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Article

Emerging Marine Protected Area Networks in the Coral Triangle: Lessons and Way Forward

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Abstract

Marine protected areas (MPAs) and MPA networks are valuable tools for protecting coral reef habitats and managing near-shore fisheries, while playing an essential role in the overall conservation of marine biodiversity. In addition, MPAs and their networks are often the core strategy for larger scale and more integrated forms of marine resource management that can lead to ecosystem-based management regimes for seascapes and eco-regions. This study conducted in 2008 documents the status of selected MPAs and MPA networks in Indonesia, Philippines and Papua New Guinea, to better understand development and their level of success in the Coral Triangle. Findings reveal that substantial gaps exist between the theory and practice of creating functional MPA networks. Across these sites, biophysical and social science knowledge, required to build functional and effective MPAs or MPA networks, lagged behind substantially. Aspects that appeared to require the most attention to improve MPA network effectiveness included essential management systems, institutional arrangements, governance and sustainable financing. Common indicators of success such as increased fish catch and habitat quality parameters were consistently associated with several independent variables: sustainable financing for management, clarity of MPA network rules, enforcement by community level enforcers, local skills development, and involvement in management by local elected politicians, a functional management board, multi-stakeholder planning mechanisms and participatory biophysical assessments. Conclusions are that although considerable investments have been made in MPAs and potential MPA networks in the Coral Triangle, management effectiveness is generally poor throughout the region and that not many large, formally declared MPAs are well managed.

Keywords: biodiversity conservation, marine protected areas, MPA networks, Coral Triangle, management effectiveness

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INTRODUCTION: MARINE PROTECTED AREA NETWORKS

Coastal and marine ecosystems are in decline worldwide, and marine systems are increasingly affected directly and indirectly by human activities (Crowder 2005; Millennium Ecosystem Assessment 2006). Coral reefs, in particular, are suffering declines in diversity due to a range of factors including overfishing, runoff of nutrients and other land-based pollutants and habitat degradation (Bellwood *et al.* 2004).

A key management strategy to address the many issues affecting marine and coastal ecosystems is the establishment and implementation of marine protected areas (MPAs). A MPA is a coastal or offshore marine area that is managed to protect natural and/or cultural resources (Agardy & Staub 2006; International Union for Conservation of Nature-World Commission on Protected Areas 2008). Globally, MPA coverage has grown rapidly since the 1970s, coincident with the adoption of various international conventions, in particular, the Ramsar Convention, the World Heritage Convention, and the Man and the Biosphere Programme of the UNESCO. However, global distribution of MPAs is both uneven and unrepresentative at multiple scales and only half of the world's MPAs are part of a coherent network (Wood *et al.* 2008). Worldwide, only about 0.08% of the world's oceans and 0.2% of the total marine area under national jurisdictions are 'no-take' where extractive uses are prohibited (Wood 2007). Less than 0.1% of the world's coral reefs are within 'no-take' MPAs with no poaching (Mora *et al.* 2006).

The increasing understanding of the interconnectedness of marine habitats and processes has highlighted the importance of moving beyond managing individual MPAs to managing MPA networks. Such larger-scale approaches are necessary to protect and conserve ecological processes (International Union for Conservation of Nature-World Commission on Protected Areas 2008). For example, a single reserve is unlikely to reduce overall mortality for a wide-ranging species that migrates during different life stages (Gerber & Heppell 2004).

The growing consensus that MPA networks are more desirable than individual MPAs requires an improved understanding of what constitutes a MPA network (Ballantine 1997; Salm *et al.* 2000; Allison *et al.* 2003; Roberts *et al.* 2003; White *et al.* 2006; International Union for Conservation of Nature-World Commission on Protected Areas 2008). A MPA network is not simply an arbitrary collection of MPAs. Partnership for Interdisciplinary Studies of Coastal Oceans (2007) suggests that a network can include MPAs of different sizes, located in critical habitats, containing components of a particular habitat type, or portions of different kinds of habitats, and interconnected by the movement of animals and plant propagules. Further, MPAs must be appropriately placed, sized and spaced to collectively function as an ecological network and successfully achieve biodiversity goals. A network implies a coordinated system of MPAs, linked through biological as well as administrative levels, reflecting a consistent approach to design, management, and monitoring. A broad definition of an ecological MPA network is: "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" (International Union for Conservation of Nature-World Commission on Protected Areas 2008: 3).

While planning for MPA networks has most commonly been driven by ecological criteria, a greater emphasis is now being given to establishing social MPA networks (Christie *et al.* 2009; Lowry *et al.* 2009; Pietri *et al.* 2009). Such networks facilitate learning and coordination of administration and planning by linking the people and institutions involved in MPAs into a coordinated and holistic initiative. The social network provides a mechanism for individual MPA stakeholders or communities to coordinate their activities and share experiences. Thus, a social or learning MPA network is a network of people managing the components of individual MPAs and promoting the network's viability. Only a few multinational, multidisciplinary, comparative, empirical evaluative research efforts have looked at integrated coastal management and MPA networks (Christie *et al.* 2003).

MPA networks are relatively new. Practitioners have expressed a need for practical guidance based on real experience on how to create and sustain both ecological and social MPA networks. This need stimulated the formation of the 'Effective Design and Management of Tropical Marine Protected Area Networks Through Cross-Institutional Learning' program (the MPA Learning Partnership), a social network of MPA implementers that aims to capture and analyse the experience gained among conservation institutions working across sites and countries around the world. This program was designed to build on the ongoing site-based MPA network initiatives within and among four Global Conservation Program partner-institution—The Nature Conservancy, World Wildlife Fund, Conservation International, Wildlife Conservation Society, and the United States Agency for International Development—that funded the work. As part of the MPA Learning Partnership a comparative study was conducted in the Coral Triangle in 2008. The hypothesis being tested in the study is that there exists a desire among MPA practitioners and governments to progress from individual MPAs to ecological networks of MPAs and that a few examples of functional ecological MPA networks are becoming effective.

STUDY AREA: THE CORAL TRIANGLE

The Coral Triangle is located along the equator where the Indian Ocean and Western Pacific Ocean meet (Figure 1). This region consists of portions of the waters and coastal regions of six countries: Indonesia, Malaysia, the Philippines, Timor-Leste (East Timor), Papua New Guinea (PNG) and the Solomon Islands. The Coral Triangle is the global epicentre of marine biodiversity and is considered a global priority for marine conservation (Allen 2000; Roberts *et al.* 2002; Allen and Adrim 2003; Bellwood *et al.* 2005). It contains over 75% of the estimated 600 coral species (Veron 2000), more than 30%

of the world's coral reefs, over 3,000 species of fish, and the greatest extent of mangrove forests of any region. The region's productivity and unique species assemblages and evolutionary significance make it a repository for the different species of the Indian and Pacific Oceans.

The Coral Triangle covers an expanse of 5.7 million sq. km or 1.6% of the world's oceans, and has a population of 360 million people. Estimates suggest that the reefs in the Coral Triangle support the livelihoods of 126 million people and the protein needs of millions more (The Nature Conservancy 2007). This area's rich marine biodiversity that disperses the largest number of marine species of different taxonomic groups warrants protection (Veron 2000). Indonesia and the Philippines hold 77% of the region's coral reefs and nearly 80% of all the threatened reefs (Burke *et al.* 2002).

Important strategies to address major management issues in this complex region include: reducing fishing pressure, preventing habitat destruction, providing alternative sources of income, and addressing broader coastal development issues (Lowry *et al*. 2009). There is also a growing realisation that maintaining high biodiversity levels and pristine coastal areas is vital to attract and sustain tourism and to maintain healthy populations of fish for food security. MPAs have existed for more than 30 years in parts of the Coral Triangle (Philippines, Malaysia and Indonesia) and more recently in the Solomon Islands, Papua New Guinea and East Timor. Unfortunately, the establishment of MPAs is rarely followed by good management and enforcement (Burke *et al.* 2002), meaning that the number of MPAs and their area of coverage are misleading indicators of effective conservation (Mora *et al.* 2006).

The six Coral Triangle countries have evolving systems of MPAs at the national and local levels. The Coral Triangle Initiative links these six countries, which have previously not cooperated as a unified group. The survey sites are in Indonesia (3), the Philippines (2) and Papua New Guinea (1) and key data on each is consolidated in Table 1.

Indonesian MPAs

Indonesia is composed of 17,508 islands inhabited by 237 million people. It is one of the world centres of diversity for coral reef ecosystems (Tun *et al.* 2004). It has a coastline of 95,181 km and includes an estimated 42,000 sq. km of mangroves and 51,000 sq. km of coral reef or about one-fifth of the world's coral reef area (United Nations Environment Programme-World Conservation Monitoring Centre 2008).

Indonesia has established 114 MPAs, 38 of which contain coral reefs as the dominant habitat (World Fish Center 2007). Legally designated MPAs currently cover almost 70,000 sq. km (Pet-Soede 2006). Most of Indonesia's MPAs are combined terrestrial and marine parks, administered by the Ministry of Forestry (MOF), many of which were gazetted during the

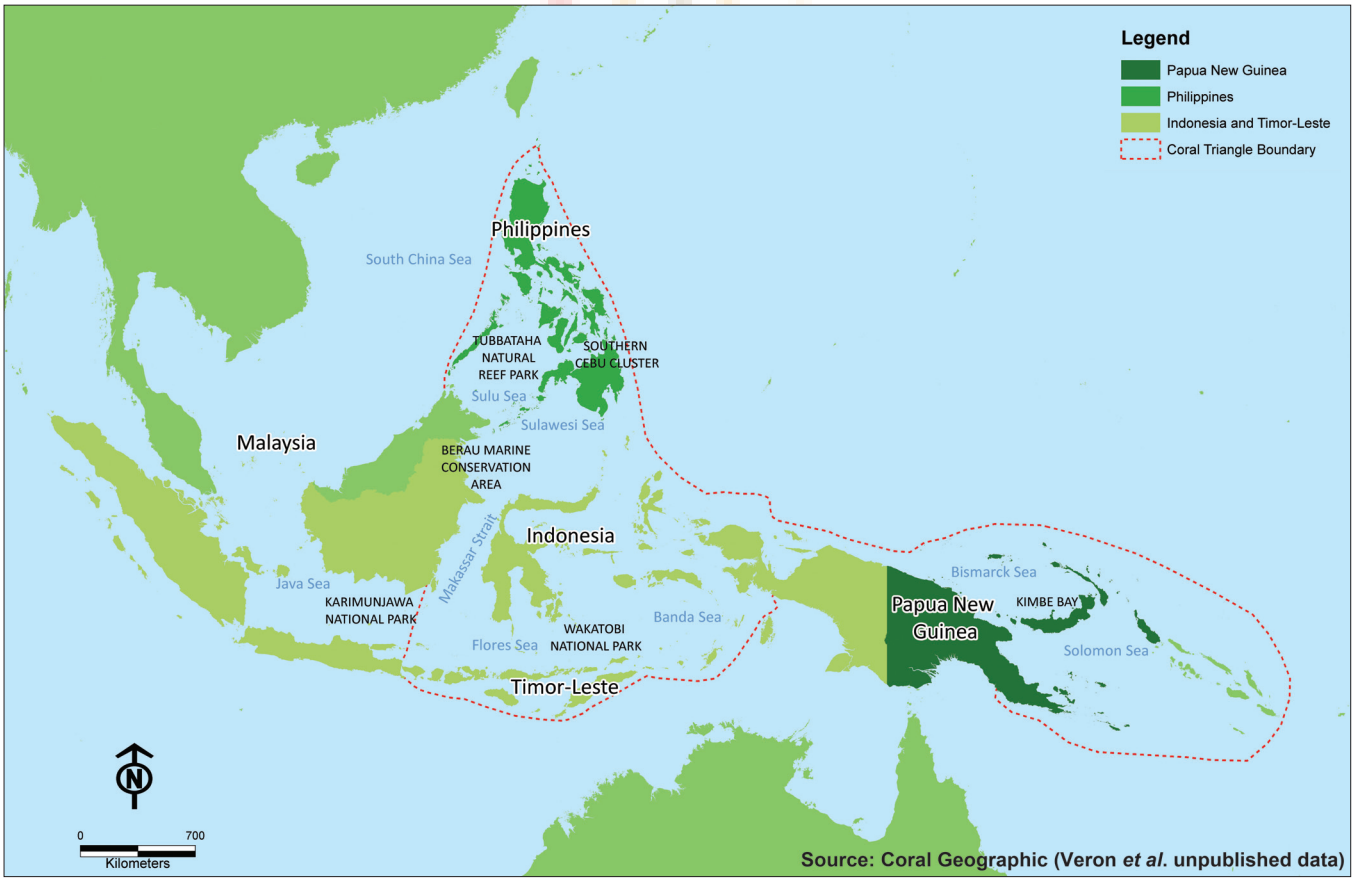

Figure 1
Coral Triangle map with study sites

1980s. Recently, the Ministry of Marine Affairs and Fisheries has taken over the administration and establishment of new marine (sub-tidal) protected areas and the district/regency/city (*Kabupaten* or *Kota*) now has jurisdiction out to 3 nautical miles. In addition, under the recent decentralisation, provinces have jurisdiction between 3 and 12 nautical miles offshore. A benefit of the decentralisation is that national marine parks are finding a common support framework where both national and district governments work together to improve management. The increased authority of the district and city governments is also assisting with the establishment and management of local MPAs that are not strictly under the national agencies. Nevertheless, it is estimated that less than 20% of Indonesian MPAs (national and local) are meeting their objectives (World Fish Center 2007; United Nations Environment Programme-World Conservation Monitoring Centre 2008). The Indonesian study MPAs are (Table 1).

The Berau Marine Conservation Area: located in Berau Regency in the Province of East Kalimantan, Borneo, at the junction of Sulawesi and the Java Sea.

The Karimunjawa National Park: located about 75 km off central Java's northern coast in western Indonesia, within Jepara Regency, central Java Province.

The Wakatobi Marine National Park: located on the southeastern tip of the island of Sulawesi. The Wakatobi Islands, previously known as the Tukang Besi Islands (Tun *et al.* 2004), consist of Wangi-Wangi, Kaledupa, Tomia and Binongko, with the first two letters of each island making up the acronym 'Wakatobi'.

Philippine MPAs

The Philippines consists of 7,107 islands. With a total coastline of 36,289 km, the country's coastal and marine waters are characterised by extensive coral reefs, seagrass beds and dense mangrove forests (World Bank 2005). The annual economic benefits from the Philippines' coastal ecosystems were estimated at USD 3.5 billion in 1998 (White & Cruz-Trinidad 1998; World Bank 2005). The economic costs of environmental degradation of these resources are significant. It is estimated that 1 sq. km of healthy coral reef generates an average of USD 50,000 from fishing and tourism alone (White & Cruz-Trinidad 1998). As a whole, the Philippine coral reefs contribute at least USD 1.4 billion annually to the economy or 1.4% of gross domestic product (World Bank 2005).

In 1991, the Philippines decentralised the management of marine waters to its 850 plus coastal municipalities. This legislation gave the municipalities and cities jurisdiction from the coastline out to 15 km offshore, including the authority to declare MPAs. Through the Local Government Code, even coastal villages have a clearly defined role and can legislate and enforce rules on coastal management. This law has led to approximately 1,100 established MPAs, covering about 500 sq. km, managed by municipal and city governments through cooperative management arrangements between local governments, coastal communities and other stakeholders. These MPAs normally contain no-take areas surrounded by some form of managed fishing areas (Arceo *et al.* 2008). These locally mandated MPAs are also encouraged by the National Fisheries Code Policy of 1998 that sets a goal of having 15% of municipal waters managed as fish sanctuaries. In addition, under the National Integrated Protected Areas System (NIPAS) Act of 1992, 28 national MPAs have been proclaimed that cover about 15,000 sq. km. These are in the process of being managed jointly with local governments. The Philippine study sites are:

The Southeast Cebu MPA Network: located in Cebu Province in the southern Philippines. The Network represents an inter-municipal partnership that attempts to address the interrelated political, institutional, socio-economic, cultural, and environmental concerns plaguing a common fisheries ecosystem. The Southeast Cebu cluster is composed of eight municipalities, each with its own MPA and management interventions. Twenty MPAs comprise the network that started through social and administrative links, but which is currently being redesigned as an ecological network.

The Tubbataha Reefs Natural Park and World Heritage Site: lies in the middle of the Sulu Sea, about 150 km offshore from Puerto Princesa, Palawan. It is under the political jurisdiction of Cagayancillo Municipality, 130 km to the north of the atoll. The Tubbataha Reefs Natural Park was declared in 1988 and contains two atoll reefs and several islets. Tubbataha is managed under a Protected Area Management Board that contains local and national stakeholders, and is jointly chaired by a representative of the provincial and national governments (Table 1).

Papua New Guinea MPA Network

Papua New Guinea (PNG) comprises the eastern half of the island of New Guinea and offshore islands. It has a population of 6. 7 million (2007 estimate), a land area of some 463,000 sq. km, and is the largest of the Pacific island countries. The country has a coastline of 20,197 km and the marine area inside the 200 nautical mile declared waters amounts to 1.6 million sq. km (Earth Trends 2003). The indigenous population of PNG is one of the most heterogeneous in the world with several thousand small separate lingual communities.

PNG declared its first MPA in 2000 with assistance from the Local Management Marine Areas Network. There are 22 MPAs (including wildlife management areas, marine parks, historic reserves and provincial parks) that have been nationally designated in PNG. The majority (97%) of the country's land is owned and managed under customary tenure and stewardship. Clans or tribes claim customary ownership over mangroves, lagoons and reefs in their vicinity. This traditional form of communal ownership is often referred to as customary marine tenure (Ruddle *et al*. 1992), and it is recognised to varying degrees in PNG (Fisheries Management Act 1998). The PNG study site is:

The Kimbe Bay Marine Protected Area Network: located on

the north coast of the island of New Britain in the Bismarck Sea. The bay is 13,794 sq. km in area and covers a coastline of 560 km that includes 3,739 sq. km of shelf habitat, a portion of which contains a network of smaller MPAs (Table 1).

Selecting MPA Networks within the Coral Triangle

The six study areas were not randomly selected, and were intended to provide insights into MPAs and emerging networks considered to be advanced in either their planning and/or implementation process. The sites represented two basic models of MPAs. The first fits the classic definition of the 'park' model for MPA establishment, whereby a government agency declares an area off limits for some or all activities (e.g., Tubbataha, Wakatobi, Berau and Karimunjawa). The second type is a 'community-based' model, whereby coastal communities and local governments assume most of the responsibilities for implementing, monitoring, and enforcing rules for protection (White *et al*. 2006; Christie *et al.* 2003). When several of the community-based MPAs began to work together for common issues such as law enforcement or integrated management, they were also considered as social and administrative MPA networks for this study. The Southeast Cebu cluster follows the second model and is composed of a collection of community-based projects that have combined their resources for efficiencies of scale in coastal law enforcement and policy at the municipal 'cluster' level and are now working towards the development of an ecological network of MPAs. The Kimbe Bay MPA in PNG is a hybrid of both approaches, with large spatial planning in place, while communities are involved in the development of localised management systems within pre-identified geographic areas of interest.

The MPA networks areas selected for the study range in size from 968 sq. km (Tubbataha) to Wakatobi MPA in Indonesia at 13,900 sq. km. The no-take zones within the network boundaries ranged from 0.24% of the total area (Cebu, Philippines) to 100% for the Tubbataha Reef Natural Marine Park, Philippines (Table 1). The MPAs were also at various stages of development; some have existed over 20 years (Karimunjawa and Tubbataha), while others were in the initial planning and implementation stages (e.g., Kimbe Bay and Berau). At the time of the study, Wakatobi was in a process of rezoning after a decade of implementation. The MPAs in this study are referred to as 'MPA networks' because they are emerging MPA networks based on ecological and administrative definitions of what constitutes a 'network'. Thus, two main types of MPA networks are described as part

Table 1

Summary information of the MPA/MPA networks covered under the study

MPA/ MPA network name	Year declared	Type of network or MPA	Management jurisdiction and/ or type of legal declaration	Management authority	Total size of MPA/ network (sq. km)*	Percent (%) of MPA as no-take zone	Number of villages within MPA network	Population living within or on perimeter of MPA (approx)	Main livelihood of inhabitants
Berau Marine Conservation Area, Kalimantan, Indonesia	2005	Individual MPA with multiple no-take zones	Both national and local	Local management working group formed	12,000	8	26	23,239 (2003)	Mining, logging, farming, fishing
Karimunjawa National Park, Java, Indonesia	1988	Individual MPA	National	National park management board	1,106	10	3	8,842 (2003)	Fishing, farming
Wakatobi Marine National Park, Indonesia	National law in 1996 (local law in 2003)	Individual MPA with multiple no-take zones	Both national and local	National management working group	13,900	3. 2	27	100,000 (2003)	Fishing, farming, trading
Southeast Cebu Network, Visayas, the Philippines	First MPA declared in 1974, network efforts initiated in 2003	Network of individual MPAs working as a social network	Local	Local management council formed	1,250	0. 2	82	252,000 (2006)	Fishing, farming and tourism
Tubbataha Reefs Natural Park and World Heritage Site, Sulu Sea, the Philippines	1988 declaration, expanded park boundaries in 2007 and own law passed in 2010	Individual MPA	National law and local jurisdiction	National and local management board	968	100	0	0	Fishing and tourism in community (80 km away form site)
Kimbe Bay, New West Britain, Papua New Guinea	2006 initiated, local areas of interest declared locally	Multiple MPAs within a MPA network	Local	Individual management councils per village	13,794	20. 75 planned	17	100,000	Palm oil, farming, fishing

*Total size of the declared MPA, not all of which is no-take zone

of this study, and a third is also described but not studied:

Ecologically and scientifically planned networks of no-take zones for which basic fisheries and habitat data are collected, scientists and stakeholders are consulted on the best 'fit' to achieve specific objectives, and management is implemented by an authority that includes a network of no-take zones that constitute a network within the overall MPA boundaries (Tubbataha, Berau, Karimunjawa, and Wakatobi).

MPA management (administrative) networks where smaller no-take zones cluster together under a formally recognised organisation to share resources and resolve common problems in adjacent geographic areas (Southeast Cebu) as part of a wider area that is protected.

In addition, Peer Learning MPA networks composed of managers and implementers who work together and share experiences among each other to improve management practices were encountered during the study but not evaluated. Examples included the Locally Marine Managed Areas Network in PNG and the MPA Support Network (MSN) in the Philippines.

METHODS

Site interview questions were defined from the initial phases of the Learning Partnership and consolidated into one survey tool that was used throughout the study without change. The survey tool was enhanced with inputs from Bunce *et al.* (2000), Pomeroy *et al.* (2004) and White *et al*. (2006), and previous MPA Learning Partnership meetings and documentation.

Field Survey Methodology and Learning Tool

The interviews in the Philippines were all conducted by one of the two study team members either in English or Filipino (both study team members were fluent in both). For interactions with a few community members who did not have a command over English in two sites in Indonesia (Wakatobi and Karimunjawa), a local translation of the interview tool was prepared and two local, non-study NGO staff members asked questions and translated. To ensure consistency, the authors sat in each interview and documented the results.

There were a total of 94 respondents to generate the data set (Table 2). A mix of stakeholders from each MPA network were interviewed at each site. The sample was not random. In each site at least two representatives of each key sector involved in the MPA planning or implementation were interviewed. At least two representatives of fishers, women's groups, ancillary industries (fish marketing or tourism), NGO, local government, and national government were interviewed. Additional interviewees were suggested by the local NGO partners. While selection of informants was influenced by availability, an effort was made to interview persons with a range of opinions. A summary of the interviewees is in Table 2.

Once the data set was organised, different scenarios looking at the relationship between management effectiveness, social success, and biophysical change factors in the MPA networks were analysed. Basic summary analysis was used to group and prioritise answers from the respondents so that their perceptions could be consistently reported. Because the sites and interviewees were not randomly selected, the results do not necessarily represent a larger population of MPA sites or a representative sample of stakeholders. Nevertheless, because the study intent was to learn from the most advanced MPAs/networks in the region, the approach seemed valid. Statistical analysis and other information are provided in detail in a printed report (The Nature Conservancy *et al.* 2008).

This analysis focuses on a portion of the survey that explored the relationship between economic and environmental changes associated with the individual MPA and its functions in the context of MPA networks. Key factors discussed pertain to data on interviewee perceptions that focus on:

- Factors that enhance fish catch, critical habitats or marine diversity inside/near the MPA
- Factors that increase involvement by local fisher leaders in the management of the MPA
- Factors that increase enforcement by community enforcers and managers
- Factors that increase household income
- Benefits from MPA and MPA network implementation

Limitations of the Approach

The main tool used to collect information was the structured interview. In social research, the reliability and credibility of results depends on the precision of the data collected (National Oceanic and Atmospheric Administration 2005). The interview approach had several limitations including:

- The learning tool asked perceptions of a range of respondents so data were based on what people know and can communicate but not independently validated facts. Perceptions shape action and policy, and are, therefore, important to understand.
- This study should not be perceived as representative of MPAs and MPA networks found throughout the entire Coral Triangle. The results are not meant to offer a menu of prescriptions for 'fixing' MPAs, but can provide at least a framework for self-evaluation by MPA managers and practitioners and guidance for further studies.

Data were not aggregated by network or country as this was a first general review of MPA networks in the region. The responses of all informants were pooled. Three MPA networks were sampled in Indonesia, two in the Philippines, and one in PNG. Selection of the six sites sampled was influenced by the perception that they represent the closest proxy to 'emerging MPA networks' in the region.

SURVEY RESULTS

MPA networks are emerging from existing MPAs in the region, and, as such, this study provides initial guidance to that process as summarised in Tables 3–7.

The top responses from persons surveyed on how to best improve fish catch, critical habitats, and marine diversity

were: sustainable financing for management (88%), clarity of MPA network rules (76%), and enforcement by community enforcers (74%). In relation to these factors, those that were most important to gain stakeholder support in the planning and implementation processes were training, participation in assessments, and engaging people through consultations among others (Table 3).

The most common problems within the MPA networks were, in order of frequency, illegal and destructive fishing activities (94%), intrusion by outsiders within no-take zones (82%), problems relating to law enforcers and enforcement (74%), intrusion by locals within the no-take zones (66%), lack of understanding of the rules and regulations (61%), and miscommunications between stakeholders and influential persons prompting selective implementation of the law (54%). Policies that helped to resolve these conflicts within the MPA were in order of priority: local regulations, national regulations, community laws, traditional laws, and religious laws. The survey also asked what was inhibiting the improvement in the MPA/MPA network management (Table 4). Lack of leadership, finances and capacity were the prominent factors noted.

Respondents were also asked to rank the most important socio-economic benefits and outcomes associated with the MPA/MPA network (Table 5). The participation of minority and ethnic groups coupled with increased community pride and skills development were seen as important benefits to people in the area, in addition to enhanced fish and reef resources.

Stakeholders were also asked to rate the key considerations that took place in the placement of the no-take zones of the MPA/MPA network (Table 6). While ecological considerations ranked first, social and practical factors were also important in planning.

Respondents were asked to rate the importance of different strategies to improve their MPA networks over the next five years. The list (Table 7) ranges from the most important (monitoring and evaluation of management as well as biophysical changes) to the least important (expansion of no-take areas).

DISCUSSION OF RESULTS: RELEVANCE FOR MPA NETWORKS

The results highlight the factors that influence certain desirable outcomes related to MPA implementation. It is noted that most of the factors and variables discussed appear to pertain only to single MPAs (with multiple no-take zones in some cases). The results do not provide a blueprint for a successful MPA or a check list of dos and don'ts for single

Table 2

Basic profile of survey respondents

Site	Number		Summary of affiliation	Summary of educational attainment
	Male	Female		
Berau Marine Conservation Area	14	2	Government: 25% Non Government: 56% Fishers: 13% Others: 6%	PhD: 13% Master's Degree: 31% Bachelor's Degree: 43% High school or below: 13%
Karimunjawa National Park	11	4	Government: 21% Non Government:53% Fishers representatives: 13% Others: 13%	PhD: 7% Master's Degree: 13% Bachelor's Degree: 80%
Wakatobi Marine National Park	14	2	Government: 56% Non Government:32% Fishers representatives: 12% Others: -	Master's Degree: 13% Bachelor's Degree: 56% High school or below: 31%
Southeast Cebu MPA Cluster	10	5	Government: 33% Non Government: 47% Fishers representatives:13% Others: 7%	PhD: 7% Master's Degree: 13% Bachelor's Degree: 73%; High school or below: 7%
Tubbataha Reefs Natural Park	7	8	Government: 58% Non Government: 21% Fishers representatives: 7% Others: 14%	Master's Degree: 13% Bachelor's Degree: 73% Undergraduate: 7% High school or below: 7%
Kimbe Bay MPA Network	12	5	Government: 19% Non Government: 53% Fishers representatives: 21% Others: 7%	PhD: 6% Master's Degree: 6% Bachelor's Degree: 58% High school or below: 30%

Table 3

Most effective strategies for gaining support from community stakeholders

Strategy	Positive response %	Total number of responses
Trainings in MPA management skills and leadership development	75	82
Participatory biophysical assessments	70	77
Social assessments/Interviews	69	75
Planning meetings with government officials	67	74
Public consultations/Community meetings	65	77
Multi-stakeholder planning workshops	65	75
Communication activities (e.g., film showings, photo exhibits)	67	79
Publications	63	75
Community surveillance and enforcement of MPA	62	73
Awareness raising activities (e.g., coastal clean-up, etc.)	62	74
National & international visitors (e.g., education tours, donor visits, etc.)	60	74
Research/survey results feedback to key stakeholders	53	75

Table 4

Factors that inhibit the improvement in MPA/network management

Inhibiting factor	Positive response %	Total number of responses
Lack of leadership	93	94
Lack of financial resources	92	94
Lack of capacity	88	94
Weak planning and implementation	82	94
Lack of interest	67	94
Political interventions	63	94
Cultural	42	94
Project implementation difficulties	37	94
Unwillingness to adopt the MPA/MPA network concept	27	94

MPA establishment, but provide key themes for subsequent studies by MPA park managers and practitioners to identify key overriding strategies that are relevant to social and biophysical success.

Of particular relevance for MPA networks is the important assumption underlying this study, that functional and effective MPAs (small or large) are a prerequisite to functional and effective MPA networks. Thus, the two are not easily separated, and factors that contribute to MPA effectiveness, also contribute directly to MPA networks. But, what the results fail to address is a more explicit discussion of what is needed to scale MPAs up to functional networks. We discuss lessons learnt through interviews and observations about the emerging MPA networks. We also discuss the emerging MPA networks

Table 5

Socio-economic benefits and outcomes of the MPA/MPA network

Benefit	Positive response %	Total number of responses
Sensitivity to minority/ethnic groups	92	94
Increased community pride	89	94
Skills development	84	94
Increased fish catch	80	94
Increased unity within the community	77	94
Education	73	94
Opened business opportunities (tourism related)	62	94
Increased household income	60	94
Supplemental or alternative livelihood programs provided	55	94
Youth development	35	94
Opened business opportunities (non-tourism related)	30	94
Outreach programs conducted (medical, health missions, etc.)	29	94

Table 6

Key considerations in the placement of no-take zones

Consideration in the placement of no-take zones	Positive response %	Total number of responses
In terms of ecological considerations	89	90
In terms of social considerations	62	90
In terms of manageability considerations	46	88

in relation to overall network criteria as set out by Roberts *et al*. (2003) and others.

MPA Networks Across Multiple Scales

There is general consensus that MPA networks are more desirable than individual MPAs (Ballantine 1997; Salm *et al*. 2000; Allison *et al*. 2003; Roberts *et al*. 2003; White *et al*. 2006; World Commission on Protected Areas-International Union for Conservation of Nature 2007). This was borne out in interactions with the practitioners in this study. All agreed that planned networks can provide important spatial links to maintain ecosystem processes and connectivity, as well as improve resilience in the case of a localised catastrophe as suggested by Stewart *et al*. (2003). Most agreed that networks are better than single sites in ensuring long-term sustainability of populations. Thus, designing and implementing MPA networks is a big first step towards an ecosystem-based approach towards meeting the multiple goals of coastal and ocean management, as well as the opportunity to provide for more inclusive representation of stakeholders (National Research Council 2000).

Informants of the study commonly noted that MPAs are just one of the tools for marine resources management, not the only approach to accomplish comprehensive conservation (Roberts 2007). Interviews also noted that the benefits that

Table 7

Strategies perceived to enhance MPA/MPA network effectiveness in the next five years (highest first)

Strategy	Positive response %	Total number of responses
Monitoring and evaluation of management and its documentation	85	83
Monitoring and evaluation of biophysical changes and its documentation	85	83
Management planning	84	83
Public education and awareness raising activities	84	83
Information management systems	84	83
Taking a 'doing and learning' approach	84	81
Developing capacity of management board	84	82
Providing livelihood activity options	83	82
Coastal law enforcement and compliance	83	80
Development of information materials targeting particular stakeholders	82	83
Sustainable financing	81	82
Adopting an integrated coastal management approach	80	78
Policy work	80	82
Scientific research e.g., larval flow	80	83
Enhancing political will	80	83
Expanding the no-take zones	60	76

MPAs can deliver are directly related to the effectiveness of management both inside and, equally, outside of MPAs as highlighted by Christie *et al.* (2002) and Cicin-Sain & Belfiore (2005). Management needs to be in place beyond core and buffer zones of MPAs and networks. Thus while MPAs limit human activities at particular locations, their resources and habitats remain vulnerable to risks from beyond their boundaries, such as sedimentation, pollution, coastal development and overfishing (Sale *et al.* 2005; Stoms *et al.* 2005). Therefore, MPAs and related systems will need to form nested layers as part of a comprehensive integrated coastal (and marine) management approach (Christie & White 1997; White *et al.* 2005). Integrated management regimes, where they are evolving, are paying dividends beyond what MPAs can deliver, especially in terms of shoreline and coastal habitat management, improved water quality, and fisheries enhancement (Green *et al*. 2003).

As viewed from a local perspective, 'fishing communities are best understood as dependent not on a single resource but on a whole ecosystem' (Bailey & Pomeroy 1996). A similar analogy applies to MPAs in that they cannot be considered independent of the surrounding system, and the MPAs must consider how they will be networked to cover whole marine systems. In countries like the Philippines, Indonesia and Papua New Guinea, where Locally Managed Marine Areas and community-based MPAs are established, social networking for management effectiveness should be a key direction for MPA development. Fitting these networks in with larger MPAs to provide the biodiversity- and ecosystem-wide benefits to protect fisheries is a parallel process. In countries with large and growing populations, and heavy reliance on coastal resources, fully integrated approaches are essential (White *et al*. 2005).

Discussion on how MPAs can scale up to MPA networks by International Union for Conservation of Nature-World Commission on Protected Areas (2008), Roberts *et al.* (2003); Roberts (2007), and others make assumptions about the process and resources required. This study offers new insights about context and resources required for networking:

- Recognised and also informal social networks need to be established;
- Need to establish a social network for resource users and resource managers, and institutions to assist with developing capable leaders for MPAs and MPA networks;
- Critical need for technical knowledge among planners, managers, and implementers;
- Need to assess and build management capacity and strengths of the persons involved;
- Need regular funding or budget for operations and maintenance; and
- Support of national or local experience and policies in marine resource management.

Papua New Guinea has a strong Locally Marine Managed Areas Network with regular quarterly and annual national-level meetings among members. This has helped managers to share experiences and develop a peer support network. The recently formed Philippine MPA Support Network is working with managers and implementers, and is developing criteria for a self-evaluation tool, and a MPA database for the country. In Indonesia, national park heads meet annually for discussions on management, and have their own social network. In Southeast Cebu, eight towns have formed their own administrative and learning network.

Interaction with the MPA managers in this study highlighted the extent to which they personally associate the development of MPA networks with ecological criteria. At the same time, the overall analysis shows the strong association between biological parameters and social variables. Social factors rose up as important overall determinants of MPA network success or failure (Christie *et al*. 2003; Mascia 2003; Wahle *et al*. 2003; Christie 2004). The traditional resource management systems (e.g., customary marine tenure and traditional fishing patterns) are often adaptive responses of the community that have evolved over time (Folke *et al*. 2005; Berkes 2004). These are

effective in certain areas because they are embedded in local institutions and value systems, and are being recognised in the emerging MPA networks as important success factors (Cinner *et al*. 2005; McClanahan *et al*. 2005).

Perceived Best Practices for MPA Network Management Effectiveness from the Study

The survey results highlighted the perceived relationship between the effectiveness of the MPAs, MPA networks, and on-the-ground work and benefits to the local inhabitants. Local skills development and a solid communication strategy resulted in significant positive impacts on household incomes and a perceived increase in unity and community pride. The opening of tourism opportunities was also found to have a positive impact on household incomes.

Poorly managed social dynamics have negative consequences for biological resources (Christie 2004). A series of best practices for MPA network establishment evolved during the partnership (Table 8), and adoption of these during the MPA planning and implementation process should lead to more effective MPAs/MPA networks.

Decision Making Processes and Stakeholder Involvement

The survey showed that the role of fishers and local leaders in management and decision making was less than the role of NGOs and National Government Agencies at all sites. Yet, effective management is only achieved when the fishers and local stakeholders take an active role in the MPA network management (White *et al.* 2006). This discrepancy highlights the difficult balancing act that NGOs and implementing agencies have to perform in catalysing the development of a successful MPA or MPA network ensuring equitable ownership and management by local resource users, responsible agencies, and officials. Ultimately MPA network management effectiveness needs to be gauged from stakeholders within and around the perimeter of a MPA or MPA network, and should not be too dependent on project staff and outsider opinion. Public participation builds trust, enhances legitimacy of rules and regulations, and ensures the sustainability of MPA implementation plans by giving stakeholders a sense of ownership or responsibility for the MPA and its management arrangements (Tompkins & Adger 2004).

Management Boards

At all sites, the capacity and development of a management board was important. Site management boards served to guide the MPA and allow a multi-level governance system where different stakeholders and authorities could be involved in the planning and implementation of the MPA as noted by Lebel *et al*. (2006). An ideal board involves local as well as higher levels of governance and aims to find a balance between decentralised and centralised control (Adger 2003; Olsson 2003). In the Southeast Cebu study site, a governing board has been established to provide accountability for all stakeholders, and ensure that decision-makers further the interests of constituents rather than personal interests, as Mascia (2003) suggested might be an issue. The board also provides an evaluation loop and potential for conflict resolution and leadership.

Local Skills Development vs Alternative Livelihood

Survey respondents perceived that only indigenous peoples and tourism businesses thought there was a correlation between alternative livelihood development and MPA success. This recognises that developing a whole new livelihood system for fishing communities is difficult to achieve. Similarly, the study verified that short-term biological gains will likely disappear unless social issues are addressed as confirmed by Pollnac *et al*. (2001). An example is the Southeast Cebu MPA Network, is where real gains were not seen until illegal fishing and other social problems (e.g., fishing rights) were addressed. Thus, planning and implementing MPA networks with a full vision for the social and economic realities of an area will increase the chances of creating sustainable networks of MPAs. Well-designed MPAs are successful not only at regulating resource use but also at building community capacity, to adapt to a variety of environmental and social changes. All the six study sites lacked ideal social design.

Table 8

Framework of best practices in the planning and implementation phases for MPA networks

Design and Planning Phase	Implementation Phase
Involve primary stakeholders	Need for policy and social arrangements to be in place
Consider secondary stakeholders	Develop the management council
Conduct resource assessment (involving local resource users)	Build conflict resolution capacity
Use Rules of Thumb for science (where it is not immediately available)	Balance social, ecological and manageability criteria for declaration of no-take zones
Establish management council	Outreach and communication programs
Evaluate financing availability	Coastal law enforcement
Balance conservation and socioeconomic development	Monitoring and evaluation that includes management effectiveness
Develop alternative livelihood and skills	Sharing of lessons learned based on management effectiveness
	Build institutional memory and capacity at local and national levels
	Develop social MPA networks
	Work on national and international policies to support

Balancing Expectations and Success

Interviewees said that having clear objectives and setting expectations at the beginning of any MPA planning process is vital. All of the lead factors indicate that careful consideration of the receptivity of fishing communities to MPAs is fundamental for their long-term success as supported by Agardy & Staub (2006), and others. Stakeholder expectations relating to marine tourism and other potential benefits need to be clarified. The existence of a MPA does not automatically lead to flocks of visitors; such myths need to be dispelled early in the process.

The survey confirmed that for MPAs to be successful, they must be set up carefully and for the right reasons in the context of the area. In the Coral Triangle, where marine resources provide income for many families, and fish serve as a key source of animal protein, attention to the underlying socio-economic issues is essential. Science-based planning is significantly constrained if local contextual factors are not fully considered. The need for strong support from local resource-dependent communities for successful MPA implementation is also confirmed by the findings of Russ & Alcala (1999) and others. Ignoring social considerations guarantees high failure rates for MPAs and may trigger their decline as an effective tool (Christie 2004).

Field discussions highlighted that MPA network establishment incurs significant social and economic costs upon inception, with the majority of these costs passed on directly to the local stakeholders. Such costs need to be incorporated into MPA planning strategies and stakeholders need to be aware of this prior to the establishment process. Reviewing stakeholder expectations of the benefits, disadvantages, and possible changes caused by MPAs helps prepare people for the effects that may occur due to MPAs.

Large or Small MPAs?

One source of tension noted by resource managers during the study was the need to show scientifically defensible evidence making the case for large no-take MPAs versus smaller areas requested by local stakeholders. Finding a workable and ecologically acceptable minimum size for no-take protection as per International Union for Conservation of Nature-World Commission on Protected Areas (2008) and other guidelines has created a dilemma for planners. Nevertheless, managers also pointed out that while small MPAs of 1 to 2 sq. km will not be able to increase fish biomass and provide larval and fish export as much as larger no-take areas, they give the opportunity to communities and government agencies to engage in management and learn from experience. Small MPAs do provide localised biological results. Russ *et al*. (2004) demonstrate significant spillover benefits from small MPAs, and Halpern (2003) shows through a meta-analysis of many MPAs that size is not significantly correlated with benefits. In any case, small MPAs represent 40% of the areas in the current global network of coral reef MPAs (Mora *et al*. 2006).

Smaller MPAs alone will not ultimately save the large herbivorous and predatory fishes that are commonly targeted by fishers, unless they are part of a larger management regime. Furthermore, if management is successful in the small MPAs, then scaling up to larger MPAs and MPA networks is feasible. Equally agreed was that large MPAs with no-take zones of greater than 10-20 sq. km (as recommended by Shanks *et al.* 2003), that follow a sound ecological basis, will not achieve significant fish biomass build-up and biodiversity conservation until effective management and enforcement is in place.

Thus, in thinking about how to scale up to MPA networks, the debate of large MPA versus small MPA is not black and white. Larger MPAs may be ecologically optimal and financially viable at economies of scale, but smaller MPAs may be more socially and financially practical in the short term and sustainable in the long term. By being clear on the objectives of the MPA and on what outcomes are possible, MPA networks will be more likely to succeed. Scaling up to MPA networks may therefore not always be related to size, but can pertain to MPA objectives, social impacts, financial investment, and management effectiveness.

Management Effectiveness

Only a small portion of the MPAs in the Coral Triangle are effectively managed (World Fish Center 2007; International Union for Conservation of Nature 2005: Mora *et al.* 2006). With about 11% of southeast Asian coral reefs included within multipurpose and no-take MPAs, and with less than 20% of these functionally meeting their management objectives (World Fish Center 2007; United Nations Environment Programme-World Conservation Monitoring Centre 2008), the percentage of well-protected reefs is still small (Tun *et al*. 2004; White *et al.* 2005).

Tracking MPAs on legally declared size alone may not be the most useful indicator of success, instead assessing field-level management effectiveness of MPAs and MPA networks can provide a more realistic indication of success. At sites where management effectiveness is tracked (in Philippines and Indonesia), there is confidence that some MPAs and MPA networks are meeting their objectives. Though success rates in these 2 countries are still low at about 25% (Coastal Conservation and Education Foundation and Partners 2007; PhilReefs 2008; Mous 2008), the fact that management effectiveness is being measured and used as a planning tool to improve management, is a sign that the science and practice guiding MPAs is maturing. While governments of the six countries of the Coral Triangle are still embarking on the legal establishment of MPAs, the need for improved management effectiveness protocols for both individual MPAs and MPA networks is critical.

Financing MPA Networks

The survey results brought considerable attention to sustainable financing of start-up and operational costs of MPAs as a significant factor related to their management effectiveness. In all sites, budgets were limiting and the

financial requirements for MPA management (especially long-term) were rarely planned from the outset. Sustainable financing was mostly viewed as an 'add-on' consideration, long after the planning phase and only when it was clear that existing funding sources were running out. It was noted that if financial requirements are not clear up front, it becomes increasingly difficult to secure long-term commitments from funders who otherwise are not aware of these financial requirements.

Insufficient long-term funding hampers enforcement and surveillance capacity (Evans & Russ 2004; Lundquist & Granek 2005). In a worldwide survey of MPAs, only 16% of respondents reported that current levels of funding were adequate for effective conservation (Balmford *et al*. 2004). However, in the Coral Triangle MPAs, many do not yet have fully functional management plans in place to ensure that objectives can be met, let alone clear financial plans or strategies to cover the operational costs. Thus, obtaining sustainable financing to support management is difficult without functioning management plans in place.

While sustainable financing generally refers to securing sufficient and reliable funding, it is important that the MPA partners and practitioners view it in the context of well-designed, functional, and cost-effective MPAs. Sustainable financing should be addressed with two strategies: Evaluating the real costs of management of each MPA and thereby identifying the level of financing that will be required to cover the costs of effective management of each MPA, and identifying opportunities for improving the use of existing financial and human resources available to focus on the priority needs of the MPA?

Each MPA will need to consider what is appropriate and possible in the given context. It is then possible to focus on specific requirements, and to identify and develop financing sources locally (local governments, private sector, communities, and other organisations that may have local vested interests), as well as attract increased commitments from national governments and international donors. Overly ambitious or poorly designed MPAs which do not consider long-term financing in early planning phases will not succeed in the long term.

MPAs and MPA networks can identify opportunities for cost offsetting, or cost sharing, where stakeholders can collaborate to shoulder certain cost burdens. Examples from the survey include compliance monitoring, communications and community capacity-building. In addition to the importance of securing financing, identifying cost-sharing opportunities also represents an important way to reduce a MPA or network's recurrent costs.

An Emerging Success Factor—Simplicity and the Art of Management and Leadership

A variety of tools have been developed to help with the planning and establishment of MPA networks (Ball & Possingham 2000), and although these tools are helpful, they are only as good as the managers' understanding and use of them. When designing MPA networks, the right balance of ecological, social, and management and financial planning is vital. The fourth factor that emerged from the field survey is best described as an 'ease of management and simplicity' factor. The clarity of the rules, awareness and involvement of local residents, fishers, and leaders, and involvement in enforcement was mentioned by most of the respondents in the interviews.

Tubbataha Marine Natural Reef Park is an example of a functional MPA with simple rules and management (e.g., the entire park is no-take and there are no residents inside the park boundaries with the nearest population being 70 km away). Its manager has the skills needed to manage a protected area effectively and in a non-confrontational manner. Despite the 'simple' rules, as the Tubbataha Park gained success, there has been increasing pressure from illegal fishers, from more tourism operators, and other interests that have had to be managed without arousing undue opposition. The various park managers we met during the study reinforced the vital role that leadership plays at all levels in the context of MPA effectiveness. There is still a significant gap in resources (human and financial) allocated to MPA leaders in the region. In some countries, the prevailing culture may mean that the gender of the park manager is important. In the Philippines, it appears that female park managers may be more adept at handling some difficult situations such as law enforcement, law enforcers, as well as dealing with politicians, and assisting organisations at the local or national levels, because they can more easily deflect tension and cut through normal bureaucratic delays and rituals.

CONCLUSIONS

Two types of MPA networks have been analysed:

1. Ecologically and scientifically planned MPA networks (Tubbataha, Berau, Karimunjawa and Wakatobi).
2. MPA management (administrative) networks where smaller MPAs cluster together under a formally recognised organisation to share resources and resolve common problems in adjacent geographic areas (Southeast Cebu).

The third type of MPA network was only observed:

3. Social (learning) MPA networks of managers and implementers who work together and share experiences among their peer group to improve management practices. (Locally Marine Managed Areas Network in PNG, and MPA Social Network, in the Philippines).

There are some overlaps among the three categories of MPA networks, but they provide a guide for explaining the manner in which MPA networks are emerging in the Coral Triangle. All persons interviewed in the study aspire to move towards functional ecological MPA networks although most have a slightly different concept about what they are working towards. Several issues and opportunities regarding the 3 network types follow.

ECOLOGICAL AND SCIENTIFICALLY PLANNED MPA NETWORKS

Each site surveyed wants to have access to better data and analysis to form a truly ecologically sound network either of zones within a large MPA or of no-take MPAs. However, few sites have achieved this because of poor information, lack of technical expertise, and lack of funding. While knowledge is available to inform MPA network design in some cases, the ability to mobilise resources, and the political will to develop robust MPA networks is lacking. The sites with scientifically rigorous plans in place still had a long road to full and effective implementation. The presence of a scientifically rigorous plan did not ensure success, plans need to also consider the social-learning and administrative aspects of a MPA network.

A question that often arises in relation to MPA networks is what should be done with MPAs that were established before network thinking and planning was prevalent (Stewart *et al.* 2003). The dilemma is that because networks were rarely considered at the start of MPA designation, optimal networks based on the best scientific design and modelling may not include all MPAs that were established prior to this knowledge. The survey results suggest that MPA networks can and should be designed in an evolving manner with each additional MPA contributing to broader resource management goals (Roberts *et al.* 2001). Developing clear planning steps and evaluative criteria for such emergent MPA networks is an important undertaking. Such planning needs to be adaptive so that past efforts and existing MPAs are integrated and improved.

Management or Administrative MPA Networks

Such networks consider ecological attributes, but are established to address governance challenges. In the Southeast Cebu MPA Network each local government had several small no-take MPAs prior to the network. Officials and stakeholders began to realise that an administrative network was needed to support individual MPA efforts and link municipal government to address management challenges such as illegal fishing (Christie *et al.* 2009; Eisma-Osorio *et al*. 2009). Then, as the network evolved, ecological information (e.g., genetic connectivity, habitat representation, size of MPAs, etc.) were brought into the planning framework. A similar process is occurring within the LMMA system of MPAs in PNG where a more formal scaling up of small MPAs is being achieved through improved administrative and management arrangements across a larger scale.

Social and Learning MPA Networks

The study also encountered various emergent social and learning networks for MPAs at scales from local to national and international. A key observation is that such networks rival the rate of expansion of scientifically designed networks because of the desire to learn and share lessons. The Philippines is an example where the level of awareness about the role of MPAs, their functions and benefits is quite high in rural areas throughout the country due to the existing social and learning networks. These can be informal or formal. The Philippine MPA Support Network, for example, includes more than 50 institutions nationwide and hosts regular meetings and includes key government agencies.

Finally, the Need to Scale Up and Manage at Different Scales to Achieve Networks

Tubbataha Reefs Natural Park offers an example of increasingly effective management and scaling up efforts towards a network. With strong management since 2000, the 332 sq. km MPA was expanded to 968 sq. km in 2008. The expansion was motivated by a need to fill gaps in habitat representation and by the opportunity to form a larger network. It also increased enforcement efficiency within the park since the new area, Jessie Beasley Shoal, was the camping grounds for illegal fishers who regularly poached in the park. This expansion is a form of 'management spillover' whereby the MPA scaling up process evolved to solve tangible management challenges as well as add to the ecological integrity of the MPA.

The Tubbataha experience highlights one of the unanswered questions: is there a minimum level of effectiveness that we need in a single MPAs first before scaling up? While the rationale for MPA networks is clear, they will only function as well as the sum of each individual MPA. As such, balancing emphasis on MPA and individual MPA implementation is critical. Kimbe Bay has adopted a hybrid approach to planning at the large scale and implementation at the village level. This allows local communities to decide on how best to manage the area and what restrictions fit local customs and marine tenure arrangements. This represents a 'thinking bay-wide, acting locally' approach. This will allow the implementers to manage at various scales within the framework of the larger Kimbe Network plan. Thus, for those MPA networks that are not under one legal umbrella (e.g., Kimbe Bay and Southeast Cebu), multi-scale management across levels within the larger system describes the network process better.

A balance of the important ingredients or themes for MPA networks—ecology and science, social management, resilience, institutions, governance, and sustainable financing—are essential for developing successful networks. In addition, 'simplicity' was also found to be a key ingredient of success together with local 'advocates' providing local leadership. Finding the balance in a particular context is the 'art' of designing and managing MPAs and cannot be expressed quantitatively or guided with blueprint approaches. Effective MPA network implementation relies on experienced and passionate managers, from the local community level to the local government and national government levels.

Capacity limitations in the Coral Triangle suggest that MPA networks should start small or medium. Interventions should

focus on making these networks functional before elaborate zoning schemes are designed. Overly complex plans can be difficult for stakeholders and implementers to comprehend and enforce. Following this strategy, management can be expanded from well-managed networks.

This study demonstrates that stakeholders have a range of expectations from MPA networks which include biological, social, and management goals. Attention to meeting multiple goals simultaneously is challenging but attainable, and necessary to maintain stakeholder engagement.

This study also clarified that while each MPA network is different in size, scale and approach, there are some very clear basic approaches that can be adopted. And, because MPAs introduce major changes, including the reallocation of user rights, altered resource use, changed social relations, increased resource protection and conservation, clear expectation setting, and involvement of communities are essential. By ensuring that MPA benefits accrue directly to the local communities near MPAs, most of these changes can be positive and beneficial to the surrounding communities (Christie *et al*. 2003; Wahle *et al*. 2003).

Finally, we found a strong desire among MPA practitioners and governments to progress from individual MPAs to ecological networks of MPAs, but there is a long way to go to achieve more functional ecological networks. Another key finding is that MPA networks need to consider local circumstances (economy, culture and politics), and leverage themselves as a resource management tool to improve the economy, governance and social capital of an area. Interview results suggest that limited available resources should be funnelled into improving management effectiveness, local incentives, and coastal law enforcement in MPAs that are already established, as opposed to creating new MPAs. Enhancing and expanding these discrete components will form a strong foundation for developing MPA networks in the region, thereby realising the benefits of 'scaling up', whilst remaining focused on achieving long-term conservation.

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REFERENCES

Adger, W.N. 2003. Social capital, collective action and adaptation to climate change. *Economic Geography* 79(4).

Agardy, T. and F. Staub. 2006. *Marine protected areas and MPA networks*. Washington, DC. National Science Foundation. United States Fish and Wildlife Service (Grant Agreement No. 98210-1-G017).

Allen, G. R. 2000. Indo-Pacific coral-reef fishes as indicators of conservation hotspots. *Proceedings of the 9th International Coral Reef Symposium, Bali, Indonesia.* 2: 921–926.

Allen, G.R. and M. Adrim. 2003. Coral reef fishes of Indonesia. *Zoological Studies* 42(1): 1–70.

Allison, G.W., S.D. Gaines, J. Lubchenco and H. P. Possingham. 2003. Ensuring persistence of marine reserves: Catastrophes require adopting an insurance factor. *Ecological Applications* 13 (1): S8–S24.

Arceo, H.O., P.M. Aliño and R.O.M. Gonzales. 2008. Where are we now with marine protected areas? In: *Reefs through time: Initiating the state of the coasts reports*. Pp. 145–151. Organised by Coral Reef Information Network of the Philippines (PhilReefs), MPA Support Network, Marine Environment and Resources Foundation and Marine Science Institute. Quezon City, Philippines.

Bailey, C. and C. Pomeroy. 1996. Resource dependency and development options in coastal South East Asia. *Society and Natural Resources* 9(2): 191–199.

Ball, I.R. and H.P. Possingham. 2000. *MARXAN (V1.8.2): Marine reserve design using spatially explicit nnnealing, a manual.* Australia: University of Queensland.

Ballantine, W.J. 1997. The design and monitoring of marine reserves: design principles for systems of 'no-take' marine reserves. *Workshop on the design and monitoring of marine reserves*. Organized by Fisheries Center, University of British Columbia Vancouver, Canada. February, 1997. Pp. 1-20.

Balmford A., P. Gravestock Hockley, N. McClean, C.J. and C.M. Roberts. 2004. The worldwide costs of marine protected areas. *Proceedings of the National Academy of Sciences of the United States of America* 101(26): 9694–9697.

Bellwood, D.R., T.P. Hughes, C. Folke and M. Nystrom. 2004. Confronting the coral reef crisis. *Nature* 429: 6. 827–833.

Bellwood, D.R., T.P. Hughes, S.R. Connolly and J. Tanner. 2005. Environmental and geometric constraints on IndoPacific coral reef biodiversity. *Ecology Letters* 8(6): 643–651.

Berkes, F. 2004. Knowledge, learning and the resilience of social-ecological systems. In: *Knowledge for the development of adaptive co-management.* Tenth Biennial Conference of the International Association for the Study of Common Property. August 23–27, 2004. Oaxaca, Mexico.

Bunce, L., P. Townsley, R. Pomeroy and R. Pollnac. 2000. *Socioeconomic manual for coral reef management.* Townsville. Australia. *Global Coral Reef Monitoring Network.*

Burke, L., L. Selig and M. Spalding. 2002. *Reefs at risk in southeast Asia*. Washington, DC: World Resources Institute.

Coastal Conservation and Education Foundation and Partners. 2007. *The 2007 marine protected coast, reef and management database*. Cebu City. Coastal Conservation and Education Foundation.

Christie, P. and A.T. White. 1997. Trends in development of coastal area management in tropical countries: From central to community orientation. *Coastal Management* 25(2): 155–181.

Christie, P., A.T. White and E. Deguit. 2002. Starting point or solution? Community-based marine protected areas in the Philippines. *Journal of Environmental Management* 66(4): 441–454.

Christie, P., B.J. McCay, M.L. Miller, C. Lowe, A.T. White, R. Stoffle, D.L. Fluharty, *et al.* 2003. Toward developing a complete understanding: A social science research agenda for marine protected areas. *Fisheries* 28(12): 22–26.

Christie, P. 2004. MPAs as biological successes and social failures in Southeast

Asia. 2004. In: *Aquatic protected areas as fisheries management tools: Design, use, and evaluation of these fully protected areas*. (ed. Shipley, J.B.). First Edition. American Fisheries Society. Maryland, USA.

Christie, P., R.B. Pollnac, E.G. Oracion, A. Sabonsolin, R. Diaz and D. Pietri. 2009. Back to basics: An empirical study demonstrating the importance of local-level dynamics for the success of tropical marine ecosystem-based management. *Coastal Management* 37: 349–373.

Cicin-Sain, B. and S. Belfiore. 2005. Linking marine protected areas to integrated coastal and ocean management: A review of theory and practice. *Ocean & Coastal Management* 48 (11–12): 847–868.

Cinner, J.E., M. Marnane and T.R. McClanahan. 2005. Conservation and community benefits from traditional coral reef management at Ahus Island, Papua New Guinea. *Conservation Biology* 19 (6): 1714–1723.

Crowder, L.R. 2005. Back to the future in marine conservation. In: *Marine conservation biology: The science of maintaining the sea's biodiversity* (eds. Norse, E.A. and L. R. Crowder). First Edition. Pp. 19–29. Washington, DC: Island Press.

Earth Trends. 2003. Papua New Guinea Country Profile. World Resources Institute. http://earthtrends.wri.org/pdf_library/country_profiles/coa_cou_598.pdf. Accessed on June 12, 2008.

Eisma-Osorio R.L., R.C. Amolo, A.P. Maypa, A.T. White and P. Christie. 2009. Scaling-up local government initiatives towards ecosystem-based fisheries management in Southeast Cebu Island, Philippines. *Coastal Management* 37: 310–334.

Evans R.D and G.R. Russ. 2004. Larger biomass of targeted reef fish in no-take marine reserves on the Great Barrier Reef, Australia. *Aquatic Conservation* 14(5): 505–519.

Fisheries Management Act. 1998. *Papua New Guinea Government Fisheries Management Act, No. 48,* 1998. http://www.spc.int/coastfish/countries/PNG/PNGFisheriesAct.pdf. Accessed on June 1, 2008.

Folke, C., T. Hahn, P. Olsson and J. Norberg. 2005. Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources* 30: 441–473.

Gerber, L.R. and S.S. Heppell. 2004. The use of demographic sensitivity analysis in marine species conservation planning. *Biological Conservation* 120(1): 121–128.

Green, S.J., A.T. White, J.O. Flores, M.F. Carreon III and A.E. Sia. 2003. *Philippine fisheries in crisis: A framework for management*. Cebu City. Coastal Resource Management Project of the Department of Environment and Natural Resources.

Halpern, B.S. 2003. The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications* 13(1):S117–S137.

International Union for Conservation of Nature. 2005. Benefits beyond boundaries. In: *Proceedings of the 5th IUCN World Parks Congress*. Gland, Switzerland. IUCN.

International Union for Conservation of Nature-World Commission on Protected Areas. 2008. *Establishing resilient marine protected area networks: making it happen.* Washington, DC. International Union for Conservation of Nature-World Commission on Protected Areas, National Oceanic and Atmospheric Administration, and The Nature Conservancy.

Lebel, L., J.M. Anderies, B. Campbell, C. Folke, S. Hatfield-Dodds, T.P. Hughes and J. Wilson. 2006. Governance and the capacity to manage resilience in regional social-ecological systems. *Ecology and Society* 11(1): 19.

Lowry, G.T., A.T. White and P. Christie. 2009. Scaling up to networks of marine protected areas in the Philippines: Biophysical, legal, institutional and social considerations. *Coastal Management* 37: 335–349.

Lundquist C.J. and E.F. Granek. 2005. Strategies for successful marine conservation: Integrating socioeconomic, political, and scientific factors. *Conservation Biology* 19(6): 1771–1778.

Mascia, M.B. 2003. The human dimensions of coral reef marine protected areas: Recent social science research and its policy implications. *Conservation Biology* 17(2): 630–632.

McClanahan, T., J. Davies and J. Maina. 2005. Factors influencing resource users and managers' perception towards marine protected area management in Kenya. *Environmental Conservation* 32(1): 42–49.

Millennium Ecosystem Assessment. 2006. *Marine and coastal ecosystem and human well-being. A synthesis report based on the findings of the Millennium Ecosystem Assessment*. United Nations Environment Program. Washington, DC: Island Press.

Mora, C., S. Andrefouret, M. J. Costello, C. Kranenburg, A. Rollo, J. Veron, K.J. Gaston, *et al*. 2006. Coral reefs and the global network of marine protected areas. *Science* 312: 1750–1751.

Mous, P.J. 2008. A strategy towards development of networks of district-managed marine protected areas (KKLD) and integration with community-managed reserves (DPL). *Report to Coral Reef Rehabilitation and Management Program (COREMAP) Phase II.* Jakarta. Indonesian Department of Marine Affairs and Fisheries.

National Oceanic and Atmospheric Administration. 2005. *Social science methods for marine protected areas: An overview for MPA managers and staff.* Washington DC: NOAA Coastal Services Center and National Marine Protected Area Center.

National Research Council. 2000. *Marine protected areas: Tools for sustaining ocean ecosystems.* Washington, DC: National Academy Press.

Olsson, P. 2003. Building capacity for resilience in social-ecological systems. Ph.D. thesis. Stockholm University, Stockholm, Sweden.

Pet-Soede, L. 2006. MPAs in Indonesia: What progress has been made since 1984? *MPA News* 8(1): 3.

PhilReefs. 2008. *Reefs through time 2008: Initiating the state of the coasts reports*. Quezon City. PhilReefs, MPA Support Network, Marine Environment and Resources Foundation and Marine Science Institute, University of the Philippines. Coral Reef Information Network of the Philippines.

Partnership for Interdisciplinary Studies of Coastal Oceans. 2007. *The science of marine reserves*. Second edition: International version. Oregon State University, Stanford University, University of California Santa Barbara and University of California Santa Cruz, California.

Pietri, D., P. Christie, R. Pollnac, R. Diaz and A. Sabonsolin. 2009. Information diffusion in two marine protected area networks in the Central Visayas Region, Philippines. *Coastal Management* 37: 300–334.

Pollnac, R.B., B.R. Crawford and M.L.G. Gorospe. 2001. Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. *Ocean & Coastal Management*. 44 (11–12): 683–710.

Pomeroy, R.S., J.E. Parks and L.M. Watson. 2004. *How is your MPA doing? A guidebook of natural and social indicators for evaluating marine protected area management effectiveness*. Cambridge. International Union for Conservation of Nature, Gland, Switzerland.

Roberts, C.M. 2007. *The unnatural history of the sea. The past and future of humanity and fishing*. London: Island Press.

Roberts, C.M., C.J. McClean, J.E.N. Veron, J.P. Hawkins, G.R. Allen, D.E. McAllister, C.G. Mittermeier, *et al.* 2002. Marine biodiversity hotspots and conservation priorities for tropical coral reefs. *Science* 292: 1280–1284.

Roberts, C.M., S. Andelman, G. Branch, R.H. Bustamante, J.C. Castilla, J. Dugan, B.S. Halpern, *et al.* 2003. Ecological criteria for evaluating candidate sites for marine reserves. *Ecological Applications* 13(1): S199–S214.

Ruddle K., E. Hviding and R.E. Johannes. 1992. Marine resources management in the context of customary tenure. *Marine Resource Economics* 7: 249–273.

Russ G.R. and A.C. Alcala. 1999. Management histories of Sumilon and Apo Marine Reserves, Philippines, and their influence on national marine resource policy. *Coral Reefs* 18(4): 307–319.

Russ, G.R., A.C. Alcala, A.P. Maypa, H.P. Calumpong and A.T. White. 2004. Marine reserve benefits local fisheries. *Ecological Applications* 14: 597–606.

Sale, P.F., R.K. Cowen, B.S. Danilowicz, G.P. Jones, J.P. Kritzer, K.C.

Lindeman, S. Planes, *et al*. 2005. Critical science gaps impede use of no-take fishery reserves. *Trends in Ecology and Evolution* 20(2): 74–80.

Salm, R.V., S.E. Smith and G. Llewellyn. 2001. Mitigating the impact of coral bleaching through marine protected area design. In: *Coral bleaching: Causes, consequences and response* (ed. Schuttenberg, H.Z.). Pp. 81–88. Selected papers presented at the 9th International Coral Reef Symposium on "Coral Bleaching: Assessing and Linking Ecological and Socioeconomic Impacts, Future Trends and Mitigation Planning. Coastal Management Report No. 2230, Coastal Resources Center, University of Rhode Island.

Shanks, A.L, B.A. Grantham and M.H. Carr. 2003. Propagule dispersal distance and the size and spacing of marine reserves. Ecol*ogical* Appl*ications* 13(1): S159–S169.

Stewart, R.R., T. Noyce and H.P. Possingham. 2003. Opportunity cost of ad hoc marine reserve design decisions: an example from South Australia. *Marine Ecology Progress Series* 253: 13–18.

Stoms, D.M., F.W. Davis, S.J. Andelman, M.H. Carr, S.D. Gaines, B.S. Halpern, R. Hoenicke, *et al.* 2005. Integrated coastal reserve planning: making the land–sea connection. *Frontiers in Ecology and the Environment* 3(8): 429–436.

The Nature Conservancy. 2007. The Nature Conservancy's Coral Triangle business plan. The Nature Conservancy.

The Nature Conservancy, World Wildlife Fund, Conservation International and Wildlife Conservation Society. 2008. *Marine protected area networks in the Coral Triangle: Development and lessons*. Cebu City: TNC, WWF, CI, WCS and the United States Agency for International Development.

Tompkins, E.L. and W.N. Adger. 2004. Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society* 9(2): 10.

Tun, K., L.M. Chou, A. Cabanban, V.S. Tuan, Philreefs, T. Yeemin, Suharsono, *et al*. 2004. Status of coral reefs, coral reef monitoring and management in Southeast Asia. In: *Status of coral reefs of the World: 2004* (ed. Wilkinson, C.). Pp 235–276. Australian Institute of Marine Science, Townsville, Queensland, Australia.

United Nations Environment Programme-World Conservation Monitoring Centre. 2008. *Establishing national and regional networks of marine protected areas: a review of progress with lessons learned.* Cambridge. United Nations Environment Programme-World Conservation Monitoring Centre.

Veron, J.E.N. 2000. *Corals of the world*. Townsville: Australian Institute of Marine Science.

Wahle, C., S. Lyons, K. Barba, L. Bunce, P. Fricke, E. Nicholson, M. Orbach, *et al*. 2003. *Social science research strategy for marine protected areas*. Santa Cruz: National Marine Protected Areas Center, MPA Science Institute.

World Commission on Protected Areas-International Union for Conservation of Nature. 2007. *Establishing networks of marine protected areas: a guide for developing national and regional capacity for building MPA networks.* Cambridge. World Commission on Protected Areas-International Union for Conservation of Nature.

World Fish Center. 2007. *Coral reef MPAs of east Asia and Micronesia*. Penang. WorldFish Center (REEFBASE Project), Sea Around Us Project, Japan Wildlife Research Center.

White, A.T. and A. Cruz-Trinidad. 1998. *The values of Philippine coastal resources: Why protection and management are critical.* Cebu City: Coastal Resource Management Project.

White, A.T., P.M. Aliño and A.T. Meneses. 2006. *Creating and managing marine protected areas in the Philippines*. Cebu City: Fisheries Improved for Sustainable Harvest, Coastal and Community Environment Foundation, and the University of the Philippines Marine Science Institute, Philippines.

White, A.T., R.L. Eisma-Osorio and S.J. Green. 2005. Integrated coastal management and marine protected areas: complementary in the Philippines. *Ocean & Coastal Management* 48(11–12): 948–971.

Wood, L. 2007. *MPA global: A database of the world's marine protected areas*. Cambridge. Sea Around Us Project, United Nations Environment Programme-World Conservation Monitoring Centre and World Wildlife Fund.

Wood, L.J., L. Fish, J. Laughren and D. Pauly. 2008. Assessing progress towards global marine protection targets: shortfalls in information and action. *Oryx* 42(3): 1–12.

World Bank. 2005. *Philippines environment monitor on coastal and marine resource management*. Washington, DC: World Bank.