CONSERVATION AND SUSTAINABLE USE OF THE MESOAMERICAN BARRIER REEF SYSTEMS PROJECT (MBRS)

COMISION CENTROAMERICANA DE AMBIENTE Y DESARROLLO

SAM / MBRS

RECOMMENDATIONS ON METHODOLOGY FOR MONITORING THE EFFECTIVENESS OF MPA MANAGEMENT

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Belize – Guatemala – Honduras - Mexico

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PROLOGUE

Since the creation of the first Protected Areas, near the end of the 1950's, until today, the concepts of conservation and management of such areas have evolved significantly, from the protection of pristine areas, without the presence of human communities, to the current need of involving these communities in the design and management of Protected Areas.

In the long run, many Protected Areas have been established primarily to reduce the loss of biodiversity and its genetic variations, focusing especially on vulnerable ecosystems and critical habitats, as well as the protection of endangered species and species of economic importance. In the case of Marine Protected Areas (MPA's), it has been demonstrated that biodiversity conservation can also support local economic development, through the improvement of fishing and the increase in tourism.

Nowadays, therefore, the organizations responsible for the management of Protected Areas, marine as well as terrestrial, have adopted different categories of management, zonations which allow different uses with particular areas, and participative processes in decision-making.

Within the region of the Mesoamerican Barrier Reef System Project (MBRS), more than sixty (60) MPA's have been established. According to analyses conducted, many of these undergo various difficulties in an attempt to achieve effective management. Such difficulties include the lack of a physical presence (the so-called "paper parks"), absence of Management Plans, and where such plans do exist, the lack of financial resources and materials to implement them.

In this way, the management of MPA's becomes more complex everyday and requires new tools and strategies, which, in many cases, need to be specific to the particularities of each situation, and which enable the achievement of the goals for which the area was established.

The monitoring or evaluation of management effectiveness is a fundamental tool. This has been defined as a set of actions, which, based on aptitude, capacity and particular competence, enable the satisfactory fulfillment of the function for which the protected area was created (Izuerieta, 1997.)

It consists of systematic and structured methods, defined to answer a series of questions related to how protection of the area supports the maintenance of ecological processes and reduces the loss of biodiversity, how the administrative processes and the elements of the Plan are implemented, and how the area has improved the quality of life of the communities nearby or within the area.

The type and level of questions can include ecological, biophysical, socioeconomic, institutional, political and administrative aspects. To answer these questions, indicators are established that could be measured periodically and that offer improved knowledge of the condition of the site and the situation in which the management actions and components exist.

Currently, various proposed methodologies exist to measure management effectiveness. Some of them are focused solely on the administrative, institutional, political and legal processes, which identify basically if the Management Plan is being implemented satisfactorily. Others are focused on measuring whether the area supports the maintenance of the ecological characteristics and the improvement of the quality of life of the human communities living within or near to the area.

In the majority of cases, the methodologies involve different elements: the context (where are we right now?), the planning (where do we want to be?), the inputs (what do we need?), the process (how do we get there?), the products (what will the results be?) and success (how will we achieve it?).

This document offers a series of recommendations that can be chosen in accordance with the capacity of each area, taking into account that, in some of the 15 priority MPA's of the MBRS, methodologies have been adopted to carry out this evaluation.

The recommendations are based on a rapid evaluation of the 15 MPA's and are focused on the health of the ecosystems, that is to say, whether the MPA's really are conserving biodiversity and the quality of the habitats; as well as the socioeconomic conditions of the local human communities and how they have benefited from the establishment of the area.

The process involved a team of scientists of the consortium of the United Nations University and the International Network on Water, Environment, and Health (UNU-INWEH), in collaboration with Coastal Zone Management Authority and Institute (CZMAI) in Belize and the Centro de Investigación y Estudios Avanzados, (CINVESTAV) Unidad Mérida, México.

The present document does not seek to assess the level of management of the 15 MPA's, but instead the intention is to discover what are the weaknesses, where are the gaps, what should be the priorities and to be able to redirect strategies as necessary. Fundamentally, its application objectively lays the foundation for the quest for financial and political support.

EXECUTIVE SUMMARY

A total of 15 marine protected areas (MPAs) within the MBRS region have been identified for special attention within the GEF-World Bank Conservation and Sustainable Management of the MBRS project. They include one area established in 1992 (Turtle Harbor Wildlife Refuge) and three locations not yet formally declared (Rio Sarstun Multiple Use Reserve and Punta de Manabique Special Protection Area, Guatemala, and Omoa-Baracoa Marine Reserve in Honduras). The MPAs range in size from less than 5,000, to 280,000 Ha.

We were able to obtain detailed information on the current status of all MPAs except Punta de Manabique and Omoa-Baracoa, neither of which is yet formally established or under active management. Information came from detailed questionnaires provided to reserve managers. While there are clearly substantial differences among the reserves, three things stood out as widely representative. Their management operations are poorly financed and their staff lack equipment and facilities necessary for effective management. While they generally have management plans in place, these are not well implemented and regulations are weakly enforced. There is little attention to educational programs aimed at informing the local population and visitors about the reserve, and at raising consciousness of conservation values and the need to ensure sustainability of fisheries and other extractive activities. Overall, while most respondents reported "moderately effective" management, there are few objective data to support the claims, and there is substantial room for improvement in management effectiveness in these MPAs.

A review of current best practice for evaluating MPA management effectiveness reveals a predominant focus on the monitoring of the biophysical attributes of the non-human components of marine ecosystems. Metrics of the abundance and health of foundation species and exploited species are the most commonly used, with a particular emphasis on coral and fish. Most measures of management outcomes for the human communities associated with MPAs quantify subsistence food and economic benefits, or less tangible benefits converted into economic terms. Most assessments of management effectiveness for particular MPAs to date are based on assessments of inputs or outputs derived from once-only interviews with managers, calling into question the objective value and potential to predict and verify the intended effects of management actions. We identify the need to move MPA evaluations to a focus on outcomes measured by scientifically rigorous programs of performance modeling against established baselines

Recognizing that MPA management must be adaptive, a program to assess management effectiveness requires that a baseline of objective data be established for a carefully selected suite of evaluation criteria. The criteria must be matched to well-specified objectives (i.e. desired outcomes) of management, and quantifiable measures of performance or achievement must be defined. These metrics must be monitored through time using consistent methods to assess whether the reserve is meeting, or at least approaching its stated objectives (conservation of natural resources in all cases, often with maintenance of sustainable fishery harvests in addition). Appropriate metrics include biophysical measurements within the reserve, and socio-economic indicators that track the outcomes of management. Eleven (11) of the former, and eight (8) of the latter are specified as the minimum suite of measures of MPA management effectiveness.

Biophysical criteria establish the quality of the non-human components of environments, ecosystems and communities within the MPA, so that changes in quality through time may be tracked. To be effective in meeting stated management objectives, as embodied in these criteria, a reserve must contain environments that improve in quality absolutely or at least relative to comparable environments outside the reserve borders. Since all 15 MPAs have been selected as Locations within the MBRS Synoptic Monitoring Program (SMP), it is logical and cost-effective to use the environmental monitoring that will take place under this program to also serve the needs of the MPA evaluation program. Our 11 biophysical measurements are included in the minimum suite of annually monitored variables under the SMP.

RECOMMENDATION 1

Make use of the SMP in all MPAs.

Monitor the minimum suite of environmental variables established for the Synoptic Monitoring Program within all 15 protected areas. The resulting environmental database will provide several measures of management effectiveness in terms of its ability to preserve habitat quality.

The details of the Synoptic Monitoring Program monitoring protocols are now close to being finalized. There will be annual monitoring during summer months at most monitoring Sites (these are permanent, and replicated within Habitats within Locations). A sub-set of Category 2 Sites will be selected for more frequent and more intensive monitoring. It will be advantageous from the perspective of assessing management effectiveness, if Sites within each MPA are designated Category 2.

RECOMMENDATION 2

Undertake more detailed monitoring of the abundance and health attributes of particularly valued or vulnerable ecosystem components when these are explicit targets of management.
Some MPAs may meet this goal by making that Location one that includes SMP Category 2 Sites, at which more intensive environmental monitoring will take place.

At present, the agreed Locations for the Synoptic Monitoring Program include very few locations not within protected areas. Since, from the perspective of management effectiveness, the goal of environmental monitoring will be to assess the trend in environmental quality of locations under active management, it will be important that Sites that are not under active management are also monitored. We strongly recommend that staff at each MPA consider undertaking the monitoring of nearby, comparable sites that lie outside reserve boundaries.

RECOMMENDATION 3

Monitor reference sites outside MPAs.

In deciding the positions of monitoring Sites at each MPA, it will be very useful to include additional Sites that are in comparable Habitat but outside the boundaries of

the protected area. In doing so, it will be necessary to follow the same rules regarding random selection and adequate replication of Sites. (Two nearby Sites in the same Habitat, one inside and one outside a protected area boundary are NOT replicates: each must be replicated.)

To be effective for monitoring management actions, environmental monitoring program must be consistently applied and sustained over ecologically meaningful periods. The value of the accumulated data grows with each successive monitoring period. Given that these MPAs generally have inadequate budgets at present, it is vital that the management agencies and staff recognize the value of the monitoring program, and make firm commitments to ensure that it will be sustained through many years.

RECOMMENDATION 4

Provide the necessary inputs of resources to the SMP.

It is vital that the administering agency, and the management staff of each MPA in the program recognize the value of a sustained environmental monitoring program, and are committed to participation in the Synoptic Monitoring Program as a high priority activity. Resources to permit this must be provided.

As an effective method for testing the usefulness of the chosen biophysical metrics, while introducing management agencies and personnel to the value of adaptive management, we encourage the implementation of a deliberate "experiment" to test the metrics by undertaking a specific management action after predicting their likely responses to it. This "experiment" should be planned within 2-3 years of the commencement of monitoring. Ideally, the various MPAs will do their experiments in consultation so that several different management actions may be employed.

RECOMMENDATION 5

Management staff of each MPA should plan a deliberate test of the effectiveness of the biophysical metrics being monitored, by implementing a management action within 2-3 years of implementation of the SMP, and assessing the responsiveness of metrics to it. Coordination among MPAs in this management "experiment" will increase the value of the outcome because a diversity of actions may be employed.

The secondary recipients of benefits from MPAs, but the primary targets of management, are the human components of coastal and marine ecosystems. The commitment of resources to management and the degree of compliance with management in MPAs is a function of the real and perceived benefits that accrue to stakeholders. The outcomes of MPA management in terms of direct and indirect benefits to people, both inside and outside the immediate domain of the MPA, are the appropriate measures of management effectiveness. We recommend a suite of metrics in four classes of socio-economic benefit: fisheries, tourism, education and public opinion.

RECOMMENDATION 6

Measure fishery benefits.

MPA managers and scientists should collaborate formally with the ministries-departments of fisheries, the regional fisheries monitoring programs (e.g. CRIPCCA), local fishing associations-NGOs, as well as fishermen to obtain (by providing added assistance as required) basic landings, sales and membership data for the major fisheries operating in the areas immediately adjacent to the MPA.

RECOMMENDATION 7

Measure tourism benefits.

MPA managers and scientists should collaborate formally with the ministries-departments of tourism, local governments, NGOs and industry associations, as well as private sector tourist operators to obtain (by providing added assistance as required) basic economic data on the incomes and employment derived from tourism operations within and in areas immediately adjacent to the MPA.

RECOMMENDATION 8

Measure educational benefits.

MPA managers, scientists and educators should collaborate formally with the ministries-departments of education, national and international universities, museums and NGOs, and industry associations to obtain (by providing added assistance as required) basic data on participation in the educational activities associated with the MPA.

RECOMMENDATION 9

Measure public opinion.

MPA managers, scientists and educators should collaborate formally with the national and local governments, local universities, local and international NGOs, and public polling consultants to conduct (by providing assistance and contracts as required) basic opinion surveys of three target groups that measure levels of awareness and support for the MPA. These groups are "persons in the street" of the nearest town, members of the national government assembly, and the international conservation community.

Additionally, we recognize the value of monitoring the inputs and outputs of the actual management processes operating in MPAs. These are often the easiest to obtain data for, and can be matched accurately to specific management decisions and actions. In the first instance, we focus on resource inputs to enforcement activities, the outputs and a simple outcome of those activities in terms of proportional compliance with MPA regulations.

RECOMMENDATION 10

Measure management input and output statistics.

MPA managers should compile annual statistics on the full operational costs of protecting given areas of marine and coastal habitat, and the proportion of the total amount of user activity within the MPA that is detected as being in contravention of regulations. Time series of these management parameters can be used to inform management decisions.

All 11 biophysical and 8 socio-economic measurements may be used to evaluate management effectiveness in a similar fashion: the values of annual metrics are compared before and after the implementation of management decisions, and among locations where the decisions differ.

We recognize that even our minimum number of measurements may be difficult to attain given present levels of staffing of MPAs. Thus, in addition to our recommended minimum suite, we provide in Table 6 (page 42), an absolute minimum set of measurements, with a methodology, that should be attainable in these 15 MPAs under present circumstances. The key to success of any monitoring program (no matter how ambitious) for the adaptive management of the MPAs of the MBRS is vertical collaboration among levels of social and government hierarchies, and horizontal cooperation among MPA management agencies. The various projects, initiatives and integrations associated with the MBRS project provide the best opportunities for achieving these interactions.

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1. BACKGROUND

The MBRS Program aims to strengthen and improve management of the ecologically, economically and socially important ecosystems along the Caribbean coasts of Mexico, Belize, Guatemala, and Honduras. Significant components of the initiative focus on the network of marine protected areas (MPAs) that span the MBRS because of the putative benefits that accrue from this mode of ecosystem-based management. MPAs function better in theory than reality, and several of those on the MBRS are "paper parks" in that they apparently fail to meet their management objectives (Barzetti, 1993; McField, 2000). Even this generalization cannot be made with assurance, however, because there is no objectively verifiable metric of the effectiveness of management applied to any, much less all of the MPAs in the network. Indeed, it is not yet a network in any operational sense. Enhancing the quality and coordination of adaptive management in MPAs is thus one of the major objectives of the MBRS project. Adaptive management (that is, experimental management that responds to objective feedback by modifying process to optimize outcomes) depends absolutely on practical methods of monitoring the effectiveness of management as it proceeds.

In this report we make recommendations for a program to monitor the effectiveness of management of marine protected areas in the MBRS. Our recommendations are made in the context of current best theory and practice of MPA evaluation, and using baseline data on the 15 designated MPAs in the MBRS region. The report will also provide a framework by which other existing, and any new MPAs in the region can integrate with a comprehensive environmental monitoring and management program to be developed through the MBRS Program.

Because of the delay in finalizing our evaluation, this single Report includes 1) an evaluation of the various models and methods for monitoring MPA management effectiveness, 2) the evaluation of current status of the 15 designated MPAs, and 3) our recommendations for the monitoring methodology to be used in this program to assess management effectiveness.

2. METHODS OF EVALUATING THE EFFECTIVENESS OF MPA MANAGEMENT

2.1 ADAPTIVE MANAGEMENT OF MARINE PROTECTED AREAS

Marine protected areas are a popular management option for the same reason as their terrestrial counterparts: they promise the achievement of multiple, apparently competing outcomes in a cost-effective fashion with little requirement for scientific knowledge. The preservation of biodiversity and cultural heritage, the conservation of exploited resources, and the reservation of access for human recreation and economic gain may all purportedly be achieved by drawing a line on a chart and preventing certain human activities within and adjacent to the enclosed area. The approach is particularly attractive in marine ecosystems because of our relative ignorance of this foreign and dangerous environment, and the very high costs of acquiring biophysical knowledge there to support more reductionist and sectoral types of management. The risks of this ignorance are commensurate, however. The remoteness and openness of marine ecosystems, and their connections to coastal and terrestrial ecosystems pose particular challenges to management by zoning human activity not faced in terrestrial protected areas.

Worldwide, with few exceptions, MPAs have been designated and are being managed *ad hoc* (Alder, 1996; Rudd et al, in press). The criteria for selection, and management objectives of any given MPA, if stated at all, are often vague, mutually interfering, and not prioritized. When stated clearly, they usually involve the preservation of biophysical attributes of the ecosystem that are difficult to measure, or the attainment of societal benefits that are unrealistic given the nature of the MPA and the human and monetary resources available. Little wonder that the managers of barely a handful of MPAs actually undertake to measure their success, depending instead on public perception, often as influenced by propaganda. The tendency for dataless management of MPAs has recently reached crisis proportion as funding agencies balk at requests to invest millions of dollars in operations that lack formal indicators of management effectiveness.

The science of management has evolved to mix the art of human judgment with the skills of implementation and the science of experimentation. Most development has gone into the skills, producing a vast array of models and methods aimed at improving control and efficiency (e.g. critical path analysis). The latter two aspects fall in the realm of decision support and adaptive management, which are of most relevance to the management of marine protected areas. Current best practice identifies outcomes, rather than outputs as the appropriate focus of management decision-making (Armstrong, 1986). The measurement of outcomes, or, more correctly, the degree of their achievement, provides input to more or less formal systems for decision support. When management actions and outcomes are linked in a cycle of trial and measurement whereby a certain management decision can be objectively evaluated and replaced, retained or modified based on that evaluation, then the management is said to be adaptive.

Adaptive management is promoted in high-risk decision-making environments such as fisheries management. The approach is akin to the hypothetical-deductive (Popperian) model of natural science through the conduct of experiments. Just as scientific experimentation demands a clear (falsifiable) statement of the hypothesis and a rigorous system of measurements (monitoring) to test it, so adaptive management requires a clear statement of the means to a desired outcome, and a rigorous method of monitoring the outcome to determine how well it is achieved. We take this as the fundamental justification for the development of guidelines and a framework method for monitoring the effectiveness of MPA management in the MBRS. It follows that there are three, absolute prerequisites for evaluating MPA effectiveness:

1. An unequivocal statement of the desired outcomes (management objectives),

2. A specific management action (decision) to be evaluated, and

3. A set of variables to be monitored that indicate the outcome(s) of that decision.

It is only recently that these requirements have been addressed in the literature of MPAs. Management objectives have received the most attention, in the form of expected benefits resulting from the successful implementation of an MPA (Dixon 1993; Dayton et al, 2000). These may be grouped into three classes (Table 1):

1. Biodiversity Preservation: those that seek to preserve the diversity of an ecosystem in perpetuity (including a unique or representative biophysical or cultural attribute, such as an endangered species, a biodiversity hotspot, a special habitat, a human cultural artifact, etc. or some combination of same) for both human and non-human benefit.

2. Resource Conservation: those that seek to conserve the abundance, standing stock biomass, breeding stock, eggs, larvae, or adult tissue production of an exploited resource (usually a fish population) for the purpose of sustaining harvestable production of target species. The objective usually requires that production within the MPA be exported to and accessible in adjacent, unprotected regions outside.

3. Recreational Reservation: those that seek to maintain access by human users for (usually non-extractive) activities such as water sports, SCUBA diving, education, knowledge acquisition (research), communion with nature and aesthetic appreciation. As with objective class 2 (above), income generation is usually explicit or implicit to this objective.

While these objectives are certainly not mutually exclusive, they are often in conflict (e.g. recreational activities can compromise biodiversity; strict protection can compromise fisheries yields). When they are, it is essential to specify which desired outcome has priority, and to focus on evaluations that reflect that priority. This is rarely done, resulting in contradictory indications of MPA "success".

Associated with each management objective is a set of management actions that experience has demonstrated to have a reasonable chance of achieving the desired outcome (Table 1). These are fairly limited in MPAs because of the restricted range of activities humans can undertake in the marine environment, and the limited ability of marine zoning to control human activities in adjacent terrestrial and upstream environments. They may be grouped into five broad classes, all of which require decision-making and implementation of decisions made:

1. Zoning: sea-use planning, habitat mapping, sea-use mapping, demarcation.

2. Enforcement: legislation, regulation, surveillance, patrolling, interception, interdiction, apprehending, evidence gathering, testifying, punishment.

3. Communication: stakeholder analysis, stakeholder engagement, public consultation,

4. Public relations, promotion, publication, consensus-building, human resource development, education, training.

5. Monitoring: experimental design, data collection, biophysical measurement, resource assessment, socio-economic assessment, opinion polls, public surveys,

6. Decision-support: pressure-state-response analysis, performance benchmarking, cost-benefit analysis, logical framework analysis, critical path analysis, multiple criterion analysis.

Achieving any given outcome will require the use of management actions from most if not all of these groups. It is only the last two, monitoring of actions for decision support, which permit management to be adaptive. They achieve this by providing feedback on the rate and degree of achievement. The outputs of the monitoring actions can also be used to support many of the planning and communication actions, thereby enhancing the effectiveness of zoning and level of compliance, and reducing the need for enforcement.

Associated with each outcome is a set of evaluation criteria or performance metrics that indicate the degree to which it has been achieved (Table 1). They constitute the appropriate focus of monitoring actions. Unfortunately, this is the area where there is least development or consensus in the field of MPA management research, and so the monitoring aspect of management is neglected (Alder *et al*, 2002). Shortcuts are most often employed, if any attempt at evaluation is made at all.

It is important not to confuse the allocation of inputs or the production of the outputs associated with any given management action, with the desired outcomes of that management action. Inputs are the resources that are used to undertake the management action (e.g. money, labour, equipment, etc.). Outputs are the direct, tangible results of the management action (e.g. reports, plans, training curricula, promotional material, monetary incomes, etc.). A great deal of money may be put into the management of an MPA that produces numerous reports, trained people and scientific papers, but these records of inputs and outputs are not in and of themselves measures of the achievement of the desired outcomes of the MPA (although they may provide measures of the size, pace and even efficiency of the management infrastructure and process). If such metrics of inputs and outputs (as in a logical framework analysis) are indeed used as measures of management outcomes, then the (often hidden) objectives of the MPA are focused on institutional development rather than the primary justifications outlined above.

Table 1. Generic framework of the MPA management path from objectives to evaluation.			
Management objectives	Preservation	Conservation	Reservation
Desired outcomes	Permanent maintenance of marine ecosystem integrity, goods & services, biodiversity (at all levels of hierarchical organization), populations of rare species, cultural artifacts.	Long-term maintenance of the export (harvestable) productivity of exploited marine resources.	Medium-term maintenance of the amenity & aesthetic value of sea-scapes & accessible marine environments.
Management Actions	Zoning large areas of intact ecosystems to prevent direct & indirect negative impacts on all ecosystem components. Extension of control to upstream ecosystems. Education & enforcement to ensure full compliance. Monitoring of ecosystem structure & function.	Zoning areas of critical habitat to protect all stages of the life cycles of exploited ecosystem components. Education & enforcement to ensure adequate compliance. Monitoring of exploited resources & societal benefits.	Zoning areas of recreational activity & scenic beauty to protect their valued ecosystem components & attributes. Education & enforcement to ensure adequate compliance. Monitoring of human activities & economic benefits.
Management outputs	No-go Zoning plans. Management & Research plans. MCS infrastructures. Educational materials & research publications. Habitat maps & Biodiversity inventories.	No-take Zoning. Exploitation & Monitoring plans. MCS infrastructures. Targeted informational materials. Stock assessments & Harvest records.	Multiple-use Zoning plans. Usage & Monitoring plans. MCS infrastructures. Promotional materials. Visitor & economic valuations.
Evaluation Metrics (change in:)	Habitat & Spps diversity. Population dynamics of rare & foundation species. Indicators of ecological integrity. Quality of cultural artifacts. # of violations & interdictions. Impact of research products.	Critical habitat area & quality. Population dynamics of exploited species. # of violations & interdictions. Harvest yields. Incomes & health of dependent human populations.	Tourist & recreation business incomes & profits. Direct, indirect & contingent values of ecosystems & components. Water quality (clarity, contaminant & pathogen load).

2.2 CRITERIA FOR MONITORING THE EFFECTIVENESS OF MPA MANAGEMENT

Several lessons may be taken from the analysis of approaches to monitoring the effectiveness of environmental management regimes such as MPAs (Miles *et al*, 2002):

1. There is no single “correct” or “best” model of evaluation. The type of valuation, and metrics to monitor, are critically dependent on the breadth and clarity of the management objectives.

2. There is a virtually limitless degree of detail and complexity in monitoring and valuation methods. The level chosen must be consistent with the resources available.

3. Evaluations must be conducted, or at least critically reviewed by assessors at arm's length from the day-to-day management staff. The grey literature is too full of self-serving self-assessments.

4. Three basic questions **must** be answered in any evaluation:

   a. Are the most valued ecosystem attributes, components or processes being maintained?

   b. Is compliance with the management regulations adequate for the intended level of protection?

   c. Is the management infrastructure economically sustainable?

5. These questions each require the objective monitoring of at least one response metric if the answers are to be used to adapt management actions:

   a. A biophysical metric that tracks the key non-human attribute(s) of the marine ecosystem(s) in which the management occurs.

   b. An economic or impact metric that tracks the tangible benefits to humans (both within and outside the target ecosystem(s)).

   c. A societal metric that tracks the alignment of the human components of the ecosystem(s) with the management objectives and actions.

The identification and selection of the actual metrics, and the design of the monitoring protocols to be used in any given MPA have received a reasonable amount attention in the case of the first (biophysical) criteria for evaluation (Table 2). By comparison, the social and economic metrics have barely been addressed (Table 2). This may be excusable in the case of MPAs intended purely for the preservation of marine ecosystems and their biodiversity, but it is not when the primary objectives involve putative benefits to human populations over the short to medium term. In many, if not most MPAs the stated or implicit management objectives includes aspects of all three of the main types of desired outcomes, yet the monitored attributes are almost exclusively biophysical (Table 2). In those cases where the results of management are measured using performance assessment methods more typical of corporate entities, the focus is on semi-quantitative ratings by the management staff itself, and does not entail an objective, on-going monitoring program.

Table 2. Metrics for evaluating the achievement of specified management goals of MPAs.

Location	Management goal	Monitoring Methods & Metrics	Reference
Global	Multiple objectives depending on the MPA (1300 examined)	- area under protection - existence of enabling legislation - existence of a management plan - evidence of active management actions	Kelleher et al, 1995
Global	conservation through management intervention (Habitat/Species Management Area: IUCN-category IV)	- estimate population size of key species - estimate extent & condition of critical habitat	Hockings et al, 2000
Global	sustainable use of natural ecosystems (managed resource protected area: IUCN- category VI)	- estimate population size of key species - calculate the magnitude of key ecosystem performance indices (ie: P/R) - measure the extent of income derived from "sustainable" production	Hockings et al, 2000
Global	Multiple objectives: - maintaining natural capital of living resources, - appropriately valuing MPA resources, - maximizing economic benefits of non-renewable resources, - meeting societal expectations, - maintaining ecosystem functions, - ensuring management efficiency.	- 10 attributes of the dynamics of fisheries (stocks of target & non-target species, CPUE, recruitment rate, change in trophic level) - 6 attributes of resource extraction (threats, impacts, exploitation rates, compensation, capital) - 10 measures of economic performance (GDP, wages, profitability, access-entry, diversity, ownership, fees, consumer rate) - 10 criteria of social equity and value (no-net-loss, growth, conflicts, stakeholder influence & association, wastes, entry, illegal activity) - 10 attributes of management process (planning, implementation, MCS, research, monitoring, awareness, assessment, review, training, emergency measures) - 10 indicators of ecosystem function (size, capacity, corridors, linkages, habitat, species & habitat diversity, disturbance, pollution, mitigation)	Alder et al, 2002.
Global: tropical	Multiple objectives depending on the MPA (90 examined)	- resons for establishment - existence of enabling legislation - existence of a management planning - constraints to implementation - involvement of stakeholders - evidence of educational outreach - perceptions of success	Alder, 1996
U.S.A.: National Parks	maintain ecosystem integrity through management intervention for generations to come	- detect changes in particular attributes of the coastal ecosystem - determine if those changes are within the bounds of natural or historic variability - predict how those changes relate to natural processes and human influences - understand how such changes, ultimately, affect the condition of the coastal ecosystem	www.nature.nps.gov/im/monitor

Table 2, continued:

Central America: generic protected areas	Multiple objectives depending on the MPA (mainly TPAs)	Weighted ISO 10004 rating (1-5) against an “optimal scenario” by PA managers using 80 variables in 10 fields: administrative infrastructure, policy support, legal instruments, management planning & implementation, information availability, legal & illegal uses, biogeographical calassification, threats.	De Faria, 1993; Cifuentes & Izurieta, 1999
Belize: Barrier reef	Multiple objectives depending on the MPA (n = 8)	Unweighted rating (%) of degree of success in meeting 6 crtiteria:	McField, 2000
U.S.A.: Cape Cod National Seashore	Maintain a permanent reference site for ecosystem changes, develop a prototype monitoring park for the Atlantic and Gulf Coast biogeographic region	- ecosystem-based, issues-oriented program is being developed to detect ecosystem changes - examine contributing factors and consequences of ecosystem changes - to inform park management of the salient issues that such ecosystem changes represent	Roman & Barrett, 1999
U.S.A. California Channel Islands National Park	Preserve, unimpaired, self-sustaining examples of coast of coastal ecosystems by providing early diagnosis of abnormal conditions & identifying agents of abnormal change	General Ecological Monitoring (GEM) program involving 12 protocols to measure ecological “vital signs” involving 63 taxa at 16 sites: - 16 year baseline to establish normal limits of resource variation -.sample sufficiently to detect a 40% variation at alpha=0.05, beta=0.20.	Davis, 1997
U.S. Virgin Islands – South Florida Cluster	conservation through management intervention (Habitat/ Species Management Area: IUCN-Category IV)	- monitoring program is designed to address effects of development and increased visitation on terrestrial and marine ecosystems - effects of hurricanes, droughts, and other natural stresses on marine and terrestrial resources - effects of fishing on fish assemblages and associated reef systems - effects of soil erosion - status of rare, endangered and endemic species.	www.nature.nps.gov/im/monitor
Australia: Great Barrier Reef Marine Park	Preserve integrity of world’s largest barrier reef while encouraging sustainable human activities. 3 issues critical to successful management: - Maintaining conservation, biodiversity and World Heritage values; - Ensuring that all industries are ecologically sustainable; - Reducing land based impacts on water quality.	- annual measurement of live hard coral cover and crown of thorns starfish density on 168 reefs along 8 cross-shelf transects - annual censuses of reef fish abundance on 25 reefs spread along reef in protected and fished areas - disaggregated fishery landing statistics for all commercial and major recreational fisheries compiled □nnually - monthly water quality and nutrient concentration analyses from 14 sites along the coast - logical framework analysis of objectively verifiable indicators of management activity	Sweatman 2002

Table 2, continued:

South Africa: generic marine protected areas	Preserve the marine biodiversity and fisheries productivity of coastal and offshore ecosystems while permitting low impact human uses.	Assess ten broad criteria against stated management objectives (survey): - scientific measures of marine species diversity & abundance of "keystone species" - economic measures of social benefits through fisheries & tourism incomes - level of investment in legal & enforcement systems & success of processcutions - evidence of active management infrastructure	Hockey & Branch, 1997
American Samoa	Preserve marine ecosystem functions and conserve marine resources	- assess ecosystem health ('vital signs') - detect short and long-term environmental change in ecosystem - assess whether change is 'normal' - provide insight into consequences of changes - feedback to management	Craig & Basch, 2001
Australia: Fraser Island	Maintain the persistence of natural populations and communities	-photographic monitoring points in each community - species/area curves for at least 90% species present	Hockings, 1998
Australia: Fraser Island	Maintain the persistence of natural fauna	- incidental fauna records - site monitoring of species list - periodic surveys for rare or threatened species	Hockings, 1998
Saudi Arabia: Ras Moham-med	Maintain recreation & conservation in a marine park	- censuses of commercially fished species at 3 levels of fishing (fished, lightly fished and not fished)	Roberts & Polunin, 1992
Bahamas Exuma Cays Land & Sea Park	Maintain & rebuild populations of rare & over-exploited species	-density, biomass and egg production estimates of primary species (Nassau grouper)	Sluka et al, 1997
Philippines: Apo & Sumilon Islands	Restore damaged fish habitat, Rebuild depleted fish stocks & Enhance fishery yield	- calculate fish yields - estimate catch per unit effort - quantitative abundance estimates of target and non-target species (fishery-independent) - measure density of large predatory fish	Alcala & Russ, 1990; Russ & Alcala, 1996
Sey-chelles	Rebuild depleted fish stocks & Enhance fishery yield	- quantitative abundance estimates of target and non-target species	Jennings et al, 1995
Barbados	Rebuild depleted fish stocks	- quantitative abundance estimates of target & non-target species in side and outside reserve	Rakitin & Kramer, 1996.
Barbados	Enhance fishery yield	- density and size of trappable fish inside & outside reserve - spill-over of adult target fish using mark-recapture	Chapman & Kramer, 1999, 2000.
Philip-pines: Apo Is.	Enhance fishery yield	visual census of fish and habitat attributes before & 1 year after MFR declaration	White, 1988

Table 2, concluded:

New Cale-donia	Enhance fishery yield	- species richness, density and biomass, size distributions and community structure of target and non-target species	Wantiez et al, 1997.
Nether-lands Antilles & Belize	Enhance fishery yield	- abundance, length and biomass of target species	Polunin & Roberts, 1993
Nova Scotia Shelf banks	Protect juvenile haddock & allow stock to rebuild	- abundance, distribution & mortality of haddock by age class	Frank & Simon, In Press
South Africa: deHoop Marine Reserve	maintain recreational fishery through conservation in a marine reserve	mark/recapture of one species of fish (Galjoen - *Coracinus capensis*)	Attwood & Bennett, 1994; .
Australia: Lizard Is. G.B.R.	Maintain recreational fishery through conservation in a marine reserve	mark/recapture of coral trout (*Plectropomus leopardus*)	Zeller & Russ, 1998.

2.3 A PARTICULAR CASE: MONITORING THE EFFECTIVENESS OF FISHERY RESERVES

Perhaps the most commonly monitored index of the effectiveness of MPA management is the degree to which marine fishery reserves achieve their reasonably well-defined objectives of conserving the abundance and yields of exploited species of fin fish. Two methodologies are typically applied (Table 3): Fishery-dependent measures (e.g. CPUE, catch rates and yields inside and outside MPAs), and fishery independent measures (visual census, sampling of large predators, and mark-recapture inside and outside of MPAs to measure spillover). In addition, some modeling studies have been used to predict spillover from extant and hypothetical MPAs (Table 3). Taken as a corpus, these fishery-related monitoring programs provide us with the best evidence of the effectiveness of MPA management in achieving desired outcomes that is available. But they are largely restricted to the evaluation of the management objective of maintaining stocks of exploited fish species, and sustaining the fisheries for them (i.e. the resource conservation outcome). The results to date demonstrate that well-managed no-fishing areas almost always develop increased abundance and biomass of exploited fish species, but demonstrations that they enhance adjacent fisheries are rare and equivocal (Hatcher, 1997; Dayton *et al*, 2000).

Table 3. Applications of various metrics of the effectiveness of marine fishery reserves.

Location	Sites & Management	Reference	Outcomes
I. Fishery-dependent methods (ie: Catch per unit effort- CPUE)			
Philippines: Sumilon Island (coral reef)	reserve, non-reserve (1974-1984); reserve (1985-1986); non-reserve (1987); reserve (1988-1991); hook & line fishing allowed	Alcala & Russ, 1990	sig. decline in CPUE outside reserve after opened to fishing
Barbados (coral reef)	fishing not allowed (> 10 yr)	Rakitin & Kramer, 1996	sig. more fish caught in traps within reserve
Canada : Scotian Shelf (continental shelf)	fishing of ‘target’ species (haddock) prohibited (> 10 yrs) in a very large area on the Emerald & Western Banks	Frank & Simon, in press	no significant effect of reserve on juvenile mortality, higher survivorship of year classes present when reserve established
II. Fishery-independent methods (visual census, length / weight conversions)			
Philippines: Sumilon Island (coral reef)	reserve, non-reserve (1974-1984); reserve (1985-1986); non-reserve (1987); reserve (1988-1991); hook & line fishing allowed	Russ et al, 1992; Russ & Alcala, 1996	- reserve acted as growth refuge - density within reserve increased
Seychelles (coral reef)	several sites with varying fishing intensity (little to none) for 15 yrs	Jennings et al, 1995; Jennings et al, 1996	- exploited fish more abundant in reserves (5); - total species richness and biomass higher in reserves (20)
Barbados (coral reef)	fishing not allowed (> 10 yr)	Rakitin & Kramer, 1996 (a); Chapman & Kramer, 1999 (b)	(a) sig. more ‘trappable’ fish in reserve but not ‘non-trappable’ fish; (b) fish in reserve larger (using traps & visual census - higher density and size of fish within reserve (visual census)
New Caledonia (coral reef)	fishing not allowed (> 5 yr) comparison with pre-reserve data and reference sites outside reserve	Wantiez et al, 1997	commercially important and ‘characteristic’ species: - number of species, density & biomass increased in reserves; - size changes varied among species; - fish community structure changed due to increase in large, ‘exploited’ species, - enhanced recruitment
Netherlands Antilles & Belize: Hol Chan Marine Reserve (coral reef)	fishing not allowed (4 yr)	Polunin & Roberts, 1999	- habitat complexity not different in reserve; - exploited species: 70% showed no difference in abundance, size or biomass; 30% were more abundant & higher biomass within reserve

Table 3, continued:

South Africa-Tsitsikamma Coastal National Park & Cape Recife (coral reefs)	No-take marine reserve (TCNP) and unprotected area (CR)	Buxton & Smale, 1989	three exploited species of sparids were more abundant and larger in reserve
Philippines: Apo, Pamilacan & Balicasag Islands (coral reefs)	community managed marine fishery reserves – fishing not allowed (2 yr)	White, 1988	- visually obvious species - species abundance and richness increased - habitat quality increased
III. Density of large predatory fish (visual census, length / weight conversions)			
Phillipines: Sumilon Island (coral reef)	reserve, non-reserve (1974-1984); reserve (1985-1986); non-reserve (1987); reserve (1988-1991); hook & line fishing allowed	Russ & Alcala, 1996	opening reserve led to sig. Decrease
Bahamas: Exuma Cay (coral reef)	park established 1958; fishing disallowed 1986.	Sluka et al, 1997	larger fish (Nassau Grouper): - more biomass and greater egg production within reserve
Egypt: Ras Mohammed (coral reef)	marine Park – fishing not allowed (15 yrs)	Roberts & Polunin, 1992	- reserve had little effect on total fish biomass (of a group of exploited species) - non-reserve sustained light fishing effort
Great Barrier Reef (coral reef)	conservation of biodiversity, ecosystem function	Zeller & Russ, 1998	- coral trout caught in higher numbers in reserves, although not more abundant; - low spillover of adults
Philippines: Sumilon Island (coral reef)	reserve, non-reserve (1974-1984); reserve (1985-1986); non-reserve (1987); reserve (1988-1991); hook & line fishing allowed	Russ & Alcala, 1996	- visual census of densities of large predatory fish showed higher densities within and just outside reserve
IV. Spillover (movements from within to outside reserves)			
Bahamas: Exuma Cay (coral reef)	- park established 1958; - fishing disallowed 1986.	Sluka et al, 1997	Nassau Grouper: - spillover of large adults for a limited distance
Barbados (coral reef)	fishing not allowed (> 10 yr)	Chapman & Kramer, 2000	- spill-over of adult fish (using mark-recapture)
South Africa (beach)	Recreation / conservation?	Attwood & Bennett, 1994	- spill-over of adult fish (mark-recapture) equivalent to 50 –110% MSY
St. Lucia, West Indies (coral reef)	marine fishery reserve in multiple use management area	Hatcher, 1997	- spillover of adult fish ranges from <1% to 15 % of MFR population / yr (calculations based on home ranges)
Hawaii (coral reef)	yield per recruit (Beverton-Holt) model of marine fishery reserve	DeMartini, 1993	- little increase in YPR in surrounding area - only benefit fish of moderate vagility (e.g. surgeonfish)

Table 3, concluded:

Philippines: Sumilon Island (coral reef)	reserve, non-reserve (1974-1984); reserve (1985-1986); non-reserve (1987); reserve (1988-1991); hook & line fishing allowed	Coral reef Russ & Alcala, 1996	- visual census of densities of large predatory fish showed higher densities near and higher catches in surrounding areas

2.4 TRADE-OFFS IN SELECTING METRICS TO MONITOR MPA EFFECTIVENESS

From perusal of Tables 1-3 (Sections 4.1-4.3) it is apparent that several trade-offs come into play when selecting metrics for monitoring the effectiveness of MPAs. First is the balance between monitoring the desired outcomes of an MPA (e.g. change in biodiversity) *versus* monitoring the actual management of the MPA (e.g. success of education and enforcement actions in changing user behaviour). Second is the balance between human and non-human targets of monitoring effort: the biophysical and ecological attributes of coastal and marine ecosystems *versus* the social, cultural and economic attributes of coastal communities. In those few cases where attempts have been made to monitor the socio-economic outcomes of MPA management, they have been based on qualitative surveys of the opinions of the managers (e.g. Alder, 1996; Amador, 1996, McField, 2000) rather than objectively verifiable measures of the management outcomes in terms of impacts on the livelihoods and attitudes of the people affected by MPA management. Clearly, these metrics have to be added to monitoring programs for MPAs that have multiple, socio-economic objectives. This is the case for most, if not all of the MPAs of the MBRS.

Another critical trade-off is the economic balance between implementation and monitoring. It is apparent from some of the multifactorial, spatially extensive and temporally intensive monitoring programs summarized above that expenditures on monitoring for adaptive management can be a major component of an MPA budget. The benefits of a good feedback to adaptive management must be weighed against the costs of the evaluation scheme in terms of compromised ability to undertake other requirements of MPA management (e.g. education, surveillance and enforcement). All MPAs have to operate within budgetary constraints. In the MBRS these will be restrictive in the extreme for the foreseeable future (although the restrictions will certainly vary among MPAs of different locations, sizes, and history – see Section 5.3 below). It follows that any program for monitoring the effectiveness of MPA management in the MBRS must select a financially and logistically feasible set of evaluation metrics. This is particularly important in nascent MPAs, given that a key secondary role of management evaluation is to provide tangible demonstrations of success to stakeholders, so that they will “buy in” to the MPA concept and implementation.

A final trade-off, unique to multi-national environmental management regimes such as the MBRS program, is that between the locale-specificity and regional generality of management monitoring programs (Miles *et al*, 2002). The benefits of comparability among measures of MPA management effectiveness across the 15 MPAs in four nations spread across the MBRS must be balanced against the costs in terms of reduced ability to tailor monitoring metrics to the specific management needs of a given MPA. This issue has already received some attention in the design of an integrated environmental monitoring program (EMP) for the MBRS (Sale *et al*, 1999). Here, we revisit the EMP in the context of evaluating MPA management effectiveness, and address the socio-economic monitoring aspects in more detail.

The four tradeoffs may be envisioned as a set of decision continua, along which the managers of individual MPAs must place their focus of action according to their priorities and circumstances. One can focus evaluation on:

1. implementation *versus* monitoring
2. management outputs *versus* outcomes
3. ecological *versus* the social attributes of ecosystems
4. locale-specificity *versus* regional generality

We suggest that the managers of most MPAs in the MBRS will appropriately first focus towards the “front” (or "left-hand") ends of these continua, and that progress towards the centre or “back” ends will be a function of the maturity of any particular MPA, and of the MBRS network.

3. CURRENT STATUS OF THE 15 DESIGNATED MARINE PROTECTED AREAS

3.1 NAMES AND LOCATION

The 15 designated Marine Protected Areas were identified early in the implementation of the MBRS project. They were selected from the total set of designated and planned MPAs in the MBRS on the basis that they offered a range of protected areas in various stages of development and management, and because they were mostly in close proximity to international border areas in the region. Thus, they comprise a northern set of 5 reserves close to the Belize-México border, and a southern set of 10 reserves in the general vicinity of the borders between Belize and Guatemala and between Guatemala and Honduras.

The northern reserves are: Reserva Biosfera Banco Chinchorro, Arrecifés de Xcalac Reserve, Santuario del Manati, Corazol Bay Wildlife Sanctuary, Bacalar Chico Marine Reserve and National Park. The southern reserves are: South Water Caye Marine Reserve, Glovers Reef Marine Reserve, Gladden Spit, Sapodilla Cayes Marine Reserve, Port Honduras-Deep River Forest Reserve, Sarstoon-Temash National Park, Rio Sarstón Proposed National Park, Punta de Manabique Proposed Special Protection Area, Omoa-Baracoa Proposed Marine Reserve, Turtle Harbor Wildlife Refuge and Marine Reserve. Three are in Mexico, eight in Belize, two in Guatemala and two in Honduras. Several of these are not yet officially declared as reserves while some have been managed for several years.

3.2 COLLECTION OF DATA

To collect comparable data on the current status of each reserve, we prepared a questionnaire that was sent (in either English or Spanish as appropriate), to each reserve manager following an initial telephone or e-mail contact. The process was intended to facilitate the collection of information, it took considerable time, and in many cases repeated phone calls and e-mail contacts were necessary to finalize the outputs. It was apparent that some reserve managers did not view provision of this information as a high priority, and we believe this may reflect some concern over how the data would be used. Indeed, at the Expert Meeting held in Cancun in May 2002, it was apparent that there was some degree of concern from managers about the whole process of assessing management effectiveness. These concerns must be addressed in the course of implementing this program if genuine adaptive management of MPA's is to be achieved in the MBRS program.

The questionnaire we used is presented in Appendix 1.

3.3 CURRENT STATUS

The information collected by questionnaire is summarized in Table 4. The fifteen MPAs differ markedly in a number of respects. Here we briefly identify the major differences we noted. For convenience we consider those MPAs within each country separately. We then summarize for the region.

3.31 MEXICAN MARINE PROTECTED AREAS

The three Mexican protected areas include one state-managed (Quintana Roo) area (Santuario del Manati) and two federally-managed areas. Of the three, Arrecifes de Xcalac was established in 2000, and at just under 18,000ha it is both the youngest and the smallest of the three. Banco Chinchorro Biosphere Reserve (over 144,000ha) and Santuario del Manati (over 281,000ha) were both established in 1996, although the latter was not assigned staff until 2000. The Santuario del Manati includes all of Chetumal Bay (180,000ha), and extensive areas of lowlands and forest to the north and east (101,000ha), while the others are predominantly marine. GIS data bases do not exist, although one for Banco Chinchorro is in final stages of preparation.

All three protected areas include human habitations, although this ranges from 18 houses for members of the fishery cooperative and a small naval station at Chinchorro, to three towns with a total of about 5,000 people within the boundaries of Santuario del Manati, which is also bordered by the city of Chetumal (population in excess of 170,000). Staff numbers allocated to the management of these areas are small. Six personnel are shared between Chinchorro and Xcalac, and five personnel are employed at Santuario. On site, there are usually two personnel at Chinchorro and one and Xcalac, but the reserve office for Santuario is located 3km outside the boundary of the reserve. No office exists for Xcalac, and a headquarters is currently under construction at Chinchorro. Visitors (fishermen, tourists, scientists) would seldom meet a staff person at any of these reserves. The managements of all these reserves seem to be under-financed, although budget details were not provided for Santuario del Manati. Xcalac relies on the equipment and facilities of Chinchorro at present. In all three reserves, enforcement of regulations is done by PROFEPA, but the presence is inadequate (fortnightly surveillance in Santuario, for example).

All three Mexican MPAs specify conservation as a primary goal (targeted particularly to manatee in the Santuario del Manati), and employ multiple use zoning plans that regulate human activities within them. The directors of all these MPAs consider their management to be moderately effective, despite the fact that they all note serious shortages of personnel, and poor enforcement of regulations.

3.32 BELIZEAN MARINE PROTECTED AREAS

The eight Belizean protected areas range in age from Glovers Reef, declared in 1993 with governing zoning regulations passed in 1996, to Port Honduras, declared on 25th January 2002. They range in size from Gladden Spit and Bacalar Chico, each under 11,000ha in area (of which just over 6,000ha are marine at Bacalar Chico); to Corazol Bay which is 72,900ha in extent. GIS databases exist for most, primarily at the Coastal Zone Management Institute (CZMAI) in Belize City.

Table 4 Summary data on the 15 protected areas

Reserve[1]	Size[2]	Habitat map or GIS[3]	Management plan	Staff[4]	Plan implemented[5]
Glovers Reef 1993 (96)	26000 Ha <10% terrest.	Yes CZMAI & WCS	Yes, draft plan	4	Yes
Port Honduras 2002	54000 Ha 15% terrest.	Yes TIDE	Yes	5	Yes
South Water Caye 1996 (01)	30000 Ha 50% terrest.	Yes CZMAI	Yes	3	Yes
Sarstoon Temash 1994	17000 Ha all terrest. with buffer	No	In preparation	2	No
Corazol Bay 1998	73000 Ha	No	No	0	No
Sapodilla Cayes 1996 (01)	12500 Ha	Yes LIC & CZMAI	Draft plan	4	Yes
Gladden Spit 2000	10500 Ha	Yes CZMAI	Draft plan	7	Yes
Bacalar Chico 1996	11000 Ha 45% terrest.	Yes CZMAI	Yes	4	Yes
Banco Chinchorro 1996	144000 Ha	Yes SEMARNAP	Yes	6	Yes
Arrecifes de Xcalac 2000	18000 Ha ~20% terrest.	Maps only SEMARNAP	In preparation	Staffed from Chinchorro	Yes
Santuario de Manati 1996	281000 Ha 36% terrest.	Maps only	Yes	5	Yes
Punta de Manabique not declared					
Rio Sarstun not declared	35000 Ha	Yes FUNDAECO	Yes	7	No
Turtle Harbor 1992	4800 Ha 54% terrest.	Yes PMAIB, WCS	Draft being approved	4	Yes
Omoa-Baracoa not declared					

[1] Date of declaration, date of effective implementation in brackets if different.

[2] Percent terrestrial shown when this exceeds 5% of total area.

[3] GIS data exist unless stated otherwise.

[4] Total number of staff. Usually only some on site at any one time.

[5] Judgement based on whether evidence of any management activity. In most cases, implementation far from complete.

Management of these MPAs is undertaken variously by the Fisheries or Forestry Departments, but often through co-management agreements with other (non-governmental) agencies. In a couple of cases (Sarstoon-Temash, Corazol Bay) no active management is currently implemented. Staff complements range from seven at Gladden Spit (with four being on site at most times) to zero at Sarstoon-Temash and Corazol Bay. Staff accommodation is present in most reserves. Facilities in Placencia serve Gladden Spit, while a building in Punta Gorda serves Sarstoon-Temash, but nothing exists for Corazol Bay). Visitors could encounter staff frequently at Glovers, Port Honduras, South Water Caye and Bacalar Chico, but seldom or never at other reserves.

Most directors report budgets to be adequate, however there is no budget for Corazol Bay, and the budgets for Gladden Spit and Bacalar Chico are reported as inadequate. The total budget allocations for some of these MPAs have declined in recent years, and most are funded from a variety of sources including international NGOs. The enforcement of regulations may be a problem, but it is rarely reported as such.

Managers of all eight Belizean reserves cite conservation as a primary goal; and several include fisheries enhancement also. Most have zoning plans in place, and directors generally report management as moderately effective (obvious exceptions are Corazol Bay and Sarstoon-Temash). Shortages of funds, and slowness with which decisions are implemented are seen as the primary challenges to achieving management goals in these MPAs. These results are in substantive agreement with those of four Belizean MPAs (including three considered here) conducted by McField (2000), also on the basis of interviews with mangers.

3.33 GUATEMALAN MARINE PROTECTED AREAS

Despite repeated attempts over several months, we were never successful in obtaining information concerning the proposed Special Protection Area at Punta de Manabique. Thus our information is restricted to Rio Sarstun Multiple Use Reserve, which is in final stages of official declaration at this time. This 35,000ha reserve will be co-managed by CONAP and FUNDAECO. It is a coastal reserve, predominantly seagrass and mangrove habitats, and has important conservation values. Management is in place despite the lack of official status, with three staff usually on site (of a total of seven personnel). The area includes some human inhabitants, and fishing is the primary reason to visit. A management plan and some habitat mapping exist, but regulations are not yet in force. The budget, described as inadequate, derives principally from international sources. Overall, the present quality of the reserve appears to be due to its relative inaccessibility, and it will be important to see how things change once the reserve has official status. The petroleum industry may place pressure on this reserve.

3.34 HONDURAN MARINE PROTECTED AREAS

Despite repeated efforts over several months, we were not successful in gaining any information about the proposed Omoa-Baracoa Marine Reserve. Our information is thus limited to Turtle Harbor. This 4,818ha reserve was established in 1992, and management responsibility was transferred from AFE-COHDEFOR to BICA in 1996. Primary habitats include mangals and seagrass meadows as well as fringing coral reefs. The reserve has conservation as its clear objective, and a management plan is in place. Primary reasons for visits to the reserve are fishing and tourism, but no people live within the reserve boundaries. The management staff of four is regularly present, patrolling daily in the reserve, but has no facilities within the reserve and a budget that is inadequate. The budget derives primarily from international and other non-governmental sources.

3.35 SUMMARY FOR REGION

It is apparent to us that, throughout the region, these marine reserves generally lack funding, personnel and facilities that would be required for truly effective management. While reserves that have been established for several years generally have management plans in place, including zoning plans to facilitate variable regulations on use, there is little evidence that the existence of these plans is effectively advertised to the user community, that the user community supports the management goals and regulations, or that users violating regulations run much risk of being charged or punished.

Clearly, there are exceptions to this unimpressive state, and we recognize that among the managers there are many who are genuinely dedicated to the effective management of their reserves. Still, despite the managers generally reporting that management of their reserves is moderately effective, we suggest that there is considerable room for progress to be made. Some of this progress will require little more than training and encouragement of existing personnel, or provision of limited equipment or other resources. Much of this progress will require a commitment, by government, of the necessary resources and personnel to make management effective. Co-management, as has been particularly the trend in Belize, or complete transfer of management responsibilities to NGOs, may be an effective approach for securing the resources and committed personnel that are required. However, co-management arrangements between government departments and NGOs, neither of which have, or are prepared to commit, significant funding to provide a stable budget, will be little if any more effective than management by the government department alone.

At the present time, despite the existence of a significant number of protected areas in the region, and despite plans for further sites to be established (including three of these 15), we do not believe that marine resources are being well conserved, nor fisheries sustained or enhanced, by their presence. There is a real need to improve the effectiveness of management, and a program to monitor effectiveness can help achieve this goal. Effectiveness monitoring can serve the managers by providing quantitative evidence that their efforts are achieving results, and can further assist them in their efforts to gain additional needed support, whether that support be increased budgets, additional personnel, new facilities, or regulatory improvements that lead to more effective enforcement. Effectiveness monitoring can also provide data confirming the efforts managers make, even when those efforts are not immediately successful in terms of improved conditions in the reserve. (Managers deserve recognition for efforts to improve conditions, even when those efforts are not immediately successful because of factors outside the managers' control.) Finally, a program that monitors effectiveness of management in reserves throughout the region can be exceptionally valuable in contrasting the results of different management approaches, whether these be different regulations, different approaches to community education and involvement, or different solutions to particular management needs. Providing the opportunity for learning from one another in this way may be the greatest benefit from establishing a program to monitor effectiveness of management.

4. RECOMMENDED METHODOLOGY FOR MONITORING MANAGEMENT EFFECTIVENESS

Recognizing the significant and often severe limitations of infrastructure, financial and human resources available for the management of MPAs in the MBRS, we have crafted a progressive set of recommendations for monitoring the effectiveness of management. Starting with the objectives and actions of MPA management and the evaluation process as classified in Section 4.1 (Table 1), we first elaborate a few, key response metrics corresponding to each of the three basic evaluation questions, namely:

1. Biophysical metrics that track the key non-human attribute(s) of the marine ecosystem(s) in which the management occurs.

2. Economic or impact metrics that track the tangible benefits to humans (both within and outside the target ecosystem(s)).

3. Social metrics that track the alignment of the human components of the ecosystem(s) with the management objectives and actions.

An extended set of more ambitious evaluation metrics is then developed for each assessment domain, giving particular attention to the specified objectives of the various MPAs considered, and the over-arching goal of the MBRS MPA network. We emphasize the principle of building on success in the implementation of a MPA monitoring program here. Far better to have a few indices measured so as to be objectively verifiable, managerially useful, legally defensible and socially convincing than to attempt a plethora of measurements in ways that fail to achieve these outcomes. When stakeholders are satisfied that management is being objectively evaluated, they will be more likely to contribute to the operation of monitoring programs that more closely match their particular objectives for the MPA.

4.1 IDENTIFYING AND SCALING MANAGEMENT OBJECTIVES

The first step is for the stakeholders in the MPAs of the MBRS to specify and prioritize the desired outcomes of management with greater precision. Clear, well-defined and achievable goals are essential pre-requisites for adaptive management. Vague or contradictory management goals inhibit the design of performance monitoring programs, limit the value of evaluations, and lead to confusion and mis-perception on the part of stakeholders. The text of the GEF program document identifies both conservation and sustainable use as management goals for the entire MBRS, but whether MPAs are to serve only the nature conservation goal, or are also expected to provide for certain human uses is not clear. We deduce that MPAs are anticipated to serve all three of the main management objectives outlined for MPAs in Section 4.1, with the preservation of marine biodiversity being the top priority at the level of the MBRS MPA network. Indeed, managers responding to our questionnaire said as much. MPAs, however, are usually designed, and always implemented at the national and local levels. There, the particular natural and social environment, and the unique needs of the various communities of interest must be considered in setting and evaluating management effectiveness. It is important to differentiate between the primary objective(s), those which have genuine commitment from the major stakeholders; and those secondary, ancillary objectives that are often enunciated on the assumption that any MPA will achieve them to some degree, and in so doing will engage other stakeholders. The most common instance is the inclusion of enhancement of local fisheries as an objective in an MPA created primarily to reserve access for tourism or to preserve biodiversity (Hatcher, 1997).

We note that some of the MPAs have very substantial components of resource exploitation and adjacent (upstream) human use, while others are virtually isolated. It is reasonable to conclude, therefore, that some MPAs will require monitoring of the social and economic benefits of human use, while others will not. This requirement will reflect, in part at least, the degree to which funding of the MPA management is dependent on income generated by the MPA (e.g. as in the case of MPAs managed by government fisheries departments, which are generally funded in proportion to the value of the fisheries. We acknowledge, however, that all MPAs in the MBRS have an expectation of contribution to biodiversity preservation at the regional scale of the barrier reef province, and therefore their management agenda is set in part by the international environmental regime. Particular indices of multi-lateral management effectiveness apply in this case, and the "law of the least ambitious program" (Underdal, 1982) must be kept in mind as a potential reality in the MBRS program.

4.2 MOINITORING BIOPHYSICAL ENVIRONMENTAL METRICS OF MANAGEMENT EFFECTIVENESS

Since conservation of local biological resources (both those exploited and unexploited by humans) is a stated goal for virtually all of the protected areas on the MBRS, it is reasonable to assume that the effectiveness of management can be measured in large part by the degree to which environmental conditions affecting marine habitat improve through time, relative to conditions at other unmanaged nearby locations. Since maintaining, or even enhancing the yields from fisheries is also a goal for many of the stakeholders in these MPAs, and yields from tropical demersal fisheries are known to vary with marine habitat quality (Christensen et al, 1996), measured environmental change in MPAs may also predict the effect of MPA management on fisheries in adjacent areas. Here we use the term "environment" to include both the physical-chemical (i.e. non-living) and biological (i.e. living) components or attributes of the marine environment that comprise the habitats for valued communities and populations. If environmental conditions do not improve, and even if they deteriorate, the extent to which the managed areas come to differ from nearby unmanaged areas, by deteriorating less rapidly, or by not deteriorating while other places do deteriorate will be evidence that management has been effective to a degree. While there are additional measures of management effectiveness, to be discussed below, monitoring of a variety of environmental criteria will be an essential component of the monitoring for management effectiveness.

The 15 protected areas differ in the habitats they include, but with the exception of Santuario del Manati, all have the preservation of all components of the marine communities contained within them as a primary objective of management. Santuario del Manati has conservation of the manatee population as its stated raison d'etre, but preservation of the habitats within the reserve boundaries is clearly intended as a way of helping ensure this species' protection. Thus, metrics of the marine environment within each MPA can be monitored as a proxy for change in the quality of habitat for valued ecosystem components (such as manatees or corals) resulting from management action (or inaction), and against baselines of natural environmental change. We recommend that a minimum, common suite of marine environmental variables be monitored within all 15 protected areas.

These, plus any existing data already available for the various MPAs can provide a baseline of metrics against which to evaluate MPA management in the future. Variations in the history of the MPAs and the effectiveness of the management regimes in which they are embedded (e.g. fisheries, endangered species, etc.), as well as temporal-spatial variations in their biophysical environment produce deviations from the baseline that are not necessarily the result of current MPA management practice (good or bad). Identifying such deviations can be accomplished by contemporaneous comparisons of relevant ecological and socio-economic parameters within MPAs with those same parameters outside of MPAs. In the first case, we absolutely recommend the participation of the 15 MPAs in the Synoptic Monitoring Program (SMP) of the MBRS as a way of ensuring comparability with reference conditions, and with other MPAs. Adopting the SMP as a central part of MPA monitoring program is a cost-effective way to meet the need for biophysical data in evaluating management, and also to enhance integration of the MPA management within the MBRS network by providing a direct link to the integrated database of ecological and socio-economic trends for the region held in the regional environmental information system (REIS).

All 15 MPAs considered here are already planned for inclusion as monitoring Locations within the MBRS Synoptic Monitoring Plan, and rather than recommend an additional, separate layer of environmental monitoring to serve assessment of management, we recommend that the SMP database be used to provide the necessary environmental metrics for assessing those management outcomes related to habitat quality (i.e. biodiversity preservation, resource conservation and valued asthetics).

RECOMMENDATION 1 – Make use of the SMP in all MPAs.

Monitor the minimum suite of environmental variables established for the Synoptic Monitoring Program within all 15 protected areas. The resulting environmental database will provide several measures of management effectiveness in terms of its ability to preserve habitat quality.

4.21 BASIC ENVIRONMENTAL MONITORING

The Synoptic Monitoring Plan recognizes permanent Locations distributed through the region at which monitoring will take place. Within Locations, the plan focuses on three Ecosystems: mangrove forests, seagrass beds, and coral reefs. Within these Ecosystems, it recognizes five Habitats – mangroves, seagrass, shallow backreef (1-5m), shallow forereef (1-5m), and deep forereef (8-15m). The SMP prescribes monitoring to take place within replicate, permanent monitoring Sites within each of these Habitats.

Not all Locations (MPAs) contain all five Habitats. Locations vary considerably in areal extent, and, more importantly, in the extensiveness of the various Habitats they include. For this reason the number of Habitats monitored will vary among Locations, and the number of replicate Sites per habitat will also vary from a minimum of two (to ensure some replication), to a maximum determined by the amount of that Habitat present at a Location, and the monitoring resources available.

The SMP entails a single annual monitoring visit to every Site in the region, to take place in summer months prior to the hurricane season, and to be constrained to the period from 1 June to 31 July each year so as to achieve the contemporaneousness essential to a synoptic monitoring scheme.

The SMP protocols are now in the process of being finalized. They have been adapted from AGRRA and CARICOMP protocols, so will be generally familiar to many of the personnel called upon to implement them. Still, despite this familiarity, there is a need for training in conducting this environmental management, and for quality control of the resulting data. This training must extend to the selection of Sites within Habitats, the decisions on number of replicate Sites to be established, and decisions on the level of replication of samples taken within Sites. (All samples will be quasi-randomly (i.e. haphazardly) selected from within the area of a Site. A Site is defined by the SMP as the area readily accessible when divers work from an anchored boat, and is notionally about 200m x 200m in extent.)

Full details of the methodology to be used in the SMP are available in the Synoptic Monitoring Program Methods Manual, now being finalized. Briefly, the protocols include the following general environmental assessments:

1. A Visit Record giving details such as date, weather, sea conditions, air temperature, Site location and name, names of observers, and so on.

2. At all Sites: Secchi disk readings (vertical from the surface and horizontal within the water column), water sample analysed for temperature, salinity, turbidity and inorganic macro-nutrients (if possible).

3. At Sites in coral reef Habitats: abundance of the major groups of sessile organisms measured by point intercept technique on five replicate 30m long haphazardly placed transects: turf algae, coralline algae, macroalgae, sponges, gorgonians, and genera of stony corals (note that only stony corals are divided taxonomically).

4. At these same coral reef Sites, on the same transects: measurements of diameter and height of at least 50 coral colonies, and estimates of the extent of bleaching and diseases on them, as well as of the percentage “recently dead” and “old dead” using the criteria for ‘recent’ and ‘old’ established by AGRRA.

5. At these same coral reef Sites, on eight replicate, haphazardly placed 30m x 2m belt transects: the abundances and lengths of a suite of target species of fish; and on superimposed 30m x 1m transects: the abundances of recently settled recruits of a defined suite of fish species, and abundances of *Diadema* urchins.

6. At Sites in seagrass Habitat: assessment of seagrass shoot density and blade size following the CARICOMP protocol, plus a measure of epiphyte load (wet weight).

7. At Sites in mangrove Habitat: assessment of mangrove abundance and tree size/age following the CARICOMP protocol, plus a measure of pneumatophore density.

We recognize the work load such detailed, periodic measures imposes on MPA staff, but argue that this is the absolute minimum annual suite of bio-physical metrics of environmental “health” that must be collected. This basic set includes 11 vital biophysical metrics: site weather; water temperature, salinity, turbidity, and dissolved inorganic nitrogen; percent cover of corals and algae; coral colony size and mortality; abundances of selected fish species; seagrass shoot density; and mangrove trunk and pneumatophore density. The physical-chemical attributes of the water column are arguably the most immediate and influential component of the marine ecosystem to respond to anthropogenic stress, and to influence other components. The set also includes the most potent indicators of the health of the most valued marine communities: live hard coral versus macroalgal cover (now a standard global metric); reef fish herbivore and piscivore abundance (a measure of food web truncation and potential for benthos phase shifts); seagrass shoot density and its epiphyte load (superb proxies for nutrification); and mangrove trunk & pneumatophore density (indicators of salinity or sediment redox stress).

4.22 DETAILED MONITORING OF VALUED ECOSYSTEM COMPONENTS AND BIOLOGICAL PROCESSES

Added to these basic metrics must be measures of valued and/or endangered biological components in MPAs that have their preservation as a primary objective. These must be customized to the specific management objectives for species' populations or habitats in any given MPA, but they would normally involve a targeted sampling regime aimed at showing change in the abundance and health of a single species, the rate of a critical process, or the area of an essential habitat. Examples might include manatee population size and age structure at Santuario del Manati, individual size and fecundity of Nassau grouper in Gladden Spit, occurrence and growth rate of *Acropora cervicornis* in coral reef-dominated MPAs, seagrass productivity, or mangrove sediment nitrogen in coastal environments.

RECOMMENDATION 2

Undertake more detailed monitoring of the abundance and health attributes of particularly valued or vulnerable ecosystem components when these are explicit targets of management. Some MPAs may meet this goal by making that Location one that includes SMP Category 2 Sites, at which more intensive environmental monitoring will take place.

Within the SMP, a sub-set of so-called "Category 2 Sites" is to be selected, at which more intensive monitoring will take place, with visits quarterly through the year (again constrained to a narrow time frame each quarter). These Sites will be at Locations that are particularly accessible, and of particular management interest. Existing MPAs are logical locations for some of these, and the establishment of Category 2 SMP Sites within them has the potential to meet the need for more targeted biological monitoring of biological components of ecosystems that are particular focus of management.

Full details of the SMP Category 2 methodology are available in the Synoptic Monitoring Program Methods Manual, now being finalized. Briefly, the Category 2 protocols include the following general environmental assessments:

1. At all Sites: measurement of sedimentation rate using sediment tubes; monitoring of nutrient enrichment by measuring algal production on plates protected from herbivory; more extensive water quality analyses; analysis of organic and nutrient concentrations in surficial marine sediments; and sampling of biomonitors (to be developed) that will integrate nutrient and contaminant loading.

2. At Sites in coral reef Habitat: monitoring of coral recruitment using settlement plates.

3. At Sites in seagrass Habitat: assessment of seagrass productivity following the CARICOMP protocol.

4. At Sites in mangrove Habitat: assessment of mangrove productivity density, following the CARICOMP protocol.

5. At Sites in coral reef, seagrass and mangrove Habitats: analysis of remotely sensed imagery (aerial and various satellite sensors) to monitor change in extent of monitored Habitat.

6. Additional procedures to be introduced as capacity grows and effective measurements are developed to assessment specific management outcomes.

We note that an important process at the initiation of the SMP will be to confirm the selection of Locations, and to choose monitoring Sites within them. At this time some decisions on which will be Category 2 Sites will also be made. At the same time, we recognize that several of these targeted MPAs lack sufficient personnel to undertake detailed monitoring immediately. Therefore, it may be necessary for specific MPAs to confirm they will be Locations within the SMP, to commence annual monitoring at a set of Sites, and to anticipate that some of these Sites will become Category 2 Sites in the future. The important thing at this early stage is to confirm intentions, and work towards fulfilling them, rather than to mount a comprehensive program right from the beginning.

4.23 COORDINATION, REPLICATION AND REFERENCING OF MPA ENVIRONMENTAL MONITORING

To implement environmental monitoring under the SMP at each of the MPAs, it will be necessary to decide whether reserve staff, or a monitoring team from a separate agency will be responsible for the monitoring, and to ensure that the personnel are fully trained in the relevant sections of the monitoring protocol. Then it will be necessary to select permanent monitoring Sites, following the SMP procedures for doing this, and to decide which of these are destined to become Category 2 Sites. It will also be helpful if the decisions made about which Sites and metrics to monitor in each MPA are reviewed by the SMP management team, and if the management staff of each MPA is advised of the monitoring being proposed for other MPAs in the region. This coordination will optimize the amount of replication at the levels of Site and Habitat that is possible within the logistic constraints.

A major problem with the initial set of 23 Locations identified for the SMP is that very few lie outside protected areas. In order to assess the effectiveness of management of protected areas, it is necessary to monitor some Sites that are not under active management. We anticipate that this problem will be addressed by the SMP management team in the process of implementing the program (i.e. during the selection of Locations). It will be very helpful for the SMP, and particularly useful in assessing effectiveness of management of particular MPAs, if comparable Sites are identified outside of (but nearby) protected areas, and used as reference monitoring Sites.

RECOMMENDATION 3

Monitor reference sites outside MPAs. In deciding the positions of monitoring Sites at each MPA, it will be very useful to include additional Sites that are in comparable Habitat but outside the boundaries of the protected area. In doing so, it will be necessary to follow the same rules regarding random selection and adequate replication of Sites. (Two nearby Sites in the same Habitat, one inside and one outside a protected area boundary are NOT replicates: each must be replicated.)

The value of environmental monitoring will grow as the database grows in size. Initial monitoring of Sites will establish a baseline for each Location that can be tracked into the future as successive years of monitoring occur. For assessing management effectiveness, it will be necessary to monitor through several years before trends will become apparent in the data, but feedback will be available in just over a year. Use of the SMP database will be particularly helpful in monitoring management effectiveness because 15 MPAs, as well as other locations not under active management, will be tracked synoptically.

The SMP is intended to become a permanent monitoring program for the region. Nevertheless, intentions require commitments. It will be particularly important that the management staff of each MPA, and the agencies that administer them, are firmly committed to long-term (permanent) monitoring of environmental conditions. Monitoring takes time and resources, and, particularly given the weak financial support of most of these MPAs at the present time, it is vital that monitoring is seen as a high priority activity that must be sustained.

RECOMMENDATION 4

Provide the necessary inputs of resources to the SMP. It is vital that the administering agency, and the management staff of each MPA in the program recognize the value of a sustained environmental monitoring program, and are committed to participation in the Synoptic Monitoring Program as a high priority activity. Resources to permit this must be provided.

We recognize that the commitment of resources to the SMP will be proportional to the degree to which it meets the local need for management evaluation and decision support. The actual suite of sites, habitats and metrics that are monitored in any given MPA will be the result of considered decisions among the trade-offs elaborated in Section 4.4 (above). We advise against allowing the maintenance of the SMP program to detract from the other implementation tasks of MPAs, or to dominate the evaluation activities to the exclusion of societal and economic metrics. Yet, we recognize the priority placed on environmental conservation in MPAs by the societies of all four nations. At an absolute minimum we recommend that the criteria and methods of the SMP be employed in monitoring the most valued Habitat in two Sites each inside and outside the boundary of the MPA. The basic annual monitoring protocol established for the SMP includes our identified minimal list of 11 biophysical metrics. At those MPA s that focus on particularly vulnerable, rare or endangered species, some basic measure of the abundance of individuals within the MPA should be added to this essential list.

We also strongly encourage deliberate tests of the effectiveness of specific biophysical metrics in evaluating management actions. We suggest that at each MPA, following no more than one or two years of monitoring, a prediction should be made of the effect of a particular management action (e.g. the banning of vessel anchoring) on changes in the monitored variates. Subsequently monitored values of these metrics should be compared with those obtained prior to the action to assess the usefulness of the selected metrics in evaluating management outcomes. If MPAs coordinate these tests with one another a variety of different management actions could be used to test the responsiveness of the various metrics, with benefits to all MPAs. Such an "experiment" will be invaluable in introducing management personnel and agencies to the use of adaptive management of their reserves.

RECOMMENDATION 5

Management staff of each MPA should plan a deliberate test of the effectiveness of the biophysical metrics being monitored, by implementing a management action within 2-3 years of implementation of the SMP, and assessing the responsiveness of metrics to it. Coordination among MPAs in this management "experiment" will increase the value of the outcome because a diversity of actions may be employed.

4.3 MONITORING SOCIO-ECONOMIC METRICS OF MANAGEMENT EFFECTIVENESS

The desired societal outcomes of MPA management are generally less well specified, but more easily measured than the ecological outcomes (discussed in previous section). For the MPAs of the MBRS the social and cultural objectives of management are linked primarily to the achievement of the environmental conservation goals, as measured by the environmental metrics described above. Translated into benefits for humans (ecosystem goods and services, *sensu* Costanza *et al*, 1997), MPAs for this purpose provide both direct and indirect benefits, which are delivered *in situ* and *ex situ* (NAS, 2001). These benefits are, broadly stated: the protection of ecosystem structure and function, improvement of fishery yields, enhancement of non-consumptive opportunities, and expansion of knowledge of marine ecosystems (Dixon, 1993; Sobel, 1996). Monitoring the accrual of these benefits to individual humans and communities of residence and interest constitutes the basis for evaluating the outcomes of management, and may thus be used to assess the effectiveness of management decisions and actions.

The direct, *in situ* benefits are those resulting from consumptive uses (mainly fishing), and from certain non-consumptive uses (mainly recreation). They are enjoyed by both residents (nationals) and visitors, but it is mainly the residents who derive the direct and indirect economic benefits (revenues) from them. Other indirect benefits accrue to people (usually *ex situ*) who do not use the resources directly, but who derive spin-off economic benefits, knowledge, and other forms of well-being from the existence of the MPA and the protected valued ecosystem components within it. More than thirty-five economic and more than 25 non-economic benefits of MPAs have been identified (Dixon & Sherman, 1990; Sobel, 1996; NAS, 2001), and methods exist to value both types of benefits in monetary terms (Costanza *et al*, 1997; King & Mazzotta, 2000). Measurements of change in the values of these benefits resulting from management decisions and actions, provide the practical basis for evaluating the effectiveness of MPA management.

Given the stated and implicit objectives of the MPAs of the MBRS, the levels of economic development of the nations involved, the nature of the human communities of residence and interest (i.e. “stakeholders”) in the region, and the current capacities for management of the various MPAs: we identify six socio-economic metrics that can initially and immediately be used to evaluate the effectiveness of management. Three of them are measures of direct benefits (both *in situ* and *ex situ*), two of which can be expressed in monetary currency. The other three are measures of indirect, *ex situ* benefit expressed as a level of satisfaction by three different groups of people. They are:

1. The total annual fishery yields and average per-capita yield to fishermen working within 10km of the MPA.

2. The gross annual income from all tourism operations and the average per capita income of local entrepreneurs and employees in the component of the tourism industry that makes direct use of the resources of the MPA.

3. The annual number of visits by people to the MPA that involve a formal (time-quantified) educational component.

4. The degree of awareness of the MPA and satisfaction with its existence expressed by “persons in the street” of the nearest village, town or city.

5. The same measure of awareness of and satisfaction with the MPA for members of the national government assembly.

6. This same measure for members of an international conservation list-serve.

4.31 MEASURING BENEFITS TO FISHERIES

Fisheries (including those for fin fish and shell fish) provide one of the major sources of income and food for humans in the MBRS. The maintenance and enhancement of yield of high quality protein and high value seafood products from the MBRS is appropriately a key objective of MPA management in the region. The fishery-based metric serves as an indirect measure of the degree to which management of the MPA is resulting in the spillover of catchable fish out of the MPA to adjacent fisheries (Table 3). In the longer term (decade plus), it may also reflect the export of reproductive products from the MPA, but this benefit cannot be separated from the spillover without undertaking detailed tagging and population studies. The 10km areal limit for quantifying this effect is arbitrary (it could be 1km or 50km, depending of the geography of the MPA and the ecosystem in which it is embedded), but its manageable size should reflect typical annual swimming ambits of the dominant fished species (typically <10km for tropical demersal species), and the logistic constraints of collecting area-specific fishery data. The important thing is to select a bounded area adjacent to the MPA where fishing of a known type and magnitude occurs, and to stick with that area for data collection.

The actual metric can be as simple as total landings or sales of fish and number of fishing units (men or boats); or as complex as species-specific catch rates, effort, CPUE and sales receipts. As these data will come from agencies other than the MPA management authority, it is important to be flexible in the type of data accepted. Quantifying direct use market values of extracted resources is one of the more straight-forward valuation challenges, and whether the data are aggregated or disaggregated, in units of raw catch rates, landings or sales reports; they can readily be converted to monetary value and per capita incomes using market prices and frame survey data (i.e. # of fishermen and boats operating in an area). The absolute minimum data set is total tonnes of consumable or marketable fish of a given average value landed per year by a number of fishermen within the prescribed area.

The effect on basic fishery yields of management decisions such as adjustments of MPA boundaries and zoning relative to the location and nature of gradients, edges and corridors in marine ecosystems, and the ambits of fished species, may be evaluated by comparing the temporal and spatial changes in annual benefits to fishermen, and, by extension the greater communities they serve.

RECOMMENDATION 6 – Measure fishery benefits.

MPA managers and scientists should collaborate formally with the ministries-departments of fisheries, the regional fisheries monitoring programs (e.g. CRIPCCA), local fishing associations-NGOs, as well as fishermen to obtain (by providing added assistance as required) basic landings, sales and membership data for the major fisheries operating in the areas immediately adjacent to the MPA.

As the capacity and sophistication of management and interventions develop in an MPA, the methods of assessing the effectiveness of MPA management on fishery outcomes can be expanded to include outputs of fish population models, empirical measures of spillover and reproductive output, estimates of recruitment connections to distant fished ecosystems (i.e. downstream seeding), disaggregated measures of monetary and subsistence benefits, calculation of indirect use values of the fishery sector, and estimates of option values of future uses of fish resources. All of these metrics of fishery-related benefits of MPAs require considerable expertise and expenditure, which we cannot justify at this stage in the development of a coordinated program of MPA management effectiveness for the MBRS. We do, however, point out the obvious efficiencies to be obtained by coordinating the monitoring of fisheries outcomes with the fisheries management component of the MBRS program, which could advance the quality of performance evaluation more rapidly.

4.32 MEASURING BENEFITS TO TOURISM

The tourism industry is the other major direct benefit to the people of the MBRS and, whether specifically designated or not in management plans, the reservation of access by paying tourists to high quality and aesthetically-pleasing coastal and marine ecosystems is a defensible (if sometimes implicit) goal of MPA management. There are many, well-established ways to measure the value of tourism (e.g. investment in tourism infrastructure, number of visitor-nights, etc.), but the requirement here is to focus on direct benefits derived from tourist use of the MPA. Depending on the mode of use, these can most readily be obtained from the summation of receipts from user fees charged over course of a year. Examples include not only fees paid to the MPA directly by tourists or on their behalf by operators, but also the incomes generated from fees for tours, water sports and land-based activities that take place within the MPA, or that make use of view planes to the MPA to sell packages. These would include charges for whale and bird-watching and SCUBA diving trips, and the differential in charges for accommodation and board at a hotel or restaurant of similar facilities that are not located within or adjacent to the MPA. It does not matter greatly whether the entire value of the MPA to tourism is calculated accurately (it is difficult to obtain fully disaggregated data of this sort). What matters is that the services selected for valuation and the methods of valuation remain constant throughout the decision-support cycle.

At an absolute minimum, we identify the total of direct user fees collected by the MPA management, plus all fees charged to tourists by any operator that provides a service that makes direct use of resources or aesthetics in the MPA. The data should be compiled on an annual basis and converted to constant value currency so that inter-annual and inter-national comparisons may be made.

The effect on tourism outcomes of management decisions such as adjustments of zoning regulations concerning water-sports and the carrying capacity of ecosystems for different types and intensities of use, may be evaluated by comparing the temporal and spatial changes in annual economic benefits to adjacent communities derived from tourism.

RECOMMENDATION 7 – Measure tourism benefits.

MPA managers and scientists should collaborate formally with the ministries-departments of tourism, local governments, NGOs and industry associations, as well as private sector tourist operators to obtain (by providing added assistance as required) basic economic data on the incomes and employment derived from tourism operations within and in areas immediately adjacent to the MPA.

As the capacity and sophistication of management and interventions develop in an MPA, the methods of assessing the effectiveness of MPA management on tourism outcomes can be expanded to include more complete and accurate measures of direct and downstream incomes attributable to MPA-related tourism, measures of the willingness to pay and contingent valuations by tourism sectors, the number, types and economic values of alternative livelihoods provided to local residents by the tourism industry. The aim of such metrics should be to precisely target the tourism-related economic benefits (and costs) of particular management decisions around the zoning and regulation of human developments and activities within and upstream of the MPA. All of these metrics of tourism-related benefits of MPAs require considerable expertise and expenditure, which we cannot justify at this stage in the development of a coordinated program of MPA management effectiveness for the MBRS.

4.33 MEASURING DIRECT, NON-ECONOMIC BENEFITS TO HUMAN KNOWLEDGE AND UNDERSTANDING

Many of the benefits of MPAs are less tangible than fish caught and tourists invoiced, but they are none-the-less important. Measuring change in non-economic, *ex situ* values of MPAs as a function of management decisions requires the use of proxy indicators of change in the ways that people perceive MPA benefits and respond to the opportunities they provide. Given the primary focus of MPA management in the MBRS on the preservation of ecosystem structure and function, we suggest that the degree to which visitors to them, and users of their resources avail themselves of the opportunities they provide for formal education is a broadly integrative metric of their effectiveness in meeting the local public good management objective of maintaining information functions (de Groot, 1994). This could be measured in the most basic way by totaling the number of person hours spent in formal educational activities by all visitors to the MPA during a year, and expressing it as a proportion of the total time spent by humans in the MPA. Time spent by people who studied the MPA from afar or used samples, images and other prepared educational or instructional products derived from the MPA in classroom, lecture, seminar and media activities would be included in this calculation. Visits by school groups, research expeditions by scientists and academics, sampling trips from museums would obviously contribute, but also time spent by MPA staff talking with local resource users (e.g. fishermen, dive masters), collecting local ecological knowledge (LEK) and explaining MPA justifications, regulations and research results. These monitoring activities could well be linked to metrics of compliance (see Section 5.4 below).

There is a clear opportunity in monitoring the education outcomes of MPA management to collaborate with the activities of the public education component of the MBRS program (IDEAS). The effect on educational outcomes of management decisions such as adjustments of staff training levels and allocations of resources to surveillance and enforcement, may be evaluated by comparing the temporal and spatial changes in the annual range and amount of educational activity undertaken in the MPA.

RECOMMENDATION 8 – Measure educational benefits.

MPA managers, scientists and educators should collaborate formally with the ministries-departments of education, national and international universities, museums and NGOs, and industry associations to obtain (by providing added assistance as required) basic data on participation in the educational activities associated with the MPA.

As the capacity and sophistication of management and interventions develop in an MPA, the methods of assessing the effectiveness of MPA management on educational outcomes can be expanded to include more complete and accurate measures of direct and indirect benefits from education. Measures of publication and documentation rates, market impact of promotions, income from and willingness to pay for *in situ* training and educational access can be refined as the educational and outreach component of the MPAs' operations grow. These measures may be progressively disaggregated to reveal particular strengths and weakness of various education strategies. The aim of such metrics should be to track the positive impacts of management decisions as revealed by educational outcomes related to change in human perception and behaviour. Such metrics of education-related benefits of MPAs require considerable expertise in the social sciences and expenditure on data collection across multiple agencies. We cannot justify all of these at this stage in the development of a coordinated program of MPA management effectiveness for the MBRS, but we emphasize the importance of coordinating this evaluation activity with the existing education program.

4.34 MEASURING INDIRECT, *EX SITU* BENEFITS TO SOCIETY

These are the most difficult societal benefits to measure. The time scale of delivery of such outcomes as maintained or improved quality of air, water and coastal land is long relative to management time frames. The probability of future benefits from yet-to-be discovered products of biodiversity is difficult to calculate. And the interests of people (often very far away in space and culture) who will never enter the MPA but feel a strong sense of stewardship for it are hard to quantify. Yet, it is precisely these kinds of values and expectations that produce the incentive, human and financial recourses required to establish and operate MPAs. This is patently true for many of the MBRS MPAs, which are largely supported by international NGOs drawing on globally distributed contributions. The degree of awareness of the MPA in groups of people who are not directly affected by it, and the level of satisfaction with its existence expressed by people who are aware of it is one, relatively straightforward metric that can indicate whether a management regime is effective in producing the hard-to-quantify outcomes.

We suggest that simple, short, questionnaire surveys be conducted biannually in three different survey groups.

1. "persons in the street" of the village, town or city nearest to the MPA can be canvassed to declare their awareness of the MPA and the benefits it might bring to them. The actual mode of survey employed must be tailored to the population and community, but well-established protocols exist (e.g. Bunce *et al*, 1999). A typical sample size for such a survey would be 0.05% of the total voting population. The responses from this group will provide a metric of the effectiveness of MPA management in achieving "buy in" from the local population of stakeholders (bottom-up support).

2. Members of the national government assembly or other elected body at the ultimate decision-making level can be polled to determine their knowledge of, and demonstrated or potential support for the MPA in terms of passing legislation and making budget allocations. The mechanisms for accessing these people are best developed through a non-partisan, inter-governmental agency (perhaps CCAD), that has broad support from elected representatives regardless of party affiliation. A large proportion of the target population can be sampled, but it is important that the survey be actually completed by the politician rather than by a technical aide or an individual in a department reporting to him or her. Maintaining anonymity is one way to ensure this. In countries where elected representatives turn over more slowly than biannually, these surveys could be conducted less frequently. The responses from this group will provide a metric of the effectiveness of MPA management in generating political will and resource allocations (top-down support).

3. Members of an international conservation list-serve with a focus on the particular type of ecosystem or human community in which the MPA is located (e.g. the NOAA "Coral List", or the UNDP's "Fisherfolk") can be quickly and inexpensively canvassed for their knowledge of an MPA, and their willingness to visit or volunteer time, money or information. The responses from this group will provide a crude metric of the value placed on the MPA by the rest of the world, and of the effectiveness of MPA management in promoting awareness of those values.

The effect on social outcomes of management decisions such as investment in different types of education, promotion and public relations, methods of enforcement, and policy on research and development, may be evaluated by comparing the temporal changes in these three indicators of social awareness, perception and engagement by the "rest of society" outside the immediate community of stakeholders.

RECOMMENDATION 9 – Measure public opinion.

MPA managers, scientists and educators should collaborate formally with the national and local governments, local universities, local and international NGOs, and public polling consultants to conduct (by providing assistance and contracts as required) basic opinion surveys of three target groups that measure levels of awareness and support for the MPA. These groups are "persons in the street" of the nearest town, members of the national government assembly, and the international conservation community.

As the capacity and sophistication of management and interventions develop in an MPA, the methods of assessing the effectiveness of MPA management using social surveys can be expanded to include more complete and accurate measures of social benefit. Measures of public opinion on key management decisions such as change in the boundaries and zoning of MPAs can be used to refine and justify particular approaches (e.g. no-take *versus* no-enter zones, community-based *versus* military mechanisms of enforcement, etc.). Contingent valuations of key MPA attributes and resources can provide powerful assessments of management effectiveness because they result in monetary valuations that may be directly compared with the direct, in situ benefits (see Sections 6.3.1 & 6.3.2 above). Survey questionnaires can be elaborated and targeted at particular stakeholder groups and communities of interest to provide very specific feedback on how management is perceived by those who are managed. For example, the ratio of supportive to antagonistic attitudes expressed by stakeholders concerning a proposed or effected management action gives a clear signal of how effective it might be (especially if it requires self-compliance to be effective). The aim of such metrics should be to track both positive and negative impacts of management decisions as revealed by human perception and behaviour. The results may also provide the inputs to formal decision-support tools, such as Multiple Criteria Analysis (e.g. Fernandes *et al*, 1999). This sort of monitoring requires considerable expertise in the social sciences, and expenditure on data collection across multiple agencies. We cannot justify all of these at this stage in the development of a coordinated program of MPA management effectiveness for the MBRS, but we emphasize the advantages of collaborating with social science units at universities (both national and international) where the appropriate expertise to design effective surveys, and the interest in producing result useful to management resides.

4.4 MONITORING INPUTS AND OUTPUTS OF MANAGEMENT

Management is an end in itself, and generates many indicators of efficiency simply by its operation. Running a large, multi-purpose MPA is a big, complex and expensive task. There are substantive economic and human resource benefits to be gained by streamlining the management process. Corporate entities have a nearly endless list of inputs, outputs and process rates that can be used to provide feedback on the effectiveness of management interventions and practices (Armstrong, 1986). Which of these are appropriate for improving the effectiveness of MPA management through evaluation? We identify two standard measures of management inputs and outputs as a minimum starting set.

Firstly: the total operation cost per unit area of marine and coastal habitat actually protected from direct (*in situ*) anthropogenic degradation. This can be calculated as the annual sum of all expenses incurred in the operation of the MPA (including not only line items on the MPA management agency's budget, but also the monetary value of "in kind" contributions from other agencies, volunteers, etc.), divided by the area (ha or km^2) of the MPA in which "no-take" "no-damage" zoning is effectively maintained. We note that the denominator will rarely be equal to the total area of the MPA, and that the determination of effective maintenance of zero local anthropogenic impact is dependent on evaluations derived from the biophysical monitoring program (Section 6.2 above). We also recognize that the absolute value of this metric will vary greatly among the MPAs of the MBRS, depending on their environmental and societal circumstances. The primary use of the metric is, however, for temporal contrasts within an MPA, rather than spatial contrasts across MPAs.

The second metric is designed to evaluate the effectiveness of management in achieving compliance with MPA regulations by calculating the ratio of illegal to legal behavior by resource users within the MPA on an annual basis. The method entails enumerating the total number of violations of regulations (whether they are prosecuted successfully or not) occurring within the various modes of MPA usage (fishing, water sports, yachting, nature tourism, scientific research, educational excursions, etc), and expressing that number as a proportion of the total number of user-days spent on each of those uses within the MPA.

We acknowledge that this method is subject to serious bias due to undetected illegal activity and poor monitoring control and surveillance (MCS). (That is, an unrealistically low ratio could be obtained simply by ignoring violations, thereby leading to a false positive indication of effectiveness.) It is also debatable whether it truly measures the desired outcome of compliance, or simply the management output of investment in MCS. We argue, however, that other evaluation metrics of habitat quality (Section 5.2 above) and socio-economic outcomes (Section 5.3 above) will provide a check against such bias, and that the ratio combines both management outputs and outcomes to give a reasonable indication of how an MPA is doing on the critical issue of compliance. As with the $\$.ha^{-1}$ metric (above), this metric is primarily of value in tracking performance within an MPA, but comparisons among MPAs will also be indicative of the relative levels of challenge and investment in this most problematic and expensive of MPA management activities.

RECOMMENDATION 10 – Measure management input and output statistics.

MPA managers should compile annual statistics on the full operational costs of protecting given areas of marine and coastal habitat, and the proportion of the total amount of user activity within the MPA that is detected as being in contravention of regulations. Time series of these management parameters can be used to inform management decisions.

As the capacity and sophistication of management and interventions develop in an MPA, the methods of assessing the effectiveness of MPA management using measures of management inputs and outputs can be expanded to include more complete and accurate metrics. The main avenues of refinement are through disaggregating collected statistics according to management objectives and activities, major budget items, and user groups. Measures of cost per output (e.g. enforcement expenses per successful prosecution *versus* education expenses per reduction in violation rate) provide potent decision support. Measures of change in input rates as a function of alternative management actions (e.g. ratio of income from user fees or contributions from foreign donors to investment in promotional materials) provide guides to the effective expenditure of limited financial and human resources for MPA management. Such metrics do not require great expertise beyond basic management accounting at a level that can be anticipated to exist already in most of the MPAs of the MBRS, and most of the data are already available in some form. The challenge is to identify a manageable set of metrics to be used for evaluation, to link them to specific management options, and to find the time to compile the data and analyze the results.

Regardless of the level of investment in monitoring the management process itself, the aim of such monitoring should remain clearly focused on providing rapid and conclusive feedback to practical management options such as hiring staff and allocation of resources to competing management activities.

4.5 CONCLUSION

In this report we have recommended a minimum suite of nineteen (19) metrics of MPA management effectiveness based primarily on an outcomes-based assessment model (Table 5).

Table 5. Recommended metrics for monitoring the effectiveness of MPAs.	
Biophysical measurements	**Socio-economic measurements**
19 essential measurements for monitoring MPA effectiveness	
Site weather Water temperature Salinity Turbidity Dissolved inorganic Nitrogen Percent cover of corals Percent cover of algae Coral colony size and mortality Abundances of selected fish species Seagrass shoot density Mangrove trunk and pneumatophore density	Value of fishery landings adjacent to MPA Value of tourist activity dependent on MPA Extent of educational component of MPA use Valuation by people in nearby town Valuation by members of national government Valuation by international conservation community Cost per unit area protected as "no-take" or similar Ratio of legal to illegal behavior by visitors
Additional measurements that could be implemented as time and resources allow	
Sedimentation rate Dissolved organic Nitrogren Sediment nutrients Algal productivity Coral recruitment Fish recruitment Seagrass productivity Mangrove productivity Change in areal extent of habitat	Spillover of fishery species Connectivity (downstream seeding) Fish virtual population analysis Fishery-specific incomes Indirect fishery value Fishery option value Indirect tourism value Alternative livelihoods value Publication rates Market impact Training income Public opinion surveys Contingent valuation Expert opinion surveys for MCA

Eleven (11) of these are biophysical attributes of the non-human components of the ecosystem(s) in which management occurs, and eight (8) of which are socio-economic attributes of the human subjects of management. We further identify another twenty-four (24) metrics for future assessment, nine (9) of which are biophysical attributes and fifteen (15) of which are socio-economic attributes that reflect the outcomes of management decisions and actions.

In an effort to further streamline the process, we have compiled an absolute minimum set of metrics and their methodologies in Table 6. They are organized around the basic metrics (above), but modified to reflect the actual capabilities known to exist in many of the MBRS MPAs today. While we term them "absolute minimum" they have to be viewed as a less-than-desirable set for monitoring of management effectiveness.

The biophysical metrics included are based on adoption of Category I monitoring as specified in the MBRS monitoring manual for the synoptic monitoring program (SMP). These require a minimum of at least two permanent "replicate" sites per habitat type, where monitored habitats are any or all of a) shallow back reef at 1-5m depth, b) shallow forereef at 1-5m depth, c) deep forereef at 8-15m depth, d) seagrass meadow, and e) mangrove habitat. The frequency of sampling is one site characterization per year, during the summer. By adopting the protocol from the MBRS Monitoring Manual, we ensure that biophysical monitoring for purposes of evaluating effectiveness of MPA management will be fully compatible with the SMP, and will therefore contribute to the region-wide database that will develop from the SMP. This also ensures that monitoring methods will be uniform across MPAs. Although we have little faith in the use of routine water chemistry to monitor water quality in coral reef ecosystems (Sale et al, 1999), we accept that that will be a part of the Category 1 monitoring. We have dropped our recommended requirement for control (reference) sites outside the MPA from the minimum protocol in order to reduce workload, despite the fact that this prevents unequivocal proof of any effect of protection. The socio-economic and management metrics are also greatly simplified in this minimum set.

The minimum requirement for human resources to carry out this protocol for MPA management evaluation is approximately 388 man-days per year, or, in excess of one man-year per year (obtained by summing the Personnel column). This total can be reduced to 316 m-d / y if an automated weather logging station is used, and some other economies might be obtained by using the same, multi-skilled person to perform multiple tasks, perhaps reducing the requirement still further to approximately 250 m-d/y. This minimum monitoring protocol for MBRS MPA effectiveness should not be seen as the goal, however, but rather as a starting point from which more accurate and informative measures may be developed as capacity and resources improve. Obviously, such developments will require even more financial and human resources, which leads us back to the fact that the implementation of even the minimum protocol will consume just under one third of the currently available man-power in the average MBRS MPA.

Given the average staffing level of 3.9 persons in each of the 13 MPAs for which we have data (range of 0 to 7), and the reports on their current responsibilities and funding (Section 4), it is clear that the human resources are not in place to undertake even the basic monitoring protocol, much less the full suite of 43 metrics recommended to be monitored. The managers are too busy managing to evaluate their management effectiveness!

The resolution of this apparent paradox lies in a combination of strategically enhanced staffing and funding (in part provided through the MBRS project), and greatly facilitated collaboration, partnering and networking among MPA management authorities and a pantheon of local, national and international organizations. In particular, we identify the necessity and benefits of cooperation among ministries of fisheries, tourism, education and finance on collecting and compiling the data for the metrics within each of the four countries. We also emphasize the contributions that municipal agencies, businesses and local NGOs can make to the data set used to evaluate MPA management. Finally, we point to the other initiatives of the MBRS project that complement the Marine Protected Areas component (i.e. the Synoptic Monitoring Program, the Regional Environmental Information System, the Sustainable Fisheries Management project, and the Public Awareness and Environmental Education component), and note the many ways that coordinated data collection and sharing can achieve multiple monitoring goals in a cost-effective fashion. Ultimately, it is only through the integration of objectives of all these projects across the four nations that management outcomes will be monitored and used adaptively. This will take political will and long-term commitment of knowledgeable people at many levels.

Table 6. Summary of minimum protocol for monitoring the effectiveness of MPAs in the MBRS

Synoptic Monitoring Program - Physical Environment								
METRIC	**PURPOSE**	**LOCA-TION**	**REPLICA-TION**	**FRE-QUENCY**	**EQUIPMENT**	**TASKS**	**PERSONNEL**	**COLLABOR-ATIONS**
Weather [air temp., wind velocity, precipitation, % cloud cover]	Characterise the physical-chemical environment of the MPA for explanatory, comparative & modeling purposes	Centrally-located site on low-lying land exposed to maritime climate	1 / MPA	1 set observations / day (minimum)	Manual or Automated weather station (AWS) (preferred)	Record daily observations – log to digital spreadsheet	1 - minimally trained 0.15 man-days (0.05 if automated) per observation = 55 m-d / y (19 m-d / y if automated)	National Met services, CPACC, Coastal GOOS, etc.
Sea Surface Temperature (STT)	Ditto + Calibration of NOAA bleaching hotspot predictors.	Top of well-mixed water column	1 / MPA (minimum) + 1 / outer slope site + 1 / lagoon site (better)	1 / tidal cycle or 2 / day (1@night & 1@day minimum)	Mercury thermometer, or thermister linked to AWS (preferred)	Record daily observations – log to digital spreadsheet	1 - minimally trained (same individual as for weather above). 0.15 man-days (0.05 if automated) per observation = 55 m-d / y (19 m-d / y if automated)	CPACC, Coastal GOOS, NOAA Coral, etc.
Salinity (ppt)	Ditto + Calibration of river flow data.	Centre of well-mixed water column	Ditto + 1 / river mouth site (if present)	Ditto + following storm events.	refractrometer, or conductivity cell linked to AWS (preferred)	Ditto		Ditto + LOICZ
Turbidity (% attenuation)	Ditto + Calculation of light attenutation through water column.	Ditto	Ditto + 1 / river mouth site (if present)	Ditto	Turbidometer, or transmissometer linked to AWS (preferred)	Ditto		Ditto
Dissolved Inorganic Nitrogen (mmoles DIN)	Characterize water quality in terms of level of eutrophication.	Ditto	Ditto with 3 replicate samples per site.	1 / week + following storm events.	Clean sample bottles & on-site lab, or freezer for storing samples for export.	Perform analysis and maintain laboratory standards.	1 – trained water chemist. 1 man-day per sample set = 52 m-d / y	Ditto

Table 6, cont.

Synoptic Monitoring Program – Biological Parameters								
METRIC	**PURPOSE**	**LOCA-TION**	**REPLICA-TION**	**FRE-QUENCY**	**EQUIPMENT / METHOD**	**TASKS**	**PERSONNEL**	**COLLABOR-ATIONS**
% cover of live hard Coral	Provide benchmark of potential for reef growth	Reef slopes (8 & 15m depth) & Backreef	2 replicate sites / Habitat type	1 / year (annually) during summer	Category I sampling as defined in MBRS Environmental Monitoring Manual	Select sites, lay transects & quadrats, record data, tabulate & analyse data.	3 – trained SCUBA divers. 3 man-days per site = 18 m-d/y sampling + 5 m-d / y analysis = 23 m-d / y total.	CARICOMP, Reef Check, ICRI, NGOs, etc. Universities, local dive clubs .
% cover of fleshy macro-Algae	Provide index of shift in benthic community	Ditto	Ditto	Ditto				Ditto
Coral colony size (cm / m2) & mortality rate (% /Y)	Provide measures of the health & longevity of reef foundation species	Forereef slopes (8 & 15m depth) & Backreef	2 replicate sites / Habitat type	1 / year (annually) during summer				Ditto
Density of target Reef Fish (# / m^2)	Provide measures of habitat quality & impacts of fishing	Ditto	Ditto	Ditto				Ditto
Density of Sea Grass shoots ($ / m^2) & epiphyte load (g / m^2)	Provide measures of the health & stress of lagoon foundation species	Lagoon Sea Grass Meadow	Ditto	Ditto				CARICOMP, LOICZ, RAMSAR, etc. Universities, local naturalist clubs & NGOs.
Density of Mangrove pneumato phores (# / m^2)	Provide measures of the health of shoreline foundation species	Coastal or island Mangal	Ditto	Ditto				Ditto

Table 6. cont.

Socio-Economic Parameters								
METRIC	**PURPOSE**	**LOCA-TION**	**REPLICA-TION**	**FRE-QUENCY**	**EQUIPMENT / METHOD**	**TASKS**	**PERSONNEL**	**COLLABOR-ATIONS**
Value of fishery landings adjacent to MPA in mass (i.e. food value), jobs & incomes.	Evaluate potential contribution of spillover of catchable fish from MPA to local fishing communities	Contig-uous habitat within 10km of MPA	1 landing site per MPA (minimum). All commercial species	Variable, depending on size & mode of landings. Weekly samples at least.	Stratified random sampling of fishery landings (by spps. or taxa), market value & effort, according to current assessment practice.	Frame survey of local fishery, landing site visits, interviews with crew, data analysis.	2 – trained in fishery-based stock assessment. 1 man-day per site per week = 104 m-d/y	FAO, CFRAMP, Min. of Fisheries, Fishermen's Co-operatives, Fishing companies, Fishers, Fish vendors.
Value of tourist activity dependent on MPA in # of jobs & $ incomes per year.	Evaluate contribution of MPA-associated tourism to the economic well-being of local communities.	Coastal zone within or adjacent to MPA, Source boat marinas.	All hotels, cruise ship, tour operators & yacht charter centres that use MPA	Variable, depending on type & intensity of tourism activities. Annual totals (minimum).	Collation & summation of proportional or marginal business earnings ($) and employment (#) attributable to the MPA, as derived from industry statistics & interviews.	Identify stakeholders, draft question-naires, hold interviews, tabulate & analyse data.	2 – trained in interview-based socio-economic data collection. 4 man-days per business per year = 20 m-d/y (assuming 5 businesses) + 5 m-d data analysis = 25 m-d/y total.	Blue Flag, Min. of Tourism, Industry Associations, Tourism business operators.
Educa-tional compon-ent of MPA use (teaching days / y)	Measure of spin-off benefits of the MPA for capacity-building and potential for long-term sustainability resulting from community support.	Local & distant educa-tional institu-tions that make use of the MPA	2 of each type (minimum) Aim for complete survey.	1 assess-ment per year.	Collation & summation of number of student-days spent studying the MPA in class or on field trips. Categorized on basis of tertiary, secondary, primary & outreach educational programs.	Identify stake-holders, draft question-naires, hold interviews, tabulate & analyse data.	2 – trained in interview-based socio-economic data collection. 4 man-days per business per year = 20 m-d/y (assuming 5 educational institutions) + 5 m-d data analysis = 25 m-d/y total.	Min. of Education, Universities, vocational schools, high schools, primary schools, private research institutions (e.g. Earth Watch, Coral Cay Conservation, RIMS, etc).

Table 6. Socio-Economic Parameters, cont.

METRIC	PURPOSE	LOCATION	REPLICATION	FREQUENCY	EQUIPMENT / METHOD	TASKS	PERSONNEL	COLLABORATIONS
Valuation by people ("man in the street") in nearby town ($ / km^2)	Measure of the actual level of support for the MPA by the urban community.	Nearest village, town or city to the MPA	None at level of community. >10 informants in each stakeholder group. ~ 0.05% of the total voting population.	1 assessment every 3 years.	Contingent valuation of individual "willingness to pay" ($) for the management of the MPA. Categorized on basis of use of the MPA.	Identify stakeholders, design randomiz-ed sub-sampling plan, draft questionnaires, hold interviews, tabulate & analyse data.	2 – trained in interview-based socio-economic data collection. 10 man-days per community per year + 8 m-d data analysis = 18 m-d/y / 3 years = 6 m-d/y total.	Elected officials, Municipal governments, village councils, citizen & residents groups.
Valuation by members of national government (# laws & regs. / y), ($ / y)	Measure the degree of awareness of & commitment to the MPA at highest level of government, and their potential impact on the MPA budget.	Nearest seat of government.	None at level of nation, >2 informants in each relevant ministry and agency.	1 assessment every 3 years (or electoral cycle – whichever comes first).	Collation of indicators of the government's support for the MPA as measured by amount of legislation passed and budget allocations for implementation.	Identify relevant public servants, draft questionnaires, hold interviews, tabulate & analyse data.	2 – trained in interview-based socio-economic data collection. 8 man-days per year + 8 m-d data analysis = 16 m-d/y / 3 years = 6 m-d/y total.	Government ministries, departments & agencies. Opposition members. Public governance & citizens' advocacy groups.
Valuation by international conservation community ($ / km^2)	Measure of the degree of interest and level of priority placed on the MPA by the international conservation community.	Offices of conservation groups & NGOs.	1 key informant (i.e. leader) in at least 3 agencies that work in the MPA, and at least 3 agencies that do not.	1 assessment every 3 years.	Contingent valuation of agencies "willingness to pay" ($ or m-d) for the sound management of the MPA.	Identify relevant stakeholders, draft questionnaires, hold interviews, tabulate & analyse data.	2 – trained in interview-based socio-economic data collection. 2 m-d/group (= 12 m-d) + 6 m-d data analysis = 18 m-d/y / 3 yrs = 6 m-d/y total.	CCC, IUCN, TNC, WWF, etc… Local NGOs & conservation organizations collaborating with these international groups.

Table 6. Socio-Economic Parameters, cont.

METRIC	PURPOSE	LOCA-TION	REPLICA-TION	FRE-QUENCY	EQUIPMENT / METHOD	TASKS	PERSONNEL	COLLABOR-ATIONS
Cost per unit area protected as "no-take" or similar ($ / km^2)	Measure of the cost-effectiveness of conservation management.	MPA manage ment authority.	None, but in large, multiple-use areas with several MPAs, costs may be calculated for each.	1 assess-ment every 2 years.	Full financial analysis of expenditures and incomes associated with all aspects of establishing and operating the MPA.	Conduct audit of MPA finances. Scale annual net cost (or profit) to area protected.	1 – trained in financial auditing and ecological economics. 8 man-days per MPA / 2 years = 4 m-d/y total.	MPA management authority, military & civilian enforcement agencies, private sector contractors working in the MPA, financial institutions.
Ratio of legal to illegal behavior by visitors (# violations / # of visitors)	Measure of the effectiveness of regulation, enforcement & compliance.	MPA manage ment authority & enforce ment agencies	None, but in large, multiple-use areas with several MPAs, ratios may be calculated for each.	1 evaluation per year.	Calculate proportion of observations, apprehensions, interventions and prosecutions of violators as a proportion of total MPA use.	Interview MPA manage-ment authority, enforce-ment agency & legal staff. Tabulate records and scale to total number of visitors.	1 – trained in maritime monitoring, control & surveillance. 1 – para-legal. 4 man-days per MPA / year.	MPA management authority, military & civilian enforcement agencies, law firms, fishermen & tourist operators.

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6. APPENDIX 1

Baseline Data on Marine Protected Area - Data Collection Questionnaire

This is a long questionnaire, however, many of the questions can be answered with one or two words. Please take the time to answer all questions carefully. Your answers will guide us in assessing the current status of this MPA. After you have received this questionnaire, and had a chance to provide your answers, there will be a follow-up telephone interview to clarify particular questions. In advance, thank you for your assistance.

A. Your name, position, contact info:
B. Name of MPA:
C. Geographical Location:
D. Date and History of Establishment:

1. When was this MPA established?

2. Under what legislation is it established, and which branch of government has responsibility for it?

3. Does that agency manage it directly, or is management responsibility ceded to others (an NGO, a private group, a company)?

4. Name of current Manager, or other individual with primary responsibility for the location?

E. Area and Description of the MPA:

1. What is the area of the MPA? How much of this is marine, and how much terrestrial?

2. Describe the primary habitats represented in the MPA (reef, seagrass, mangrove, lagoon, estuary, caye, beaches, coastal forest, etc), and the relative coverage of each.

3. Do habitat maps, or a GIS database of the MPA exist? If so, where are these kept, and are they available to us?

4. What are the most notable flora and fauna found in the MPA?

5. Is there any cultural heritage within this MPA?

F. Purpose of this MPA

1. In your opinion, is there a clearly stated, and clearly understood reason for the establishment of this MPA? What was it formed to do (preserve biodiversity, manage fisheries, restrict recreational access to the area, other)?

2. Is the MPA zoned for multiple uses?

3. What human activities are controlled in the MPA?

4. In your opinion, is the MPA proving to be very effective, moderately effective, or not effective at all in fulfilling its objective?

5. What are the main reasons for its success or failure (legislation, enforcement, personnel, budget and resources to do the job, problems that arise outside its borders cannot be controlled, and so on)?

G. Local Human Population, Levels of Use:

1. Do any people live within the boundaries of the MPA? How many (approximately)?

2. What is the nearest population center outside the MPA boundaries? How near is it, and how many people does it contain?

3. What are the primary human activities within the MPA (commercial fishing, sport fishing, tourism, diving, etc)?

4. Do people fish within the MPA boundaries? Is this fishing legal? If fishing occurs, for what species, and by what methods?

5. Are there data concerning the fishing effort and fishing yield from within the MPA?

6. Has fishing effort/yield increased, decreased, or remained the same over the past 5 years?

7. Do people visit the MPA for reasons other than fishing? What are these other uses (do they extract other resources, or not)?

8. If one use is tourism, how many tourists visit each year? Are there tourist accommodations within, or near the MPA? How many tourists can be accommodated at one time? What are the main tourist activities in/on the water?

9. Has tourism increased, decreased, or remained the same during the past 5 years?

10. Do people visit the MPA for reasons other than fishing or tourism? What reasons are these? How many people visit each year for these purposes?

11. Do people living near the MPA understand the value of, and support the existence of the MPA?

H. Management of the MPA – Staffing:

1. How big is the management staff for this MPA? What are the educational/experience qualifications of the management staff?

2. Are there management staff permanently present at the MPA? How many?

3. Are management staff present some of the time? If so, how much of the year will staff be present?

4. Does the MPA management agency have a headquarters, a visitor center, or other buildings at the MPA? Are there plans in place for development/expansion of these facilities?

5. Do visitors to the MPA encounter management staff frequently, seldom, hardly ever, or never?

I. Management of the MPA – Budget:

1. What is the annual budget for management of this MPA?

2. Does the budget come from core government funds, from visitor fees, from donations, from international NGOs, or from other sources?

3. Is the budget adequate to achieve the goals of management? Has the budget increased, decreased, or remained the same over the past 5 years?

4. Can details of the budget be made available to us?

5. What equipment, infrastructure, and physical resources does the management staff have to assist them in their work (vehicles, computers, database, specialized scientific, meteorological, hydrographic equipment)?

J. Management of the MPA – Programs:

1. If detailed habitat maps for the MPA do not exist, is work being done to create these? What kind of work?

2. Are any aspects of the MPA being monitored in a systematic way, to track and document changes over time? Briefly describe any monitoring programs (for e.g. environmental quality, resource replenishment, amenity value, management effectiveness)?

3. Does the MPA participate as a site in any national or international environmental monitoring program such as CARICOMP, CPACC, GCRMN, AGRRA or similar? Which programs does this MPA participate in?

4. What are seen as the most pressing environmental problems in this MPA? What data collection programs are in place to document and monitor these problems?

5. Are any records kept of the number of visitors to this MPA? If so, for how long have they been kept? Do they show the purpose for which each visitor entered the MPA?

6. In general, how reliable are the various data that are being collected for this MPA? How are data stored? How accessible are they?

7. How knowledgeable are management staff concerning the monitoring of environmental quality, or other aspects important for this MPA?

8. Does the management staff (or another group) provide any educational programs or materials for visitors?

K. Management of the MPA – Effectiveness

1. Is there an MPA Management Plan? If so, does it include regulations that govern the activities of people who visit the MPA? Do these Regulations restrict what people can do there? What are the restrictions?

2. Can a copy of the Management Plan be made available to us?

3. Do visitors generally respect the Regulations? If people visit the MPA for more than one purpose, which types of visitor are most respectful of the regulations? Which visitors respect the regulations the least?

4. Has respect for the regulations in the MPA increased, decreased or remained the same over the past 5 years?

5. Do MPA management staff have the resources and people for surveillance of usage, and enforcement of regulations? Which agency is responsible for enforcement of regulations?

6. Do MPA management staff have the authority to charge someone with a violation? If not, who does? Are charges ever laid?

L. Other topics

1. What topics concerning this MPA are important but have not been discussed? What are these important issues?

2. What are the major problems faced by the management of this MPA?

3. Any other comments?