5 November 2008

To: CTI Townsville Workshop participants
   CTI Coordinating Committee
   CTI marine resource managers and scientists

Dear Colleagues

The Australian Research Council Centre of Excellence for Coral Reef Studies at James Cook University and the Australian Institute of Marine Science, both based in Townsville, Australia, have been asked to provide scientific expertise to the Coral Triangle Initiative (CTI). As part of our contribution, in early September, we circulated 16 background papers on issues related to achieving the goals of the CTI. The updated versions of these papers are provided here.

These papers will remain living documents and available on the web at www.coralcoe.org.au/events/ctiworkshop/issuespapers.html. We welcome further contributions and discussion to enhance their relevance and quality. We will continue to update these papers to ensure they assist in the development and implementation of the CTI, encourage strong research collaborations and forge productive relationships for the future.

The draft background papers have been written by a range of international experts including from the Coral Triangle countries. Our thanks to these authors.

Many thanks also to WWF and the Queensland Department of Tourism, Regional Development and Industry for their financial support in the development of these papers.

Sincerely,

Terry Hughes     Ian Poiner
Director     Chief Executive Officer
ARC Centre of Excellence     Australian Institute of Marine Science
for Coral Reef Studies     Coral Reef Studies
James Cook University

PO Box 643
Townsville Qld. 4810
Australia

Email: leannef@earth2ocean.com
Telephone: +61 (0)7 4725 1824
Facsimile: +61 (0)7 4781 6722
# Draft background papers version 2

5 November 2008

## Table of Contents

1. Sustaining ecosystems and livelihoods: ecosystem-based management and the Coral Triangle ...... 2
2. Existing and potential non-spatial management options in the Coral Triangle ........................................ 8
3. Ecological resilience and “shifting baselines” ......................................................................................... 4
4. Data sufficiency and dealing with uncertainty........................................................................................... 24
5. How human uses and values can matter for the CTI ............................................................................... 28
6. Participatory marine resource management planning ................................................................................. 33
7. Climate Change Threats to Coral Reefs in the Coral Triangle .................................................................. 37
8. Threat of climate change to fish and fisheries ......................................................................................... 47
9. Capacity building for marine resource management including MPAs .................................................... 53
10. Objectives and multiple-use zoning for a network of MPAs for the Coral Triangle .............................. 57
11. Connectivity and the design of marine protected area networks in the Coral Triangle ......................... 63
12. Incorporating information about marine species of conservation concern and their habitats into a network of MPAs for the Coral Triangle region .................................................................... 69
13. Designing a network of MPAs for the Coral Triangle ............................................................................. 77
14. Long-term biophysical monitoring of a network of Marine Protected Areas in the Coral Triangle .......................................................... 84
15. Human adaptation to climate change ...................................................................................................... 88
16. “At least do no harm”: Coral Triangle Initiative contributing to Livelihoods and Poverty Reduction ........................................................................................................ 93
17. Outbreaks of Crown-of-Thorns seastars add to coral depletion in the coral triangle ....................... 98
1. Sustaining ecosystems and livelihoods: ecosystem-based management and the Coral Triangle

Alino, P.M.¹, Fernandes, L.², Hughes, T.³, M.E. Lazuardi⁴, J.M.L. Tan⁵, Tanzer, J.⁶

5/11/08

Outline of the issue

Socio-economic and ecological commonality of the Coral Triangle

The “Coral Triangle” (CT) region is located around the equator at the confluence of the Western Pacific and Indian Oceans (see Map 1). Coral and reef fish diversity were the two major criteria used by scientists to define the boundaries of this region which cover all or part of the Exclusive Economic Zones of: Indonesia, Malaysia, Papua New Guinea, the Philippines, the Solomon Islands and Timor-Leste (the CT6). These countries have launched a Coral Triangle Initiative that aims to transform marine resource management within the entirety of their waters, even beyond this biological space.

Although the area covers only 1.6% of the world’s oceans, the CT represents the global epicenter of marine life abundance and diversity containing:

- more than 75% of all known coral species,
- more than 3,000 fish species,
- the greatest extent of mangrove forests in the world,
- 33% of the world’s coral reefs, and
- spawning and juvenile growth areas for the world’s largest tuna fishery.

There is oceanographic connectivity, a shared palaeontologic history, commonality in species ranges and ecological similarities across habitats within the Coral Triangle.

The CT countries also share economic connections, trade flows, common threats and socio-economic challenges. They share concerns to do with, for example, the trade of endangered species and the depletion of higher level carnivores for the live food fish trade which are causing the depletion of the sharks and groupers and resulting in fishing down the food chain. These socio-economic commonalities are true despite real and significant cultural and social differences between, and even within, countries.

¹ The Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines. pmalino@upmsi.ph
² Marine Resource Management Coordinator, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University and the Australian Institute of Marine Science, Townsville, Q. Australia. Ph. +61 (0)7 4725 1824; leannef@earth2ocean.com
³ Director, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University
⁴ Science and Monitoring Coordinator, Raja Ampat Program, Conservation International Indonesia,
⁵ Vice-Chairman, WWF Philippines, lorytan@gmail.com
⁶ Coral Triangle Facilitator, Australian Government Department of the Environment, Water, Heritage and the Arts, The Nature Conservancy, WWF. jmtanzer@bigpond.com
At the intersection of biology and people is the challenge. The biogeographical conditions within the CT are such that, with adequate management, the region could maintain its exceptional productivity in the face of future pressures and disturbances including climate change. This makes it potentially one of the planet’s most important marine “food bowls” as well as a globally important “refuge” for marine life.

Also, for these reasons:

- No part of the Coral Triangle region is as unique or productive as the whole.
- Degradation of any part of the Coral Triangle has potential impacts across the whole.
- No part of the Coral Triangle can be managed as effectively, in the long term, without effective resource management across the whole.

These exceptional marine and coastal living resources provide extremely important benefits to the ~200 million people who reside within the Coral Triangle, as well as many millions more outside the region:

- The value of the coral reefs, mangroves, and associated natural habitats in the CT is estimated to total US $2.3 billion annually.
- One-third of the inhabitants within the CT live in coastal communities and depend directly on local marine and coastal resources for their income and food security.
- Healthy reef systems and mangrove forests protect coastal communities from storms and tsunamis, reducing casualties, reconstruction costs, and the need for international aid.
- Tuna spawning and nursery grounds support a multi-billion dollar tuna industry, providing an important food source for tens of millions of consumers worldwide, and providing thousands of jobs for inhabitants within the region.
Other wild-caught marine products (e.g., snapper, grouper, beche-de-mer, shrimp) are sold to local markets and exported worldwide, generating hundreds of millions of dollars in annual revenue, as well as providing important food sources.

Productive coral reef systems provide for most of the US $800+ million annual trade in live reef food fish (primarily supplying markets in China).

Productive coral reef systems also provide for a major share of the multi-million dollar annual trade in live reef aquarium fish (supplying markets worldwide).

Healthy marine resources contribute to a growing nature-based tourism industry in the region (e.g. dive tourism), generating tens of millions of dollars annually and thousands of jobs.

Leaders of the CT6 have acknowledged these values across the CT and are aiming to maintain them via the Coral Triangle Initiative.

**Ecosystem-based management of the Coral Triangle**

Adopting a region-wide ecosystem-based management approach to dealing with the escalating pressures and threats offers a more effective range of tools and options to decision-makers and private sector resource users than one based on fragmented institutional arrangements, individual resources or stocks or site-specific actions that do not take into account issues of interrelatedness and connectivity.

Ecosystem-based management recognizes that humans are an integral component of ecosystems, and the value of sustaining the goods and services (such as fisheries and tourism) provided by ecosystems for human well-being. Ecosystem-Based Management (EBM) is based on management and governance approaches that:

- Integrate ecological, social, and economic goals, recognizing their strong interdependencies
- Considers multi-scale ecological processes, that often transcend political boundaries
- Acknowledges *interconnectedness* between air, land and sea
- Addresses the complexity of natural processes and social systems
- Uses an adaptive management approach adapt to uncertainties and risks, and
- Engages the range of stakeholders, including the private sector, in a collaborative process to define problems and seek equitable solutions.

Within one part of the Coral Triangle, an ecosystem approach is already being implemented. Conservation International in collaboration with The Nature Conservancy and WWF has been developing an Ecosystem-Based Management Program in Bird Heads Seascape. The activities in this effort include, for example, a Marine Rapid Assessment Survey in Cendrawasih Bay and Fak-fak - Kaimana (2006), a sea surface temperature stud, a connectivity study and a study on spawning aggregation sites (SPAGS).

**What does this mean for achieving the goals of the draft CTI Plan of Action?**

The Coral Triangle is facing rapidly expanding populations, economic growth and the pressures of international trade. Fish and other marine resources are a principal source of food, livelihoods and export revenues in all of the CT countries. Tuna, live reef fish and shrimp, for example, supply a fast-growing demand in Japan, the US, Europe, China and elsewhere.
These factors are generating increased pressures on marine and coastal resources, including: over-fishing, unsustainable fishing practices, land-based sources of marine pollution and coastal habitat destruction. Overlaying these pressures are external threats such as climate change. The current status of marine and coastal resources across the region, and future projections, are alarming. For example:

- More than 80% of the coral reefs across the Southeast Asia portion of the CT are at risk (under medium and high potential threat), and over half are at high risk – primarily from fishing-related pressures and coastal development.
- Many of the commercial pelagic fish stocks – particularly species of tuna and shark - are also depleted, with some heading toward collapse.
- Many coastal fisheries across the region are depleted, with some fisheries already collapsed or heading toward collapse.
- Hazards associated with climate change (such as mass coral bleaching, ocean acidification, sea level rise, increased intensity of storm and cyclone events and flooding) will pose increasing threats in the coming decades to marine and coastal resources.

Marine and coastal resources are a cornerstone for the CT economies and for the CT societies. The growing threats to these resources must be taken seriously, and must be acted upon. Transformation changes are required rather than merely incremental changes. They include, for example:

- the highest political levels of support and leadership for the multi-lateral CTI which is translated throughout countries’ governments at all levels and through to local communities;
- raising sustainable marine and coastal resource management to the highest and most immediate political priority;
- applying new and ongoing national budgetary support to enable implementation of sustainable marine and coast resource management as well as sourcing external sustainable financing;
- a new and powerful regional collaboration to address the transboundary problems (e.g. shared tuna stocks; live reef food fish trade; illegal, unregulated and unreported fishing; broadscale ecoregion planning; declines in threatened species populations and in biodiversity); and
- recognising that joint efforts can be mutually beneficial and economically efficient because lessons learned and successful management programs can be shared across nations (and scaled-up) rather than duplicated.

In sum, adopting a large scale ecosystem approach seeks to ensure that local and regional actions are part of a broad, integrated plan of action, such as the CTI draft Plan of Action.
What does this mean for MPA network design, management and implementation?

A comprehensive, ecologically representative, fully functioning, and region-wide Coral Triangle MPA Network can help build resilience to the pressures and threats facing the Coral Triangle. It can help protected the resources and hence the values of those resources to the countries of the Coral Triangle. It can be a cornerstone upon which the entire suite of management interventions, as identified in the draft Plan of Action, can and must build.

But an MPA network is not a panacea. Other management actions will be required such as ecosystem-based fisheries management and human adaptation to threats such as climate change (see also draft background papers on non-spatial management, MPA objectives, connectivity, MPA network design and human adaptation to climate change).

None-the-less, there are multiple objectives for an MPA network cited in the Jakarta draft Plan of Action that mean any network across the CT will likely be multiple-use and multi-scale. Multiple-scale networks of MPAs based on the principles of EBM can not only help provide protection for key habitats and species but help put in place a ‘ecological insurance policy’ to help the region cope with major threats to ecosystem function and productivity such as those associated with climate change. Properly designed and flexible in time and space fully functioning network can provide an evolving framework for long term sustainability.

Background Reading


economics of ecosystem-based management of marine resources. Marine Ecology Progress Series 300: 270-274.

Scientific Consensus Statement on Marine Ecosystem-Based Management. Prepared by scientists and policy experts to provide information about coasts and oceans to U.S. policy-makers. Released on March 21, 2005


Some existing projects
UNEP Regional Seas Program http://www.unep.org/regionalseas/

Bismark-Solomons LME
http://www.panda.org/about_wwf/where_we_work/oceania/solutions_region/bismarck_solomon/index.cfm

Sulu-Sulawesisie LME
2. Existing and potential non-spatial management options in the Coral Triangle
Foale, S.¹, Friedman, K.² Gomez, E.³, Nash, W.⁴, Tanzer, J.⁵
4/11/08

Outline of the issue
Non-spatial fishery management tools include size limits, gear restrictions, species bans, and quotas; these are in use throughout the CT to varying degrees already. All of these tools can, of course, be used in conjunction with spatial approaches such as seasonal closures, permanent no-take areas, area-based gear restrictions or rotational closures (see also issue paper on existing spatial management). As outlined in the Jakarta draft of the CTI Plan of Action and the briefing paper on Objectives and Multiple Use Zoning for a Network of MPAs, no-take areas should be envisaged as part of a suite of management approaches, all of which can contribute to fisheries management (and to other goals) rather than as the primary fishery management tool. Most examples of stable and productive fisheries in Australia, the Pacific, and around the world successfully use non-spatial approaches, or combinations of spatial and other management systems (including several trochus fisheries in Polynesia and Micronesia, the Western Australian Rock Lobster fishery and Northern Prawn Trawl Fishery).

There are already in place a variety of non-spatial management systems for commodity fisheries within the CT6 countries, but many have limited or no efficacy due to corruption, population pressure and/or poverty. This is one of the reasons MPAs are so widely advocated.

However, the implementation or improvement of non-spatial management measures for several high-value commodity fisheries (e.g. beche-de-mer, trochus, pearl shells, and shark-fin) can deliver, and, in some cases (see SPC Policy Brief 2/2008), already has delivered improvements in the performance, and cash flow, of these important fisheries. Such approaches include a) the enforcement of size limits for trochus (Foale and Day 1997) and beche-de-mer, and b) setting constituency- or ward- or municipality-based species-level quotas, based on routinely generated stock assessment data (Nash et al 1995, Skewes et al 2002). Enforcement of size limits, closed seasons and quotas at points of sale, in many cases, can be more cost effective than other fishery management measures such as no-take areas. For some species (e.g. trochus) however, no-take areas, can be more effective and easier to use than for other species (e.g. sharks). In some cases, such as the annual six-month closed season for beche-de-mer in some provinces of Papua New Guinea, any resultant improvements to fishery performance have not been measured.

Given the vulnerability of the shark fishery it may be wiser to consider some kinds of moratoria until more reliable fishery monitoring and management regimes can be developed and implemented.

¹ ARC CoE for Coral Reef Studies, James Cook University; simon.foale@jcu.edu.au
² SPC_Secretariat of the Pacific Community, BP D5 - 98848 Noumea, New Caledonia kimf@spc.int
³ GEF CRTR SEACoE, Univ. of the Philippines Marine Science Inst.; edgomezph@yahoo.com
⁴ Worldfish Centre, Noumea. WarwickN@spc.int
⁵ Coral Triangle Facilitator, jmtanzer@bigpond.com
Moratoria have already been applied to commodity fisheries in Solomon Islands, Vanuatu, and Tonga in response to severe over-fishing. Bell et al (2008) show that the severity of overfishing makes a large difference to the rate of recovery of fisheries following implementation of moratoria (see Figure 2 from their paper, below). For fisheries that are highly vulnerable and/or already overfished, precautionary approaches, such as early implementation of moratoria, are clearly preferable to continued fishing in the absence of good data.

![Figure 2](image-url)

**Fig. 2.** Schematic recovery profiles of a population for one sea cucumber species under different scenarios, assuming fishing is banned by moratorium. R represents recovery that has been fast–tracked by a restocking program to create additional groups of spawners. M denotes a moderately depleted population that recovers over many years. D represents a depleted population that may take decades to recover. S is a severely depleted population, where densities are so low that the Allee effect causes negative per-capita population growth and the population becomes extinct. Decisions to invest in restocking for M populations will depend on whether income gained from catches during period ‘a’ outweigh the costs. For D populations the benefits gained from restocking during period ‘b’ are likely to exceed the costs and for S populations there is no alternative but to intervene to form effective groups of spawners. Thresholds for the Allee effect (depopulation) are unknown for tropical sea cucumbers, but we postulate these may be between 10 and 50 individuals ha⁻¹, depending on species and location.

Non-spatial measures, if supported with appropriate levels of political and financial support to national fisheries departments, could effectively slow or even reverse the processes of ‘fishing down the price list’ (sequential depletion of commodity fisheries in decreasing order of market value). Spatial measures can contribute to fisheries management, in the longer term, with larval spillover effects and adult movement from within no-take areas to outside. However the contribution of spillover to fishery production is likely to vary a great deal among species, depending on larval dispersal patterns and adult mobility, and the size, number and spacing of no-take closures. While there is a substantial body of research on spillover (mainly of adults) for reef fish in Philippines, (e.g., Russ and Alcala 1966; Russ et al. 2003) there is relatively little work looking at spillover for the important commodity fisheries in the coral triangle (cf Lincoln-Smith et al 2006, Ramohia 2006). This is an important consideration if we remember that in Melanesia, fishing pressure on reef fish outside
of urban areas tends to be limited by comparatively low human population densities, as most reef fish are harvested for subsistence and local markets, and not for export.

If lucrative commodity fisheries can be sustained, along with the widely distributed income streams they generate, the economic pressures that drive fishers to move on to more ecologically destructive types of fishing can potentially be averted.

What does this mean for achieving the goals of the draft CTI Plan of Action?

Non-spatial fishery management systems should ideally be improved or implemented (where the need and the benefits are supported by existing research) in addition to an MPA network. If, over the medium to long term, commodity fishery productivity can be sustained or even increased through non-spatial measures, then the resultant income flows to poor rural people will be maintained. This can also help reduce the likelihood of non-compliance with any no-take areas that is driven by desperation.

What does this mean for MPA network design, management and implementation?

To achieve effective fishery management goals both spatial and non-spatial management tools are needed; an MPA network would not be adequate to this goal. Improvements to commodity fishery performance as a result of immediate enhancements to non-spatial management approaches will, for example, reduce the effects of any displaced fishing effort (due to no-take closures) and make it easier to minimise the immediate, negative social and economic impact of no-take closures if they are implemented.

Background reading

For more information about these papers contact simon.foale@jcu.edu.au unless otherwise indicated.


Kinch, J. (2004). A Review of the Beche-de-mer Fishery and it's Management in Papua New Guinea. Port Moresby, Motupore Island Research Centre - University of Papua New Guinea: 133. (contact: jeffreyk@sprep.org)


**Some existing datasets**

Papua New Guinea Coastal Fisheries Management and Development Project (PNG CFMDP): [http://bluesquid.net/CFMDP.html](http://bluesquid.net/CFMDP.html). At this site there are several downloadable reports containing the results of detailed surveys of commodity fisheries for three provinces of PNG. The research includes both fishery and socio-economic data.


Pakoa, K., K. Friedman, E. Tardy, F. Lasi, M. Kronen and A. Vunisea (2008). Status of Trochus Fisheries in the Pacific Islands. Noumea, SPC: 1. (contact: kalop@spc.int; KimF@spc.int)

**Some existing projects**

National CTI Plans of Action

Project compiling information on national programs and priorities in each country covering the marine / coastal resources sector (contact CTI Secretariat, Mr. M. Eko Rudianto (Eko): mrudiant@yahoo.com)
The Reef Fisheries Observatory at the Secretariat of the Pacific Community (SPC) (http://www.spc.int/Coastfish/sections/reef/PROCFish_Web/default.aspx) is analysing and writing up data from extensive fishery and socio-economic surveys across the Pacific, including data from Papua New Guinea, Solomon Islands and another 15 countries and territories. Contact: Mr Lindsay Chapman: LindsayC@spc.int
3. Existing spatial management in the Coral Triangle
Cinner, J.1, White, A.T.2, Aswani, S.3 Tan, J.M.L4

4/11/08

Outline of the issue
The six Coral Triangle countries (CT6) have evolving systems of MPAs at the national and/or local levels (Figure 1). The Coral Triangle Initiative (CTI) links these six countries, which have previously not cooperated as a unified group. Previously, Indonesia, Malaysia and Philippines cooperated with other Southeast Asian countries to produce a Regional Action Plan for an MPA network in Southeast Asia in 2002. Papua New Guinea and the Solomon Islands previously linked with Pacific Island nations through networks such as the Locally Managed Marine Area network (LMMA). The CTI aims to learn from, build upon and scale up existing efforts. A brief description of each country’s marine protected area (MPA) program and its national MPA Commitments follows.

![Map of Coral Triangle MPAs](image)

Figure 1. MPAs in each country, by size, and the Coral Triangle area as defined by a gradient of diversity of corals and fish.

**East Timor** (no information except for Nino Konis Santana National Park of which the marine component is informally known as Jako Marine Park)

---

1 ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD, 4811, Australia. Email: Joshua.cinner@jcu.edu.au. Phone +61 074781-6751
2 Senior Scientist, Global Marine Team, The Nature Conservancy, Hawaii alaw_white@tnc.org
3 Department of Anthropology and Interdepartmental Graduate Program in Marine Science, University of California at Santa Barbara, CA 93106-3210, USA. aswani@anth.ucsb.edu
4 Vice Chairman, Board of Trustees, WWF Philippines
**Indonesia** has established 114 MPAs (37 within the Coral Triangle), 38 of which contain coral reefs as the dominant habitat. Legally designated MPAs currently cover almost 70,000 km². Many of these National Parks were designated in the 1980’s. Most of Indonesia’s MPAs are combined with terrestrial parks, and are administered by the Ministry of Forestry. All MPAs are administered at a national level but managed at a district (regional) level. There are also a growing number of village-level MPAs that are co-managed with the district and national governments. Monitoring of selected MPAs in Indonesia, by large NGOs working in collaboration with the government management units, indicates that a few areas are showing positive impacts on fish stocks and coral reef condition. It is estimated that less than 20% of Indonesia’s MPAs are functionally meeting their management objectives. Indonesian institutions are just beginning to develop a MPA monitoring and management effectiveness system. The Government currently aims to protect 100,000 km² by 2010 and 200,000 km² by 2020. Besides the formally declared MPAs, customary management of marine resources is present in parts of Indonesia, including Sangihe-Talaud, Muluku, and Aceh (see below).

**Malaysia** has established 83 MPAs of which 51.8% or 43 MPAs include coral reefs covering about 14,168 km². Sabah Province has 5 MPAs managed through the Sabah Wildlife Department (state government). The total no-take portion of MPAs in Malaysia is 2310 km² (16% of total MPA area). The management effectiveness of MPAs in Malaysia is considered good by regional standards given that destructive fishing is not common in most MPAs and fishing effort is at least partially controlled. Nevertheless, there is no standard monitoring system that includes measures for management effectiveness being implemented at a state or national scale.

**Papua New Guinea** has nationally designated approximately 22 MPAs (including Wildlife Management Areas, Marine Parks, Historic reserves, and Provincial parks). In Papua New Guinea, inshore marine resources are owned by communities through customary marine tenure, rather than by the state. This customary ownership is legally recognized and provides the basis for a number of local restrictions such as fisheries closures, gear restrictions, and species avoidance, known as customary management. Within this customary ownership and management framework, MPA systems have been developed through the LMMA network since 2000.

**Philippines** declared its first national marine park (Hundred Islands) in 1940, followed by MPA designations at the local and national government levels in the 1970s up to the present. Approximately 1100 MPAs, covering about 200 km², are managed by municipal and city governments through co-management arrangements, all of which contain no-take areas surrounded by some form of managed fishing area. Under the National Protected Areas System Act of 1992, 28 national MPAs have been proclaimed that cover about 15,500 km². The Philippine Marine Sanctuary Strategy, endorsed in 2002, has a target of 10% of “marine waters” to be fully protected by 2020 in a MPA network. The Sulu-Sulawesi Marine Ecosystem area of the southern Philippines is the first regional “seascape”¹ area to be systematically planned at a large scale. The Philippines has a monitoring protocol for MPAs that is adopted by most implementing organizations that feed information into a national MPA database coordinated by the MPA Support Network (MSN), which involves both governments and NGOs.

---

¹ Seascape refers to large resource management areas defined by ecological and oceanographic affinities. The Sulu-Sulawesi Seascape, the first defined “seascape” in the Coral Triangle, covers areas in southern Philippines, Sabah Malaysia and Celebes Sea, Indonesia
**Solomon Islands**, similar to Papua New Guinea, inshore marine resources are owned by communities through customary ownership. This customary ownership is recognized to varying degrees in government law in the Solomon Islands (The Fisheries Act 1998). In the past decade, many Solomon Islands communities have established MPAs on their reefs as a means of managing and conserving their marine resources. These MPAs have often been established in partnership with NGOs or universities who provide scientific and monitoring assistance. The Ministry of Environment is increasingly getting involved in MPA design, management, and finance and is now beginning to recognize various local initiatives (e.g., the Roviana/Vonavona MPA network was officially recognized by the government in August 2008). Legislation is being drafted to legally accommodate locally-driven initiatives and there is a move towards focusing on local initiatives instead of exclusively depending on NGOs. There are now over 50 community-based MPAs established in the Solomon Islands. Although many of these MPAs are small (ranging from 1 km² to 145 km²), the vast majority of them are effectively conserved and have high compliance with community-based regulations. The Arnavon Islands is the oldest (1995) and largest community-managed MPA with national recognition in the Solomon Islands.

**What does this mean for achieving the goals of the draft CTI Plan of Action?**

The need for more and better managed MPAs is highlighted in the CTI draft Plan of Action as a key goal (#3) that needs to be addressed in all the countries of the Coral Triangle. But the CTI proposed network of MPAs is certainly not starting from scratch. Most countries have existing: 1) systems of protected areas; 2) plans for networks of MPAs; 3) legal and institutional mechanisms for marine and coastal resources management, and 4) customary or local practices, all of which should be recognized by and incorporated into the proposed network, where appropriate. At the same time, there are large discrepancies within and among the six countries in terms of MPAs and network design, plans, levels of implementation and means for monitoring and evaluation.

**What does this mean for MPA network design, management and implementation?**

Several important questions need to be considered regarding the goal of scaling up to networks of MPAs by 2015. These include:

- Is developing a standard system of socioeconomic, governance and ecological monitoring to survey MPAs throughout the CT region viable? If so, how can monitoring best include nationally relevant processes (ecosystem and social) and potential for adaptation to climate change?
- What is the minimum acceptable data required to plan functional MPA networks (see issue paper on data and uncertainty, also, Marine Learning Partnership Final Report, in press, contact Alan White [alan_white@tnc.org])?
- How can the number, size, location and spacing of new MPAs be coordinated to maximize resilience (e.g., by integrating with existing and planned spatial and non-spatial management tools)? How can this be driven by country-level initiatives with adequate room for national flexibility?
- Can enforcement of MPAs be improved if coordinated at network scales?
- What are viable revenue streams for MPA management and how might network-scale coordination help to maximize revenue?
- How can we best build on lessons learned to date?
**Integrating customary management and marine conservation.** In parts of the Coral Triangle, communities have customary ownership over marine resources and have established customary management practices, particularly in Indonesia, Papua New Guinea (PNG), and the Solomon Islands. These practices can include exclusive use rights, gear restrictions, and fisheries closures. Customary closures are often implemented for short periods (several weeks to 12 months—although in some cases they can last for years or even be permanent), and a concentrated effort of a family, clan, or the wider community may be applied to harvest the closed area after it is opened again. Customary closures include “fallow” rotation of fishing areas and the closure of certain areas to allow over-fished species to recover. These are often very small in spatial scale and generally operate within the area owned by a specific clan or village. Although tenure arrangements and customary management practices create a platform for resource management in parts of the coral triangle, they also present unique challenges (such as coordinating at larger spatial scales). Despite apparent similarities with MPAs, the practices, motives, and expectations behind customary management are often very different from what conservation groups, governments, and scientists wish to achieve. An externally-derived focus on biodiversity as the primary driver for designing MPAs may not coincide with local expectations and forms of customary management. Acknowledging this is important because many NGO initiated projects have already failed due to their insistence in placing biodiversity over the needs and expectations of local populations. Alternative management tools that can meet local utilitarian goals must also be considered.

There are examples of ‘hybrid’ management systems, which link customary practices and contemporary conservation goals, such as in the Marovo and Roviana Lagoons in the Solomon Islands. In parts of the Philippines, local Imams have used the Islamic principle of Al Khalifa to reinforce legal conservation measures, essentially creating a “double layer” of protection. Figure 2 presents some key considerations for planning MPAs where marine tenure and customary management systems exist, but these considerations are generally applicable to developing MPAs with communities.

![Diagram](image)

Figure 2. Properties of successful hybrid management institutions. Customary/traditional and contemporary management systems can have contrasting: goals; social and ecological benefits; and spatial scales. The six principles (denoted as grey boxes) may help overcome these differences as managers, scientists, and communities hybridize the two systems. Adapted from Cinner & Aswani 2007.
In contrast to the countries where customary management practices are still common and have potential to further the objectives of marine conservation, the more populated countries of Indonesia, Malaysia and the Philippines depend primarily on statutory law being implemented at the local and national government levels to further their implementation of MPAs and related mechanisms for marine conservation. In these countries, there is a trend to decentralization of authority to local government bodies that are increasingly playing an active role in the planning and implementation of MPAs and MPA networks. This trend is most developed in the Philippines where municipalities and cities have full jurisdiction over their coastal and marine areas to 15 km offshore and are closed to commercial fishing. Enforcement is left up to local government. In effect, this constitutes a band of locally managed areas that covers twice the length of the US coastline. In Malaysia most management is under the state (provincial) government and in Indonesia, regional and district governments are playing a more active role. This trend of devolution allows for management planning and implementation processes to be more sensitive to local customs and encourages greater stakeholder involvement, thus the principles in Figure 2 are highly relevant to community-based management in these areas. Although in the Philippines and Malaysia customary management systems seem to have vanished, it is important to conduct social and ecological research in coastal communities to truly understand whether or not these systems are completely gone and if remnants can be built on and hybridized with government goals to manage marine ecosystems

**Background reading**


Cinner, J and S. Aswani. 2007. Integrating customary management into marine conservation. Biological Conservation: 140: 201-216  email: Joshua.cinner@jcu.edu.au


Some existing datasets

UNEP and WCMC 2007. World Database of Protected Areas. www.unep-wcmc.org/wdpa/
Philippine MPA Database (Philreefs 2007 www.philreefs.org/)
Coastal Conservation and Education Foundation: [www.coast.ph]

Some existing projects

National CTI Plans of Action

Project compiling information on national programs and priorities in each country covering the marine / coastal resources sector (contact CTI Secretariat, Mr. M. Eko Rudianto (Eko): mruediant@yahoo.com)
4. Ecological resilience and “shifting baselines”

Laurence M’Cook¹, Terry Hughes ², Angel Alcala³, David Bellwood⁴, Carl Folke⁵, Jamaluddin Jompa⁶, John Pandolfi⁷, Bob Steneck⁸, Hugh Sweatman⁹

5/11/08

Outline of the issue

Ecological resilience refers to the “capacity of an ecosystem to resist, or recover or regenerate from disturbances or damage, without changes in state (“phase shifts”) so as to maintain key functions and processes.” Just like healthy humans are better able to deal with and recover from diseases and injuries, resilient ecosystems can cope with stresses and disturbances.

Much more is known about the resilience of coral reefs than most other tropical marine ecosystems. Coral reefs are subject to frequent disturbances and damage, which stress or kill corals, often resulting in seaweeds or algae colonising the dead coral. Healthy coral reefs are usually able to rebuild themselves after damage, with corals re-establishing dominance. Such reefs are considered “resilient”, and continue to provide key ecosystem goods and services, such as fish and attractiveness to tourists.

Diagram illustrating resilience: A. Healthy reef, symbolised by the ball at position A, will recover from disturbances and return to its usual state. Human impacts may reduce the resilience of the system, making it more likely to “tip” over into the algal dominated state; this is illustrated by the ball at position B, in a shallower bowl. In position C, the reef is degraded, and it is much more difficult and expensive to return the ball to position A.

---

¹ Pew Fellowships Program in Marine Conservation; ARC Centre of Excellence for Coral Reef Studies, Australia
² ARC Centre of Excellence for Coral Reef Studies, James Cook University.
³ Silliman University - Angelo King Center for Research and Environmental Management, Philippines
⁴ ARC Centre of Excellence for Coral Reef Studies, James Cook University.
⁵ The Beijer Institute, Royal Swedish Academy of Sciences, Sweden
⁶ Coral Reef Rehabilitation and Management Program, Ministry of Marine Affairs and Fisheries, Indonesia
⁷ The University of Queensland, Australia; ARC Centre of Excellence for Coral Reef Studies, Australia
⁸ School of Marine Sciences, University of Maine, U.S.A.; ARC Centre of Excellence for Coral Reef Studies, Australia
⁹ Australian Institute of Marine Science, Australia
Human impacts on coral reefs, such as climate change, over-fishing, destructive fishing and water pollution can reduce the ability of the reef to recover from such damage, making it less resilient. The reef will often fail to recover from disturbances, and will gradually become degraded, and unable to provide fish, tourist value, and many other ecosystem services.

In the Coral Triangle, human activities that reduce reef resilience include over-fishing, fishing practices that damage reef habitats (such as blast fishing, cyanide fishing, muro-amí fishing), water pollution, and direct destruction of reefs, such as by uncontrolled tourism or mining for building materials. Water pollution often includes sediment and nutrient runoff from the land, from agriculture, deforestation and sewage, other chemical pollution, and garbage and litter, such as plastic bags.

Similar impacts can occur in other ecosystems. Mangrove forests are also vulnerable to widespread clearing, for coastal development and aquaculture ponds. Seagrass beds are also vulnerable to dredging, destructive fishing practices such as blast fishing and trawling, as well as pollution. Unfortunately, for many other habitats, such as sponge gardens, shoals and muddy or sandy bottom areas, there is insufficient information about the basic ecological processes that underpin ecosystem information.

Ecosystem managers seek to protect and enhance the resilience of ecosystems, by reducing human stresses and impacts. Importantly, reducing one stress will often help the ecosystem recover from other stresses. For example, protecting the herbivorous fishes on a coral reef will help protect from seaweed overgrowth of corals, even when nutrient runoff from the land is causing increased growth of seaweeds. Importantly, it is much easier, and cheaper, to maintain the resilience of a healthy reef, than to try to restore the reef once degraded. When recovery does occur, it may take many years or decades, due to the slow growth of most hard corals.

“Shifting Baselines” (also known as sliding baselines) refers to the way that the reference points against which we compare the condition of an ecosystem, often undergo chronic, slow, hard-to-notice changes or degradation. If our reference points or baselines are gradually degrading, then we will underestimate how severely degraded our ecosystems are. For example, if the current generation of reef users or scientists have only ever seen a reef which has been over-fished or exposed to runoff, then they may not recognize the reef as degraded. Even those reefs in a region that are in the best condition may be significantly degraded in comparison with what our grandfathers knew 50 years ago.

There is increasing evidence that many, apparently healthy coral reefs and other tropical ecosystems around the world have already been significantly altered by human activities, such as over-fishing of top-predators like sharks. If the baseline shifted before we really had a chance to chart it, then we can end up accepting a degraded state as normal or healthy.

For example, in the Philippines, total fish biomass on good reefs has declined from around 100-150 tons per km² to 5-10 tons per km² at present. Historical biomass has been estimated by extrapolation from the few remaining relatively unexploited reefs, such as Tubbataha Reef in the Sulu Sea. With full protection for 5-10 years some fringing reefs have been able to return to a biomass of only 50-60 tons/km².
What does this mean for achieving the goals of the draft CTI Plan of Action?
• Resilience science tells us that reducing the impact of one threat or stress will often also increase the resilience to other threats.

• Also, that the greatest benefits are to be gained from managing all the threats and stresses on ecosystems, in an integrated manner.

• Thus for example, providing protection from destructive fishing and from over-fishing in MPAs will often help fisheries productivity.

• In particular, in the CT6, many reefs and other habitats are affected by runoff of chemicals, sediments and nutrients from the land, as well as by activities in the sea. This means that the greatest benefit to reefs, and to food security, will come from combined efforts to address land runoff and fishing practices at the same time.

• In the CT6 countries, many reefs have now been degraded for some time, so that many people have become used to poor coral condition and low fish stocks. It is important that the CTI efforts incorporate these “shifting baselines” and the need for increased effort to help reef recovery, not to just maintain the present, degraded condition. This will often mean working to restoring processes which are important to resilience.

What does this mean for MPA network design, management and implementation?
MPAs generally serve to protect against over-fishing and destructive activities, but may not be effective tools for managing environmental quality (e.g. water pollution) and may be insufficient to protect the overall ecosystem (i.e. including areas outside MPAs). Achieving resilient reef and other ecosystems requires much more than careful design of MPA networks. It requires:

• Comprehensive and integrated management of all the major stressors in the region and the broader seascape, including in particular water pollution and runoff from the land;

• Effective implementation of protection within MPA-designated areas (e.g. effective compliance and enforcement);

• Protection and management of coral reefs should include protection of linked marine ecosystems such as seagrass beds and mangroves, because of the close ecological relationships among these ecosystems;

• Complementary management of areas outside MPA networks (e.g. careful fisheries management in areas open to fishing, with emphasis on maintaining processes such as herbivory and connectivity). This includes provision of alternative livelihood options for local communities which do not exacerbate environmental degradation;
• Increased levels of protection to compensate for the effects of existing degradation (e.g. increased proportion of protected areas, and/or increased levels of protection within protected areas). From the perspective of building resilience, 30-40% of total area should ideally be protected in no-take areas;

• Active participation of local, and traditional or indigenous communities and local government agencies, integrated within national government frameworks of legislation and governance. The extent of involvement of different levels of government and community organisations must be appropriate to local circumstances: what works in one context may not be appropriate in others;

• Understanding past natural states provides managers with a ‘measure of success’ to use in evaluating the effectiveness of management actions. It also provides restoration/rehabilitation goals that, even if not realistically achievable, provide a framework for ecosystem improvement.

Finally, because it is easier and cheaper to protect ecosystems now to maintain resilience than to restore degraded ecosystems, where possible, proactive management will always be much more cost effective than reactive management, after degradation. Even where degradation has already occurred, initiating remediation efforts sooner and more strongly may dramatically improve outcomes.

**Background reading**


Jackson J. B. C. Reefs since Colombus. Coral Reefs 16: S23-S32


Some existing datasets
Silliman University - Angelo King Center for Research and Environmental Management, Philippines has a database including, for example, data from 1996-2007 from the Spratly Islands. (contact: Angel Alcala also www.su.edu.ph/suakcrem/index.htm)

The Reefs Through Time Series (4th series) under the Philippine Coral Reef Information Network www.philreefs.org

Some existing projects
Coastal Conservation Foundation: www.coast.ph

One Ocean: oneocean.org/about_crmp/where_we_are.html

Silliman University - Angelo King Center for Research and Environmental Management www.su.edu.ph/suakcrem/index.htm

Acknowledgements
Invaluable comments were provided by JML Tan, Dr P. Alino and Dr K. Dobbs.
5. Data sufficiency and dealing with uncertainty
PM Alino\textsuperscript{2}, B Pressey\textsuperscript{2}, L Fernandes\textsuperscript{2}, J Oliver\textsuperscript{3}, H Possingham\textsuperscript{5}, JML Tan\textsuperscript{6}, B Vallejo Jr. \textsuperscript{7}

5/11/08

Outline of the issue
There is never perfect data for natural resource management. How can managers and decision-makers deal with imperfect and incomplete information? How can they assess if the available data is good enough to take action versus waiting for better information?

What does this mean for achieving the goals of the draft CTI Plan of Action including an MPA network?
There isn’t perfect information available to inform the CTI draft Plan of Action; nor has there been for any other marine conservation initiative. While much is known about the broad biophysical processes and the overall conditions and patterns of use with regard to the Coral Triangle there remains considerable uncertainty and significant information gaps (e.g. finer scale maps of coral reef diversity, OTHER????). While efforts to close such gaps must continue, there is a need for regional management action now so that the significant threats to the sustainability of the area and its peoples can be effectively diminished.

Through the development of a draft Plan of Action, the countries of the CT have indicated that their preference is to act now. How best, then, to deal with the imperfect data? Some options (not mutually exclusive) include:

1. Determining which data sets are crucial for decision makers and which provide background secondary support

\textsuperscript{1} The Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines, pmalino@upmsi.ph
\textsuperscript{2} Program Leader, Conservation Planning for a Sustainable Future, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University, Q. +61 (0)7 4781 6194, bob.pressey@jcu.edu.au
\textsuperscript{3} Marine Resource Management Coordinator, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University and the Australian Institute of Marine Science, Townsville, Q. Australia. Ph. +61 (0)7 4725 1824; leannef@earth2ocean.com
\textsuperscript{4} Director, Science Coordination, The WorldFish Center
\textsuperscript{5} Director, Applied Environmental Decision Analysis, University of Queensland, Brisbane, Q. Ph. +61 (0)7 3365 9766; h.possingham@uq.edu.au
\textsuperscript{6} Vice-Chairman, WWF Philippines, lorytan@gmail.com
\textsuperscript{7} Assistant Professor, Institute of Environmental Science and Meteorology, Villadolid Hall, College of Science University of the Philippines, Diliman, Quezon City, 1101 Philippines.
2. Collation of existing data and information including data management to ensure the most current information is available to managers.

3. Provision of the collated data and information in a manner that is useful to the decision-makers and managers who will be implementing the goals of the CTI. This matching of information collation efforts with end-users (e.g. decision-makers, managers) will work best if those doing the collation work closely with the end-users.

4. Investigate data sufficiency as a basis for conservation planning versus the cost and time required to collect additional data. Devise rules-of-thumb or principles for planning with uncertain data.

5. Design of management solutions to incorporate the uncertainty and, ideally, to be adaptive. This latter means that the design of the management solution is such that information can be collected to determine the success of the solution and determine how management can be improved (see also issue paper on MPA design)

6. To improve the basis for management in the future, the draft Plan of Action also advocates development of systems to enhance information collection. This could include a combination of systems for

   (a) systematic identification of the most important data gaps in the region and within countries against agreed criteria

   (b) targeted priority research to collect the most important information that is currently absent – ideally in collaboration with the potential end-users (managers and decision-makers) and

   (c) regular review of management objectives and practices as new information becomes available.

   The timing of the latter (c) should not be so often as to cause (i) confusion with resource users as to the rules, (ii) business uncertainty nor (iii) failure to give the natural system time to respond to the management interventions. The timing of any review of management practices however should be frequent enough to take timely advantage of new information as it becomes available.

Workshop participants could ask themselves, given the natural, social, economic and institutional systems (including the rate of production of research and monitoring outcomes) of their various countries:

1. “Do we know what information is available?”

2. “Do we know what is the most important information that is currently missing?”

3. “How should we deal with the inevitable uncertainty in data on biodiversity and socio-economics? “
4. “Can we use expert opinion to compensate, somewhat, for the data gaps? How?”

5. “Can we use rough statistical models, like distance to population centres, to estimate socio-economic values?”

6. “How much can biophysical data, like currents, temperature and depth, substitute for biological data?”

7. “Once we have a handle on uncertainty, how can that be used to inform decisions?”

8. “What would be an appropriate timeframe over which to review, say, boundaries of any new MPA network in the light of new information? “.

Similar questions could be asked of any new management initiative under the CTI.

**Background reading**


Some existing projects
Assessing relative costs and benefits of available data for conservation planning (contact: bob.pressey@jcu.edu.au)

Incorporating uncertainty into conservation planning with consideration of patch dynamics of resources (e.g. pelagic productivity) and disturbance (e.g. storms, coral bleaching) in the Bismarck Sea (contact: bob.pressey@jcu.edu.au)
6. How human uses and values can matter for the CTI
Bunce, L.¹, Cinner, J.², Foale, S.³, Nash, W.⁴
4/11/08

Outline of the issue
The identification and listing of the variety of human uses and values will be a key (and significant) component of the CTI (some sample projects are listed below). Uses that have been or will be documented include the variety of types of fishing and non-fishing uses of resources. Values that are pertinent include livelihoods/income values, food security/access and shoreline protection, for example. This paper aims to explore how issues around human uses and values can influence choices about the best management options and potential management success.

While the CT6 countries all share marine resources such as coral reefs with exceptionally high species richness, there is significant variation in both pressure upon the resources and management actions and options among and within them. Fishing pressure relates to both human population density (see Table 1) and the existence of alternative economic opportunities, while management options are mediated by rights of access, and a variety of social, political and economic factors, including the extent to which the state can be considered ‘weak’ or ‘strong’. Philippines and Indonesia both have vastly higher human population densities than the two Melanesian countries (though the western half of the island of New Guinea, which has an even lower population density than PNG, is part of the state of Indonesia). There is considerable variation in rights of access also; customary land and marine tenure institutions enjoy a significantly greater level of recognition by the state in PNG and Solomon Islands than in the Southeast Asian countries.

Table 1. Population density and per capita GDP data for the CT6 countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Total population</th>
<th>Population density (people/km²)</th>
<th>Per capita GDP (US$) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papua New Guinea</td>
<td>6,331,000</td>
<td>13</td>
<td>1,972</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>506,992</td>
<td>17</td>
<td>1,864</td>
</tr>
<tr>
<td>East Timor</td>
<td>1,155,000</td>
<td>64</td>
<td>ND</td>
</tr>
<tr>
<td>Indonesia</td>
<td>231,627,000</td>
<td>117</td>
<td>3,725</td>
</tr>
<tr>
<td>Philippines</td>
<td>90,457,200</td>
<td>277</td>
<td>3,400</td>
</tr>
<tr>
<td>Malaysia</td>
<td>27,170,000</td>
<td>77</td>
<td>13,300</td>
</tr>
</tbody>
</table>

* NB: Per capita GDP figures for Solomon Islands and PNG do not take into account the monetary value of the subsistence economy in those countries, which is significant.

¹ Conservation International: l.karrer@conservation.org
² ARC Centre of Excellence for Coral Reef Studies, James Cook University: joshua.cinner@jcu.edu.au
³ ARC Centre of Excellence for Coral Reef Studies, James Cook University: simon.foale@jcu.edu.au
⁴ Worldfish Centre, Noumea. WarwickN@spc.int
Population Pressure and Alternative Economic Opportunities

The significantly lower human population densities of PNG and Solomon Islands mean that, generally speaking, over-fishing has so far only occurred for a small number of relatively vulnerable export commodity fisheries (see issue paper on non-spatial management approaches). Because fin-fish are mostly consumed for subsistence or sold domestically, populations of these are mostly in relatively good shape in these countries. In Southeast Asia, the picture is somewhat different, with over-harvesting of many species, including fin-fish, commonly reported. These differences in the level of pressure on fisheries have important implications for the capacity of different populations within the Coral Triangle to absorb the immediate economic costs associated with increased constraints on fishing effort, whether through spatial or non-spatial management interventions. For example, because they enjoy a relatively high level of food security, coastal subsistence farmers in the Solomon Islands have been able to accommodate the recently (April 2008) imposed total ban on harvesting of beche-de-mer in Solomon Islands, even though for many of them it was the most significant source of cash income.

Cultural attitudes to capitalist endeavour

When seeking alternative or supplementary livelihoods or sustainable financing to support conservation, tourism is often discussed as an option. This option can be quite successful in some situations. In parts of Melanesia, however, there can be constraints on the use of tourism to defray the short-term costs of MPAs, in the form of cultural constraints on widespread engagement with capitalist enterprise (Schoeffel 1997, Foale 2008, Fukuyama 2008). In the Philippines (and elsewhere in the Coral Triangle) there are problems with equitable distribution of the benefits from dive tourism ventures, which inevitably generates resentment (Fabinyi 2008).

Rights of Access

Traditional rules of access to coastal waters (customary marine tenure - CMT) are largely enshrined in the constitutions of PNG and Solomon Islands, while state support for CMT in the Southeast Asian countries is more limited, though increasing under recent decentralisation schemes in Philippines and Indonesia.

Some claim that the CMT system is an important element of traditional management institutions, because it prevents the over-fishing that has been observed in (inadequately regulated) open access systems. This is famously referred to as the ‘Tragedy of the Commons’ because it is in no individual fisher’s interest to limit fishing effort in an open access fishery while other fishers are not also limiting theirs. While it is true that CMT restricts access to the group that share customary rights to a territory, it is still possible to observe ‘micro’ Tragedies of the Commons even within marine territories defined under the CMT system, particularly where social cohesion is low, local leadership is weak, and/or the limits to resources are either not perceived or only partially understood (Foale and Manele 2004).

Perceptions of limits to stocks

While extreme poverty and desperation may drive over-fishing in regions with high human population densities, in sparsely populated areas the lack of an appreciation of the limits to fisheries
(Johannes 2002) combined with expanding markets and rising commodity prices can do the same for exportable species. In the latter case, however, there may be more scope for interventions based on well-designed and culturally informed education campaigns which include, among other things, a clear explanation of stock-recruitment dynamics and the role of over-fishing in recruitment failure for fisheries that are experiencing rising pressure. This may in the future help to avoid last-resort measures such as the complete closure of severely over-harvested fisheries by the government, which we have recently observed in Solomon Islands and Vanuatu.

**Gender, culture and religion**

Use of marine resources in many parts of the CT6 is highly gendered. Women often perform a key role in subsistence fishing, but often target different species from men. They also tend to have less access to transport and fishing technology than men, and as such are more spatially constrained in their activities. This has implications for the location of no-take closures (see below).

In some places there are aspects of culture such as totems and sacred places which can result in a (usually small) conservation effect. Many traditional beliefs and values are undergoing constant change however. Modern religious beliefs can also have some conservation effect, such as the prohibition on consumption of turtles, and fish without scales by the Seventh Day Adventist Church.

**What does this mean for achieving the goals of the draft CTI Plan of Action?**

Uses and values that pertain to the marine environment are likely to be very different among the different CT6 countries, with poverty and low levels of food security likely to comprise a somewhat greater challenge to efforts to manage fishing effort in densely populated locations.

**What does this mean for MPA network design, management and implementation?**

The other side of the ‘two-edged sword’ of Customary Marine Tenure (in Melanesia) is that because marine territories represent a level of exclusivity at a fairly fine spatial scale (typically hundreds of metres to kilometres), the incentive (in theory at least) for any given group of reef owners to accept no-take areas within part of their territory can be compromised by the extent to which they are likely to be sharing the benefits (i.e. the spillover) with neighbouring groups to whose territories they may not enjoy any rights (Foale and Manele 2004). This means that any network of MPAs must be negotiated with multiple contiguous reef-owning groups, depending, of course, on the match or mismatch between the scale at which MPAs are ecologically effective, and the scale at which customary territories are divided.

Economic and gender issues should be taken into account when zoning no-take areas. Where a choice exists between locating a no-take zone at various distances from a village, the more distant location should be selected, so that women, who (unlike men) commonly do not have access to motorised transport, can continue to access nearby reefs and mangroves for subsistence fishing and gleaning (Vunisea 2008). These closer locations would in theory ultimately benefit from spillover...
from the reserve. However, it should be kept in mind that MPAs are also harder to enforce the further they are from the residence(s) of the manager(s).

In sum, MPAs are more likely to be optimally located, and indeed successful, if their proposal and establishment is preceded by careful and systematic social, political and economic baseline and feasibility surveys. This work should include a focus on existing perceptions and beliefs about limits to fish stocks, and the impacts of fishing. Baseline research is also vital if the social and economic success of the MPAs is to be accurately measured. It is also vital that people are provided with an accessible form of the latest research outputs on a) the time scale and b) the economic value of spillover (i.e. CPUE outside of the closure) that they can expect from the MPAs, so that expectations are not unduly inflated.

**Background reading**


Some existing datasets
Solomon Islands Household Income and Expenditure Report:  
http://www.spc.int/prism/sbtest/Publication/Annual/HIES-Report.htm


Some existing projects
Global Socioeconomic Monitoring Initiative (Southeast Asia Region) is listing the major uses and available statistics on levels of use. Contact Sheila Vergara, Chair, SocMon Southeast Asia (s.vergara@conservation.org or sheila_vergara@yahoo.com) or Professor Michael Pido, Palawan State University (mpido@yahoo.com)


ADB RETA 6446-REG: Strengthening Sound Environmental Management in the Brunei Darussalam, Indonesia, Malaysia and Philippines East ASEAN Growth Area. Approved in February 2008, the RETA will be implemented by Southeast Asia Department of ADB.

7. Participatory marine resource management planning
P.M. Alino¹, Leanne Fernandes², Bob Pressey³, JML Tan⁴, Alan White⁵

5/11/08

Outline of the issue
Including the right people at the right time(s) in the right amount and in the correct manner throughout a natural resource planning and management process enables its success. Who the right people are, when are the right times, how much is the right amount and what is the correct manner, is highly situation specific. These matters must be worked out through a locally sensitive and scale specific planning process. The process for the CTI would need to acknowledge that different CTI countries may have different CTI priorities at different times in terms of implementing the CTI Plan of Action.

The crux of the issue is that planning that adequately involves stakeholders so that sufficient buy-in is created, must occur at appropriate scales. This implies that nested (and coordinated) layers of planning activities occur simultaneously.

What does this mean for achieving the goals of the draft CTI Plan of Action including delivery of an MPA network?
For each CT country, for each CTI draft Plan of Action goal, objective and strategy there will be an ideal level, type, amount and timing of interaction with all the relevant players that will enable success. However, resource limitations will require setting priorities regarding what amount of involvement can happen, with who, how and when. Planning for and implementing the CTI must also coordinate and complement efforts, including consultation and participatory efforts, with existing planning efforts. Such efforts include local (municipal level planning, management, systems and processes), national (e.g. National Biodiversity Action Plans which includes priority setting efforts) and regional plans (e.g. the Sulu-Sulawesi Marine Ecoregional planning, Solomon-Bismark Sea Marine Ecoregional planning, the South China Sea Strategic Action Plan)(Ong et al. 2002)

Therefore, the planning for natural resource management projects, such as those in the CTI draft Plan of Action, should include a plan for what is feasible with regard to participation and involvement in management. Consideration could be given to who will be affected positively or

¹ The Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines; pmalino@upmsi.ph
² Marine Resource Management Coordinator, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University and the Australian Institute of Marine Science, Townsville, Q. Australia. Ph. +61 (0)7 4725 1824; leannef@earth2ocean.com
³ Program Leader, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University 61 (0)7 4781 6194, bob.pressey@jcu.edu.au
⁴ Vice-Chairman, WWF Philippines, lorytan@gmail.com
⁵ Senior Scientist, Global Marine Initiative, The Nature Conservancy, Hawaii; alan_white@tnc.org
negatively by the planning exercise, who can influence the planning exercise positively or negatively, who can provide information, and who will be responsible for taking action to implement the planning exercise.

The plan for inclusive, but still feasible, participation in management could address the following questions:

1. What are you trying to achieve through participation and involvement in your marine resource management project?

2. Who are the primary stakeholders? Stakeholders may include:
   a. decision-makers including (but not limited to) relevant elected and appointed official representatives at local, state and national government levels;
   b. economically involved stakeholders;
   c. government technical and administrative persons at local and national levels;
   d. ultimate resource managers (e.g. selected resource users and government persons)
   e. other local community members who may not be using the resource (as in (d) above) nor otherwise economically engaged (as in (b) above)
   f. local and external technical experts
   g. Assisting organizations (e.g. NGOs, donors, academe etc.)

While there will be overlap between these groups, it is important that for any given situation that these groups be considered and key organizations and individuals are prioritized for participation.

3. To what degree can or should these various players be involved when considering the risks and advantages of involvement in the management process? What level of involvement is appropriate and possible given resources, time constraints, institutional culture and overall objectives of the activity or strategy.

4. What will be the concerns and views of the various stakeholders?

5. What will be key messages to these stakeholders (both in terms of sharing information about what is happening and providing answers to potential questions)?

6. What is the best plan for who to involve, in what way and at what points in time throughout the planning and management process? This includes identification of which consultation/communication mechanisms will work best in which situations and at what points in time.

Throughout the management process it will be important that those being engaged are clear as to the degree that they will be able to inform and influence the management outcomes; failed
expectations should be avoided where possible. Hence, this information could comprise part of the key messages to share with stakeholders.

It is also important to not over-engage stakeholders until the prospects for their relevant involvement are clear and warranted. Many past projects that have involved stakeholders prematurely to the appropriate time for their engagement, have squandered the support and enthusiasm of stakeholders that is needed at the time of full project implementation (White et al 2005).

**Background reading**


Some existing projects
The Fisheries Improved for Sustainable Harvest (FISH) Project  http://www.oneocean.org/

Coastal Conservation and Education, Foundation, Cebu City, Philippines  http://www.coast.ph

Guide to participatory LMMA planning: http://www.lmmanetwork.org/Site_Page.cfm?PageID=64

Marine and MPA Network Learning Partnership results and publications (c/o A. White, TNC and K. Newman, WWF)

Coral Reef Rehabilitation and Management Program (COREMAP)  http://www.coremap.or.id/language/

Spatial patterns of customary tenure and its implications for putting marine conservation planning into practice (contact: bob.pressey@jcu.edu.au or simon.foale@jcu.edu.au)
8. Climate Change Threats to Coral Reefs in the Coral Triangle

Willis B.L.\(^1\), Dove S.\(^2\), Hoegh-Guldberg O.\(^2\), Lough J.M.\(^3\), McCulloch M.\(^4\), Munday P.L.\(^1\), Pratchett M.S.\(^1\), Salm R.\(^5\), van Oppen M.J.H.\(^2\)

3/09/08

Outline of the issue

Climate change poses enormous risks for coral reefs within the Coral Triangle (CT). The human implications of these risks are significant, important and addressed in separate background papers in this series (for example, “9. Threat of climate change to fish and fisheries”, “16. Human adaptation to climate change”). This paper focuses on the biophysical dimensions of climate change.

The CT lies at the heart of the “Maritime Continent” with a complex distribution of islands and shallow seas and some of the warmest sea surface temperatures (SSTs) in the world. This “boiler box” of the tropics is an area of intense tropical convection, which is a dominant heat source for the global atmospheric circulation. It contains complex ocean current systems that link the Pacific and Indian Oceans. Principal atmospheric circulation features are the Intertropical Convergence Zone (ITCZ) separating the Northern and Southern Hemisphere circulations and its extension, the South Pacific Convergence Zone (SPCZ) in the southeast of the CT. The ITCZ lies south of the CT in January and to the north in July. The CT has a monsoonal climate with seasonal reversal of wind fields and much of its rainfall arises from intense, localized thunderstorms. Inter-annual rainfall variability is significantly modulated by El Niño-Southern Oscillation (ENSO) events with parts of the CT typically experiencing much drier conditions during El Niño years. Tropical cyclones (which do not form within ~10\(^\circ\) of the equator) are significant weather phenomena primarily in the northern parts of the CT.

**Observed climate change:** Climate change is not a future event for the CT, significant warming has already occurred. Averaged over the CT region, annual average, annual maximum and annual minimum SSTs in the most recent 20 years (1988-2007) are ~0.3-0.4°C warmer than over the earlier period, 1950-1969 (Figure 1). The current rate of warming for annual CT SSTs (~0.11°C/decade between 1950-2007) is slightly greater than the rate for the tropical oceans as a whole (0.08°C/decade) and comparable to that for global average land and sea temperatures (0.12°C/decade). CT SST warming is also greater for annual maximum than annual minimum SSTs. There are spatial variations within the CT in the observed rates with warming being greatest in the

---

\(^1\) School of Marine and Tropical Biology, and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD 4811, Australia.

\(^2\) Centre for Marine Studies, and ARC Centre of Excellence for Coral Reef Studies, The University of Queensland, St Lucia, QLD 4067, Australia

\(^3\) Australian Institute of Marine Science, PMB 3, Townsville QLD 4810, Australia

\(^4\) Research School of Earth Sciences, and ARC Centre of Excellence for Coral Reef Studies, Australian National University, Canberra, 0200, Australia

\(^5\) Director, Coastal Marine Program, Asia Pacific Region, The Nature Conservancy
northern CT EcoRegions 1 and 2 (~0.13-0.14°C/decade) and lowest in the southern EcoRegions 7 and 10 (~0.08°C/decade).

Projected climate change: Observed and projected global warming is greater at high than low latitudes and greater on land than in the oceans. The CT, despite lying in the warmest ocean region on earth, will not be immune to significant warming nor to other changes in its physical environment, with significant consequences for its tropical coral reefs and associated ecosystems. Evidence is emerging that tropical organisms may be more sensitive to the relatively smaller magnitude warming predicted than their higher-latitude counterparts, as the latter are adapted to much larger ranges of temperatures. Projecting how climate will change both globally and for the CT depends on several factors, particularly global and local responses that are taken in the short and long term to curb and stabilise greenhouse gas emissions. In addition, there are still difficulties in applying global climate models to correctly model current climate of the Maritime Continent, which makes future projections more speculative for this region than in other parts of the world. Changes in the following physical environmental variables will be of consequence for the CT’s coral reef ecosystems:

- **Sea surface temperatures:** Annual, maximum and minimum SSTs in the CT have already significantly warmed and are projected to be between 1-3°C warmer by the end of this century. There is, however, little spatial detail in the pattern of projected warming from existing models.

- **Ocean acidification:** pH of the global oceans has already decreased by ~0.1 units due to absorption by the surface oceans of ~1/3 of the extra carbon dioxide injected into the atmosphere from fossil fuel burning and other human activities. This progressive ocean acidification is projected to continue, with pH decreasing by 0.3-0.4 units by 2100. Projections indicate that the aragonite saturation state and hence coral calcification will become “marginal” for coral reefs of the CT within the period 2020-2050.

- **Rainfall and river flow:** There are some indications that equatorial Pacific rainfall, especially in the vicinity of the ITCZ, will increase but there are conflicting scenarios from different climate models. Even without changes in average rainfall, it seems likely that rainfall events will become more extreme and that inter-annual variability of monsoon rainfall will increase. Importantly, the intensity of drought associated with a given rainfall deficit will be greater in a warmer world.

- **Sea level:** Global sea level has already increased (mainly through thermal expansion) by ~10 to 20cm over the 20th century. Current IPCC (2007) projections suggest a further ~30-60cm rise by 2100 but this is regarded as a very conservative estimate due to underestimation of the contribution of melting of land ice. The IPCC (2007) report also recognises the possibility of scaled-up ice sheet discharges from melting of the large land-based ice sheets in Antarctica and Greenland, which would lead to sea level rises in the order of +4m to +6m. However, because of uncertainties associated with the possible timing of such events, these much higher estimates are not directly included in predictions for 2100.

- **Tropical cyclones:** There is no clear consensus amongst global climate models as to whether the location or frequency of tropical cyclones will change in a warming world but there is agreement that they will become more intense (with greater maximum wind speeds and heavier rainfall), and there is some evidence that this is already occurring.
• **El Niño-Southern Oscillation events**: There is no clear consensus as to how the frequency and intensity of ENSO events will change in a warming world though this phenomenon is likely to continue as a significant source of inter-annual climate variability in the CT region.

• **Ocean circulation patterns**: There is little information currently available about what may happen to the complex ocean circulation patterns of the CT as the world warms.

In summary, although some aspects of future climate projections for the CT region are not well constrained at present, SSTs will continue to warm, sea-level will continue to rise, the surface ocean saturation levels will become progressively less hospitable for coral reef development and extreme events, which are a source of localised destruction for coral reefs (eg floods and drought, tropical cyclones), will become more intense. A key issue is the unprecedented rate at which these changes are occurring. Another important issue is that, for the foreseeable future, the physical climate and environment of the CT will be changing and we do not, at present, know what the end point will be (i.e. it is not simply a change to a new climate regime to which coral reef organisms can adapt).

**Implications of climate change for coral populations**

**Thermal stress and bleaching**: Thermal stress is one of the key threats to coral reef ecosystems in the coming decades. Most corals live within 1-2°C of their upper thermal limits. Beyond these thresholds, the association between corals and their symbiotic algae, commonly called zooxanthellae, breaks down. Loss of zooxanthellae from the partnership causes corals to turn white (i.e. bleaching; Figure 2), with dire consequences for the nutritional economy of the coral host. Approximately 16% of the world’s coral reefs died during the severe global bleaching event in 1998. Climate change models predict that large scale mortality caused by bleaching will occur regularly and potentially annually by 2030 in some reef regions. Branching species of *Acropora*, which currently dominate many communities in the CT and provide 3-dimensional habitat for many reef-associated fish and invertebrates, are among the most vulnerable to rising temperatures. While rapid growth rates of these species augment their recovery potential, increasingly frequent and severe bleaching events will potentially outstrip their capacity to recover. Unless corals can adapt to predicted thermal regimes, coral reef ecosystems will change dramatically (Figure 2c).

**Potential for acclimatisation or adaptation to thermal stress**: Some corals harbour thermally tolerant zooxanthella types at low densities in addition to a more sensitive dominant type, providing a possible mechanism for short term acclimatisation to thermal stress. These thermally tolerant zooxanthellae may repopulate coral tissues from surviving resident populations following bleaching, protecting corals from starvation, reducing mortality and enhancing their recovery, although growth rates are reduced. Initially, these corals are less susceptible to bleaching in subsequent thermal stress events, but typically they revert to their original zooxanthella communities and their tolerance to temperatures predicted by moderate to extreme IPCC scenarios is unknown. Whether zooxanthellae, or the corals themselves can acquire increased thermal tolerance through genetic adaptation in response to selection is currently not known. The long generation times of corals argue against their potential to adapt to predicted rates of ocean warming. Little is known about sexual reproduction in zooxanthellae, but they may have greater scope for genetic adaptation within time scales predicted for climate change given their likely short generation times.
**Ocean Acidification**: Unlike in the atmosphere, where the main greenhouse gas, CO₂, causes warming through its strong physical interaction with infrared radiation, CO₂ is a highly reactive species in the oceans, where it dissolves in surface waters and initiates a series of chemical reactions that alter seawater chemistry. Rapidly rising levels of atmospheric CO₂ have resulted in an overall increase in seawater acidity (i.e. a reduction in seawater pH) in a process that has become known as ‘ocean acidification’. Increasing ocean acidity also has a major impact on seawater carbonate equilibria, causing a reduction in the concentration of carbonate ions and hence in the saturation state of the oceans. Ocean acidification will thus inhibit the ability of many marine organisms that produce carbonate skeletons, especially corals, to calcify. This is likely to be a more serious problem than originally perceived, as experimental data now indicate that coral calcification rates are dependent on the degree of over-saturation of carbonate in seawater. Thus doubling of atmospheric CO₂ will result in an approximately twofold reduction in carbonate ion concentration, which, in turn, will cause a significant reduction in coral calcification. The tropical regions of the CT are expected to be particularly vulnerable to ocean acidification because corals are already calcifying in an environment close to their upper thermal limits and hence are especially sensitive to lower carbonate ion concentrations from decreasing seawater pH. Hence skeletons are likely to become more fragile and growth and recovery of corals is predicted to become progressively slower.

**Increasing disease**: The outcomes of interactions between corals and disease-causing pathogens are significantly affected by the surrounding environment. Warming seas, increasing acidification and rising intensity of storms predicted by climate change models represent sources of stress that will increase the vulnerability of corals to disease. Increased temperatures may also increase the virulence of pathogens, compounding the likelihood of disease outbreaks. Links between high thermal anomalies and outbreaks of a number of coral diseases (Figure 3) highlight the potential for significant losses of coral with predicted climate change.

**Increasing storm damage**: Coral reefs are naturally highly dynamic ecosystems, but increasingly frequent acute disturbances, coupled with human induced chronic stressors, threaten the physical framework of coral reefs in the region. Increased frequency and severity of injuries will further compromise the resistance of corals to disease and increase the potential for disease outbreaks.

**Implications of climate change for fish and invertebrate populations**

**Declining abundance with loss of critical habitat**: Live corals and the complex physical structures they provide are critical habitat for many reef fishes and invertebrates. Extensive coral loss caused by increasingly frequent and more severe coral bleaching events will cause local extinctions, and possibly even global extinction, of some species that depend on live coral for food and/ or habitat. Other species, will suffer population declines due to the loss of settlement habitat and a reduction in shelter from predators. Structural collapse of dead coral colonies will affect many small prey species, with potential flow-on effects to larger coral reef fishes, such as coral trout.

**Declining physiological performance and reproduction**: Increased ocean temperatures will directly affect the physiological performance and behaviour of reef fishes, especially during their early life history. Small temperature increases may favour larval development, but this is likely to be countered by negative effects on adult reproduction. Recruitment is typically variable, but it is
expected to become even more unpredictable. This will make optimal harvest strategies for coral-reef fisheries more difficult to identify and populations more susceptible to overfishing.

**Shifting distributional ranges**: A substantial number of species will exhibit geographic range shifts, potentially away from the CT, as oceans warm. Reef fishes differ in their thermal tolerance, consequently some species will shift their ranges more rapidly than others, with consequences for community composition. Species that already have small ranges near the margins of reef development will face an increased risk of extinction due to range contractions.

**What does this mean for achieving the goals of the draft CTI Plan of Action?**

Impacts of climate change on coral reef ecosystems will act synergistically with other stressors, particularly those relating to over-fishing and poor water quality. The key to increasing the capacity of coral reef ecosystems to cope with climate change is to enhance their resilience. The following recommendations, in relation to the goals of the draft PoA, aim to increase the resilience of the CT ecosystem primarily by controlling and reducing additional human-related stressors. It should be noted, however, that the only effective long-term strategy for reducing the physical threats of climate change will be concerted global efforts to reduce greenhouse gas emissions.

**Goal 1. Priority seascapes**: Large-scale areas prioritized for investment, management and action should be distant from sources of non-climate related stress, such as those associated with degraded coastal catchments, poor land use practises or uncontrolled urbanisation and development. Given current lack of knowledge regarding stress tolerance and functional roles for most coral reef species, high diversity areas with layers of functional redundancy should be prioritized.

**Goal 2. Ecosystem approach to management of fisheries and other marine resources**: Coordinated governance of marine ecosystems and adjacent terrestrial ecosystems that drive water quality in coastal areas will help to reduce stressors and buffer reefs and fisheries from climate change impacts. Coordinated governance of all marine resource user groups is integral to maintaining regional biodiversity and fish stocks. It will be critical to work concurrently with global efforts to reduce greenhouse gas emissions to constrain the magnitude of global warming and ocean acidification below critical ecosystem thresholds.

**Goal 3. Marine Protected Area networks (MPAs)**: Placement of MPAs should consider thermal refugia, identified through analyses of current temperature and current patterns. Such regions could become important sources of larvae to replenish degraded reefs. Stewardship of local resources is critical for effective implementation of local MPAs and will depend on socio-economic adaptation of local communities to climate change (see issue paper 7 in this series).

**Goal 4. Climate change adaptation measures**: Management practises cannot accelerate the adaption of biological systems to climate change, but they can remove hindrances or barriers that would impede adaptation of coral reef populations. Understanding the links between ecosystem health and biophysical stressors associated with climate change, particularly warming and acidifying oceans, increasing storm damage and rising sea levels, is critical to the development of new management approaches and should be a focus for future research efforts (see issue paper 16 in this series). Development of management strategies to cope with increasingly fragile reef structures and corals that are increasingly vulnerable to bleaching, disease and predator outbreaks will be critical to
the long-term persistence of reef-associated fish and invertebrate stocks. Towards this end, education programs to help affected communities understand current and projected ecosystem changes due to climate change will be essential (see issue paper 16 in this series).

**Goal 5. Improving threatened species status:** The identification of biophysical thresholds for key species that underpin the reef ecosystem, as well as other tropical communities like seagrasses, is a critical knowledge gap that should be addressed with some priority. Coordinated governance arrangements should be developed for migratory species to improve threatened species status.

**What does this mean for MPA network design, management and implementation?**

Climate change impacts on ocean temperature, chemistry and circulation are not readily reversible and MPA networks do not address the underlying physical causes of climate change. However, management strategies can contribute to ameliorating the impacts of physical, climate-related changes by maximising the resilience of reefs to these threats. This can best be achieved through coordinated regional governance of marine resources, including an integrated network of MPAs. Such a network, in conjunction with coordinated management of coastal terrestrial regions, will serve to maintain biodiversity, protect areas of refugia, sustainably manage extractive activities, particularly fishing, and improve water quality through better land-use practices. The biophysical impacts of climate change also raise significant social and economic concerns, including compromised regional food security and decreased alternative livelihood opportunities through activities like ecotourism. Such impacts will significantly influence the degree to which the region’s burgeoning human population can adapt, highlighting the need for an effective MPA network.

**Extent of MPA networks.** It is critical that future management of coral reef systems in CT countries address and alleviate climate and non-climate stressors in partnership. Extension of an MPA network throughout the CT region, in the context of local variations in projected climate change risks, will enhance the resilience of the region as a whole.

**Design of MPA networks.** MPAs cannot protect reefs from climate change, but they can increase their capacity to cope with the effects of climate change. To this end, the design of MPA networks must complement regional efforts at maximising resilience of the whole ecosystem. MPAs should conserve biodiversity especially of key groups, such as herbivores, to maintain the health of coral reefs. Additionally, MPAs should be placed not only in highly visited sites, but also in sites identified as important refugia for fish and coral species, for instance thermal refugia where cooler local conditions protect against mass coral bleaching. The identification and protection of refugia is critical for seeding more heavily impacted reefs, thereby enhancing the resilience of the system as a whole.

**Implementation and management.** Physical stressors resulting from climate change will be exacerbated by anthropogenic use of CT marine resources and reefs, for example: water pollution caused by agricultural, industrial and sewage runoff; overfishing, especially through destructive fishing practices involving cyanide and dynamite; and increased sedimentation and damage to reefs resulting from dredging for commercial developments and shipping access (e.g. Arceo et al. 2002). Hence it is critical that MPA management plans and implementation strategies minimise human-related stressors through the promotion of local
practices that support reef stewardship. Coastal zone management and adaptation programs that provide alternatives to habitat-destroying practices are essential to improve the quality of water flowing onto coral reefs. Ultimately, lobbying countries that are the highest producers of global greenhouse gases to reduce their emissions is the fundamental course of action required to minimise (and potentially reverse) emerging and predicted physical impacts of climate change on coral reef and tropical ecosystems that underpin CT economies.

Background reading


**Some existing datasets**
Lough JM (Australian Institute of Marine Sciences): Analyses of sea surface temperatures in the Coral Triangle

**Some existing projects**
Haapkyla J, Willis BL (ARC CoE for Coral Reef Studies, James Cook University: Coral disease prevalence in the Wakatobi Marine Park, Indonesia)
Figure 1: Observed SST variations for the Coral Triangle, 1950-2007 (data from HadISST) for a) annual average, b) annual maximum, and c) annual minimum SSTs. Dashed line is linear trend; Grey lines are respective means for 1950-1969 and 1988-2007 illustrating the significant warming that has
already occurred. Red lines give SST values for 2020 through 2100 based on projecting the 1950-2007 warming trend.

**Figure 2.** Predicted ocean warming will cause increasingly frequent and more severe thermal stress for reef-associated organisms and corals are especially vulnerable. Widespread mortality of corals will have flow-on effects for fish and invertebrates that are dependent on corals for habitat or as a food source. Ultimately, healthy reefs may undergo transitions to degraded, low diversity reefs: A) healthy reef with abundant fish life; B) bleached staghorn corals; C) severely degraded reef undergoing algal colonisation of dead staghorn corals. Photos courtesy of the Great Barrier Reef Marine Park Authority.

**Figure 3.** Outbreaks of coral diseases, such as the ones shown here, are more likely to occur when summer sea temperatures rise above normal maxima. A) White syndrome causing tissue loss on a plating *Acropora*. B) Black band disease causing tissue loss on a plating *Pachyseris*. Photos by Meir Sussman and Mike Flavell.

**Acknowledgements:** Many thanks to P.M. Alino, R. Beeden, K. Dobbs, P. Marshall and L. Tan for their input.
9. Threat of climate change to fish and fisheries

Morgan S. Pratchett¹, Johann D. Bell², Patrick Lehodey³, Philip L. Munday¹, and Shaun K. Wilson¹

4/11/08

Outline of the issue

Fish and fisheries are fundamental to food security and economic development in the Coral Triangle, and a major goal of the Coral Triangle Initiative (CTI) is to promote long-term sustainable fisheries development. However, impacts of climate change on the key habitats that support fisheries (coral reefs, mangroves, and sea grasses), and the direct effects of climate change on fishes, could derail these plans by reducing local abundance and access to important stocks.

The key threats to CTI fisheries from climate change include:

Changes to the distribution and abundance of tuna. Within the Coral Triangle, increasing water temperature is expected to lead to declines in abundance of skipjack tuna (Katsuwonus pelamis). Recent modeling forecasts that skipjack tuna will be increasingly concentrated in the central Pacific as a result of climate change (Figure 1). If so, this will reduce the number and biomass of skipjack tuna within by CTI waters.

Degradation of coral reefs and declines in coastal fisheries. Rising sea surface temperatures, combined with increasingly severe storms and ocean acidification, are expected to severely damage coral reef habitats. Degraded coral reefs support a lower abundance and diversity of fishes, which compounds existing pressures on fisheries associated with these ecosystems (e.g., over-exploitation) and further reduces the amount of fish that can be sustainably harvested from coastal waters in CTI countries.

FIGURE 1. a) Estimated distribution and abundance of skipjack tuna in the Pacific in 2000; and b) preliminary modeling of skipjack tuna distribution in 2050; based on the study ‘Forecasts of population trends for two species of tuna under an IPCC scenario’ presented by Lehodey et al. at the international symposium “Effects of Climate Change on World’s Oceans”, Gijon, Spain, 19-23 May 2008.

¹ ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville QLD 4811, Australia. Email: Morgan.Pratchett@jcu.edu.au, Ph. +61 7 4781 5747.
² Secretariat for the Pacific Community, BP D5, 98848 Noumea Cedex, New Caledonia.
³ Marine Ecosystems Modeling and Monitoring by Satellites CLS, Satellite Oceanography Division, Toulouse, France
Skipjack tuna (Katsuwonus pelamis)

Relevance to the draft CTI Plan of Action
A major goal (Goal #2) of the draft CTI plan of action is to implement a multi-national, ecosystem-based management policy for major fisheries resources, recognizing the importance of fish and shellfish in sustaining human populations and supporting economic development throughout the region.

Food fishes – In the Coral Triangle, there is great reliance on fish for food, which mainly centered around coastal fisheries. Fish caught in near-shore habitats, including shallow-water coral reef environments, account for a significant proportion of the seafood consumed in the region (Figure 2). The major families of coastal fish used for food vary within and among countries (Table 1), but many of these stocks are facing over-exploitation. Increasing demands from rapidly growing human populations will only increase the pressure on coastal fisheries.

Climate change is projected to compound the existing stresses (such as over-exploitation) on coastal fisheries and further limit their capacity to provide the fish required for food security. In particular, increasing water temperatures and acidification are likely to reduce the area and quality of the coral reefs (Figure 3) that underpin much of the coastal fisheries production. Seagrasses, which also provide nursery and feeding habitats for many species, may also be affected. In addition, higher water temperatures are projected to directly affect the physiology and behaviour of coastal fishes, particularly during their early life history. This may lead to declines in abundance or redistribution of fish within the Coral Triangle.

FIGURE 2. Proportional consumption of fish from different sources for the Solomon Islands, based on national annual per-capita consumption of 7kg of Tuna, 19kg of reef fish, and 6kg of other seafood. Data source: 2007 SPC Statistics and Demography Programme - Household income and expenditure surveys

TABLE 1. Variation in dominant families of coastal fishes caught within representative areas of the CTI. Data source: Russ et al. 2004, and Dalzell et al. 1996

<table>
<thead>
<tr>
<th>Location</th>
<th>Dominant Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phillipines (Apo)</td>
<td>Carangidae (jacks), Acanthuridae (surgeonfish)</td>
</tr>
<tr>
<td>Northern PNG</td>
<td>Mugilidae (mullet)</td>
</tr>
<tr>
<td>Southern PNG</td>
<td>Lethrinidae (emperors)</td>
</tr>
<tr>
<td>Solomon Is.</td>
<td>Lutjanidae (snapper)</td>
</tr>
</tbody>
</table>
FIGURE 3. Healthy coral assemblages (a) are important for sustaining high diversity and abundance of coral reef fishes. Climate-induced coral bleaching (b) leads to structural collapse of the reef habitat (c). The loss of habitat structure provided by intact coral colonies impacts on most reef fishes, including large predatory fishes such as coral trout. Photos: P Marshall (GBRMPA) and SK Wilson

**Commercial fisheries** – In CTI countries, fisheries commodities produced for export are usually based on:
1. Pelagic oceanic fishes (mainly tuna),
2. Invertebrates collected from coastal habitats (sea cucumbers, trochus, spiny lobsters), and
3. Fishes caught over deep-reef slopes and sea mounts.

The potential benefits of tuna are not fully realized by some of the CTI countries, particularly PNG and Solomon Islands, due to the limited capacity of national fleets and infrastructure. Instead, much of the tuna in the western and central Pacific is caught by large purse seine and longline vessels owned by distant water fishing nations (DWFNs), mainly Japan, Taiwan, Korea and USA (Figure 4). The DWFNs typically pay PNG and Solomon Islands around 3-4% of the landed value of the catch in access fees. In 2001, of the total landed value of fish in the entire western and central Pacific was ~US$2 billion and access fees totaled ~US$60 million.

Increased use of pelagic oceanic fish stocks by CTI countries would be expected to reduce demands on coastal resources, spread the risks of over-exploitation, and provide more revenue for local economic development. A key strategy in facilitating increased access to pelagic resources for both smaller-scale commercial enterprises, and subsistence, may be the deployment of low-cost, anchored Fish Aggregating Devices (FADs) in near-shore waters. While the ecological effects of FADs are unknown, it is clear that they provide better access to pelagic fishes in near shore waters.
Climate change could impede plans to increase national benefits from tuna by increasing the percentage of the catch taken by local operators. The projected movement of skipjack tuna to the east, as they follow the water temperatures and prey concentrations that optimize their survival and growth, may jeopardize the long-term profitability of national industrial fishing fleets and canneries developed within the CTI.

What does this mean for MPA network design, management and implementation?

An important step in minimizing future effects of climate change on coastal fisheries is to reduce other direct stresses. This means:-

i) Reducing and redistributing fishing effort through implementation of effective fishing closures and MPAs, gear restrictions, and/or quotas on target stocks. This will require effective localized management measures designed to maintain spawning biomass within sustainable bounds.

ii) Maintaining critical fish habitats by:

- preventing removal of, or physical damage to, the corals, seagrasses, and mangroves that provide the physically complex habitats that support fish and invertebrates; and

- improving water quality by preventing rubbish and pollutants from entering waterways, and minimizing nutrient inputs from land run-off.

Other adaptations
To meet national aspirations to increase the economic benefits from tuna, under the scenario of skipjack tuna moving further east, CTI countries may wish to consider limiting harvests by DWFNs within their Exclusive Economic Zones.

To increase resilience to many of the uncertain effects of climate change on coastal fisheries, countries within the CTI could consider diversifying ways of catching and producing fish, and reducing reliance on highly vulnerable fish stocks. Identifying alternative sources of fish, and innovative ways to meet increasing demands for fish as food (such as low-cost inshore FADs to attract pelagic fish for subsistence and small pond aquaculture), is a critical step in building adaptive capacity to climate change.

Diversification of fisheries will also help sustain those people who rely most heavily on fish as the pressures from population growth and higher fuel costs increase. Vulnerability of coastal communities to the effects of climate change will also be reduced by developing supplies of food, and livelihoods, outside the fisheries sector.

**Relevant projects**

The Secretariat of the Pacific Community (SPC) is coordinating a major project (with funding from AusAID) to assess the impact of climate change on fisheries and aquaculture in the Pacific. This project will identify the potential threats posed by climate change to fisheries and aquaculture in the region, and the adaptations needed to retain the benefits of fisheries as recognized by the Pacific Islands Framework for Action on Climate Change (PIFACC) 2006-2015.

The primary goals of the SPC project are to assess:

- Implications of climate change for national and regional plans to optimize the use of fisheries resources for food security, livelihoods and economic growth.
- Adaptations and management needed to maintain the benefits of fisheries in the face of climate change;
- Regional capacity to forecast and mitigate the effects of climate change on fisheries and aquaculture; and
- Priorities for cost-effective development assistance to address the effects of climate change on fisheries.

The SPC vulnerability assessment is being coordinated by Dr Johann Bell (Email: johannb@spc.int), with significant contributions by many international scientists including the authors of this paper. It’s outcomes may also be of interest to other CT countries.

**Background reading**

*For information about these publications, please contact Dr Morgan Pratchett (Email: morgan.pratchett@jcu.edu.au)*


Secretariat of the Pacific Community (SPC) Policy Briefs 1/2008 (Fish and Food Security) and 5/2008 (Fisheries and climate change)
10. Capacity building for marine resource management including MPAs
Foale, S.¹, Russ, G.R.² Preston, G.³
4/11/08

Outline of the issue
‘Capacity building’ is a term that means a great many things. In the context of marine resource management it can include 1) holding workshops in villages, 2) supporting talented environmental leadership 3) improving capacity through restructuring and reforming fisheries, environment and other relevant departments of national and provincial (or state) departments, 4) teaching locally-relevant fisheries science to school students, 5) funding postgraduate scholarships, 6) drafting ‘enabling legislation’, 7) business management training, 8) supplying boats, equipment, training and operating budgets for monitoring and enforcement. Which of these different approaches warrants funding and support by foreign capital will inevitably vary considerably among locations, and should ideally be based on relevant research on needs and gaps in needs.

The Big International Non-Government Organisations (BINGOs) have in the past devoted substantial funding to village-based workshop-format ‘awareness’ work, and similar work continues to be done by newer organisations such as the Locally Managed Marine Area (LMMA) Network. Reefcheck, LMMA, FSPI and other conservation organisations teach local people various reef resource monitoring methods as part of their MPA programs.

Support and encouragement for local environmental leadership may well turn out to be one of the most fruitful investments in capacity-building, if the achievements of several Papua New Guinea and Solomon Islands local leaders are anything to go by. The fact that many of the region’s inspiring leaders work for the BINGOs and not for government (and that most of these were recruited from government departments) is a form of brain drain that deserves some discussion. An additional problem is that within governments, positions in resource sector departments such as fisheries and forestry are not as prestigious as in others, such as foreign affairs, and talented people are often lost in this way as well. Should fisheries (and forestry) departments be subsidised by aid grants in an effort to help them retain good staff? Given the vastly greater capacity of the BINGOs to adequately remunerate talented personnel, how is the power relationship between BINGOs, large regional organisations and national governments likely to evolve in the context of the CTI? What might be the implications for capacity building and capacity retention within CT countries?

Governance challenges and inefficiency have both been significant problems in PNG and Solomon Islands fisheries departments in the past. The PNG National Fisheries Authority underwent a major restructure in the early 2000s, (a form of institutional capacity building), which transformed the

¹ ARC CoE for Coral Reef Studies, James Cook University; simon.foale@icu.edu.au
² Professor of Marine Biology, Dept of Marine Biology, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University
³ Gillett, Preston and Associates Inc. (http://gillettprestonassociates.com/): gpreston@canl.nc
organisation from one which in 1999 had a net cost to government of about 2.5 million kina per year, to one that, four years later, generated a profit of 44 million kina (the figure for 2007 was 52 million), mainly through improved collection of fishery access revenues  A roughly analogous NZAid-funded process (SIMROS) is underway in the Solomon Islands at present, although the prospects for such large gains are less, due to the smaller size of the Solomon Islands tuna fishery and the resources on which it is based.

One knowledge capacity gap that has been identified in some situations is understanding of processes of stock replacement; it is also one of the key underpinnings (along with governance problems at various levels) of poor fishery management (Foale 2006a,b). Incorporating locally-relevant fishery biology information into the science curricula of upper primary and secondary schools is a long-term strategy that may yield substantial benefits over the medium to long term.

Funding of scholarships for undergraduate and postgraduate students of fishery management and integrated coastal management is likely also to be a productive use of money, particularly for the smaller countries of the CTI.

**What does this mean for achieving the goals of the draft CTI Plan of Action?**

Little is likely to be achieved under the CTI initiative without a critical mass of effective local and national support in each country (e.g. Alcala and Russ 2006). Local support, in turn, depends upon communities and their leaders understanding the importance of an integrated system of marine resource management tools in preventing stock collapse in fisheries and ecosystem degradation on coral reefs. These understandings depend on education as well as adequate governmental capacity at local, regional and national level, as well as convincing demonstrations of the economic and other benefits of any proposed changes to resource exploitation arrangements.

Due to the variety of levels and situations within which capacity may be an issue, we consider development of a menu approach to capacity building to be a useful consideration (coupled with needs/gap analyses):

- **What topics?** (from the natural and social science to the legal to the technical to project and team management)
- **What level?** (primary, secondary, tertiary, alternative?)
- **What delivery mechanism?** (learning-by-doing, workshops, lectures/classrooms, combinations)
- **What duration?** (weeks, months, years)
- **What location?** (in-country, overseas, e.g. Australia)
What does this mean for MPA network design, management and implementation?

A variety of capacity building approaches is more likely to be successful than one. Strengthening science education in schools so that the curriculum includes locally relevant material on fishery biology and marine ecology will at least generate a succession of cohorts of environmentally aware high school graduates within a relatively short time. As these people move out into communities they will inevitably contribute to some increases in conservation by their knowledge of the limits to fisheries, and to stock-recruitment processes and dynamics for economically important species. They will also have a solid understanding of the importance of non-spatial and spatial management tools to maintaining the productivity of these fisheries. However the relationship between knowledge and behaviour can never be assumed to be a linear one, and a range of other factors, such as economic pressures, governance and social cohesion, which also influence choices relating to the sustainable or unsustainable use of fisheries, must also be taken into account.

Sustained financial, training and logistic support should also go to the government fishery departments and agencies of the CT6, and not just to ‘communities’, however these are conceived. Innovative institutional solutions must be found to problems with setting, monitoring and enforcing export commodity fishery regulations, as governments play a key role in management of these fisheries.

Background reading


http://effectivempa.noaa.gov/docs/socio_manual.pdf (14.6Mb)


**Some existing datasets**
The LMMA, which works in Indonesia, Philippines, Papua New Guinea, and Solomon Islands, post reports on their work (which includes various forms of capacity building) here: http://www.lmmanetwork.org/

Reefbase Pacific Education Resources: http://www.reefbase.org/pacific/education.aspx


**Some existing projects**
Foundation of the Peoples of the South Pacific International http://www.fspi.org.fj/

Solomon Islands Marine Resources Organizational Strengthening (SIMROS) project, funded by NZAID from 2006-2009. SIMROS II is due to follow on in 2009. and Solomon Islands Diagnostic Trade Integration Study (DTIS) (need contact here)

LMMA is also an ongoing project (http://www.lmmanetwork.org/)

Mahonia na Dari: http://www.mahonia.org/marineeducation.htm  This is a marine education organisation based in Kimbe Bay, West New Britain, Papua New Guinea.


ReefCheck - http://www.reefcheck.org/

GEF Lessons Learned Project (contact: m.tupper@cgiar.org)

The Philippine Marine Sanctuary Strategy has involved a series of national multisectoral workshops and targets at least 10% of municipal waters by 2020: http://www.upmsi.ph/midas/docs/ting.pdf
11. Objectives and multiple-use zoning for a network of MPAs for the Coral Triangle
PM Alino\(^1\), L Fernandes\(^2\), GR Russ\(^3\), JML Tan\(^4\), JM Tanzer\(^5\)

Draft 5/11/08

Outline of the issue
The draft CTI Plan of Action identifies, as a goal, the development of a fully-functional, region-wide network of marine protected areas (MPA). These terms, network and marine protected area, mean different things to different people. To achieve any objectives, the MPA network needs to be developed against a clear understanding of:

a. What is intended by the term marine protected area and network
b. The objectives of the MPA network
c. The priorities amongst those objectives
d. The available protection levels/zoning options that can be applied in designing the network (see also paper on designing an MPA network).

Within all the discussions presented in this paper, we remain cognisant that even multiple-use, multiple-objective MPAs are but one tool in the marine resource management toolbox (for example, see other background papers on non-spatial management tools, human adaptation to climate change, climate change and fisheries).

Relevance of the issue to the goals of the draft CTI Plan of Action
The Coral Triangle Initiative draft Plan of Action identifies five goals as well as subordinate objectives or strategies that would benefit from a functional network of MPAs including an ecosystem approach to fisheries management, food security, better protection of threatened species, building resilience, including resilience to impacts of climate change, as well the MPA network goal itself. Other considerations for objectives are to do with desirable degrees of representation, resilience, profitability, access to local users and more.

For the purposes of this workshop, an MPA is not just a no-take area. The following is a list of some of the kinds of MPAs that could be used to help achieve across the range of CTI draft Plan of Action goals: no go/no entry areas except for scientific research; no take areas; seasonal closures; other temporal closures; areas with gear restrictions for various reasons (e.g. limiting effort, limiting by-catch, protection of threatened species; protection of habitat); local/traditional use only (e.g.

---
\(^1\) The Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines, pmalino@upmsi.ph
\(^2\) Marine Resource Management Coordinator, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University and the Australian Institute of Marine Science, Townsville, Q. Australia. Ph. +61 (0)7 4725 1824; leannef@earth2ocean.com
\(^3\) Professor of Marine Biology, Dept of Marine Biology, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University
\(^4\) Vice-Chairman, WWF Philippines, lorytan@gmail.com
\(^5\) Coral Triangle Facilitator, Australian Government Department of the Environment, Water, Heritage and the Arts, WWF and The Nature Conservancy, jmtanzer@bidpond.net.au.
LMMAs), tourism only or areas with other kinds of limitations (e.g. prohibiting interference with threatened species). The international standard for categorising protected areas, including marine protected areas, encompasses this range of kinds of protection (see Table below).

<table>
<thead>
<tr>
<th>IUCN Category</th>
<th>Main objective or purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>Strict Nature Reserve</td>
</tr>
<tr>
<td>IB</td>
<td>Wilderness Area</td>
</tr>
<tr>
<td>II</td>
<td>National Park</td>
</tr>
<tr>
<td>III</td>
<td>Natural Monument</td>
</tr>
<tr>
<td>IV</td>
<td>Habitat/Species Management Area</td>
</tr>
<tr>
<td>V</td>
<td>Protected Landscape/Seascape</td>
</tr>
<tr>
<td>VI</td>
<td>Managed Resource Protected Area</td>
</tr>
</tbody>
</table>

In some countries, various multisectoral consultations have agreed on a common basis of definition of terminology with the term Marine Protected Area (MPA) as a generic term of protective management (White et al. 2006, Miclat et al. 2004).

An alternative way of considering both the different kinds of categories of protection and marine protected areas is to have very large MPAs within which there is different levels of protection – otherwise known as multiple-use zoning. Within such an MPA, no-take areas or no-take zones comprise just part of the overall MPA. The Great Barrier Reef Marine Park is an example of this. Within the CT region there are also examples of multiple use zoning within marine protected area boundaries but under the banner of Integrated Coastal Management [ICM]. In the Philippines, for example, there is the Sustainable Philippine Archipelagic Development Strategy which was one impetus for the formulation of the IRR of the Executive Order 533 on the ICM in the Philippines.
Previous work suggests that no-take areas can be an effective, if not sufficient, part of the solution to issues of over-fishing. The figure below shows the positive impact of no-take areas upon fish stocks inside the protected areas, and data showing that fish catch has been maintained or increased outside the protected areas.

Figure: Changes in biomass within reserves and catch outside reserves in the Philippines (Alcala & Russ 2006)

A network of marine protected areas, as distinct from lots of separate MPAs, can be defined as comprising areas that are ecologically connected and possess a self-replenishing function (see also paper #10 on connectivity).

With this definition of what an MPA network comprises, explicit identification of clear MPA network objectives against the CTI draft Plan of Action goals will enable better design of the network to help achieve these goals. MPAs with purely fisheries objectives could be designed quite differently to MPAs whose objectives are only to do with protection of threatened species or overall biodiversity protection, and so on. The MPA network to support the CTI draft Plan of Action will require multiple objectives. Defining those objectives clearly can then enable MPA network design efforts to focus on achieving those multiple objectives.
Objectives to consider for the CTI MPA network should be defined with consideration of the draft Plan of Action and could address:

- Enhanced protection of fisheries resources
- Enhanced protection of threatened species
- Enhanced protection of species, habitats and natural processes
- Provision of a safety margin against human and natural disturbances including climate change
- Maximising positive and minimise negative impacts upon human uses and values

Any network of MPAs will assist with dealing with threats and impacts but not suffice in isolation. A network of MPAs will provide a potentially significant level of effective resource management but must be developed and implemented as one of a suite of management measures aimed at ensuring protection and sustainable use.¹

**What is the relevance of this issue with regard to an MPA network in the CT?**

In the design of an MPA network with multiple objectives, there may be design decisions whereby one design favours objective A over objective B. For these reasons, it is important that the relative priority of the multiple objectives is explicit. Then decision-makers can align the MPA network design against the most important MPA objectives.

A next step might be, against each of the prioritised MPA objectives, identify the types of protection that might be most useful. For example:

- Enhanced protection of fisheries resources: no take areas, limited fishing areas, controls on destructive fishing, seasonal closures
- Enhanced protection of threatened species: limits on practiced that are destructive to threatened species and their habitats (this may include no-take areas)
- Enhanced protection of species, habitats and natural processes: no take areas, areas with limited fishing controls on those aspects of fishing that are destructive to other species, habitats and natural processes
- Provision of a safety margin against human and natural disturbances: this may mean more of the above or additional lower level protection both as “insurance”, and
- Maximising positive and minimising negative impacts upon human uses and values: no-take areas, limited fishing areas, controls on destructive fishing, seasonal and/or other temporal closures, zones that separate conflicting uses.

¹ See [http://www.cbd.int/decisions/?dec=VII/28](http://www.cbd.int/decisions/?dec=VII/28)
Given the multiple-use nature of MPAs being discussed here, the overall boundary of the entire suite of MPAs could be set quite broadly, in geographic terms. That is, do the countries wish to consider the MPA network as:

a) A large set of interlinked areas which have a variety of types of protection within them or

b) One (or several) large area(s) within which there is multiple-use zoning.

Within each of these options, the Jakarta draft Plan of Action refers to the need for a minimum amount of non-extractive areas that are ecologically linked. For the CTI, peace parks and transboundary networks of various kinds can be used to help build confidence in working together and thus are crucial in dealing with the many governance challenges.

**Background reading**


http://groups.google.com/group/wcpamarine-summit/web/preparing-for-the-iucn-categories-summit (see also Draft Guidelines in toolbar on the right)

Miclat, E. and Ingles J. 2004. Standardized Terms and Definitions for use in Marine Protected Area (MPA) Management in the Philippines. In: Third National Workshop on the Formulation of the PhilMARAST. (contact: pmalino@upmsi.ph)


**Existing projects**


PALNet is a knowledge sharing platform for people working on protected areas.
http://www.parksnet.org/

*Acknowledgements to: Jon Day and Hugh Possingham for input.*
12. Connectivity and the design of marine protected area networks in the Coral Triangle

Jones G.P.¹, Ablan Lagman M.C.², Alcala A.C.³, Almany G.R.⁴, Botsford, L.W.⁵, Doherty P.J.⁶,Green A.⁶, McCook L.J.⁷, Munday P.L.¹, Planes S.⁸, Russ, G.R.¹, Sale P.F.⁹, Steneck R.S.¹⁰, Thorrold S.R.¹¹, Treml E.A.¹², van Oppen M.J.H.⁵ and Willis B.L.¹

5/11/08

Outline of the issue

Connectivity usually refers to linkages between populations of marine plants and animals in different places. More technically it is “the demographic linking of local populations through the exchange of individuals among them as larvae, juveniles or adults” (Sale et al. 2005). The term is loosely used as an umbrella term which includes the full range from no connectivity (where all populations are effectively isolated = closed populations) to high connectivity (where most of the recruitment occurs through dispersal among populations = open populations). Many coral reef organisms, including broadcast spawning corals and most reef fishes, do not move between distant locations as adults, but have a pelagic larval phase that can potentially travel vast distances. However, until recently, we had little knowledge of how far larvae actually go. The extent of connectivity can have important implications that determine the natural processes that limit growth of populations, their resilience to natural and human-induced disturbance, and the appropriate scale of management.

Larval connectivity is receiving more scientific attention due to a global increase in coral reef marine protected area (MPA) networks (Mora et al. 2006; Wood et al. 2008). No-take marine protected area networks have been widely advocated and embraced as one of the means to manage reef-fisheries and conserve coral reef biodiversity. MPA networks appear to be particularly applicable to

¹ School of Marine and Tropical Biology, and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, 4811, Queensland, Australia.
² Biology Department, De La Salle University Manila, 2401 Taft Avenue, Manila, Philippines 1004
³ Silliman University - Angelo King Center for Research and Environmental Management (SUAKREM)
        Dumatugue City, Negros Oriental 6200 Philippines
⁴ 1Dept. of Wildlife, Fish, and Conservation Biology, University of California, Davis, One Shields Ave
       Davis, CA 95616
⁵ Australian Institute of Marine Science, PMB 3, Townsville QLD 4810, Australia
⁶ The Nature Conservancy, 57 Edmonstone St, South Brisbane, Qld, 4101, Australia
⁷ Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, Qld 4810, Australia
⁸ Centre de Biologie et d’Ecologie Tropicale et Méditerranéenne, Université de Perpignan, 52 Av. Paul Alduy -
        66860 Perpignan CEDEX, France
⁹ United Nations University, 175 Longwood Road South, Hamilton On, L8P 0A1, Canada
¹⁰ School of Marine Sciences, University of Maine, Darling Marine Center, 193 Clarks Cove Road,
        Walpole, Maine 04573, USA
¹¹ Biology Department MS # 50, Woods Hole Oceanographic Institution, Woods Hole, MA 0254, USA
        , Ph.D.
¹² World Wildlife Fund Fuller Fellow, School of Integrative Biology, 121 Goddard Building
        University of Queensland, St. Lucia, QLD 4072 Australia
managing the community-scale fisheries of developing countries that depend on reef resources (Alcala and Russ 2006) and for the conservation of highly diverse and fragmented habitats, where species level management is not practical (Jones et al. 2007). Increases in the abundance and biomass of exploited fishes within MPA boundaries are well-known. However, it is also clear that MPA networks alone cannot protect non-exploited species from external threats such as coastal pollution and climate change (e.g. Jones et al. 2004). Hence, MPA networks need to be integrated with a range of different approaches to protecting coral reef biodiversity in the Coral Triangle (CT).

While much is known about the benefits of no-take coral reef areas to populations within their boundaries, there are many questions that relate to the extent of population self-replenishment and connectivity. *Are populations within individual no-take areas self-sustaining and therefore effectively protected? Do no-take areas export larvae and provide recruitment subsidies to all reefs beyond their boundaries? And is there significant larval exchange among protected populations that could enhance the resilience of the overall network? How is population resilience in MPA networks influenced by human impacts on coral reef health?* Scientists are still searching for the answers to all of these questions and some of their work is already being carried out in the countries of the CT (e.g. Jones et al. 2005, Almany et al. 2007, Treml et al. 2008). Recent progress is helping us understand how existing marine protected area networks operate, and how MPA networks can be designed in the future to achieve particular management goals. A series of six papers in a special theme section in the journal “Coral Reefs” to be published in 2009, provide an up-to-date summary of the current knowledge of connectivity in coral reef environments (see Almany et al. 2009, Botsford et al. 2009, Jones et al. 2009, McCook et al. 2009, Munday et al. 2009, Steneck et al. 2009).

**What does this mean for achieving the goals of the draft CTI Plan of Action?**

Knowledge of coral reef connectivity is critical to the following goals listed in the draft management plan.

- **Priority seascapes:** High conservation priority should be given to places that are important sources of larvae and isolated places that are reliant on self-replenishment.

- **Ecosystem approach to management of fisheries and other marine resources:** Appropriately sized and spaced MPAs are one critical element of ecosystem management. However, MPA design requires knowledge of linkages among MPAs, linkages between MPAs and fished areas, and linkages between MPAs and adjacent ecosystems. MPA networks alone are not sufficient by themselves as fishery management tools.

- **Marine Protected Area networks (MPAs):** Connectivity is a critical aspect of network design, relevant to the optimal size, number, spacing and placing of no-take areas.

- **Improving threatened species status:** Knowledge of larval and adult movements is critical for determining the size of MPAs designed to act as sanctuaries for threatened species.
To achieve this knowledge, a significant increase in the level of scientific research in the CT region will be required. The CT coral reefs are diverse and complex ecosystems, and to fully understand connectivity, we need information on more species at more places and at more times. No single approach to studying connectivity will provide all the answers. We recommend the support of collaborative projects that can apply a range of different approaches, including biophysical modelling, genetics, and adult and larval tagging. These projects will be most successful if they incorporate in-country expertise, local communities and knowledge into the scientific process.

**What does this mean for MPA network design, management and implementation?**

We propose **10 guidelines** for MPA network design to maximise the benefits of no-take MPAs for sustainable harvesting and biodiversity conservation, based on current knowledge and expert opinion concerning larval retention, connectivity and population resilience. Note that while each recommendation should be viewed as an ultimate goal, significant benefits can be achieved by setting interim targets. Also, it is not necessary to address all 10 guidelines at once to achieve significant benefits. We stress that knowledge of CT coral reef connectivity is incomplete and scientific opinion varies. These guidelines will be subject to change as new information is obtained.

1. **Aim for ~30% of total reef area in no-take MPAs.** This should ensure adequate protection of spawning stocks inside MPAs, sufficient % retention of larvae for persistence within MPAs, and sufficient larval export to supplement adjacent fished areas and other MPAs. Approach this goal by setting interim targets and evaluate the benefits.

2. **Manage large exploited species outside MPAs.** Traditional catch quotas, size limits and gear restrictions are necessary because larval subsidies from MPAs to all fished areas cannot be guaranteed. Gear restrictions are necessary to reduce impacts, for example, on by-catch of threatened species outside MPAs.

3. **Establish representative MPAs in different “bioregions”**. Connectivity among “bioregions” (biologically and physically distinct areas) is expected to be low. Therefore, each bioregion must be partially represented in MPA networks to sustain biodiversity.

4. **Establish many MPAs rather than 1 large MPA in each “bioregion”**. One large MPA cannot provide recruitment subsidies to all fished areas. Several MPAs minimises the risk of any one disturbance affecting all reef in MPAs. A large number of smaller MPAs is also far more practical, since local communities are more likely to accept such a design.

5. **Deliberately vary the size of individual MPAs.** This will take account of natural variation in population sizes and dispersal distances within and among species, so as both larval retention within MPAs, and larval dispersal from MPAs into fished areas can be achieved. There has been no MPA that has been too small to provide some benefits within boundaries. However, small MPAs may not adequately protect large mobile animals.
(6) Deliberately vary the spacing between MPAs. This will take account of natural variation in dispersal distances within and among species, contributing to both connectivity among MPAs and dispersal into fished areas.

(7) Priority sites for MPAs: (a) Remote locations > 20km from nearest other reef habitat, especially off-shore islands. (b) Unique places with distinctive assemblages of animals or plants. (c) Sites frequently used by threatened species and/or hotspots for endemic species. (d) Larval sources and up-stream sites with unusually high currents. (e) Sites known to be resilient to bleaching and other disturbances.

(8) Match scale of MPA networks to the scale of human communities. Larval retention should be sufficient for local communities to benefit directly from their own MPAs, which will encourage compliance and expansion of MPA networks. Ensure local communities involved with MPA decision making and enforcement.

(9) Evaluate MPA effectiveness for fished species and biodiversity. Quantitative monitoring of coral cover, fish and invertebrate abundance (inside and outside MPAs) and catch (outside MPAs) is essential to assess whether MPAs are achieving their goals, and as a basis for adaptive management. Where possible, link implementation of MPA networks with connectivity research.

(10) Link coastal MPA design with coastal terrestrial reserves and land management. MPAs will be ineffective in protecting marine biodiversity where coral reefs are being degraded from coastal pollution, sedimentation and other external influences.

**Background reading**


Some existing projects

(1) Joint ARC Centre of Excellence (JCU) and The Nature Conservancy (Brisbane) project in Kimbe Bay (PNG), including the design of an MPA network in relation to patterns of larval connectivity (Contact G. Jones geoffrey.jones@jcu.edu.au or A. Green agreen@tnc.org)

(2) Joint ARC Centre of Excellence (JCU) and The Nature Conservancy (Brisbane) project at Manus Island (PNG) funded by US-based National Fish and Wildlife Foundation. This project uses barium-marking methodology to tag the larvae at spawning aggregation sites. (Contact G. Almany glenn.almany@jcu.edu.au or R. Hamilton rhamilton@tnc.org)
(3) Woods Hole Oceanographic Institute, Packard Foundation funded project on direct estimates of connectivity in PNG using larval marking and genetic analyses. (Contact S. Thorrold sthorrold@whoi.edu)

(4) ARC Centre of Excellence (JCU) and SUAKCREM project in the Bohal Sea, Philippines, including the design of an MPA network in relation to patterns of larval connectivity (Contact G. Russ garry.russ@jcu.edu.au)

(5) World Wildlife Fuller Fellowship project focusing Regional Marine Conservation: Merging seascape genetics and biophysical modeling within a graph-theoretic framework. (Contact E Treml e.treml@uq.edu.au)

(6) ARC Discovery Grant to E. Treml, H. Possingham & C. Riginos: Coral reef connectivity: an empirical and theoretical synthesis. (Contact E Treml e.treml@uq.edu.au)

(7) PIRE-NSF Grant to E. Treml, K. Carpenter, P. Barber, P. Halpin: Origins of High Marine Biodiversity in the Indo-Malay-Philippine Archipelago: Transforming a Biodiversity Hotspot into a Research and Education Hotspot (Contact E Treml e.treml@uq.edu.au)
13. Incorporating information about marine species of conservation concern and their habitats into a network of MPAs for the Coral Triangle region

Mark Hamann¹, Michelle Heupel², Vimoksalehi Lukoschek², Helene Marsh¹ (alphabetical order). ¹School of Earth and Environmental Sciences, James Cook University Townsville, 4811, Australia; ²Dept. Ecology and Evolutionary Biology, University of California, Irvine, Irvine, CA, 92697, USA.

5/11/08

Email contacts: mark.hamann@jcu.edu.au, michelle.heupel@jcu.edu.au, vlukosch@uci.edu, helene.marsh@jcu.edu.au

Outline of the issue

Introduction:

The conservation status of a species is an indicator of the likelihood of that species continuing to exist either now or in the near future. The IUCN Red List of Threatened Species produced by the Species Survival Commission (SSC) of the International Union of the Conservation of Nature (IUCN) is the best-known worldwide conservation status listing and ranking system. The IUCN Red List System lists the status of species at a global scale. Species are classified as threatened if they are listed as ‘Critically Endangered’, ‘Endangered’ or ‘Vulnerable’ by the IUCN or a similar system operating at a national scale. However, the information about many species occurring in the Coral Triangle is insufficient for their conservation status to be assessed. Such species are typically classified as ‘Data Deficient’. A ‘Data Deficient’ categorisation does not mean that the species is not threatened, but indicates that more research is needed for its status to be determined. The Global Marine Species Assessment, which began in late 2005, is the first global review of the threat of extinction for every marine vertebrate species, plants and selected invertebrates. The project involves a range of partners in compiling and analyzing all existing data on approximately 20,000 marine species, and will determine the risk of extinction according to the IUCN Red List Categories and Criteria.

The term ‘species of conservation concern’ is more inclusive than the term ‘threatened species’ because it includes ‘Data Deficient’ species. In this briefing, we have concentrated on four groups of species of conservation concern: sharks and rays, sea snakes, marine turtles, and marine mammals.

These species have similar characteristics that need to be recognised for management, including their:
- high social, cultural and economic values
- vulnerability not only to short-term or acute impacts, but also to cumulative or chronic impacts;
- high levels of mobility, requiring management efforts to be mounted at local, State, national, and international levels to ensure protection throughout their ranges;
- slow rate of natural increase so that recovery is slow and increases in numbers take many decades to detect.
These characteristics increase the management challenge because it will be difficult to determine whether the Goal of the Coral Triangle Initiative ‘Threatened species status improved’ is being achieved in a management timeframe. In addition, there is considerable controversy about the effectiveness of using high profile species of conservation concern as a basis for designing marine protected areas. Nonetheless, because of their high social values they can be useful flagship species for the Initiative. In addition, marine protected areas are increasingly used as a tool to conserve marine megafauna especially the groups considered here.

**Biodiversity significance within the Coral Triangle (CT) of marine species of conservation concern:**

*Sharks and Rays*
The Coral Triangle supports hundreds of species of sharks and rays and is an important global centre of endemism and a hotspot of shark and ray diversity. The fauna includes several iconic species including manta rays, whale sharks and reef sharks (grey reef, blacktip reef, whitetip reef). The life history strategies of sharks and rays makes them vulnerable to over-exploitation. In addition, many of the species that are harvested in artisanal and commercial fisheries are poorly known or studied; some species have yet to be formally described. This lack of data combined with limited fisheries management renders these populations highly susceptible to over-exploitation and possible extinction.

*Sea Snakes*
Sea snakes occur exclusively in the Indo-West Pacific region. The Coral Triangle supports the highest sea snake species diversity in the world. Over two-thirds of the world’s ~90 sea snake species occur in the region including all four major evolutionary sea snake lineages, each the result of an independent invasion of the marine environment. All sea snake species rely on shallow-water, near-shore habitats including coral reefs, inter-reefal rocky and soft sediment habitats, mangroves and estuaries, making them vulnerable to habitat loss and destruction. Very few studies have been conducted on sea snakes, and most published work has taken place in Australia. These studies indicate two important factors of conservation concern: (1) sea snake abundances has declined significantly at two locations where long-term surveys have been conducted: Ashmore Reef Region in the Timor Sea and the Swain Reefs in the southern Great Barrier Reef; (2) sea snake populations tend to be highly aggregated. Recent genetic studies indicate limited genetic connectivity (dispersal) among populations, suggesting that local populations will not easily recolonize if they become extinct. In February 2009, all sea snake species will be assessed for their threat of extinction for the first time under IUCN Red List Criteria. It is anticipated that some Australian endemic species will be listed as threatened and that many species that occur in the Coral Triangle will be listed as Data Deficient.

*Marine Turtles*
The Coral Triangle contains globally significant nesting, foraging, migration and courtship areas for four of the world’s seven species of sea turtles: green, hawksbill, leatherback, olive ridley turtles and marginal foraging area for two other species: the flatback and loggerhead turtles. The region also encompasses >90% of nesting habitat for the PNG/Indonesia/Solomons leatherback population. At least five distinct populations of green turtles have 100% of their rookeries in the Coral Triangle, along with several minor rookeries that have not been sampled for genetics. Hawksbill and olive ridley nesting also occurs in the region. Migration paths for sea turtles through the Coral Triangle area are well documented for each of the turtle species nesting in the region. Nesting populations of green turtles in the region have declined by over 80% in some areas. Similarly, nesting hawksbill populations have declined by as much as 90% in areas such as Indonesia and the Solomon Islands. No data exists on foraging turtles in the CT and hence population characteristics such as sex ratios, growth and survivorship are not known. There is still much data lacking on population trends throughout the region for all species. The current global population status according the IUCN Red List follows:
Green turtles – Endangered
Hawksbill turtles – Critically Endangered
Olive Ridley turtles – Vulnerable
Leatherback turtles – Endangered

Marine Mammals
The Coral Triangle supports a diverse marine mammal fauna; more than 30 species of marine mammals spend at least parts of their lives in the region. Almost all of these animals are members of the order Cetacea—whales and dolphins. The cetacean fauna includes at least six species of great whales: blue, Bryde’s, fin, humpback, minke and sperm and more than 20 species of oceanic and coastal dolphins and small whales. The region also supports populations of one member of the order Sirenia (sea cows), the dugong, *Dugong dugon*. It is likely that some of the coastal species of marine mammals that occur in the Coral Triangle are genetically distinct from populations in other regions. There may also be different genetic stocks on either side of the Timor Trench. e.g. the Irrawaddy dolphin occurs in Indonesian waters of the Coral Triangle while a sister species, the Australian snubfin dolphin occurs in Australian waters and possibly those of Papua New Guinea and the Solomon Islands; the stocks of dugongs that occur in Australian waters are genetically distinct from those that occur in Indonesian waters. The marine mammals of greatest conservation concern in the Coral Triangle are the coastal species, many of which are listed by the IUCN as ‘Data Deficient’. Some other species are listed as threatened e.g. the Malampaya Sound ‘subpopulation’ of the Irrawaddy dolphin is now officially assessed and listed as Critically Endangered by the IUCN; the dugong is listed as ‘Vulnerable’ by the IUCN at a global scale.

Threats to marine species of conservation concern in Coral Triangle region:
The species groups of conservation concern considered here are subject to similar threats including:
- Direct harvest
- Fisheries bycatch
- Habitat loss/destruction
- Climate Change
- Lack of sufficient data regarding their taxonomic identity and population status.

In addition, the following are threats specifically for sea kraits (a type of sea snake) and marine turtles because they have to come on land to lay eggs:
- Direct harvest of adults on nesting beaches (legal/illegal)
- Direct harvest of eggs
- Predation of eggs by both native and introduced species

What does this mean for achieving the goals of the draft CTI Plan of Action?
Goal 5 of the draft CTI Plan of Action states that targeted threatened species are no longer declining, and by a certain date, their status is no longer threatened. The first step towards achieving this goal should be to complete assessments to ascertain which species are present in the region and require protection. This could involve a compilation of all the most up-to-date information to:
- Document the distribution and abundance of populations and species in the region;
- Identify key locations or habitats that require protection;
- Document the roles of the species, especially the top predators such as sharks and odontocete cetaceans, in the ecosystem and evaluate the ecosystem consequences of the depletion of their stocks on local production;
- Evaluate the nature of the different threats and their impacts on different species and populations;
• Develop strong legislative, policy, and regulatory frameworks for EAFM (Ecosystem Approach to Fisheries Management)
• Establish a fully functioning region-wide Coral Triangle MPA Network (CTMPAN);
• Complete and implement an Early Action Climate Adaptation Plan for near-shore marine and coastal environments;
• Develop conservation plans for the various species of conservation concern;
• Embed these conservation plans for megafauna into an ecosystem management plan.

It should be noted that because of the longevity of marine reptiles, marine mammals and sharks/rays, the ability to assess their status as ‘no longer threatened’ can take many decades so indicators of recovery may need to be developed to ensure populations are recovering to the desired goal.

What does this mean for MPA network design, management and implementation?

Several important lessons were learned during the recent process which established an ecosystem wide system of no-take marine protected areas in the Great Barrier Reef Marine Park.

(1) The use of the best available science to inform decisions and identify areas important to species is crucial.
(2) A close working relationship between managers working in different jurisdictions is essential to identify priority nesting/breeding/foraging/migratory areas to ensure complementary zoning arrangements are put in place. This approach requires open communication and a trusting relationship between jurisdictions and across regions.
(3) Community acceptance of the value of protecting the habitats of threatened species is a key aspect of successful zoning. A prioritized list of sites based on the best available scientific information will help the community to understand that not all locations are equal and hence greater protection is required in certain areas.
(4) A balance must be sought between social and economic values held by stakeholders within the zoning region. This balance will be particularly important in the Coral Triangle because of the issues of food security.

It will not be feasible to protect the entire distribution of large, wide-ranging species of conservation concern in the Coral Triangle, but identification and protection of multiple sites, each of which consistently supports relatively high densities of the target species may provide ‘safe havens’ for these populations. It will be most effective to try to protect animals at a point in their life when they are highly vulnerable. Most of the species of conservation concern considered here are most vulnerable to adult mortality. It is also important to provide protection during periods when large numbers of individuals are present and easily targeted by fishers e.g. breeding aggregations. The designation of closure areas should be based on available data from the Coral Triangle region and from studies of the same or similar species in other regions. Protected areas should include multiple habitat types (e.g. inshore mangrove areas, seagrass beds, coral reef, nesting beaches etc) to ensure as many populations/life stages benefit as possible. Regions should be as large as possible to allow for movement of larger individuals, but should be placed in areas where enforcement is possible/probable to ensure their protection. Grech and Marsh (2008) developed a rapid approach to assess the risk to species of conservation concern in a region and evaluate options to ameliorate that risk. This approach relies on expert opinion and is a useful tool in data poor environments such as the Coral Triangle.

While MPAs are integral to species conservation, they are but one tool in the toolbox. Management actions should not rely solely upon highly protected areas for conserving species of conservation concern. The range of human-related mortality factors directly and indirectly affecting threatened species must be considered and appropriate actions undertaken to minimize these specific impacts.
upon depleted populations. For example, as Foale et al. (this volume) have pointed out given ‘the
vulnerability of the shark fishery it may be wiser to consider some kinds of moratoria until more
reliable fishery monitoring and management regimes can be developed and implemented. Moratoria
have already been applied to commodity fisheries in Solomon Islands, Vanuatu, and Tonga in
response to severe over-fishing’.

**Background reading**

**General**

Global Marine Species Assessment http://sci.odu.edu/gmsa/

IUCN Red List of Threatened Species http://www.iucnredlist.org/

**Sharks/rays**


**Sea Snakes**


**Marine Turtles**


**Marine Mammals**


Some existing datasets

Sharks/rays
The most informed individual to contact regarding shark issues is Dr. William White at CSIRO in Hobart. ([William.White@csiro.au](mailto:William.White@csiro.au)) There are few or no data sets for most species.

Sea Snakes
There are currently no existing datasets that will be directly relevant to designing a network of MPAs in the CT region. The 2009 IUCN Red List assessment of sea snakes will produce the most up-to-date and complete dataset on the status of sea snakes in the CTI region (Dr Suzanne Livingstone, SRLiving@odu.edu).

Marine Turtles
- SEAFDEC Marine turtle database for Philippines, Indonesia & Malaysia
- IOSEA & CMS IMAPS database of nesting sites and migration paths
- Malaysian state fisheries agencies (Sabah) turtle tagging database
- Philippines Government’s turtle tagging database
- Indonesia Government department’s turtle tagging database
(Contact: mark.hamann@jcu.edu.au)

Marine Mammals
Marsh et al. (2002) and Perrin et al.(2005) provide useful if rather dated overviews of the information available for coastal species of marine mammals. For more information contact: helene.marsh@jcu.edu.au

Some existing projects

Sea Snakes
There are several existing projects that are relevant to sea snakes and MPAs in the CTI. An IUCN workshop in Brisbane 2009 will assess extinction risk of all sea snake species against Red List Criteria. V. Lukoschek, A. Lane and K. Sanders are three of a team of advising sea snake experts. Contacts: SRLiving@odu.edu

Marine Turtles
Considerable work is being undertaken in the Coral Triangle and globally looking at many of the issues. Where projects are complete and outputs, results and lessons learned are available in references and datasets they have been referenced in the above sections on “Background reading” or
“Datasets”. Some projects are ongoing and the deliverables are not easily accessible and could be pursued via websites, personal contacts etc.. For example a SEAFDEC funded/coordinated project is investigating the genetic population structure for hawksbill turtles and completion of the green turtle genetic projects (some of which are relevant to the Coral Triangle region). Results should be available in late 2008/early 2009. A ‘Memorandum of Understanding on the Conservation and Management of Marine Turtles and their habitats in the Indian Ocean and South-East Asia’ has been signed under the convention on Migratory Species. A dedicated secretariat that has been established to coordinate activities under the MoU can be contacted by emailing iosea@un.org.

Marine Mammals
There is considerable work being undertaken in the Coral Triangle and globally considering many of the issues relevant to this initiative. There are many ongoing projects and Action Plans are being developed e.g. Action Plan for Dugong Conservation in Indonesia being coordinated by Hans de Jongh (DeLongh@imap.aol.com). The Ocean Park Conservation Foundation in Hong Kong funds many of these projects and could potentially provide a useful overview. A ‘Memorandum of Understanding on the Conservation and Management of Dugongs (Dugong dugon) and their habitats throughout their Range’ has been signed under the convention on Migratory Species. A dedicated Secretariat has yet to be established. Contact should be made by emailing iosea@un.org.

Acknowledgments
The assistance of Kristen Weiss and the input from Porfirio M. Alino, Kirstin Dobbs, and Lory Tan is gratefully acknowledged.
14. Designing a network of MPAs for the Coral Triangle

PM Alino1, L Fernandes2, E Game3, A Green4, H Possingham5, B Pressey6, JMLTan7

5/11/05

Outline of the issue

To develop a fully functional, region-wide network of marine protected areas that are comprehensive, adequate, ecologically representative and designed to address the threat of climate change, as desired in the draft CTI Plan of Action, the first step is to develop concrete design principles (sometime called “operational” principles). These principles could include a set of biophysical design principles and a set of socio-economic, cultural and management feasibility design principles. They can be best developed against a clear understanding of:

e. The objectives of your MPA network
f. The priorities amongst those objectives
g. The available protection levels/zoning options that can be applied in designing the network.

Another paper (11) has discussed issues around MPA network objectives, priorities and zoning options and provides one important basis for this paper. Many of the other papers have discussed issues that need to be addressed in developing operational principles.

While much literature and advice abounds in general terms for MPA design, there is less on MPA networks and less that is concrete in terms of how much, how far, how many, how big and where (in terms of biodiversity, habitats, uses etc). Furthermore most of these issues concerns trade-offs, for example the optimal ecological size of a marine reserve system may not be consistent with other socio-economic objectives. But even for data poor situations, some more concrete guidelines and case studies have recently become are available (see Background Reading section).

Protected areas should also be designed to accommodate future natural and human-induced disturbances. Main responses to threats and disturbances include:

---

1 The Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines. pmalino@upmsi.ph
2 Marine Resource Management Coordinator, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University and the Australian Institute of Marine Science, Townsville, Q, Australia. Ph. +61 (0)7 4725 1824; leannef@earth2ocean.com
3 Conservation Planning Specialist, The Nature Conservancy, egame@tnc.org
4 Senior Scientist, Tropical Marine Conservation Program, Asia Pacific Region, The Nature Conservancy, 51 Edmondstone St, South Brisbane, Q, 4101 agreeen@tnc.org
5 Director, Applied Environmental Decision Analysis, University of Queensland, Brisbane, Q, Ph. +61 (0)7 3365 9766; h.possingham@uq.edu.au
6 Program Leader, Conservation Planning for a Sustainable Future, Australian Research Council Centre of Excellence in Coral Reef Studies, James Cook University, Q, +61 (0)7 4781 6194, bob.pressey@jcu.edu.au
7 Vice-Chairman, WWF Philippines, lorytan@gmail.com
• larger targets for protection if occurrences of the resource are unlikely to be retained outside the protected area, that is, build in an insurance factor (Alison et al. 2003; Game et al. 2008a, 2008b); 
• all else being equal, choose areas less exposed to the threat(s); and 
• prioritise (in time) protection highly irreplaceable and/or highly threatened resources or features.

The design principles will be most useful if they are quantitative so that, when applied, they provide specific guidelines for designing an MPA network and for measuring success of the network against the design principles.

Relevance of the issue to the goals of the CTI Plan of Action

MPA network objectives and design principles must be explicit. By being explicit, the MPA network can support achievement across the CTI draft Plan of Action goals and develop clearer measures of achievement.

Explicitness has several advantages: makes it clear what planners and managers are aiming for; allows people to estimate the requirements for achieving objectives (including socio-economic benefits and costs); allows individual areas to be identified that function as parts of a coherent, integrated regional system; allows progress towards objectives to be measured. Explicit objectives can be achieved for minimum cost using a suite of mathematical tools, from the complex to a simple spreadsheet.

The MPA network can help: to sustain fisheries; improve food security; build resilience against climate change; protect threatened species; with applying a seascapes approach as well as contribute to biodiversity protection. Determining the relative priority of these types of objectives will inform any MPA network design.

Relevance of the issue with regard to an MPA network in the CT

The MPA network component of the draft Action Plan already identifies that certain percentages of areas must be set aside; what those percentages are is not yet defined. Nor are other design principles about how big, how far apart and so on.

There are information gaps regarding the plants, animals and habitats of the Coral Triangle, therefore any MPA network should attempt to represent examples of what is not known as well as what is known. To enable an MPA network to represent both what is and isn’t known in the Coral Triangle then, it could be agreed that it is necessary to identify biologically distinct areas that can be used as the basis for designing the network. Much of this can be achieved using existing biophysical data as a surrogate (see also paper number 5 on dealing with insufficient data). This would then allow for a comprehensive description of the biodiversity of an area in the absence of complete knowledge. Some examples have already been developed for the Coral Triangle (for example see Figure below).
What descriptions of biologically distinct areas have already been developed and which should the MPA network be built upon, while still ensuring the design principles are adequate to insure against imperfections in the description of biodiversity that is used. Ideally the principles should be able to cope with what is know (e.g. regarding connectivity) and with uncertainty about the ecosystem and how it may respond to future threats (e.g. potential habitat shifts in response to climate change). The principles should also address the multitude of socio-economic values and uses including environmental governance regimes and more. The principles should aim to ensure comprehensive and representative examples of the entire range of biological diversity in the CT are included within the MPA network despite data gaps. Any principles developed will be a best guess: there is not perfect information to ensure a perfect set of principles.

Concrete design principles, developed with consideration of the MPA network objectives, could answer the following questions.

A. For designing the no-take component of the MPA network:

**BIOPHYSICAL OPERATIONAL DESIGN PRINCIPLES**

i. What minimum amount (%) of protection should occur for each biologically distinct area?

ii. What level of replication should occur for each biologically distinct area?

iii. Where habitat information is available on habitat types within biologically distinct area (e.g. coral reefs), how much of each habitat type should be protected?
iv. Should the MPA network avoid fragmentation of habitat as far as possible (e.g. include whole reefs units instead of parts of reefs where possible)?

v. How to include existing no-take MPAs in consideration of a CT-wide MPA network?

vi. How to address available information about ecological processes (e.g. spawning, breeding, foraging or aggregation sites)

vii. How to address connectivity? That is, what should be the distance between MPAs for them to function as a network, and how should they be arranged?

viii. How to consider biophysically special and/or unique places?

ix. How should we deal with threats that can, or cannot (climate change) be stopped?

x. How should we deal with already degraded areas?

xi. What minimum size should be used?

SOcio-economic, Cultural and Management Feasibility Operational Design Principles

xii. How best to complement human uses and values?

xiii. How to consider all the costs and benefits?

xiv. How to best incorporate existing management and marine tenure arrangements?

xv. How to optimise compliance (sustainability of management arrangements) in the design?

B. For each type of area-based/zoning protection of the broader MPA network that is not no-take the same questions need to be answered as above. Different principles may also be required depending on the management framework (eg. government versus community-based MPAs).

Throughout this process, decisions may need to be made regarding the scale at which any MPA network should be designed and implemented – it may be different for different objectives.

It is possible that to achieve collectively agreed resource management goals across the CT, one set of biophysical operational principles will need to be applied across the entire CT area. However, each country is different (and areas within countries are different) socially, economically and culturally. For these reasons it is likely that the socio-economic, cultural and management feasibility operational principles will be different, at least, per country. It may even be necessary to have different socio-economic, cultural and management feasibility operational principles within different areas within one country. Alternatively, workshop participants may consider it possible to develop just two set of these principles for South East Asia and for Melanesia.

By starting to define some of these principles at the Townsville Workshop, we will be supporting the Coral Triangle Initiative’s draft Action Plan goal for MPAs.
Various types of software are available that might be useful as decision support tools for to start implementing the kinds of operational principles discussed above. The usefulness of the software will depend on the degree to which the principles are explicit and quantitative, and the data are available to inform the principles.

Marine reserve design software can be excellent tools for processing large amounts of information (Moilanen et al. 2008). However, it is important to remember that they are decision support tools and not the decision makers. Final decisions regarding the MPA design will be made by local managers and stakeholders.

**Background reading**

Airime, S., J.E. Dugan, K.D., Lafferty, H.Leslie, D.A.McArdle, R.R. Warner. 2003. Applying ecological criteria to marine reserve design: a case study from the California Channel Islands. Ecological Applications 13 (1)S170-S184 (contact: Leannef@earth2ocean.com)


Game, E. T., E. McDonald-Madden, M. L. Puotinen and H. P. Possingham 2008a Should we protect the weak or the strong? Risk, resilience and the selection of marine protected areas Conservation Biology in press. (contact egame@tnc.org)

Game, E. T., M. E. Watts, S. Woolridge and H. P. Possingham 2008b Planning for persistence in marine reserves: a question of catastrophic importance Ecological Applications 18:670-680. (contact egame@tnc.org)

Green A.L., Mous P.J. 2007. Delineating the Coral Triangle, its ecoregions and functional seascapes. Report based on an expert workshop held at the TNC Coral Triangle Center, Bali Indonesia (April -
May 2003), and on expert consultations held in June – August 2005. Version 4.0 (August 2007). Report from The Nature Conservancy, Coral Triangle Center (Bali, Indonesia) and the Global Marine Initiative, Indo-Pacific Resource Centre (Brisbane, Australia). 50 pp. (contact: agreen@tnc.org)


http://conserveonline.org/workspaces/pacific.island.countries.publications/kimbebaycontents/kimbe (contact: agreen@tnc.org)


McLeod, E., Salm, R., Green, A., Almany, J. (in press) Recommendations for designing marine protected area networks to address the impacts of climate change. Final Frontiers. (contact: agreen@tnc.org)


http://cmsdata.iucn.org/downloads/nsmail.pdf or contact (leannef@earth2ocean.com)

http://cmsdata.iucn.org/downloads/iucn_information_paper.pdf or contact (leannef@earth2ocean.com)

West, J.M., Salm, R.V. 2003 Resistance and resilience to coral bleaching: implications for coral reef conservation and management. Conservation Biology 17 (4): 956-967. (contact: agreen@tnc.org)
Some datasets
TNC CTI Data Atlas Project (contact: across@tnc.org)
World Fish Centre (http://www.worldfishcenter.org/v2/index.html)

Some existing projects/resources
Conservation planning with connectivity for coral reefs (m.berger@uq.edu.au)
Convention on Biological Diversity http://www.cbd.int/protected/work.shtml and
http://www.cbd.int/decisions/?dec=VII/28
C-Plan. A conservation planning software tool. (contact: bob.pressey@jcu.edu.au)
Marine Learning Partnership. Contact Alan White (alan_white@tnc.org)
Marxan (conservation planning software) http://www.uq.edu.au/marxan/

Need Sulu-Sulaweisi, Bismark-Solomon Sea references here

PALNet is a knowledge sharing platform for people working on protected areas.
http://www.parksnet.org/

Planning principles for Australia’s MPAs within bioregions of the EEZ:

World Commission on Protected Areas (WCPA) Best Practice Series. In prep: ”Designs for nature:
regional conservation planning, implementation and management” (contact:
bob.pressey@jcu.edu.au)

Acknowledgement: Thanks to Nancy Dahl-Tacconi for her input.
15. Long-term biophysical monitoring of a network of Marine Protected Areas in the Coral Triangle

Hugh Sweatman\(^1\), Jamaluddin Jompa\(^2\), Cleto Nanola\(^3\), Garry Russ\(^4\)

4/11/08

Outline of the issue
The CTI aims to implement a fully functioning region-wide Coral Triangle MPA Network (CTMPAN) by 2020, with the joint objectives of reducing poverty and conserving the region’s biodiversity.

The broad MPA objectives under Goal #3 of the draft CTI Plan of Action are clear, and other parts of the draft CTI Plan of Action also refer to using MPAs to achieve other objectives. But how will we know if the CTMPAN is achieving them?

The draft CTI Plan of Action specifically identifies the need for “a well-defined monitoring program to assess management effectiveness over time of CTMPAN sites and networks” (Goal #3 Strategy 8).

What does this mean for achieving the goals of the draft CTI Plan of Action?
As mentioned, an effective MPAN in the CT has been identified as one tool to help achieve multiple goals within the draft Plan of Action. Monitoring programs can provide measures of progress against these multiple objectives. Results can be used for internal review of management of projects that implement and manage the CTMPAN and to report to agencies and governments, NGOs and the world wide community. They can also be a regular source of “news” to promote community knowledge and interest.

What does this mean for MPA network design, management and implementation?
A regional program to monitor the effectiveness of the CTMPAN will be required. There are a number of coral reef monitoring programs in several nations of the CT6 (e.g. COREMAP in Indonesia, Philreefs in the Philippines) that are already monitoring sites in MPAs and these programs should form key components of the CTMPAN monitoring.

---

\(^1\) Australian Institute of Marine Science, PMB 3, Townsville MC, Qld 4810 Australia (+61 7 4753 4470 h.sweatman@aims.gov.au)
\(^2\) Executive Secretary, COREMAP II, (Coral Reef Rehabilitation and Management Program, Ministry of Marine Affairs and Fisheries, DG of Marine, Coasts, and Small Islands) Jl. Tebet Raya No. 91 Jakarta.
\(^3\) University of the Philippines - Mindanao, Davao City, Philippines,
\(^4\) School of Marine and Tropical Biology, and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Queensland, 4811, Australia.
Requirements of monitoring programs

The joint objectives of Goal #3 mean that both biological and socio-economic monitoring will be required; this paper will focus on biological monitoring associated with assessing the effectiveness of MPAs in conservation of biodiversity rather than their role in reducing poverty.

A lot has been written about the design and implementation of biological monitoring programs and it is clear that there are some general principles, but no single best option.

Objectives and monitoring

All authors agree that a clear statement of the specific objectives is a key to success in designing a monitoring program. For instance, the broad objective of the CTI to conserve the region’s biodiversity implies that species diversity within the CTMPAN should not decrease over the long term (>10 years). Alternatively, in view of changing climate or in case of major natural disturbing factors such as tropical storms, the measure might be that species diversity should decrease less than in comparable sites outside the CTMPAN. The abundances of exploited species (one part of the Network’s contribution to poverty reduction) should also be higher within the CTMPAN in general, and particularly within no-take zones of the CTMPAN, than in other comparable areas.

These are qualitative goals; they need to be refined into quantitative statements of how big the differences in biodiversity should be, how much greater the abundances of exploited species should be and after how many years? (for instance, the draft CTI Plan of Action states that the CTMPAN will be fully functional by 2020).

The forthcoming workshop could be a forum for discussion to set values for these goals which will then feed into the next stage.

How sure do you want to be about detecting what level of change?

A critical aspect of the design of a monitoring program is that it must be able to detect the kinds of changes that are relevant to the objectives of the draft CTI Plan of Action this is the subject of “statistical power”. Monitoring programs are usually labour-intensive and therefore expensive; if a program cannot detect relevant changes then those resources are wasted. The ability of a program to detect changes will depend on the size of the changes that are of interest and how variable the observations are and the amount of sampling (see Field et al 2007 and Legg & Nagy 2006 for comments on strategies to increase statistical power of monitoring programs).

Some critical information, particularly about the variability of data, can only be estimated approximately (based on information from existing programs in the CT and elsewhere) before monitoring starts, so the initial design for a program is usually a best guess. This makes it particularly important that the results of early surveys are processed rapidly so that they can provide better estimates of variability that can be incorporated to improve the design and ensure that the program can detect relevant changes in the time frame of the project. Importantly, this can help to secure political support, gives reassurance to donor organizations and represents a logical basis for additional funding requests.
Data storage, analysis and management

This points to a generality about monitoring programs: while data collection usually receives much greater attention and the majority of resources, the effective management of the large quantities of monitoring data and particularly, the prompt and comprehensive analysis and reporting of results are at least as important as the data collection and funding for these activities must be considered accordingly. The biologists who organise the field program and collect the data need to form effective partnerships with advanced biometricians who can fully analyse the complex data sets and advise on survey design. This may involve either employing biometricians directly within the program (potentially at the Coral Triangle Center for Marine Protected Areas proposed in the draft CTI Plan of Action) or else through collaboration with departments of statistics at universities in the region or internationally. This may be a field of expertise where capacity within the CT needs to be increased (Goal #3, Strategy #4).

Survey methods

A lot has been written on survey methods for coral reefs (notably English et al. 1997). Indicators such as live coral cover are relatively easy to measure, but may give less information about the likelihood that a coral community will persist than indicators that are more concerned with population processes, such as growth, reproduction and recruitment. These are all much more difficult and time-consuming to measure reliably. Environmental stresses tend to be associated with less diverse communities because species that are more susceptible to the stressor are more likely to be eliminated over time, or else do not recover after disturbances because recruits are unable to establish successfully. However, measuring changes species diversity depends on an ability to distinguish among species; reliable identifications require extensive training and frequent comparisons between observers to maintain consistency.

The survey methods that are chosen should be clearly and comprehensively documented in Standard Operating Procedures that are regularly reviewed and updated. Frequent training and observer calibration sessions are important to ensure that survey methods are consistent between sites and over time, so the changes that are recorded reflect changes in the environment rather than differences among observers.

Some background reading

For information about documents contact: hugh.sweatman@aims.gov.au unless otherwise indicated.


Wilkinson, C., Green, A., Almany, J. Dionne, S. 2003. Monitoring Coral Reef Protected Areas. A practical guide on how monitoring can support effective management in MPAs. AIMS, Australia (bookshop@aims.gov.au) and IUCN Marine Program, Switzerland (info@books.iucn.org).


**Some existing projects**

COREMAP - [www.coremap.or.id](http://www.coremap.or.id)


GEF’s Coral Reef Targeted Research and Capacity Building for Management Project is setting up monitoring sites in the Philippines:


ReefCheck - [http://www.reefcheck.org/](http://www.reefcheck.org/)

**Acknowledgments**
The input from Kirstin Dobbs and Porfirio Aliño is gratefully acknowledged.
16. Human adaptation to climate change
Alino PM¹, Cinner, J², Brown, K³

4/11/08

Overview of the Issue
Climate change is expected to increase the frequency and intensity of extreme climatic events, such as high-intensity cyclones and increased sea surface temperatures (which can cause corals to bleach and die), in addition to more gradual changes such as sea level rise. These extreme events can have profound impacts on ecosystems such as coral reefs and the communities that depend on them. For example, estimates of economic losses from recent coral bleaching events have been staggering, ranging from tens of millions of dollars for a single country ($US6-27 million in the Philippines) to as much as US$8 billion of dollars for the wider Indian Ocean. These impacts potentially have profound impacts for people who earn a livelihood, and nations which gain income, from coastal and marine resources. This briefing paper highlights key components of social resilience theory and discusses how these can be integrated into a regional Action Plan (e.g. CTI draft Action Plan) to prioritize early climate adaptations.

The impacts of climate change are likely to vary from place to place, and for different people within society. These impacts are largely determined by differing levels of vulnerability, which is a critical component of social resilience. Differences in vulnerability can be assessed at different scales, including national, regional, community and even household levels.

**Vulnerability** in this context is the level of susceptibility to harm from events such as coral bleaching, cyclones, and sea level rise. Vulnerability is often perceived as having distinct components, which include exposure, sensitivity and adaptive capacity (Figure 1).

![Vulnerability Diagram]

**Exposure** is the degree to which a system is stressed. This can be characterized by the magnitude, frequency, duration and spatial extent of a climatic event such as coral bleaching or a cyclone. Exposure may vary based on factors such as oceanographic conditions, prevailing winds, and/or latitude, which may cause some areas to have a higher likelihood of being impacted by events such as cyclones or coral bleaching. There are limited adaptations societies can undertake to minimize exposure. These adaptations primarily rely on engineering solutions (e.g. levees, sea walls) or coastal

---

¹ The Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines, pmalino@upmsi.ph
² ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD, 4811, Australia. Email: Joshua.cinner@jcu.edu.au. Phone +61 074781-6751
³ Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, UK

---

88
planning (e.g., building away from danger zones). There are various sites being established which considers the social concerns under the LOICZ (Land Ocean Interaction in the Coastal Zone) program.

*Sensitivity* is the degree to which the stress actually modifies or affects a system. Sensitivity may be affected by things such as local level dependence on marine resources. Low dependence on marine resources may mean that climatic events such as coral bleaching have a lesser impact on coastal communities. Societies, governments, and donors can develop a number of adaptations to minimize sensitivity to climatic events. These might include early warning systems for cyclones, alternative livelihood programs to reduce dependence on marine resources, and minimizing or prohibiting the use of gear types that specifically target fishes that are more likely to be impacted by climate change.

*Adaptive capacity* refers to the conditions that enable people to adapt to or cope with change. A number of conditions can influence adaptive capacity, including among others: 1) peoples’ ability to switch to non-reef related occupations, 2) social capital (the bonds within a community), 3) level of wealth, 4) access to technology, 5) access to infrastructure, 6) capacity to anticipate change, and develop strategies to respond, and 7) recognition of causal agents impacting ecosystems (Figure 2).

People with low adaptive capacity may not be able to adapt to changes in the flow of ecosystem goods and services brought about by climate change, management strategies which change access, or opportunities created by change.

Building adaptive capacity will be a key feature in preparing for climate change in many areas throughout the Coral Triangle. Adaptive capacity can be assessed at national, sub-national, community and household scales. There is no one set of agreed-upon indicators, and measures such as Gross Domestic Product (GDP) per capita or the Human Development Index (HDI) are often used as a “rough-and-ready” indicator of adaptive capacity, although composite indicators such as Figure 2 may be more appropriate.

Adaptive capacity is currently a major focus of research seeking to identify adaptation strategies and build both social and ecological resilience to climate change.

Figure 2 is an example of an adaptive capacity index developed for adaptation to changes in coral reef systems for 25 communities from five countries in the Western Indian Ocean (MD=Madagascar, TZ= Tanzania, KY=Kenya, MS= Mauritius, SZ=Seychelles). These scores were developed based on detailed socioeconomic surveys designed to address adaptation to climate change, and the figure shows the contribution of each indicator to a site’s total adaptive capacity score. This is an example of a study that helps to define priority early climate adaptations as part of a region-wide climate adaptation plan for near-shore marine and coastal environments (from McClanahan et al. 2008).
What does this mean for MPA network design, management and implementation?

One way to integrate human adaptation into MPA network design, planning and management is to plot aspects of vulnerability against adaptive capacity. This reveals four domains or quadrants where differing conservation and policy may be required: protect and preserve; capacity building; relief and reorganization; and adapt and transform (Figure 3).

Protected areas are likely to be most effective and useful in sites with high social adaptive capacity because local communities can readily adapt to changes in access and take advantage of new opportunities, such as increased tourism. But differentiation in social or ecological vulnerability may help inform the type of MPA and management required in an area.

Regions with high vulnerability are likely to feel the impacts of climate change most. Protected areas may also be important strategy to conserve marine resource in these regions, but will require a different management approach. For example, they should not depend on tourism revenue for funding, since tourists are unlikely to visit these areas after major bleaching events and funding may fluctuate considerably.

![Diagram](image)

Figure 3. (A) Theoretical model indicating gradients of social adaptive capacity against vulnerability to produce four quadrants of differing conservation priorities. (B) A case study plotting 28 communities from five western Indian Ocean countries.

Communities with low adaptive capacity are poorly equipped to cope with even short-term restrictions on resource use imposed by no-take areas. These communities may be unwilling or unable to comply with no-take measures. In these areas, other types of management that have lower social costs might be more appropriate (Figure 3A). These regions first require building social resilience through investments in poverty alleviation, infrastructure, social capital, and alternative incomes. Once local capacity is enhanced, these regions are more likely to be able to take advantage of the opportunities arising from conservation and successfully implement management strategies. Prior to these developments, management options with minimal social costs are required- these
might include managing fishing gears that specifically target reef fishes that are considered key to recovery after a bleaching event (Figure 4). Regions with high vulnerability and low adaptive capacity do not currently have the resources or ability to adapt to climate change. These regions are a primary concern for human development and require government or donor assistance to ameliorate disaster risk, strengthen social safety nets, diversify sources of livelihoods, and reduce dependence on local natural resources.

![Figure 4. Shows catch data from the PNG artisanal fishery. Fish species are broken down by functional group. Groups in red represent groups or species that have feeding habits (e.g. herbivores) that may play a key role in the recovery of coral reefs. Banning gears such as spear guns may help the recovery of coral reefs after a bleaching event, but have a smaller socioeconomic impact on fishing communities than a fisheries closure.](image)

**What does this mean for achieving the goals of the draft CTI Plan of Action?**

For each CT country, there will be varying levels of exposure, sensitivity, and adaptive capacity. These will influence the types of conservation strategies that are most appropriate and the region-wide early action plan for adaptation. It will be important to identify where resilience is especially lacking through the proposed Objective 1, Strategy 1 (mapping) of the CTI draft Plan of Action. It will also be important to identify local sources of resilience and build upon those. Building adaptive capacity will require region-wide coordination of governments, information providers, and donors.

**Background reading**

For information about these resources contact Dr Josh Cinner ([joshua.cinner@jcu.edu.au](mailto:joshua.cinner@jcu.edu.au))


**Some existing projects**

Asian Disasters Network Resilience Communities work

LOICZ (Land Ocean Interaction in the Coastal Zone) program (contact: pmalino@upmsi.ph)
17. “At least do no harm”: Coral Triangle Initiative contributing to Livelihoods and Poverty Reduction

Lea M. Scherl¹

4/11/08

Outline of the Issue

Poverty and biodiversity are critical issues of our time. It is estimated that billions of people are living on less than a dollar worldwide and at the same time the rate of species extinction is 100-1000 times that above normal. This situation will be similar within the CT6 countries. Poverty and biodiversity are also interlinked in a complex nexus of sometimes contradictory issues that play out most often at the local level. This is because, it is in many places where poverty has persisted and is widespread that there are remaining areas with ecosystems that are very rich in biodiversity a situation also encountered within the CT6 countries. Conservation efforts could contribute to exacerbating poverty of communities that are dependant materially, culturally or spiritually on those resources, if their well-being is not properly taken into account.

Conservation initiatives can generate significant economic, environmental and social benefits. These benefits are realized at local, national and global levels, but the often disproportionate nature of the distribution of such benefits needs to be analysed carefully. Moreover, there is a need to stress that given the fact that many local communities living in and around conservation areas have limited development opportunities, those areas offer a somewhat still untapped opportunity to contribute to poverty reduction while continuing with their vital function of maintaining healthy ecosystems. Increasing the benefits of conservation areas and reducing their costs to local people can help mobilize public support, and reduce conflicts and the enforcement costs for management, particularly in areas of widespread poverty.

The Bali Plan of Action Towards Healthy Oceans and Coasts for the Sustainable Growth and Prosperity of the Asia-Pacific Community² call for “managing living resources sustainably.” In the global context, there are several specific recommendations adopted at the last World Parks Congress related to the role of Protected Areas in contributing to Poverty Reduction³: Protected areas should strive to contribute to poverty reduction at the local level (either directly or indirectly) and at the very minimum not create, contribute to, or exacerbate poverty; Knowledge about the linkage between protected areas and poverty needs to be improved; Mechanisms for the poor to share actively in decision-making related to protected areas should be strengthened. The Program of Work on Protected Areas adopted by the Convention of Biological Diversity⁴ inside its preamble: “Call the attention of the parties and the development agencies to integrate in their development strategies (for instance: strategy for assistance to the countries, strategy for poverty reduction and national and development strategies) objectives related to protected areas and to reflect the contribution of protected areas for sustainable development, as a means to achieve the Millennium Development

¹ Senior Social Scientist, Asia Pacific Region, The Nature Conservancy: lscherl@tnc.org [Views expressed in this paper are the author’s]; Co-chair Protected Areas, Equity and Livelihoods Taskforce of the World Commission on Protected Areas and Commission on Environment, Economics and Social Policy (IUCN); Adjunct Associate Professor, School of Earth and Environmental Sciences, James Cook University of North Queensland.

² APEC 2005

³ IUCN 2003 - World Parks Congress recommendation #29 on Poverty and PAs

⁴ At CBD COP 7 in 2004 in Kuala Lampur
Goals, an in particular Objective 7” (ie; environmental sustainability). Inside the General Purpose it reads that the CBD should: “...... contribute to attain the objectives of the convention of reducing significantly the actual loss of biodiversity at a global, regional, national and sub-national levels and contribute to poverty reduction and the search for sustainable development”. At the most recent CBD COP 9 meeting the decision related to “Process for the Revision of the Strategic Plan”2 recognizes that the revised and updated strategic plan of the convention (to be approved in 2010) should: “Highlight the importance of biodiversity for poverty reduction and the achievement of the Millenium Development Goals, taking into account that conservation and sustainable use of biodiversity should contribute to poverty reduction at the local level and not harm the livelihoods of the poor

The World Bank definition of poverty recognizes that this is a multi-dimensional concept. Defining poverty by income alone is widely recognized as too narrow an approach. To reduce poverty, greater income is important, but poverty reduction can also come from increasing opportunities for the poor through, for example, education and new livelihoods. It can come from empowering the poor in areas such as decision-making on public services and resource allocation. It can come from enhancing the security of poor people by reducing their risk from food shortages, natural disasters, health crises, and other catastrophic events. In a study to address the linkages between Marine Protected Areas and Poverty Reduction in the Asia-Pacific region the World Bank Definition of Poverty was adapted to the context of Marine Protected Areas3 and includes the dimensions and indicators showed in the table below.

Table 1: Dimensions of Poverty and indicators relevant to addressing the links between Marine Protected Areas and Poverty Reduction

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Empowerment</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>Governance mechanisms</td>
<td>Health</td>
</tr>
<tr>
<td>Housing</td>
<td>Community participation</td>
<td>Social cohesion</td>
</tr>
<tr>
<td>Luxury goods</td>
<td>Benefits to ☟</td>
<td>Cultural traditions</td>
</tr>
<tr>
<td>Fish catch</td>
<td>Access and rights</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative livelihoods</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A very important consideration in addressing the contribution of marine resources management to livelihoods and poverty reduction is related to governance systems that are put in place for managing these resources. Governance is about power, relationships, responsibility and accountability. It is about processes for decision-making, who decides, who has influence and how decision-makers are held accountable. It is also about mechanisms that are created to foster and harbour decision-making processes. IUCN in its new version of the Guidelines for Protected Areas Categories4 identify the

---

1 Held in Bonn, May 2008.
2 COP 9 Decision IX/9
4 Those Guidelines were recently launched at the World Conservation Congress, Barcelona, October 2008
following four broad types of governance of protected areas, any of which can be associated with any management objective of the different I-VI IUCN Protected Areas categories.

Table 2: Types of Governance of protected areas (IUCN Guidelines)

A. Governance by government  
B. Shared governance  
C. Private governance  
D. Governance by indigenous peoples and local communities

A diversity of governance systems in each country should at least be considered, if appropriate, and this will differ across the CT6 country and even within a country or a system.

In sum, no loss of biodiversity should at least imply no loss of livelihood opportunities – conservation should not be undertaken at the expense of the poor, the principle of at least “do no harm” should be applied – ie; Where conservation activities affect people at the local level, those activities should strive to contribute to poverty reduction and, at the very minimum, do no harm.

It is important to recognize that in the CT6 countries the governments (different levels), NGOs, civil society groups and communities are already addressing a number of dimensions of the contribution of marine resource conservation to livelihoods and poverty reduction. There are, no doubt, already many governance systems in place in each country that take into account the participation of a myriad of stakeholders and address issues of transparency, accountability and equity, and many projects and activities which are investigating and incorporating ways to reduce poverty, including through the provision of alternative livelihoods’ options. A thorough understanding of all of these activities through a more systematic compilation and analysis of information would be critical to move forward with the Coral Triangle Initiative. As a step towards this process the following guiding questions to participants of the workshop are provided in the hope to stimulate discussion on ways forward and gain more information on what is already taking place.

What does this mean for achieving the goals of the CTI Plan of Action and delivering tangible benefits to local and indigenous communities?

For each CT country, for each CTI draft plan of Action goal, objective and strategy there is a need to understand the links between establishment and management of conservation areas and the potential costs and benefits that they can generate; with implications for Conservation Areas at least causing no harm and/or endeavoring to contribute to poverty reduction. Considerations of those dimensions will differ across the CT6 countries and according to the level of planning and implementation – whether at a regional, country, system or site level. Some or all of the following questions could be addressed during these processes, which would lend to different types of activities that are tailored to specific contexts and levels of intervention.

1 Note that governance types describe the different types of management authority and responsibility that can exist for protected areas but do not necessarily relate to ownership.  
2 Those will need to take into account what is already underway in each country and build from these experiences.
✓ How can understanding of the linkages between conservation (its functions and governance systems) and poverty (reduction or exacerbation) be promoted in each CTI country?
✓ What is needed to ascertain at the site or eco regional level how marine conservation can at the very minimum do no harm to relevant stakeholders and particularly local communities?
✓ What is needed to ascertain at the site or eco regional level how marine conservation can contribute to poverty reduction where this is considered necessary for the sustainability of the natural resource, biodiversity and livelihoods?
✓ How can a balanced assessment of both benefits and costs be undertaken for a proper understanding of the actual benefits (ie. benefits after costs are taken into account) in a particular area or system?
✓ What are the key poverty reduction benefits of a marine conservation site or system and what are their factors for success in doing so in that particular location or system?
✓ What governance mechanisms can we put in place that are accountable, transparent and takes into account the interests of all stakeholders (including the most vulnerable groups) in an equitable manner?
✓ What mechanisms can we put in place for equitable sharing of costs and benefits across a range of stakeholders?
✓ What mechanisms, if appropriate, can be put in place for payment of environmental services and how can it be assured that those will be equitably distributed?
✓ How can the efforts of managing a particular conservation site or eco region contribute to sustainable development at a local, national and regional level?
✓ How can the ecological, economic, social and cultural dimensions of conservation be addressed simultaneously in the on-going management of the marine resources to ensure a sustained impact on poverty reduction – and also acknowledging that poverty is a multi-dimensional concept (the three pillars of sustainable development)?

Useful References and resources:


Indigenous and local communities and protected areas. Towards equity and enhanced conservation
Fisher, RJ; Maginnis, S; Jackson, W; Barrow, E; and Jeanrenaud, S (2005) Poverty and Conservation: Landscapes, People and Power. IUCN Gland.

Governance as key for effective and equitable protected area systems.

www.nature.org/mpapovertystudy.


Sharing Power—Learning by doing in co-management of natural resources throughout the world http://cms.iucn.org/about/union/commissions/ceesp/ceesp_publications/sharing_power.cfm

Useful websites:

Marine Protected Areas and Poverty Reduction Study in Asia-Pacific (The Nature Conservancy) www.nature.org/mpapovertystudy

Locally Managed Marine Area Network in the Pacific and SE Asia (www.LMMAnetwork.org).

Poverty and Conservation Learning Group www.povertyandconservation.info

18. OUTBREAKS OF CROWN-OF-THORNS SEASTARS ADD TO CORAL DEPLETION IN THE CORAL TRIANGLE.

Morgan S. Pratchett¹, Andrew H. Baird¹, Hugh P.A. Sweatman², Ian Miller², Stuart Campbell³, and Fraser A. Hartley⁴

5/11/08

Outline of the issue

The coral-feeding crown-of-thorns seastar (*Acanthaster planci*) is a natural inhabitant on coral reefs throughout the Indian and Pacific Oceans and mostly occurs at very low densities (typically <1 seastar per hectare). However, this species periodically experiences massive population explosions referred to as “outbreaks”. Each individual seastar is capable of consuming up to 40cm² of live coral per day and the combined feeding activities of hundreds and thousands of these starfish on a single reef causes rapid and extensive devastation of coral reef habitats. Outbreaks of crown-of-thorns seastars (up to 20,000 seastars per hectare) have been occurring throughout the Indian and Pacific Oceans since at least the 1960’s, and represent the principal cause of long-term coral loss at many locations in the Pacific, including Australia’s Great Barrier Reef (GBR), southern Japan, Palau, Guam and Fiji.

Outbreaks of crown-of-thorns seastars have also been reported from several locations throughout the Coral Triangle over the last 2 decades, but have never appeared to cause the levels of devastation recorded in other nearby regions (especially, the GBR and southern Japan). However, there has been a recent spate of outbreaks in both Indonesia and Papua New Guinea (Figure 1), which have caused extensive coral loss. Most recently (in 2008) there was a major infestation of *A. planci* reported near Halmahera, Indonesia, which reduced coral cover to <5% on approximately 20% of reefs. In many areas, outbreaks are occurring for the first time in recorded history.

¹ ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville QLD 4811, Australia. Email: Morgan.Pratchett@jcu.edu.au, Ph. +61 7 4781 5747
² Australian Institute of Marine Science, PMB 3, Townsville MC, Queensland 4810, Australia.
³ The Wildlife Conservation Society, Marine Programs, Bronx, New York 10460, USA
The Coral Triangle represents a diversity hotspot for coral reef species and many of the species within this region have life history traits, such as limited ranges or habitat specialization, which make them vulnerable to extinction. Coral loss caused by outbreaks of *Acanthaster planci* may pose a significant threat to coral reef biodiversity within the Coral Triangle, but few countries have monitoring programs to quantify the abundance of these crown-of-thorns seastars and the damage caused.

**Relevance to the draft CTI Plan of Action**

Sustainable long-term exploitation of coastal marine resources is critically dependant upon the health of ecosystems (e.g., coral reef ecosystems) that sustain important fisheries species. Coral reef environments are facing global degradation due to the combined impact of climate change, coral disease, destructive fishing and over-exploitation, pollution, and sedimentation. Coral depletion caused by crown-of-thorns compounds these other agents of coral reef degradation to further jeopardize biodiversity and sustainable fisheries.

Within the Coral Triangle, the threat posed by outbreaks of crown-of-thorns seastars to coral health and reef condition is currently greater than that affected by climate change and coral bleaching. Many equatorial reefs, particularly those located in the Coral Triangle, have as yet, been largely unaffected by climate-induced coral bleaching. Meanwhile, reports of outbreaks of crown-of-thorns seastars have increased rapidly within this region, which may be attributable to either increased research activity and or real increases in their occurrence.

**Figure 1.** Outbreak of *Acanthaster planci* on the Great Barrier Reef, where outbreaks appear to occur more frequently in areas open to fishing.
Outbreaks of *A. planci* can cause massive and widespread coral depletion. For example, at Green Island in 1962 outbreak populations of *A. planci* killed 80% of scleractinian corals across the entire reef, from the shallow reef crest (<2 meters depth) down to a depth of 40 meters. The critical question is what causes outbreaks. The life-history dynamics of this species (e.g., phenomenal fecundity and early maturation) makes them very prone to massive population fluctuations, but this does not explain when and where outbreaks actually occur. A variety of factors have been proposed to initiate outbreaks of *A. planci*, including high levels of terrestrial run-off, or temporary increases in sea surface temperatures, which could both lead to increases in the survival of larval sea stars. In addition, depletion of natural predators (such as large carnivorous reef fishes) by fishing may increase survivorship of juvenile seastars once they have settled on the reef. On the Great Barrier Reef (GBR), recent research has shown that there have been fewer outbreaks within area protected from fishing (Sweatman 2008). There is no definitive evidence that heavily exploited coral reef fishes, such as coral trout (*Plectropomus* spp.), are significant predators of crown-of-thorns seastars, but the proportion of reefs that had outbreaks of *A. planci* on the GBR were 3.75 times higher where fishing was permitted (Figure 3).
What does this mean for MPA network design, management and implementation?

If crown-of-thorns outbreaks are attributable to anthropogenic activities (e.g., Brodie et al. 2005), then there is definite need to try and manage effects of outbreaks on coral reef ecosystems. Even if outbreaks are largely a natural phenomenon, the threat of coral reef degradation to coastal fisheries, and food security provides appropriate incentive to manage and mitigate against all sources of coral mortality. Minimizing coral loss is also critical to maximizing the adaptive potential and resilience of coral reef ecosystems to future unknown disturbances, such as climate change.

An important step in minimizing future effects of crown-of-thorns starfish within the coral triangle is to:

i) **Urgently address low and declining water quality throughout the region.** The primary steps to improve water quality are to ensure appropriate treatment of sewage and reducing the release of raw or poorly treated sewage into coastal ecosystems, as well as minimizing land runoff due to farming, coastal development and forest clearing, by building physical barriers to sediment displacement or minimizing clearing during periods of high rainfall.

ii) **Enhance protection of large carnivorous fishes, which are highly prone to over-fishing.** Implementation of effective Marine Protected Areas to reduce fishing on large predatory fishes may reduce the likelihood of outbreaks of crown-of-thorns seastars by 73% (Figure 3).

![Figure 3](image-url). Occurrence of outbreaks (1994–2004) in the mid-shelf region of the GBR where most outbreaks occur; number of reefs with outbreaks (black bars) and without outbreaks (white bars). Outbreaks are much more prevalent on reefs that are open to fishing versus reefs that are closed to fishing (no-take) by the Great Barrier Reef Marine Park (GBRMP) zoning.
Other adaptations

In many areas affected by outbreaks of *A. planci* (or during initial increases in seastar densities) there have been attempts to kill or remove individual sea stars to halt or minimize effects on coral communities. The most effective method of killing individual seastars is to inject them with sodium bisulphate, whereby 140 grams of sodium bisulphate is mixed with 1 litre of sea water and then injected into seastars using DuPont Velpar Spot Guns with long needles. Localized control efforts (through collection and injection of individual starfish) may be effective in reducing or delaying effects of outbreaks, but is not feasible and rarely effective over large reef areas. Because starfish can quickly move from one area to another, control of a specific area must be an ongoing effort with almost daily monitoring and controls.

In at least two cases, the end of an outbreak of crown-of-thorns seastars has coincided with the appearance of several diseased individuals. The symptoms of this disease, which include numerous dermal lesions, collapsed spines, and a debilitated water vascular system (Figure 4), are suggestive of attack by a highly virulent *Vibrio* bacteria. Research is currently underway in the ARC Centre of Excellence for Coral Reef Studies to better understand the role of pathogens in regulating population of *A. planci* (especially at very high densities), which may ultimately lead to the development of an appropriate biological control for outbreaks of *A. planci*.

![Image of infected and healthy starfish](image)

**Figure 4.** An infected crown-of-thorns sea star (left) exhibiting dermal lesions and collapsed spines, indicative of a disease. The adjacent starfish (right) is healthy.

Relevant projects

The Wildlife Conservation Society in collaboration with Dr Andrew Baird has recently instigated a review on the recent and historical occurrence of *A. planci* outbreaks throughout Indonesia and PNG.
This project has revealed however, that while outbreaks of crown-of-thorns seastars are widespread, most outbreaks are not adequately reported. For example, it is not possible distinguish localized aggregations of *A. planci* from extensive regional outbreaks in current anecdotal reports. A central role of this project is therefore to instigate a centralized mechanism for reporting sudden increases in the abundance of *A. planci* and provide advice on studying outbreaks to establish likely causes. Critical information pertaining to the occurrence of outbreaks (including localized densities of seastars measure using prescribed sampling protocols, as well as maximum diameter measurements for a sample of 50-100 individuals) is very simple to collect and will contribute greatly to increasing understanding of proximal causes for outbreaks.

A definitive outcome of the Coral Triangle Initiative might be to expand this project to encompass the entire coral triangle and establish a necessary structure for reporting and responding to new reports of outbreaks throughout the region. Genetic sampling of outbreak populations is also required to establish the connectivity of populations of *A. planci* within the coral triangle and to better understand the dynamics and origin of outbreaks. Such studies are now viable, following the recent development of microsatellite markers for *A. planci* (Yasuda et al., 2006) and should be a research priority.

**Background reading**

*For information about of these publications, please contact Dr Morgan Pratchett (Email: morgan.pratchett@jcu.edu.au)*


