


Establishing Resilient Marine Protected Area Networks – Making It Happen

Full Technical Version, including Ecological, Social and Governance Considerations, as well as Case Studies

2008

IUCN
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Acronyms and Abbreviations

AOI	areas of interest
CBD	Convention on Biological Diversity
CCIF	Conservation and Community Investment Forum
CDFG	California Department of Fish and Game
CINMS	Channel Islands National Marine Sanctuary
CONAMA	Chile's National Environmental Commission
CRM	coastal resource management
FANP	Natural Protected Areas Fund
FAO	Food and Agriculture Organization of the United Nations
FMCN	Mexican Nature Conservation Fund
GBRMP	Great Barrier Reef Marine Park
GEF	Global Environment Facility
GIS	geographical information system
ICM	integrated coastal management
IUCN	The World Conservation Union (formally The International Union for Conservation of Nature)
LGU	local government unit
LMMA	Local Marine Management Area
MAR	Mesoamerican Reef
MCA	marine conservation area
MLPA	Marine Life Protection Act
MPA	marine protected area
MRWG	Marine Reserves Working Group
NGO	non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
PAN	protected areas network
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
PLD	pelagic larval duration
SST	sea-surface temperature
TNC	The Nature Conservancy
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNDP	United Nations Development Programme
UNEP	United Nations Environment Program
WCMC	World Conservation Monitoring Centre
WCPA	World Commission on Protected Areas
WSSD	World Summit on Sustainable Development
WWF	World Wildlife Fund

Foreword: Protecting Ocean Ecosystems— The Challenge Ahead

Regardless of where we live, all of us depend upon healthy ocean ecosystems: either as a source of food or revenue, or as a key shaper and regulator of climate and weather.

This dependency and the need to embrace sustainable development led nations of the world to agree to a series of high-level political commitments for marine conservation and marine protected areas. The World Summit on Sustainable Development, the 5th World Parks Congress, the Convention on Biological Diversity and the G8 Group of Nations have all called for the establishment of a global system of marine protected area (MPA) networks by the year 2012. In line with this commitment are strategies of marine conservation organizations and some governments to increase the development, use and effective management of MPAs as a tool for marine conservation across the oceans.

The challenge, however, is to turn such commitments into practical and effective reality—part of a broader management approach to our oceans and seas to benefit the environment and people. It is particularly important at a time when the impacts from climate change and from ocean acidification are major issues that will shape our future. The Second Millennium Assessment also tells us that wildlife and habitat losses continue. Clearly, the need for action to conserve and restore marine ecosystems, and thereby help sustain livelihoods, has never been greater.

We all have a common responsibility to ensure that future generations enjoy such benefits of healthy marine ecosystems and abundant marine life; this is, after all, the cornerstone of what sustainable development means. This publication, which has pooled global experience on MPAs, is intended to be useful to countries and their various organizations in helping them build effective networks of MPAs. Not only does it provide a wealth of real-life examples from around the globe, it outlines the steps necessary to turn political ambitions into reality.

This guide represents a global first in capturing the emerging experience on building MPA networks. We are grateful to all those who have worked so hard to bring it to fruition over the last 5 years. We hope you will find the advice it contains will support improved protection and management of our marine areas, and ensure that future generations benefit as we have done from the ocean's diversity of species, the opportunities it provides, and its splendor and natural wonders.

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Preface: Purpose and Use of This Guide

This guide helps us to better understand the role of MPAs and MPA networks at local and regional scales to achieve marine conservation. It utilizes current scientific knowledge, institutional experience and global case studies to outline the latest information pertaining to building resilient and functional MPA networks. It also highlights global commitments for marine conservation and shows how to move from individual MPA sites to an effective system of national and regional MPA networks.

The design of an MPA network encompasses many considerations, including social, economic, legal and ecological, which collectively contribute to management decisions and implementation. Guidance contained in this document provides MPA practitioners, managers and field staff with techniques for designing effective MPA networks that are resilient to human and environmental threats.

Five main elements compose this guide for management application:

1. Essential information on the role of MPAs and the value of scaling up to networks.
2. The importance of understanding the social, economic and political context and the need for broader marine and coastal management frameworks.
3. Emerging best practices for planning and implementing MPA networks.
4. A comprehensive summary of the best available scientific information on 5 ecological guiding principles in relation to MPA network design.
5. Case studies from the field that demonstrate methods used to design and implement both scientifically rigorous and functional MPA networks.

The core of this guide is 5 biophysical and ecological principles most relevant for decision-making by marine managers and practitioners in designing and implementing MPA networks. These are: *(1) include the full range of biodiversity present in the biogeographic region, (2) ensure that ecologically significant areas are incorporated, (3) maintain long-term protection, (4) ensure ecological linkages, and (5) ensure maximum contributions of individual MPAs to the network.*

While using this guide, it is important to remember that the sub-divisions of the overall MPA process are artificial. While many issues have been separated out within this guide, all elements are to be considered parallel actions. Processes such as education, communication, leadership and political will operate throughout the process of MPA design, implementation and management. This guide recognizes that MPA networks are only one aspect of achieving sustainable development. Effectively managed networks are intertwined with improvements in wider oceans and seas governance, especially for fisheries, climate change and water quality.

This information is intended for MPA planners, managers and other practitioners. We also hope it will interest a wider audience, including those concerned with sustainable development and the future of our coasts, seas and oceans.

Chapter 1

BRIDGET BESAW

The Colombian coast of the Caribbean Sea at Tayrona National Park. The park is within the Sierra Nevada de Santa Marta region, located in northern Colombia.

Introduction—Why Marine Protected Areas?

"...fish densities were 6 to 10 times greater than in areas outside the reserve..."

(ROBERTS AND HAWKINS 1997).

The Problem

Coastal and marine ecosystems are in decline worldwide. Overfishing, runoff of nutrients and other land-based pollutants, habitat degradation and the increasing impacts of climate change are leading to ecosystem collapses in all the major coastal and ocean regions of the world (Wilkinson 2004; Hughes et al. 2005)

Globally, over half of the stocks (52%) of fisheries are fully exploited and producing catches that are at or close to their maximum sustainable limits, while more than 25% are either overexploited, depleted or recovering from depletion. Furthermore, most of the stocks of the top 10 species (e.g. anchoveta, Alaska Pollock, herring, yellowfin tuna, etc.) are fully exploited or overexploited and cannot be expected to produce major increases in catches (FAO 2006). Large predatory fishes are largely absent in many parts of the ocean due to technological advances that enable fishing and other extractive activities in once remote ocean areas (Roberts 2007). Yet, despite these ominous signs, the annual world total demand for fish and fishery products is projected to increase to 183 million tons by 2015, implying an 18% increase from 2000 to 2015 (FAO 2004).

Increasing human population and demand for resources and development are causing a rise in the distribution and size of harmful algal blooms and *dead zones* (marine areas where oxygen levels are so low that naturally occurring organisms cannot survive) (Anderson 1997; Verheij and Aitaro 2006; Golbuu et al. 2007; Hinchley et al. 2007). These demands also contribute to the destruction of coral reefs, with 70% of the world's coral reefs threatened or destroyed, 20% of those damaged beyond repair, and within the Caribbean alone, coral cover has declined by up to 80% on some reefs (Wilkinson 2004). Like harmful algal blooms and dead zones, coral bleaching events are also increasing in frequency and severity due to higher sea surface temperatures (SST) related to climate change.

Mass coral bleaching events can cause whole coral colony mortality.

In addition, rising levels of atmospheric carbon dioxide are making surface waters more acidic (Orr et al. 2005). Such changes diminish the amount of chemical ions essential for the growth of organisms that construct calcium carbonate shells or skeleton (e.g. corals, mussels and calcareous phytoplankton). Phytoplankton builds the foundation of marine ecosystem food chains and their productivity ultimately shapes the ecosystem composition of the system.

A key management strategy to address many issues affecting marine and coastal ecosystems and resources is the implementation of marine protected areas (MPAs). A marine protected area is a coastal or offshore marine area that is managed to protect natural and/or cultural resources

(Agardy and Staub 2006). An international definition of a protected area, including MPAs, is provided by the World Conservation Union (IUCN) (WCPA 2008):

> *"A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values."*

Purpose and benefits of MPAs

Healthy marine resources require healthy, intact ecosystems. Marine and coastal ecosystems are highly productive and deliver various goods and services that support communities and economies, including food security, clean water, recreational opportunities and other benefits. Effective area-based protection, through MPAs, helps maintain ecosystem health and productivity, while safeguarding social and economic development. They also help maintain the full range of genetic variation, essential in securing viable populations of key species, sustaining evolutionary processes and ensuring resilience in the face of natural disturbances and human use (Agardy and Staub 2006).

In response to a growing recognition of the need for conservation efforts, as seen through the degradation of ocean systems, MPAs are being established worldwide. If designed correctly and managed well, MPAs have an important role to play in protection of ecosystems and, in some cases, enhancing or restoring the productive potential of coastal and marine fisheries. However, it is recognized that MPAs are not the only solution for coastal and marine problems. For example, when MPAs are used in conjunction with other management tools, such as integrated coastal management (ICM), marine spatial planning and broad area fisheries management, they offer the cornerstone of the strategy for marine conservation. The benefits that MPAs can deliver are also related to the effectiveness of the management outside of the MPAs (Christie et al. 2002; Cicin-Sain and Belfiore 2005).

When appropriately placed and well-managed, MPAs contribute to:

- Conserving biological diversity and associated ecosystems.
- Protecting critical spawning and nursery habitats.
- Protecting sites with minimal direct human impact to help them recover from stresses.
- Protecting settlement and growth areas for marine species and spillover benefits to adjacent areas.
- Focal points for educating the public about marine ecosystems and human impacts upon them.
- Nature-based recreation and tourism.
- Providing undisturbed control or reference sites that serve as baselines for scientific research and for designing and evaluating other areas.
- Sharing costs and benefits among local communities, the private sector, regional and national governments, and other stakeholders.
- Reducing poverty and increasing the quality of life of surrounding communities (Figure 1).

Example from the field – MPAs and poverty reduction. Across 4 MPA sites **(Navakavu, Fiji; Bunaken, Indonesia; Arnavon Island, Solomon Islands; Apo Island, Philippines)**, clear evidence indicates that poverty has been reduced by several factors:

- Improved fish catches, spillover effects to adjacent areas.
- New job opportunities, mostly in tourism and MPA management.
- Empowerment through stronger local governance and community decision-making.
- Benefits to women, by helping to empower women economically and in some cases socially.
- Benefits to health from greater protein intake from greater fish catches, particularly in children's health.
- Strengthened social cohesion and cultural tradition.

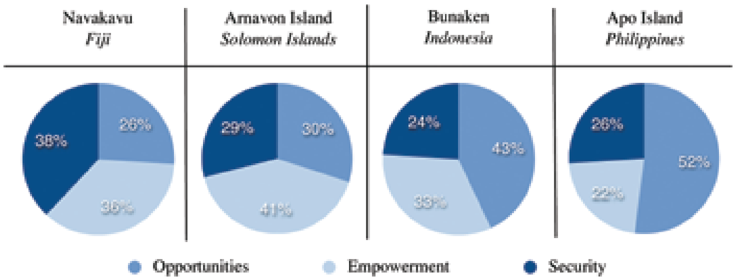

Figure 1 Relative contribution to poverty reduction from the three elements of poverty (Adopted from Leisher et al. 2007)

MPAs cover a diverse set of tools and spatial, temporal and resource management frameworks. MPAs exist in multiple forms, with diverse definitions and objectives. The diverse array of MPA goals (e.g. biodiversity, fishery, social and cultural) and their relative priority vary throughout the world (Table 1), ranging from village-level community-managed areas to multi-million hectare national parks. Additionally, various names including marine reserve, fishery reserve, closed area, no-take area or zone, sanctuary, park, wilderness area and locally managed area, among others, are used to describe an MPA (Lutchman 2005; Marine Protected Areas Center 2008). The definition of the terms can vary drastically, depending on national, local or international contexts (Agardy and Staub 2006; White et al. 2006; Christie and White 2007). For example, in Kenya and Belize, "marine reserves" allow for non-destructive forms of fishing; whereas in Tanzania, "marine reserves" are no-take areas. For purposes of this document, MPA is used as the single, generic term to encompass the range of different protection and conservation strategies, from areas that allow multiple-use activities to areas that restrict all access.

Table 1 Regional types and forms of MPAs

INCREASING ECOLOGICAL AND BIOLOGICAL PROTECTION ⟷ INCREASING MANAGED LAND USE AND SOCIAL PROTECTION

COUNTRY	BIODIVERSITY CONSERVATION & HABITAT PROTECTION	BALANCE OF CONSERVATION AND MULTIPLE USES	SUSTAINABILITY OF EXTRACTIVE USES	TRADITIONAL AND INDIGENOUS COMMUNITY PROTECTION
Philippines	• Community-based MPA • No-take MPA • MPA Network • National Marine Park • World Heritage Site • Ramsar site	• Integrated Coastal Management • Multi-use MPA	• Fishery Management Reserve • Ecosystem-based Fishery Reserve • Locally Managed Marine Area	
Papua New Guinea	• Marine Protected Area	• Integrated Coastal Management • Treaty-based MPA Reserve	• Wildlife Management Area • Fishery Management Reserve	• Customary Marine Tenure-based MPA • Marine Sacred Sites
Solomon Islands	• World Heritage Site • Marine Protected Area	• Integrated Coastal Management • Treaty-based MPA • Large Marine Ecosystem	• Wildlife Management Area • Fishery Management Reserve	• Customary Marine Tenure-based MPA • Marine Sacred Sites
Brazil	• National Marine Park • Ramsar Site	• Integrated Coastal Management • Multi-use MPA	• Customary Marine Tenure-based MPA	• Marine Sacred Sites • Culture-ecological Indigenous Peoples Territory
Australia	• MPA Network • Ecosystem-based Reserve	• Integrated Coastal Management • Treaty-based MPA • World Heritage Site • Biosphere Reserve	• Fishery Management Reserve	• Culture-ecological Reserve Traditional (non-indigenous) communities • Customary Marine Tenure-based MPA • Indigenous MPA • Indigenous Landscape Management MPA • Marine Sacred Sites

(Adopted from World Bank 2006)

Key Concept

MPAs can offer a spectrum of management strategies ranging from full protection, or no-entry areas, to multiple-use areas which prohibit limited activities. No-take MPAs are spatial closures that prohibit all forms of resource extraction, especially fishing. Limited-take MPAs include those MPAs with mixed harvest or restricted harvest prohibition areas.

The broad applicability of MPAs as a tool for protection and management of marine resources covers a wide spectrum. MPAs range from no-entry areas, where access is restricted and designed to protect all marine resources, to extensive, multi-use protected areas that integrate multi-species and fisheries management, incorporating regulatory mechanisms enabling limited take for certain species. MPA protection levels include no-take areas, designated to protect a single species or habitat type. No-take areas prohibit all forms of extraction, particularly fishing (Dayton et al. 2000; Roberts et al. 2001; Russ and Alcala 2004). As such, no-take areas are one of the most restrictive types of MPA, and act as benchmarks for assessing the state of the environment and the success of management regimes. They also contribute significantly towards recovery and protection of marine ecosystems (NRC 2000). Multiple-use, or limited take, areas include those MPAs with mixed harvest, restricted harvest and/or complete harvest prohibition areas, as well as other zones (e.g. recreation, research, etc).

MPAs involve a series of trade-offs that must be balanced to meet ecosystem protection goals. For instance, a large MPA may be ecologically optimal but economically or institutionally impractical. Multiple-use MPA zoning, to include no-take areas, provides a way to accommodate multiple users, balancing the trade-offs between sustainable use and conservation objectives for effective management.

The World Conservation Union classifies MPAs into 6 categories, ranging from highly protected reserves, intended only for scientific research or wilderness conservation, to multiple-use areas, created to foster the sustainable use of natural ecosystems and resources (Table 2).

CASTILLO

Big-eye snapper aggregate in the no-take zone of an MPA in the Philippines.

Table 2 IUCN protected area management categories[1]

IUCN CATEGORY		MAIN OBJECTIVE OR PURPOSE
IA	Strict Nature Reserve	Strictly protected areas to protect biodiversity and possibly geological / geomorphological features. Human visitation, use and impacts are strictly controlled and limited to ensure preservation of the conservation values. These areas can serve as indispensable reference areas for scientific research and monitoring.
IB	Wilderness Area	Large or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.
II	National Park	Large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, to provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.
III	Natural Monument	Set aside to protect a specific natural monument, which can be a landform, sea mount, submarine caverns, geological feature such as caves or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.
IV	Habitat/Species Management Area	Protect particular species or habitats and management reflects this priority. Regular, active interventions often needed to address the requirements of particular species or to maintain habitats.
V	Protected Landscape/ Seascape	Where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value; and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.
VI	Managed Resource Protected Area	Large, with much of the area in a natural condition and where a proportion is under sustainable natural resource management. Exploitation is a main aim of the area.

(IUCN 1994; Wells and Day 2004; WCPA 2008)

1 For an in-depth review of the application of IUCN protected area management categories in the marine environment, see Wells and Day (2004).

MPAs can take many different forms (and names) as evidenced from examples from around the world and the categories assigned by IUCN. In the end, all variations must provide some level of protection to the marine environment to be considered effective.

Chapter 2

NANCY SEFTON

Enforced no-take areas accumulate fish that become tame quickly in the corals of the Caribbean.

Scaling Up to a Network Approach

"The power of synergy is great, let's make it work for MPAs!"

Why scale up to networks?

When used in isolation, small MPAs may not support fish and invertebrate populations that are large enough to sustain themselves. To ensure that young marine organisms are available to replenish and sustain populations within MPAs, the area of protection must be fairly large. However, in many regions, economic, social and political constraints make it impractical to create one single large MPA of sufficient size to support viable, self-sustaining populations of all species. Establishing networks of several to many small to moderately sized MPAs may help to reduce socioeconomic impacts without compromising conservation and fisheries benefits (PISCO 2007). Furthermore, well-planned networks provide important spatial links needed to maintain ecosystem processes and connectivity, as well as improve resilience by spreading risk in the case of localized disasters, climate change, failures in management or other hazards, and thus help to ensure the long-term sustainability of populations better than single sites (NRC 2000).

As science and experience continue to provide more evidence of the importance of biological connectivity and resilience in the face of climate change, natural disasters and economic, political and social fluxes, networks of MPAs are increasingly valuable management tools. MPA networks can contribute to sustainable development goals by fostering integrated ocean and coastal management through 3 inter-related functions and benefits:

- **Ecological** – A network can help maintain functional marine ecosystems by encompassing the temporal and spatial scales of ecological systems.
- **Social** – A network can help resolve and manage conflicts in the use of natural resources.
- **Economical** – A network can facilitate the efficient use of resources.

The implementation of MPA networks that cover all major marine habitats and ecosystems will be a major step in restoring and sustaining the health of the oceans. If widely adopted, MPA networks can help stem the losses of marine resources and recover not only marine life, but entire ecosystems. When effective, MPA networks can magnify benefits of individual sites, protect large-scale processes, slow the loss of endangered marine species and restore depleted fisheries.

Setting aside marine areas to help replenish resources has been part of traditional management in many societies. But conservation of biodiversity through management tools, including MPAs, is a relatively new concept. It has its roots in the 1982 World Parks Congress in Bali, where participants recognized that conserving biodiversity through the use of protected areas should be applied to the oceans, as well as the land (McNeely and Miller 1982). Since 1982, many international gatherings have endorsed the need for MPAs and MPA networks. Recently, the 5th World Parks Congress called on the international community to create a global system of MPA networks that greatly increases the coastal and marine area covered, and that MPA networks should seek to include strictly protected areas that amount to at least 20 to 30% of each habitat. Currently, only a small portion of this area is being protected. Since 1984, the global marine area protected has grown at an annual rate of 4.6%. This rate of increase will require more than 50 years to achieve the current goal of 30% habitat protection. Thus, much work remains to reach sufficient area covered within networks and achieve international commitments (Table 3).

Table 3 International commitments and current global status of MPAs

- **World Summit on Sustainable Development (WSSD)**, **2002**, called for establishing a global system of MPA networks by 2012, as part of a strategy to protect and restore marine biodiversity and to maintain the natural resource base for economic and social development.
- **Evian agreement signed by the G8 group of nations, 2003**, called for the establishment of ecosystem networks of marine protected areas, consistent with international law and based on scientific information by 2012.
- **Convention on Biological Diversity (CBD)**, **2004**, agreed to the establishment and maintenance of MPAs to contribute to a global network. Various regional agreements complement these global undertakings.
- **The 5th World Parks Congress**, **2003**, calls on the international community to create a global system of MPA networks that "greatly increases" the marine and coastal area covered. MPA networks should be extensive and seek to include strictly protected areas that amount to at least 20 to 30% of each habitat (IUCN 2005).

Current global marine protection targets aim to protect 10 to 30% of marine habitats within the next 2 to 4 years. Based upon the MPA Global database, current estimates of MPA coverage include (Wood 2007):

- Approximately 5,000 MPAs have been designated worldwide.
- Approximately 2.58 million km^2, 0.65% of the world's oceans and 1.6% of the total marine area within Exclusive Economic Zones, are currently protected.
- Only 0.08% of the world's oceans, and 0.2% of the total marine area under national jurisdiction is no-take, where extractive uses are prohibited.
- Currently, the three largest MPAs include: the Phoenix Islands Protected Area (410,500 km^2), The Great Barrier Reef Marine Park (344,400 km^2) and the Northwestern Hawaiian Islands (341,400 km^2).
- An immediate global concern is the need for a rapid increase in MPA coverage in conjunction with scaling up of ocean management. The increase required to meet the targets is equivalent to another 35 countries creating an MPA the size of the Phoenix Islands Protected Area (410,500 km^2) before 2012.
- The global distribution of protected areas is both uneven and unrepresentative at multiple scales, and only half of the world's marine protected areas are part of a coherent network.
- A global review of MPA network programs underway documents the experiences generated and variety of approaches taken to develop MPA networks (UNEP-WCMC 2008).

What constitutes an MPA network?

An MPA network can be defined as a collection of individual MPAs or reserves operating cooperatively and synergistically, at various spatial scales, and with a range of protection levels that are designed to meet objectives that a single reserve cannot achieve.

Not just any collection of MPAs constitutes an MPA network[2]. A network can include several MPAs of different sizes, located in critical habitats, containing components of a particular habitat type or portions of different kinds of important habitats, and interconnected by the movement of animals and plant propagules (PISCO 2007). They must be appropriately placed, sized and spaced to function collectively as an ecological network and successfully achieve biodiversity goals. Protection of the ecological interconnectedness between and within ecosystems through strategically placed MPAs can strengthen the resilience of the systems to maintain the key functions and processes in the face of stresses (Holling 1973). Additionally, a network implies a coordinated system of MPAs, linked through biological levels, as well as administrative levels, reflecting a consistent approach to design, finance, management and monitoring.

Incorporating no-take areas is considered a foundation in most networks. The proportion of no-take areas contained in the network system depends on the degree of protection, recovery being sought and the level of decline in an area. For some areas, preservation and conservation may be the motivating force for a no-take MPA. And for these areas, no-take areas can be an effective tool for maintaining or enhancing fisheries, especially those that target long-lived demersal species with planktonic larval dispersal and sedentary adults. Social, economic and environmental benefits are generally greater where the no-take area is sufficiently large and well-integrated into broad ecosystem-based management regimes.

An MPA network is also a network of people managing the components of individual MPAs and promoting the network's viability and longevity. In addition to MPA networks based on ecological considerations, social MPA networks can be formed to facilitate learning and coordination of administration and planning by linking people and institutions involved in MPAs into a coordinate and holistic initiative (White et al. 2006). In the social MPA network, all agencies, management authorities or communities share the same overall goal and they can mature, just as ecosystems mature (Agardy and Wolfe 2002). The social network provides a rationale for individual MPA stakeholders or communities to coordinate with each other to share experiences and to enhance each others efforts in managing their respective MPAs (White et al. 2006).

In association with the formation of a network, an information base for the MPAs in an area should be created. Having an information base for the MPAs helps to develop logical choices in how to expand MPAs effectively and how to efficiently manage them through strategic efforts based on the network design. This information base stimulates the development for effective expansion and management of MPAs within the network design by providing a rationale for individual MPA stakeholders or communities to coordinate with one another to share experiences, enhancing the efforts to manage their respective MPAs (White et al. 2006).

2 For a complete discussion of what constitutes a network or "system" of MPAs in various countries around the world, see UNEP-WCMC (2008).

Example from the field – social network of MPA networks. The PAMANA KA (Philippines) is a nationwide alliance of community-based MPA managers represented by fisher-leaders. The network focuses on capacity-building, alliance-building policy advocacy and r esearch. The Local Marine Management Area (LMMA) network is a group of conservation practitioners working in Asia and the Pacific with hundreds of members, including landowners, traditional leaders, government representatives, elected decision makers, scientists and donors. The network provides solidarity and learning opportunities for participants, with national policies in multiple coastal areas. Within this network of MPA managers, community members and scientists, cross-project knowledge and trainings are shared and information is transferred (More information is available at http://www.lmmanetwork.org/) (White et al. 2006; Govan et al. 2008).

MPA networks in a broader management context

MPA networks can only be effective at curbing the decline of ocean health and reducing threats if they are implemented within larger frameworks of ecosystem based management, integrated ocean governance and coastal management. Without effective policy and management on a broad scale, MPAs can only serve as isolated aquaria of protection in a larger sea of degradation.

Marine spatial planning is gaining momentum as a planning tool to align ocean resources uses with the most appropriate use and protection areas over the wide expanse of ocean. This tool can be linked with the many developed planning approaches that involve MPAs and integrated coastal management (ICM). ICM is an intersectoral, spatial management approach that aims to align policies and incentives across sectors to minimize environmental impacts from coastal resource use while maximizing benefits to society (World Bank 2006). Depending on community needs and management concerns within the context of a larger ICM plan, MPAs can be designed and managed to accommodate various objectives and activities. ICM governance can create an enabling environment for MPAs and an ideal platform for elevating the scale of marine biodiversity conservation and sustainable fisheries management (Figure 2) (World Bank 2006). (For detailed information on ICM, refer to Chapter 4.)

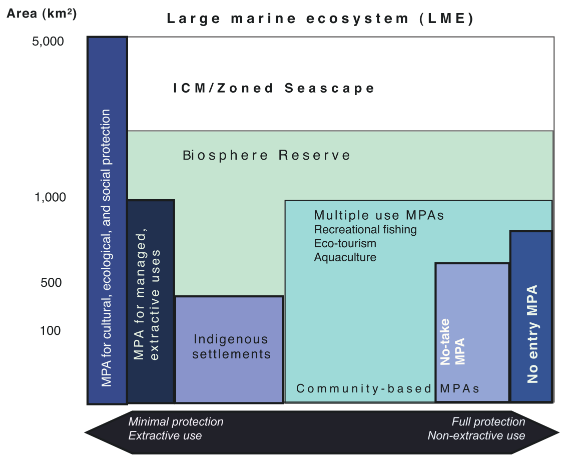

Figure 2 Marine management zones and categories within ICM framework
(Adopted from World Bank 2006)

Key Concept

The process of ICM is aimed at guiding coastal area development in an ecologically, socially and ecomically sustainable manner, in context with the following priorities (White et al. 2006):

- Protect physical habitat.
- Recover and protect species and populations.
- Rebuild ecosystem resilience.
- Safeguard against management uncertainty.
- Reduce conflicts over the use of ocean space.
- Provide economic and cultural benefits.
- Promote public education and enjoyment.

In places where integrated coastal management is insufficient or lacking, the development of an MPA can encourage a more integrated approach to coastal zone legislation and more effective management of coastal areas in general (Agardy and Staub 2006; The World Bank 2006). MPAs that meet their stated objectives can serve as a positive reinforcement, or serve as a building block for the creation of additional MPAs and scaling up to MPA networks, as well as other coastal management initiatives (Agardy and Staub 2006). Currently implemented in about 100 countries, usually at the sub-national level, ICM provides the potential to scale up marine management. This process has occurred in the Philippines, where MPAs of the 1980s are presently managed within an ICM framework (White et al. 2005; UNEP-WCMC 2008) (Figure 3).

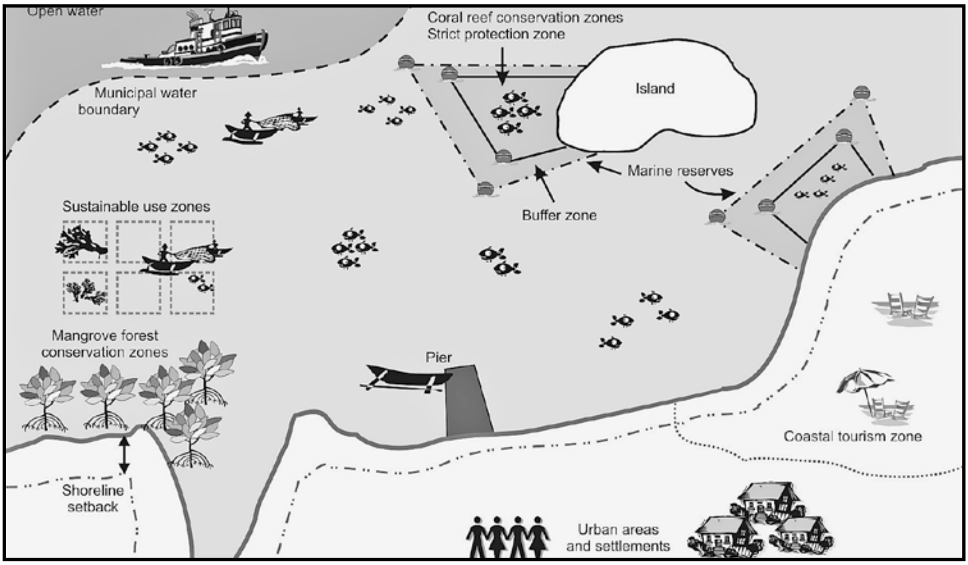

Figure 3 ICM area in Philippines with various spatial management tools, including MPAs (White et al. 2006)

MPAs and the ecosystem approach

An ecosystem-based management (EBM) approach takes into consideration the cumulative impacts of different sectors affecting the structure, functionality and key processes of the ecosystem. EBM is generally defined as being all inclusive to the total ecosystem, including the human community. Thus, human use patterns, culture and social norms are within the EBM planning framework. EBM, while being sensitive to the true marine ecological parameters, does not exclude the human elements of the system.

MPAs networks, formed through the scaling up of single MPAs to zoned networks with multiple-use MPAs, can provide an ecosystem-based management approach (Christie et al. 2007). Large-scale, multiple-use protected areas demonstrate the concept of ecosystem management, where the geographical extent of protection is based on the movements of organisms and physically linked processes. In recognition of these linkages, MPA managers and planners should consider protection of ecosystem function, structure and integrity, in addition to individual resources (such as specific species or habitats) and physical characteristics (Agardy and Staub 2006). Tools for regional planning to advance marine and coastal ecosystem-based management can be accessed at www.marineebm.org/index.htm.

Resilient MPA networks

The term resilience incorporates the capacity of socio-ecological systems to cope with, adapt to, shape change and learn to live with uncertainty and surprise (Brand and Jax 2007).

Resilient systems are adaptable, flexible and prepared for change and uncertainty (Hughes et al. 2005). Non-resilient systems, in contrast, are prone to irreversible change and are at risk of shifting into another, often undesirable, state (Marshall and Marshall 2007). Resilience is a critical aspect of MPA network design, particularly in the face of global climate change. If an MPA, or network, is resilient it can rebound from or withstand environmental fluctuations or unexpected catastrophes and support populations which can potentially replenish other damaged populations (Figure 4) (West and Salm 2003).

Strong resilience can include both intrinsic factors, such as biological or ecological characteristics of a community (i.e. potential for recruitment success), and extrinsic factors, such as physical features (i.e. current patterns that may favor larval dispersal or an effective management regime) (West and Salm 2003). For example, certain environmental factors, such as those that cause cooling of heated surface waters, can ameliorate stress associated with thermal bleaching of corals in tropical systems. Sites displaying these traits could be given higher priority in the selection process, as a means of mitigating biodiversity loss from climate change. Similarly, in temperate environments, oceanographic regimes are expected to change due to climate change and some species may move pole-ward as waters warm. Planning a connected network of MPAs across latitudinal gradients can help to protect species as their ranges change. MPAs can ensure healthier ecosystems that may also withstand climate changes and other stresses longer than highly disturbed or degraded ecosystems.

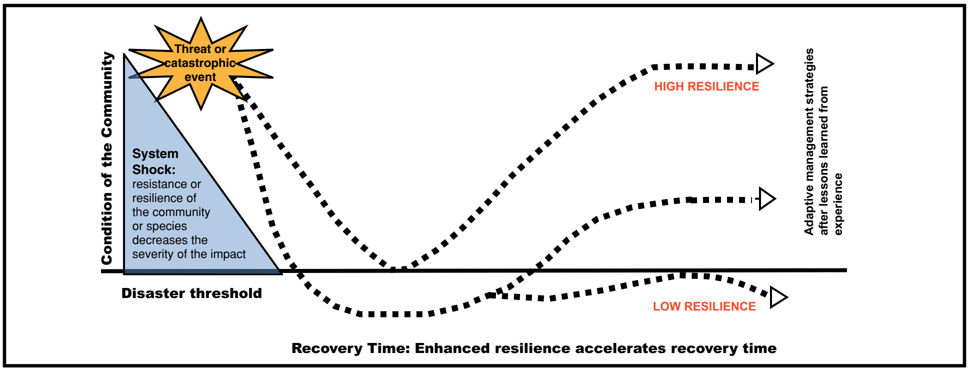

Figure 4 Resilience system responses Adopted from (US-IOTWSP 2007)

MPA networks, assuming all the ecological and biological factors are considered and maximized, will only be resilient through time if the management regime is capable, effective and sustainable. Thus, resilient MPA networks have social, economic and governance aspects, related to the coastal communities that must be anticipated and addressed to ensure development and maintenance (US-IOTWSP 2007).

Key Concep t

Components of a resilient MPA network include:

- Effective management.
- Risk spreading through inclusion of replicates of representative habitats.
- Full protection of critical areas that can serve as reliable sources of seed for replenishment/preserve ecological function.
- Maintenance of biological and ecological connectivity among and between habitats.

Example from the field – applying resilience principles in coral reef management. The Nature Conservancy's Reef Resilience Toolkit, provides guidance to coral reef managers on how to incorporate resilience into management strategies in the context of global climate change. While the focus of the toolkit is primarily on coral bleaching and reef fish spawning aggregation conservation, the recommendations and tools within the toolkit can be applied to most threats facing coral reefs today. Access the Reef Resilience Toolkit at www.reefresilience.org or request a copy at resilience@tnc.org.

Chapter 3

MARK GODFREY

Fishing village on Derawan Island within a large marine conservation area off East Kalimantan, Indonesia.

Broad-scale Considerations for Resilient MPA Networks

"We must think globally to be effective locally."

MPA networks are set in a world context that varies by place and will affect their ultimate success. Considering and adapting to the following contextual variables is essential.

- **Institutional and governance considerations** acknowledge institutional structures and the importance of integrating actions within a broader management context.
- **Economic and social considerations** form the 3 pillars of sustainable development alongside ecological design criteria.
- **Spatial and temporal considerations** acknowledge that ecosystems function at different spatial scales and change over time due to factors such as human activities and climate change.
- **Scientific and information management considerations** build upon the use of the best available information for both planning and management purposes.

Institutional and governance considerations

Institutional and governance capacity can have a significant effect and influence on the design, implementation and longevity of MPA networks. Governance relates to the power, policies, structures and processes used for decision-making for an area of responsibility. Emerging from the interactions of many actors, including local communities, the private sector and government, governance takes form through laws, regulations, debates, and negotiations, among other decision-making mechanisms (Lebel et al. 2006). In most instances, institutional arrangements have developed over many years, often devised to meet the demands of the time. In general, there are 4 main protected area governance "types" (Borrini-Feyerabend 2007)[3]:

1. Government-managed areas
2. Collaboratively managed areas
3. Private-protected areas
4. Community-based management areas

Key Concept: Governance vs. Management

Institutional capacity is the ability of government agencies to provide public goods and services, ensuring that laws and regulations will be adequately enforced (Jameson et al. 2002). As the political dimension of human activity, governance acts to create a system of authority and accountability, and management is the process leading to implementation within the institutional framework.

COORDINATION AND BUILDING LINKAGES

To work effectively within existing governance structures, network planners and managers must coordinate and build linkages with all participatory stakeholders. This includes engagement with applicable agencies, organizations and institutions, respecting rights of indigenous and local communities and developing appropriate instruments

3 For more information: "IUCN protected area matrix – A tool towards effective protected area systems." http://www.iucn.org/themes/wcpa/theme/categories/summit/papers/papers/Governancepaper4.pdf

(i.e. policies, regulations and standards) specific for the area. In the first stages of the planning process, network designers and managers need to identify the framework and legal authorities and institutional responsibilities associated with the MPA network (WCPA/IUCN 2007).

MPA management is often part of an integrated coastal management (ICM) governance framework. In cases where no ICM institutions have been established, MPA management should relate to the sectoral institutions concerned with watershed management, fisheries, tourism, maritime transportation or others (Cicin-Sain and Belfiore 2005). Supporting such inter-departmental collaboration and coordination across all stakeholders requires sustained leadership and recognition that diversity and capacity of the institutions and groups involved will influence the efficacy of the network (WCPA/ICUN 2007).

LEGAL FRAMEWORK AND AUTHORITY

Appropriate legislative and regulatory frameworks are fundamental to achieving an effective MPA network. Many countries have special legislation enabling individual MPAs, along with a variety of agencies with marine responsibilities, but few have a strategic legislative framework or institutional arrangements for a representative MPA network. Unless clarity is achieved, a poorly integrated array of legal and institutional responsibilities can lead to problems such as competing mandates, overlaps, gaps and inefficiencies, all of which undermine an effective MPA network.

Special authorities are sometimes needed to coordinate overlapping and complex jurisdictional arrangements. They can help establish coordination among coastal and marine management regimes, and even establish mechanisms for public and stakeholder involvement in developing an efficient, sustainable MPA network.

IMPROVING INSTITUTIONS TO SUPPORT MARINE RESOURCE MANAGEMENT

To be successful, responsible parties for the management of MPAs and networks, institutions need to be efficient and effective in meeting goals and legitimate among relevant stakeholders. Key institutional attributes include (Hughes et al. 2005; Brown 2006):

- Embrace uncertainty, be adaptive and able to function with dynamic and fluctuating ecological resources and conditions.
- Recognize and manage a range of users, uses and the trade-offs between them.
- Build knowledge and understanding of resource and ecosystem dynamics.
- Develop management practices that measure, interpret and respond to ecological feedback.
- Enable the sharing of management power and responsibility through linkages among communities, government agencies and non-governmental organizations.

It is rare for a single agency to have complete authority; instead, a diverse range of institutions and agencies may be involved in managing a network. Because each region is unique, no single approach to MPA governance or legislation can be universally advocated or applied.

Creating and strengthening an MPA network can proceed only as quickly as the institutions and individuals responsible develop the skills and attributes needed to manage it well. Managers may need new skills in science, management, communications, monitoring and financial administration, among others. Frequently, existing organizations will need to take on new and different roles. Sometimes, entirely new institutions will be created to oversee or coordinate activities at the network level. Substantial investment is often required to build the skills, abilities, experience and reputations of the institutions and managers responsible for key functions within an MPA network, and this will take time.

TRANS-BOUNDARY MPA NETWORKS AS MEANS FOR COOPERATIVE MANAGEMENT

Ecosystems and species distribution frequently do not correspond to political or jurisdictional boundaries. Therefore, cooperative management among states, regions, nations and jurisdictions is required. In the case of protected areas, such cooperation can come in the form of trans-boundary[4] protected areas or "peace parks" (Sandwith et al. 2001). These areas straddle the boundaries of jurisdiction and sovereignty and often involve high-level political initiatives by governments, local groups or third-party interventions by NGOs, academic institutions or international conventions.

Trans-boundary MPA networks can provide a range of potential benefits (Sandwith et al. 2001). They can:

- Enhance conservation and management of shared natural resources, ecosystems, habitats and species.
- Promote international cooperation and shared responsibilities (including education and outreach, enforcement, monitoring and capacity-building).
- Engage stakeholders at multiple levels through increasing commitments.
- Harmonize legislation and management, and expand financing mechanisms.

Using local and regional advisory committees to develop and support MPA network management encourages regional relevance, accountability and ownership. Technical advisory committees with appropriate scientific, social or economic expertise are also important to the planning and development phases.

Economic and social considerations

Economic and social concerns are fundamental pillars of sustainable development and important components of best practice for planning and implementing MPA networks. MPA networks can be designed and managed as an integral part of national and local strategies to achieve sustainable development. To accomplish this integration, network planners must be sensitive to the economic and socio-cultural setting and promote activities that maximize positive benefits.

4 'Trans-boundary Protected Areas' are defined by IUCN (Sandwith et al. 2001) as *"Areas of land and/or sea that straddles one or more boundaries between state, sub-national units such as provinces and regions, autonomous areas and/or areas beyond the limits of national sovereignty or jurisdiction, whose constituent parts are especially dedicated to the protection and maintenance of biodiversity, and or natural and associated resources, and managed cooperatively through legal or other effective means."*

A full understanding of the costs and benefits of functioning coastal and marine ecosystems and resources is an important starting point for planning effective MPA networks. For example, networks may provide value-added services such as coastal protection, nutrient recycling, and increased spawning or nursery areas for economically important species, or reduced management costs per unit area. They may provide economic contributions from alternative livelihoods such as tourism. The costs of inaction may involve continuing loss of resources, decreased ecosystem resiliency and diminishing economic returns from potential sources or a decrease in quality of life (White and Cruz-Trinidad 1998).

Key Concept—Trade-off of scaling up to networks

In the process of scaling up from individual MPAs to national and regional networks and systems, financing strategies at a network level will involve trade-offs, such as between income retention at specific sites versus pooling of resources for the overall network, or concentrating tourism impacts in particular areas to generate funds for conservation of more natural sites (Lutchman 2005).

The potential costs and benefits of MPAs often differ between user groups. The establishment of an MPA may create a financial and social burden on resource-dependent communities, even in the anticipation of higher yields in the future (World Bank 2006). A direct cost associated with MPAs, in particular no-take fishery reserves, is the effect that the closure will have on the surrounding environment, both social and biological (Agardy and Staub 2006). For example, MPAs may entail restrictions on commercial and recreational fishing, thus directly affecting personal incomes of fishermen. Another consideration involves the rights of commercial user groups such as the tourism industry (cruise ships and ecotourism) and commercial fishing industry. Through zoning, MPA networks can help maintain equity by addressing the needs of different user groups and by permitting different types of access.

The information gained by doing economic cost-and-benefit analysis will provide a sound basis for informing stakeholders and developing political will. MPA networks may need to incorporate compensation or other structural adjustments for displaced user groups for opportunity costs or lost benefits due to restrictions on activities such as fishing. Compensation can help foster acceptance of MPA networks and may well reduce enforcement costs. MPA networks may also provide value-added benefits over individual MPAs such as increased ecosystem services and reduced management costs per unit area.

MPAs may have social consequences by altering the profile and distribution of participation in marine dependent activities (Scholz et al. 2004). One social cost incurred by a community is if an MPA is viewed as being imposed on locals by "outsiders," or an attempt to police a local community. Such costs can alter community infrastructure and erode community integrity. Another cost associated with MPAs is that of not meeting the intended objectives, which facilitates a loss of confidence by the public and decision makers (Jones 2006). Social relationships, cultural values and political processes that influence attitudes and decisions about coastal and marine resource use and protection are thus important in the MPA network design (IUCN/WCPA 2007). MPAs that use strategies that reflect the local socioeconomic conditions may be able to achieve better compliance and, consequently, conservation benefits.

Example from the field: Community perceptions of MPAs. As a way to understand community perceptions and understanding of MPAs, The Nature Conservancy in Indonesia implemented a system to monitor the perception of stakeholders on resource status, use and management at 4 sites: Komodo, Wakatobi, Derawan and Raja Ampat (Halim and Mous 2006). The objectives of the monitoring tool were to produce basic quantifiable indicators on community attitudes (i.e. rules and regulations, perceptions on resource conditions, outreach and awareness programs, etc.) and to identify cultural and socioeconomic factors that either obstruct or facilitate management strategies. Incorporated into the broader context of MPA design, the socioeconomic information gathered from a monitoring program as illustrated above, can indicate areas for improved public education programs, inform adaptive management measures and measure program effectiveness.


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Socioeconomic factors and community dynamics need to be considered in the MPA planning and management. Children in Papua New Guinea.

While there is growing emphasis on the role of MPAs in biodiversity protection and maintenance of ecosystems, MPA networks can play a major role in fisheries management. This role of MPAs and their socioeconomic impacts (positive and negative) will depend on the fisheries management context. In areas with ineffective fishery management or poor enforcement of fishery regulations, MPAs can serve as a primary fishery management tool at the local level to protect stocks of targeted species. In those cases, the benefits and costs of MPAs can be directly related to either the improvements in fishery benefits or the spatial loss of fishing opportunities at the local MPA scale. In areas with regionalized industrial-scale fishing and effective top-down fishery management, MPAs are often layered on an existing system of fishery regulations. Such areas may include other types of fishery closures, catch limits or management measures. The socioeconomic cost of MPAs has to be considered in the context of these other fishery management measures. The fishery benefits of MPAs may not be as high where fisheries are already being well-managed outside of MPAs.

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MPAs may entail restrictions on commercial and recreational fishing, which can have economic and social costs. The cultural setting and the socioeconomic costs and benefits of the MPA need to be considered in the MPA network design. Fishing boat in Baja, Mexico.

Spatial and temporal considerations

Biodiversity patterns in the marine realm are closely coupled with cultural, atmospheric, oceanographic and biogeochemical dynamics – each operating at their own spatial and temporal scales – MPA network planners must, therefore, consider important spatial and temporal issues that affect marine ecosystems. These factors include the extent of human impact on marine resources and the need for restoration, integration between marine and terrestrial systems and the many linkages with coastal watersheds, and the broader oceanographic and climatic context. After identifying the appropriate planning boundary for the MPA network, it is important to consider the following:

ECOLOGICAL PROCESSES, RESOURCES AND IMPACTS THAT EXTEND BEYOND NETWORK BOUNDARIES OR INFLUENCE MPA NETWORKS

Given the fluid nature of the ocean environment, no marine area is truly isolated. Network planners must understand and apply all available information on biological, chemical and physical linkages within the network and beyond. Just as MPA network design must account for connectivity within and between networks, network design must also factor in the impacts of activities outside network boundaries, including terrestrial linkages to coastal watershed catchments. Identifying important linkages to adjacent freshwater and terrestrial systems and the exchange of materials (nutrients, species, pollutants, etc.) among these systems that affect the marine environment will help to place the MPA network in a broader coastal management context. Similarly, there can be important ecological linkages with pelagic or archipelagic regions further offshore and with adjacent regions along the coast.

THE CONCEPT OF “SHIFTING BASELINES” IN NETWORK DESIGN

Since the earliest days of human settlement along the coast, humans have shaped and changed marine and coastal ecosystems. Planning for an MPA network needs to recognize how human activity has influenced the world’s oceans and coasts, and the extent to which these areas have been driven from their natural state. One important function of MPAs can be to help restore ecological communities and replenish species to conditions that reflect less human impact. MPA networks should therefore be designed to restore marine ecosystems and associated populations to their full productivity and diversity, not to maintain the status quo which in many cases is degraded.

A key issue is recognizing and addressing the concept of *shifting baselines* (Pauly 1995) whereby stakeholders, managers and decision makers fail to see the enormous changes that have occurred in ocean ecosystems because they have occurred gradually over many years. In fact, managers, and people generally, often accept what they first observe, such as species composition, abundance and stock size, as a natural baseline from which to evaluate changes (Bellwood et al. 2004). Often, the baseline may already represent a disturbed state. The result is that the resource continues to decline, while the next generation of managers resets its baseline to an even lower state. This narrowed human perspective fosters the slow disappearance of species and continued degradation of marine ecosystems.

ARC CENTRE OF EXCELLENCE FOR CORAL REEF STUDIES/MARINE PHOTOBANK

Two points in time at the same reef site illustrates the shifting baseline syndrome or the shift over time in the expectation of what a healthy ecosystem baseline looks like. There is a loss in knowledge of the changes that have occurred when each generation redefines the natural state of the ecosystem.

This problem of shifting baselines leaves managers and stakeholders without a clear understanding of how coastal and marine systems function in the absence of human impacts (Knowlton and Jackson 2008). To address the concept of the shifting baseline, and reset expectations, planners need to set historically appropriate objectives for MPA networks and accommodate spatial and temporal variations. Doing this presupposes that historical data exist, which is often not the case. Nevertheless, reference to past states is important, even if data are not complete or only approximate. One important function of no-take MPAs can be, over time, to help define less impacted conditions (Dayton et al. 2000).

Scientific and information management considerations

Data compilation and information sharing are fundamental components in the planning and implementation of effective MPA networks. Planners and managers generally need to improve access to all available information by fostering coordination among institutions, developing information archives and creating mechanisms that enable broad access. Often, a coordinated effort is needed to ensure that information is shared and not guarded by individuals or protective agencies (White et al. 2006). To be effective, information systems must be well designed, actively maintained and easy to use.

DATA AND INFORMATION NEEDED FOR MPA NETWORK PLANNING AND IMPLEMENTATION

The MPA planning process requires the development of an effective decision support system (data, maps and tools) for stakeholders, scientists and decision makers involved in the process. The intent should be to bring the best readily available data and science to bear on the planning process in a manner that is transparent and participatory. Scientific data and the local knowledge of stakeholders should be compiled and made available for MPA planning. Generally, mapped data are required for spatial planning and may include maps of biophysical, management and socioeconomic factors (see Table 4).

Table 4 Important categories of spatial data for MPA planning

Base maps: study region boundary, nautical charts, shoreline features, etc.

Physical and bathymetric: depth contours, bathymetric imagery, submarine features, coastal watersheds, land cover, etc.

Biological/habitats: habitats, ecologically significant areas, species occurrences or distribution, etc.

Cultural: towns, harbors, ports, coastal access points, etc.

Consumptive uses: commercial fishing areas, recreational fishing areas, mariculture, etc.

Non-consumptive uses: dive sites, kayaking areas, wildlife viewing, shipping lanes, etc.

Existing coastal and marine managed areas and other jurisdictions: existing MPAs, fishery closures, coastal protected areas, etc.

A regional profile can help to inform planners and stakeholders about the distribution of key habitats, ecological features, threats and socioeconomic uses of marine resources in the region. A marine gap assessment, in which the amount of area and habitats already under existing spatial management or protection is quantified, can help to focus on areas that need additional protection.

Mapping of key habitats, areas of ecological importance and important threats to marine resources provide the scientific framework for identification of potential sites for MPAs. Generally, the trade-off between ecological and socioeconomic goals is the main driver for MPA design and to have good information on both factors is important.

PLANNING SUPPORT TOOLS

Compiling spatial data into a Geographic Information System (GIS) database is the most effective way to store, analyse and map relevant information. In cases where a GIS system is not available, hardcopy maps can be created and used in a planning process. There are also participatory GIS approaches whereby stakeholders identify and map important resources or potential MPA sites on hardcopy maps, which are then digitized into GIS format.

In some cases, it may be appropriate to use marine reserve design software tools to facilitate identification of initial areas of interest for MPAs. There are software tools,

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Once data are gathered, analyses can be performed by map overlays. With stakeholder involvement, these maps can be used to help determine potential sites for protection.

such as MARXAN[5] that identify "optimal" reserve designs based on explicit trade-offs that have been used in many locations as part of the planning process (e.g. MARXAN) (Airame et al. 2003; Leslie 2005; Green et al. 2007). These software tools have limitations as the solutions identified are very dependent on the data and assumptions included as inputs, they generally do not explicitly address network connectivity, and results may not mesh with local knowledge or more complex socioeconomic considerations.

INFORMATION FOR MONITORING AND ADAPTIVE MANAGEMENT

The information and data for the planning process also provide a foundation and a system for designing and implementing a monitoring program that will be part of an adaptive management framework. To provide useful and durable information that assists with adaptive management of MPA networks, it is critical that consistent, long-term data be available so that changes over time can be measured. Long-term information provides reliable feedback on the effectiveness of management that can be provided to managers, scientists, the communities and stakeholders. However, it is important to identify and match the relevant monitoring indicators to the goals and objectives of the MPA network from the start of the planning process. This will allow for improvement of protected area management through learning, adapting and the diagnosis of specific issues influencing whether goals and objectives have been achieved (Pomeroy et al. 2004).

5 MARXAN is a computer software decision support tool for reserve system design. Through optimization algorithms, MARXAN produces an efficient system of spatially cohesive reserve sites, by minimizing the costs and meeting biodiversity targets (Ball and Possingham 2000).

Systematic monitoring and information gathering of key indicators for MPA networks require the application of the appropriate scientific skills, personnel, training and partnerships. Training, science programs and research priorities should be based on the management strategies and needs of the network, as a method to optimize results. For example, applied research on ecosystem functions, sustainable fishery yields and economic valuation analyses can provide essential detail and information of the system when they are consistent with the goals and objectives of the network.

Government agencies can play an important role in improving access to information by making publicly funded information readily available. They must also strive to make privately funded studies and information available by purchasing access rights or creating agreements to share the information publicly. Private donors can help this exchange of vital information by requiring that their grantees share data publicly. Examples of publicly open databases and the process to develop them are shown in Tables 5 and 6.

Table 5 A database of the world's MPAs

MPA Global is a database of the world's Marine Protected Areas. It is a collaborative project between the University of British Colombia Fisheries Centre, Sea Around Us Project, WWF, UNEP-WCMC and IUCN. The project has two main goals: 1) to develop a robust global MPA baseline and 2) to develop alternative scenarios of global MPA networks using spatial modelling techniques. The database is freely searchable at http://www.mpaglobal.org, and is currently based on information from the World Database on Protected Areas (WDPA).

Table 6 A national MPA database in the Philippines

In the Philippines, organizations and information involved in MPA establishment and implementation are linked together via a national MPA database. Each organization contributing to the database has open access to the information. Through its structure and design, the MPA database compares all sites' biophysical resources, status and trends, as well as the management status of each site according to a management rating system.

The Philippines MPA database constitutes a simple forum that is relatively easy to maintain and augment in a developing country setting. It also serves as a national database on MPAs that is current and comprehensive. Challenges to maintain the database include maintaining an institutional foundation to support it; keeping data current, given the diffuse sources and the variety of methods used to collect data; institutional expense of ensuring current and accurate data; and ensuring that all organizational members continue to participate actively.

An MPA network has been formed through memoranda of agreement signed and acted on by all participating member organizations, which include 30 government, academic and other non-government organizations. Member organizations provide technical assistance through research, monitoring and evaluation of MPAs or other forms of technical guidance and assistance. While MPA managers at the community level benefit from the MPA database, they are not actual members of the database group because they are not the primary holders of information pertaining to MPAs in the country.

The Philippines MPA database has succeeded in creating a national database for MPAs, and it has helped to form a large network of all the primary Philippine organizations engaged in MPAs called the MPA Support Network (MSN). It has also encouraged MPA managers and assisting organizations, including government, to adopt a standard management rating system to evaluate management effectiveness (Coastal Conservation and Education Foundation, Inc. Cebu City, Philippines, www.coast.ph).

Chapter 4

JEZ O'HARE

Marine resources planning meeting, Rock Islands, Republic of Palau, Palau.

Best Practices for Planning MPA networks

"Good plans do not guarantee success, but without plans, failure is highly probable."

Six best practices have been identified for network planning that will apply in almost every network planning process. Employing these best practices will help the network to realize environmental, economic and social benefits. These best practices, however, should also be applied in conjunction with the broad-scale considerations for the development of resilient MPA networks (Chapter 3) and with the ecological design principles (Chapter 5) to achieve its objectives.

The 6 areas of best practice for planning MPA networks include:

1. Clearly defined goals and objectives.
2. Legal authority and long-term political commitment.
3. Incorporate stakeholders.
4. Use of best available information and precautionary approach.
5. Integrated management framework.
6. Adaptive management measures.

Clearly defined goals and objectives

Clear and measurable objectives are essential for guiding management decisions and tracking progress and performance. Goals should be determined as early as possible in the process because, once set, they will influence critical decisions regarding such things as the size, location, boundaries of the MPA, as well as the management measures and the focus of the monitoring and evaluation programs (Botsford et al. 2003; Roberts et al. 2003; Leslie 2005; Halpern et al. 2006). Furthermore, such management goals need to be fully endorsed by the community and solidly supported in an appropriate political and social manner if they are to be effective.

Network goals and objectives must reflect both the specific needs of an MPA network and the objectives of individual component MPAs. Thus, goals and objectives can be viewed at the level of individual MPAs that, through their placement, may perform different roles within the network to contribute to the goals for the larger network. The combined effects of each individual MPA can achieve the overall goals for the network. National conservation policies and regional and global environmental commitments, such as biodiversity targets and sustainable development goals, should also be supported through the objectives of the MPA network.

Example from the field – Clearly defined goals in Mesoamerican Reef (MAR) region. In the efforts to scale up the MPA framework in the Mesoamerican Reef (MAR) region, the TNC MAR Program has set as a goal the development of a network of MPA that is resilient to bleaching events through representation and replication and conservation of key biological processes (Arrivillaga and Windevoxhel 2006). This network goal has helped planners and managers concentrate the initial efforts on the elements of representation and replication, and critical areas through regional assessments for identification of priority conservation sites.

All MPA network objectives should be determined through an open, transparent and balanced dialogue with all stakeholders. To ensure that the goals are compatible with local and traditional uses, community stakeholders, local leaders, resource users, government, industry and other groups that influence investment and development in the area should be included in the goal-setting process. To be measurable, goals and objectives must specify time frames for achieving objectives and indicators for measuring performance. Unrealistic targets can hinder the MPA network's effectiveness, so timetables should be appropriate.

Key Concept

Setting clear and agreed-upon network objectives at the outset:

- Guide designation of component sites, levels of protection and management needs.
- Guide monitoring and adaptive management of network sites.
- Guide opportunities to reduce, mitigate or eliminate activities that degrade resources or ecosystem services, while promoting those that support natural processes.
- Help determine future investments in sustainable use of coastal and marine resources.
- Improve transparent decision-making.
- Provide a framework for reviewing the contribution of existing MPAs to a network.
- Promote stakeholder buy-in and support.

Planners and designers should consider 3 broad categories of objectives for MPA networks:

1. **Ecological objectives.** These typically seek to protect, manage and/or restore marine ecosystems and their components, including processes, structure, function and integrity, as well as wildlife and geographic features. Planners must especially consider objectives that a single MPA cannot achieve.
2. **Economic objectives.** To determine economic objectives, network planners must understand current resource uses, users and economic prospects for the area. Assessments need to be made on how the region will benefit from the network and who may suffer negative economic impacts. Economic considerations should involve a short- and long-term view of costs and benefits, as well as a perspective on how local needs may interface with national sustainable development goals. Economic objectives may seek to distribute benefits to offset short-term costs incurred by limiting unsustainable uses or to achieve national poverty reduction goals.
3. **Socio-cultural objectives.** MPA networks should contribute to quality of life of the local community. Fostering understanding, ownership and support for MPA networks includes assessing the full range of benefits that biodiversity provides, including those that directly affect human health and well-being. Exploring social and cultural values, how those values are threatened, and the costs and benefits involved in meeting socio-cultural objectives will help ensure success. Such values might include pride in the uniqueness of a natural area, local traditions that involve activities such as fishing or hunting, and places considered sacred to local groups.

Legal authority and long-term political commitment

The authority to establish and manage MPAs is held by various levels of jurisdictions; from national, regional, local and/or traditional, depending on the region. One factor that can greatly contribute to the implementation of the MPA is a solid legal authority in the form of clear rule. For some regions, statutory law can provide the necessary tool for effective implementation and management of an MPA. There is also a long history of traditionally managed areas which function on the basis of tenure systems or village rules, which can provide a means to support and manage an MPA. A strong legal (or customary) basis supporting and/or mandating the development of MPAs can be the driving force in successful network implementation.

Key Concept

Clear and effective leadership, commitment and support at both the political and agency levels, with a shared vision and capacity to achieve success are key to an optimal MPA network design.

Ensuring the long-term benefits of the network requires ensuring consistent support for the network in the face of changing government regimes. In some parts of the world, legal frameworks are often the only way to ensure consistency. Voluntary support can be susceptible to changes in political priorities; these changes can force governments to focus on short-term gains at the expense of longer-term and wider benefits for society. In some regions, the political will and resources may already exist to implement the components of a network, either through a rezoning exercise or through a strong government mandate supported by sufficient resources. But in most cases, implementing an MPA network will take place over time, as political will and resources for the network and component sites grow.

Political commitment and support are essential for establishing networks of MPAs and must be established early in the process and maintained throughout the duration of the development, establishment and implementation of the MPAs. The creation of political will and an enabling environment to support MPA networks framed in the broader coastal and marine area will allow local concerns in the context of regional and global pressures to be addressed (Cicin-Sain and Belfiore 2005). By involving elected officials and the community in the planning process, more legal support is likely through the development process, implementation, maintenance and enforcement at each of the sites. Sustainable measures in the form of enforcement capacity and financial support reinforce political commitment. Political commitment at the national and regional level can also catalyse sustainable financing efforts for MPA networks (e.g. TNC's Micronesia Challenge, Caribbean Challenge, Coral Triangle Initiative, etc.).

Effective coordination among government agencies requires sustained leadership (ideally through one agency or specially formed committee). An established authority can coordinate complex jurisdictional arrangements, establish coordination among coastal and marine management regimes, and provide mechanisms for public involvement in developing the MPA network. Consistent legal and institutional frameworks can also resolve inconsistencies where jurisdictions' responsibilities overlap. Coordinating existing legislation is critical, and should include identifying matters of national significance and matters requiring a consistent approach.

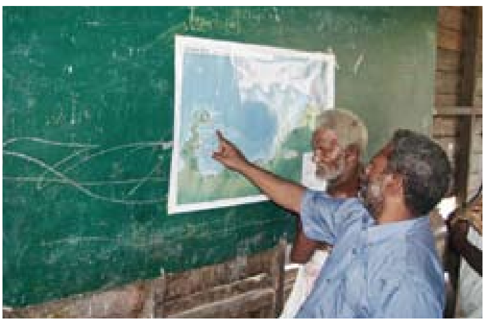
Example from the field - Maintaining political commitment and support for implementing a state-wide MPA network under California's Marine Life Protection Act. The California Marine Life Protection Act (MLPA) directs the state to redesign its system of marine protected areas (MPAs) to increase the cohesion and effectiveness of the network and to improve ecosystem protection within state waters. Legislators designed the MLPA in response to growing public pressure for more ocean protection and to address inadequacies in existing MPAs; a review of MPAs showed many were ineffective and together they protected far less than 1% of California's oceans. This law was passed by a majority in the Legislature and garnered broad public support. After initially being vetoed in 1998, it was signed into law by the governor in 1999. However, implementation of the law faced significant fiscal and political hurdles resulting in delays.

The MLPA provides the foundation and impetus for an effort to create a strong MPA network with goals and objectives, enforceable regulations and a scientifically based network design. The California Department of Fish and Game (CDFG), the state agency responsible for managing marine resources, is the lead implementing agency. The MLPA calls for the use of the best readily available science and for involvement of scientists, resource managers, stakeholders and members of the public. Two attempts to implement the MLPA in 2000 and 2001 were unsuccessful, mostly due to lack of stakeholder involvement in the first attempt and lack of adequate funding and capacity in both efforts. In 2004 a public-private partnership created the MLPA Initiative that is leveraging public money with private resources to provide additional funds and professional staff nee ded to complete planning of the state-wide network of MPAs. The planning process is being completed sequentially in 5 study regions throughout the state (2 of the 5 study regions have been completed), with the goal of completing the statewide network by 2011. Timely implementation of the Act and a legacy of improved marine protection are strong commitments by the current governor and leadership within the California Resources Agency. The political will at the highest levels of state government has been essential to the process, especially in the face of some organized opposition.

Public and political support for implementing the MLPA has been maintained and bolstered over time by having a fair and inclusive MPA planning process that is characterized by strong stakeholder involvement, scientific input and guidelines, clearly defined roles and many opportunities for public engagement. (More information on MLPA can be found at http://www.dfg.ca.gov/mlpa)

Incorporate stakeholders

Developing effective MPA networks requires involvement with relevant stakeholders from the start of the scoping process. Engaging stakeholders enhances information sharing; fosters the accountability of experts, authorities and scientists; increases the transparency of management decision-making; and enables stakeholder groups to collaborate and find mutually acceptable solutions. It is also important to provide a variety of opportunities to allow stakeholders to actively participate in network design, implementation and management. Although the breadth and extent of stakeholder involvement vary among cases and circumstances,



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Stakeholders who fully understand and endorse MPAs are the best guarantee of sustainable protection. Marine resource meeting at Kimbe Bay, Papua New Guinea.

incorporating diverse interest groups should be recognized as a necessary component of successful MPA planning. Active and continuous participation by stakeholder groups is essential to the long-term success and sustainability of networks.

When designing the process for developing MPA networks, it will be important to understand stakeholders' uses and values of the marine environment. Local and traditional knowledge can help network designers identify important traditional, cultural, historic or religious uses of resources, places or species. Engaging stakeholders early allows planners to better understand the range of stakeholder concerns and considerations, including issues such as current social relationships; relevant distinctions among ethnic or other groups; power dynamics and power-sharing relationships within communities; jurisdictional issues and conflicts (between different levels of government or between traditional community leaders and formal government agencies); and tenure rights, conflicts and other related issues.

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When designing the process for developing MPA networks, it will be important to understand fishermen's uses and values of the marine environment.

Additionally, stakeholder involvement from the initial planning stages helps to instill a sense of ownership and commitment which can encourage long-term local interest and support for overseeing activities (i.e. monitoring, enforcement) in the protected

Example from the field - Stakeholders take local ownership to further MPA network development in New Zealand. During the 1980s and 1990s, concern among stakeholders, marine scientists and conservation groups grew with noticeable declines in fish catches and increasing growth pressures in New Zealand's Fiordland region. In 1996, *The Guardians of Fiordland's Fisheries and Marine Environment (the Guardians)* formed to initiate a more holistic approach to marine management of the area. Representatives from the commercial and recreational fishers, charter boat and tourism operators, scientists, conservationists, communities and indigenous groups gathered to address their concerns.

During 2000 to 2003, the *Guardians* developed a strategy for managing the marine area, utilizing the technical and financial support of a number of key central government agencies and local government. This bottom-up approach initiated, by the *Guardians*, was a critical period during which the Guardians and central government worked together to produce a management strategy for the marine resources. As a result, in 2005, the Fiordland Marine Management Act was implemented. The Act provided jurisdiction for over 928,000 ha of sea, established a Guardians committee, created 8 marine reserves, introduced controls on anchoring and strengthened biosecurity measures.

areas (Lundquist and Granek 2005). By involving a broad spectrum of stakeholders in network design, managers and decision makers can address the social and scaling up complexities involved in establishing a network. To be truly open, the development process should seek to accommodate differences in stakeholder groups, including marginalized and disadvantaged communities. Timely, planned consultation processes operating at meaningful spatial scales are critical to success.

Example from the field - Involving stakeholders, scientists and policy-makers in MPA network planning under California's Marine Life Protection Act. The California Marine Life Protection Act (MLPA), passed in 1999, has 6 goals focused on ecosystem protection; sustaining and restoring marine life populations; improving recreational and study opportunities; representation of marine habitats; ensuring clearly defined objectives and sound science; and ensuring that MPAs are designed and managed, to the extent possible, as a network. The MPA network planning and implementation process is guided by a Master Plan Framework (CDFG 2007) and is characterized as science-based, but stakeholder driven. Regional groups of stakeholders, representing broad interests, are charged with designing alternative network proposals for each region, which are then evaluated against science guidelines by a science advisory team.

The planning process has been very open and transparent, with many opportunities for public input. A task force, appointed by the governor, is charged with providing policy guidance and recommending a preferred alternative to the Fish and Game Commission, the final authority for adopting a statewide MPA program. The task force has demonstrated in the 2 regions completed to date that the key factors weighed in identifying the preferred alternative include meeting scientific guidelines, identifying MPA designs that protect marine ecosystems while minimizing socioeconomic impact, and the degree of cross-interest support for proposals. California's Department of Fish and Game provides input throughout the process, especially on issues of feasibility and enforceability. The interactive planning process has facilitated public understanding of and general support for the MPA proposals, allowed for scientific review and refinement of proposals, and given policy-makers sufficient information to guide their decisions. (More information on MLPA can be found at http://www.dfg.ca.gov/mlpa).

Use of best available science & a precautionary approach

Optimal design of MPA networks requires ecological and socioeconomic information. From the start of the planning process, network designers must bring all best available data and information together in a form that is useful for marine gap analysis, planning and decision-making. The data should consist of both scientific and socioeconomic information and traditional and local ecological knowledge—the knowledge that indigenous and local community groups have gained about the ecology of the area, accumulated by experience and passed through generations. Incorporating traditional and local ecological knowledge into the planning and design of MPA networks can foster mutual learning and improve relationships between communities and management.

While the uncertainty and lack of information can be a challenge in conservation and MPA design, MPA networks can still be established, making adjustments and filling in gaps in science and information throughout the process. The precautionary approach suggests that caution be taken in decision-making, but that it does not lead to paralysis until perfect information is available. Thus, a lack of certainty or science should not be used as an excuse for not planning the MPA network.

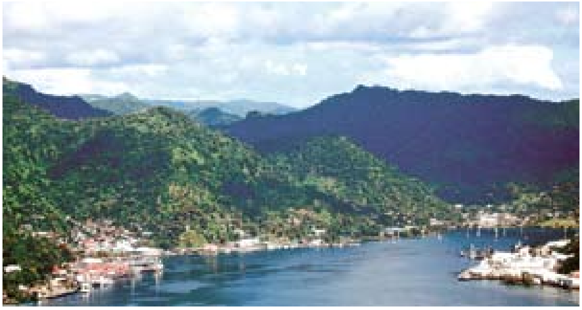
Designing MPA networks using local knowledge and customary management practices (when possible) are important elements of a precautionary design, and can be accessed in situations when limited "formal" data has been acquired. Local practices can be similar to a precautionary management approach because they offer empirical knowledge and governance institutions, which can complement (or be used in lieu of) scientific data and statutory law, and can further be used to design and enforce conservation efforts (Aswani et al. 2007). When designing MPA networks, there may be temptation to delay action to gather more scientific information. Such delays only make the development of MPA networks more difficult and costly. In some cases, delays can cause further degradation to the marine resources that the network is intended to conserve, potentially adding to the long-term difficulty and cost of achieving management goals. Ultimately, delaying MPA design and implementation rarely, if ever, benefits marine conservation.

Integrated management frameworks

MPAs are affected by the larger ecological, social, economic and political context of the island or coast and ocean of which they are a part. Human activities that lie outside of boundaries of the protected area, ranging from marine transportation and fishing to land-based actions (e.g. agriculture, coastal development and industry), have a profound impact on the MPAs and the benefits they can deliver. In the absence of mechanisms to buffer MPAs against exogenous sources and high-use areas, even well-managed MPAs are subject to continuous and cumulative stress which undermines the overall effectiveness (Christie et al. 2005). When developing effective MPA networks within a broader coastal and ocean framework, designers should consider:

- Political and jurisdictional complexities of authority (ocean, coastal and terrestrial).
- Proximity of rural and urban populations to the coast and the level of dependency and impacts on marine and coastal areas.
- Competing user group use patterns.
- Unique and diverse ecological value of the areas.
- Use patterns of terrestrial environments.

A hierarchy of planning and management scales must be developed to encompass the range from national frameworks to regional and local coordination to site planning. Such



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The broader coastal framework needs to be considered in the development of the MPA network. A "ridges to reefs" approach is an integrated management framework which incorporates impacts, uses and ecological aspects outside the immediate marine habitat. Pago Pago, American Samoa.

efforts cannot focus solely on coastal and ocean systems, but must be coordinated with terrestrial management, since land-based uses can greatly affect marine environments. A spatially based planning approach will help coordinate and improve management, separate conflicting uses, and ensures appropriate spatial allowances for industry, wildlife and healthy ecosystems. Collaborative, flexible and transparent planning and management processes are integral to the success of these frameworks, especially since ecological boundaries rarely align with jurisdictional or political ones. One way to ensure consistency across jurisdictions is to develop complementary management strategies that retain independent authority, such as rules and regulations.

Integrating the network into the economic and socio-cultural setting of an area involves identifying economic opportunities that are compatible with the network's social and ecological goals. This involves assessing the socio-cultural, economic and ecological values related to all scales of local, national and regional economic settings. Socioeconomic valuation should identify the changes in current and potential resource use, those benefiting from such uses and those disadvantaged by them. Discussions with affected user groups about alternative sources of income and livelihoods help develop consensus about future economic goals.

Promoting the use of sustainable technologies and industries in MPA networks provides an opportunity to derive significant economic benefits and to support sustainable economic development. Opportunities for cultivating sustainable practices include using "green" buildings to house network managers and employees, promoting certified sustainable aquaculture or partnering with restaurants that serve sustainable seafood.

Adaptive management measures

Adaptive management means using the best available information to develop the MPA network and incorporating monitoring and evaluation systems to systematically test the effectiveness of management methods and refine them over time (Figure 5). The availability of scientific information changes over time. As science evolves and new information is distributed, MPA guidelines and strategies should be modified, if changes are warranted. To do this, the management (institutions and stakeholders) needs to be adaptive. Adaptive institutions are those that are able to deal with dynamic and fluctuating ecological conditions and resources and recognize the range of users and the trade-offs between them; and which can learn from and adapt to experience (Brown 2006).

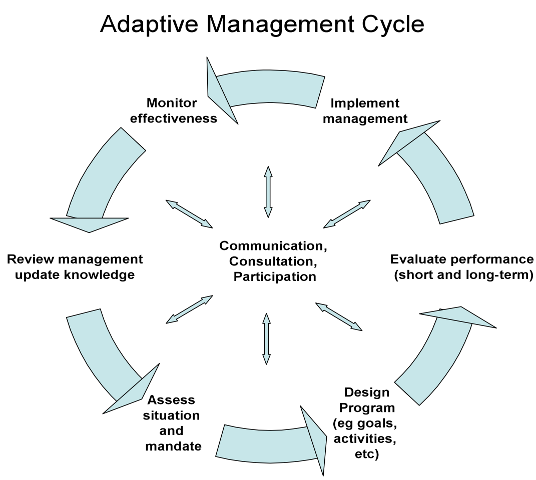

Figure 5 Adaptive management cycle
(Salafsky et al. 2001)

Adaptive management entails incorporating network monitoring protocols into the framework from the earliest stages of development. Monitoring techniques, many of which are continually being developed to improve design and implementation in the face of uncertainty, provide a valuable method to update and refine management strategies. In order to adjust management decisions, re-formulate objectives and find the most effective ways of addressing MPA network priorities, managers must establish an evaluation plan in each step of the management process: during the definition of objectives, the selection of management methods, the definition of the network's scale, and during fundraising and budget allocation.

Key Concept

An adaptive management approach enables a flexible and timely decision structure that allows for quick management responses to new information about, or changes in, ecosystem conditions, fishing operations, community structures or any other issues that may be revealed.

Evaluating management effectiveness requires the identification of appropriate indicators to measure success and establish long-term databases. For example, at the national level, planners and managers should adopt performance indicators to measure MPA network goals and objectives and institutionalize the indicators within the national or local management plans. At the global level, planners and managers should establish a follow-up expert group to monitor advances at the regional level and to develop mechanisms to assess progress and address new issues. Indicators should be specific enough to be measured consistently and flexible enough to adapt to changing circumstances. Table 16 provides a comprehensive list of links and various tools available for monitoring and assessment of management effectiveness to support adaptive management.

Adaptive management can also be used to improve management capacity, particularly through professional development programs for network managers and staff. Management capacity-building training within a network of MPAs provides a forum for sharing knowledge, expertise and lessons learned among sites, as well as opportunities for coordination and communication with MPA managers and planners outside of the network. Another important component of adaptive management is the emphasis on local participation through the incorporation of indigenous common property institutions, customary management practices and ecological knowledge in community-based conservation regimes (Aswani et al. 2007). Incorporating local knowledge into the decision-making process and creating community-based resource management systems can be an adaptable method for MPA design and management.

Example from the field – Adaptive management measures at Nusa Hope MPA, Western Solomon Islands. Following the establishment of the Nusa Hope MPA, in 2002, it was realized that a species of grouper spawning aggregation had not been incorporated within the boundaries of the MPA. Because the MPA was designed using local knowledge and sea tenure as elements of the precautionary and adaptive management approach, the system to modify the MPA was already in place to adapt the new information. Based on aggregation discovery, the community revised the management plan and extended the MPA to cover the aggregation. This type of flexibility is a result of employing ecological and social research techniques that supplement indigenous ecological knowledge (Aswani et al. 2007).

Chapter 5

Schooling jacks (Carangidae sp.) near the Solomon Islands in the South Pacific.

Five Ecological Guidelines for Designing Resilient MPA Networks

"The basic rules that govern marine systems must be the cornerstone of marine conservation..."

Five guidelines form the core of MPA network design[6] and can be addressed by employing specific planning and implementation approaches. These design principles should be applied in the context of emerging best practices and the broader considerations involved in making MPAs happen. The following guidelines are intended to provide a framework on which managers and planners can initiate, assess and modify the MPA network design to reach an effective MPA network:

1. Include the full range of biodiversity present in the biogeographic region.
2. Ensure ecologically significant areas are incorporated.
3. Maintain long-term protection.
4. Ensure ecological linkages.
5. Ensure maximum contribution of individual MPAs to the network.

Guideline 1: Include the full range of biodiversity present in the biogeographic region

In general, species diversity increases with habitat diversity, therefore the greater the variety of habitats protected, the greater the biodiversity conservation. MPA networks should aim to protect some of all habitat types found in each biogeographic region (PISCO 2007). MPAs that represent and replicate all habitat and community types within well-connected networks are more likely to lead to persistence and resilience in ecosystems and ecological processes in a changing world (Roberts et al. 2003). Components associated with this guideline include the following, which are expanded upon in detail below:

- Representation
- Replication
- Resilience characteristics

REPRESENTATION

MPA networks should represent the range of marine and coastal biological diversity – from genes to ecosystems – and the associated oceanographic environment within the given area.

Representation focuses on ensuring that all ecosystems and habitats within the region are represented in the MPA network. Representation at the habitat scale assumes that by representing all habitats, most elements of biodiversity (species, communities, physical characteristics, etc.) will also be represented in the network. Biodiversity changes locally, regionally and with latitude. To address the changes in biodiversity across space, each MPA should be carefully placed to capture the full diversity of habitat types and adjacent

6 In 2004, the Convention on Biological Diversity's (CBD) Ad Hoc Technical Experts Group on Marine and Coastal Protected Areas provided a list of design principles for developing MPA systems. The CBD design principles have provided a foundation for the list provided herein, while several of the key management approaches have been incorporated as planning best practices. Additional criteria have been supplemented based on discussions during the Coastal Zone '05 International Workshop *Establishing MPA networks: Making It Happen,* July 2005, among others.

linked habitats, and to include the diversity of the area. The physical factors such as oceanographic conditions, bathymetry and geology should also be represented within the network of MPAs. The concept of representativeness can also be expanded to include areas representative of cultural or heritage values, including iconic and spiritual areas.

The first step in planning for adequate representation is to assess the type and distribution of habitats and determine what biogeographic regions exist within the overall target area (Roberts et al. 2003). To identify representative and unique habitats to address conservation goals, a simple multidimensional classification of habitat, including but not limited to depth, exposure, substrate and dominant flora and fauna can be essential in design planning. Assessment of the habitat, in this manner, provides a proxy for species richness, enabling management decisions to be made regarding the value of the site as reservoirs of biodiversity in the absence of detailed species-level data (Roberts et al. 2003).

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Tropical coral reefs are a primary marine conservation target given their high biodiversity. Asia Pacific.

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The productive, diverse kelp forest ecosystems are a marine conservation target. When planning for an MPA network, kelp forests need to be represented. La Jolla, CA.

When assessing representation for MPA network design and planning, 3 universal factors should be considered:

- **Capturing the full range of biodiversity:** Each habitat supports a unique community and most marine organisms use more than one habitat during their lives. MPAs should contain many different habitats to maintain a full complement of biodiversity. Areas that contain several key biodiversity elements (e.g., rare habitats, high-quality habitats, areas with multiple contiguous habitats) should be targeted for protection.
- **Ensure representation across depth ranges and biogeography:** Biological communities vary across environmental and latitudinal gradients and with depth. To ensure protection of a multitude of species in a region and to protect species as they transition between habitats during their life stages, it is important to include a variety of depths and transition zones while planning for representation of habitat types throughout their biogeographic range within a network. MPA design should aim to capture the onshore-offshore or habitat-habitat ontogenetic (or life-stage) shifts of species.

- **Ensure ecosystem integrity:** MPAs need to be large enough and sited appropriately to protect and maintain ecological processes (such as nutrient flows, disturbance regimes, food-web interactions, etc.) that help to maintain biodiversity. Ecosystem integrity refers to the degree to which a given area (potential MPA site) functions as an effective, self-sustaining ecological unit. MPAs should be designed at an ecosystem level, recognizing patterns of connectivity within and among ecosystems. In general, an MPA which is designed to protect a diverse array of habitat types will also conserve the ecological processes and integrity of the ecosystem.

Example from the field - Planning for adequate representation through a regional assessment in the Western Caribbean, Mesoamerican Reef (MAR) Program. Scientists and planners performed a region-wide rapid reef assessment of MAR to identify priority conservation sites, based on the geographic distribution of ecologically significant areas, such as nurseries or feeding areas, that are functionally linked to reefs by physical and ecological processes. The regional assessment approach identified different reef habitats through the use of maps to characterize and estimate the extent of shallow coral reef ecosystems and through rapid reef assessment surveys. Distinct reef habitat types, communities of corals and associated organisms were identified to produce a classification scheme of reef types and major reef zones which helps to ensure more complete representation for biodiversity protection (Arrivillaga and Windevoxhel 2006).

The total area set aside for the protection of each habitat should be approximately related to its relative prevalence in the region (Roberts et al. 2003). Global targets for protection have helped to guide regional targets for MPA planning. It is estimated that in order to meet all fishery and conservation goals, networks of fully protected reserves should cover 20% or more of all biogeographic regions and habitats (Roberts et al. 2003; NRC 2000). Furthermore, the World Parks Congress calls for strictly protected MPAs covering 20 to 30% of each habitat to contribute to a global target for healthy and productive oceans by 2012 (IUCN 2005). Ultimately, the total area protected within an MPA will be based on the degree of threats to marine resources and the feasibility of the social, political, institutional and management environment.

REPLICATION

MPA networks should include replicates of each representative habitat within the biogeographic region.

Replication of habitats within MPAs in a network is important for several reasons:

- To provide stepping-stones for dispersal of marine species. Replicate MPA sites enable the dispersal of marine species between areas as populations exchange larvae with adjacent populations (Palumbi 2004). Replicate MPAs can be designed to accommodate dispersal patterns of species and facilitate connectivity between the sites.
- To provide a safeguard ("spreading the risk") against local environmental disaster (e.g. oil spills or other catastrophes) that can significantly impact populations and habitats in an individual, small MPA.

- To provide replicate sites and analytical power for studies on MPA effectiveness, such as changes in populations and communities inside and outside MPAs.

Example from the field – Rezoning process of the Great Barrier Reef Marine Park. The rezoning process for the Great Barrier Reef Marine Park considered a number of key planning principles. The final zone configuration for the GBRMP was guided by the Biophysical Operating Principles, which ensured that the resulting network was representative and comprehensive, and considered a range of fundamental planning and design principles. In particular, the zoning plan includes representation of a minimum amount of each community type and physical environment type in the overall network of no-take areas, including critical habitats (such as dugong habitat, turtle habitat and nesting sites) (Fernandes et al. 2005).

BIOPHYSICAL OPERATIONAL PRINCIPLES TO HELP ACHIEVE ECOLOGICAL OBJECTIVES OF REPRESENTATIVE AREAS (Fernandes et al. 2005):

Ensure local integrity: No-take areas should be at least 20 km long on the smallest dimension (except for coastal bioregions).

Maximize the amount of protection larger (vs. smaller) no-take areas have.

Replicate: Have sufficient no-take areas to ensure against negative impacts on some part of a bioregion.

Avoid fragmentation: Where a reef is incorporated into a no-take area, the whole reef should be included.

Set minimum amount of protection: Represent a minimum amount of each reef and non-reef bioregion in the no-take area.

Maintain geographic diversity: Represent cross-shelf and latitudinal diversity in the network of no-take areas.

Represent all habitats: Represent a minimum of each community type and physical environment type in the overall network.

Apply all available information on processes: Maximize the use of environmental information to determine the configuration of no-take areas to form viable networks.

Protect uniqueness: Include biophysically special/unique places.

Key Concept

Replication provides a safeguard against unexpected habitat loss or population collapse, whether that might be the result of a natural event or human disturbance.

The number of replicates of each habitat type must be a balance between ensuring representation and ensuring effective monitoring and enforcement (Airame et al. 2003). For large biogeographic regions, fulfilling the critical stepping-stone role may require more MPA replicates than for a smaller region. MPA networks are most effective when each habitat type is represented in more than one MPA, thus it is recommended that at a minimum three replicates of habitat type are included.

REPRESENTATION OF RESILIENT AND RESISTANT CHARACTERISTICS

MPA networks should be designed to maintain ecosystems over time, particularly in the face of long-term climate changes. Habitats that exhibit characteristics of resistance and resilience to climate change can be a vital component of MPA networks, since more resilient networks may be able to resist or adapt to long-term changes.

Resilience and resistance factors of a community can include both intrinsic factors (such as biological or ecological traits) and extrinsic factors (such as physical factors). In terms of MPAs, focus should be placed on areas which exhibit resistance and/or resilience factors relative to regional disturbance factors and climate change. This maximizes both strong and reliable recruitment of all species within the community and the likelihood that a portion of the recruits will seed surrounding areas.

Key Concept

Resilience: The ability of a system to maintain key functions and processes in the face of stresses or pressures by either resisting or adapting to change (Holling 1973; Nyström and Folke 2001). Resilience can be applied to both ecological systems as well as social systems.

Resistance: The ability of an ecosystem or species to maintain diversity, integrity and ecological processes during or following a disturbance (i.e. corals that resist bleaching or survive after bleaching events) (West and Salm 2003).

By protecting the full range of biodiversity and ecological processes across a range of environmental variation, networks of MPAs can help to provide healthier and more resilient ecosystems. In the temperate environment, there is increasing emphasis on the health of ecosystems as a key component in resistance to and resilience from climate change and other perturbations. Networks of MPAs that have the goal of maintaining or improving protection of ecosystem structure and function, as well as protecting the full-range of ecological processes, should provide healthier ecosystems that can buffer against climate change. In addition, representation of all habitats across a range of natural environmental variation in an MPA network will provide some accommodation for changes in species distributions, oceanographic conditions and ecosystem dynamics that may result from climate impacts. Reductions in life spans of targeted species, distortions of food webs and phase shifts in dominant organisms can all affect the ability of temperate systems to resist and recover from long-term perturbations (Steneck et al. 2002; Hughes et al. 2005).

In the tropical environment, determinants of resistance to coral bleaching have been identified and include physical factors that: reduce temperature stress, enhance water movement and flush toxins, decrease light stress and other factors that correlate with bleaching tolerance (Table 7) (West and Salm 2003). In the context of coral reefs, areas where environmental conditions enhance apparent resistance and resilience to bleaching events and other hazards such as storms should be incorporated into MPA networks (West and Salm 2003; Ledlie et al. 2007).

Table 7 Resistance factors of coral reefs

Physical factors that reduce temperature stress	Physical factors that enhance water movement and flush toxins	Physical factors that decrease light and radiation stress	Factors that correlate with bleaching tolerance	Indirect indicators of bleaching tolerance
Localized upwelling of cool water	Permanent strong currents (eddies, gyres, tides)	Shade (from high land profile, undercut coastlines or reef structure)	Temperature variability regime (warmer waters in shallow back-reef lagoons)	High diversity and abundance of reef species
Areas adjacent to deep water	Wind topography (narrow channel, peninsulas and	Steep slope from coral assemblages and structure points)	Frequent exposure and emergence at low tide	Wide range of coral colony sizes and species distribution
Regular exchanges (cooler waters replace warm water)	High wave energy	Presence of naturally turbid water		History of coral survival afterreplace bleaching
	Tidal range	Cloud cover		

(Mumby et al. 2007)

Maintaining resiliency and adaptability will become even more important over the coming decades in the face of accelerated climate change. While network design cannot solve the problem of climate change, it can help to promote ecosystem recovery and resilience by ensuring that a high proportion of MPAs within a network are free from extractive uses, habitat-altering activities and other stresses that will compound the impacts of climate change.

Key aspects of habitat representation and replication that should be considered in the design of MPA networks include:

- The first step in planning for representation is to assess the type and distribution of habitats within the region.
- It is important to include MPAs in both transition zones (between biogeographic areas) and core zones within each biogeographic unit.
- Representation of ecosystem processes is as equally important as the representation of all habitat types.
- The optimal number of replicates is a balance between ensuring adequate representation, minimizing socioeconomic costs, and effective monitoring and enforcement; generally for research studies at least three replicates are needed.
- Areas which exhibit characteristics associated with resistance/resilience should be incorporated where possible.

Guideline 2: Ensure ecologically significant areas are incorporated

Biologically and ecologically significant areas, such as unique habitats, spawning aggregations and nursery areas, play a crucial role in sustaining populations and maintaining ecosystem function and should be considered in MPA network design.

PROTECTION OF UNIQUE OR VULNERABLE HABITATS

Including unique places in the network will ensure that the network is comprehensive and adequate to protect biodiversity and the known special or unique areas (Fernandes et al. 2005). The presence of rare, endangered, relict or restricted-range species, or populations with unique genetic composition should be considered in MPA design. Some marine habitats are more vulnerable to natural and human impacts, such as rocky reefs, coral reefs, deep-sea cral communities, oyster reefs, salt marshes, seagrass beds and mangroves, and should be given special attention. Some sites warrant protection because they are unique in their biodiversity composition due to biophysical factors or degree of human impact.

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Sea turtle hatching beaches are critical habitat to consider in the MPA network design. Sangalaki Island, Indonesia

Example from the field – inclusion of habitat for vulnerable species. In the Great Barrier Reef Marine Park, dugongs (or sea cows) habitats (e.g. seagrass habitats, locations where previous research indicated significant numbers of dugongs on a regular basis) were specifically included in the identification process for the network of no-take areas (Dobbs et al. 2007).

PROTECTION OF FORAGING OR BREEDING GROUNDS

Many species utilize permanent foraging or breeding grounds. MPAs that are placed at these locations (i.e. roosting sites, nursery areas, foraging grounds, etc.) can offer protection for marine mammals, seabirds, fish, turtles, etc., by reducing human disturbances and interactions and by protecting the prey base and key habitat features important to specific areas. In some cases, limiting access to breeding grounds during breeding season can be an appropriate objective on of an MPA.

MARK GODFREY © 2004 THE NATURE CONSERVANCY

A sea lion colony on the coast at Huiro, an indigenous Mapuche-Huilliche community that borders the Reserva Costera Valdivian. This area is protected in the Nature Conservancy's Valdivian Coastal Reserve, a 147,500 acre reserve comprising temperate rainforest and 36km of Pacific coastline south of Valdivia, Chile.

PROTECTION OF SOURCE POPULATIONS

Protection of important sites for reproduction (nurseries, spawning areas, egg sources) and protection of areas that will receive recruits and be future sources of spawning potential are important targets for establishing self-sustaining MPAs. Fish spawning aggregations are critical in the life cycle of fishes that use this reproductive strategy and are vulnerable to overexploitation. Spawning aggregations are known to occur for over 120 reef species, in nearly 20 different families, including surgeonfishes, wrasses, goatfishes, parrotfishes, groupers, rabbitfishes and snappers (SCRFA 2007).

Larval "sources," if they can be identified, make better MPA areas than sink populations (Roberts 1997), regardless of whether the goal is biodiversity conservation or fisheries management. MPAs strategically located at areas with source populations can not only retain recruits and larvae to sustain local populations, but can also serve to export surplus larvae to other areas. Source areas functioning as a refuge from fishing for individuals

Key Concept

A source area is a habitat patch that tends to accept new individuals to the population but produces few of its own. In general, a source area shows no net change in population size but is a net exporter of individuals (Crowder et al. 2000).

Many grouper species form spawning aggregations, which should be identified and incorporated in the boundaries of the MPA. Nassau grouper. Bahamas, Caribbean.

of certain species lead to an increase in the number of larger, older individuals who carry an important role for reproduction in the community, and can also potentially act as sources of propagules for other areas (Allison et al. 1998; Botsford et al. 2001). Larval sinks, on the other hand, receive less benefit from protection and should be resilient to "recruitment" overfishing (Roberts 1997). MPAs located at sink populations often depend upon replenishment from outside areas, thereby diminishing prospects for long-term viability as well as fishery benefits if the source is removed or depleted (Pulliam and Danielson 1991; Roberts 1998; Stewart et al. 2003). Typically local knowledge can play an important role in identifying current or historic aggregations or source areas.

Key aspects of ecologically significant areas that should be considered in the design of MPA networks include:

- Critical areas to consider include: feeding grounds, breeding and spawning grounds, nursery grounds, areas of high species diversity, socializing areas, migratory routes, etc.
- Vulnerable marine habitats (e.g. rocky reefs, coral reefs, seagrass beds, mangroves, etc.) provide critical ecosystem processes and should be included in MPA network design.
- Including source populations (if they can be identified) in MPAs is desirable.
- Understanding the different needs of a target species in different life stages, as well as the risk of mortality in each stage, can help to determine which areas best act as refuges for these species and should be selected as MPA sites.

Guideline 3: Maintain long-term protection

Network design must provide long-term protection, including no-take zones, to effectively conserve diversity and provide ecosystem benefits; long-term arrangements for funding, management and enforcement are essential for effective management.

The use of MPA networks as a key strategy for long-term sustainability of marine ecosystems and the services they provide is dependent on areas of long-term protection. The time to accrue social, economic and environmental benefits can vary from a few seasons to decades, depending on the life history of target species, the condition of the ecosystem at the time of implementation level of enforcement and the effectiveness of management outside the MPA (PISCO 2007).

Fully protected MPAs (i.e. areas designated as no-take) have been shown to enhance fish biomass of fish species inside the MPA boundaries (Murray et al. 1999; Roberts et al. 2001; Halpern and Warner 2002). Throughout the tropical and temperate regions, MPAs have proven highly effective in rebuilding stocks of exploited organisms, suggesting that MPAs can increase population sizes of many species with protection and thus provide economic benefits (Figures 6 and 7). While some biological changes can happen rapidly, the full effects of an MPA may take decades to become apparent. Therefore, network design must provide long-term protection to effectively conserve and replenish resources and to generate an overall long-term economic benefit.

At **Sumilon Island and Apo Island** MPAs in the Philippines, the biomass of target fish inside the no-take reserve increased 3.1-fold over 9 years of no-take protection, and 4.6-fold over 18 years of no-take protection, respectively. Furthermore, biomass of large predatory fish (surgeonfish and jacks) increased almost 12-fold over 9 years of no-take protection at Sumilon Island and 17.3-fold over 18 years of no-take protection at Apo Island (Alcala and Russ 2006).

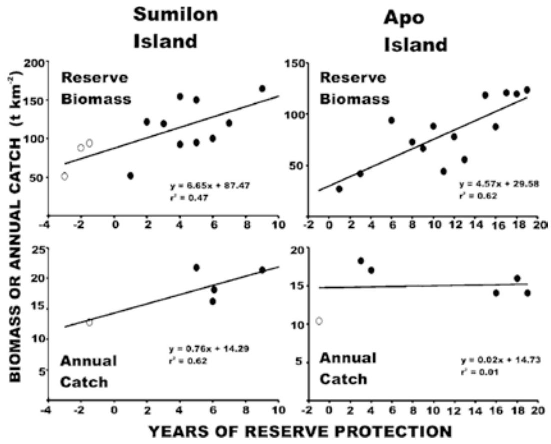


Figure 6 Biomass at Apo and Sumilon islands MPAs
Biomass of fish targeted by fisheries in the no-take reserve and fisheries catch of the fish outside the reserve, plotted against years of no-take protection .

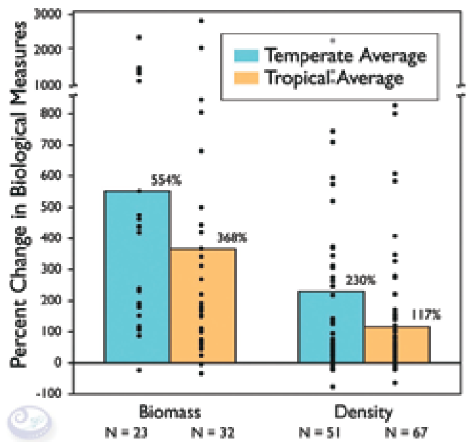


Figure 7 Average changes in biomass and density in temperate and tropical region MPAs
Average changes in fishes, invertebrates and seaweeds within reserves from temperate (blue bars) and tropical (orange bars) around the world. Changes varied among reserves (black dots), but most reserves displayed positive changes in both regions data: Lester et al. in revision; PISCO 2007.

SPILLOVER OF LARVAE, JUVENILES AND ADULTS FROM LONG-TERM PROTECTION

Because most marine species produce larvae that disperse, resulting in "open" populations that are replenished by both local and distant sources of recruitment, populations protected within MPAs have great potential to replenish areas outside MPAs (Botsford et al. 2003). Long-term, especially no-take, MPAs can not only positively affect the biomass, abundance, size and diversity of some species within the MPA, but those impacts can also extend outside the boundaries. With protection from exploitation within an MPA, fish and invertebrates will be able to live longer and grow larger. Larger fish generally have greater egg production per spawning event than smaller ones (Figure 8). For example, a 10-kg snapper produces the same amount of eggs as 212 one-kg snappers (Bohnsack 1990). A greater abundance of fish within the MPA will result in increased egg production, and successful recruitment inside and outside of MPAs. Higher densities of fish inside MPAs can result in emigration of adults to outside areas. At no-take MPAs on the Great Barrier Reef, batch fecundity, longer spawning seasons and potentially greater larval survival due to larger egg size from bigger individuals were observed compared to fished areas (Evans et al. 2008).

Fisheries that have benefited from the spillover of juveniles and export of eggs and larva have been documented from MPAs throughout the world (Gell and Roberts 2003; Halpern 2003; Abesamis and Russ 2005; Bartholomew et al. 2007). However, it can often

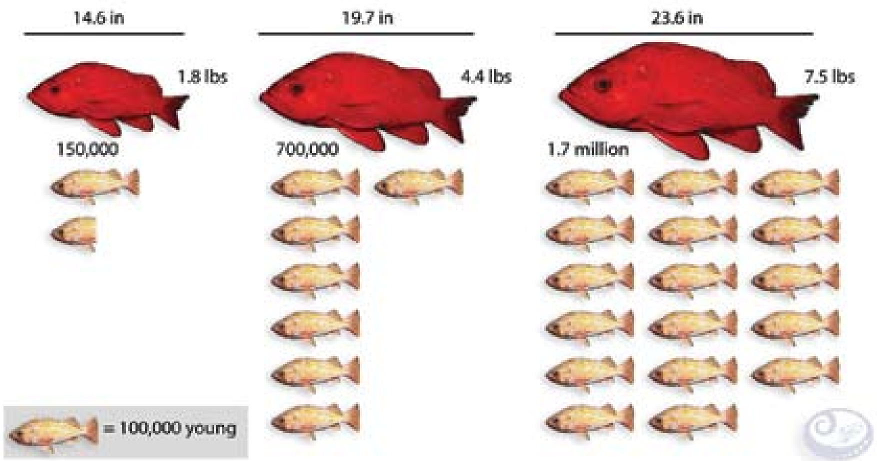


Figure 8 Average numbers of young produced by mature fish
The number of young produced by vermillion rock fishes increase with the size of the adult. (Data: Love et al.1990; PISCO 2007)

take years for the signs and benefits of spillover to occur. Potential scales of spillover vary across species and ecosystems. Fish tagging and movement data from coral reefs suggest spillover may extend a few hundreds of meters to a few kilometres from reserves. In contrast, spillover for more mobile species in systems such as estuaries, rocky reefs and continental shelves, can reach tens to hundreds of kilometres (Gell and Roberts 2003).

Key Concept

Enhancements in growth, reproduction and biodiversity in an MPA can replenish fished areas when young and adults move out of the MPA (PISCO 2007). *Spillover* from an MPA accounts for 2 types of movements outside the MPA:

1. Adults and juvenile animals swim into adjacent areas.
2. Young animals and eggs can drift out from the MPA into the surrounding waters.

ADAPTIVE STRATEGIES TO LONG-TERM PROTECTION

While establishing permanent or long-term MPAs is critical to the success of large-scale marine conservation measures (Cinner et al. 2005), it is not always the most viable management tool. Providing effective enforcement and compliance for long-term protection can be an overwhelming task, especially when financial resources are limited, capacity is weak and the resource users are not aligned with the need for strict protection. Long-term MPAs can displace fishers who have traditionally or historically fished in an area that becomes off limits. This may result in increased conflict over natural resource use where biological successes can be disrupted with social failures (Christie et al. 2005; Christie et al. 2007; Christie and White 2007). Strategies being used to avoid undue social conflict and ecological damage include: 1) making MPAs smaller than are optimal for complete ecological success (this entails some compromises to accommodate to social situations; 2) engaging resource users in a manner that raises awareness and brings local ownership to the protection of closed areas; and 3) rotational or seasonal closures so that a managed area is occasionally opened to fishing as an alternative to permanent closures.

For MPAs that have a goal of fisheries management, seasonal closures may beneficially be applied to species that have a well-defined reproduction cycle. Adaptive periodic closures can increase fish biomass and average fish size (although well below the levels that might be expected for unexploited ecosystems), and can enhance the harvest potential through management. In situations where there are specific social and economic factors (such as low human population density, decentralized and flexible control of marine resources, high adherence to traditions and relatively low dependence on fisheries), adaptive periodic closures are one of the many potential tools in the effort to conserve resources and enhance fisheries (Cinner et al. 2005).

Key aspects of long-term protection that should be considered in the design of MPA networks include:

- Whether the goal of the MPA site or network is fisheries management or biodiversity conservation, having long-term, permanent, no-take closures provides the greatest level of ecological protection and benefits.
- Through long-term protection, the maintenance of larger, older, longer-living fish is possible, resulting in increased egg production.
- In order to develop dynamic MPAs and MPA networks for highly migratory species, “bottlenecks,” or areas with certain oceanographic features related to key behaviors (feeding, breeding, and socializing) should be protected both spatially and temporally (depending on season of focal species use).
- Adaptive periodic closures may be a more viable conservation strategy in some cases; however they will not be as effective as permanent closures and may incur more management costs. Non-permanent closures should be limited to situations with specific socioeconomic characteristics and where permanently closed MPAs are unrealistic.

Guideline 4: Ensure ecological linkages

MPA network design should seek to maximize and enhance the linkages among individual MPAs and groups of MPAs within a given network.

CONNECTIVITY

A key premise of a network is that individual MPAs interact through ecological linkages. These linkages may include (White et al. 2006):

- Connections of adjacent or continuous habitats such as coral reefs and seagrass beds, or among mangrove and seagrass nursery areas and coral reefs.
- Connections through regular larval dispersal in the water column between and within MPA sites.
- Regular settlement of larvae from one MPA to another MPA that promotes population sustainability.
- Movements of mature marine life in their home range from one site to another or because of regular or random spillover effects from MPAs.

Key Concept

Connectivity describes the extent to which populations in different parts of a species' range are linked by the exchange of eggs, larvae recruits or other propagules, juveniles or adults (Palumbi 2003).

Connectivity between 2 populations is dependent on the larval characteristics of the species (e.g., competency period, dispersal duration and swimming behavior), the health and abundance of the source population, the permeability of the intervening environment (speed and direction of the ocean currents, temperature, salinity, etc.), and the availability and suitability of downstream habitat (Treml et al. 2007). Sediments, nutrients, plankton, animals and pollution are distributed from their origins up and down coastlines and across oceans, and different habitats are connected by the species that transfer between them. For example, the connectivity between mangroves, seagrass and coral reef systems provides a functional role; mediating the exchange of resources and providing critical habitat for certain life history stages of species that move between those habitats through their life stages (Mumby 2006). Therefore, contiguous habitat systems and adjacent habitats tightly linked through the flow of matter, energy and organisms, are also important connectivity considerations for network design (Granek 2007).

Key Concept

A number of reef fish in different feeding guilds use mangrove and seagrass habitats as juveniles, and coral reefs as adults (Mumby 2006). For example, adult groupers spawn in aggregations on the shelf in water depths of 25 to 50 m. After an extended larval period, juveniles settle in mangrove estuaries, remaining there for up to 7 years before moving to the shallow reef. An MPA designed to protect the various life stages of this species must consider all habitats in the life cycle.

MPAs in a network need to be arranged in a way to protect and secure connectivity of populations within protected areas, between protected areas and in adjacent habitats (Roberts et al. 2006). Patterns of connectivity in a network of MPAs are important in understanding the supply of adults and larvae into and out of an MPA (Palumbi 2003). The design of MPA networks to incorporate connectivity requires some estimates of larval dispersal distances, adult movement patterns, habitat distribution and patchiness, and oceanographic conditions.

ADULT MOVEMENT PATTERNS

Ocean neighborhoods are defined as the area centered on a set of parents that is large enough to retain most of the offspring of those parents. The scale of ocean neighborhoods is key to understanding how marine species make use of the seascape, and is therefore fundamental for management strategies (Palumbi 2004). If adults of a species move widely, the neighborhood is large and diffuse. In contrast, if adults are sedentary and larvae are restricted in their dispersal, then an ocean neighborhood might be small and distinct. Species with sedentary adults and dispersed larvae may have large neighborhoods if long distance dispersal is common or small neighborhoods if long distance dispersal is rare (Palumbi 2004).

Key Concept

Adult species movement patterns vary greatly. To protect a range of species within the MPA network, a range of adult movement patterns needs to be considered in the size of MPAs in the network.

One approach to incorporate adult movement patterns and connectivity into the MPA network is to design the size of the individual MPAs based on adult neighborhood scales of highly fished species to ensure that at least some adults remain protected during their adult life stage, and to space the MPAs based on larval neighborhood scales (Palumbi 2004). Spatial management of marine populations over scales of 10 to 100 km may be sufficient to cover the adult neighborhood sizes of a large fraction of species, particularly those species important for commercial harvest (Table 8). Ultimately, accommodating

Table 8 Approximate adult and larval neighborhood sizes

Movement range (km)	Adult	Larval
> 1000s	Large migratory species	Many species
100s – 1000s	Large pelagic fish (e.g. blue fin tuna)	Some fish
10s – 100s	Most benthic fish; smaller pelagic fish (e.g. mackerel, kingfish)	Most fish; most invertebrates
1 – 10s	Small benthic fish; many benthic invertebrates	Algae; planktonic direct developers, few fish
<1	Sessile species; species with highly specialized habitat needs	Benthic direct developers

(Adopted from Palumbi 2004)

species with the largest adult movement patterns should also protect species with smaller adult movement distances. For example, MPAs designed to ensure self-seeding for species that move up to 100 km as adults should be sufficient for self-seeding of species that move only 10 km as adults (Palumbi 2004).

For species with low dispersal, small MPAs may be sufficient, yet may be susceptible to local extinction and low recruitment. As illustrated in Figure 9 through a simple representation, connectivity builds as the number of MPAs and their coverage increases (Roberts et al. 2006). With few MPAs, the network is highly fragmented and only local clusters of MPAs are interconnected. With an increase in coverage, the MPAs are linked to many others either directly or through a series of stepping-stone recruitments events.

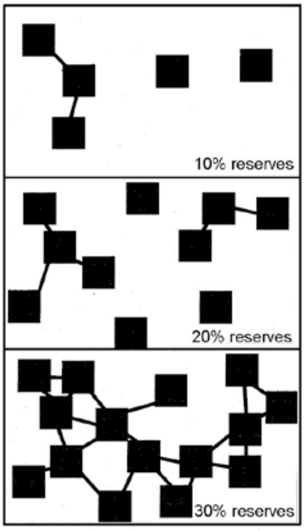


Figure 9 Number of MPAs builds connectivity
Each reserve (represented by a black square) covers 2% of the management area. Links between MPAs are displayed for those reserves ≤ 25 km apart, indicating connections between the network for species with a 25 km dispersal range. The network in the top box, with 10% coverage, is highly fragmented. Connectivity increases with coverage until, in a network of reserves covering 30% of the management area (bottom box); all reserves are linked (Roberts et al. 2006).

Protection of migratory species

Large migratory species have the largest neighborhood sizes. For example, baleen whales and most marine turtles disperse widely, travelling over 10,000 km in a year. There has been little consideration of designing MPA networks to protect marine megafauna whose survival requires access to large oceanic pelagic areas. The design of MPA networks that protect highly migratory species, such as marine mammals, turtles and tuna, should take into consideration permanent protection of the spaces in the pelagic zone related to some key life history patterns, including breeding, feeding and nursery areas, as well as migratory routes. Because some of these elements fluctuate, for example with currents and upwelling patterns, MPA networks can be designed in dynamic ways that include a mixture of permanent spatial closures with temporal closures that fluctuate (Hyrenbach et al. 2000). Developing dynamic temporal and spatial MPAs and MPA networks for highly migratory species, including certain oceanographic areas related to key behaviors, will provide an additional approach for ocean basin protection (Hyrenbach et al. 2000). For example, critical cetacean habitats, such as those at the specific seamount at the tip of the Willaumez Peninsula, were included in the Kimbe Bay Marine Reserve Network design (Green et al. 2007).

LARVAL DISPERSAL

Physical oceanographic processes and larval behavior combine in different ways to produce an extensive variety of larval dispersal patterns among different species. The distances that larvae disperse depend on several factors which act synergistically over the larval duration period including behavior, drifting duration, food resources, predators encountered (which affect survival, condition and growth rates) and influences of currents or other oceanographic factors (Mora and Sale 2002).

Key Concept

To compensate for constantly changing ocean conditions, MPAs should be located in a wide variety of places in relation to the prevailing currents (Roberts et al. 2001). Also, where currents are complex, with eddies or reversing, an even spread of reserve locations is recommended.

Water currents that transport organisms from one location to another help facilitate connections between populations, but do not necessarily determine them. There is little doubt that many species make use of currents as vectors of dispersal, but most species are not thought to ride them passively. Instead they behave in ways that interact with prevailing currents to enhance their probability of future survival (Leis and Carson-Ewart 2003; Leis 2006). In places where currents are strongly directional, MPAs sited in upcurrent locations will be more likely to support recruits to the downcurrent areas (Roberts 1997). Similarly, it is important to consider the direction of water flow and transport, as well as water quality (or activities that might affect water quality) "upcurrent" of the MPA (Allison et al. 1998). The degree to which larval behavior influences biophysical dispersal potential and local retention is considered to be highly species-specific (Cowen et al. 2000; Mora and Sale 2002).

One approach to account for larval dispersal in MPA design is to match the spatial scale of MPAs to the spatial scale of larval dispersal (ensure that the MPA is large enough to be self-seeding to sustain the population) and to space MPAs, with the appropriate habitat for that species, at a distance that will allow for connectivity of the populations (Palumbi 2004; Jones et al. 2007). In practice, this design approach is possible when the pattern of species dispersal is known or can be estimated for a target species, enabling protection for source populations. While data may not be available on larval dispersal distances of all or even many species, patterns of larval dispersal can be applied to identify a range of dispersal distances expected within species in the region. Generally, various species in a community display a range of larval dispersal distances that can be evaluated to estimate MPA sizes and spacing that may accommodate the dispersal distances of either focal species or the broadest range of species. The specific pattern of larval dispersal of any particular species is not as important for the MPA network design as the sum of all the patterns of larval dispersal for all the species of concern.

Further, technological advances in genetics, modelling and otolith chemistry, coupled with a recognition of the importance of behavior, mortality, physical variability and oceanographic features have all indicated that larval ranges are much smaller than previously suspected and long-distance dispersal may be unusual (Palumbi 2004; Cowen et al. 2006; Almany et al. 2007; Becker et al. 2007; Jones et al. 2007). For example, local retention of reef fish larvae is found to be more prevalent than previously thought, even in species with long larval durations (on the scale of 1 to 100 km) because of localized currents, eddies and various topographical influences.

Figure 10 shows the scales of larval and spore dispersal distance for marine plants (13 species), invertebrates (51 species), and fish (26 species) estimated from a compilation of genetic data of species around the world (Kinlan and Gaines 2003). Scales of larval movement vary enormously among species. In the study, genetic data indicate relatively wide marine invertebrate dispersal from <1 to 100 mi, 1 to >100 mi for marine fish larvae, while seaweeds do not disperse as widely.

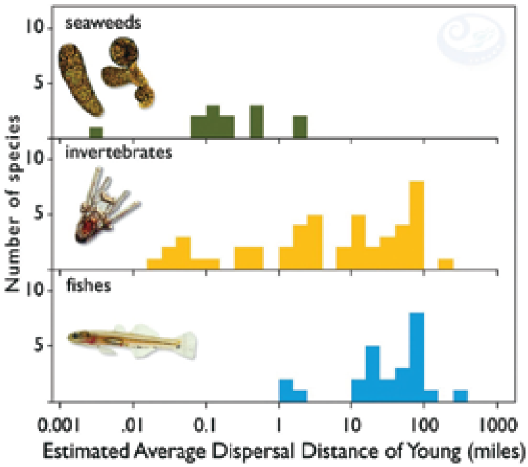


Figure 10 Estimated dispersal distance by organism group (Kinlan and Gaines 2003).

Coral larvae dispersal patterns can be used to estimate distance ranges for consideration in the MPA design. Coral spawning at Flower Garden Banks National Marine Sanctuary, Gulf of Mexico.

Example from the field – Ensuring ecological connectivity in a statewide network of MPAs in California (USA).

The California Marine Life Protection Act (MLPA) currently being implemented in state waters in California has an explicit goal of ensuring that MPAs function, to the extent possible, as a network. The MLPA Science Advisory Team has developed a set of science guidelines for the stakeholders charged with designing proposals for arrays of MPAs within each of the 5 study regions in California that will ultimately form the statewide network. These include guidelines on size and spacing of MPAs to promote ecological connectivity. The size and spacing guidelines are based on the best available scientific data on the patterns of adult movement and larval dispersal of species likely to benefit from MPAs; patterns of movement or dispersal vary broadly from a few meters to hundreds of kilometers for species found along the California coast. The size and spacing guidelines need to be considered together to ensure that MPAs are large enough to protect adults of species that move short to moderate distances and to allow for self-seeding of short-distance dispersers. The MPAs should be spaced to ensure that larvae from as many species as possible can reach other MPAs with appropriate habitat. The MLPA size and spacing guidelines are (CDFG 2007):

SIZE GUIDELINES

- **Size Guideline #1:** For an objective of protecting adult populations, based on adult neighborhood sizes and movement patterns, MPAs should have an alongshore span of 5 to 10 km of coastline, and preferably 10 to 20 km. Larger MPAs are required to fully protect marine birds, mammals, and migratory fish.
- **Size Guideline #2:** For an objective of protecting the diversity of species that live at different depths and to accommodate the movement of individuals to and from shallow nursery or spawning grounds to adult habitats offshore, MPAs should extend from the intertidal zone to deep waters offshore [note California state waters extend 3 nautical miles offshore].
- **The combination of size guidelines #1 and #2** result in a size range recommendation of a minimum size of 25 km^2 [5 km alongshore by 5 km offshore] to a preferred size of 45 to 100 mi^2 [9 to 20 km alongshore by 5 km offshore].

SPACING GUIDELINE:

Spacing Guideline: For an objective of facilitating dispersal of important bottom-dwelling fish and invertebrate groups among MPAs, based on currently known scales of larval dispersal, MPAs should be placed within 50 to 100 km of each other.

California's Central Coast Marine Protected Areas extend from Pigeon Point (San Mateo County) south to Point Conception (Santa Barbara County). The series of 29 marine protected areas represent approximately 204 square miles (or approximately 18%) of state waters in the Central Coast Study Region. http://www.dfg.ca.gov/mlpa/ccmpas_list.asp#anonuevo

Key aspects of ecological connectivity that are important to consider in the design of MPA networks include:

- Connections between functionally linked habitats due to species life cycle patterns, such as coral reefs, seagrass and mangroves, should be incorporated into the network design.
- When larval retention and connectivity are incorporated into the design of MPA networks, optimal outcomes rely on whether the overall goal is to maximize benefits within MPA boundaries, beyond the boundaries or a balance between the two.
- Connectivity is more local than previously thought; recent results indicate smaller dispersal distances on average.
- To ensure that populations are connected and therefore more resilient, the spatial scale of MPAs should match the spatial scale of larval dispersal of many species.
- Connectivity is not only a function of the distribution of MPAs and their sizes, but also the distribution of the habitat type provided in each MPA.

Guideline 5: Ensure maximum contribution of individual MPAs to the network

The size, shape and spacing of the MPAs in the network greatly influence the connectivity in the network, the degree to which there are edge effects and the ease of enforcement of the MPAs.

SIZE

To provide any significant protection to a target species, the size of an individual MPA must be large enough to capture the home-range sizes of many species, as well as allow for self-seeding by short-distance dispersers. The choice of any MPA size determines the subset of species that will potentially benefit; generally, larger MPAs provide benefits to a wider diversity of species than smaller MPAs.

Key Concept

MPAs will be most effective if they are substantially larger than the distance that individual adult and juvenile fish and invertebrates move. MPAs that are larger in size will capture the adult movement ranges and larval dispersal distances of more species than small MPAs. Although small-sized reserves can certainly have positive impacts, larger MPAs provide a benefit to a wider diversity of species. A network of smaller-sized MPAs can be a viable alternative to one large MPA.

As MPA size increases, the potential fisheries benefit from spillover and larval production will increase, but only to a certain point, and only if those targeted species are protected in the MPA and exploited outside the MPA. The criteria for choosing MPA size to maximize catch in surrounding waters are different from those used to design an MPA for conservation goals. If the MPA is too large, spillover and export will no longer offset the losses to fisheries due to the reduction in fishing grounds (PISCO 2002; 2007). Therefore, minimum MPA size constraints should be set by the more mobile target species common to a given area, while acknowledging that some wide-ranging species may not benefit from even very large MPAs (CDFG 2007). For example, for sedentary animals living on coral reefs, reserves of <1 km across have augmented local fisheries, especially when established in networks (Galal et al. 2002)). For more mobile estuarine fish, larger MPAs in Florida, for example, (16 and 24 km2) have sustained spillover to local recreational fisheries for decades (Gell and Roberts 2003).

Another consideration in terms of the optimal size of an MPA is management effectiveness. A smaller MPA is easier to enforce, and the monitoring efforts are less demanding. Larger MPAs may take longer to establish and implement and require greater financial support than smaller MPAs. From the perspective of fisheries, networks consisting of many smaller MPAs may be preferable to a few very large MPAs. The benefits of several smaller MPAs will spread the benefits more widely over the management area (Roberts and Hawkins 2000).

Example from the field – Cousin Island MPA in the Seychelles. If inappropriately sized or placed, even an established and well-managed MPA may not be resilient to anthropogenic stresses and have the ability to recover from disturbances. The localized benefits of small MPAs may become ineffective if those areas in protection are not resilient to global disturbance events (i.e. coral bleaching). The complexities of trophic interactions on coral reefs and the impacts of multiple stressors in MPAs do not necessarily result in protection of ecosystems. The 1.2 km^2 Cousin Island MPA in the Seychelles, exhibited a dramatic phase shift from coral to macroalgal dominance, accompanied by a collapse in reef structure despite the full protection of herbivorous fish in the well-managed MPA, in the face of a coral bleaching event. The lack of resilience in Cousin MPA and the consequent phase shift from a coral to macroalgal-dominated reef system suggest that individual, small-scale protected areas may not be successful on their own (Ledlie et al. 2007).

SPACING

The exchange of larvae among MPAs is a fundamental biological rationale for MPA networks. Movement out of, into and between MPAs by adults, juveniles, larvae, eggs or spores of marine species depends on their dispersal distance, and guides spacing aspects of MPA network design. In general, the lower the effective dispersal of a species, the closer the MPAs will have to be to provide benefits to unprotected areas (Jones et al. 2007). MPAs that are more closely spaced can be ecologically connected and serve to protect a greater fraction of species through movement of young and increased recruitment subsidies from other MPAs (PISCO 2007). Therefore, MPAs should be spaced appropriately to capture the broadest range of dispersal distances as possible.

Furthermore, the MPA spacing consideration also is habitat dependent. Habitat distribution patterns should influence where the MPAs are placed and how far apart they are spaced. Within the network, what matters is not spacing to the next MPA but spacing to the next MPA that offers suitable habitat for the target species (or range of target species).

SHAPE

Two key components of shape in the design of the MPA are 1) the concept of edge effects and 2) the enforceability of regularly shaped boundaries with clear landmark or coordinates (see Chapter 7, Enforcement and Compliance). It is important to consider the ratio of edge habitat versus core interior habitat, as the edges of MPAs are often extensively fished, and therefore do not offer the same refuge to fish species as core interior protected areas do (Willis et al. 2003). The more edge a reserve has, the faster it will export or spillover, relative to the total protected area (Roberts et al. 2001).

To ensure protection of the varied species in the MPA, it is important to include a variety of depths and transition zones while planning for representation of all habitat types within a network (Roberts et al. 2001). The shape of the MPA should aim to capture the onshore-offshore or habitat-habitat ontogenetic (or life-stage) shifts of species. For example, in the tropical environment, the shape of the MPA should capture the gradient from mangrove to reef; and in the temperate environment, the MPA should capture shallow to deep water movement of species over their life spans.

The shape is also a critical factor in the effective delineation and enforcement of the MPAs in the network. While evidence indicates that MPAs with boundaries that conform to natural habitat edges can better protect species than reserves with boundaries that cross reef habitat (Bartholomew et al. 2007), ease of compliance and enforcement capabilities need to be taken into account. Therefore, it is important to consider obvious reference points for ease of monitoring and enforcement as well as building awareness of boundaries with resource users (CDFG 2007). The most desirable shapes are squares or rectangles because they can be delineated by lines of latitude and longitude, and consequently are more easily identified by user groups (Meester et al. 2004). Furthermore, within an MPA network, it is convenient to eliminate the bias that may arise due to shape differences between individual MPAs. Within the range of possible rectangular shapes for MPAs, compact MPAs are preferred because MPAs with larger perimeters will likely

Natural boundaries, such as bays and headlands, can provide obvious reference points for MPA shape consideration, California.

"lose" more fish across the borders due to exploitation effects (spillover). For example, a 16 km^2 MPA can be designed as a 4 km square or a 64 x 0.25 km rectangle. The latter shape has 8 times the perimeter and is harder to implement, utilize and enforce (Meester et al. 2004).

The most important aspects of the ecological guidelines are summarized in Table 9. These guidelines should be applied within the local context and that will dictate to what extent they are implementable. Also, the social, economic, political and cultural attributes of an area need to be balanced with the ecological considerations for the MPA network; ultimately, integration is necessary.

Key aspects to maximize individual MPA contribution to the network:

Size

- To ensure self-seeding of a reserve it should be as large as the mean larval dispersal distance of the target species (Shanks et al. 2003, Botsford 2001). Aim for MPAs that are 10 to 20 km in diameter across their minimum width.
- To meet both fishery and conservation goals, intermediate sizes of MPAs and a variation of sizes within a network is considered ideal.
- If the design is focused on target species, optimal sizing may differ depending on the particular species characteristics.
- One approach to network design is to establish the size of MPA based on adult neighborhood sizes of highly fished species, and space the MPA based on larval neighborhood scales.

Spacing

- To facilitate dispersal and promote connectivity between MPAs, MPAs should be placed appropriately to capture the middle range of dispersal distances. Spacing guidelines vary by habitat and region, with estimates ranging from 10 to 20 km of one another (Shanks et al. 2003) to 50 to 100km (CDFG 2007) to capture effective connectivity.
- MPAs should be spaced to capture the biogeographic range of variation in habitat and species.
- Variable spacing is better than fixed spacing when there are several small MPAs rather than a few large MPAs.

Shape

- The shape of the MPA should capture the gradient from onshore-offshore or habitat-habitat shifts of species of interest.
- A shape that allows for clear marking of boundaries for both resource users and enforcement personnel awareness may increase effectiveness. MPAs should be contiguous, compact and easily delineated.
- When designing shape for biodiversity conservation it is important to minimize edge habitat and maximize interior protected area. In contrast, for fisheries management, it is important to consider the type and spatial extent of the habitat bordering the MPA, since this will influence emigration (e.g. continuous habitat inside and outside of the reserve will enhance spillover effects (Carr et al. 2003)).

Table 9 Summary of ecological guiding principles to help build resilient MPA networks

Ecological Guideline	Strategies
1. Include the full range of biodiversity present in the biogeographic region	Representation: Represent a minimum of each habitat type and physical environment type in the overall MPA network.
	Replication: Have sufficient replication to safeguard against catastrophic events or disturbances.
	Representation of resilient and resistant characteristics: Chose sites that are more likely to be resistant or resilient to global environmental change.
2. Ensure significant areas are incorporated	Protection of unique or vulnerable habitats: Design MPAs to include biophysically special and unique places.
	Protection of foraging or breeding grounds: Design MPAs to include important areas for breeding feeding or socializing areas (rookeries, haul-outs, nesting, etc.).
	Protection of source populations: Design the MPA to include important sources of reproduction (nurseries, spawning areas, egg sources, etc.). MPAs located at source populations, when identifiable, can help retain recruits and larvae to sustain local populations, as well as serve to export surplus larvae.
3. Maintain long-term protection	Consider spillover: Spillover of adult and juvenile fishes and invertebrates can contribute to populations in fished waters outside MPAs, but may not be evident for years after protection. Spillover has been documented in MPAs around the world, including Saint Lucia, Kenya, the United States, Australia and the Philippines.
	Adaptive management: Include adaptive strategies in the MPA design which allow for adjustments as science evolves and community dynamics change. Design the MPA boundaries to be flexible in space and time so that they can be expanded or contracted, have seasonal or other time limits, be moved to different levels of protection, and so to be made more responsive to changing conditions (ecologically, social, economically).
4. Ensure ecological linkages	Connectivity: Recognize the patterns of connectivity within and among ecosystems (e.g. ecological linkages among coral reefs, seagrasses and mangroves).
	Consider adult movement and larval dispersal: Larval dispersal and adult movement vary greatly with species; design size and spacing of MPA network to maximize benefits.
	Consider adult movement patterns: Adult movement patterns and distances vary greatly with species, which influence the design of the MPA and response of species after the MPA is created.
5. Ensure maximum contribution of individual MPAs to the network	Consider size: Design individual MPAs large enough to: (1) accommodate the large-scale movement of adults and (2) include enough habitat for viable species and ecosystem protection.
	Consider spacing: Design network of MPAs to: (1) accommodate the long-distance dispersal of larvae and (2) capture the biogeographic range of variation in habitats and species.
	Consider shape: Design the shape of individual MPAs to: (1) take into account edge habitat (for biodiversity conservation it is important to minimize edge habitat and maximize interior protected area; in contrast, for fisheries management continuous habitat inside and outside of the reserve will enhance spill over effects); (2) maintain the latitudinal and longitudinal gradient in habitats and communities; and (3) facilitate enforcement.

Chapter 6

RICHARD HERRMANN

A man fishes at Jalama beach in Santa Barbara County, CA.

Case Studies of MPA Networks

"The test of our theory is measured results -- even if the number of replicates are few."

The following four case studies describe how the selected and evolving MPA networks are applying some of the principles and criteria that are important in well-designed networks. These highlight some of the practicalities and limitations to the use of all criteria in any given situation and that scaling up from single MPAs to networks of MPAs is only beginning and still in preliminary stages. The cases also illustrate how design and planning need to go hand-in-hand with field implementation so that learning from experience can occur and support an adaptive management approach.

Case Study 1

Case Study 1: Scientific design of Kimbe Bay MPA network, West New Britain, Papua New Guinea[7]

LOCATION AND BACKGROUND

Kimbe Bay is located on the north coast of the island of New Britain in the Bismarck Sea, West New Britain Province, Papua New Guinea (Figure 11). Kimbe is one of the Nature Conservancy's platform sites, where the aim is to establish a resilient network of MPAs. Kimbe is a large, well-defined bay with distinct boundaries. The bay comprises a wide variety of shallow (coral reefs, mangroves and seagrasses) and deepwater marine habitats (oceanic waters and seamounts) in close proximity. This provides an ideal opportunity to protect a wide range of high diversity marine habitats in one location.

Figure 11 Kimbe Bay location

CONSERVATION BASIS

Kimbe Bay is one of the most diverse and significant tropical marine ecosystems, composed of many habitat areas of high conservation value. It provides an excellent opportunity to establish an MPA network due to the unique combination of biophysical and socioeconomic characteristics, as well as its history of conservation activities. The bay is an integral component of the Bismarck Sea, which supports extensive high diversity coral reef ecosystems, critically important habitats for rare and threatened whales and sea turtles, and a productive tuna fishery. Kimbe is also part of the Coral Triangle, which is the epicentre of marine diversity and a global priority of conservation. While the Coral Triangle encompasses a large area (7,077,203 km^2), it comprises less than 2% of the world's oceans and yet it comprises approximately 30%[8] of the world's coral reefs, 76% of the coral species (Veron et al. in prep) and almost 40% of the world's coral reef fish species (Allen unpubl. data). As part of globally and ecoregionally significant areas, Kimbe Bay is a high priority for marine conservation and an ideal candidate for a MPA network to anchor a larger scale network in the Bismarck Sea.

NETWORK DESIGN AND APPROACH

The objectives of the Kimbe Bay MPA network are twofold: (1) to conserve marine biodiversity and natural resources of the bay in perpetuity and (2) to address local marine resource management needs. The scientific design of the Kimbe Bay MPA network is

7 All content for this case study is based on the report *Scientific Design of a Resilient Network of Marine Protected Areas* (Green et al. 2007). Available at http://www.reefresilience.org/pdf/Kimbe_Complete_Report.pdf

8 Percent based on WCMC coral reef atlas data.

based largely on a scientific assessment of biodiversity values and the identification of 15 Areas of Interest (AOIs or individual MPAs) that meet specific conservation goals. The scientific design of the MPA network was developed through a 6-step process, involving expert scientific advice, targeted research and monitoring, and an analytical design process (using marine reserve design software MARXAN). Specific design principles were defined which were used to design the network by taking into account both the biophysical and socioeconomic characteristics of the bay (Table 10).

Table 10 Application of design criteria, Kimbe Bay

Representation and replication criteria were accounted for by:
■ Conserving representative examples of each shallow-water habitat type and key oceanic habitats (seamounts).
■ Including a "sufficient" number and area of each habitat type.
■ Protecting 20% of each habitat type.
■ Aiming to protect at least 3 replicate areas of each habitat type, and spreading them out geographically to reduce the possibility that all areas will be affected by the same disturbance.
■ Choosing representative areas based on knowledge to maximize number of species protected.
■ Choosing sites that are more likely to be resistant or resilient to global change.
Critical area criteria were accounted for by:
■ Including key habitats including:
● Areas that may be naturally more resistant or resilient to coral bleaching.
● Permanent or transient aggregations of large groupers, humphead wrasses and other key species.
● Turtle nesting areas.
● Cetacean preferred habitats (breeding, resting, feeding areas and migration corridors).
● Breeding areas for crocodiles.
● Areas supporting high diversity.
● Areas supporting species with limited abundance/distribution.
● Areas that are preferred habitats for vulnerable species.
● Areas that contain a variety of habitat types in close proximity to one another.
Connectivity criteria were accounted for by:
■ Taking a system-wide approach that recognizes patterns of connectivity within and among systems (particularly coral reefs, mangrove forests and seagrass beds).
■ Where possible, including entire ecological units (e.g. whole offshore reefs, seamounts) and a buffer around the core area or interest. Where this wasn't possible, larger areas of continuous ecological units were included (e.g. coastal fringing reefs).
■ Maximizing acquisition and use of environmental information to determine best configuration, taking connectivity into account.
■ Using rules of thumb for MPA network design, i.e. where possible AOIs or MPAs were a minimum size of $10km^2$ (10 to 20 km in diameter) with a maximum spacing distance of 15 km between them.

The results of the MARXAN analysis identified priority conservation areas, which were used to identify broad AOI for inclusion in the MPA network. To ensure that the design principles and goals were applied successfully and to confirm that the network objectives would be achieved with these areas, the AOIs were refined using manual accounting. For example, AOI boundaries were modified to ensure that biological, socioeconomic and cultural interests had been taken into account. The outcome was the scientific design of the MPA network for Kimbe Bay (Figure 12), which highlights 15 AOIs where the Conservancy will aim to work with communities that own and manage marine resources within these areas through a detailed community-based planning process. Since communities are the marine resource owners and decision makers in Kimbe Bay, final decisions regarding the MPA network design will be at their discretion.

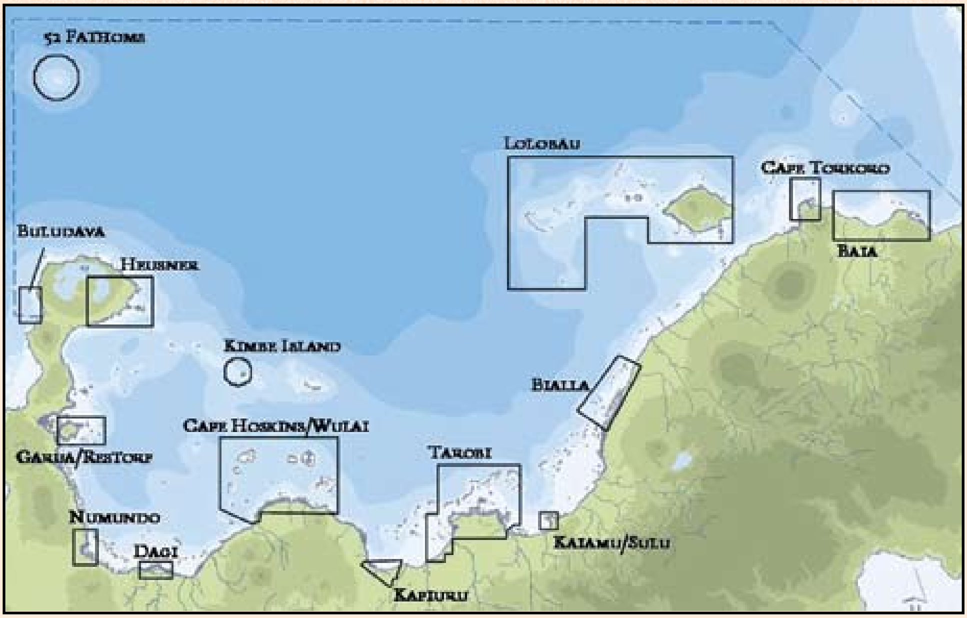


Figure 12 Reserve placement based on optimization analysis, Kimbe Bay
The figure shows the Areas of Interest (those boxed) for biodiversity conservation [Note: This is the end result of the whole process, not the MARXAN result.]

IMPLEMENTATION

The implementation process of the Kimbe Bay network design will require multiple strategies for working with local communities and government at a range of scales, and is expected to take 5 years or more to complete. The MPA network and the scientific design have been endorsed by all levels of the government in the region (local, provincial and national) and implementation is currently underway. A priority for the successful implementation of the design is sustainable financial planning for the establishment and long-term management of the MPA network. Additionally, long-term monitoring protocols will need to be incorporated for adaptive management application. For the MPA network to be successful, it will also need to be embedded in broader marine resource use and land use strategies

Case Study 2: Palau, Micronesia MPA Network[9]

LOCATION AND BACKGROUND

The Republic of Palau is an archipelago of 343 islands in the Micronesian region of the Pacific Ocean, 965 km east of the Philippines. Palau is composed of 12 inhabited islands and 700-plus islets, stretching 700 km from Ngenuangel Atoll in the Kayangel Islands in the north to Helen reef in the south (Figure 13). The archipelago consists of a clustered island group and the Rock Islands, and 6 isolated islands that lie approximately 340 to 500 km to the southwest. Palau has numerous islands and reef types, including volcanic islands, atolls, raised limestone islands and low coral islands. A barrier reef surrounds most of the main island cluster, from the north stretching down to the southern lagoon.

Figure 13 Map of Palau's main island cluster
(Map: A. Shapiro; accessed from [Golbuu et al. 2005])

CONSERVATION BASIS

With the most biologically diverse coral reefs, lagoons, mangroves and seagrass beds in Micronesia, the Republic of Palau is considered one of the "Seven Underwater Wonders of the World." Palau supports over 350 hard coral species, 200 species of soft coral species and over 300 species of sponges, covering over 500 km^2 of reef area. More than 1,300 reef fish types, vulnerable and endangered species such as the dugong, salt water crocodile, hawksbill and green sea turtles, and giant clams are found in the waters of Palau.

Over the past decade, considerable changes in coral cover on Palau's coral reefs have been observed, including wide-spread coral bleaching and coral mortality. In November 2003, the Palau Protected Areas Network (PAN) Act was signed into law. The PAN provides a framework for Palau's national and state governments to collaborate to establish a network of terrestrial and marine protected areas to protect areas of biodiversity significance, important habitats and other vulnerable resources that are essential for the future social, cultural, economic and environmental stability and health of Palau. The PAN allows for designation of protected areas under a variety of categories, ranging from full protection to multiple-use management areas.

9 Content for the case study is based on the following reports: *Biodiversity Planning for Palau's Protected Areas Network* (Hinchley et al. 2007); *Building a resilient network of protected areas in Palau* (Verheij and Aitaro 2006); *Palau's coral reefs show differential habitat recovery following the 1998-bleaching event* (Golbuu et al. 2007).

NETWORK DESIGN AND APPROACH

The PAN design is based on 4 broad, interrelated components: 1) effective governance and management, 2) building capacity, 3) sustainable financing, and 4) strong science. Two categories of design principles have been identified: 1) biophysical design principles and 2) socioeconomic design principles to guide MPA designation. The development of the nationwide PAN in Palau is a collaborative effort involving all the locally based environment-related agencies and organizations, local communities, state and national governments, and research organizations. It also involves a number of international agencies and organizations that are providing specific assistance. Ecological and biodiversity data have been collected by a number of agencies, including the Palau Conservation Society, Coral Reef Research Foundation and the Palau International Coral Reef Centre. Although data have been collected, there are still gaps in ecological and biodiversity data.

Attended by representatives of the main science and resource management agencies, the communities, and state and national government in Palau, workshops were held to initiate the development of a network plan. The workshops produced 2 outcomes: (1) an agreed set of Protected Area design principles, conservation targets, goals and stratification and (2) a range of PAN scenarios based on these data. To ensure effective representation across the study area, the total area was divided into 6 stratification units. The stratification approach was used to enable the effective capture of the full range of environmental, geographic and hydrological variation within each system, and also to spread the risk of the failure of any one area in the event of detrimental stochastic events.

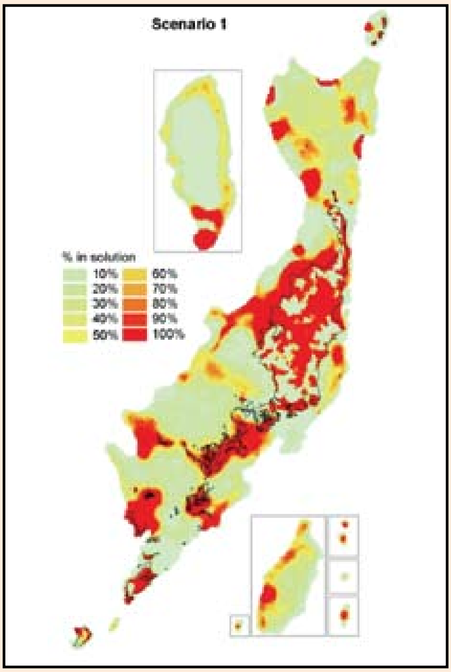


Figure 14 MARXAN scenario, Palau Network
This MARXAN scenario prioritizes areas for conservation to meet targets and goals, while not incorporating the existing protected areas. This is one of several MARXAN scenarios that can be used and evaluated when determining the appropriate protected area configuration, meeting all conservation, socioeconomic, political and cultural goals.

Incorporating the conservation targets, goals, stratification and costs deciphered from the workshops, 5 scenarios were developed in MARXAN to examine a range of options for the selection of areas that together would meet the conservation goals. Each scenario examined a range of options, taking into account well-defined measures of likely economic impacts of the reserve system, as well as existing protected areas, traditional areas and dive areas, for selection of areas that would meet conservation goals. Figure 14 illustrates one such scenario for the Palau MPA network, produced with MARXAN. This scenario allows MARXAN to search for areas to meet all conservation goals, without taking into consideration any existing or proposed protected areas. This scenario highlights the most important areas to achieve conservation goals.

The biophysical principles focus on maximizing the biological objectives of the network by taking into account key biological and physical processes, and the socioeconomic design principles focus on maximizing benefits to local communities and sustainable industries (Table 11). Connectivity is accounted for in the current design of the network through surrogates, due to a lack of detailed information on currents and larval dispersal patterns. The assumption is that sufficient representation and replication within the network design will help address connectivity issues. Several studies on the physical and biological characteristics and dynamics of the reef fish spawning aggregations and movements of fish larvae in Palau have been done which support connectivity uncertainties. Through these studies spawning aggregations can be quantified to produce a density measure of aggregated fishes that can be an additional data layer on bathymetry maps and aerial photos.

Table 11 Application of biophysical criteria, Palau MPA network

Representation and replication criteria accounted for by:
■ Conservation of representative examples of each biodiversity feature (conservation target).
■ "Sufficient" number and area of each habitat type included; geographically space them to reduce chance negative impacts.
■ Aiming to include 3 replicated areas representing or exceeding percentage goal of each biodiversity feature.
■ Choosing representative areas based on knowledge to maximize number of species protected.
Critical area criteria accounted for by:
■ Special and unique sites including: resident or transient species aggregations and nursery areas of groupers, humphead wrasse and other key species to ensure ecological processes.
■ Marine mammal and reptile preferred habitats (breeding, resting, feeding areas and migratory corridors).
■ Cetacean preferred habitats (breeding, resting, feeding areas and migration corridors).
■ Nesting and roosting areas given priority.
■ Areas that contain a variety of habitat types in close proximity to one another.
Connectivity criteria accounted for by:
■ System-wide approach taken, which recognizes patterns of connectivity within and among systems.
■ Including entire biological units (e.g. whole reefs, seamounts) and a buffer around the core area.

IMPLEMENTATION

Areas defined in the MARXAN scenarios identified those areas that are important for protection and management in Palau to reach the conservation goals. The use of MARXAN enabled network designers to prioritize conservation sites, providing several scenarios for consideration. However, the limitations of MARXAN, due to site specific data gaps, have been recognized. Due to limited data, the assessment was based primarily on coarse filter conservation targets. The existing targets form a solid foundation for the preliminary identification of areas of biodiversity for potential inclusion in the Protected Areas Network. However, for the next iteration, and prior to implementation, fine-scale targets and more detailed analyses will be required at the state level to ensure the development of meaningful outcomes.

Discussion between local communities, including state and traditional leaders and the national government, regarding areas for consideration in the Protected Areas Network will need to occur. The current outputs from MARXAN can be used to promote such discussion and also to examine options for linking protected areas across state borders.

The MARXAN analysis will need to be an ongoing process as consultation and discussion within each state is undertaken and realistic boundaries of potential areas are developed. Improvements to the MARXAN analysis and the quality and detail of the produced outputs can be made as data gaps are filled and more detail and information on socioeconomic, cultural, resources management needs and ecological considerations are made available and refined.

Case Study 3: Cebu Island, Philippines MPA Network[10]

LOCATION AND BACKGROUND

Cebu Island in the Philippines lies in the center of the Visayan Islands, known as an area high in biodiversity and fisheries resources. Historically the marine resources of these islands have provided the primary source of food and livelihood for human populations. Coastal dwellers, until the present, comprise a traditional fishing economy that depends largely on reefs and their associated fisheries. Presently, in addition to fisheries, the coral reefs provide increasing economic revenues to communities from their tourism appeal. Visitors snorkel, dive and pay fees to enter MPAs for recreation.

The coastal area under management in southeast Cebu Island covers approximately 118 km of shoreline with about 726 hectares of diverse coral reefs and associated habitats. The coast is bounded by the Cebu/Bohol Strait, 1 out of 7 key fisheries ecosystems in the Central Visayas. Its area of jurisdiction traverses 8 coastal municipalities covering a total of 3,933 km^2. Of the total ecosystem area only 2.4% of the area is beyond local government jurisdictions—outside of the 15 km municipal water limits (Figure 15).

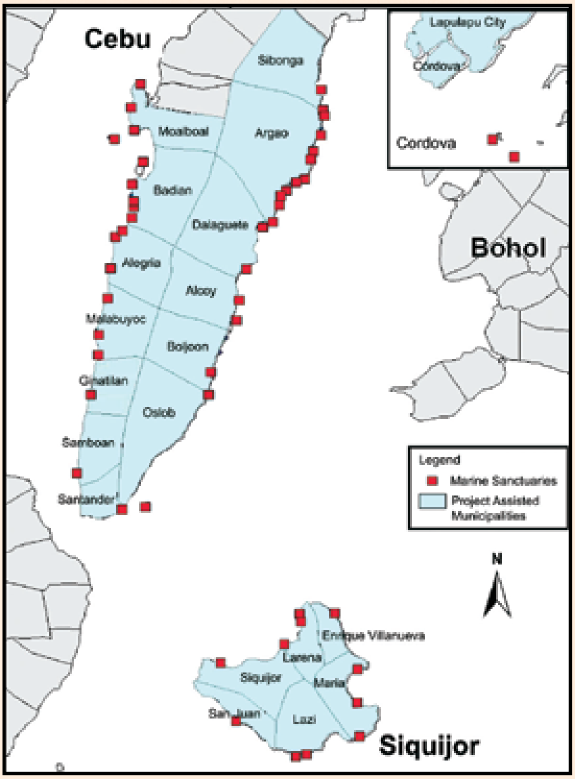


Figure 15 Location of Southern Cebu
Southern Cebu, as part of Cebu Province and Siquijor Island in central Philippines showing municipal-based MPAs

10 See Eisma, Amolo, White (in review) for full version of the case study.

CONSERVATION BASIS

The southern Cebu marine and coastal areas support a rich and diverse fishery that depends partially on coral reef and mangrove habitats and partially on offshore habitats for small and large pelagic species. The primary basis for conservation, driven by the need to sustain fisheries, is focused on maintaining the diverse coral reefs to support a full range of natural diversity in the area that ensures a relatively intact food chain and biomass of fish and invertebrates.

The primary resource threats of concern are degradation of coral reefs, mangroves, estuaries and beaches; overfishing; and dwindling fish stocks. This progression has been aggravated by weak law enforcement mechanisms and through uncontrolled coastal and shoreline development. These issues have been prioritized by the municipalities and primary resource users in a manner that has stimulated collective action. Thus an opportunity was created for a multi-local government unit (LGU) collaboration system within the context of the Cebu Provincial Government to implement stringent marine conservation and management measures. The key strategy that has emerged from the coastal resource management system in each municipality is the establishment of MPAs and more recently the formation of an area-wide MPA network.

NETWORK DESIGN AND APPROACH

The development of an MPA network in southern Cebu is predicated on the need for coral reef habitat conservation that restores the shoreline fringing reefs to a state that maximizes the benefits to local reef-associated fisheries. The concept of a network evolved after the establishment of individual MPAs in each of the municipal jurisdictions. The use of MPAs as a primary strategy reflects their use in other parts of the Philippines where they have been effective in protecting reef ecosystems to increase fish biomass inside the MPAs and fish yields outside their boundaries (Russ et al. 2004). Such MPAs are also credited with distribution of fish and invertebrate larvae into surrounding waters and to adjacent and more distant reefs. These benefits are understood by the stakeholders of the southern Cebu MPA network. This awareness has played a key role in the network design and implementation.

The criteria that were defined and used to design the MPA network evolved over a planning period from the years 2000 to 2006. The principles applied considered the biophysical characteristics of the Cebu coastal resources as well as the use patterns and socioeconomics of the human communities dependent on these resources (Table 12) (White et al. 2006).

Table 12 Application of design criteria, Cebu Island

Representation and replication criteria were accounted for by:
■ Mapping surveying and qualifying all habitat areas for coral reefs and mangroves by level of diversity, general habitat condition, biomass of fish and presence of key species of importance for either conservation or fisheries.
■ Including highest quality and representative reef and mangrove areas in MPAs where fishing or any extraction is not allowed.
■ Spreading out MPA designations along the coastline and including small islands.
■ Including up to 15% of each reef habitat in no-fishing areas.
■ Selecting sites in best condition that appeared to be resistant or resilient to warm water bleaching based on the 1998 bleaching event.
Critical area criteria accounted for by:
■ Key habitats included in the MPA network from baseline information included:
• Areas that may be naturally more resistant or resilient to coral bleaching.
• Permanent residential sites for groupers, humphead wrasses and other key fisheries species.
• Areas supporting high coral and fish diversity.
• Areas that are preferred habitats for vulnerable species such as sea turtles.
Connectivity criteria accounted for by:
■ Sink and sources considered in locale of no-fishing MPAs.
■ Entire ecological units (e.g. whole reefs) included with small buffers as possible given limitations in size permitted.
■ Larger areas of coastal fringing reef included as acceptable to traditional use patterns.
■ Collected extensive baseline line data on coastal ecosystems and traditional use patterns to determine best configuration, recognizing importance of connectivity and practical socioeconomic limitations.
Size and spacing criteria accounted for by:
■ A minimum area of 10 ha was achieved for most of the 38 MPAs, and all are placed less than 10 km apart from each other.

IMPLEMENTATION

In the Philippines, all important habitat areas are protected by national and local laws that when enforced, prevent physical damage and minimize pollution impacts. Thus, to ensure the use and enforcement of the basic laws, the implementation of MPAs is in the context of Coastal Resource Management (CRM) programs in each of the local governments that plan for multiple uses and fisheries management within their jurisdictions. Participatory planning was an important strategy to engage as many stakeholders as possible in implementation.

Regular assessment of changes in substrate and reef fish populations in MPAs has been a top priority of management bodies. Biophysical reef monitoring of MPAs involves a participatory method in estimating fish populations and substrate composition with competent local community members. Surveys are conducted on the shallow (3 to 4 m depth) and deeper reefs (7 to 9 m) both inside and outside of MPA boundaries to make comparative studies to gauge protection. Local managers provide inputs about the changes in the marine resources they are protecting and the details of their management efforts. The results of the monitoring surveys have been useful for management decision-making processes. Municipal MPA monitoring reports, documenting changes in the reef areas, are produced and fed back to the management and the local community.

Of the 38 MPAs being implemented in the area and assisted from 2000 to 2007, there has been an increase in the management effectiveness as quantified through rating levels measured with the MPA rating system[11]. Most MPAs that had Level 1 or 2 at the onset of the project have increased their management rating to Level 3 or 4 (Figure 16)

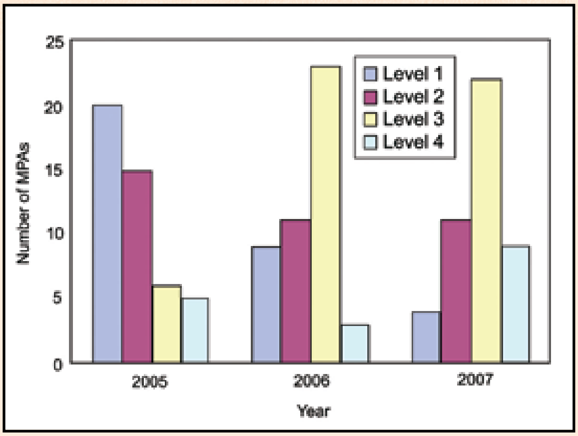


Figure 16 Cebu Island MPA management rating
Ratings of 38 MPAs assisted by the project from 2005 to 2007.

To enhance the economic benefits derived from tourism activities in coral reef areas, environmental user fees for diving and boat mooring have been imposed through municipal government legislation. Education campaigns promoting the municipal-wide user fee system to dive resorts and tourists have also been conducted.

Foreshore management is another aspect of maintaining the integrity of the MPAs along the Cebu coastline. Since much of the coast is plagued by illegal shoreline development, different management steps have been implemented to protect the shoreline and set up coastal setbacks to prevent further illegal foreshore development in project areas.

The Philippine Fisheries Code requires municipal governments to register municipal fishers, fishing gears and fishing vessels of 3 gross tons and below. To address this, training and workshops for boat measurement and registration were conducted. This

11 See White et al. 2006, or www.coast.ph for a description of the MPA database and rating system used to monitor improvement in the management of the MPAs and of the condition of the biophysical environment. The MPA rating system is a guide for managers to improve management interventions for more effective MPAs. These ratings have provided important baseline information for planning the scaling up from single MPAs to an MPA network.

assisted the registration process through the formulation and adoption of municipal ordinances, and information dissemination at the village level which reinforced fisheries

Critical for all implementation is having an effective coastal law enforcement system functioning at all levels in southern Cebu. In the process, municipalities were prompted to establish coastal law enforcement groups that were trained to patrol municipal waters of their respective towns. Capacitating and providing support to these groups was essential to prevent poaching in the MPAs as well as enforcement of all fisheries laws.

To deter the intrusion of commercial fishing boats in municipal waters, joint seaborne operations have been maintained in the municipal waters of Southern Cebu. To date, numerous illegal fishing activities have been identified, offenders apprehended and cases filed against offenders. Together with pro-active enforcement activities, preventive measures were taken through information dissemination and increased dialogues with the community.

Building the capacity of local governments and communities is a primary strategy for improved management conservation in Southern Cebu. The various trainings conducted since 2003 are shown in Table 13.

Table 13 Capacity – building training, Cebu Island

TRAINING CATEGORIES	PARTICIPANTS		
	YEAR 1	YEAR 2	YEAR 3
Legal and institutional development	439	765	105
Marine Protected Area management	471	1107	420
Habitat management	91	500	50
Skill enhancement	85	134	260
Fisheries management	24	178	150
Coastal law enforcement	157	255	55

The ultimate success of MPAs in the Philippines is normally determined by how the MPA contributes to reducing threats on coral reefs and associated habitats. In over 3 years of monitoring, biophysical data suggests stability of the coral community in most of the sites protected. Over the period, the percentage of live hard coral cover recorded inside the protected areas shows an increasing trend from 2005 to 2007 (Figure 17). This implies the corresponding effectiveness of MPA management measures which include regular monitoring, regular enforcement activities along boundaries, strict observance of rules and regulations, and increased awareness of resource users and communities.

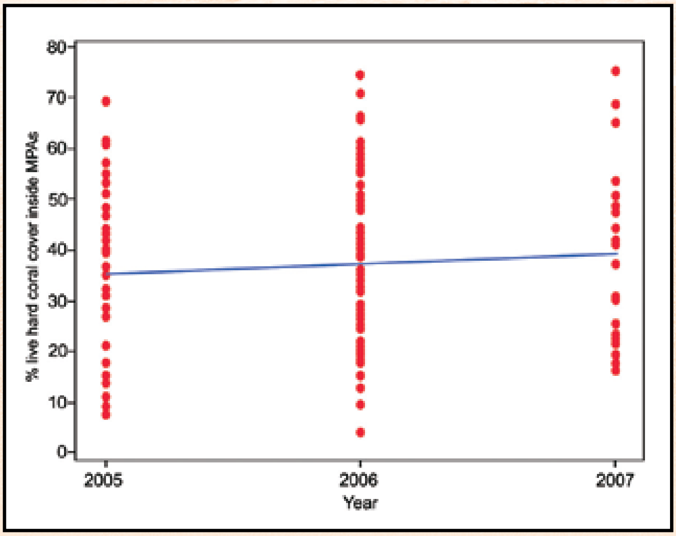


Figure 17 Live hard coral cover, Cebu Island
Trends observed inside MPA (Eisma et al. in prep.)

Similar trends were also observed in reef fish abundance inside MPAs. Moreover, fish abundance of commercial valuable reef fishes has increased inside MPAs. These positive results have encouraged not only managers but also marginal fishers to support establishment of MPAs because their actions are contingent upon enhancement of depleted fish stocks in corresponding fishing grounds. These results are also encouraging and strengthening the social and governance network of MPA practitioners in southern Cebu.

Case Study 4: Channel Islands, California MPA Network[12]

LOCATION AND BACKGROUND

The 8 California Channel Islands, 260 to 25,000 ha each, lie 20 to 100 km off the coast of California, in the southern California Bight (Figure 18). Four islands in the north mark the southern boundary of the Santa Barbara Channel, and the remaining found are scattered from Los Angeles to San Diego, California. Beginning in the early 20th century, many people recognized the 4 northern islands (San Miguel, Santa Rosa, Santa Cruz, Anacapa) Santa Barbara Island in the south, as important places, designating them and portions of the surrounding ocean in an overlapping mix of jurisdictions, as protected areas, including an international biosphere reserve, a national park, a national marine sanctuary, 2 state areas of biological significance, 3 state ecological reserves, a state natural reserve and a private reserve (Davis 2005).

Figure 18 Channel Islands location
http://upload.wikimedia.org/wikipedia/commons/0/04/Channel_Islands_NMS_map.jpg

CONSERVATION BASIS

The waters surrounding California's Channel Islands represent a globally unique and diverse assemblage of habitats and species. This region is a subset of the larger ecosystem of the Southern California Bight and areas bounded by Point Conception in the north and Punta Banda, Mexico in the south. In the area between Santa Barbara Island in the south and San Miguel Island in the northwest, colder waters of the Oregonian oceanic province in the north converge and mix with warmer waters of the California oceanic province. The mixing of these regions creates a transition zone within the island chain, and upwelling and ocean currents create a nutrient rich environment that supports high species and habitat diversity.

A perceived steady deterioration of marine resources in the California Channel Islands initiated public concern regarding the ability of current fisheries management approaches to maintain the natural biological communities, habitats, populations and ecological processes of the diverse marine system (Airame et al. 2003). In 1998, a group of

12 For further information go to http://channelislands.noaa.gov/marineres/main.html

recreational anglers and the Channel Islands National Park requested that the California Fish and Game Commission establish a network of MPAs in the park that constituted no less than 20% of the park's waters to restore the integrity of the ecosystem and rebuild collapsed fish populations (Davis 2005). Furthermore, in 1999, the California legislature approved and the governor signed the Marine Life Protection Act (MLPA), which requires the preparation and implementation of a Marine Life Protection Program throughout the state of California. Within this plan, one of the goals is to improve and manage the state's MPAs as a network, to the extent possible, which implies a coordinated system of MPAs. It was acknowledged that the outcome of the Channel Islands process was likely to influence fisheries regulations and the distribution of future reserves throughout the state waters (Airame et al. 2003).

NETWORK DESIGN AND APPROACH

The network design within the Channel Islands National Marine Sanctuary (CINMS) is described in 3 distinct phases: 1) the community-based phase, 2) the state regulatory phase, and 3) the federal regulatory phase. Collectively, the 3 phases are the "Channel Islands Marine Reserves Process."

In April 1999, the National Marine Sanctuary Program and the California Department of Fish and Game developed a joint federal and state partnership and process to consider establishing marine reserves within the CINMS. To support this joint process, the Sanctuary Advisory Council (SAC), which is comprised of local community and federal, state and local government agency representatives, created a multi-stakeholder Marine Reserves Working Group (MRWG) to seek agreement on the establishment of marine reserves within the CINMS. From July 1999 to May 2001, the MRWG met monthly to receive, weigh and integrate advice from a Science Advisory Panel (SAP), Socio-economic Team and the public to develop a marine reserves recommendation (CINMS 2007). Ultimately, a local community consensus statement of the problem to be resolved and a set of shared community goals was established by the MRWG, including conservation of ecosystem biodiversity; achievement of sustainable fisheries; economic viability, restoration and sustainable natural and cultural areas; and increased educational opportunities (the community-based phase). (Davis 2005, Airame et al. 2003). The MRWG itself could not, however, achieve consensus on a specific recommendation for MPAs. Rather, they forwarded their work to the agencies and requested that the agencies prepare a recommendation. The final recommendation was to create a network of 10 MPAs that constituted approximately 20% of the state and federal waters within the National Marine Sanctuary. The state waters portion of this recommendation was completed first and became effective April 2003 (the state regulatory phase). The federal waters portion took several more years to complete and was put into place in July 2007 (the federal regulatory phase). The criteria used to design the network are displayed in Table 14.

After consideration of both conservation goals and the risk from human threats and natural catastrophes, the MRWG science panel recommended 1 to 4 reserves be designated within each of the 3 biogeographic regions, comprising an area of at least 30% and as much as 50% of all representative habitats in the Channel Islands National Marine Sanctuary. As an alternative to species distributions information, suitable habitats for species of concern were used to locate potential reserve sites. The agencies, in their final recommendation noted that a wide range of scientific recommendations for percent set aside were available at the time and that 20% of each habitat represented an "adequate" amount while 30% or more would be "well" represented.

Hundreds of people participated directly in the public process at public meetings and work sessions. Government agencies received more than 9,100 written comments from the public in the first 2 years, with 94% in favor of the science panel's recommendations. Despite the overwhelming support, many members of the local fishing community felt disenfranchised from the working group members and did not feel any of the members accurately represented their fishing interests, community or ethnicity (Davis 2005). The sense of exclusion from the process is highlighted by the lawsuit filed by the fishing interests for an injunction to stay implementation of regulations making the reserves effective, the preliminary injunction was denied and the case was eventually withdrawn (Davis 2005). Shortcomings in the stakeholder involvement process, namely that the constituency of involved groups was more diverse than the number of representatives in the working group, may have resulted in reduced support by some user groups in the final decisions.

Table 14 Application of design criteria, Channel Islands

Representation and replication criteria were accounted for by:
■ 3 major biogeographical regions identified using data on biota and sea surface temperature (SST).
■ Representative and unique marine habitats in each biogeographical region classified using depth, exposure, substrate type and dominant plant assemblage.
■ 1 to 4 reserves designated within each of the 3 biogeographic regions, comprising an area of 30 to 50% of all representative habitats in the Channel Islands National Marine Sanctuary.
■ Habitats likely to support exploitable species, especially rockfish, included for specific representation.
Critical area criteria accounted for by:
■ Vulnerable habitats (such as coral reefs, mudflats, rocky intertidal areas and seagrasses) considered unique habitat types.
■ Island coastlines and emergent rocks weighted according to the distributions of pinniped haul-outs and seabird colonies.
Connectivity criteria accounted for by:
■ Zones spaced no more than 50 to 100 km apart to facilitate larval and adult exchange between zones.
Size accounted for by:
■ Individual zones designed to accommodate species' home ranges.

MARXAN was used to identify areas of high habitat diversity within small geographic areas and areas most likely to represent all habitats within the smallest area possible (Figure 19). The analysis produced a "summed solution" map which indicated blocks that occurred most frequently in an array of potential reserve network scenarios that each met the established goals, as illustrated in Figure 20. The location of potential reserve sites required (1) selection and description of planning units in the planning region, (2) evaluation of potential reserve networks using the ecological criteria, and (3) selection of the best set of sites that provided the greatest degree of flexibility to accommodate various interests of stakeholders (Airame et al. 2003).

The MRWG was given the opportunity to evaluate the potential stakeholder created reserve scenarios in an interactive GIS that included socioeconomic information about major commercial and recreational activities in the Channel Islands. To facilitate consideration of diverse goals, the MRWG was able to adjust and evaluate potential reserve networks and modify potential boundaries within the GIS tool framework. Proposed changes were evaluated according to both ecological and economic criteria, allowing for a flexible iterative approach (Airame et al. 2003).

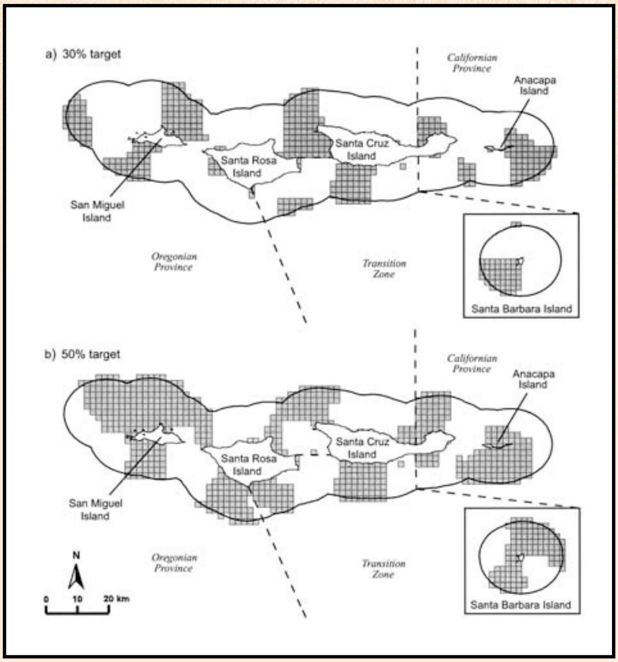


Figure 19 MARXAN analysis, Channel Islands
Conservation targets were set at (a) 30% and (b) 50% of the total value for each ecological criteria. Separate analyses were conducted for each of the biogeographic regions (those in the dashed lines). (Airame et al. 2003)

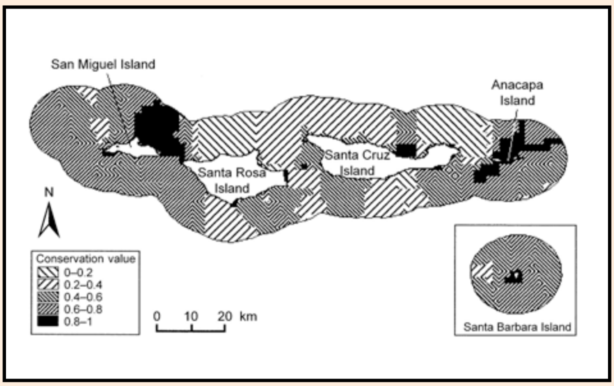


Figure 20 Priority conservation areas for Channel Island National Marine Sanctuary.
Each planning unit is weighted by the number of times it was selected for a final solution from the total number of simulated annealing runs, or the "summed solution" map. Individual planning units are compared on a scale of 0 to 1 by dividing the number of times each unit was selected for a final solution by the total number of runs in a particular bioregion (Airame et al. 2003).

IMPLEMENTATION

The approach taken in the Channel Islands case study illustrates the feasibility of using MARXAN with data on representative and unique habitats, and distributions of vulnerable species to identify reserve network scenarios with the potential to achieve both fisheries and conservation goals (Airame et al. 2003). In the absence of data on many of the ecological criteria, reserve networks were still identified and successfully implemented (Figure 21), demonstrating a precautionary approach taken for the reserve placement.

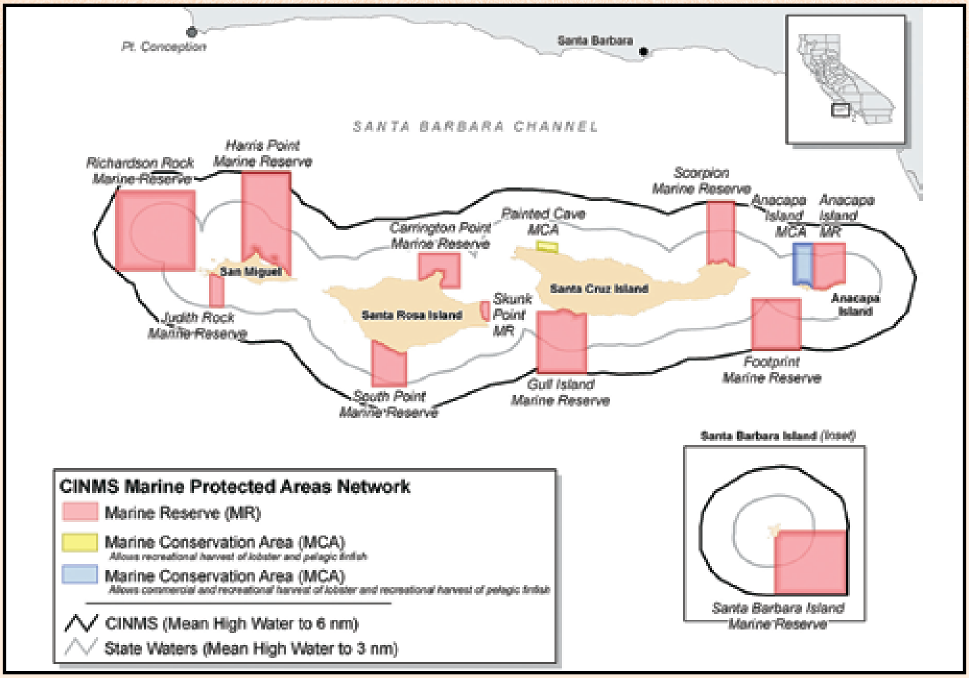


Figure 21 Channel Islands MPA network
(http://channelislands.noaa.gov/marineres/main.html)

Active public involvement and interest in the area has been a driving force in the establishment of the reserve network. Public involvement ensures that the agencies and research institutions continue to effectively manage and monitor the MPAs network. Strong partnerships between the Channel Islands National Marine Sanctuary, California Department of Fish and Game, the U.S. Coast Guard and Channel Island National Park facilitate a lasting commitment to monitoring and enforcement of the network. Additionally, research institutions, such as the U.S. Geological Survey and the University of California, Santa Barbara, substantially contribute to the implementation of MPA monitoring programs.

Upon approval of the state portion of the reserves in 2003, the groundwork for monitoring socioeconomic conditions was established. Understanding the long-term effects and the human-MPA interactions is a priority research issue for reserve managers and with the help of partners a more complete analysis of human-MPA interactions is in construction (Anderson 2006). Recreational boater surveys, anchorage choice surveys and a postcard survey each contribute to the National Marine Sanctuary's socioeconomic research priorities. Additionally, biological monitoring programs seek to determine the impacts of MPAs on species abundance, individual sizes, biomass, spawning biomass, species compositions, habitat as related to physical alterations and secondary impacts of biological community changes, spillover, and catch per unit effort. Several biological monitoring projects have been implemented or expanded to track the effectiveness of the reserves including: fish transect surveys, kelp forest monitoring, rocky intertidal monitoring, deepwater submersible surveys, ROV monitoring, SCUBA fish surveys, invertebrate and eelgrass monitoring, and acoustic monitoring (Anderson 2006). As a result of well-funded and consistent monitoring programs, a robust data set has been collected.

During the past 5 years, ecological and socioeconomic monitoring scientists in the region have monitored changes in marine animals and habitats, as well as human activities in and around the MPAs of the Channel Islands. Findings of the first 5 years of monitoring show consistent differences in abundance and size of species found within the MPAs versus the surrounding waters. By using SCUBA surveys to monitor kelp forest communities inside and outside the MPAs, higher densities and bigger fish were observed in the MPAs than in surrounding waters, including species that are targeted by fishing, such as kelp bass and California sheephead. The preliminary research also indicates that the California spiny lobsters found within the MPAs are larger in size and in greater abundance than outside the MPAs. Mature large-sized lobsters are essential to successful reproduction of the fishery, indicating that MPAs can be an effective tool in ecosystem health (CDFG 2008). Additionally, an independent study (Tetreault and Ambrose 2007) evaluated the response of fish populations to protection from fishing in several of the Channel Islands MPAs by comparing fish population densities and sizes inside and outside. The results revealed a biologically meaningful increase for target fish populations inside the MPA borders for density, size, biomass and egg production (Tetreault and Ambrose 2007).

Combining monitoring and enforcement efforts, The Sanctuary Aerial Monitoring and Spatial Analysis Program conducts mammal and vessel surveys as well as MPA enforcement flights within the sanctuary (Anderson 2006). Enforcement of the regulations is a collaborative effort between NOAA, the Department of Fish and Game, the National Park Service and the U.S. Coast Guard. The cooperative partnership between these agencies contributes substantially to the overall effectiveness of the reserves.

Chapter 7

MARCI EGGERS/TNC

Visitors walking along the coast of Paracas National Reserve, Peru

Implementation Strategies

"Starting implementation early in the process is the best way to ensure long-term success."

While implementation of successful MPA networks is the overall goal, the process to get there is extremely variable and dependent on site-specifications. This chapter of the book, although sequential from the planning and design strategies should be considered a parallel action to address the different facets of the issue.

Implementation of any MPA network, as described in this chapter, is a long-term and complex endeavour. It requires cross-institutional collaboration in almost every region and circumstance. Technical assistance, education and capacity development are some of the cornerstones of developing effective MPA governance and effective MPA networks. Furthermore, the long-term success of an MPA network will require political will and leadership, public education and communication, stable and functional financial support, effective monitoring efforts and practical enforcement capabilities.

Political will and leadership

Political awareness and support are fundamentally important throughout the process of developing and implementing an MPA network. Plan implementation and management usually involves some legislative action or other legal basis.[13] Politicians and often legislators will inevitably become involved in the planning process; thus, early involvement will help to build their support. Strong political support can greatly assist a proposed MPA network to gain the necessary statutory approvals and funding.

Generating broad-based political support among government agencies and key stakeholders is essential for securing revenue sources, as well as ensuring governance systems and policies needed to build MPA networks. It is also important to factor in political timeframes and the need for political compromise. In many cases, it is better to compromise and achieve a reasonable conservation outcome than to hold out for the ideal MPA network and achieve nothing because the aim was politically untenable.

Strong and effective leadership are also fundamental to develop and maintain an effective MPA network. Many marine planning programs around the world emphasize scientific knowledge but place proportionally less importance on involving the public and the political decision makers throughout the planning process. This short-sighted approach can undermine a network's implementation and its prospects for success.

13 Customary or traditional approaches to marine conservation may be effective without legislation; however, even in these cases, there is a need for critical "political" support.

Example from the field – Chile's GEF-Marino Project and the national system of MPAs.

In 2003, the government of Chile launched a series of initiatives related to the protection of coastal marine environments. The National Biodiversity Strategy, a result of Chile's ratification of the Convention on Biological Diversity, was one of the first steps for the protection of marine biodiversity. As part of this national strategy, the GEF (Global Environment Facility)-funded project "conservation of coastal biodiversity of global importance along the Chilean coast" (GEF-Marino) was developed with the objectives of protecting marine and coastal resources, improving the public-private partnerships, and promoting sustainable and local-supportive economic activities (e.g., ecotourism).

The project's participants include the GEF, which provides funding; UNDP, which handles implementation; and Chile's National Environmental Commission, which serves as the coordinating agency. The project identified 3 demonstration pilot areas to develop marine and coastal marine protected areas of multiple uses, based on the IUCN's protected area management category VI. Its objectives highlight environmental resource and cultural heritage protection, and sustainable development of coastal activities. The demonstration MPAs were selected based on representation of Chile's marine environments, consultations among different national and local stakeholders, and feasibility of sustaining the project. Institutional structures and staff capacities were built for managing each one of these areas, considering regional characteristics and replication. The 3 pilot areas are: 1) Punta Morro- Río Copiapó (Atacama Region), 2) Lafken Mapu Lahual (Los Lagos Region), and 3) Francisco Coloane, Carlos III Island (Magallanes and Antarctica Region).

These 3 areas are part of Chile's network of multiple-use MPAs. A second existing network of coastal protected areas in Chile is composed of marine reserves and parks created under the Fisheries and Aquaculture Act and managed by the National Fisheries Service. Chile's current work to develop national systems of MPAs considers consolidating both networks under a single administration system. However, it is recognized that this system does not have enough elements yet for acceptable biological connectivity. In order to reach connectivity, the system will eventually incorporate some of the approximately 400 benthic resource management areas under the administration of fishing communities along the Chilean coast.

The integration of the different networks seeks a conservation objective, integrating fisheries, research, and other social and productive sectors. Strengthening the institutional capacities for managing MPA networks includes the active participation of local governments and community representatives, including indigenous groups. Three regional MPA commissions, headed by the Intendentes (regional governors) and administered by The National Environmental Commission are in place. Public-private management unit partnerships are being designed to co-manage the 3 GEF-Marino MPAs.

At the national level, the systems of MPA networks will be administered by a Managing Council, which will be advised by an already functional technical committee. The design of this national structure will be developed in 2008. Channels for public participation and public-private partnerships will be created as part of the national and local management institutional structures.

Public education, communication and awareness

Common to all successful MPA management operations are the elements of education and communication. Communication, education and outreach can influence people's attitudes and behaviors and increase awareness, understanding of and participation in MPA network development and management. Broad outreach efforts, for example, can increase understanding of the overall benefits of MPA networks, while more specific programs can address particular resource issues and promote other essential services such as research, monitoring and enforcement. Education efforts can also strengthen legislative commitment by training policy-makers on how legal frameworks can support best management practices and conservation-based decision-making.

The development of a communication plan must establish consistent education and outreach messages, tailor messages to key audiences, and foster opportunities for sharing resources and leveraging new partnerships. The educational component of a network occurs throughout all stages of development and implementation (White et al. 2006). Initial education materials may focus on the management objectives and, as the process for MPA establishment matures, topics may shift. An effective communication plan should also strengthen partnerships and cooperation between and among networks. Suggested education and communication strategies include (White et al. 2006):

- Nonformal methods to encourage participation, interaction and personal contact.
- Recruiting academics, divers, fishers, resort owners and others who can share observations and opinions to encourage local enthusiasm and interest.
- Organizing cross-site information learning networks to share lessons and progress.
- Monitoring information as it becomes available to prepare education programs and materials that describe the changes in the ecology, biodiversity, quality and quantity of ecosystem and species.
- Refining knowledge of threats, use patterns in the area and management options.

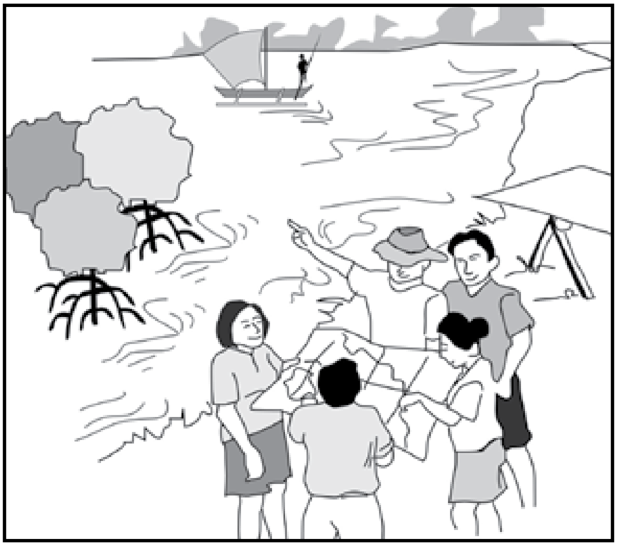
By providing information on marine conservation and stewardship opportunities for the public, managers can help foster community pride in an MPA network. Through active participation in stewardship activities, people are more likely to become ambassadors for conserving natural resources. Volunteer programs provide an important means for engaging the community in resource management, building a stewardship ethic and reaching broader audiences.

Key Concept

To ensure effective communication about the network, designers must develop a well-coordinated communication plan among component MPAs. Such a plan should:

- Identify key audiences.
- Establish consistent education and outreach standards.
- Tailor messages and programs to key audiences.
- Increase consistency among sites by identifying objectives and strategies relevant to the entire network.
- Foster opportunities for sharing resources and expertise, and forming new partnerships.

While education and outreach efforts may focus on the unique natural and cultural resources of each MPA, ultimately they must be part of a larger strategy for the entire network. Network-wide, coordinated communication will unify efforts to promote network awareness, while encouraging site-specific individuality and appreciation. It will also ensure that the objectives of component MPAs align with those of the network.



Community participation and awareness improves management success and helps to build sustainability.

Example from the field—Indonesia Rare Pride conservation education campaign contributes to MPA success.

Rare Pride (http://www.rareconservation.org/) is a social marketing program designed to raise public awareness and promote conservation in critical ecosystems. Proven successful in more than 30 countries, Pride campaigns are intensive, 18-month programs that elevate a charismatic flagship species as a symbol of local pride to build support for habitat and wildlife protection. Social marketing techniques—such as billboards, posters, songs, music videos, sermons, comic books and puppet shows—used in Rare Pride, make conservation messages positive, compelling and fun for the community. Campaigns appeal to people on an emotional level to dramatically influence attitudes and behavior, generating an increased sense of public stewardship unlike that achieved by other community education programs.

The Rare Pride methodology was applied in Indonesia's Togean Islands, Central Sulawesi Province. In 2004, the Indonesian Ministry of Forestry declared 362,000 hectares of the Togean Islands as a national park. The park includes 292,000 hectares of marine ecosystems. The establishment and success of the park was partially due to the efforts of a Rare Pride campaign, which was established to build support for protecting the country's fragile marine ecosystems by informing people of the Togean islands of the value of biodiversity, and of the need to conserve marine and terrestrial life to sustain their future. The campaign was so popular with local schools that teachers incorporated conservation education into school curricula. Momentum for conservation grew even after the campaign ended. In 2002, the village of Kabalutan established a regulation to protect 10 sites within its traditional fishing grounds from destructive practices. In addition to the park, there are now 2 community-managed natural reserves in the islands.

Sustainable financing

Creating and maintaining representative, effectively managed networks of MPAs requires substantial funding at local, national, regional and possibly international levels. In the efforts to scale up from individual MPAs to networks, it may be necessary to develop more comprehensive funding mechanisms than those that have worked at single sites. Financing strategies at a network level will involve trade-offs, such as retaining income at specific sites versus pooling resources for the network overall, or concentrating tourism in particular areas in order to generate funds for conserving more remote, delicate or pristine sites in other areas. Whereas individual MPAs are often supported by local or short-term financial support, the complexity of networks creates a need to share resources among protected areas, institutions and management capabilities.

Developing MPA networks introduces a need to share resources among protected areas and institutions, some of which may depend on areas not formally protected to sustain critical functions, habitats and resources. Business approaches for protected area management and long-term financing are critical for long-term success (Lutchman 2005). Since available funding is likely to be scarce relative to needs, network designers and managers are encouraged to ensure that funds are used cost-effectively. They must also explore creative ways to engage stakeholders in funding strategies that build resilience into protecting financial resources from events such as rapid downturns in tourism or financial markets.

COMPONENTS OF FINANCIAL SUSTAINABILITY

A financially sustainable MPA network should be able to meet, on a continuing basis, the initial and recurring costs needed to achieve its objectives. It should also be able to generate tangible and lasting local sources of income, as well as economic benefits for the country or region in which it is located.

Key Concept

Sound financing strategies consist of 4 main elements:

- Approaches that build local support for network objectives and share costs with those who have a stake in the resources sustained by the networks.
- Diverse portfolios of complementary revenue sources and cost-effective management approaches, supported by appropriate policies.
- Administrative and governance systems that achieve desired results and that generate a high degree of confidence.
- Processes for generating broad-based political support–among government and other stakeholders–for securing revenue sources, management approaches, governance systems and policies.

Share costs and management responsibilities

Approaches that lower costs and engender a greater sense of ownership for conservation activities are important ingredients of sustainable financing strategies. Many of the investments and recurring expenditures needed to sustain MPA networks can be shared or assumed by communities, NGOs, private businesses or others with a clear interest in coastal and marine resources. Collaborative management of protected areas can help to generate broad support for conservation and sustainable development. It can also leverage funding from local governments for activities that benefit communities in or near protected areas.

NGO and private sector involvement, including privately owned or managed MPAs, can lower costs and attract additional resources or donors to the MPA network. Volunteers can provide valuable support to education programs, interpretation for visitors, research and fund-raising. In-kind support from the tourism industry can also reduce the MPA network's direct costs. Examples may include maintaining mooring buoys, providing scuba training for rangers, transporting monitoring teams or assisting with surveillance.

The tourism industry and local volunteers can help install and maintain mooring buoys to help lower MPA costs. Reliable moorings reduce dropping of anchors on fragile habitat, Florida Keys.

Build diverse portfolios

Finance strategies that are resilient are comprised of a diverse portfolio of complementary revenue sources (including government funds, grants and non-governmental organizations) and cost-effective management approaches. No single source of financing will be able to cover, on a long-term and reliable basis, the recurring costs associated with a network. This is true for individual MPAs, and even more so for networks composed of several different MPAs. Network designers and managers must work to create diversified portfolios tailored to their unique circumstances.

Various types of funding mechanisms are appropriate for different MPA needs. Locally operated mechanisms may generate resources for an individual MPA or activity, whereas earmarked taxes, lottery proceeds and other such mechanisms are national or network-wide in scope. Funding mechanisms of this type require transparent arrangements to allocate resources between headquarters and the field and among MPAs.

Further, some funding sources are more appropriate for recurring expenses, while others are better suited for investments or other one-time expenditures. Likewise, some funding mechanisms are suitable for activities implemented by government agencies, others for non-governmental partners. Government budgets, for example, frequently cover salaries and other core costs, but public agencies often have difficulty transferring resources to private businesses or efficiently covering a large number of small expenditures related to field work. Endowment funds may be best able to provide a modest but secure source of funding to underpin operating costs and allow managers to concentrate on fund-raising for specific investments. Business promotion activities, including credit programs to support the development of more sustainable livelihoods, may be most effectively administered by business and financial institutions. Park entry fees and other tourism-related sources work best when fees are directly applied to the areas that generate them.

Governments also play an important role in the financial sustainability of MPA networks beyond direct budgetary support through incentives provided by their policies and programs. Such policies include tax treatment of resource-based industries or private philanthropy, subsidies that increase fishing capacity beyond sustainable levels, fee retention at sites, private ownership of protected areas, tenure rights and land and ocean-use regulations, payments for environmental services, flexibility and transparency of transfers among MPAs, and tourism promotion.

All of these considerations are important in developing diverse portfolios of funding sources, sound management and supporting policies and incentives. Table 15 provides a summary of options for developing possible financing mechanisms and their contribution to MPA network financing.

Administrative and governance systems

The governance of an effective MPA network must be based on robust science, cost-effective use of resources, transparent decision-making, measurable outcomes and equitable distribution of benefits (World Bank 2006). Additionally, a network's administration and governance must generate a high degree of public confidence. In particular, local confidence in and support for funding systems is critical for a successful network. Funding for MPA networks must be channelled to local activities to build local confidence in and support for the network. This can be done through research opportunities, community-based project grants or other locally based project funding.

The pace at which priority activities can be carried out depends on the network's capacity to use funding efficiently, effectively and transparently. To do so involves creating sound management and accountability procedures and employing staff with the appropriate skills, abilities and reputations. To help secure long-term funding, network designers should create mechanisms to track and report spending with a high degree of accountability.

All financing strategies must be adapted and updated based on changing conditions. Thus, it is essential to develop a set of objectives and time-phased benchmarks for measuring progress toward financial sustainability. Political leaders and stakeholders must have input on these objectives and indicators, which will help to foster their long-term support. These measures can be used regularly to monitor the performance of funding mechanisms and management approaches and their impact, both financially and in terms of compatibility with other MPA network objectives. Managers can then adapt their actions and identify new opportunities as circumstances change.

Political support for implementation

Implementing new fees, changing revenue allocations, adopting management approaches that involve new participants or making policy changes that stimulate cost-effective management approaches require broad-based political support from governments and key stakeholders. It is one thing to propose new collaborative management approaches that give preferential access to local communities or that expand the roles of NGOs or local businesses, and quite another to change the government policies, procedures and legislation needed for the arrangements to work. Also, moving from planning to implementation is often complicated by overlapping or unclear agency mandates.

Too often, the costs of a new MPA or a network are calculated as a substantial one-time set-up cost followed by greatly reduced ongoing operating costs. But periodic costs in subsequent years, such as vessel and engine replacement and salaries, can be substantial. Successful and sustainable financing strategies will require investment and nurturing of processes to foster agreement among competing ministries, different levels of government and key economic interests. It is important that planning and budgeting for MPA networks be incorporated as fully as possible into regular government processes.

STEPS FOR BUILDING SUSTAINABLE FINANCING STRATEGIES

When scaling up from individual MPAs to networks, it may not be sufficient to expand or replicate mechanisms that have worked at specific sites. Financing strategies at a network level will involve trade-offs, such as retaining income at specific sites versus pooling resources for the network overall. Planners and policy-makers will also need to explore system-wide mechanisms, like endowments, and other funding sources that reflect resource uses and the benefits that MPA networks can provide.

The following steps will help to determine the appropriate strategies for achieving financial sustainability:

1. **Assess the benefits people receive from coastal and marine resources, as well as the costs incurred and benefits provided by conservation–including current and prospective MPAs.** Identify those who bear the costs and receive the benefits, and the current and potential extent of user fees.
2. **Include the potential for generating resources or for creating partnerships to cover costs at different sites as an explicit criterion for selecting the MPAs in a network.** When determining the composition of an MPA network, designers must make conscious choices to meet ecological, economic and social objectives. An area's financing prospects constitute an important socioeconomic consideration affecting site selection.
3. **Quantify the financial needs and the contributions of potential partnerships and management approaches based on MPA network objectives and the activities essential to meet them.** Financial needs may include costs of salaries and benefits, vehicles, fuel and other operating costs. Equally important are costs for capacity-building for MPA staff or partners, monitoring, documenting lessons learned, research, social infrastructure or services to surrounding communities to enable them to transition to more sustainable livelihoods. Compensation to offset temporary or long-term costs to specific groups caused by the creation of an MPA, and contributions to endowment funds to provide long-term funding flows may also be needed.

4. **Identify the strengths and weaknesses of each mechanism, as well as potential partners and funding sources appropriate for each.** The Conservation Finance Guide[14] may be used to screen and determine the feasibility of different sources and approaches. Preparing a multi-year business plan for individual MPAs and the MPA network is an excellent way to identify funding requirements and options for meeting them. Such a plan can also clarify needs and results. To be effective, however, the plan must be periodically reviewed and updated.
5. **Develop a strategy that includes diverse finance mechanisms and management approaches that complement each other, that engage a wide range of stakeholders and investors, and that can buffer fluctuations caused by events beyond the control of MPA network managers.**
6. **Identify management (including collaborative management), accountability and oversight arrangements needed for the effective and efficient generation and allocation of resources, as well as for the development and maintenance of partnerships among those involved in critical aspects of the financing strategy.** Determine the individual and institutional skills, abilities and reputations needed to implement these arrangements and partnerships. Where needed, develop programs to strengthen this capacity and adjust the phasing of the financing strategy to match.

One source of steady revenue for marine protected areas is well-managed tourism. Diving operation in Tubbataha Reefs Natural Park, Philippines.

14 Conservation Finance Alliance. The Conservation Finance Guide, 2003 http://www.conservationfinance.org/index.htm

Table 15 Components of MPA network financing strategies

POSSIBLE FINANCING MECHANISMS AND MANAGEMENT APPROACHES

MECHANISM/APPROACH	POSSIBLE CONTRIBUTIONS TO MPA NETWORK FINANCING STRATEGY
Government budgets/policies	
• Central, provincial and/or local direct budget allocations for MPAs, or to social and economic activities to communities impacted by MPAs	Recurring costs, MPA management and staff, social and economic infrastructure within and around MPA.
• Earmarking tax receipts, bond proceeds, fines and/or penalties and penalties imposed.	Investment and recurring costs, activities to offset impacts of activities for which fines and penalties imposed.
• Designated taxes, e.g., hotel or tourist departure/airport tax	Recurring costs, MPA management and staff, social and economic infrastructure within and around MPA.
• Lottery revenues	Recurring costs, if revenues are regular and reasonably predictable.
• Tax incentives, e.g., deductions for conservation contributions, incentives for certain land uses (including private reserves), support for sustainable livelihood alternatives	Encourage private investments, sustainable uses, abate threats (e.g., over-fishing, sedimentation) that require enforcement or mitigation costs.
• Incentives for private investment (e.g., coastal development, waste disposal).	Encourage private investments in sustainable activities, abate threats from unsustainable infrastructure
• Removal of perverse subsidies	Reduce costs of enforcement to curtail unsustainable activities.
• Policy on retaining fees generated by MPAs	Provide incentives for fee collection and for greater willingness to pay by MPA users.
• Policy on allocating resources among MPAs in a network	Provide financing options to MPAs that are less able to raise their own unsustainable infrastructure resources, e.g., from tourism fees.
• Policies detailing steps required to create new MPAs	Increase/lower costs and time to create new areas to constitute the network.
• Decentralization and local control, authority over resources	Empower community-based management, promotes effective stakeholder participation.
Direct payments	
• MPA entrance fees	Recurring costs, important to retain at site.
• Licenses, dive or other use fees	Recurring costs, important to retain at site.
• Payments by tour operators or resorts	Recurring costs and covering costs incurred from tourism.
• Concession proceeds	Recurring costs, investments related to concession.
• Merchandise sales	Recurring costs.
• Payments for providing ecosystem services	Recurring costs, investments to maintain ecosystem service.
• Research permits/bench fees	Recurring costs, investments in research facilities and scientific capacity-building.
• Resource extraction or royalty fees, including fees from offshore oil and gas leases	Recurring costs, investments to mitigate adverse impacts of resource extraction.
• Right-of-way fees for pipelines and telecommunications cables	Investment costs, activities to mitigate damage caused by underwater infrastructure.
• Pollution fines and judicial damage awards	Activities to clean up pollution and other damage, investment costs.

MECHANISM/APPROACH	POSSIBLE CONTRIBUTIONS TO MPA NETWORK FINANCING STRATEGY
Grants and donations	
• International and regional donors (e.g., World Bank, Global Environment Fund, bilateral agencies)	Typically projects of 3 to 5 years, sometimes longer; high transaction costs for design and reporting investment costs; technical assistance; capacity-building; equipment/materials.
• Debt reduction agreements	Proceeds often used to capitalize trust funds/endowments.
• Foundations	Typically projects of 2 to 3 years. Technical assistance; capacity-building; equipment/materials.
• Private donors	Flexible uses, but often high accountability requirements for large donations.
• NGOs	Includes short-term projects and assistance, co-management and possibly long-term commitment at sites or to MPA network. Technical assistance, capacity-building, conservation tools and lessons, connections to other MPA networks, financial resources, management models.
• Voluntary contributions, e.g., by tourists, corporations provide volunteer services.	Recurring costs, investments to improve tourist-related infrastructure or services, equipment/materials, sometimes
Trust funds/endowments	
• Annual funding dependent on investment results and time-horizon (i.e., permanent endowment or sinking fund), requires capable financial management and transparent allocation criteria/processes. Primary advantage is as a relatively reliable source of recurring expenditures; some funds also finance short-term projects within or around protected areas.	
Management approaches to share/reduce costs	
• Partnerships with communities, tourism operators to perform specific management activities or provide in-kind support	Share/delegate performance of specific activities to others, thus reducing direct management costs; enhance presence to improve surveillance.
• Engage local communities in planning and enforcement through collaborative management	Share/delegate performance of specific activities to others, thus reducing direct management costs.
• Preferential access to multiple-use areas by local communities	Build greater support for MPAs; helps create more sustainable economies in/around MPAs.
• Develop alternative, sustainable livelihood activities for surrounding communities	Build greater support for MPAs; helps create more sustainable economies in/around MPAs.
• Encourage allocation of government resources to local communities	Build greater support for MPAs; helps create more sustainable economies in/around MPAs.
• Volunteer programs	Technical assistance, education and awareness, help with fund-raising.
Direct private investment	
• Privately owned/managed MPAs	Allow inclusion of additional MPAs with little or no costs to public agencies.
• Purchases/donations of land and/or underwater property	Allow expanded or new MPAs and/or buffer zones with little/reduced costs to public agencies.
• Investments in sustainable enterprises	Attract other sources of funding (e.g., eco-tourists) and/or provide employment opportunities.
• Eco-labelling and product certification employment creation.	Incentive for sustainable production that reduces enforcement costs to curtail destructive activities; alternative employment creation.

Example from the field: Developing long-term financing needs for MPA management in Berau, Indonesia.

The District Government in Berau, in East Kalimantan, Indonesia, declared a new 1.27 million hectare Marine Conservation Area (MCA) in 2005. Working closely with the District Government and its NGO partners, in 2007 the Conservation and Community Investment Forum (CCIF) conducted an assessment of the Berau MCA's financial and operational management plans to determine long-term financing needs, suggest possible means for securing future revenues in a sustainable manner, and recommend management improvements that could increase the cost effectiveness of funding for the MCA.

The assessment involved site visits, literature reviews and extensive interviews with stakeholders. Using a bottom-up cost model, CCIF assessed and analyzed both costs associated with the current activities of the partners and a proposed future MCA management plan. Typical cost categories used by businesses and non-governmental organizations (personnel, contractors, assets, activities, etc.) were mapped against typical functions of MCAs. These functional components included (1) management and planning (including financial planning), (2) conservation science, (3) zoning and enforcement, (4) information, education and communication, (5) sustainable livelihoods, (6) tourism management, and (7) finance and administration. Then the majority of Berau's current stakeholders were consulted in order to understand their planned activities under current funding levels. Finally, additional activities that are needed to effectively manage the MCA using best practices and optimal funding levels were identified. Based on this information, the 2 scenarios—current and optimal—of the total costs needed to implement an MCA management plan over the next 10 years were calculated.

Current revenues consist primarily of funding sourced by the NGO partners through a number of foundations. No long-term financing commitments have yet been made. To begin thinking through and securing long-term commitments, CCIF suggested that a number of critical issues need to be addressed. Firstly, capacity-building of the stakeholders, particularly the District Government, was necessary. Related to this was the importance of properly designing the governance structure of the planned management unit to ensure that it is accountable and transparent. This will ensure investor confidence when developing future finance strategies. Specific revenue-generating opportunities reviewed by CCIF and the local partners included the creation of a regional or country-level (not MCA-level) endowment fund, implementation of a tax system for fishermen and establishing a tourism fee system. CCIF also recommended engaging the tourism industry to be active contributors to the management of the MCA to help reduce costs, as well as beginning to explore both donations and possible means for securing business biodiversity offset payments from local and the private sector, such as Berau Coal and others.

As of early 2008, the Berau District Government and NGO partners are finalizing the management plan and plans for the management unit to oversee implementation of the MCA. More work will be needed to assess and design specific financing mechanisms once these plans and unit are in place.

Example from the field: Mexico: Increasing funding and partnerships for MPAs. A partnership between the Mexican government and a protected areas endowment within the private Mexican Nature Conservation Fund (FMCN) has increased funding and partnerships in 7 MPAs in Mexico. In 1997, a grant from the GEF created the Natural Protected Areas Fund (FANP) within FMCN, which grew as a result of the approval of a second donation from GEF in 2000. The interest from this endowment contributes to operations of these seven MPAs. This collaboration has led to substantial increases in government budget allocations to these MPAs over the past 11 years, as assistance in planning and accountability provided to these areas by the FANP has given authorities greater confidence in Mexico's National Commission for Protected Areas that funds will be used effectively. The protected areas funded by the FANP and counterpart funds have served as a showcase to attract a higher federal allocation each year.

Government budgets cover salaries of permanent MPA staff, but appropriations to cover operating costs typically arrive late in the year. FANP funds, however, are available at the beginning of the year. Support from FANP pays for complementary personnel and additional conservation activities in the 4 MPAs. FANP's funds can also be used for certain expenses that are relatively difficult to pay for using government allocations. Thus, diversified revenue streams allow sources to complement one another. While 75% of the FANP funds were historically used to cover complementary personnel, in 2008 the National Commission for Protected Areas negotiated an increase in personnel with the Finance Ministry. Starting in 2009 the FANP funds will be used for operation expenses, strategic projects in each MPA and emergency funds to address unexpected disasters. The latter have helped communities after hurricanes and landslides in river deltas.

The long-term and stable funding base provided by the government's and FANP's contributions to these MPAs has successfully leveraged additional financial support for specific projects. This has been further encouraged by FANP's focus on monitoring the results of activities it has funded on the conservation of protected areas; additional funding sources are attracted by the MPAs' ability to clearly demonstrate conservation impacts. The fact that resources from the FANP are implemented through local NGOs has also encouraged partnerships with the protected area authorities and increased confidence of other donors. This has led to additional financial support, including from private foundations with which local NGOs already have relationships. Short-term funding is now provided by a variety of donors and has helped to renew the infrastructure in the protected areas, thus making the reserves more attractive to tourists. Long-term funding includes the establishment of specific endowments for 3 MPA (US$3.5 million) and for a network of MPA (US$6 million). The latter will explore synergies with additional public agencies involved in fisheries and enforcement at sea.

Increased visitation means that entrance fees will contribute significantly to the long-term financial sustainability of these and other MPAs within Mexico's national protected areas system. In 2002, authority was granted to charge entrance fees at MPAs and use the proceeds to cover operating costs. Six of the 7 MPAs supported by FANP have implemented a system to collect fees. In 2007, MPAs in Mexico collected more than US$3 million in entrance fees.

Monitoring and assessment

Monitoring and evaluation provide the foundation for learning lessons and adaptive management of the MPA network. It is important for measuring success towards objectives and for applying active adaptive management strategies to change course if the MPAs are not effective. Changes in policies and management strategies can and should be guided by monitoring results of changes in environmental conditions.

Key Concept

Clearly defining objectives for MPA networks, and developing a well-established monitoring and assessment can help managers and policy-makers to:

- Improve MPA planning and priority setting.
- Improve accountability.
- Assess cost and management effectiveness.
- Provide models and best practices that can be useful to others.
- Compare data from different time periods and sites.
- Improve management practices over time.
- Justify requests for additional staff or funding.
- Build stakeholder support.

Often little post-implementation institutional support for monitoring is present, which undermines the ability to determine whether protected area goals are being achieved (Davis 2005). To avoid this, it is essential that monitoring and assessment structures be built into network plan from the start, and are used as a tool for improving efficiency. Investing resources and effort into monitoring and assessment should result in timely and real feedback to managers and staff on how they are performing. It also provides transparency and accountability in overall management and governance.

Ongoing monitoring includes continual assessment to measure attainment of ecological, social and governance objectives, as well as measure the performance and ecological impacts of various management strategies (i.e., size, shape, spacing, etc.) of the MPAs in the network. Assessing progress requires clear performance indicators that address the management objectives of the MPAs and the network as a whole. Indicators should be specific enough to be measured consistently and flexible enough to adapt to changing circumstances. It is also essential that monitoring frameworks include control sites outside the network, against which overall performance can be assessed.

The key elements that can maximize the value of monitoring and assessment for MPA networks are:

- Identify appropriate indicators related to network objectives.
- Develop long-term and reliable databases and integrated information systems (including results from scientific studies).
- Coordinate and standardize data collection among individual MPAs within a defined region so that managers can compare data over time and sites.

- Maximize data access, analysis and reporting to support public processes.
- Ensure dedicated capacity and institutional support.
- Link management decisions to monitoring outcomes and ensure accountability of participants in monitoring processes.
- Build flexibility into systems to manage for change and new technologies.

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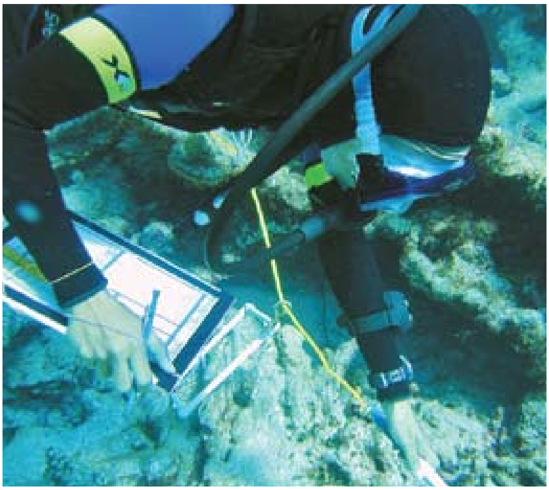
Biologist performs a rockfish survey in the canopy of a mixed giant kelp (Macrocystis pyrifera) and bull kelp (Nereocystis) forest in California.



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Reef surveys provide data for adaptive management. Coral reef in Pedro Bank, Jamaica.

Additionally, monitoring can contribute to maintaining interest and support of stakeholder groups by demonstrating short- and long-term successes. Publicizing the results of the monitoring work aids to increase interest in and acceptance of the MPA by local people (White et al. 2006). Although much is written on monitoring and the informational needs for marine resource planning and MPA management, there is often more information collected than is required. In this regard, managers need to be strategic in selecting the most appropriate and yet robust and reliable tools for monitoring, analysis and evaluation of MPAs and their management effectiveness (Stern 2006). Several publications provide guidance on how to best accomplish efficient MPA monitoring and evaluation, and which technique is most suitable for a particular area and situation (Table 16).

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Hill, J. and C. Wilkinson. 2004. **Methods for Ecological Monitoring of Coral Reefs**. Australian Institute of Marine Science. http://data.aims.gov.au/extpubs/attachmentDownload?docID=1563
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Bunce, L. and B. Pomeroy. 2003 **Socioeconomic Monitoring Guidelines for Coastal Managers in Southeast Asia: SOCMON SEA.** World Commission on Protected Areas and Australian Institute of Marine Science, Townsville.
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White, A.T., P.M. Aliño, A. T. Meneses. 2006. **Creating and Managing Marine Protected Areas in the Philippines**. Fisheries Improved for Sustainable Harvest Project, Coastal Conservation and Education Foundation, and University of the Philippines-Marine Science Institute. Cebu City, Philippines. 83p. http://www.oneocean.org

Enforcement and compliance

Consistent and just enforcement of MPAs represents a major practical challenge for successful implementation. Enforcement challenges stem from lack of surveillance because of inaccessibility (far offshore or inaccessible sites); lack of funding to police an area; failure to assign enforcement responsibility; or lack of public support for a protected area, resulting in socially acceptable poaching (Jones 2006). One solution for enforcement problems is considerable involvement by local communities and other stakeholders in conservation projects. For example, in the Philippines, the organized and deputized *Bantay Dagat* ("sea watch") is key to successful enforcement at reserves. This community enforcement group has been effective and less costly than government enforcement and legal prosecution (White et al. 2006).

Key Concept

Enforcement consists of the actions taken against people who fail to abide by the rules. The feasibility of an enforcement program is a primary consideration when developing an MPA network. An effective enforcement program requires that the design of the network areas be practical to enforce with transparent boundaries.

Compliance is when people accept and act in accord with the rules and regulations of the MPA network. Building compliance requires that policy-makers, government leaders and citizens are aware of the network's regulations and that they agree that they are needed.

The following design elements will help to ensure effective enforcement and compliance:

- **Build in compliance and enforcement considerations into the MPA network design.** Rules must be consistent with—and contribute to—the network's objectives. Primary considerations include feasibility, affordability, public understanding and protecting areas most vulnerable to impact from human activities. Designers should determine which areas are at the highest risk and target enforcement activities in those areas, rather than areas that have the least public resistance.
- **Educate to build compliance.** To ensure compliance, network designers must work to educate policy-makers and government leaders as well as citizens. Building compliance entails raising public awareness about the MPA network, its regulations and why those regulations are needed. Gaining public support for the laws can contribute to cooperative enforcement, whereby user groups willingly help enforce the rules.
- **Develop surveillance programs to support compliance and enforcement.** Surveillance entails monitoring people's activities within the MPA network to ensure that they follow the rules. Some new technologies can increase the efficiency of enforcing regulations and require less manpower. For example, satellite-assisted vessel monitoring systems enable managers to know whether a vessel is in a restricted area, but gives little indication as to the vessel's activities.

- **Enforcement should be supported through appropriate penalties.** Social acceptability is a powerful driver of compliance and enforcement. To foster compliance and ease of enforcement, regulations and penalties must be clear, understandable and appropriate to the socio-cultural context of the network. Because compliance can be weak where people have few alternatives for income or food, enforcement programs must include appropriate deterrents and incentives to change behavior. Culturally appropriate enforcement can range from a public verbal reprimand to confiscating property, suspending a license or prosecution. Regardless of the penalty, enforcement officers must work alongside judicial prosecutors to build strong cases and ensure that violators are caught and penalized. Just as enforcement branches must understand the laws and violations, judicial authorities must understand the offense. In the end, network designers must make it more beneficial for the public to comply with the rules rather than not comply.

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Patrolling large marine areas is expensive and requires sustainable financing. Patrol boat in Komodo National Park, Indonesia.

In addition, network developers and planners must consider the cost-effectiveness of the enforcement program. Surveillance and enforcement activities should focus on the marine areas that are most vulnerable to human impacts, rather than those that are easiest to enforce. Awareness of the links between certain human activities occurring in specific areas during specific seasons or events can help target surveillance and enforcement activities. Partnerships among nations, government agencies, local communities and resource users can help make surveillance and enforcement more affordable by sharing costs and resources. Finally, enforcement across an MPA network allows for economies of scale. Aerial surveys, for example, are more cost-effective when employed across an MPA network as opposed to a single MPA.

Example from the field—California Marine Life Protection Act.

Feasibility analysis was conducted for MPA network enforcement by the California Department of Fish and Game, during the second phase of the Marine Life Protection Act Initiative (CDFG 2007). Design elements that increase the feasibility of enforcement include:

- MPA boundaries delineated by straight lines—oriented north/south and east/west, major landmarks and whole number latitude/longitude.
- Simple and easy to understand regulations.
- Accessibility.

Design elements that decrease the feasibility include:

- Boundaries delineated by distance-to-shore or marker buoys (which are not practical for long boundaries).
- Depth contour boundaries.
- Irregular boundaries.
- MPA "doughnut" configurations.
- Multiple zoning of adjacent areas.

Example from the field—Great Barrier Reef Marine Park compliance and enforcement design.

The rezoning of the Great Barrier Reef Marine Park in 2004 provided an opportunity to improve the design of network of zones to improve compliance. The redesign sought to facilitate user education, surveillance and enforcement. One-third of the Marine Park consists in highly protected zones where extraction is prohibited. Other zones allow specific types of fishing—such as one-line, one-hook fishing—and about two-thirds of the Park is in zones that are free from trawling.

Compliance is encouraged through education, intelligence, surveillance and enforcement.

- Designing a system of zones that works for compliance was successful due to the planners understanding and working with compliance specialists during planning. A key aspect was public consultation. It was essential to obtain information on where and why people used the areas, what were effective elements of the previous management arrangements and whether existing compliance issues were due to ignorance or deliberate actions. Principles for the design phase included:
- Zones should be large. This allows observers on planes and vessels to more easily collect clear evidence that an offender is within a zone.
- Zones are defined by latitude and longitude. Since most vessels or users have a GPS and charts, coordinates allow everybody to locate the zones.
- Boundaries are straight. Users and surveillance staff find straight lines much easier to find and follow than lines following depth contours or distance from land or reefs.
- Boundaries should follow major latitude and longitude lines where possible.
- Boundary lines are oriented along north/south and east/west lines where possible. It is much easier for users to tell which side of such a line they are on than with an angled line.
- Zone shapes are as simple as possible. Squares are easier for users and compliance staff to find and work with than odd shapes.
- Where there are options for the location of no-take zones that meet conservation objectives, choose the one which causes least conflict with users to minimize future compliance issues.
- For inshore zones, clear sight lines onshore or other fixed objects are a good alternative to zones defined by coordinates.
- Match zones with other protected areas. This includes National Parks on land and other protected waters. This allows for collaborative compliance efforts between agencies.
- Test proposed boundaries by first consulting with the users. Difficult issues can be identified and addressed before they are cemented in place.
- Design the system so it can be realistically enforced with the resources available. It can be difficult to design and fund compliance after a system has been set up.

The new zoning for the Great Barrier Reef Marine Park started in 2004. An enhanced enforcement program was instigated to ensure the new zoning was understood and respected.

Malcolm Turner, Mick Bishop
Great Barrier Reef Marine Park Authority

Chapter 8

MARCI EGGERS/TNC

The “La Catedral” formation along the desert coastline of Paracas National Reserve, Peru.

Conclusion and Next Steps

“Let’s learn from our successes and failures to build more and better managed MPA networks.”

This guide presents a substantial body of information to improve the application of MPAs and MPA networks and how to make them an effective strategy to address the increasing pressures on marine and coastal resources in our modern world. There are several cross-cutting themes in this guide that will ideally be incorporated into the planning and implementation of MPA networks to increase their likelihood of success. These broad themes are extremely useful to keep in the forefront of our thinking, planning and application in the various contexts we work. These themes are:

1. **Know what problems MPAs can address.** It is important to understand how MPAs and MPA networks can address the problems of habitat degradation, overfishing and impacts of climate change among other impacts through the implementation of more and larger non-extractive areas within individual MPAs and within "networks" of MPAs.
2. **Try to scale up to MPA networks.** The benefits of individual well-managed MPAs are significant while networks of MPAs, when well-planned, can add up to more than the sum of their individual MPA parts. Developing such networks is a complex process that has various ecological and social aspects that must be considered to succeed.
3. **Adapt to the context in which an MPA network is being developed.** The context of planning and managing MPAs and MPA networks will greatly influence the outcome. Social, political, institutional, economic and environmental forces shape our society and must be dealt with in the most adaptive way possible to enable MPA network success.
4. **Utilize best practices for planning MPA networks based on experience.** Much experience with the development of MPAs points to the need for clear goals and objectives, the full participation of various stakeholders, knowing and molding legal and political commitment, interfacing with broader integrated management frameworks as appropriate and beneficial, and being fully adaptive in approach to move forward.
5. **Consider critical ecological guidelines for designing resilient MPA networks.** The essential guidelines are: 1) Include the full range of biodiversity present in the biogeographic area of concern within protected areas, 2) Ensure that ecologically significant and critical areas are incorporated, 3) Maintain long-term protection to ensure permanence, 4) Ensure ecological linkages are addressed and incorporated in design, and 5) Ensure maximum benefits of individual MPAs in the network through attention to size, spacing and shape.
6. **Adopt implementation strategies that build sustainability.** Ensuring long-term success in our dynamic world requires that implementation of MPA networks is supported by political will and leadership and has a foundation of an educated and supportive public and stakeholders. Equally, financial mechanisms must be creative, appropriate and supported. Lastly, monitoring, evaluation, enforcement and compliance are essential for effective MPAs and MPA network implementation.

The 6 themes summarized above and discussed in detail in Chapters 1 through 7 of this guide are based on a large body of experience around the world in designing, planning and managing MPAs and MPA networks. Yet, the ingredients of success vary from one place to another and there are no set prescriptions that will guarantee positive outcomes. Thus, this work is only a guide that can assist to improve our work. Figure 22 presents a perspective on what it takes to "make MPA networks happen." Figure 22 reminds us that there are several overlapping sets of practices and processes that are essential to ensure that MPA networks are developed in the best and most sustainable manner possible.

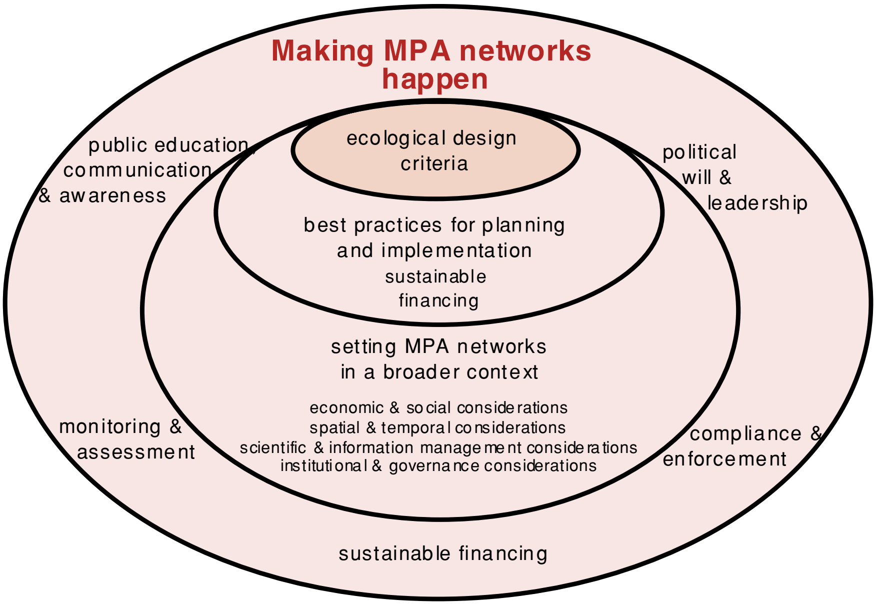

Figure 22 Important ingredients for MPA network success

Self-assessment checklist

A self-assessment checklist on progress towards the development of MPA networks, based on the flow of key considerations presented in this book, is shown in Table 17. The checklist is designed to help planners, managers and national and regional authorities assess current progress towards building effective MPA networks as well as to evaluate progress toward long-term network objectives. It can be used periodically throughout the process of design and implementation and to justify additional resources by demonstrating the improvements required to achieve best practices. The checklist provides an opportunity to gauge progress against perceived best practices and as described in this book through the case studies and chapters on planning and design. It can help identify the gaps or weaknesses that need to be addressed.

Table 17 Self-assessment checklist[15],[16]

GUIDELINE	YES, NO, PARTIALLY
Broad-scale consideration s and planning practices	
Scientific & information management considerations Has all available scientific information and local knowledge of stakeholders been used to support planning and management, and is it is regularly updated and used for effective decision-making?	
Use of best available science & precautionary design Is the MPA network configured to take into consideration all or most of the scientific and socioeconomic information and traditional knowledge within the area, while uncertainty and lack of information has not delayed decision-making?	
Incorporate stakeholders Has a wide range of stakeholders (including local and regional stakeholders) been directly involved in planning the network and assisting the managers by being involved in virtually all of the planning and management decisions for the network?	
Clearly defined objectives Is there a range of clear, achievable and measurable objectives (including ecological, social and economic objectives) defined for the MPA network and derived from the legislation?	
Integrated management framework Does the MPA network fit within a clear integrated and holistic framework, including both planning and management at differing scales (ranging from national planning frameworks, through to regional/local planning and site planning)?	
Adaptive management Is the MPA network readily able to incorporate changes such as new information from field experience or as a result of changing external circumstances?	
Economic & social considerations Does the design and implementation of the MPA network consider the economic and socio-cultural setting, as well as the real benefits and costs of the network (including both tangible and intangible benefits and costs)?	
Spatial & temporal considerations Does the MPA network design include a wide range of spatial and temporal considerations, such as ecological processes, connectivity and external influences, and do managers continue to consider these factors as part of ongoing implementation?	
Institutional & governance considerations Does the MPA network have well-established mechanisms for horizontal integration among all levels of government and vertical integration among agencies with different mandates, as well as involving local communities, indigenous peoples and regional groups?	

15 To use the checklist, each question should be answered, as possible, based on the current situation. Another option is to assign points to each question on a scale of 0 to 5 where 5 represents a 'yes' answer and 0 a 'no' answer, and other points a 'partial.'

16 This checklist reflects a shortened version of the original draft by Day and Laffoley (2006) for the earlier drafts of this book. It represents a work in progress and as such, suggestions for amendments/improvements to the checklist will be gladly accepted. This checklist is built upon the principles and approaches of existing checklists that include those by (Staub and Hatziolos 2004), (Mangubhai (no date), (Corrales 2005), and, (Micronesians in Island Conservation (MIC) Network 2004).

GUIDELINE	YES, NO, PARTIALLY
Ecological	
Size Has specific consideration been given to the size of the individual MPAs within the network to account for adult species movement ranges and larval dispersal distances to maximize the network's effectiveness in achieving its ecological objectives?	
Shape Has specific consideration been given to the shape of the individual MPAs within the network to account for edge effects and the enforceability of regularly shaped boundaries with clear delineation?	
Replication Does the MPA network include spatially separated replicates of no-take areas within the ecoregions to spread risk?	
Long-term protection **Does the MPA network have an efficient combination of legislative** instruments (statutes, laws, regulations) and/or administrative instruments (policies) at various levels (local/state/national), that collectively provide long-term protection for the MPA network and ensure its viability?	
Full range of biodiversity in biogeographic region Does the MPA network fully represent the region by capturing the full range of biodiviersity, ensure representation across depth ranges and biogeography, and ensure ecosystem integrity?	
Ecological linkages Is the MPA network purposefully designed to maximize all ecological processes (spatial and/or temporal) known to occur in the area?	
Implementation	
Political will & leadership Is there strong and effective leadership, commitment and support at both the political and agency levels, with a shared vision and capacity to achieve success?	
Public education, communication & awareness Is the community (including the local communities and the wider public) aware of the MPA network and the management agency(ies), through effective education outreach and communication plans?	
Compliance & enforcement Are feasible enforcement programs and methods to build compliance considered in the MPA network?	
Monitoring & assessment Does a monitoring and evaluation system exist showing progress against most, if not all, of the MPA network objectives being monitored regularly? Are the results widely disseminated and used in adaptive management?	
Sustainable financing Does the MPA network have a well-developed and periodically audited program of long-term funding (assessed, and if necessary, increased against a recognized financial index) to meet both core and emerging costs?	

How to increase the area of MPAs and MPA networks and to improve effective management to meet globally accepted goals is clarified through the information presented herein. Our biggest challenge in this regard is to increase the level of effort, many times over, towards marine and coastal conservation and management to accomplish these goals. This will be possible as the results of existing well-designed and managed MPA networks become common knowledge. The benefits from individual MPAs are already widely disseminated and as networks come online, the increased level of benefits will become more prevalent to serve as the best advertisement for more and better MPAs (and networks). The next step is to continue to educate and to raise awareness among key stakeholders about the value of MPAs and networks based on positive results. Thus, our challenge is to put our ideals, words and lessons into action. This will only lead to more and better MPAs!

Key Definitions

Biogeography: a study of the geographical distribution of biodiversity over space and time.

Biogeographic region: an area of animal and plant distribution having similar or shared characteristics throughout.

Closed population: a population that is self-seeding and receives its recruits primarily as larvae produced from spawning by its own residents (Mora and Sale 2002).

Closure: a population achieves closure when the life cycles of its members are such that offspring remain within it, or return to become members of the reproductive assemblage (Mora and Sale 2002).

Connectivity: the degree to which local production results in recruitment to other populations. For any local population, connectivity could be characterized by (1) the proportion of recruitment into the local population that is endogenous, (2) the proportional contributions of other populations to recruitment into the local population, in a spatially explicit manner, and (3) the spatial distribution and proportional representation of the contributions of local production to exogenous recruitment on other populations (Warner and Cowen 2002).

Dispersal: the movement of individual organisms away from a starting location, such as the site where they were spawned. Dispersal may be active or passive (Mora and Sale 2002).

Ecosystem-based management: a process that integrates biological, social and economic factors into a comprehensive strategy aimed at protecting and enhancing sustainability, diversity and productivity of natural resources. EBM emphasizes the protection of ecosystem structure, functioning and key processes; is place-based in focusing on a specific ecosystem and the range of activities affecting it; explicitly accounts for the interconnectedness among systems, such as between air, land and sea; and integrates ecological, social, economic and institutional perspectives, recognizing their strong interdependences (*COMPASS Scientific Consensus Statement*).

Edge effects: a change in species composition, physical conditions or ecological factors at the boundary between a protected area and a non-protected area. The degree of these changes will vary depending on the size of the protected area.

Integrated Coastal Management (ICM): a broad and dynamic process that requires the active and sustained involvement of the interested public and many stakeholders with interests in how coastal resources are allocated and conflicts are mediated. ICM is multi-purpose oriented, it analyses and addresses implications of development, conflicting uses and interrelationships between physical processes and human activities, and it promotes linkages and harmonization among sectoral coastal and ocean activities.

Marine protected area (MPA): 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 (Kelleher 1999). MPA is used as a generic term to cover all sites that meet the IUCN definition, regardless of purpose, design, management approach or name (e.g. marine reserve, sanctuary, marine park).

Marine protected area network: a system of individual marine protected areas operating cooperatively and synergistically, at various spatial scales, and with a range of protection levels, in order to fulfill ecological aims more effectively and comprehensively than individual sites could acting alone. The system will also display social and economic benefits, though the latter may only become fully developed over long time frames as ecosystems recover.

Marxan: (MPA Design using Spatially Explicit Annealing) was developed by Ball and Possingham of the University of Queensland to aid in the design of the Great Barrier Reef Marine Park. MARXAN software is a decision support tool for reserve system design. MARXAN finds reasonably efficient solutions to the problem of selecting a system of spatially cohesive sites that meet a suite of biodiversity targets (Ball and Possingham 2000; Possingham et al. 2000))

Mean dispersal distance: the distance that the mean propagule disperses from an adult source population. At this distance, it is assumed that settlement rates are sufficient to sustain a substantive recipient adult population (Shanks et al. 2003).

Neighborhood: for marine species, neighborhood can be defined as the area centered on a set of parents that is large enough to retain most of the offspring of those parents (Palumbi 2004).

Network: collection of individual MPAs or reserves operating cooperatively and synergistically, at various spatial scales and with a range of protection levels that are designed to meet objectives that a single reserve cannot achieve.

Open population: recruitment is independent of local production, and local dynamics are determined by recruitment and post-recruitment mortality.

Ocean neighborhood: areas centered on a set of parents that is large enough to retain most offspring of those parents (Palumbi 2004).

Recruitment: the addition of a new cohort to a population, or the new cohort that was added. The magnitude of recruitment depends on the time and life history stage at which it is recorded (Mora and Sale 2002).

Recruitment overfishing: recruitment overfishing occurs when the adult population is fished so heavily that the number and size of the adult population (or spawning mass) is reduced to the point that it did not have the reproductive capacity to replenish itself.

Resilience: the ability of a system to maintain key functions and processes in the face of stresses or pressures by either resisting or adapting to change. Resilience can be applied to both ecological systems as well as social systems (Holling 1973; Nystrom and Folke 2001; Folke et al. 2002).

Retention: avoidance of dispersal from a natal site either due to specific hydrographical features or by active behavioral processes used by the larvae (Mora and Sale 2002).

Self-recruitment: the addition of a new cohort (age group) to a population consists largely or entirely of larvae spawned by that population (Mora and Sale 2002).

Settlement: the action of moving from the pelagic realm of open water to the demersal habitat. Settlement occurs at a distinct time in the life cycle of coral reef fish and is usually closely associated with metamorphosis from larvae to juvenile form (Mora and Sale 2002).

Shifting baselines: refers to the fact that people measure ocean health against the best that they have experienced in their own lifetimes—even if those measures fall far short of historical ones—which causes a lowering of standards from one generation to the next. One generation sets a baseline for what is “healthy” and “natural” based on their own experience. Successive generations see even more degraded ecosystems as “healthy,” and therefore set their standards for ecosystem health even lower (Pauly 1996).

Spillover: the emigration of adults and juveniles across the MPA borders

Sustainable development: means using natural resources in a way that avoids irreversible damage to ecosystem structure and function, the loss of irreplaceable features or a reduction in ecosystem resilience. Environmental interests must be considered alongside social and economic interests, so as to prevent the irreplaceable loss of natural features, function or processes and to ensure a long-term and dependable flow of benefits from the exploitation of renewable resources. Delivering such sustainable development will involve significant measures to recover ecosystem structure and function, where the flow of benefits is already reduced or impaired, or where ecosystem resilience is at risk.

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