

# A Method for Evaluating Marine Protected Area Management

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*An assumption underlying the growing support for marine protected areas (MPAs) is that they meet conservation goals and provide economic benefits to fisheries and ecotourism. However, support for MPAs will be at risk if managers cannot assess whether various MPA objectives are being fulfilled. Current approaches to MPA management emphasize the need to evaluate performance criteria; however, there is little consensus on criteria and their evaluation.*

*We propose a marine protected area evaluation model (MPAEM), based on and modified from a multidisciplinary approach used to assess the sustainability of fisheries, called rapid appraisal of fisheries (Rapfish). The application of the MPAEM was explored in a pilot study of 20 MPAs located in different regions of the world. Results indicate that the MPAEM can be used to evaluate MPA management effectiveness. However, the manner in which the evaluation attributes are scored and ways of engaging user groups should be explored before MPAEM can become part of the day-to-day management of MPAs.*

**Keywords** coastal management, management evaluation, marine protected areas, model, performance criteria

## Introduction

There is a growing consensus that marine protected areas (MPAs) should be an integral component of any marine management plan, including fisheries management programs (Costanza et al., 1998; Boersma & Parrish, 1999; Sumaila et al., 2000). For example,

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under certain conditions, MPAs will improve the sustainability of exploited fisheries (Bohnsack, 1996; Brown, Sheehans, & Figuerido, 1998; Russ & Alcala, 1999). Much of this observed MPA effect is due to the improved biomass, abundance, or biodiversity noted after protection of exploited resources. Studies on the economic benefits and costs of MPAs are fewer, although they generally support the benefits of MPAs under specific conditions (Hannesson, 1998; Sumaila, 1998; Conrad, 1999; Sanchirico & Wilen, 1999). However, most of these studies are theoretical and await field validation. There have been even fewer studies on the potential social benefits of MPAs (White et al., 1994; Alder, 1996; Bunce et al., 1999), but one could assume that if MPAs provide improved economic returns, ultimately (and with good governance) social benefits would follow.

In general, these studies have been topical (e.g., fisheries related) and site specific. None have examined the overall impact of MPA management in an integrated and holistic management framework. Often the impetus to establish a MPA is to protect an ecosystem or resource while providing a range of economic and social benefits. This results in objectives being set for the area, with consequential expectations of stakeholders, managers, and politicians. In terms of fisheries management, effectiveness in maintaining (or recovering) fish stocks is critical to community support for MPAs (Agardy, 2000a). The ability to evaluate whether these objectives are being met will become increasingly important as more MPAs are established. The process of goal setting is closely linked to stakeholder expectations, reserve design, and the establishment of criteria to evaluate the progress made in meeting those objectives (Agardy, 2000b). If goals are not well articulated, it is difficult to define criteria to measure progress or to identify and quantify the indicators of progress (Kay & Alder, 1999).

The aim of this article is to present a new evaluation approach for MPA performance. The scheme is multidisciplinary and may be adapted to show progress in achieving different specified goals.

## Evaluating MPAs

In MPA management, monitoring and evaluation of management performance is beginning to receive attention, and several approaches are emerging from broad, strategic comparisons of MPAs, as indicated in this article, to park-specific programs (Hockings, 2000). Management process models used in business provide a framework for developing a method for evaluating the effectiveness of MPAs. One such model uses a cyclic process of planning, implementation, monitoring, and evaluation, with evaluation feeding into planning and implementation (Armstrong, 1986). The planning process focuses on setting objectives and identifying criteria for the evaluation of the objectives. Ideally, the criteria should be simple, measurable, cost-effective, and reflect the objectives of management (Kay & Alder, 1999). These same concepts of management can be applied to MPAs (Alder, 1996) and form the basis on which we develop a marine protected areas evaluation model (MPAEM).

If the objective of an MPA is to maintain (or increase) resources, we can measure the effectiveness of a resource management program by assessing if the resource in question has increased, diminished, or even collapsed. The objectives of MPAs are rarely so simple. Most often, MPAs are seen as one means of reaching the goal of sustainable use of marine ecosystems.

Evaluating whether the exploitation of an ecosystem is sustainable is difficult (Boesch, 1999). There is ongoing debate on the definition of "sustainability" and how it should be measured (e.g., Berke & Conroy, 2000). This debate is outside the scope of this article. There is, however, a general agreement by many that the definition of sustainability should include ecological, social, economic, and ethical components (Antunes & Santos,

1999, Costanza et al., 1999; Garcia, Staples, & Chesson, 2000). Therefore, any approach that assesses sustainability should utilize a multidisciplinary approach encompassing these components. Other objectives such as recreation, tourism, research opportunities, and maintenance of cultural links may also apply and may require inclusion in the evaluation (Alder, 1996; Boersma & Parrish, 1999).

Few methods have been developed to evaluate the effectiveness of MPA management (Kelleher, Bleakley, & Wells, 1995; Alder, 1996; Hockey & Branch, 1997). Most of these studies investigated whether designated MPAs were transformed from “paper parks” to functional management systems. For example, Hockey and Branch (1997) proposed broad criteria to measure the scientific, practical, socioeconomic, and legal performance of MPAs against the management objectives. Some of their criteria are difficult to score because they included several factors such as education, recreation, tourism, and research in a single criterion. Furthermore, their method does not provide any measure of uncertainty or the degree of influence of each criterion. The paucity both of criteria to measure the progress of management objectives and of multidisciplinary approaches also applies to similar fields such as coastal management, stream management, and marine water quality (e.g., Harris & Silveira, 1999; Hershman et al., 1999).

There are at least three published multidisciplinary approaches. Garcia, Staples, and Chesson (2000) have developed a reference system, based on multicriteria analysis, to assess the sustainability of single species fisheries. In 1998, the Marine Stewardship Council introduced an accreditation scheme to assess the sustainability of capture fisheries (Anon., 1998). Performance criteria and guideposts are used with an analytical hierarchy process to evaluate a fishery against ecological and biological principles (Anon., 1998). However, social, cultural, and technological aspects are given limited attention. The third approach, which forms the basis of the present study, is based on a rapid appraisal method for fisheries, called Rapfish.

## The Rapfish Approach

The analytical approach incorporated in Rapfish uses multidimensional scaling, an ordination method, to appraise the sustainability of fisheries (Pitcher et al., 1998; Pitcher & Preikshot, 2001). The development of the Rapfish approach is detailed in Pitcher et al. (1998), and it has now been used to evaluate the sustainability of fisheries throughout the North Atlantic (Alder et al., 2000). Rapfish uses a multidisciplinary appraisal technique to evaluate the comparative sustainability of fisheries, based on a number of easy-to-score attributes (Pitcher & Preikshot, 2001). The attributes within five evaluation fields (ecological, economic, social, technological, and ethical) are chosen and defined to reflect the notion of sustainability. All attributes can be refined or substituted as improved information arises. An ordination of each set of attributes using multidimensional scaling (MDS) is the analytical tool of the technique, with separate ordinations being performed on each set of attributes (evaluation fields). The results, expressing the relative sustainability in each evaluation field, are reported on a scale from zero to 100%. The technique has been used to assess 153 fisheries worldwide including commercial, subsistence, artisanal and industrial fisheries in temperate and tropical regions (Pitcher & Preikshot, 2001).

There is considerable flexibility in defining the entities to be compared (e.g., fisheries) for a MDS analysis, and these can be based on a range of attributes (e.g., spatial, temporal, technological, anthropological, and political). Entities within a single MDS analysis should be defined consistently at a scale that identifies significant changes in management, resource use, or extraction practices. Two hypothetical reference entities, which are scored as zero (0%) and 100% for all evaluation fields, also provide extreme reference points for comparing the sustainability scores.

Once entities (e.g., fisheries) are defined and the attributes and associated scoring criteria confirmed, each entity is scored according to the attributes within each evaluation field. These scores are standardized and distances between entities in multidimensional space are calculated before ordination. The resulting distance matrix is the input for the multivariate ordination. The resulting reduction in dimensionality permits the relationships between the entities to be shown in one or more dimensions (e.g., Pitcher & Preikshot, 2001). Dimensions greater than 3, however, are difficult to represent visually and to interpret. The coordinates and distances have no units and can be rotated and re-scaled for ease of interpretation.

The present study modifies the Rapfish appraisal technique (which was applied to fisheries) for use in the MPAEM and applies it to several case studies in order to evaluate the effectiveness of the management of existing MPAs.

## **Marine Protected Area Evaluation Model**

### *The Model*

Rapfish was modified for MPA use based on the following considerations: First, the original Rapfish approach measures sustainability (of fisheries), whereas in this study the focus is broadened to the assessment of management effectiveness. Can management effectiveness be measured in a pragmatic and cost-effective way? Any measure of management effectiveness must be pragmatic so that policy and decision makers can readily understand what is being measured and apply its relevance in MPA management. Similarly, the cost of collecting and analyzing the information needed to evaluate management effectiveness must be small compared to the market and nonmarket value of the MPA and the cost of managing the area. If we measure effectiveness based on meeting management objectives, then for many objectives, pragmatic and measurable criteria can be defined. Alder (1996) and Boersma and Parrish (1999) showed that for MPAs, management objectives are varied and multidisciplinary, spanning ecological, social, and economic issues. Clearly, if we are to apply the present methodology, a new set of attributes reflecting measures of MPA management effectiveness across a range of disciplines will need to be defined.

Second, can any MPA be evaluated? An MPA can be defined with the same degree of flexibility as can fisheries in the Rapfish approach. MPAs can be defined broadly, as in IUCN's protected areas system (Kelleher, Bleakley & Wells, 1995, p. vii), or very specifically, such as strictly no-take areas (Bohnsack, 1999, p. 9). The definition of the MPA has to meet the same requirements as the definition of fisheries in the Rapfish approach; i.e., the same assessment attributes have to be applied consistently to all MPAs, and the MPAs should be spatially independent of each other.

Third, does the size of the MPA matter? If attributes can be defined so that scoring is independent of size of the MPA, then size should not be a constraint for the methodology. We acknowledge that for some attributes, differences in scale might be important in meeting management objectives. For example, larger MPAs, due to their physical size alone, may better meet management objectives such as maintaining connectivity and buffering adjacent areas (Watson, Alder, & Walters, 2000) and therefore may score higher than smaller MPAs.

Fourth, can temporal differences between MPAs be accommodated in the analysis? Given that temporal comparison between individual fisheries over time can be evaluated using the Rapfish approach, differences in MPA management effectiveness over time can also be analyzed using the present methodology. Indeed, time series to examine the effectiveness of management over time for more than one MPA can be investigated simultaneously.

### ***MPA Attributes***

The key to applying the Rapfish approach to assess MPA management effectiveness is identifying and defining appropriate attributes within the evaluation fields. These attributes are defined by MPA management objectives. The Rapfish approach, for example, assesses the sustainability of fisheries using five evaluation fields: ecological, economic, social, technological, and ethical. Several elements of these fields are also important attributes in MPA evaluation, e.g., precautionary management of living resources, exploitation, maintenance of biodiversity and habitats, and economic benefits, as well as social attributes such as equity, stewardship, management resilience, and efficiency (Hanna, 1995). However, MPA management objectives include more than just sustainability, e.g., maintaining diverse user opportunities, facilitating research, maintaining tourism sites as well as places of historical and cultural value, meeting transportation needs, and preserving intrinsic values (Alder, 1996; Boersma & Parrish, 1999). Consequently, new sets of attributes and evaluation fields were developed for MPAEM to assess management of MPAs.

The following six evaluation fields were defined for their use in MPAEM for assessing MPA management effectiveness:

1. Living (renewable) resources: Maintaining the natural capital so that future generations can derive social and economic benefits from the system.
2. Nonliving (nonrenewable) resources: Managing the resources so that economic and social benefits are maximized now and for future generations.
3. Economic (market values): Ensuring that the MPA and its resources are appropriately valued in the market place.
4. Social: Meeting society's expectation of the nonmarket benefits of setting aside areas in a fair and equitable manner, and relinquishing access to resources, meeting the cultural needs of society, etc.
5. Ecosystem functions: Ensuring that the ecosystem and its functions are being maintained or rebuilt (in the case of degraded areas).
6. Management: Ensuring that management programs are functioning efficiently and effectively.

These evaluation fields categorize the attributes that best reflect effective management. As part of the development of this method, other MPA researchers and managers were consulted on the factors that should be included in an evaluation of management. Their comments were combined with a literature review to define attributes and the rationale for each attribute within the above fields (Table 1; see also <http://www.fisheries.ubc.ca/Projects/MPAEM.htm>)

### **Model Pilot Testing**

Twenty-two MPA managers and researchers tested the MPAEM by scoring MPAs in which they were presently or recently working. These managers and researchers are considered experts in the areas they scored, and they based their scores on reports or studies with which they were familiar. Respondents were provided with background information on the MPAEM, a list of attributes with the corresponding rationale (Table 1; see also [www.fisheries.ubc.ca/Projects/MPAEM.htm](http://www.fisheries.ubc.ca/Projects/MPAEM.htm)), and a scoring sheet to record their assessment of the MPA based on the attributes. Furthermore, managers were also asked to assess the feasibility of using the MPAEM method to assess management effectiveness and to comment on the attributes used. Informal comments were collected at this stage of the model's development due to the preliminary nature of the pilot test, the small sample size of managers surveyed, and the considerable effort that was required to encourage these managers to complete the assessment.

**Table 1**  
 Attributes used in the MPAEM grouped by evaluation fields  
 (a complete description of the attributes can be found at [www.fisheries.ubc.ca/Projects/MPAEM.htm](http://www.fisheries.ubc.ca/Projects/MPAEM.htm))

		Evaluation field			
Living resources	Economic	Nonliving resources	Social	Management	Ecosystem function
Exploitation status (targeted)	Local profitability	Exploitation	No-net-loss	Planning	Capacity
Exploitation status (nontargeted)	GDP	Hotellings rule	Losses	Implementation	Size
Change in trophic level	Average wage	Compensation	Growth	Monitoring, control, and surveillance (MCS)	Corridors
Migratory range	Limited entry	Threats	Conflicts	Research	Linkages
Recruitment variability	Access rights	Habitat impact	Stakeholder influence	Monitoring	Habitat
Catch per Unit Effort	Other income	Capital conversion	Stakeholder Association	Awareness	Diversity
Catch before maturity	Economic diversity			Environmental assessment	Species diversity
Catching power and efficiency	Ownership, transfer		Entry	Reviews	Mitigation
Direct exploitation impacts	Consumers		Illegal activities	Emergency measures	Disturbance
Indirect exploitation impacts	User fees		Wastes	Training	Pollution

The pilot testing was used to determine whether the approach was feasible for a range of MPAs: from small to large, tropical to temperate, developed to developing economies, and from fully protected to multiple use areas. A total of 20 MPAs covering a range of situations were scored (Table 2). The testing was not designed to evaluate each MPA specifically. The attributes were also evaluated for their relevance to managers and researchers, and to identify inconsistencies or difficulties in using the attributes.

The Statistical Package for the Social Sciences (SPSS) was used to standardize the MPA scores, and to calculate the distance matrix, which was used as input for the ALSCAL (SPSS) routine. The ALSCAL routine performs the MDS ordination using an iterative approach to derive the optimal configuration of MPAs in two-dimensional space for each of the six MPA evaluation fields.

## Pilot Test Results

The ALSCAL routine in SPSS obtained an optimal solution with five iterations for the six MPA evaluation fields, with STRESS1 values between 0.28 and 0.29 (Manly, 1994). These STRESS values are considered acceptable given the low number of MPAs tested. The purpose of the pilot study was to assess the potential of the methodology and not the accuracy of respondents. (The detailed scores for each attribute can be obtained from the senior author.) Sensitivity analysis indicated that the standard error of scores varied between 2% and 8% when a single attribute was omitted from the analysis.

The resulting configurations of the MPAs relative to “lowest” (0%) and “highest” (100%) scoring case scenarios (reference points) were close to expected, based on reports about the areas, managers’ comments, and the scores provided (Table 3). None of the respondents commented that the results were contrary to what they expected of their area, and three managers did comment that they considered their areas to be well managed. MPAs that are known or perceived to be poorly managed were usually found at the “poor” management end of the scale and those MPAs that are considered well managed were usually found at the “better” end. Figure 1 illustrates the relative position of

**Table 2**  
Summary of MPAs evaluated using the MPAEM

Geographic area and country	Code	Size range <sup>a</sup>	Economic status	Protection level <sup>b</sup>
<b>Tropical</b>				
Australia	A1-6	5 M, 1 L	Developed	6 MU
Central America	C1,2	2 M	Developing	2 LT
Indonesia	S3-5	2 M, 1 L	Developing	1 LT, 2 MU
Indian Ocean	I1	M	Developing	MU
Pacific	P1	M	Developing	LT
Philippines	S1,2	2 S	Developing	1 NT, 1 LT
USA	N2	L	Developed	MU
<b>Subtropical</b>				
Australia	A7,8	2 M	Developed	2 MU
<b>Temperate</b>				
Australia	A9	M	Developed	MU
Canada	N1	S	Developed	LT

<sup>a</sup>S = small (< 1 km<sup>2</sup>), M = medium, L = Large (> 10,000 km<sup>2</sup>).

<sup>b</sup>NT = no extraction of any form allowed; LT = limited extraction, MU = multiple use.

**Table 3**  
MPA management scores (in %) for the six evaluation fields,  
sorted alphabetically by MPA code (range: 0-100%)

MPA code	Living resources	Economic	Nonliving resources	Social	Management	Ecosystem functions
A1	65.5	67.9	45.4	39.7	80.5	82.5
A2	59.3	45.8	59.9	45.3	63.3	86.3
A3	54.2	73.4	51.0	31.0	73.6	79.6
A4	56.0	64.4	51.2	34.4	72.8	81.1
A5	62.3	59.7	54.0	43.0	69.7	84.0
A6	50.5	48.6	47.5	51.5	60.2	61.5
A7	47.7	46.7	52.7	47.2	62.6	60.6
A8	73.3	36.4	57.0	52.3	58.6	60.3
A9	65.3	36.4	47.5	46.3	54.5	62.2
C1	27.6	38.5	54.9	60.8	50.9	36.3
C2	59.2	38.4	53.2	70.8	47.7	50.0
I1	74.4	23.6	61.5	53.2	66.2	74.3
N1	62.2	61.0	34.4	24.1	2.3	17.9
N2	54.8	68.3	26.9	64.6	82.8	22.7
P1	56.5	57.6	73.9	81.0	50.3	44.9
S1	60.5	41.4	76.5	67.7	87.5	62.0
S2	78.0	45.4	76.5	62.0	86.2	82.3
S3	25.9	21.4	29.4	51.2	27.7	55.6
S4	36.9	44.6	37.4	44.4	27.7	52.9
S5	22.6	22.7	22.3	40.0	32.9	26.9

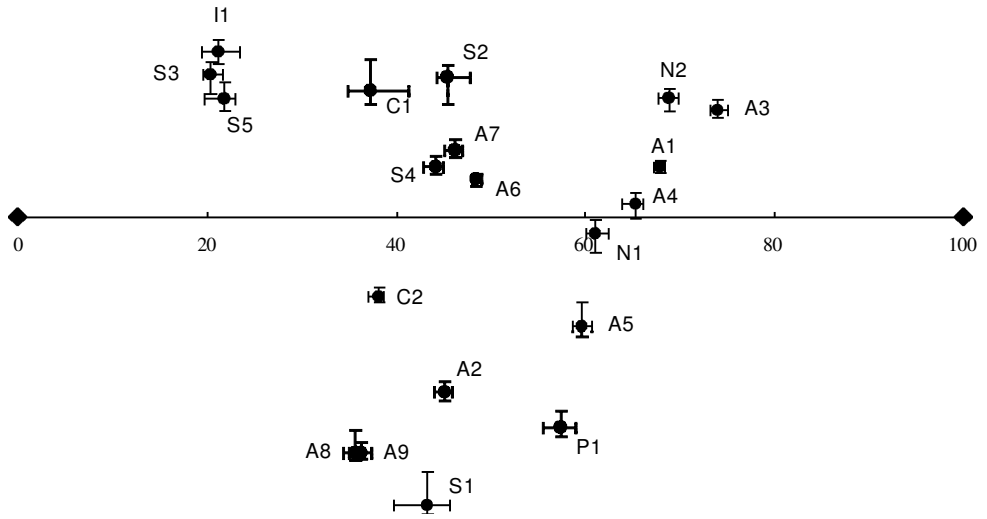
MPAs (on a relative scale from 0% to 100%) for the economic evaluation field. In this example, management effectiveness for MPA S3, I1, and S5 is considerably less than for A3, N2, and A1. Figure 2 gives an overall comparison of northern and southern hemisphere MPAs based on the average score in each evaluation field. In this case, northern hemisphere MPAs scored better for ecosystem management objectives compared to southern hemisphere MPAs. Southern hemisphere MPAs, however, scored better for meeting social objectives than northern hemisphere areas.

## Discussion

The results of the pilot evaluation are encouraging and suggest that the proposed model (MPAEM) has considerable potential for evaluating management of MPAs. Managers and researchers agreed that the six evaluation fields were appropriate as a framework for the model. Note that not all attributes within an evaluation field are applicable to all situations, especially for smaller community-based MPAs. Further work on revising and refining the attributes, as well as guidelines for devising attributes in collaboration with experts, managers, researchers and other stakeholders will improve the utility of this method.

Based on the present results, we consider the MPAEM model suitable for the evaluation of MPA management, as long as it is the management unit that is assessed. For example, the Great Barrier Reef Marine Park (Australia) is divided into management sections, which are further divided into management areas. Either unit could be assessed; the attributes may need to be modified to suit the scale of management, but the



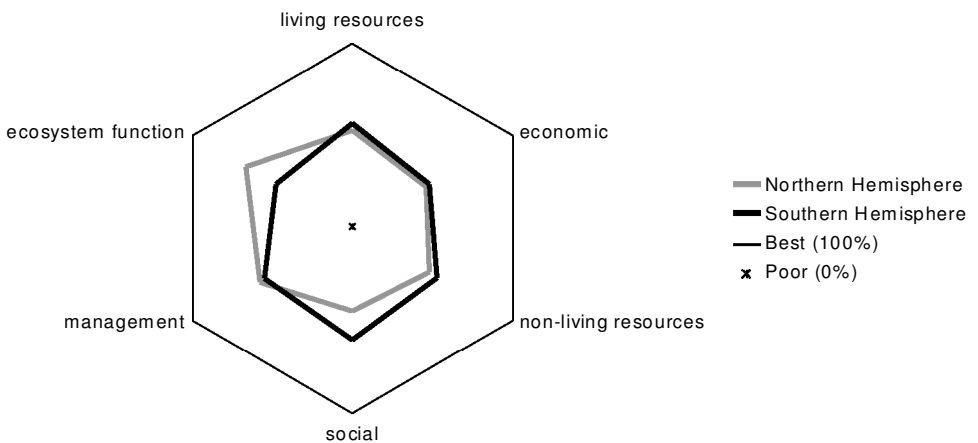


**Figure 1.** Two-dimensional ordination of the economic evaluation field (error bars based on Monte Carlo resampling). For location and codes of individual MPAs, see Table 2.

approach remains the same. Similarly, community-based reserves can be evaluated by modifying the attributes to reflect the management objectives the community has set.

In the absence of other comprehensive methods, the MPAEM provides an approach to explore and develop an area of MPA management that is in urgent need of attention. The development of the present model has been undertaken in collaboration with managers and researchers. However, meaningful engagement of other stakeholders is essential for this model to be of use in MPA management. Ways to actively engage stakeholders in the evaluation process should be explored (e.g., through local workshops). Clearly, this inclusion needs to be done at both the planning and review stages of MPA management.

Finally, the model currently requires the use of SPSS, a statistical program that is commercially available throughout the world. However, it is expensive and beyond the



**Figure 2.** Composite kite diagram of the average scores in each evaluation field for all MPAs evaluated, grouped by northern and southern hemispheres.

budgets of most developing nations or community organizations. A Visual BASIC version for EXCEL has been developed (Kavanagh, unpubl. data), and once tested will be available at the previously mentioned URL.

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