Designing and Implementing Effective Marine Protected Areas

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Statement of Issue

MARINE protected areas (MPAs)—including underwater parks, fishery reserves, wildlife sanctuaries, and the like—are an increasingly popular policy instrument designed to conserve coral reefs and sustain reef benefits for society. A marine protected area (MPA) is "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN, 1988). Explicit reference is made to "no-take" MPAs (that is, MPAs where no extractive uses are permitted) when discussions are restricted to this particular category of MPAs. MPAs have been demonstrated to increase coral reef fish and invertebrate abundance, biomass, and species richness, as well as redistribute stakeholder access to reef resources and thus redistribute wealth in coastal communities. The promise of MPAs as a tool for biodiversity conservation and sustainable development has yet to be fully realized, in part because both the natural and social science underlying effective MPA development and management are poorly understood. Presentations at the 9th ICRS underscored the scientific uncertainty that surrounds the biophysical design of MPAs, but provided some basic guidance for policymakers.

Photo: Barbara Best

Manager and assistant proudly display the results from community-based fish surveys at Gilutongan Marine Sanctuary, Cebu, Philippines

State of Knowledge

Siting of MPAs

There was general agreement that coral reef MPAs should be established in high quality habitats located either in the midst of ocean gyres or in "upstream" locations. Research indicated that coral reef MPAs are more likely to function as relatively independent units than interdependent ecological systems, especially over large spatial scales. Research also indicated that the biological performance of "no-take" MPAs is not correlated with their spatial extent, suggesting that bigger is not necessarily better. Presenters noted that reef management efforts, including individual MPAs and MPA networks, must match the scale of relevant ecological processes to sustain ecosystem goods and services.

Several presentations provided insights into the sociopolitical characteristics of effective coral reef MPAs. MPA effectiveness depends upon the larger matrix of coral reef management initiatives. If adjacent areas are not well managed, MPAs will be less likely to maintain productive coral reef ecosystems. Devolving authority for MPA development and management to local governments, user groups, and non-governmental organizations spurs MPA establishment and enhances MPA management effectiveness. Collaborative MPA management structures, however, appear to offer the greatest potential for linking national resources with local interests and knowledge.

Emerging Best Practices

The rules governing resource use within coral reef MPAs must be clear, easily understood, and easily enforceable.

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Likewise, internal and external MPA boundaries must be easily recognized by resource users and by enforcement personnel.

MPA decision-making must be an adaptive and broadly participatory process. Such processes permit social learning, draw upon diverse sources of knowledge, build trust, and enhance the legitimacy of MPA rules and regulations. Exactly *how* and *when* participation should occur was a matter of contention. Mechanisms must be established to ensure that stakeholder representatives are accountable and responsive to their constituents. Finally, differences among stakeholders with respect to their beliefs (that is, perceptions of how the world works), values (that is, perceptions of what is good, desirable, or just), and interests (that is, desired outcomes) often hinder MPA development and management, reflecting the need for decision-makers to agree on *process* before trying to decide *outcomes*.

MPA Management and Administration

Clear management goals and objectives, as well as environmental education and outreach initiatives, facilitate effective MPA management. Devolution of authority for enforcement could enhance capacity; there is a need to design enforcement systems that promote accountability among enforcers and appropriate (not draconian) penalties for noncompliance with MPA rules and regulations. It is important to monitor both biological *and* social performance indicators, collecting baseline data, and sampling at multiple spatial and temporal scales. These monitoring activities should inform site development, measure change over time, and provide the basis for adaptive management. Enlisting stakeholders in the collection and analysis of research and monitoring data educates participants and builds capacity and trust.

Relevant Actions Being Taken to Address the Issue

In recent years, scientists and practitioners have focused tremendous effort upon the development and management of effective coral reef MPAs. Local, national, and international conservation organizations and government agencies are actively working to develop effective coral reef MPAs in dozens of countries around the world. The ecological theory of ecological no-take MPAs has been exhaustively reviewed by an international team of scientists under the auspices of the National Center for Ecological Analysis and Synthesis (NCEAS) in the United States (Web site: http://www.nceas.ucsb.edu). The social theory of coral reef MPAs is in its infancy, but promising research initiatives are underway in the United States and abroad.

Management and Policy Implications

Scientific research on the development, management, and efficacy of MPAs has significant implications for coral reef MPA policy and site management. Incorporating the best natural and social scientific knowledge available into coral reef MPA development and management as "working hypotheses" does not guarantee site effectiveness, but it should increase the probability of success. The following section outlines select recommendations for coral reef MPA development and management, based on the scientific evidence presented at the ICRS.

Specific Recommendations for Action

- *Remember the surrounding environment.* As one of many coral reef management tools, MPAs should be designed to complement existing fisheries management and integrated coastal management initiatives. MPAs alone may be insufficient to conserve biodiversity and support productive and sustainable fisheries.
- *Place MPAs where they have a chance to work.* High quality habitat is essential for MPAs to conserve marine biodiversity and support sustainable fisheries.
- *Focus on effectiveness.* If well designed and managed, smaller MPAs can provide greater benefits than poorly designed and managed larger MPAs.
- *Target MPAs at relevant scales.* Conservation efforts need to match the scale of ecological processes and human activities that threaten these processes. Because larval dispersal appears to be a more localized phenomenon than earlier recognized, MPAs separated by long distances are unlikely to serve as part of a functionally interconnected whole.
- *Share authority for MPA establishment.* National governments can stimulate development and establishment of MPAs by sharing their authority to designate MPAs with local governments, non-governmental organizations (NGO), and resource users.
- *Share authority for MPA management.* Delegating full or partial responsibility for MPA management to NGOs, user groups, or local communities can enhance site effectiveness.
- *Make MPA rules and boundaries clear.* Clear MPA boundaries and clear rules governing MPA resource use facilitate compliance and simplify enforcement.

- *Encourage adaptive decisionmaking.* If a MPA is not meeting its policy objectives, decision-makers should not hesitate to revise the rules governing MPA resource use and decisionmaking in an effort to enhance performance.
- *Encourage participatory decisionmaking.* Bringing diverse stakeholder groups into MPA decisionmaking processes can improve the substance and legitimacy of these decisions.
- *Make stakeholder representatives accountable to their constituents.* To ensure that representatives further constituent interests rather than their own, establish mechanisms (for example, elections, consultative sessions, or open meetings) to foster accountability.
- *Decide on process before deciding on substance.* Identifying basic rules and criteria for decisionmaking (i.e., process guidelines) before attempting to make substantive choices about MPA rules and regulations may help to reduce conflict and facilitate informed choices.
- *Share authority for enforcement.* Enlisting the aid of resource users and others in MPA enforcement efforts will enhance enforcement capacity and likely increase compliance with MPA rules and regulations.
- *Build accountability into enforcement.* Establishing mechanisms to ensure that enforcement personnel are accountable for their actions will foster more fair and active enforcement of MPA rules and regulations.
- *Make punishment fit the crime.* Excessive penalties for noncompliance undermine the legitimacy of the enforcement system and encourage further noncompliance.
- *Establish advisory committees.* The guidance of broadly representative advisory groups enhances MPA effectiveness through improved decisionmaking and increased legitimacy.
- *Set goals and rank threats.* Setting goals and ranking the threats to achieving these goals facilitates identification and prioritization of necessary management responses.
- *Collect social and biological baseline data.* Baseline data can enhance MPA effectiveness by informing the design of both biophysical and governance systems. The presence of social and biological baseline data also permit more accurate measurement of MPA performance.
- *Measure both biological and social performance.* MPAs usually have both biological (e.g., maintain viable fish stocks) and social (e.g., enhance livelihoods of fishermen) objectives, so it is critical to measure both biological and social performance indicators in order to evaluate MPA effectiveness over time.
- *Sample wisely.* Data must be gathered at socially and ecologically relevant temporal and spatial scales in order to inform adaptive MPA management.
- *Make research and monitoring participatory.* Enlisting stakeholders in data collection and analysis educates participants, builds capacity, and fosters trust.

Useful References and Resources

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Examples of Coral Reef Management: Great Barrier Reef

Alison Green [1]

Statement of Issue

THE Great Barrier Reef (GBR) is the largest coral reef ecosystem and marine protected area in the world. The GBR is a multiple use Marine Park (343,500 square kilometers {km^2} in area), of which 4.7 percent (15,991 km^2) is a "no take area." It is also the largest World Heritage Area, and one of the few that meets all four natural world heritage criteria.

The Great Barrier Reef Marine Park is widely recognised as one of the best-managed coral reef ecosystems, and it is often used as a model for other marine protected areas. There are several reasons why the GBR is considered well-managed, including the fact that this huge area is under one system of management lead by the Australian Government's Great Barrier Reef Marine Park Authority (GBRMPA). Presenters at the 9th ICRS described GBRMPA's approach to management, and how managers and scientists work together to provide the best scientific information for management.

Photo: Great Barrier Reef Marine Park Authority

A Marine Park boat berths next to a fishing vessel

State of Knowledge

GBRMPA has been managing the Great Barrier Reef Marine Park since it was established in 1975, and has learned many lessons about how to manage coral reefs, having tested and used a variety of management techniques over the last 25 years. One important lesson has been that management must be adaptive and able to keep changing in response to new information and emerging needs.

Another important lesson has been that coral reef management requires a strong legal framework. As a result, management of the Marine Park involves the use of a combination of management tools including the *Great Barrier Reef Marine Park Act*, zoning plans, reef-wide policies, permits, plans of management, and regulations.

The GBR is also considered to be well managed because there is a strong scientific basis for management, since Australian reefs are among the most studied and monitored in the world. The reefs are also generally in good condition, although some areas have been impacted by human activities.

The good condition of most reefs on the GBR is not entirely due to management. Many reefs are a long way offshore and receive some degree of protection by their distance from land. Coastal human populations, and their associated pressures on the marine environment, are also lower than in many other countries where reefs occur. While that may be true, there are still some critical issues threatening the Great Barrier Reef Marine Park and World Heritage Area which need to be addressed.

Relevant Actions Being Taken to Address the Issue

Over the last few years, GBRMPA has adopted a critical issues approach to management. This has involved identifying issues believed to be critical for the successful management of the Marine Park and World Heritage Area,

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Photo: Great Barrier Reef Marine Park Authority

Tourism management of the Marine Park is a complex exercise that focuses primarily on ensuring ecological sustainability

which require a targeted management response. They are: maintaining conservation, biodiversity and world heritage values of the site, ensuring ecologically sustainable uses (especially fisheries, tourism and recreation), and reducing land-based impacts on water quality.

To address these issues more effectively, GBRMPA's institutional arrangements are structured around critical issues groups, which provide a strategic, policy-based approach to these issues. Policies developed by the critical issues groups are implemented through developing and implementing zoning and management plans, environmental impact assessment and permitting of use. Compliance, surveillance and enforcement programs are managed through a Day-to-day management unit jointly funded by GBRMPA and the State Government of Queensland. Since management actions have the potential to impact on a wide range of stakeholders, GBRMPA places a high priority on stakeholder liaison and consults with interest groups on a regular basis through a variety of committees.

Key management initiatives currently underway include:

- **Maintaining the conservation, biodiversity and world heritage values** of the site through the Representative Areas Program, which is aimed at the identification and protection of representative examples of all habitats and communities in the Marine Park and World Heritage Area. This is one of the most comprehensive and challenging projects ever undertaken by the Authority.
- **Fishing** is the largest extractive activity in the Marine Park and World Heritage Area, which includes commercial, recreational and Indigenous fisheries. GBRMPA considers that all fisheries in the Marine Park must be ecologically sustainable and if not, the Authority will seek, in collaboration with fisheries management agencies, to minimise ecological impacts. The current focus is on the trawl and reef line fisheries.
- **Tourism** is the principal commercial use of the Marine Park, and tourism management is a complex exercise with issues including access, permits and best

environmental practices. Tourism management focuses primarily on ensuring that the industry is ecologically sustainable through management of heavily used sites, industry training and best environmental practices. Future directions will focus on partnerships with industry and performance based management.

- The ecosystems of the Great Barrier Reef owe their existence and continued health to suitable **water quality** environments. However, catchments adjacent to the reef have altered extensively since European settlement, which has led to a substantial increase in sediment and nutrient input to the reef from terrestrial discharge. Pesticide residues also continue to be found in coastal ecosystems. Reduction of land based pollutant loads entering the Marine Park is seen as the most important water quality issue facing the World Heritage Area .

Science and Management

Science plays an important role in the management of the GBRMP and WHA, since GBRMPA is committed to ensuring that management decisions are based on the best scientific information available. The Authority, as a matter of policy, has chosen to obtain this information primarily from external research agencies, consultants and institutions. Therefore, it is essential that managers maintain strong links with scientists, and provide a clear indication of information needs for management.

To manage this process, the Authority has employed a group of scientists who act as information brokers between scientists and managers. Their role is to identify information needs for management, co-ordinate relevant research tasks, ensure that scientific results are presented in a way that is useful to managers, and assist managers in the interpretation of scientific issues.

While research is a major focus of the organisation accounting for a considerable proportion of the Authority's annual budget and staff time, available resources for research are limited. Therefore, it is important to ensure that they are focused on only those tasks that are directly relevant to the Authority's highest priority management needs.

In order to do this, GBRMPA has taken a proactive approach to setting the research agenda for management. Last year, the Authority undertook a detailed process aimed at clearly identifying and prioritising research needs for the critical issues management of the Marine Park and World Heritage Area.

The outcome was a comprehensive list of the Authority's high priority research tasks across all of its critical issue and major support groups. This is of great benefit to GBRMPA, because it provides a strategic framework for the Authority to make informed decisions regarding which research projects to support. It is also beneficial to scientists, because for the first time GBRMPA has taken the initiative of proactively informing scientists of our information requirements.

Given the fundamental role that the research priorities will play in setting GBRMPA's research agenda, this list will be a living document that is updated and reviewed on a regular basis to ensure that the priorities remain current and relevant to the Authority's management needs. Finally, and perhaps most importantly, managers will need to maintain a close partnership with scientists so that together we can produce the best scientific basis for the management of the Marine Park and World Heritage Area.

Useful References and Resources

This paper is based upon presentations at the 9th International Coral Reef Symposium, Mini-Symposia B6, *Managing the World's Largest Coral Reef Ecosystem.* Authors and titles of presentations can be found at www.nova.edu/ocean/9icrs/. Further information on the GBR and its management is available on GBRMPA's Web site at: www.gbrmpa.gov.au

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Great Barrier Reef Catchment Water Quality Action Plan. www.gbrmpa.gov.au/corp_site/key_issues/water_quality/action_plan/index.html

Challenges to Management of Coral Reef Ecosystems

Dave Gulko [1]

Statement of Issue

MANAGEMENT of coral reef resources has been around for centuries, practiced to various degrees by many indigenous peoples at the village and tribal level. However, management of such resources by governments at a scale beyond food-based fisheries is relatively new. With a few notable exceptions (see chapter on Australia's Great Barrier Reef), management of coral reefs at an ecosystem level is only now becoming a focused goal in many areas. The need for such an approach goes beyond the highly visible and publicly-recognized global bleaching events and regionalized disease outbreaks, and takes into account a wide suite of anthropogenic impacts which together can cause cascade effects throughout the complex trophic and symbiotic webs that characterize most coral reef ecosystems. The papers presented at the 9th ICRS synthesized the status of coral reef resources and management response at the country and regional level and highlight the need for better coordination and communication between coral reef managers.

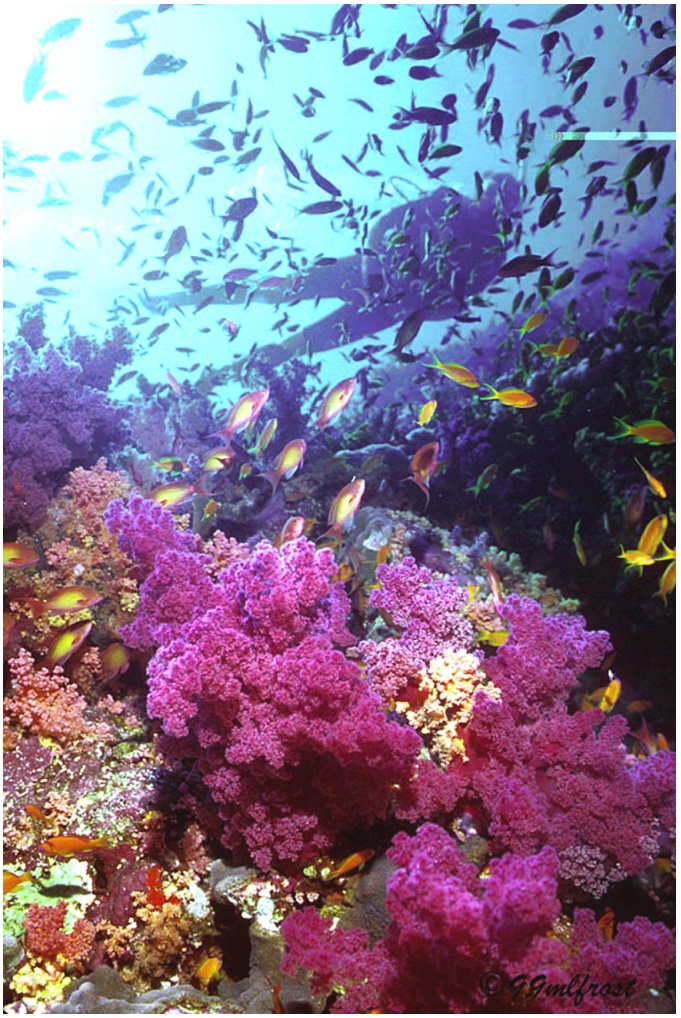

Photo: Mary L. Frost

Redsea Reefscape with pink soft corals, schooling orange anthias and the silhouette of a diver in the background, Egypt

State of Knowledge

The management issues that various resource management groups deal with can be divided into three broad categories: Intra-country, Inter-country, and Global management issues.

Intra-Country Issues

These impacts and management issues exist at a localized scale and are dealt with solely within a single geo-political framework, often by a single, local management agency, community-based management or the focal subject of a non-governmental organization (NGO). Decision-making can be either limited to select government officials or involve wide-scale public buy-in at an extremely localized level. Some issues that might be addressed at this level include dynamite fishing, cyanide fishing, alien species concerns, endemism impacts, coastal development, and deforestation.

Inter-country Issues

These are impacts and management issues that exist at a regional scale, often over-lapping a number of countries' borders and management jurisdictions. As such, they have to be dealt with by a suite of management agencies, often with the guidance of an international body or NGO. Some issues that might be addressed at this level include broad-based over-fishing, the live fish trade, *Acanthaster* outbreaks, disease outbreaks, marine debris issues, etc.

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Global (International) Management Issues

These are impacts and management issues that` occur on a scale where the impacts are experienced across a number of coral reef regions, often in more than one ocean. While these usually encompass the most well-known of impacts, and those which receive the most press coverage, these topics by their very nature often prove the most elusive to manage or to minimize their impacts on reef ecosystems. Generally, any management response that requires the creation or modification of international agreements and treaties is extremely time consuming. Some issues that might be addressed at this level include global bleaching events and international trade in marine ornamentals and corals.

Overarching Issues

Interestingly, the one management paradigm that can often transcend these three different scales is the creation of no-take reserves; not surprisingly, much discussion has recently taken place regarding this approach (please see Chapter on Designing and Implementing Effective Marine Protected Areas).

A second all-encompassing realization has been the need to shift away from species-level towards ecosystem-based management approaches. The role of ecology in marine resource management is only now starting to take on the standing that it has had in terrestrial systems for decades. The rapid loss of live coral cover in the past couple years has led to a closer inspection of the role of synergy between land-based organic pollution, sedimentation, overfishing, disease and coral bleaching. Such synergy is thought to have enhanced phase shifts on coral reefs in some areas where algal proliferation has resulted in a shift from multi-species coral reefs to reefs dominated by only a few species of fleshy algae.

Relevant Actions Being Taken to Address the Issue

Intra-country Management

In many areas, existing resource management authorities are suspected of improperly managing extractive reef resources and are resistant to effective change. Frequently, however, it is the field managers that work for, or are associated with, such authorities that are most aware of the impact problems and are raising (or at least acknowledging) this concern. This suggests that a major stumbling block to effective coral reef management at all levels is the disconnect between coral reef scientists/field resource managers and the policy makers who can change the rules/regulations. Often at the governmental level there is a substantial lag between awareness of a resource problem and ground-level management implementation, often leading to continued degradation of local coral reefs. Many areas have circumvented this issue through empowering small communities adjacent to reef resources to take an active role in their management. Usually, these efforts are associated with attempts to increase depleted local fishery resources. Throughout the tropics there are many success stories from such community-based management, but these are frequently extremely small-scale, associated with small villages, and rarely with developed coastlines or urbanized areas. Some areas are even reverting to traditional management schemes such as the Hawaiian *ahupua'a* or the Bohol Philippines' *sona*, which emphasize management of both land and sea in a small area. The success of empowering local communities to assess, monitor, and manage their coral reef resources may be dependent on the range of locally and regionally-generated impacts and the direct support provided by the regional governments and international community.

There is a recognized need to more actively involve both tourism and fishery stakeholders in government management decisions. In Florida (USA) attempts to involve such stakeholders in the planning process to designate a small, remote no-take reserve has taken over three years, and has been complicated by recreational fishing interests. In other areas such as the Philippines, country-wide stakeholders' planning meetings have been held to identify key players and emphasize the population dynamics, cultural processes, and resource use associated with decisions related to the country's coral reefs. In general, smaller countries seem to be more aware of the importance of coral reef impacts on tourism than larger countries with such resources (such as the United States); one result of this is a greater focus on the effects of land-based reef impacts in many of these countries. A twist on this is the realization by certain jurisdictions that tourism itself can serve as a major impact to coral reef resources. Such a shift in reef resource management requires a paradigm shift away from decades-old rules, regulations, and agency mandates that have focused on extractive uses towards new approaches that deal with non-extractive impacts and the economic value of the resource from an ecosystem (versus extracted species) viewpoint.

There is also recognition that rapid ecological assessments must be done in many of these areas prior to resource management decisions and policies being implemented. Such assessments catalog not only the biodiversity present

in an area, but also note other important ecological factors such as reef three-dimensional complexity, biomass estimates, trophic complexity, invasive species, habitat mapping, endemism, along with anthropogenic impacts present in the surrounding area. With appropriate training, non-professionals may provide much of this data. Such volunteers may provide local and regional governments with a low-cost source of needed data to manage their coral reef resources.

Many areas are actively creating MPAs that equate broad protection over a wide area, but numerous coral reef managers professed that many of these reserves are effectively "paper parks" without active management, and most are sorely lacking in active enforcement. While zoning within MPAs appears to provide for broad user group acceptance, few effective examples exist that are well managed, monitored, and enforced. Some areas, such as Guam and Brazil are actively incorporating coastal zone management strategies into MPA planning. Recognizing the frequent failure of government to properly support marine reserves, some MPAs are starting to focus on alternative income sources to support needed management activities. For example, initiating user fees from both fishers and tourists in order to meet long-term conservation and sustainability goals.

Inter-country Management

Ineffective overfishing controls have region-wide impacts on coral reefs. Issues such as lack of coordination at a regional level, and in some cases, regional scale mismanagement of fisheries resources is contributing to difficulties in management of reef resources within individual countries.

In order to protect large-scale ecosystems or important source/sink reef areas, some regions are considering creating cross-boundary MPAs. Active discussions concerning the Mesoamerican Barrier Reef System, which extends from the Mexican Yucatan Pennisula to the Bay Islands in Honduras, may serve as a precedent for creation of regional plans to facilitate both conservation and sustainable use for transboundary ecosystems. While government commitments to such undertakings are essential, international agencies such as the World Bank, the Global Environmental Facility and others, are often critical to facilitating such action.

Many areas (Caribbean, Southeast Asia, South Pacific, North Central Indian Ocean) are promoting the need for greater efforts on a regional/international scale to educate

Photo: Alan White

Community-based monitoring with quadrat, Philippines

policy makers within both coral reef and non-coral reef countries regarding coral reef management issues. The urgency of such ecoregional planning is starting to be expressed in Southeast Asia where Indonesia, Malaysia and the Philippines have all recently produced independent Management Framework Plans that are being merged in order to effectively deal with issues related to the Sulu-Sulawesi Marine Ecoregion.

Global (International) Management

Protection of ecosystems through the designation of protected status for single coral reef species (such as *Acropora cervicornis* and *A. palmata* in the Caribbean) may have impacts on a wide scale by directly influencing industrial nations' policy decisions on international commerce, funding and technical assistance. Outside of CITES Appendix II listing for stony corals, no international legal protections currently exist that protect stony corals from a wide range of impacts outside of direct trade. Protection of coral species and species assemblages may be one of the few existing mechanisms available to almost all governments, designation of which might also benefit associated coral reef organisms and the ecosystems upon which they depend. When such protected status is made by a major industrial or financially-important government, it may play an important international educational role and may also serve to affect other countries' coral reef policy decisions from the administrative top down.

International measures often involve going before international organizations that are uneducated in regards to the importance of, or impacts to, coral reef resources. The creation of international laws, while extremely slow in occurring, may offer some of the widest positive impacts in regards to modifying behaviors at the international, regional and country level. For example, once the impacts

Photo: Coastal Resources Center, URI

Tourist destination on Lurik Island, Indonesia

of anchoring damage caused by large vessels was brought to the International Maritime Organization, the organization adopted a new rule under international law that allows countries to establish no-anchoring areas for large ships.

The trade in non-food marine products (bioprospecting and the marine ornamental trade) is starting to raise concerns regarding private industry (usually from the United States, Japan, or Europe) depleting biodiversity on isolated reefs around the globe. More than one region has raised concerns regarding such "biopiracy" leading to extirpation of unique or rare species, and has strengthened the call for regulated trade at an international level. In some areas the view is that local communities are overwhelmed by their government's improper management in accommodating private industry extraction, suggesting that solutions need to occur at an international level that works directly with community-based resource management. Creation of World Heritage Sites and Biosphere Reserves might serve to facilitate this, though in the case of the Gulf of Mannar Biosphere Reserve this has not happened, suggesting the need for greater international oversight of these important coral reef areas.

Recommendations

Lack of funding, insufficient public recognition of the impact of the problem, and (the resulting) lack of policy-maker focus on the issues are limiting effective coral reef management. While there is wide spread agreement by coral reef managers as to the effectiveness of no-take refuges, the creation and active maintenance of such refuges differs greatly amongst countries and regions. The importance of community involvement in active management of reef resources is recognized at all levels, yet tends to be most effective within single countries with isolated communities that are least impacted by industrialized/commercialized business interests which often influence governmental decision-making.

Useful References and Resources

This paper is based upon presentations made at a symposium on International Coral Reef Management Perspectives at the 9th International Coral Reef Symposium, October 23–27, 2000, Bali, Indonesia. Authors and titles of presentations can be found at: www.nova.edu/ocean/9icrs.

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Coral Reefs Fisheries

Charles Birkeland [1]

Statement of Issue

AT the 9th ICRS, presenters discussed the rapid economic and human population growth that has been putting unprecedented stress on coral reef fisheries isolated and far from urban centers, as well as those near concentrations of humans. Technological developments have allowed depletion of breeding stocks by providing the ability to harvest thoroughly and by allowing access to all previous natural refuges.

Photo: Mark Erdmann

Napoleon wrasses in a cage

State of Knowledge

Traditional Techniques

When fishers used traditional techniques, and human populations were low, coral reefs were able to provide subsistence fisheries for hundreds of years. Nevertheless, archaeological evidence shows that obligate reef fishes such as scarids, acanthurids, lutjanids, and serranids underwent large reductions in size distributions over the centuries in the Caribbean due to localized fishing pressure using traditional techniques. Historical evidence also indicates that there was also a shift in prevalence of fisheries from high to low trophic levels. Pelagic fishes such as carangids and clupeids showed little change and there was a general shift from reef-associated to pelagic fishes as the reef fishes declined.

The traditional fishing techniques used in the Pacific have provided sustained subsistence, but modern techniques (dynamite, poisoning, scuba) are becoming widely used in some areas such as Indonesia. These techniques have had a major impact on resource sustainability and habitat integrity and are now one of the major concerns of fisheries resource managers and law enforcement bodies in tropical countries.

Life History Information

The diversity of coral reef systems brings about intense predation pressure and competitive interactions for small fish, especially for recruiting juveniles. Many of the larger species that are targeted by fishers grow rapidly to adult size before reaching sexual maturity, probably to escape the risks of predation and competition for space. After reproduction begins, the fish are long-lived and slow-growing. For pelagic fishes, which reach sexual reproduction early and continue to grow rapidly, size can be used as a proxy for age in management calculations. But in long-lived, slow-growing species of coral reef fishes, size is not a good proxy for age and so age must be assessed directly through otoliths or other morphological indicators. Life-history aspects of coral-reef fishes that require the use of age rather than size include sequential hermaphroditism and rapid growth to adult size before sexual maturity is attained.

Eritrea Case

Most reef fisheries are already overdeveloped towards economic goals but require much improved management towards the goal of sustainability. In order to do this, nearly US $5 million dollars has been invested to promote the development of artisanal fishery and limit the development of the industrial fisheries system in Eritrea. In this nation the fisheries are being developed with ecosystem and precaution approaches by using multiple social and natural science criteria rather than maximum sustainable yield alone.

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The Analytic Hierarchy Process (AHP) is a method by which complete or incomplete data sets, local knowledge, catch per unit effort (CPUE) information, and expert judgement can complement each other to be combined into an optimization model. Multicriterion assessment methods are used to measure intangible aspects such as habitat quality, preferred fishing locations, behavior of different gear types, and opinions of local fishers. Science is never complete and consideration of multiple socioeconomic factors increases the reliability of CPUE and the efficacy of no-take reserves.

Ecological and No-Take Reserves:
In present times, no-take reserves are being shown to sustain higher levels of reef fish abundance and larger sized fishes for reef-associated species. Pelagic fishes, such as carangids, showed no significant differences inside and outside the reserves except in selected large reserves where small pelagics can thrive. Since the life-history characteristics of pelagic fishes allow them to sustain exploitation at a higher level than do coral-reef fishes, they tend to survive the pressure of overfishing.

The effects of fishing activities on coral reef ecosystems include long-term shifts from coral to algal-based systems, ghost fishing by derelict gear, bycatch, anchor damage and grounding of fishing vessels. The complexity of interactions among coral-reef resources makes the usual management approaches of restrictions of gear type and catch quotas ineffective and with unpredictable results. Therefore, the present method used for U.S. coral reefs is the holistic approach of establishing ecological no-take reserves. The U.S. Coral Reef Task Force has set a goal of protecting a series of reefs as reserves, which represent a variety of reef habitats. The ultimate goal is to set aside at least 20 percent of U.S. reefs by 2010. It is only with the holistic approach that we can expect to effectively maintain ecosystem integrity and fisheries sustainability. The long distance dispersal of the larvae of many species indicates that management of a number of fishery species requires coordination on an international scale.

Relevant Actions Being Taken to Address the Issue

The realization that the most viable management option for reef fisheries is to establish no-take reserves has led other countries besides the U.S. and Australia to take this approach. A 1998 law in the Philippines mandates local governments to set aside up to 15 percent of nearshore waters as fish sanctuaries or no-take reserves. This trend is starting to take hold. Since 1990, more than 400 small no-take areas have been established in the Philippines. Indonesia is also showing interest in this approach as well as other Asian and some Caribbean countries.

Management and Policy Implications

Technological advances have provided humans with the means to gain access to all natural reserves and deplete entire breeding stocks. Modern fishing apparatus and techniques can be destructive to habitats for adults and juveniles on an unprecedented scale.

Specific Recommendations for Action

- Modern techniques that are destructive to the habitat (for example, explosives, poisons, dredging) and equipment that allows complete access to all the breeding stocks (the use of scuba with fishing gear) should be prohibited.
- Because of the complexities of the coral-reef ecosystem, the holistic approach of marine reserves should be implemented.

Useful References and Resources

This paper is based upon presentations at the 9th International Coral Reef Symposium, Mini-symposium C5, *Coral Reef Fisheries*. Authors and titles of presentations can be found at www.nova.edu/ocean/9icrs/.

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Coral Reef Restoration in the Next Millennium

William F. Precht [1] and Richard E. Dodge [2]

Statement of Issue

CORAL reefs around the world have changed dramatically over the past two decades. Many types of disturbance—separately and in combination—are changing the face of reefs. These include: hurricanes, coral bleaching, diseases of corals and sea urchins, overfishing, destructive fishing, nutrient loading, sedimentation, hyper- and hypothermic stress, various forms of pollution, harvesting of reef invertebrates, coral mining, trampling by tourists and divers, and the destruction and devastation caused by ship anchors and groundings. It is obvious that this resource needs protection, and that many of the cited anthropogenic causes can be reduced or avoided by implementation of scientifically-based management programs.

Photo: Florida Keys National Marine Sanctuary

The freighter Miss Beholden being pulled off the Sambo Key reef, Florida Keys National Marine Sanctuary

At the present rate of destruction, reef ecosystems will likely suffer continued significant degradation, possibly to the point of irreversible decline. Accordingly, one appropriate course of action is to replace or restore damaged and disturbed reefs with functional ecosystems at a rate resulting in no-net loss of ecosystem value (that is, rate of reef destruction offset by rate of reef repair). While a potentially worthy goal, the discipline of coral reef restoration is in its infancy. Not only do managers and policymakers need to understand the effects of human-induced disturbances and to be able to properly assess these damages, they also need the knowledge, understanding, and tools to successfully develop restoration efforts on degraded reefs under their stewardship. In addition, it may be futile to attempt restoration unless some chronic causes of degradation, such as pollution or sedimentation, are first reduced or eliminated. These issues were addressed at the 9th ICRS and relevant findings are presented.

State of Knowledge

To date, most coral reef restoration programs have been focused on the physical damage caused by humans. Of these, ship groundings are among the most destructive chronic anthropogenic factors causing significant localized damage on coral reefs and have been the focus of many early attempts at reef restoration. In fact, much of what we know about the rehabilitation of coral reef systems stems from our work in trying to repair reefs injured by vessels that have run aground.

The main themes in reef restoration include:

- The most widely accepted definition of restoration is "the return of a habitat to a close approximation of its condition prior to disturbance." This includes placing all restoration efforts in a landscape context where the restored patch is integrated into an ecosystem.
- As we move into the new millennium, it will be imperative that we restore anthropogenically disturbed reefs to a level that closely resembles (both functionally and aesthetically) a pre-injury baseline.
- Available technology allows us to grossly recreate almost any lost physical structure.
- Research is ongoing to determine best substrates and expected interactions of substrates composition, texture, orientation, and design with the damaged environment and biota desired to be restored.

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- Developing countries could be aided by the development of low cost and low-tech restoration programs.
- Coral nursery programs, the use of cultured coral larvae, and larvae attractants could be a bellwether for returning coral cover to damaged reefs.
- The quantity of reef restoration projects has been slowly increasing over the past decade. Compared to terrestrial and wetland restoration, which range in the 1,000's of implemented projects, coral reef restoration is in its infancy (10's of projects).
- Finding appropriate solutions to a particular damage scenario is often hampered by a general lack of quantitative descriptions of the ecological effects of anthropogenic disturbance on coral reefs and an even greater lack of data describing the direction and rate of natural reef recovery. Therefore, there is little basis for understanding what works, what does not, and why.

Implications for Management and Policy

- Hypothesis-driven, ecological research coupled with quantitative assessment and long-term monitoring programs are the keys to answering these critical questions in reef restoration.
- Restoration results may vary significantly with methods and at different locations. If restoration designs are not meeting the desired objectives, modifications should be considered. The use of adaptive management techniques to guide future restoration efforts can also be an important approach.
- Developing successful restoration efforts in the future will depend upon acquiring and applying a scientific base to this emerging discipline. In addition, because of the infancy of this enterprise, the continued sharing of information will be vital to improving restoration strategies over time. The status of reef restoration has advanced a great deal in a short time; as reef scientists and managers, we should be excited about the opportunities that lie ahead.

Specific Recommendations for Action

- Develop and implement hypothesis-driven, ecological research coupled with quantitative assessment and long-term monitoring programs to address critical questions.
- Formulate and test hypotheses about the response of both corals and reefs to disturbances and about the process of reef recovery, to establish:
  - (1) the degree to which corals and coral reefs have the capacity to naturally recover,
  - (2) how intervention in recovery can retard or enhance the process (or have no effect),
  - (3) the scientific protocols necessary to design and implement restoration strategies, and
  - (4) a scientific baseline for developing quantifiable success criteria, and the efficacy of the restoration effort.

Useful References and Resources

This paper was prepared from presentations at the 9th International Coral Reef Symposium, Mini-Symposium D4 *Coral Reef Restoration in the Next Millennium.* Authors and titles of presentations can be found at: www.nova.edu/ocean/9icrs/

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Florida Keys National Marine Sanctuary. Web site: www.fknms.nos.noaa.gov

Damage Assessment and Restoration Program of NOAA. Web site: www.darp.noaa.gov/

New International Measure to Prohibit Anchoring on Coral Reefs by Large Ships

Lindy S. Johnson [1]

Statement of Issue

ANCHORING by ships on coral reefs can destroy and degrade a significant portion of these fragile and valuable habitats. The dragging and swinging of large anchor cables and chains destroys coral heads and creates gouges and scars that destabilize the reef structure, which can take thousands of years to build. The regeneration of coral reefs from such damage may never occur. At the 9th ICRS, information was presented on international efforts to address the damage from the anchoring of large ships.

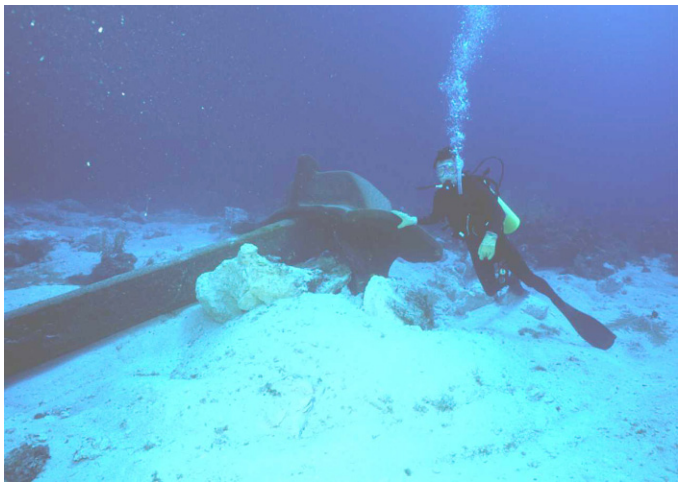

Photo: G.P. Schmahl

Freighter anchor on the Tortugas Bank, Florida, United States, which is now part of the Tortugas Ecological Reserve and off limits to anchoring

Relevant Actions Being Taken to Address Issue

In December 2000, the International Maritime Organization (IMO), a Specialized Agency of the United Nations that addresses international shipping issues, adopted a new rule under international law that allows countries to establish no-anchoring areas for large ships. Such areas may, after submission to IMO, be established in areas where anchoring is unsafe, unstable, or particularly hazardous or where anchoring could result in unacceptable damage to the marine environment. Coral reefs do not provide for stable anchoring, and anchors and anchor cables and chains of large ships also cause devastating harm to coral reefs.

The adoption of no anchoring areas by IMO will assist ships steer clear of these areas by requiring that all countries producing charts for international navigation mark such areas on their charts. The no-anchoring areas measure focuses on prevention of damage, instead of enforcement and liability for damages.

In the first application of this new rule, the IMO also adopted a U.S. proposal to establish three mandatory no anchoring areas for all ships for the unique reefs of Flower Garden Banks National Marine Sanctuary. These areas went into effect on June 1, 2001. In July 2001, IMO's Subcommittee on Safety of Navigation approved the establishment of three mandatory no anchoring areas in the vicinity of the Tortugas, off the coast of south Florida. These areas will be considered and hopefully adopted by the Maritime Safety Committee when it meets in May 2002.

The International Coral Reef Initiative has formed a Working Group on No Anchoring Areas, which will produce documentation to assist countries in submitting proposals to establish such areas to the IMO. This documentation, as well as examples of proposals which have already been submitted will be displayed on the ICRI Forum Web site: www.icriforum.org.

Useful References and Resources

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