and bacterial infections, cancers, inflammation or swelling, and as sunscreens.

Repairing damage

Reserves as reference sites with undisturbed marine biodiversity and ecosystem processes are particularly important in the search for effective methods to mitigate damage and restore damaged ecosystems. We know that restoring damaged ecosystems is hugely expensive and unlikely to be completely successful (Pitcher 2001) but many marine sites have been so damaged that management must attempt restoration. Without biodiversity reference areas and benchmarks it is difficult to assess the outcomes of restoration attempts or build improvements on the basis of systematic analysis of past performance.

Restoration and rehabilitation

The recent ITMEMS2 concluded that it is clear from many reports of the condition of the world's coral reefs that efforts to restore or rehabilitate damaged ecosystems are an increasingly important management issue, particularly to those close to major cities and heavily populated coasts. While it is preferable and most cost-effective to prevent or minimise damage as far as possible, restoration and rehabilitation techniques are being developed.

ITMEMS2 recommended that:

- The focus of restoration and rehabilitation be on removing threats and applying methods that accelerate natural recovery processes in tropical marine ecosystems that otherwise have little potential for recovery to restore fisheries and protect tourism assets;

- A systematic review be made of restoration and rehabilitation methods and initiatives to evaluate effectiveness in recovering damaged ecosystems, overall cost, area coverage, and the contribution towards the effectiveness of MPAs and ICM. This review could also be used as an education tool; and

- A network of managers, scientists, practitioners and local communities be established to share information and develop guidelines on appropriate restoration and rehabilitation practice;

4. What are the fisheries benefits of MPAs

The global fish catch is reported to be in decline since the 1980s (Watson & Pauly 2001, Pauly et al 2002). Other important symptoms of the decline in global fisheries include:

- fishing for smaller and lower-value species,
- having to fish further from home bases, and
- the destruction or degradation of fish habitats in coastal areas.

Most recent analyses of the global condition of wild capture fish stocks are pessimistic about maintaining the current levels of production and many scientists and managers are calling for new approaches to fisheries management (Pitcher 2001, Hutchings 2000, Pauly et al 2002, Ward et al 2002, FAO 2002).

The effects of a declining fish catch fall disproportionately on poor coastal communities because it has been estimated that about 94% of all fishers are subsistence fishers, producing nearly half of the world's fish for human consumption. In the face of the increasing world population, reversing the decline and maintaining the high quality protein supply from the sea will require considerable improvement in the management of wild capture fisheries, aquaculture and the health of the ecosystems upon which they depend.

Marine Protected Areas, with "no-take" reserves in a context of ecosystem-based management offer the tool most often mentioned as most likely to arrest and possibly reverse the global decline in fish populations and productivity (Ward et al 2001).

Evidence for the protective role of reserves in fisheries is rapidly accumulating, as researchers and managers alike undertake detailed studies of specific closures. There is a substantial weight of evidence mounting in favour of the beneficial role of reserves in a range of different types of fisheries, in different global localities, and used within different fisheries management regimes. The nature of benefits that can be derived from reserves in fisheries will always depend on the nature of the supporting fisheries management system, as well as the reserves management system. Reserves on their own are not sufficient as a single management tool, except possibly in small-scale subsistence fisheries where other management systems may not be very effective.

For fisheries, MPAs generally can be considered to provide four basic benefits:

1. Support for stock management, including:
   - protection of specific life stages (such as nursery grounds)
   - protection of critical functions (feeding grounds, spawning grounds)
   - provision of spillover of an exploited species
   - provision of dispersion centres for supply of larvae to a fishery
2. Improved socio-economic outcomes for local communities.
3. Support for fishery stability
4. Ecological offsets
   - trade-off for ecosystem impacts
   - better understanding of impacts and options.

Support for stock management

Traditionally MPAs and reserves have benefitted fisheries through stock enhancement and management. Protection of habitat critical to key life cycle stages including spawning, juvenile settlement, nursery grounds and major feeding grounds can be a significant benefit. The role of protected areas as sites for settlement and early growth of juveniles that when grown subsequently spill over into adjacent fished areas has been demonstrated. The importance of strategically located protected areas in providing a breeding population of adults leading to larval production and export to fished areas is also well established.

The spillover effect in commercial and recreational fisheries

The Merritt Island National Wildlife Refuge at Cape Canaveral, Florida, USA, contains two areas that have been closed to fishing since 1962 - the Banana Creek Reserve and the North Banana River Reserve. Like many areas closed for national security, defence, or other military purposes, these areas were not chosen for the purposes of biodiversity protection or fisheries enhancement. The two estuarine areas that make up the refuge are closed to public access for the security of the nearby Kennedy Space Center, and have a total area of $40km^2$. Before these areas were closed, there was intensive commercial and recreational fishing effort in the area and fish stocks were heavily exploited. Between 1957 and 1962, an average of 2.7 million kilograms of fish was landed annually in the vicinity of Merritt Island by 628 commercial fishers, and a further 1.47 million kilograms landed by an average of 764,000 sport fishers (Gell & Roberts 2003).

The value of this reserve for the adjacent recreational fishery has been assessed by examination of the number of record-size ('trophy') fish caught by recreational fishers. The area enclosing 100 km to the north and south of the reserve was found to provide 62% of record-size black drum, 54% of red drum and 50% of spotted seatrout. The area considered comprises only 13% of the Florida coast, and the habitats found in the Merritt Island National Wildlife Refuge are found in many other parts of Florida (Gell & Roberts 2003). Since the mid-1980s most Florida records for black drum and red drum have been recorded from the vicinity of the Merritt Island Refuge. Fish tagging studies show that these species move out of the reserve and into surrounding waters, and this, together with the evidence of record sizes, is evidence for a substantial level of spillover of these fish from the reserve into the adjacent recreational fisherv.

Support for fishery stability

Studies of Marine Protected Areas with "no-take" reserves established in coastal and island areas with evident overfishing have demonstrated benefits of significantly improved fish catch. This has reversed trends to use increasingly destructive methods and led to stabilised and sustained catch levels.

Tropical subsistence fisheries

– better socio-economic outcomes and improved stability

In 1995 in St Lucia, West Indies, a network of 4 reserves was created to cover about 35% of available fishing grounds (reef and offshore waters) to attempt to restore a fishery that had no other form of management and was severely over-exploited. Research indicates that the reserves increased the adjacent artisinal fishery catches by 46% for large fish traps and 90% for small fish traps in 5 years, and provided an overall increase in yield of the fishery (Roberts et al 2001).

Similar outcomes were achieved in a small-scale fishery in Egypt where, in 1995, in collaboration with local Bedouin and fishermen, five no-take fisheries reserves were established within the Nabq Natural Resource Protected Area, South Sinai, in the Egyptian Red Sea. The abundance, size, structure and catch of commercially targeted groupers, emperors, and snappers were investigated before the establishment of these reserves, then in 1997 and again in 2000. By 1997, these fish had shown a significant increase in mean abundance within two of the reserves. By 2000 each fish family and three individual species had increased in abundance in the reserves. Mean recorded catch per unit of fishing effort within the adjacent fished areas increased by about two-thirds during the 5 years. The establishment of the reserves appears to have played a key role in maintaining the sustainability of the fishery. The involvement of local Bedouin and fishermen in the co-management of fisheries resources was considered to be critical to the success of this initiative (Galal et al. 2002).

Continental shelf fisheries pose much greater problems, both in design and establishment of MPAs and in measuring the impacts of reserve creation. These fisheries are usually of a much larger scale than inshore fisheries, the life history strategies of the fish are often different, and the scales of the ecosystems and the fisheries themselves are typically much greater and more complex.

Protection and fisheries on Georges Bank

The fisheries for groundfish – species living closely associated with the seabed – on the US and Canadian Georges Bank in the north-west Atlantic Ocean were once one of the most productive in the world. After decades of intensive fishing the stocks of several of these species, including cod and haddock, declined and eventually collapsed in the 1980s and early 1990s. Overfishing and the impact of intensive scallop dredging on juvenile stages of the groundfish and their habitats were considered to be the major causes of the fishery crashes.

In 1994 in the US waters of Georges Bank and Southern New England, three large areas of about 17,000km^2 of historic importance to groundfish spawning and juvenile production were closed to any fishing gear capable of retaining groundfish (trawls, scallop dredges, gill nets, hook fishing). In the following 5 years, the closed areas significantly reduced fishing mortality of protected groundfish stocks. The location of the reserves also provided year-round protection to the stocks of sedentary fishes, primarily flounders, skates, miscellaneous other fish, and bivalve molluscs. The closures afforded less protection to migratory age groups of cod and haddock, but additional fishing regulations in the fished areas and in the Canadian parts of Georges Bank contributed to stock-wide reductions in fishing mortality. The stocks have not yet recovered, but there are encouraging, if early signs from the reports of fishers and from research surveys that stocks of cod are recovering from their former highly depleted condition (Gell & Roberts 2003).

As a result of the reserve, by 1998 the harvestable scallop biomass was 14 times denser in the reserves compared to the fished areas. Parts of one closed area were opened to scallop dredging in 1999, but restrictions on gear and the areas fished were used to limit the impact on gravel substrates, limit the by-catch of groundfish and minimise the impact on juvenile cod and haddock. Results from these re-openings have encouraged managers to contemplate a formal 'area rotation' scheme for scallops intended to improve overall yield in the scallop fishery. The overall impact of this rotational harvest approach on groundfish stocks is unclear.

In a related area, in 1987 about 13,700 km^2 associated with 2 offshore banks on the continental shelf of Nova Scotia, Canada (adjacent to Georges Bank) were closed to commercial trawling for groundfish in order to protect the juvenile stages of haddock. The closures were implemented in stages by reducing gear types permitted to fish on the banks, until 1994, when all fishing was prohibited because of the collapse of stocks of cod and haddock in the region. The reserve resulted in a change in the fish composition and an increase in numbers and sizes of several commercially important species in both the reserves and also in an adjacent fished area. Haddock are only now beginning to respond to the area closure. The effects of the reserve on the adjacent fished area are thought most likely to be caused by spillover and possibly larval export from the reserve (Fisher & Frank 2002).

Overall, fishery closures of large portions of Georges Bank and adjacent areas have proved to be an important element leading to more effective conservation of a wide range of commercial and non-commercial species, even though the closed areas were selected on the basis of seasonal spawning grounds of haddock and the distribution of yellowtail flounder. There is clear evidence that the MPAs have provided a very important contribution to ongoing restoration of the fisheries in this area (Murawski et al 2000).

Ecological offsets

There is often a tension between fisheries and Protected Areas even though Marine Protected Areas provide benefits to both fisheries and conservation. Recent technical reviews have consistently identified the high potential value of MPAs, and specifically “no-take” reserves, for fisheries management purposes. Increasingly, fisheries operate in communities or seek to sell their product in markets where concern at the environmental damage they can cause and the adverse impacts on other users and interest groups is a matter of high political and economic sensitivity. One approach to this is to seek recognition that the fishery is managed in a way that is designed to be environmentally sustainable and to provide offsets so that there is provision for resilience or capacity to recover from the environmental damage caused in the fishing process. Protected Areas and particularly “no-take” reserves are increasingly being recognised as the means to identify offsets, to achieve stability and stock management benefits and to move away from the political and economic risks associated with confrontation with other user and interest groups.

The Australian Northern Prawn Fishery

The Northern Prawn Fishery (NPF) is Australia's most valuable federally-managed fishery, with an average annual catch of about 8,000 tonnes, worth between AUD$100 and $175 million, taken by 96 modern trawlers. The NPF operates within a 771,121 km^2 area across most of the top of tropical Australia.

The fishery survived the early history of overcapitalization/overfishing common to most prawn trawl fisheries during the 1970s and early 1980s, when up to 302 trawlers were operating in the NPF. Since the mid 1980s, fishing effort has been greatly reduced through industry-funded buybacks, spatial and temporal closures, and substantial gear (net) reductions. The fishing season has been reduced from the entire year to just over 4 months. The fishery has been highly innovative in addressing bycatch issues, including being the first Australian fishery to voluntarily withdraw from shark fishing, formerly a profitable by-product, in order to protect shark species.

Currently, all known critical juvenile prawn nursery seagrass areas in the NPF are protected from trawling under the NPF Management Plan in what are called Fishery Closure Areas. Continuous Vessel Monitoring System (VMS) surveillance ensures that the closures are protected from trawling. There are 15,830 km^2 of juvenile prawn habitat that mostly could be fished, but is now protected within permanent closure areas, and a further 51,470 km^2 protected within seasonal closure areas. These amount to 2% and 6.7 % of the NPF managed area respectively. While it is to the NPF industry's credit that such extensive areas of prawn habitat are protected from NPF fishing, these areas are not protected from other human activities, including other forms of fishing.

The NPF has recognized that "no take" marine protected areas are an important management tool that can benefit the fishing industry by providing greater protection to critical nursery habitat than can currently be provided by Australian Fisheries legislation, as well as providing refugia for many of the benthic and bycatch species impacted by NPF trawling.

The NPF now has a significant research effort underway with Environment Australia to identify benthic species assemblages, model the performance of existing spatial closures, and identify different reserve configurations that can fully achieve biodiversity conservation objectives, while at the same time maximizing the value of the commercial fishery.
(adapted from Carter et al in press).

Determining the impacts of a fishery on its ecosystems can be very difficult and can only be achieved by comparative studies of fished with unfished areas. Where there are no “no-take” reserves the ecological impact of fishing is hard to determine with any rigour.

Where ecological impacts of a fishery are uncertain, “no-take” reserves are usually identified as the most cautious and effective solution to the need for conservation in a region.

Whether they recognise it or not, many fisheries already use various forms of MPAs in their routine management, including seasonal and spatial closures of fishing grounds. Even reserves that are managed by limitations on the range of fishing gear (such as by traps but not nets or lines) or on the number of people allowed to fish (such as in a controlled subsistence fishery) can sometimes provide an important form of conservation for a range of species and habitats that are not directly affected by the traps or by the removal of the exploited species.

The benefits of less strictly protected MPAs for aspects of biodiversity other than the harvest of exploited species have not generally been studied. While such MPAs may provide important contributions to fishery management and biodiversity conservation, the cost for research design and implementation to obtain the information to evaluate the biodiversity value of such intermediate forms of protection is higher than for a relatively simple fished/unfished comparison.

Fisheries now increasingly recognise the need for effective ecosystem-based management, and the potential broad range of benefits that can be delivered by MPAs, from “no-take” reserves to managed resource area levels of protection.

5. How do MPAs benefit Tourism?

Tourism is now a primary source of income in many developing countries and frequently exceeds the value, particularly the foreign currency value, of marine fisheries in those nations. For example in the Republic of Maldives in 1997 and 1998 the estimated gross domestic product contribution of tourism exceeded the combined total of all primary industries and was about twice as great as the contribution of fisheries (Govt of Maldives 1999). In Australia the Great Barrier Reef attracts about 1.6 million tourist visits with the industry valued at over $1 billion per year (GBRMPA 1998). This may be compared with estimates of $250 million for the annual worth of Great Barrier Reef fisheries.

Tourism can bring rapid economic development to remote and small nations and to remote areas of large countries. Tourism is a globally competitive activity that depends on repeat business, positive word-of-mouth recommendation and marketing, but is vulnerable to fashion cycles and negative reports by customers.

The components of coastal and marine environments that are important for tourism include clear water, clean sandy beaches and an “exotic” natural and cultural setting when compared with the normal urban and suburban environments of most visitors. The range of activities available to visitors will usually include guided tours to areas of natural and cultural interest, nature based activities including hiking and boating and some moderate risk activities such as snorkelling, SCUBA diving, white water rafting and sport fishing.

The quality of the natural environment is important for the setting and the activities, yet coastal and marine tourism areas are vulnerable to hasty and inappropriate development with consequent beach erosion and beach and water pollution. Unmanaged or inadequately managed visitation can lead to rapid resource and site degradation and a decline in visitor numbers.

Well-managed marine protected areas with marine reserves are often major tourist attractions. They can provide the means and an assurance that all activities and impacts are managed within criteria of verifiable sustainability. Visitors may be attracted by opportunities for snorkelling, scuba-diving or whale watching, to hire boats or to take boating tours to enjoy the natural beauty of marine protected areas. Even though visitors may spend little of their time in the marine reserves the opportunity to experience them can be the factor that leads to the choice of one destination over another.

An important attraction for many visitors is to view abundant marine life from observatories, with glass bottomed boats, by snorkelling or SCUBA diving. Marine reserves that prohibit fishing and other extractive activities and provide some level of management of tourist visitors are particularly important for maintaining this attraction. The quality of these experiences depends on the ability to see large fish and the diverse life of algal beds, rocky seabeds and reefs undisturbed and undamaged in their natural environment and free from the debris of lost fishing gear, discarded plastic and drink containers.

The establishment of a marine protected area with a “no-take” reserve is an excellent way to raise the profile of an area for marine tourism and to broaden the local economic options. It is important that the introduction and development of tourism is carefully planned to ensure that it is acceptable and sustainable in terms of impacts on local human communities as well as the ecosystem. With initial training and support local communities can receive additional economic benefit through establishment of, or employment in, businesses that take visitors to the marine reserve as well as receiving the benefits of improved local fishing in the MPA surrounding the reserve.

Well-managed tourism to MPAs can be a major source of income and pride for local communities, as well as for governments, even where the MPA is large and/or expensive to manage.

There is now widespread experience from many countries to show that protected areas often earn significant revenue and make an important contribution to local economies. For example, in 1991 Costa Rica spent about $US12 million to maintain its national parks, but foreign exchange earnings were more than $US330 million from 500,000 overseas visitors. Park-generated income made national park tourism the second-largest industry in the country (IUCN WCPA, 1998).

The Great Barrier Reef Marine Park

Australia's Great Barrier Reef Marine Park (GBRMP) extends over 345,000 km^2 of which 16,000 km^2 is zoned as "no-take" Marine Reserve (IUCN Category 1a-530 km^2, Category II -15,470 km^2). The vast majority of tourism sites are managed as IUCN Category II.

An economic assessment of the value of tourism to the GBRMP in 1991-92 (Driml 1994) indicated that 2.2 million visitors spent $A682 million. Travel to the region would bring this expenditure to over $A1 billion. In this same year commercial fishing was valued at $A128 million, private boating and fishing at $A94 million and research at $A19 million. The multiplier effect of the $A682 million tourism expenditure on the economy amounted to $A1,159 million.

The management budget for the GBRMP at this time was $A18.1 million, while direct revenue from users was $A0.75 million. Since mid-1993, the Australian Government has recovered part of the management costs for the Great Barrier Reef Marine Park through an environmental management charge (EMC) on each visitor.

In 2002 the EMC raised $A6.4 million from 1.6 million visitors. The tax revenue to government from the GBRMP, however, is much higher as the Reef tourist industry is subject to various additional charges, including a high tax on fuel, which is a substantial cost to many operators.

Bonaire Marine Park

The value of marine tourism to Bonaire Marine Park (BMP) has been studied by Dixon et al (2000). Bonaire is a 288 km^2 island located in the Caribbean Sea some 80 km to the north of the Venezuelan coastline. The BMP was created in 1979, although management did not begin until 1984. The 2700 ha BMP covers all coral reef areas around the island (www.bmp.org).

While the resident population was estimated at only 10,800 in 1990, almost 17,000 SCUBA divers visited Bonaire in 1991. The economic mainstay of the island is tourism, particularly dive tourism. Growth in dive tourism in this period was 9-10% a year.

Total gross revenue generated through dive-based tourism was estimated at $US23.2 million in 1991. The government generated an additional $US340,000 through taxes levied directly on visiting divers. The costs directly associated with the establishment, subsequent rehabilitation and initial operation of the BMP was about $US 518,000 with annual recurring costs of $US 150,000, which was more than covered by visitor fees. The BMP also generates substantial employment with up to 755 local workers and 238 foreign workers employed in Park-associated activities (Dixon et al 2000).

While a more recent economic assessment is not yet available, by 1994 annual visitor numbers to BMP had increased to 65,820, of whom 24,081 were divers, and 57 cruise boats visited the BMP.

There are now five full time staff for the BMP. Current annual visitation is about 70,000 (www.bmp.org).

The Bonaire government has ceded management of BMP to a local non-government organization, called STINAPA. The STINAPA board has recently been restructured to provide key user groups (hoteliers, dive operators, fishermen and the tourist office) positions on the STINAPA board (www.bmp.org).

According to De Meyer (1998), the Bonaire tourism industry has successfully helped police to protect the marine environment and has used programs to educate tourists and industry professionals concerning the sustainable use of the Bonaire Marine Park.

6. What are the broader benefits of MPAs?

Healthy functioning marine ecosystems provide many benefits to human society. The term *ecosystem goods and services* addresses the full range of benefits, recognised or as yet unrecognised, that human populations may derive from ecosystems, directly or indirectly. While the benefits of ecosystem goods, particularly fisheries, are generally understood, those of ecosystem services - including waste assimilation, coastal protection, flood management and provision of critical environmental requirements for fished species - are often unrecognized. Marine protected areas can help to ensure continuity and future options for those benefits by protecting the health of marine ecosystems.

The benefits of ecosystem services are often unrecognised because they are often taken for granted. For example, the ecosystem services of coral reefs include shoreline protection, sediment production, and sediment retention (Moberg & Folke (1999). Figures for limestone production per square metre of healthy coral reef range from 0.8 to 8.9 kilograms of per year. Fragments of calcium carbonate skeleton accumulate as sediments on the sheltered, low energy side of reefs. There they may foster the growth of mangrove forests and seagrass beds which in turn also assist shoreline protection and produce ecosystem goods in the form of seafood products.

We may be able to identify and value the current range of goods and services provided by a particular marine or coastal ecosystem but we know little of what the ocean might provide in the future in the way of new products, new resources and new opportunities to create wealth. Keeping samples of the ocean ecosystems in their natural form is a prudent investment in the future.

In the last 50 years we have discovered some of the interactions in coastal and marine ecology. Thus we now understand that the physical structure of some components of marine habitats can play a crucial role as the spawning and nursery grounds supporting many fisheries. Similarly increasing understanding of the defence mechanisms of marine plants and animals is revealing an array of marine biochemical compounds some of which have been identified as having value as sun-screens, anti-viral, anti-inflammatory or related medicinal applications. More recently the oceans have been found to support an entire set of ecosystems that are independent of carbon produced from the sun's energy (the sulphur-based geothermal vent fauna) where rare-earth minerals are also concentrated. The full potential of these discoveries has yet to be realised and we can expect that future research and new technology will identify new possibilities in the next 50 years.

Coastal and marine ecosystem goods and services

Goods

- Sea food products
- Raw materials such as seaweed
- Cultivated food and material production
- Medicinal treatments and products
- Live specimens for aquariums
- Non-renewable or very slowly renewable building materials
- Minerals, oil and gas

Services

- Shoreline Maintenance
- Flood and storm protection
- Sand production
- Nutrient cycling
- Waste assimilation and remediation
- Water quality maintenance
- Habitat
- Maintenance of biodiversity
- Maintenance of biological resilience
- Mixing and transport of organic production to food webs
- Development and transport of larvae and young
- Wave and tidal energy
- Recreation
- Inspiration and support of cultural, aesthetic, and spiritual values

We have also begun to understand the mechanisms and the capacity whereby coastal and marine ecosystems contribute to beach and shoreline stability, assimilate and process wastes and contribute to the quality of life of coastal people. This has led us to understand the consequences of ecosystem damage. The box below lists a wide range of goods and services that can be provided by marine and coastal ecosystems. Most are important for continuing quality of life for people in coastal communities. Most also represent options for future forms of use and benefits that we cannot yet predict.

Maintaining representative samples of ocean ecosystems in intact condition is a provident investment. Ecosystem-based management with viable core "no-take" reserves will ensure that areas are fully protected and provide the most effective tool to avoid foreclosing on future opportunities for marine goods and services.

7. Why are MPAs important for education, training, heritage and culture?

MPAs and education

Because ignorance is a major factor in human damage to coastal and marine environments, MPAs have a vital role in education. Even in fishing communities few people understand how marine ecosystems function, how fish develop, how fishing and pollution affect the ecosystem that produces the fish, how to avoid damage, or how to sustain fisheries for the future.

Ignorance comes in part because in many coastal and marine areas people have never experienced an undamaged marine environment or had the opportunity to learn of the range of benefits that it could bring. In heavily fished and locally polluted areas there are few if any large fish and the habitat is damaged by the impacts and debris of fishing and coastal settlements. Often there is a history of decline with fishers having to travel further and further to find large fish. The decline may be accepted because people in each generation tend to accept as normal the condition of their environment at the time they first become aware of it.

Ignorance and selective awareness of facts can breed fanciful and fantastic explanations of declining fish catch that avoid focussing on the core issue of the impact of increasing effort of the individual, the community or the industry. Accounts of good fishing nearby in the old days may be discounted as folk tales or senile fantasy. Declining catch may be attributed to fish and invertebrates becoming smarter at avoiding catching gear or to competing predators becoming more efficient.

In part this is because most of the processes of marine ecosystems are invisible to the unaided human eye. Most of the planktonic plants and animals are microscopic. Some plants and animals that can survive a high temperature range, freshwater from rainfall, or desiccation from exposure to air and winds can be seen on beaches and in intertidal pools. Even when they can be seen, the form, life histories and behaviour of marine creatures are very different from those on land. To observe and understand the behaviour and interactions of marine plants and animals usually requires a mask and snorkel, an aquarium tank, or SCUBA diving gear and good information to interpret what is seen.

Marine protected areas with “no-take” reserves and education centres are particularly important because they provide areas where people can experience and study marine plants and animals that are undisturbed by fishing and collecting. They can thus become points of comparison where people can observe and compare what they see with more impacted areas and appreciate the issues of sustainability.

Marine protected areas with education centres and trained education staff have an important role in helping children and older students learn how fish and other marine animals find food, hide from predators, grow, reproduce, migrate or defend their territories. As children learn and share their knowledge with their families and as they grow up to become leaders in their communities they play an increasing role in developing community understanding and demand for sustainable management of their marine environments.

There is a natural link between MPA education centres, research and monitoring. The researchers may teach some of the classes and they should certainly be a source of local information for teachers and students. Some senior students may do field projects as part of their studies and work with the researchers. In some protected areas repeated field surveys by classes over many years can provide good information about long term change that can not be obtained in any other way. This also has the advantage that students involved in collecting and analysing their year’s data are likely to acquire a good understanding of change in comparison to earlier years. They are also more likely in later years to be informed participants in future decisions about marine environments and resources.

MPAs and training

A further important educational role of MPAs with “no-take” reserves is in the training of resource management staff involved in policy development and implementation of a wide range of activities in coastal and marine areas. Typically most such staff come from backgrounds with little if any exposure to the nature and values of marine plants, animals and ecological processes. Courses at MPA field stations can provide a valuable introduction and contribute to understanding and implementation of measures to achieve sustainability and maintain ecosystem processes.

Marine protected areas with education centres also play an important role in tourism through providing training and support for local people involved in the tourist industry. The centres themselves often provide an attraction for tourist visitors seeking local knowledge of the area.

MPAs, culture, history and heritage

MPAs have a major role in educating local communities and visitors about the culture, history and heritage of the areas they protect. In most coastal areas there is a history of use, culture and values associated with specific localities and uses in the marine environment. There are often linkages to prehistoric use and legend, traditional practices of use and management that are important to understanding and maintaining present values and future options.

Today governments and local communities in some countries are attempting to protect these sites of historic, cultural, and religious significance through the declaration of various forms of MPA. Some historic and cultural MPAs are declared to fulfil a single purpose, such as protecting a submerged cultural resource site from amateur souvenir hunters or professional salvagers, or to protect a single marine species from exploitation. Others are created within a multiple use approach that includes protecting historic and cultural values alongside biodiversity conservation and sustainable use.

Protection and education at sites of historic significance are important in helping to illustrate the relationship between people and marine environments. Such sites can include physical evidence of earlier forms of use such as:

- shipwrecks;
- lighthouses;
- customary tenure boundaries;
- battle sites;
- hunting and collecting areas;
- , ceremonial and sacred sites;
- middens;
- fish traps;
- harbours;
- coastal fortifications;
- fish markets;
- whaling stations;
- fish smokers;
- salting and drying sheds;
- sail lofts, and
- old ships and small boats.

Such sites are important for developing local understanding of rights and responsibilities in using and caring for marine environments and affirming local identity, providing information and interesting activities for local people and visitors.

Multiple-objective MPAs with a cultural component include transboundary MPAs established where two or more adjoining protected areas are established between adjacent countries and managed co-operatively. “Parks for Peace” are transboundary protected areas that are formally dedicated to the promotion of peace and co-operation, the protection and maintenance of biological diversity and natural and associated cultural resources (Sandwith et al 2001).

The Red Sea Marine Peace Park

Israel and Jordan share 41 kilometers of shoreline around the northern Gulf of Aqaba/ Bay of Eilat. This area contains outstanding coral reefs which attract large numbers of visitors and associated tourist development.

In 1994, during the Trilateral Peace Negotiation Process between Jordan and Israel with the support of the United States, the two countries agreed to develop a Binational Red Sea Marine Peace Park within the framework of an "Agreement on Special Arrangements for Aqaba and Eilat." The Agreement calls on the parties to "collaborate in research efforts on coral reefs and marine biology, and in implementing comparable policies and regulations designed to protect the coral reefs as a tourist attraction which is soundly managed from an ecological point of view."

Jordan has established a Marine Park off the shores of Aqaba and has designated a protected coral reef strip covering 7 km on the eastern side of the northern Gulf of Aqaba. Israel has set aside the southern part of the Eilat coast for nature conservation. A 4 km "marine protected belt" lies in the sea, approximately parallel to two on-shore nature reserves which stretch from the southern end of the city of Eilat to the border crossing to Egypt at Taba.

There is a cross-boundary cooperative research, monitoring and management program that is assisted by NOAA and US-AID.

Source: Anon. (1997).

Transboundary MPAs are particularly important in areas where a single marine ecological unit is divided between the jurisdictions of two or more countries. Often there is a history of rivalry or conflict between adjacent nations and creation of a means to conserve and sustain a shared resource can be an important step in building mutual understanding and co-operation.

8. Why are MPAs important for research?

Research baselines or control sites

MPAs protecting viable representative samples of biodiversity provide broad benefits as sites for reference in long term research to understand marine ecosystems and ecosystem services, to develop and evaluate techniques for verifiably sustainable management and to explore and evaluate options for new forms of use.

Marine research is costly and demanding because vessels, aquariums, diving equipment or expensive instruments are usually needed. To gain the benefits of expensive investments in marine research it is important to provide the undisturbed reference or control sites needed so that researchers can compare and understand the results of experiments or of forms of management in other areas. In the past, research has used remote areas as study sites free from human impact but the reach and impacts of human activity have extended to distant coasts and oceans. There are almost no natural refuges that are untouched by fishing, and even in the deepest and most remote parts of the oceans, pesticides and synthetic chemicals can now be found in living creatures and sediments.

The slow and incremental changes caused by human activities result in ‘sliding baselines’ that are difficult to measure. Without reference sites the value of comparisons in the same period of time between observations taken between different sites with different and often unknown uses is limited.

“No-take” reserves provide the only realistic option for establishing baselines or control sites as points of reference for determining performance and sustainability of management.

They are part of the means to progress from ad hoc sectorally-based management to verifiably sustainable ecosystem-based management.

Research to set targets for restoration

In many coastal areas the ecosystems are highly degraded. This has happened for a variety of reasons, often out of ignorance of the values and services that oceans provide. These degraded areas are now the focus of attempts to restore the original services, such as healthy fisheries. Even after removal of the main impacts (such as sewage wastes), the designers of restoration efforts have found it difficult to determine how to re-establish the former ecosystems, what they should contain, and how they should function. These restoration efforts have recognised the need for detailed studies on non-degraded areas to provide guidance on what ecosystem structure and functions should be identified for priority restoration, and what aspects of biodiversity might be expected to need human assistance in the recovery process.

Research to understand climate impacts

Along with all other areas of the earth, the oceans are experiencing the effects of a gradually changing climate. This is evident in the persistent trend to warmer average surface ocean temperatures, and apparently in the increased number of extreme temperature and storm events affecting the ocean. Planning to cope with these changes requires models to predict how the oceans ecosystems will respond. Measurements of long term changes in MPAs are the main way that the changes in biodiversity can be monitored across such time and space scales, and provide the basis for models to predict the nature and rates of changes in response to such long term impacts.

Research to improve the effectiveness of research and monitoring tools

The vast scale of the global oceans, and the difficulty of exploration and sampling, makes ocean research expensive. Sustainable use of marine resources requires detailed knowledge of the ocean's biodiversity, and since most nations can support only limited ocean research, there has been a recent emphasis on developing more sophisticated tools for observing and measuring the physical, chemical and biological characteristics of the oceans.

New initiatives in the past decade include high-resolution and multi-spectral satellites designed to measure ocean wave heights, sea level, ocean currents and phytoplankton productivity; acoustic techniques for mapping of water column and seabed habitats; and underwater video techniques for improved census of fish populations in continental shelf waters.

The development of much new ocean technology depends, to some extent, on the availability of areas where trials can be conducted free of interference from other users and where normal ocean biological conditions will prevail. This is especially true of the video and acoustic technologies, which require natural systems complete with typical levels of primary and secondary production, such as the natural levels of zooplankton and phytoplankton, in order to determine the effectiveness of the equipment across a range of biological conditions that may be encountered in typical applications. Other technology that requires testing in natural conditions includes antifouling designs and treatments, fish-finding equipment, benthic ecosystems mapping, in-water calibration for satellite-based ocean and marine weather observing systems, and much more. Near-pristine ecosystems allow the developers of new technology to assess the performance of such systems within ecosystems that are behaving ‘normally’.

One of the major constraints on managing marine ecosystems is the lack of empirical observations and data on larger and mobile marine organisms in waters beyond comfortable SCUBA diving depths (deeper than 10m) because of the increasing safety issues with scientific diving, the sheer extent of area of marine habitats and the high cost of maintaining active teams of scientific divers. The recent development of remotely deployed underwater video technology is likely to provide a major boost to the capture of knowledge in marine ecosystems. Deployment of remote video may be able to provide data across large areas and in deep water that are inaccessible to divers. However, the effectiveness of video as a sampling tool has to be tested, and this can only be effectively calibrated within highly protected areas where near-pristine conditions can be expected to prevail. Without such calibration/reference areas, the rigour of video-captured data would always be open to considerable technical dispute and thus downgrade the value of such data.

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