

Measuring the effects of Marine Managed Areas: A global management effectiveness study

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Abstract. This paper presents preliminary results from a multidisciplinary research project on factors influencing the performance of Marine Managed Areas. This study is unique in that it investigates the impact of the timing of management interactions on a number of performance outcomes, across a global sample of MMAs. Data sources for the study comprise an extensive review of literature, key informant interviews, and household surveys in 24 villages from eight MMA sites in tropical regions. Analysis of household surveys indicate that adequate funds at the beginning, enforcement, shared benefits, community organizations, conflict management mechanism, and external support during implementation, and education and training programs, government support, and legislation today together account for 18% of the variance in the socio/ecological component of MMA performance. Alternative livelihoods, shared benefits, and leadership in the beginning, education and enforcement during implementation, and legislation, conflict management, and accountability today account for 17% of the variance in the empowerment and security component of MMA performance. Finally, the combined effects of community influence and education in the beginning, consultations, leadership and education programs during implementation, and influence, shared benefits, community organizations, and legislation today, account for 20% of the variance in the conflict component of MMA performance.

Key words: Marine Protected Areas, Economics of natural resources.

Introduction

The purpose of this study is to assess the factors related to the social and environmental effects of Marine Managed Areas (MMAs). In particular, it explores the links between socioeconomic, governance, and ecological circumstances, events, or interventions and changes in the human or natural environment of the MMA over time.

Attention to the links between MMA design and implementation processes and their longer-term outcomes has increased in recent years. In June of 2006, the Food and Agriculture Organization of the United Nations convened an expert group to develop recommendations for the use of Marine Protected Areas as a fisheries management tool. The panel, composed of social and environmental scientists from many disciplines, developed numerous recommendations for the effective design and management of MPAs. The panel noted that “the design of MPAs would benefit from more support for effectively designed and conducted studies of MPAs, emphasizing the diversity of situations in which MPAs have been applied, design and implementation processes, monitoring and performance, and ultimately, lessons learned.” (FAO 2006)

This study support the goals articulated in the FAO document by investigating the relationships between

socioeconomic, governance, and ecological factors and MPA outcomes. As noted by Pomeroy and Mascia in the FAO report, “The four principal elements of MPA design – decision-making arrangements, resource use rules, monitoring and enforcement systems, and conflict resolution mechanisms – directly and indirectly shape human resource use patterns and, ultimately, the biological and social performance of MPAs.” (FAO 2006)

Material and Methods

Data sources for the study comprise an extensive review of literature, key informant interviews, and household surveys in 24 villages from eight MMA sites in tropical regions.

Figure 1 is a graphic representation of the analytic framework for this study. The outcomes (effects) of the MMAs are defined as a difference in the levels of MMA performance indicators from a time before the MMA was initiated to today. Socioeconomic, governance, and ecological factors were measured at three time periods – in the early phases of the MMA project, during implementation of the MMA, and today. The curved arrows in the graphic represent relationships between the socioeconomic, governance, and ecological factors that are related to the outcomes of MMAs. The dark, straight arrows represent

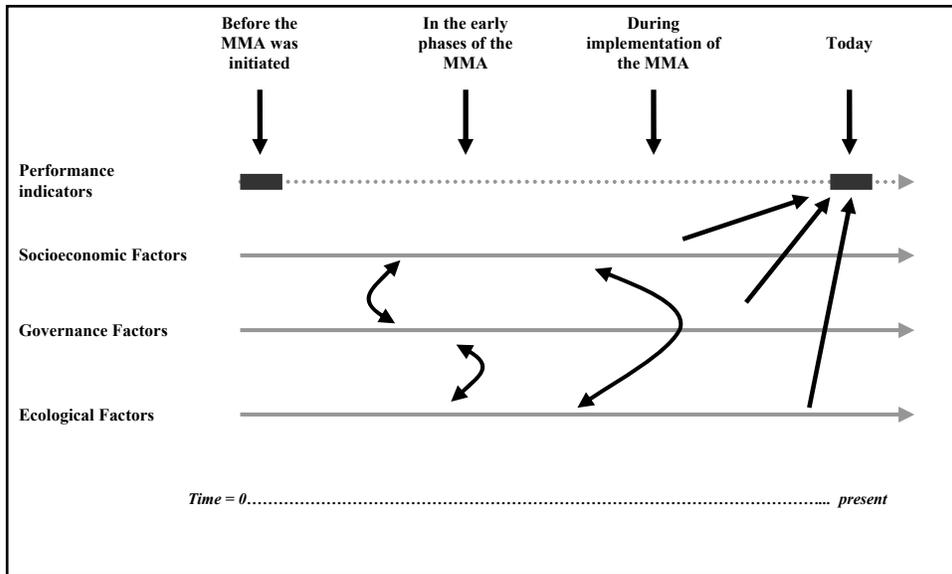


Figure 1: Analytic framework for GME study

relationships between independent variables (socioeconomic, governance, and ecological factors) and dependent variables (the change in performance indicators, or the effects of the MMA).

In order to conduct a quantitative assessment of the relationships between these dependent and independent variables, it was necessary to obtain comparable data from each MMA site. Although these sites were chosen based in part on the availability of secondary data, the data on socioeconomic and governance factors was not directly comparable across sites. Therefore, it was decided to conduct surveys with 40-60 households at each MMA. These surveys utilize the baseline-independent method for impact evaluation developed by Pomeroy et al. (1997) and widely employed by authors involved in coastal management research since that time (for example, Cinner et al. 2005; McClanahan et al. 2006). These household surveys provide comparable data on socioeconomic and governance factors present at each site and their timing, as well as the levels of socioeconomic and governance performance indicators before the MMA project and today. A significant difference in the reported level of a performance indicator is considered an effect of an MMA.

The household surveys were developed following a review of guidelines on the socioeconomic assessment of MMAs and coral reef management (Bunce et al. 2000; Pollnac 1998; Pomeroy et al. 2004). The survey instrument consists of three sections and about 50 questions. The first section contains questions about general household characteristics, respondent demographics, and community characteristics. The first section also asks

the respondents whether they consider the MMA a success. The second section asks about the timing of factors that might be important in establishing and managing an MMA. These are our Critical Determining Factors, or CDFs.

The third section asks about respondent perceptions of the level of indicators (before the MMA and today) that could be considered the outcomes or outputs of MMAs. This study uses a visual, self-anchoring, ladder-like scale which allows for making fine ordinal judgments, places minimal demands on informant memory, and can be administered rapidly. Using this technique, the subject is shown a ladder-like diagram with 10 steps. The subject is told that the first step represents the worst possible situation. For example, with respect to coastal resources, the subject might be informed that the first step indicates an area with no fish or other resources, that the water is so foul nothing could live in it. The highest step could be described as rich, clean water, filled with fish and other resources. The subject would then be asked where the situation was before the MMA, and where it is today.

In all cases, local partners were enlisted to lead the implementation of the household surveys. The research team worked on-site with each local project leader to ensure that the survey questions were clear, and that they were appropriate to the communities being surveyed. Samples were drawn from the population of stakeholders in communities surrounding or near to the MMA who are involved with or are knowledgeable about the MMA. These individuals were either identified by the survey enumerators on-site by asking a screening question of randomly selected community members, or pre-

screened by MMA management prior to the research visit.

Results

For the overall sample, there was a statistically significant increase in perceived levels of all 12 of the impact indicators ($p < 0.01$). In particular, there were large positive changes perceived in compliance, and ecological health and biodiversity. The next highest positive change was in livelihoods, with the smallest changes reported for peace and order and crime levels. Changes in the levels of effect indicators were not as pronounced for the subsample of fishers.

Indicator	T2-T1	P
Livelihoods	1.348	<0.01
Food security	.973	<0.01
Resource conflicts	1.054	<0.01
MPA conflicts	.933	<0.01
Participation	1.143	<0.01
Influence	1.233	<0.01
Peace and order	.877	<0.01
Crime	.771	<0.01
Village conflict	.935	<0.01
Compliance	2.247	<0.01
Ecological health	2.294	<0.01
Biodiversity	2.126	<0.01

Table 1: before/after MMA differences in perceptions of performance indicators

The next step was to reduce the number of independent variables for further analysis. Principal component analysis with varimax rotation was used to elucidate patterns of relationships between the degrees of change in the 12 indicators. The scree test was used to determine the number of components, resulting in three components, which account for a total of 62% of the variance in the data set.

	Component		
	1	2	3
Livelihoods	.639	-.065	.470
Food security	.659	-.038	.458
Resource conflicts	.254	.181	.773
MPA conflicts	.131	.244	.806
Participation	.032	.712	.310
Influence	.034	.682	.322
Peace and order	.340	.591	.073
Crime	.213	.686	-.053
Village conflict	.426	.358	.454
Compliance	.620	.384	.165
Ecological health	.794	.232	.109
Biodiversity	.841	.264	.079

Table 2: factor loading for principal component analysis

Items loading highest on the first component are clearly related to both livelihoods and ecology; thus, the component is named “*Socio/ecological*.” On the second component items related to participation and

peace and order load highly, resulting in identifying the component as indicating “*Empowerment and security*.” Finally, items loading highest on the third component are related to various types of conflict in the community; hence, the component is named “*Conflict*.”

We can then investigate the relative importance of the predictor variables in terms of their individual and combined ability to account for variance in the three indicator components. This can be accomplished with regression analyses, and most efficiently with stepwise regression analysis. The results of these analyses for the three components can be found in Table 3.

Independent variable	Stand. β coefficient	Prob.
<i>A. Dependent variable: socio/ecological component score^a</i>		
ENF_IMPL	.166	.001
EDUC_TODAY	-.179	.000
SHAREBEN_IMPL	.165	.000
COMMORG_IMPL	.123	.010
GOVTSUP_TODAY	-.101	.027
LEGISL_TODAY	.127	.010
CONFLMGMT_IMPL	-.100	.032
EXTSUPP_IMPL	.171	.000
FUNDS_BEG	-.090	.050
<i>B. Dependent variable: empowerment and security component score^b</i>		
EDUC_IMPL	.169	.000
LEGISL_TODAY	.097	.050
CONFLMGMT_TODAY	.126	.009
ENF_IMPL	.126	.006
ALTLIV_BEG	-.138	.003
SHAREBEN_BEG	.173	.001
LEAD_BEG	-.162	.002
ACCOUNT_TODAY	.111	.035
<i>C. Dependent variable: conflict component score^c</i>		
COMMINGL_TODAY	.136	.011
SHAREBEN_TODAY	.162	.002
COMMORG_TODAY	.195	.000
LEGISL_TODAY	-.176	.000
COMMINGL_BEG	.145	.003
EDUC_BEG	-.143	.010
CONSULT_IMPL	.142	.008
LEAD_IMPL	.120	.020
EDUC_IMPL	-.121	.028

^a $R = 0.450, R^2 = 0.202, \text{Adj. } R^2 = 0.186, F = 12.288, p < 0.001$

^b $R = 0.433, R^2 = 0.187, \text{Adj. } R^2 = 0.173, F = 12.603, p < 0.001$

^c $R = 0.469, R^2 = 0.220, \text{Adj. } R^2 = 0.204, F = 12.288, p < 0.001$

Table 3: regression coefficients

The results in Table 3(A) indicate that adequate funds at the beginning, enforcement, shared benefits, community organizations, conflict management mechanism, and external support during implementation, and education and training programs, government support, and legislation today together account for 18% of the variance in the Socio/ecological component score.

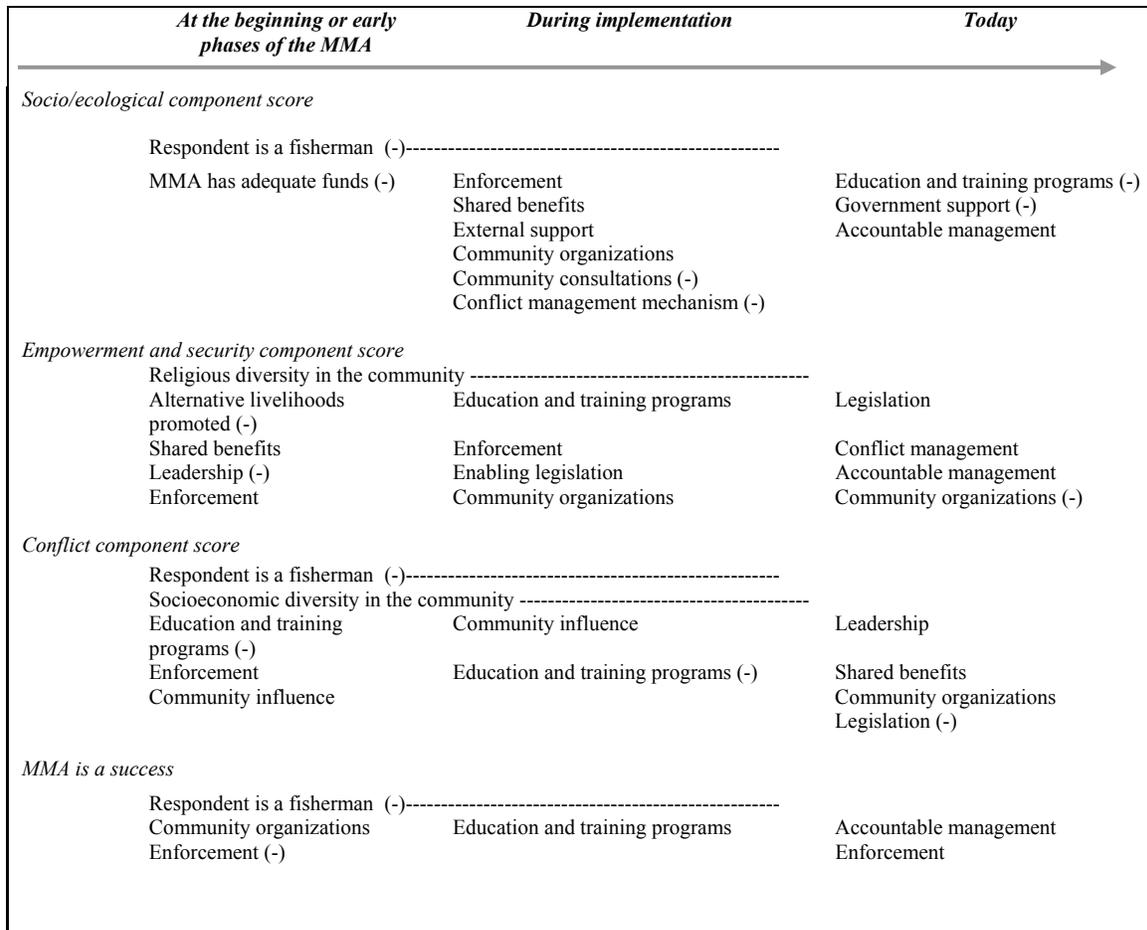


Figure 2: timeline representation of significant regressors

Likewise in Table 3(B), alternative livelihoods, shared benefits, and leadership in the beginning, education and enforcement during implementation, and legislation, conflict management, and accountability today account for 17% of the variance in the Empowerment and security component score. Finally in Table 3(C), the combined effects of community influence and education in the beginning, consultations, leadership and education programs during implementation, and influence, shared benefits, community organizations, and legislation today, account for 20% of the variance in the Conflict component score. Figure 2 is a timeline-type representation of these regression results.

Discussion

The most striking result of the component regressions is that some of the coefficients are negative, contrary to expectations. Recall that these are supposed to be critical *success* factors; therefore all coefficients would be expected to be positive. Thinking about the implications of measuring perceptions can help to make sense of these counterintuitive findings.

For example, there may be some psychology at play in which respondents feel a sense of “bonding together in a difficult situation” that would explain why the coefficient on *adequate funds* is negative. Similarly, both *alternative livelihoods* and *leadership* at the beginnings are negatively related to the empowerment and security component score. Recall that the empowerment and security component is loaded most highly with perceptions of changes in influence and participation. It might be the case that if a strong leader comes in to a community with new ideas about changing traditional ways of life, that situation could be alienating and disempowering for some members of the community.

In general, the variables with negative coefficients are associated with situations that may be generated from outside the community itself – for example, strong leadership, legislation, education and training programs associated with the MMA, government support.

It is also noteworthy that some of the coefficients are positive for one component but negative for another. Education and training programs, for instance, have a positive effect on the *Empowerment and security*

component score but a negative effect on the other two components. Strong leadership has a negative effect on the *Empowerment and security* component score but a positive effect on the *Conflict* score. Investigating the robustness of this finding will be a fruitful area for further research.

This paper reports results from the first phase of an ongoing research project. Further steps will involve integrating quantitative ecological data from study sites into a comprehensive analysis. The authors welcome comments from readers to improve future versions of this report.

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