CONSERVATION INTERNATIONAL
GLOBAL MANAGEMENT EFFECTIVENESS STUDY:

INTEGRATED SOCIAL AND ECOLOGICAL

REPORT FOR NON-NODE and NODE SITES

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EXECUTIVE SUMMARY

The creation of MMAs (Marine Managed Areas) has accelerated as part of an increased global awareness of the close relationship between natural resource management regimes, and sustainable economic development. These projects were undertaken through a variety of processes, from top-down, government-led infrastructure projects to community based, small-scale managed areas developed in accord with traditional management systems indigenous to the local culture. To date, over 1300 Marine Managed Areas have been implemented; however, many of these have not been able to achieve their objectives, and exist only on paper. These MMA projects and their rich range of outcomes provide a vast pool of information for more successful planning and implementation of MMAs. While project evaluations have been undertaken by project staff and consultants for many individual MMAs, and national and regional cross-project analyses have been conducted, there have been few integrative analyses of both ecological and social effects of MMAs globally.

The purpose of this study is to provide a critical assessment of the implementation, impact, and performance of MMA projects to serve as a basis for improved planning and implementation of new MMA projects worldwide. The specific objectives of the study are (1) to determine the socioeconomic, governance and ecological effects of MMAs; (2) to determine the critical factors influencing MMA effects, as well as the impact of the timing of those factors on the effects of the MMA; and (3) to provide tools for predicting MMA effects based on ecological, socioeconomic and governance variables.

The present project is part of Conservation International's (CI) Marine Management Area Science (MMAS) research program. The MMAS program is an integrated research agenda combining social and biological science to study the management of marine areas in order to improve their effectiveness and support conservation and human development goals. Most of the research in the MMAS program is concentrated in four "nodes": Belize, Brazil, the Eastern Tropical Pacific Seascape (Panama), and Fiji. These nodes were chosen because they have established marine management areas to study, they are rich in biodiversity, they are home to several unique species, and they have a stable base of social, political, and economic resources to manage critical marine areas.[1] In addition, the MMAS program incorporates several projects that are global in scope. The present study is one of those.

The selection of MMA project sites to be evaluated in the GME study was conducted by the authors in consultation with personnel from Conservation International and numerous personal contacts. The GME study includes an analysis of data from nineteen

[1] Information about Conservation International's Marine Management Area Science Program can be found at http://science.conservation.org/portal/server.pt?open=512&objID=469&parentname=CommunityPage&parentid=5&mode=2&in_hi_userid=127745&cached=true

sites, concentrated in five regions of the world (Africa, wider Caribbean, South America, Pacific and Southeast Asia). This provides both diverse geographic representation and a variety of MMA structures. In order to optimize financial resources and leverage the findings from the MMAS project as a whole, half of the sites in the GME study are located in CI's Core Research Node areas (Panama, Fiji, and Belize). The remainder of the sites are located in Africa and Asia. These non-node sites represent a variety of management structures and effectiveness. Included are four sites in Asia (Apo Island, Mabini, and El Nido in the Philippines and Hon Mun in Vietnam), three sites in the Western Indian Ocean (Mafia Island, Menai Bay, and Misali in Tanzania), and one site in the Caribbean (Soufriere Marine Managed Area in St. Lucia). Where possible, data was collected from two or three communities within each of the study sites.

This is where we put in the information about the two types of analyses To facilitate cross-project comparisons of MMA sites, we used a baseline-independent technique for impact assessment following Pomeroy et al (1996, 1997). This makes it possible to conduct quantitative analysis of variables impacting project success. In addition, a qualitative analysis of secondary literature was combined with the baseline-independent impact assessment technique in hopes of gaining additional insights, particularly with regard to variables that have been omitted from prior research efforts. The socioeconomic and governance data obtained from these two data sources are integrated with quantitative data on ecological factors potentially affecting the performance of MMAs, as well as quantitative data pertaining to the ecological outcomes of MMAs, in an integrated quantitative analysis.

The nineteen MMA sites included in this study are quite diverse, ranging from tiny, community based *tabu* sites with no tourism or outside influence, to large, established MMAs with multiple users including a large tourism base. Some of them are world-renowned examples of successful marine conservation, and some are barely more than "paper parks". A one size-fits-all analytic approach would not be appropriate for this sample of MMAs. Therefore, the study sites were divided into subsets using a number of different grouping schemes, based on 1) the availability of data and the analytic options associated with it, and 2) the socioeconomic profile of the communities included in the study.

The first grouping scheme entailed subdividing the MMAs according to whether or not the MMA was one of Conservation International's node sites. Although the number of non-node sites was small – only eight – these MMAs were chosen for this study because they have reliable ecological data associated with them. Therefore, it was possible to incorporate the ecological data into the analysis in ways that were not possible for the other sites. For these MMAs, we used a multilevel mixed effects statistical model to incorporate site-level effects into the logit regression analysis, reported in section 5.3.

In addition, some of the node sites included ecological data on the fish biomass and/or coral cover inside the MMA vs. in a control site. This second group of MMAs (non-node sites plus the node sites with ecological data) was used for the detailed correlation analysis reported in section 5.2. In this way, we were able to gain some insight from the relationships among Critical Determining Factors that were associated with both the key socioeconomic and governance outcomes, and the ecological outcome indicating a positive difference in fish biomass inside the MMA vs. at a control site.

The third grouping scheme involved segregating the MMAs based on their socio-economic profile and the perceived level of success of the MMA. Within this scheme, Group 1 includes traditional fishing communities with minimal tourism and high levels of "success" reported by survey respondents. Group 2 includes highly successful MMAs located in or near communities in which fishing is not a major economic activity. Group 3 includes MMAs with lower levels of reported success, or in which poverty is and remains a serious concern. We used forward logit regression to elucidate the most critical factors associated with perceived improvements in various MMA effect indicators, as reported in section 5.3.

As noted above, the first objective of this study is to understand the effects of MMAs. In terms of the effects measured via household surveys (perceptions of improvements in various social and ecological indicators), the data indicate statistically significant (but not large) difference in before/after levels of all MMA performance indicators. When the survey respondents were subdivided according to the schemes noted above, most subsets perceived the greatest improvements in ecological health and biodiversity. The survey respondents in "Group 2", (MMAs near communities with a diverse economic base) reported a more even improvement of social and ecological indicators. Survey respondents at MMAs with ecological data indicating a positive differential in coral cover inside the MMA vs. at a control site, as well as those in "Group 3" (less successful) MMAs, do not perceive any improvements in MMA effect indicators and in fact reported statistically significant (but small) worsening of conflict levels.

Because before-after data were only available for non-node sites, our assessment of the ecological effects across all sites was limited to comparisons of outcomes inside and outside MMAs. One outcome compared across all sites, the difference in coral cover within versus outside MMAs varied among sites with approximately half of the study sites (n = 7) showing no difference between MMA and control sites or greater coral cover in control sites, and approximately half of sites (n = 8) having higher coral cover within MMAs. Because we do not know the starting conditions at any of the node sites and how coral cover changed within these sites compared to control sites, it is difficult to say how MMA management has affected coral cover, but clearly, any positive MMA effects are limited.

There was a greater occurrence of potentially positive MMA effects on the abundance and/or biomass of key fishery species, with 10 MMA sites reporting greater abundance or biomass than their controls and only 4 sites reporting no difference or greater abundance or biomass at control sites. Again, because time series data does not exist for node sites, we cannot correlate changes in biomass or abundance of key species with the implementation of MMA protection, however the high frequency of occurrence of cases where abundance or biomass is greater within MMA sites is suggestive of a positive effect of MMA management.

For the second objective of the study, we determine the critical factors affecting MMA success through a correlation analysis similar to what has been done in many prior studies. However, in this study we drill a bit deeper to try to understand the cross-correlations between factors over time. There are several patterns in the correlations and regression coefficients that are useful for managers and policy makers to understand:

- There are a finite number of actions that can be undertaken by MMA management that are directly related to improvements in perceptions of several key indicators of

MMA effects. These include a situation where the *benefits exceed the cost* of the MMA, an equitable *sharing of benefits* from the MMA to the community, *community influence* over the MMA, *accountable management* of the MMA, and *conflict management mechanisms*.

- Perceptions of improvements in biological indicators do not have as many direct correlates as the socioeconomic and governance indicators. A positive differential in fish biomass inside vs. outside the MMA was related to *leadership* and *community influence* at the beginning, as well as *shared benefits* and *benefits exceeding costs* now.

- If we look at the prior period correlates of the important CDFs occurring today, we see that the same set of CDFs is strongly correlated across time not only with MMA effects, but also with each other. There are interesting and statistically significant relationships between ecological CDFs and socioeconomic/governance CDFs occurring in later periods, but it is probably not realistic to ascribe any meaning to those relationships.

- The inferences on CDFs that arise from analyzing secondary literature are broadly consistent with the results of the analysis of survey data, but they are incomplete. The two CDFs that show up most strongly in the literature are *shared benefits* from the MMA to the community (equity), and *accountability* of management. These are two CDFs that appear as both bivariate correlates and significant regressors on multiple MMA outcomes. On the other hand, reading the literature would have led us to believe that *adequate financial resources* was a significant CDF. This factor did not appear as a positive correlate for very many MMA outcomes. This absence probably implies that community perceptions are not the most reliable measurement of the financial resources of an MMA.

- On the topic of the financial resources of an MMA, we did see that perceptions of MMA *financial resources* at the beginning of the project were negatively related to conflict and compliance levels for the non-node sites, and with conflict levels for Groups 1 and 2. This finding aligns with anecdotal reports that a new MMA entering an area with lots of money is likely to generate resentment and resistance among the communities affected.

- The predictive power of the regression model for the 19 MMAs as a whole was generally weak – the forward logit regressions generally had pseudo R^2s on the order of .15 to .25. These improved greatly when we subdivided the data into groups, but the regressions for Group 3 (the less successful MMAs) consistently exhibited the least predictive power of the three groups. The R^2*s* associated with the regressions on perceptions of improvements in ecological health and biodiversity were by far the most satisfactory, even for Group 3.

- There was some consistency in terms of important regressors for multiple governance outcomes across groups. Leadership, conflict management mechanisms,

and accountable management style were strong predictors of several governance outcomes.

- There were some surprising results in terms of what was NOT important in the regression models. *Enforcement* and *enabling legislation* did not appear as strong regressors for many outcomes, which was surprising given the emphasis on these two factors in policy and the operations of MMAs.

- There was not a great deal of overlap in the most significant regressors for socioeconomic and ecological outcomes of MMAs for the three groups. For example, *capacity building, external agents*, and *alternative livelihood projects* were the most important determinants of improvements in livelihoods for Group 1, benefits *exceeding costs , accountable management*, and *shared benefits* were important for Group 2, and *adequate funding* and *leadership* were important for Group 3.

For the third objective, predictions of changes in MMA outcomes arise directly from the interpretation of the coefficients in the multilevel logit regression. Exponentiating the coefficients on CDFs gives the change in the odds ratio for a particular outcome associated with a unit change in the CDF.

Another CDF with a strong relationship to multiple MMA outcomes is *shared benefits* from the MMA to the community. This finding has important implications for MMA managers, policy makers, and donors. MMAs are more likely to encounter positive community perceptions and consequent support for their projects if they share the benefits of conservation with the community in a meaningful way. This is logical and expected. At the same time, however, MMAs are increasingly being expected to be self-funding; to be financially sustainable. Given the imperative of financial sustainability, then, how is an MMA manager to distribute the proceeds of user fees, for example? Should he distribute those fees to the community and be left without enough money to buy gas for patrol boats or pay rangers? Should he pay rangers more because they have to enforce regulations among a hostile and impoverished populace? This is a real challenge and one that merits further study. What is the relationship between enforcement expenditures and shared benefits to the community?

Finally, there are tradeoffs between socioeconomic, governance, and ecological effects of MMAs. Actions taken by management that may have a positive effect on one suite of outcomes may have a negative effect on others. For instance, *alternative livelihood* projects, which are positively related to improvements in livelihoods, are negatively related to improvements in compliance (in the multiple regression analysis for the non-node sites). This may be disheartening for conservationists who want to be able to say that MMAs can help alleviate poverty, but who also want ecosystem protection rules to be complied with.

Several important limitations of this study should be highlighted. The study cannot claim to be a globally representative evaluation of all MMAs worldwide. It evaluates only a small sample of MMAs, and those MMAs were not sampled at random. The evaluation was conducted without controls for either MMAs (i.e. looking at "unsuccessful" vs. "successful"

MMAs) or the local context (i.e. looking at areas not under any kind of management vs. these managed areas[2].) Therefore, it was not possible to conduct the evaluations using an experimental research design of before/after, control/impact (or "differences in differences") data generation. Biophysical impacts of MPAs are generally recorded as treatment-control (for example, biomass inside vs. outside an MPA); reliable before-after ecological data are rare. Although household surveys will generate before-after values, they will not be conducted in communities unaffected by MMAs – that is, there are no directly comparable treatment-control data.

In summary, MMAs do lead to positive outcomes and changes for marine resources and users, specifically large positive changes perceived in compliance, and in perceptions of ecological health and biodiversity. It should be noted that while community members may feel good about the changes the MMA has brought, they don't feel equally good about everything.

The more important CDFs affecting MMA outcomes identified include:

- Community influence – As has been reported in many publications, participation of community members in the MMA project design and implementation provides them with a sense of 'ownership' over the MMA.

- Accountable management – The MMA has a management process in which business is conducted in an open and transparent manner. All MMA partners must be held equally accountable for management. Without strong accountability, decision making can become corrupt and arbitrary.

- Conflict management mechanism - Arbitration and resolution of disputes are imperative when conflicts arise over MMA management and institutional arrangements. If resource users are to follow rules, a mechanism for discussing and resolving conflicts and infractions is a must. There is a need for a forum for resource users to debate and resolve conflicts and to appeal decisions.

Benefits exceed costs - Individuals must feel that the benefits to be obtained from participation in the MMA, including compliance with rules, will be greater than the costs of such activities.

- Sharing of benefits – The perception of benefits from the MMA, as well as sharing of economic benefits for participants and non-participants resulting from the MMA. Real or perceived economic benefits from the MMA influence participants to sustain the MMA.

However, it should be noted that there was not a great deal of overlap in the most significant regressors for socioeconomic and ecological outcomes of MMAs for the three groups. This may be the most important result coming out of this work – that there is no single recipe for success with marine conservation, but that it is important to understand

[2] We did use control data for the ecological effects wherever possible.

the circumstances of the local community before deciding on the appropriate policy mix to meet conservation or development objectives.

Consider that there are two kinds of results. One consists of statistical relationships between human perception of reality and how this perception changes over time. The second is the relationship between peoples' perceptions and reality as measured in a deliberately more objective and independent manner.

1.0 INTRODUCTION

In recent years, Marine Managed Areas (MMAs) have become increasingly common management tools in the ocean environment, with ambitious goals potentially including the conservation of marine resources, the enhancement, maintenance, or recovery of fisheries, and the empowerment of local people. In order for MMAs to sustain themselves, however, they need to make economic sense. Policy makers and MMA managers need to understand the incentives facing various stakeholders, and they need to be able to make a realistic case for the economic viability of their (existing or proposed) projects. MMA performance outcomes must be understood, and the drivers of various aspects of MMA performance must be quantified.

The term Marine Managed Area (MMA) has emerged over the last decade with the intention of reducing the implication of complete protection or ban on all extractive activities inherent in the term Marine Protected Area. There are a number of definitions of the term MMA but for the purposes of this report the broadest is adopted without entering into details of permanence or duration: "*An area of marine, estuarine, and adjacent terrestrial areas designated using federal, state, territorial, tribal, or local laws or regulations intended to protect, conserve, or otherwise manage a variety of resources and uses."* (Govan 2009). The number and scale of MMAs around the world are likely to increase dramatically in the near future. In 2001, one hundred and fifty scientists attending the Academy for the Advancement of Science annual conference called for 10 percent of the world's oceans to be placed in marine (no-take) reserves, and in 2003 the World Parks Congress also called for to 10 percent of the oceans to be placed into marine reserves. At the United Nations Convention on Biological Diversity in 2004, participating governments agreed to establish a "globally-representative" network of MPAs by 2012. "MPA" is a vague term but usually includes some proportion of marine reserves. Yet despite this global interest and the substantial financial investment it implies, there are significant gaps in our understanding of MMA performance and sustainability.

In June of 2007, the Food and Agriculture Organization of the United Nations convened an expert group to develop recommendations for the use of MMAs 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, p. 16) This research will support the goals articulated in the FAO document by investigating the relationships between socioeconomic, governance, and ecological processes and MPA performance in diverse situations.

The present project is part of Conservation International's (CI) Marine Management Area Science (MMAS) research program. The MMAS program is an integrated research agenda combining social and biological science to study the management of marine areas in order to improve their effectiveness and support conservation and human development

goals. Most of the research in the MMAS program is concentrated in four "nodes": Belize, Brazil, the Eastern Tropical Pacific Seascape (Panama), and Fiji. These nodes were chosen because they have established marine management areas to study, they are rich in biodiversity, they are home to several unique species, and they have a stable base of social, political, and economic resources to manage critical marine areas.[3] In addition, the MMAS program incorporates several projects that are global in scope. The present study is one of those.

The main objectives of this study are to:

1. determine the socioeconomic, governance and ecological ***effects*** (outcomes and outputs) of MMAs (and where possible, specific management regimes within MMAs);

2. determine the ***critical factors*** (ecological, socioeconomic and governance) affecting MMA outcomes and outputs, as well as the impact of the ***timing*** of those factors on the outcomes and outputs of the MMA;

3. provide management tools for ***predicting*** MMA outcomes based on ecological, socioeconomic and governance variables.

This study will be unique in its assessment of how ecological, socioeconomic and governance factors interact during the MMA planning and design process, as well as during MMA implementation, to affect MMA performance. Specifically, this project will enhance the understanding of the relationship between:

(a) the context of MMAs (the purpose for establishment: status, threats, and opportunities);

(b) the planning of the MMAs (goals and objectives) and the process of implementation (activities/actions involved in implementation and, critically, the timing of such activities); and

(c) the outputs (results of management actions) and outcomes (impacts and achievement of objectives) of the MMAs.

This project was conducted in two phases. Phase one of the GME project - an initial set of five site visits and associated case studies - was completed between summer 2006 and winter 2007. It was hoped that these case studies would provide enough data to develop a predictive model as described above. While the data gathered in Phase 1 has been useful for generating hypotheses on the factors critical to the success of MMAs, and for developing the prototype for the spatial decision support tool (see Appendix F for the full report from Phase 1), it was evident that the limited quantitative analysis possible with the case study approach would not be adequate to achieve all of the objectives of this study.

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[3] Information about Conservation International's Marine Management Area Science Program can be found at http://science.conservation.org/portal/server.pt?open=512&objID=469&parentname=CommunityPage&parentid=5&mode=2&in_hi_userid=127745&cached=true

Consequently, the team decided to adjust the plans for Phase 2 of the GME project to include primary data collection via household surveys.

The selection of MMA project sites to be evaluated in the Phase 2 study was conducted by the authors in consultation with personnel from Conservation International and numerous personal contacts. The Phase 2 study includes analysis of data from approximately 15 sites, concentrated in five regions (Africa, wider Caribbean, South America, Pacific and Southeast Asia). This provides both global representation and a variety of MMA structures. In order to optimize financial resources and leverage the findings from the MMAS project as a whole, half of the sites in the Phase 2 study are located in CI's Core Research Node areas (Panama, Fiji, and Belize). The remainder of the sites are located in Africa and Asia. These non-node sites represent a variety of management structures and effectiveness. Included are four sites in Asia (Apo Island, Mabini, and El Nido in the Philippines and Hon Mun in Vietnam), three sites in the Western Indian Ocean (Mafia Island, Menai Bay, and Misali in Tanzania), and one site in the Caribbean (Soufriere Marine Managed Area in St. Lucia). Where possible, data was collected from two or three communities within each of the study sites.

This study should have the following conservation impacts:

1. *Determine the effects of MMAs from an ecological, socioeconomic and governance perspective.* This will help site, regional and global-level conservationists demonstrate the benefits of MMAs to the public and policy-makers as well as help them mitigate the potential negative impacts in their management strategies.

2. *Determine the key factors affecting outcomes and outputs, how these factors interact, and how the timing of events and responses to those events influence MMA performance.* This will help determine where and when to deploy limited conservation resources for maximum impact.

3. *Provide a tool for MMA managers to predict the effects of MMAs based on socioeconomic, governance and ecological conditions.* This will help conservationists demonstrate the likely effects of a new MMA, and will enable conservationists working in existing MMAs to determine the likely effects of alternative strategies and, therefore, where they should most effectively focus resources.

In addition, this study is unique in several ways:

- *Interdisciplinary* – unlike most previous studies of MMAs, this project will not only focus on the ecological effects of MMAs, but will also examine MMA socio-economic and governance effects.

- *Interactions* – in addition to being interdisciplinary, the research team will specifically examine the interaction between ecological, socioeconomic and governance variables in assessing MMA effects

- *Temporal scale* – Unlike most studies that focus on the outcomes of MMAs at a specific point in time, this project will examine interactions between factors and MMA effects over time, from the MMA planning process, through implementation. Specifically, this project will examine the timing of conditions and events and how

the timing of key events or conditions affect MMA success – i.e. when is awareness key, alternative livelihood options, and stakeholder participation critical for positive ecological, socioeconomic and governance effects.

- *Decision-making tools* – The final difference between this project and others is the development of models that will underlie GIS-based decision-making tools. These will differ from existing models in their incorporation of the interdisciplinary and temporal dynamics described above.

These differences represent significant advances in the way that MMAs are studied, and the results of these efforts are likely to have impact on MMA science and the creation of MMAs globally.

This report represents the following deliverable as specified in the GME plan of work:

- Technical research report intended for scientific audiences that synthesizes from all sites

2.0 RESEARCH FRAMEWORK AND METHODOLOGY

2.1 ANALYTIC FRAMEWORK AND RESEARCH APPROACH

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. 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.

This is an empirical study built upon the institutional analytic approach described in Bromley (1992) among others. In this approach, the analyst first identifies the variables characterizing the resource and the resource user. In the present study, this group of variables includes socioeconomic and ecological factors such as livelihoods, community demographics, coral bleaching events, and many others (see section 4 below for a full discussion of all the variables). These "contextual" variables are then linked with the institutional arrangements pertaining to resource access and use. The institutional arrangements for the present study are characterized as governance factors, detailed also in section 4 below. Second, the outcomes resulting from marine resource management efforts are measured according to performance criteria -- in this case improvement in various indicators of the effects of an MMA -- toward assessing the management strategy's impact on the well-being of both human and non-human elements of the coastal ecosystem.

The relationship between outcomes and independent variables can be defined in the familiar functional form:

MMA effects $_{jj} = f(soc_i, gov_i, ecol_i)$, where

MMA effects $_{jj}$ is measured by 1) household *j* perceptions of changes in various indicators and 2) scientific research on the status of ecological indicators at a particular MMA site *i* relative to that of control sites.

soc_{ij} are socioeconomic factors present at both the household and site levels, measured via household surveys and a review of pertinent literature.

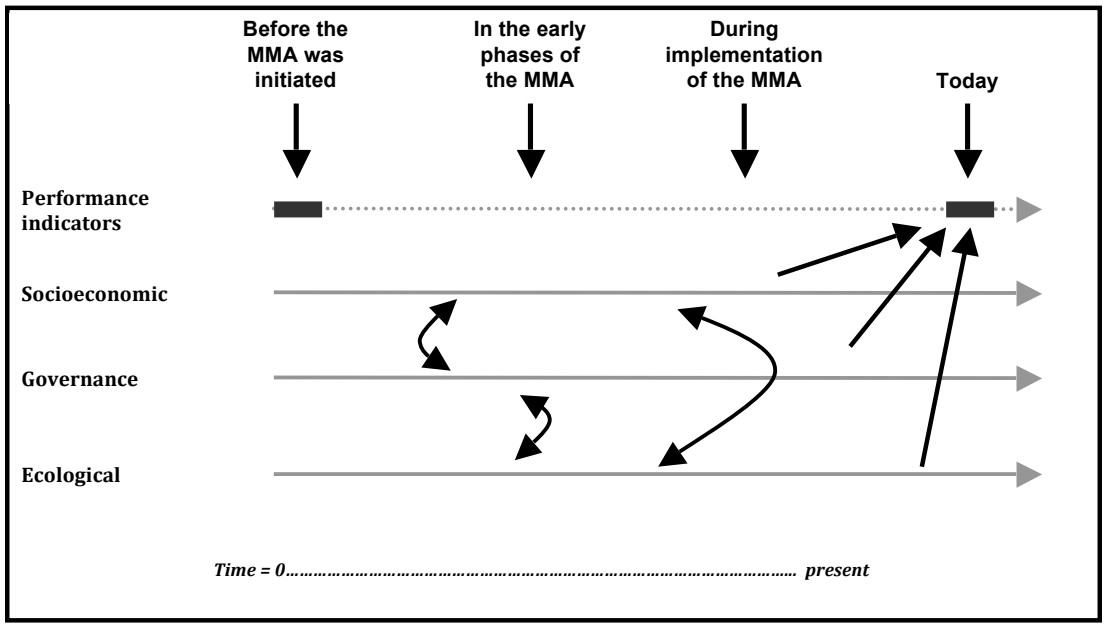
gov_{ij}, are governance factors present at both the household $_j$ and site levels, measured via household surveys and a review of pertinent literature.

$ecol_i$ are ecological factors present at the MMA level, measured via a review of pertinent literature and/or data collected by collaborators at node sites.

It is important to note that "in an institutional theory, the relationship of the dependent variables is not a deterministic function but is rather one of facilitation so that "*f*" here should be read as the independent variables facilitating the realization of the dependent variables." (Schmid 2004, page 70). Therefore, while an econometric analysis isolating the effects of individual independent variables will be included in this study, a great deal of attention will also be paid to the interpretation of bivariate correlations between dependent and independent variables and between the independent variables themselves.

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 – correlations – between the socioeconomic, governance, and ecological factors that are related to the outcomes of MMAs. The dark, straight arrows represent relationships between independent variables (socioeconomic, governance, and ecological factors) and dependent variables (the change in performance indicators, or the effects of the MMA).

Figure 1: GME Analytic Framework



In order to conduct a quantitative analysis 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[4]. 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[5] in the reported level of a performance indicator is considered an effect of an MMA.

Ecological effects of MMAs were determined using a quantitative approach. Because of the paucity data on ecological factors before MMA implementation, we were unable to follow a Before-After Control-Impact (BACI) comparison as was done for non-node sites (e.g. Schmitt and Osenberg 1996). Instead an approach was used in which key ecological variables were compared within the MMA area and nearby control areas (open access areas) using the most recent data available. While this approach is less rigorous for detecting MMA effects than the BACI approach used for non-node sites, it provided the best possible means of assessing MMA effects given data limitations. Even using this approach, node sites in which implementation of management has not occurred yet or has only recently occurred could not be used in analyses because differences between control and non-control sites were not due to management, but underlying ecological variability. All data used in analyses was from published literature and/or unpublished data provided by researchers working in node sites.

[4] A thorough discussion of the opportunities and limitations associated with relying on secondary data for this analysis can be found in the report from the first phase of this research, included as Appendix E.

[5] Following Pomeroy et al (1996) we define as "significant" a difference of 2 points on a 10 point scale

2.2 DATA COLLECTION AND SAMPLING

Secondary data collection

At each non-node MMA site, a thorough review of prior literature was undertaken. This secondary data was compiled during the course of the research team's site visits. Data sources included published scholarly articles, books, statistical databases, scientific publications, and unpublished reports and documents from MMA management, government agencies, and NGOs.

Socioeconomic and governance data was extracted into a relational database which associates each data point with one of the variables under investigation, and which identifies a data point as a "*critical determining factor*" (CDF) as appropriate. Each data point was also tagged with a date relative to the inception of the MMA, which enabled it to be associated with a time line in a visual display (see Section 4), or incorporated with the same factors at other MMAs (Section 5.2) in a qualitative analysis.

The ecological component of this research relied on both published information on the status of marine resources and ecosystems within and outside of the MMA areas, and unpublished data collected by researchers currently working on node sites. Ecological data on MMA sites varied in the quantity and quality of data available for determining Ecological CDFs and outcomes. While some data from each site was readily available in the primary scientific literature, other data was available only in obscure reports that could only be obtained from local management agencies or directly from the researchers. These documents were gathered with the assistance of researchers working in node sites.

Household surveys

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.

Survey implementation

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[6] to the communities being surveyed. Samples of 40-60 individuals 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.

Table 1: Data structure and sample size

Country	MMA	Community	Sample size
Tanzania	Menai Bay	Dimani	30
		Kizimkazi	12
		U' ukuu	8
		K'mkungani	10
	Mafia Island Marine Park	Chole	19
		Jibondo	20
		Kiegani	20
	Misali Island Conservation Area	Wete	10
		Gando	10
		Ndagoni	19
		Shidi	20
Saint Lucia	SMMA	Soufriere	55
Philippines	Apo Island	Apo Island	52
	El Nido	Masagana	18
		Sitio Simpian	20
		Sitio Cagbatang	20
	Mabini	Balanoy	18
		Balitan	22
		Looc	11
Vietnam	Hon Mun	Bich Dam	28
		Dam Bay	7
		Hon Mot	9
		Vung Ngan	6

[6] For example, at a site with a painful history of ethnic tensions, the question about ethnic heterogeneity was dropped.

Country	MMA	Community	Sample size
Panama	Coiba	Bahia Honda	5
		Gobernadora	5
		Hicaco	5
		Los Diaz	4
		Malena	5
		Pedregal	4
		Pixvae	5
		Puerto Mutis	5
		Puerto Remedio	5
		Sta. Catalina	5
Fiji	Kubulau	Kiobo	10
		Namalata	7
		Navatu	15
		Raviravi	10
	Malolo	Solevu	23
	Navakavu	Muaivuso	14
		Muavuso	2
		Nabaka	5
		Namakala	10
		Navakavu	1
		Waiqanake	28
	Waitabu	Vurevure	6
		Wai	5
		Waitabu	14
Belize	Gladdin Spit	Placencia	52
	Laughing Bird	Placencia	48
	Lighthouse Reef	Sarteneja	50
	Port Honduras	Monkey River	25
		Punta Gorda	25
	Sapodilla	Punta Gorda	50
	South Water Caye	Dangriga	25
		Hopkins	25

2.3 DATA ANALYSIS

Qualitative analysis (case studies)

This study relied on a mixture of qualitative and quantitative analysis to produce the final results. The qualitative analysis entails two distinct components. The first component, documented in section 4 of this report, is a set of brief *case studies* for each (non-node) MMA. Case studies are widely employed in the social science literature when the objective of a research project is to obtain a holistic understanding of a location, community, or process. The study of cases can be a particularly fruitful method for providing insights into processes about which little is currently known. An important characteristic of this approach is its reliance on the integrative powers of investigators, on their ability to draw together many diverse bits of information into a unified interpretation.

The qualitative analysis will provide insight into:

- the evolution of MMAs,
- the flow of information and decision-making and how they are influenced by ecological factors,
- the sequencing (over time) of activities/actions/interventions,
- an assessment of outputs and outcomes in relation to both process and ecological, socioeconomic and governance elements, and
- the key factors for success or failure

Correlation analysis

Correlation refers to the degree of association between two variables in a data set. It is often used as an exploratory tool – significant indirect and direct relationships among variables can point to potential causal mechanisms that can be explored in further analysis. Pairwise correlation matrices were calculated for the twelve indicators of MMA effects and a large number of the explanatory variables. These correlation coefficients were particularly useful for assessing the relationship between the indicators of success and explanatory variables which could not be included in the multivariate regressions (i.e. the site-level data). In order to turn the matrix of correlation coefficients into meaningful information, and especially to compare the qualitative timelines with the quantitative correlations, significant correlations were assembled in a timeline-type display as well.

- Correlation analysis allows us to: determine the degree and direction (positive or negative) of association between critical determining factors and MMA effects
- describe chains of associations among critical determining factors over time

Regression analysis

The appropriate multivariate regression techniques for this data set were driven by the fact that the data is hierarchical – that is, the population consists of MMAs and households within these MMAs, and the sampling procedure proceeds in two stages: first we take a sample of MMAs, and next we take a sample of households within each MMA. Households are said to be *nested* within MMAs. Because most econometric estimators assume independence, the standard errors would tend to be biased if no correction was done to take into consideration the clustering of the data. To accommodate the complex structure of the data set, the analysis used a correction that allowed the standard errors to be calculated under the assumption of stratified, clustered, random sampling (with clustering by site). The variance estimators used in the analysis allow for any amount of correlation within the clustering units, and allow for secondary clustering. While not explicitly accounting for clustering by survey respondent, the standard error calculation accounts for this by allowing for a flexible correlation structure within sites. In multistage designs such as the one used by this study, the correlation yields variance estimates that are either approximately unbiased or biased towards more conservative estimates. Therefore, the standard errors should be approximately correct.

This modeling approach allows relationships across and within hierarchical levels of a multistage design to be explored, taking account of the variability at different levels. Intercorrelations between variable at the same level are also taken into account. In the present case, coefficients on the household level independent variables are determined by a function of the random term and the MMA level characteristics.

The multilevel (hierarchical) mixed effects model is defined as follows:

$$Y = X\beta + Zu + \varepsilon$$

where Y is a n x 1 vector of MMA performance outcomes, X is a n x p matrix of fixed effects regressors (in this case, site-level ecological, social, and institutional or governance factors), Z is a n x q matrix of random effects regressors (household survey responses), u is a (q x 1 vector of) random effects, and ε is a (n x 1 vector of) error terms.

Note that it is possible for a variable to appear as both a fixed effect and a random effect. For example, the fixed effect (β) would refer to the overall expected effect of a site-level variable on the MMA performance outcome being considered, and the random effect gives information on whether or not this effect differs between survey respondents. The sample of eight MMAs in the present analysis is too small to do this type of advanced analysis, but it is hoped that by adding the remainder of the project (node) sites to this database we will be able to do so in the future.

Regression analysis enables us to:

- predict the probability of any MMA effects occurring, given a particular combination of critical determining factors.

2.4 LIMITATIONS

Several important limitations of this study should be highlighted. The study cannot claim to be a globally representative evaluation of MMAs. It evaluates only a small sample of MMAs, and these were not sampled at random. The evaluation was conducted without controls for either MMAs (i.e. looking at "unsuccessful" vs. "successful" MMAs) or the local context (i.e. looking at areas not under any kind of management vs. these managed areas[7].) Therefore, it was not possible to conduct the evaluations using an experimental research design of before/after, control/impact (or "differences in differences") data generation. Biophysical impacts of MPAs are generally recorded as treatment-control (for example, biomass inside vs. outside an MPA); reliable before-after ecological data are rare. Although household surveys will generate before-after values, they will not be conducted in communities unaffected by MPAs – that is, there will be no directly comparable treatment-control data. Finally, the number of MMAs included in this analysis was small. As this research project moves forward, it is hoped that the inclusion additional MMAs will lend greater robustness to the findings reported.

[7] We did use control data for the ecological effects wherever possible.

3.0 VARIABLES

To evaluate the effects of an MMA or determine what factors influence MMA outcomes, we must first define what the effects of an MMA are. Successful MMAs are ones in which specific goals and objectives are met with respect to protecting or restoring key species and ecological function, or improving quality of life for local communities and other stakeholders. Few MMAs will meet all criteria of success. While an MMA may be judged successful in one or two dimensions, it may not be successful in all dimensions. Thus, we must evaluate an MMA's success at achieving specific goals, including:

1. Socioeconomic goals

   Material style of life enhanced or maintained
   Food security improved

2. Governance goals

   Resource use conflicts reduced
   Participation occurring
   Compliance at high levels

3. Ecological goals

   Protecting critical "ecological engineers"
   Maintaining high biomass of extractable species
   Ensuring ecosystem resilience following disturbances
   Conserving or enhancing biodiversity

3.1 DEPENDENT VARIABLES: EFFECTS OF MMAS

The sustainability of a Marine Managed Area depends critically on the support and acceptance of the community of stakeholders. This support, in turn, depends on a number of factors including the level of participation in project design and implementation, compliance with regulations, level of economic benefits received, and how equitably the economic benefits are distributed in the community. If local residents perceive that the MMA project does not address local concerns, or has no positive impact on their well-being, they will be unlikely to support or become involved in project activities. Therefore, *all socioeconomic and governance effects of MMAs are operationalized as survey respondents' perceptions of the difference in levels of each of the variables listed above, from before the MMA was established, to now*.

For example, for the first MMA effect indicator, material style of life, the respondent will be shown the ladder scale and told that the lowest step indicates the worst possible existence, little or no food, inadequate furnishings and shelter, and sickness. The highest step indicates the best possible house, fully furnished, more than enough food, and

everyone healthy. The respondent is asked to point to the level of the ladder showing where they stood before the MMA was established, and today. A difference of two steps on the ladder is coded as an "improvement" in that MMA effect indicator. Using perceptions in this way to define the effects of MMAs is well established in the literature (for example, Pomeroy et al, 1997; McClanahan et al, 2006, Pollnac et al, 2001, Cinner et al, 2005).

For the ecological effects of MMAs, we needed to rely on data from scientific research conducted by others. MMA sites varied in the amount and quality of data available for determining ecological outcomes. While some data from each site was readily available in the primary scientific literature, other data was available only in obscure reports that could only be obtained from local management agencies or directly from the researchers. Other data were entirely unavailable.

There were several issues that hindered efforts to quantify the ecological effects of MMAs. The first was the lack of any baseline data on most factors and effects from many sites before an MMA was created. While the improvement in data collection following the creation of an MMA shows one value of creating an MMA, it does little to help our analyses. The second issue was the failure of many MMA assessment and monitoring programs to include control sites outside the MMA. In addition to hindering our analyses, this points to a critical shortcoming in MMA monitoring and evaluation programs, since conclusions drawn about MMA effects or "successes" are suspect with no contextual basis from control sites. Finally, a third issue is that little, if any data has been collected on several important aspects of evaluating MMA success. Details of measurement issues for each MMA effect indicator are described below and in section 5.2 of this report.

3.1.1 MMA EFFECT INDICATORS

Goal: Livelihoods enhanced or maintained

Many MMAs include the enhancement or maintenance of livelihood opportunities as a stated goal (Pomeroy et al, 2004). The GME survey captures changes in livelihoods through two survey questions. We ask about respondents' material style of life before the MMA was implemented and today using the ten-point ladder scale described above. We also pose a general quality of life question, asking survey respondents whether their quality of life has improved, gotten worse, or stayed the same over the past five years. It is important to note that while survey respondents' perceptions of changes in their material style of life are considered possible effects of the MMA, livelihoods in general and alternative livelihood projects in particular are also independent variables, as discussed in section 3.2 below.

Goal: Food security improved

Household food security can be defined as "that state of affairs where all people, at all times, have physical and economic access to adequate, safe, and nutritious food, without undue risk of losing such access" (Pomeroy et al, 2004, p. 127). An MMA could potentially improve food security by increasing the yield of fish or by reducing the number of outside users in the area under management. We capture food security through two survey questions; we ask about any changes in the amount of local seafood available in the market, and we ask about perceptions of household food security before the MMA and today.

Goal: Resource use conflicts reduced

Following Pomeroy et al, (1997 and 2004), we include changes in community conflict levels as a possible impact of an MMA. The GME survey asks about several different types of conflict – conflict in the community at large, conflict specifically related to the MMA, and conflict over the resources in general. Survey responses regarding changes in these specific types of conflict are highly correlated, not surprisingly.

Goal: Participation occurring

Participation measures how active people are in coastal management. The level of stakeholder participation is useful to understanding the importance of the coastal resources to the public. The more people value the resources, the more likely they are to participate in management (Bunce et al, 2000). An increase in participation would be a positive impact of an MMA (Pomeroy et al, 1997).

As with livelihoods, while changes in perceived levels of participation and influence are possible effects of the MMA, community participation at various stages of the MMA design and implementation process is also an independent variable, as discussed in section 4.2 below.

Goal: Compliance at high levels

Compliance measures to what extent people are perceived to be complying with regulations. Lack of compliance is not only detrimental to the resources, but to gaining stakeholder support. If it is widely perceived that people are not complying with regulations, then it will be difficult to gain anyone's trust, support, participation, or compliance (Bunce et al, 2000). Compliance, like all the socioeconomic and governance effect variables, is measured as changes in respondents' perceptions of the levels before vs. after the MMA.

Goal: Protecting ecological engineers

Ecological engineers include those species which create and provide habitat for other organisms. In tropical systems, these include seagrasses, corals, sponges, and mangroves. *Percent cover of coral, seagrass and mangrove habitats* was the indicator chosen to represent this MMA goal. For the present analysis, values were based entirely on coral cover, since that was the indicator for which data was available at the most sites. There are several reasons for this, including the fact that all MMAs included coral reef area, but some did not include mangrove or seagrass habitats. Furthermore, data on the change in cover of mangrove or seagrass habitats was not available in published literature, unpublished datasets or remote sensing for many sites. In contrast, coral cover data from different time periods was available for all sites.

Goal: Maintaining high biomass of extractable species

Many MMAs are created in response to dwindling fisheries. Since protecting key species within MMAs can support fisheries through spillover and larval replenishment, an important goal of MMAs is maintaining a high biomass (e.g. large sizes and/or high abundance) of fishery species. Based on the data available, the size, abundance or biomass

of fishery species was used in our analysis. The suite of species used for calculating these values were site-specific, as was the type of data used (e.g. abundance, biomass), based on available data for both MMA and control sites. Similarly, it is important to note that not all fishery species were included in these values. Based on data availability, the values for fishery species reflect some of the most important species (or families) in finfish fisheries, such as serranids and lutjanids. Invertebrate fishery species are underrepresented in these values due to a lack of data from most sites.

Goal: Ensuring ecosystem resilience following disturbances

By reducing human impacts within MMAs natural processes that regulate ecosystem function can play a greater role. For example, natural processes that make ecosystems resilient to disturbances may be greater within MMAs. As a proxy measure for ecosystem resilience, we selected the *recruitment rates of ecological engineers* as an indicator. However, only 1 or 2 studies provide any data on recruitment rates of corals or coral colony size structure (or other ecological engineers) within MMAs at non-node sites and even less was available for node sites. Thus, this outcome will be excluded from analyses.

Goal: Conserving or enhancing biodiversity

Biodiversity can be measured in a number of ways, including *Species Richness, Species Diversity and the Evenness of species* occurring within an MMA. Very few studies include these data within and outside MMAs and even fewer studies exist from before MMAs were created. Those that have collected data only report species richness and/or a diversity index, with different indices used in different studies. Thus, this goal is excluded from analyses.

3.2 INDEPENDENT VARIABLES: CRITICAL DETERMINING FACTORS

The existing literature on Marine Managed Areas, and the case study analysis performed in Phase I of this project, provided a starting point for defining the ecological, socioeconomic and governance factors that are likely to determine the effects of MMAs. The hypothesis is that the effects of MMAs will vary based on the combination of the *Critical Determining Factors* (CDFs) present at a site, their levels, and the timing of their occurrence. Data on these variables was gathered via both surveys and a review of the secondary literature. Where possible (i.e. for the survey data and for those factors for which there was data for the full set of MMAs) the variables were coded into a database and were subjected to statistical analysis (described in the next section).

3.2.1 SOCIOECONOMIC FACTORS

Factor	***Survey question***	***Secondary literature***
1. Livelihoods	✓	✓
2. Degree of homogeneity among stakeholders	✓	✓
3. Individual incentives - benefits and costs	✓	✓
4. Equity - shared benefits among stakeholders and between the MMA and the communities	✓	✓
5. Small population size		✓
6. Perceived crisis in the resource		✓
7. Role of women		✓

1. Livelihoods

As discussed above, the enhancement or maintenance of livelihoods is a goal of many MMAs and is a dependent variable in this analysis. At the same time, however, livelihoods are an independent variable. An individual's livelihood (i.e. whether he is a fisher, or engaged in the tourism sector) may affect how he responds to resource management regimes. The establishment of an MMA removes some of the resource that had previously been available for harvesting. Many MMAs provide for alternative livelihood activities in order to make up for this potential loss in access (Pollnac, 2001). Data on livelihoods was gathered from both secondary literature and from survey questions.

2. Group homogeneity

Socioeconomic and cultural homogeneity have been identified as factors contributing to the success of MMAs (Pomeroy et al, 1996). This is may be due to the fact that it is easier to achieve consensus with respect to project activities where the population is more homogeneous (Pollnac et al, 2001). Data on group homogeneity was gathered from both secondary literature and from survey questions. The survey questions ask about socioeconomic, religious, and ethnic diversity.

3. Individual incentives: benefits and costs

The incentive structure facing individuals in a community will directly impact their support for an MMA (ICLARM, 1998). Community members are more likely to feel positively about an MMA and therefore support it voluntarily if the costs of participating and/or complying with the regulations (i.e. traveling further to get to new fishing grounds, restricting lucrative but destructive activities) do not exceed the benefits (such as any personal enjoyment from conservation, or the positive MMA outcomes identified above) (Pomeroy et al, 2001). Data on the incentives facing individuals was gathered through two survey questions – one general question asking about whether the respondent supports the MMA and why, and a specific question asking whether the benefits of the MMA exceed the costs to that respondent.

4. Equity

Equity, or the fair treatment for all people involved in managing, governing and using the resource, is often considered a very important driver of MMA outcomes. As noted in ICLARM (1998) ""The presence of inequities may lead to the collapse of reciprocity, resulting in less efficient use. Equity problems are apt to be aggravated by asymmetries (unequal proportions) among users, which create opportunities for some to benefit at others' expense. This, in turn, can lead to costly conflict where all parties lose." Data on equity was gathered from both secondary literature and from survey questions.

5. Small population size

A small population in the area has been associated with successful MMAs in prior literature (Pollnac et al, 2001). Small populations may be easier to organize, and rapid increases in population can lead to disorganization and conflict. Moreover, having fewer people involved in the MMA might make it easier for the MMA management to communicate with stakeholders. Data on population was gathered from secondary literature.

6. Perceived crisis

A perceived crisis in the resource prior to the implementation of an MMA project has been identified as an important factor in prior literature (Pomeroy et al, 1997). Community members or outside observers may mobilize support for protecting an area more readily when it seems that the area is threatened in some significant way. Data on this variable was gathered from secondary literature.

7. Role of women

Adams (1998) suggests that understanding the role of women in the fishery and in the governance structure is crucial for gaining a full understanding of the factors influencing the success of various types of fisheries management systems. Data on this variable was gathered from secondary literature.

3.2.2 GOVERNANCE FACTORS

Factor:	***Survey question***	***Secondary literature***
Supra-community level factors:		
1. Leadership	✓	✓
2. External agents involved	✓	✓
3. Continuing advice from implementing organization	✓	✓
4. Enabling policies/legislation	✓	✓
Community-level factors:		
5. Long term support of local government	✓	✓
6. Participation by those affected	✓	✓
7. Community organizations	✓	✓
MMA management actions		
8. Appropriate scale/defined boundaries		✓
9. Management rules enforced	✓	✓
10. Conflict management mechanism	✓	✓
11. Empowerment, capacity building	✓	✓
12. Adequate financial resources	✓	✓
13. Accountability	✓	✓

1. Leadership

Strong, persistent leadership was one of the most important factors identified in the first phase of this research project (via key informant interviews at three pilot MMA sites). Pollnac (2001) notes that "successful local level management systems (sasi) in the Moluccas (Indonesia) were likely to be associated with the authoritarian power of a strong local leader", and other authors include leadership as an important factor associated with successful coastal resource management projects (Pomeroy et al, 1996). Data on leadership was gathered from both secondary literature and from survey questions.

2. External agents involved

All of the MMA sites included in this study involved external agents in some

capacity. Most of these projects, for instance, were initiated by conservation or community development NGOs in response to some existing or impending crisis in the resource. Even if external agents did not initiate the MMA, there was almost always external funding for at least the beginning phases of the project. Pomeroy (1996) suggests including "full-time codevelopment workers and community organizers living in project communities" as an important project implementation strategy for the fulfillment of coastal management objectives. Data on this variable was gathered from both secondary literature and survey questions.

3. Continuing advice from implementing organization

Having consistent support and advice from the organizations who implement the MMA is considered important in ensuring its viability (Pomeroy et al, 1996, Pollnac et al, 2001). A lack of consistency in advice and support can lead to the loss of engagement of communities in coastal management projects - the community members may decide that the project isn't worth supporting if the implementing organization retracts its support. Data on this variable was gathered from both secondary literature and survey questions.

4. Enabling policies/legislation

Enabling legislation is "the formal legislation in place from government to provide coastal resources management with a sound legal foundation so that…procedures can be recognized, explained, respected and enforced" (Bunce et al, 2000). Data on this variable was gathered from both secondary literature and survey questions.

5. Long term support of local government

Supportive local leadership has been cited by prior authors as contributing to the success of marine resource management projects (Pollnac et al, 2001). Data on this variable was gathered from both secondary literature and survey questions.

6. Participation by those affected

The justification for including participation in this analysis is discussed in section 3.1 above. To reiterate, changes in the level of participation or influence over coastal resource management decisions are considered an effect of the MMA – a dependent variable in our analysis. At the same time, the existence of different types of participatory activities at different times in the life history of an MMA are independent variables in our analysis. Specifically, the GME survey asks whether community members were able to influence the size and location of different reserve areas, and whether there were community consultations about the MMA.

7. Community organizations

Communities with a tradition of cooperation and collective action have been identified as those most likely to effectively respond to marine resource management projects (Bunce et al, 2000, Pollnac et al, 2001). Such collective action groups could include fishermen's cooperatives, tour guide associations, and the like. Data on this variable was gathered from both secondary literature and survey questions.

8. Appropriate scale/defined boundaries

The scale for an MMA should be appropriate to the area's ecology, people, and level of management. Decisions on physical scale include not only the boundaries of the area to be managed, but also the species or ecosystem level to be managed. Boundaries should be distinct so that the fishers have an accurate knowledge of them and can easily observe them (Pomeroy et al, 2001, Pollnac et al, 2001). Data on this variable was gathered from secondary literature only.

9. Management rules enforced

Enforcement is a critical step in the MMA management system (Pomeroy et al, 2004, Ehler, 2003). Having clear systems for enforcement, and engaging the community in enforcement and monitoring may help the MMA to achieve its objectives with minimal levels of conflict and costs. Data on this variable was gathered from both secondary literature and survey questions.

10. Conflict management mechanism

If resource users are to follow rules, a mechanism for discussing and resolving conflicts and infractions is necessary. There is a need for a forum for resource users to debate and resolve conflicts and to appeal decisions. Pomeroy et al. (2001) and ICLARM (1998) recommend including mechanisms for conflict resolution among resource users as an indicator for community institutional arrangements and patterns of interaction between resource users. Data on this variable was gathered from both secondary literature and survey questions.

11. Empowerment/capacity building

Empowerment and capacity building has been identified as another important variable contributing to the success of MMAs. This is a fairly broad concept, and can include the overall educational and skill levels of the communities, the level of environmental awareness in general, and/or specific training for community members in management issues around the MMA (Pomeroy et al,1996 and 2004). Data on this variable was gathered from both secondary literature and survey questions.

12. Adequate financial resources

Financial or material resources are essential to project success. Carrying out surveillance, constructing guardhouses, installing marker buoys, etc. have costs which must be met (Pollnac et al, 2001). Data on this variable was gathered from both secondary literature and survey questions.

13. Accountability

Accountability is the overall availability of information for transparency, reporting to communities, etc. This is considered central to any impact evaluation of a marine resource management project (Ehler, 2003). It is desirable to have a process in which business is conducted in an open and transparent manner. Ideally, venues should be provided for public discussion of issues and to reach consensus. Moreover, there needs to

be accepted standards for evaluating the management objectives and outcomes. Without strong accountability, decision making can become corrupt and arbitrary (Pomeroy et al, 2001). Data on this variable was gathered from both secondary literature and survey questions.

3.2.3 ECOLOGICAL FACTORS

Ecological factors:	*Secondary literature*
1. Life history characteristics of key species	✓
2. Functional redundancy within the ecosystem	✓
3. Trophic structure	✓
4. Habitat characteristics	✓
5. Incidence and severity of storms	✓
6. Outbreaks of disease or harmful algal blooms	✓
7. Frequency and degree of coral bleaching	✓
8. Impact of land use and human activities on habitat and water quality	✓
9. Characteristics of fisheries	✓

Ecological CDFs were derived from a review of secondary literature and input from researchers working at the node sites; a detailed discussion of the development and values for numeric metrics is contained in Appendices B and C. The quantitative assessment of ecological CDFs followed a combination of approaches. Some CDFs for a particular location did not vary in space and time (e.g., life history characteristics of key species). In these cases, CDF data does not follow the BACI-style approach described for the ecological outcomes and is independent of space and time. In other cases CDF data was highly variable temporally (e.g. incidence of storms, disease outbreaks, coral bleaching events), but varied spatially on scales larger than that used for MMA vs. control area comparisons. In these cases, only the temporal component is used in analyses for individual sites; however comparisons between MMA sites (e.g., between individual MMAs in a country or between MMAs in different countries or regions) was possible. Only a few of the CDFs from specific sites varied spatially and temporally on scales appropriate for BACI-style comparisons.

To facilitate integrated analyses with socioeconomic data, it was decided that ecological CDF data should be presented as ordinal data on a scale from 0-1. To accomplish this, a combination of quantitative and ordinal data was used and then scaled appropriately.

1. **Life History Characteristics of Key Species**

In this CDF, life history characteristics of were limited to those key fishery species to address factors that contribute to ecological Outcome 2 in particular. While adding analysis of life history characteristics of coral species (Ecological Outcome 1) and/or ecologically important species (Ecological Outcome 3) may be useful, they were not included for several reasons. The fact that the general life histories of corals found at MMAs and control sites are not likely to vary much means that their addition would contribute little to our analyses. Thus, they were excluded. Ecologically important species were not explicitly included in this CDF since there is some overlap between some ecologically important species and fishery species for several MMAs (e.g., parrotfish) and for other MMAs, no data provided on ecologically important species.

Life history characteristics were broken down into four key characteristics: Movement; Age at Maturity; Reproductive Output; and Planktonic Larval Duration (PLD). Ordinal values for each of these characteristics were on a scale of 1-5 (Table 4), and then converted to a 0-1 scale by dividing by the maximum value (5). Ordinal values included decimal to encompass a range in each characteristic for individuals or when several species (or families) were averaged together to come up with the final value.

2. Functional Redundancy within the Ecosystem

There was insufficient data to accurately assess this for any sites. Furthermore, since all MMA sites are primarily coral reef areas, this CDF will vary little between MMA sites (with the possible exception of comparisons across regions between MMAs in the Indo-Pacific and Atlantic).

3. Trophic structure

There was insufficient data to accurately assess this for most sites, since species-specific data at many sites only included a small subsample of species targeted in local fisheries. Thus, in many cases it was not possible to adequately assess one trophic level, let alone the trophic structure of the system. This CDF was dropped or included as an ordinal value based on "expert opinion".

4. Habitat Characteristics

Since all MMAs are in coral reef areas, the critical aspect of habitat characteristics to be captured in this CDF is the connectivity among different habitats in the MMA area (within and outside the MMA). Thus, habitat maps and published descriptions were used to rank habitats and their connectivity following a modification of the ranking system used by Stoner et al. (1999) for evaluating MPA sites. A value of 1 was assigned to MMA sites containing coral reef only. A value of 2 was assigned to MMAs containing reef and seagrass. MMAs with reef and seagrass with mangrove habitats outside the MMA by nearby were assigned a value of 3. A value of 4 was assigned to MMAs containing all three habitat types. A value of 5 was assigned to MMAs containing all three habitats plus terrestrial areas. Values were then converted to a 0-1 scale by dividing them by the maximum value (5).

5. Incidence of Storms

This CDF accounted for both the frequency and intensity of tropical cyclones likely to affect each MMA (i.e. those whose center tracked within approximately 50 km of the MMA). Since the incidence of storms is highly variable temporally, this is the first CDF to incorporate a temporal component in its values (i.e., different values for before MMA implementation, during implementation process, and after implemented). Since most control sites were located near MMA sites, there was insufficient spatial variability to include separate values for control sites. Incidence of storm values were calculated by assigning each storm passing within approximately 50 km a number from 0-5 based on its rating on the Saffir-Simpson scale (Tropical Depressions receiving a 0 and Tropical Storms receiving a 0.5) adding up the values for each year and calculating the average value over the specified time period. For the before MMA implementation time period a 10 year average was used. Values were then converted to a 0-1 scale by dividing them by the maximum value (5).

6. Outbreaks of Disease or Harmful Algal Blooms

This CDF included outbreaks of coral diseases, die-offs of key ecological species, fish kills and documented cases of algal blooms (e.g. red tides). To calculate an index for disease and harmful algal blooms, the severity of episodes during each specified time period (up to 10 years before, during and after MMA implementation) was rated on a scale of 1-5, and then converted to a 0-1 scale by dividing them by the maximum value (5). A value of 0 was assigned when there were no reports of disease or algal blooms. While this may lead to a bias of low scores before the MMA was implemented, enough cases of fish kills (i.e., the absence of a report does not necessarily mean the absence of disease outbreaks or harmful algal blooms), coral disease or harmful algal blooms were reported from time periods prior to MMA implementation (primarily 1980's and 1990's) that any major episodes are likely to have been reported. A value of 1 was assigned if coral disease or other episode was reported in the literature but not thought to have had an impact on ecological communities. A value of 2 was assigned when partial mortality was documented for some species. A value of 3 was assigned to incidences when there was some widespread mortality (or total mortality of individual coral colonies) was observed in a few species. A value of 4 was assigned to incidences where widespread mortality was reported for a few species. Incidences where there was widespread mortality of many species received a value of 5.

7. Frequency and degree of coral bleaching

Similar to the past few CDFs, this CDF had a temporal component for analyzing events before, during and after MMA implementation. Since some control sites and MMA sites also differed in severity of bleaching, a spatial component is also included for this CDF. To calculate an index for coral bleaching, the severity of episodes during each specified time period (up to 10 years before, during and after MMA implementation) was rated on a scale of 1-5, and then converted to a 0-1 scale by dividing them by the maximum value (5). Values were assigned based on a scale identical to that of *Outbreaks of disease and harmful algal blooms* (see above).

8. Impact of land use and human activities on habitat and water quality

Two of the ecological Critical Determining Factors depend upon social data for their values. These are ecological CDF #8: *Impact of land use and human activities on habitat and water quality*, and ecological CDF #9: *characteristics of fisheries*. Each of these CDFs is a composite of a number of measurable variables thought to impact the marine environment and the effectiveness of MPAs. As with the other ecological CDFs, these socio/ecological CDFs will be presented as ordinal data on a scale from 0-1

Humans can impact habitat and water quality through both the number of people in the area and the activities that they engage in, including tourism, aquaculture, various types of land use and coral mining. A detailed description of the development of this CDF is provided in Appendix C. The value of this CDF is presently conceived as a weighted average of the rankings of the five subcomponents of this metric, divided by the maximum value, to give a ranking on a scale of 0 to 1. At present, the weights are equal at 20%.

Because of a paucity of secondary data for the node sites, these CDFs were only calculated for non-node MMA sites.

9. Characteristics of fisheries

This CDF is defined as a combination of the effort expended in the fishery and the types of fishing gear used. Details of the gear ranking scheme are provided in Appendix C.

4.0 CASE STUDIES OF NON-NODE MMA SITES

The selection of MPA project sites to be evaluated in this study was conducted by the authors in consultation with personnel from Conservation International and numerous personal contacts. Given that primary data on ecological indicators was not collected for this study, it was important to select MMA sites that had reliable pre-existing ecological data.

Of the four node sites, three were included in this study (Belize, Fiji and Panama). These sites were selected based on the ability of local partners to undertake a socioeconomic survey and the reported availability of ecological data. The Brazil site was not included in the analysis due to potential issues in undertaking a socioeconomic survey. More complete information on the node sites can be obtained from the CI Marine Management Area Science Program website: http://www.conservation.org/discover/centers_programs/mmas/Pages/marine_management_area_science.aspx

Following are brief case studies of the (non-node) MMA sites included in this report. Each case study consists of one page of narrative information and one timeline. A complete list of the literature reviewed as part of this studied is included as Appendix E[8].

Table 2 provides a brief overview of the key features of non-node MMAs included in this report.

[8] Specific citations are not included in this section for the purpose of ease of reading. The information contained in these case studies is re-shuffled and reiterated, with full citations, in the content analysis portion of section 5.

Table 2: Key features of (non-node) MMAs included in this report

	Year of establishment	Size of protected area	Population	Donors and government partners
Apo	1986	691 ha	700	Initiated in 1970s through the efforts of scientists from Silliman University. Co-managed through Protected Area Management Board Including DENR (National level), local government and the community
El Nido	1991	95,000 ha both marine and terrestrial	16,000	Involved in a debt for nature swap in late 1980's – Haribon involved. Since then, has evolved into being co-managed through Protected Area Management Board Including DENR (National level), local government and the community
Hon Mun	2001	Entirety of Nha Trang Bay is managed, several core zones and buffer zones within the MMA. Area in km^2 not specified within the literature.	5000	Funded by GEF and jointly financed by the Danish International Development Agency, IUCN, and the Government of Vietnam. Administered by the provincial government with some assistance from the Department of Fisheries
Mabini	1998	Entire shoreline and reef of 700 meters offshore under management; several fish sanctuaries within these waters	42,000	Initiated by Haribon with the Local Government Unit of Mabini; WWF supporting enforcement efforts; numerous other NGOs as well as the LGU involved
Mafia Island Marine Park	1995	822 km^2	18,000	NORAD, WWF in partnership with the Marine Parks and Reserves unit (National level)
Menai Bay	1997	476 km^2	16,000	Formerly WWF, currently Zanzibar Department of Fisheries with increasing involvement of MACEMP
Misali	1998	22 km^2	Approx 11,000 in stakeholder communities; Misali Island itself is uninhabited	Managed by CARE Tanzania with the Zanzibar Department of Commercial Crops, Fruits and Forestry and the Misali Island Conservation Association; supported by MACEMP
SMMA	1994	75 km of coastline to a depth of 75 meters	8,000	Administered by Soufriere Marine Management Association (multisectoral, community based management association)

APO ISLAND PROTECTED LANDSCAPE AND SEASCAPE

Apo Island, in the Philippines, is a small (74 hectare) island with 700 residents, where fishing is still the main livelihood. The island is surrounded by a narrow fringing reef. The total marine area under management is 691 hectares, of which 45 km is a no-take sanctuary. Apo Island Protected Landscape and Seascape (AIPLS) was established by municipal ordinance in 1986, and given national protection in 1994. The current system of management and fee collection was instituted in 1999.

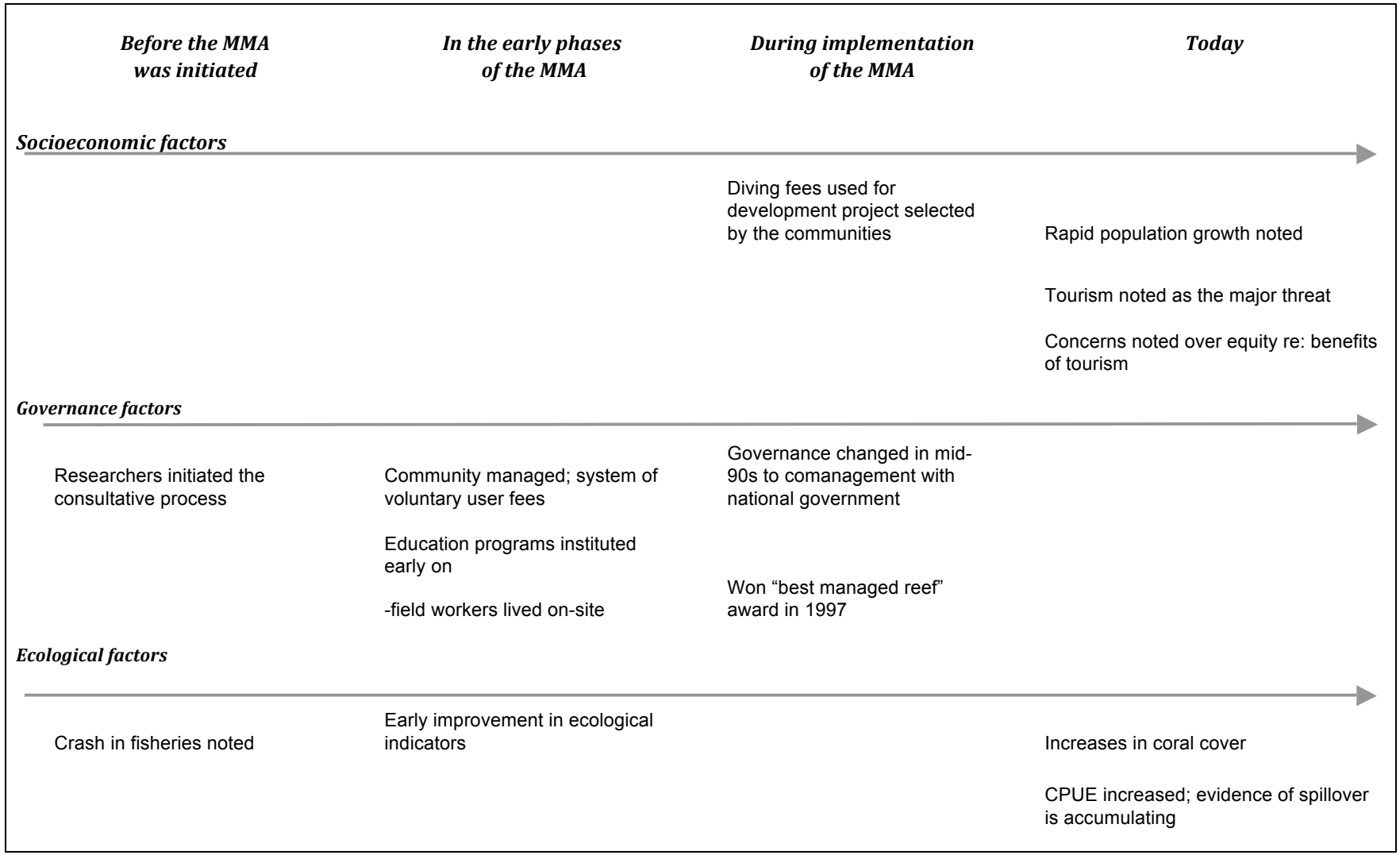
Apo Island is located in one of the poorer provinces in the Philippines; 37 percent of families live below the poverty line. At Apo Island itself, the majority of households still engage in fishing as their primary livelihood, although the increase in tourism that has emerged since the area was protected provides some alternative livelihood opportunities. Other alternative livelihood projects that were directly associated with the protected area have not been successful.

The managed area was initiated in response to the collapse of local fish stocks due in part to destructive and illegal fishing practices. As far back as the 1970's, conservation workers integrated themselves in the community, and a major focus of their work was to build the capacity of community organizations for managing their marine resources. Women were actively involved in enforcement in the early days. The legislation recognizing the protected area was not in place until after community-level protection had already been implemented.

Although live coral cover showed steady improvement since the beginning of protection, the area was hit hard by the El Nino bleaching events of the late 1990's. Recovery of the coral has been rapid, however, and coral cover was to be back to its prior levels by 2001. Also in 2001, the community worked together to deal with a crown-of-thorns starfish outbreak by literally diving into the water and pulling the starfish out.

AIPLS won the "best managed reef in the country" award in 1997, and is generally considered very successful. There has been an improvement in CPUE, (that is, yields have been stable while effort has been reduced) and there is evidence of spillover from the protected area into the surrounding waters. The increase in fish has led to a boom in tourism, as well. There are some frictions between the local communities and the national government over disbursement of MPA revenues, and excessive tourism is considered to be the greatest current threat to the area.

Timeline 1: Apo Island



EL NIDO-TAYTAY MANAGED RESOURCE PROTECTED AREA

El Nido-Taytay Managed Resource Protected Area comprises 95,000 hectares of marine and terrestrial areas. The marine reserves are managed within the context of the larger resource management project. There are 16,000 residents within the Protected Area, and their main occupation is farming. The area became a marine reserve in 1991 after having been a turtle sanctuary since 1984. The operational framework for the Protected Area was developed via a consultative process that began in 1996. El Nido became one of ten sites included in the National Integrated Protected Area Programme (NIPAP) a five-year project set to run from 1997 to 2001.

The protected area was initiated in response to decreasing fish catches and general degradation of the reef environment. The proximate cause for diminishing environmental quality appears to have been rapid population growth through the 1980s due to increased logging in the area. Apparently, the situation became so bad that in 1989, the site was one of eight locations in the Philippines that was included in a debt-for-nature swap.

The majority of residents live below the poverty line, and farming is the major source of livelihoods in the region. Tourism is a significant sector as well, with about 20,000 visitors in 2001. Recently, there have been discussions about opening up the area to the (highly lucrative but environmentally damaging) live fish trade.

Enforcement has been an ongoing challenge at El Nido. When NIPAP ended in 2001, funding for enforcement dropped to 10 percent of its pre-2000 levels. Due to this crisis, various sectors in the community and conservation organizations got together to develop a new enforcement plan. The plan has been implemented through multi-sectoral cooperation between tourism, NGOs, and the communities.

The outcomes of the El Nido MMA are not universally positive. Biophysical studies have shown negative results in terms of coral cover and overall ecosystem health. There is some concern that current funding sources will be inadequate for long term management. An additional threat is ongoing deforestation upland, which could cause siltation and further water quality degradation.

Timeline 2: El Nido

Before the MMA was initiated	*In the early phases of the MMA*	*During implementation of the MMA*	*Today*
Socioeconomic variables			
Massive population increase when area was opened up to commercial resource extraction		Majority of residents live below the poverty line	
Tourism began at the same time		Tourism – about 20,000 visitors in 1999	
Governance variables			
			2001 – major push for increased enforcement; now regulations are enforced not only in the protected area but in all municipal waters
The area had been a turtle sanctuary since 1984	Became a marine reserve in 1991	In 1999 reserve was expanded to include terrestrial areas	
Site was included in a debt for nature swap in 1989	1996 – participatory process for developing the management plan	2000- funding for enforcement was pulled back	
Ecological variables			
Declining fish catches and degraded reefs		Coral widely damaged from bleaching	Current push for allowing live fish trade – concern that tourism will suffer

HON MUN MARINE PROTECTED AREA

Hon Mun Marine Protected Area, in Nha Trang province, is the first MPA in Vietnam. This is a pilot project, implemented with the expectation that lessons learned there will be applied to future MPAs throughout the country. The MPA operates under a zoning scheme, with core zones in which no fishing other than traditional fixed net fishing is allowed, and buffer zones outside in which fishing is regulated. The Protected Area contains 6 villages with a total of about 5000 inhabitants, the majority of them fishers. The area is a major tourist destination. Aquaculture is also becoming an important economic activity.

The decision to declare Nha Trang bay the first MPA in Vietnam arose from scientific surveys conducted in the early 1990s. Participatory Rural Appraisal was conducted in 2001 and 2002 in order to build the capacity and engagement of the local communities in the project, which was planned as a community-based natural resource management project. After some delays, it was eventually decided that the project would be administered by the provincial government with some assistance from the Department of Fisheries.

A major focus of the protected area is improving livelihood opportunities, especially for women. At the time the project began, 79 percent of men were engaged in fishing full time and 79 percent of women were not employed outside the home. At a mid-term review in 2005, manufacturing jobs had been created for women and the number of women with no livelihoods outside the home was reduced.

Participation has been an important element of this project from the beginning. As noted above Participatory Rural Appraisal was undertaken to solicit community input in the planning stages of this MMA. The results of impact analysis were also shared with the community. Education and capacity building programs are an additional focus of this MMA. The overall level of capacity at the beginning of the project was quite low, so it is a challenge to develop the community based monitoring capacity needed.

Impact assessments conducted in 2005 note improvements in socioeconomic indicators. In particular, family planning programs seem to be having an effect on the population growth rate. CPUE has improved. Destructive fishing has been eliminated. The greatest threat to the area seems to be unregulated lobster culture, which has grown by over 200 percent in the time period of the project.

Timeline 3: Hon Mun

Before the MMA was initiated	*In the early phases of the MMA*	*During implementation of the MMA*	*Today*
Socioeconomic variables			
Low skill level and limited capacity building efforts noted prior to the project	Microcredit, job creation (especially for women) and family planning important elements of the plans for the MPA	MPA was established in 2002 Aquaculture becoming important in the area; not a part of the MPA project	Tourism increased; other job creation projects have been somewhat successful
Governance variables			
	Participatory rural appraisal method used for community consultations No legal/institutional framework yet exists for MPAs		Some conflict between dive tourism and traditional fishing practices noted
Ecological variables			
Scientific surveys in the 1990s indicate high biodiversity levels – impetus to set up the MPA Additional impetus from pollution associated with (tourism) infrastructure development and aquaculture			Unregulated aquaculture considered a threat Destructive fishing has been "terminated"

MABINI-BATANGAS MARINE RESERVE AREA

The Mabini-Batangas Marine Reserve Area in The Philippines is a major dive destination being only 3 hours away from Manila by car. This is a zoned MMA, with three no-take areas associated with resorts and the remainder of the area open to fishing on a regulated basis. The resident population in the area is 42,000, and the local economy is diverse, with fishing considered a supplemental activity and tourism employing about 10% of the working population. The overall Reserve Area regulates fishing uses, and contains three no-take marine sanctuaries associated with resorts. Dive fees go into a conservation trust fund which covers some of the operating expenses of the Reserve.

The management history of the area is closely related to the development of dive tourism. A national park was proposed in as early as 1982, and a municipal ordinance creating the MPA was passed in 1991. Without effective enforcement, however, illegal and destructive fishing continued and coral cover was low. In 1998, two communities joined forces with WWF and finally succeeded in eliminating destructive fishing practices. Enforcement occurs via a semi-volunteer system called "Bantay Dagat" where community members are deputized and enlisted to patrol the area. In addition, many of the resorts in Mabini are actively engaged in resource management by providing financial, technical, and human support through for enforcing fishing regulations in the closed areas.

There are ongoing governance challenges at this MMA relating to equity and accountability. There has been some friction between tourism and divers over the years, related to inequities between the distribution of costs and benefits from tourism between stakeholder groups. There are limitations on diving use of the no-take sanctuaries which are apparently not enforced, yet the fishing bans are strenuously enforced. The MMA is funded through a "conservation fee" system, but there are concerns about perceived mismanagement of funds for coastal management at the local government level, which undermines community support.

There has been a significant increase in fish, and especially large predatory fish, within the no-take sanctuaries. The number of fishing families in the area has declined, and catch per unit effort has improved. Scientists note, however, that there is an "alarming lack of target species" in the areas that are open to fishing. Live coral cover levels are highly variable. Biophysical surveys conducted over a period of time indicate that human impact, rather than natural disturbances, has largely contributed to changes in coral cover. In most non-MPA dive sites, boat anchor damage was apparent. Additional threats include pollution and erosion from upland development.

Timeline 4: Mabini

Before the MMA was initiated	*In the early phases of the MMA*	*During implementation of the MMA*	*Today*
Socioeconomic variables			
Dive tourism started in the 1970's		1994 study shows that divers would be willing to pay a fee	
Over 1000 FT fishing families			Now only 600 FT fishing families
Governance variables			
Area was declared a "tourism zone" with some fishing limitations	1988- Haribon foundation started a community based conservation project – 3 sanctuary areas	1998 – new local leadership with more environmental awareness	Enforcement through community-based "bantay dagat" and with the involvement of resort operators
Resort operators spearhead efforts to get the MPAs protected	1993 amendment prohibits diving in protected areas (largely ignored)	2001 – many more NGOs and government agencies became involved in coastal resource management in the area	
		2003 – fee system launched Resort operators engage in enforcement – negatively perceived	
Ecological variables			
"rampant" illegal fishing			Improvement in CPUE noted
			Pollution and erosion are major environmental concerns

MAFIA

Mafia Island Marine Park (MIMP), off the coast of Tanzania, is the largest marine park in the Western Indian Ocean region. Its diverse marine and terrestrial habitats support a rich array of species, including several endangered turtles and a resident pod of whale sharks. It is a government-managed, multiple use MPA with a zoning scheme that includes no-take reserves as well as extractive use areas. Scientific research is an important part of the Park's activities and mission. Approximately 18,000 people live within the Park's boundaries, and most economic activity in the area is subsistence agriculture and fishing.

The Park was established in 1995 and formally gazetted in 1996, although smaller marine reserves did exist in the area prior to then – at least on paper. WWF has been involved (to varying degrees) in the management of MIMP since the 1980's. MIMP is currently managed by the Government of Tanzania's Marine Parks and Reserves Unit in collaboration with WWF.

Mafia Island is a poor district, even by Tanzanian standards. Per capita income on Mafia is approximately US$120, compared with the national average of approximately US$290. Few Mafians gain employment on the mainland. Most economic activity is subsistence farming and fishing, with fishing comprising the main activity for about half the island's population. The influx of resources associated with the Park is significant, and leads to many challenges associated with perceptions of inequities in the distribution of those resources. For instance, the Village Liaison Committees who are supposed to interact with MIMP management often have better office buildings than the village government does, which sometimes lead to resentment. When MIMP enjoyed direct donor funding, the VLC used to get a monthly allowance, but since 2005, that has ceased, leading to complaints from some VLC members who viewed the allowance as a right.

Although research has shown strong positive trends in most biophysical indicators, the Park faces a number of serious and ongoing challenges. Fish catches have improved, but that has not translated into higher local incomes. A 2006 study indicated that most of the income from Mafia fisheries goes to vessel owners and fish dealers or middlemen, many of whom are Dar es Salaam traders, and about 70 per cent of the fish caught is sold at the fish market in Dar es Salaam. Local fishers sell their fish where prices are low, and thus, in terms of cash income, they benefit less from Mafia's improved fisheries.

In addition, several authors note a general attitude of distrust and resentment toward MIMP management on the part of local communities; in fact, one community refuses to comply with Park regulations. In response, MIMP management and WWF have increased their focus on economic development activities, but progress is slow.

Timeline 5: Mafia Island Marine Park, Tanzania

Before the MMA was initiated	*In the early phases of the MMA*	*During implementation of the MMA*	*Today*
Socioeconomic factors			
increased fishing pressure from outside fishermen		absence of fishers' organizations noted	revenue from user fees $50K but this does not nearly cover operating costs
	destructive fishing practices noted	tourism level - 300 foreign visitors in 2000	tourism level - 3000 visitors in 2005
		resource use values estimated at $.25 million U.S.	octopus fishery in decline
			seaweed farming becoming important in some communities
			WWF provides support for economic development activities (alternative livelihoods, etc.)
Governance factors			
marine reserves existed in the area but there was no enforcement	WWF became involved	Set up Village Liaison Committees (VLCs) and Village Enforcement Unites (VEUs)	donor funding ends - can no longer pay VLCs
	planning process was disorganized and somewhat dysfunctional		one community in particular is in outright defiance of MIMP zoning and regulations
Ecological factors			
baseline biological values studied	coral mining was an important economic activity	heavily impacted by coral bleaching/el Niño event	Strong positive trends in most biophysical indicators noted

MENAI BAY CONSERVATION AREA

Menai Bay Conservation Area (MBCA) comprises an extensive and interconnected area of coral reefs, seagrass beds, and mangrove stands in southern Zanzibar. The conservation area encompasses 478 square kilometers, mostly less than 10 meters deep. The population in the area is about 16,000, located in villages with varying degrees of infrastructure and accessibility. This conservation area has always been oriented toward livelihood support rather than environmental conservation.

In the early 1990's, fisheries and general ecosystem health had declined dramatically due to destructive fishing practices and an increase in fishing pressure from outside migratory fishermen. The communities in the area, with the assistance of WWF and the Institute of Marine Science, developed regulations and procedures governing fishing and the establishment of fishing camps. Enabling legislation was enacted after the project was already underway, and the Menai Bay Conservation Area was established in 1997. There are no exclusion zones where fishing is not permitted, but MBCA has slightly more stringent regulations and a higher level of enforcement than other areas in Zanzibar. A management plan was never adopted, although a draft plan was produced in 2006.

The project seems to have been successful in stopping dynamite fishing, and fish harvests and biodiversity have reportedly increased. Ongoing challenges are related to livelihoods and equity, as well as the administration of the Conservation Area. Although tourism has increased dramatically over the past 15 years, few benefits seem to reach local communities. Various alternative livelihood projects have been initiated, but results are slow in coming. WWF has reduced their support for the project due to a combination of poor project performance and political issues with the Zanzibari government. Recently, the World Bank has begun supporting this and other MMA projects in the region. It is hoped that this infusion of resources will enable continued improvements in ecosystem health and livelihoods.

Timeline 6: Menai Bay

Before the MMA was initiated	*In the early phases of the MMA*	*During implementation of the MMA*	*Today*
Socioeconomic variables			
	High population growth rate and extreme poverty		Bivalve farming project initiated
	Rapid expansion of tourism through the 1990s	User fee system implemented but fees rarely collected	Now about 20,000 tourists per year
Governance variables			
Structural adjustment programs move ZNZ away from common property to private ownership regimes	1994 WWF begins providing some support for conservation in the area	WWF Support withdrawn in response to political issues in ZNZ and poor performance of the MMA	MACEMP (World Bank) becomes involved in supporting enforcement
			Draft management plan created
	Outlying villages dismantle their own patrol systems to fit in with the Menai conservation project		Community monitoring program for bivalves initiated, following FLMMA model (Fiji)
Ecological variables			
Coral reefs either completely destroyed or extensively damaged by destructive fishing		Reduction in illegal and destructive fishing noted	Fish harvest increased
			Modest improvements in biodiversity; live coral cover only 17-29%

MISALI/PECCA

Misali Island Marine Conservation Area (MIMCA) is located 10 km off the west coast of Pemba, the northern of two major islands making up the semi-autonomous state of Zanzibar. The island itself is .9 square kilometers, and is a holy site in Islamic tradition. There are no permanent habitations on Misali Island, and the coral reefs surrounding the area are considered to be relatively pristine. About 1640 fishers from 29 communities use the area. The Conservation Area has both extractive use and no-take zones.

The impetus to protect the island and its surrounding waters arose in 1993, when the government of Zanzibar agreed to lease the island to a private company for hotel development. Community and international objections led to the establishment of Misali Island as a conservation area. It was legally established in 1998. The Misali Island Conservation Association (MICA), a local fisher's association, is charged with assisting communities to protect the island and enhance livelihoods. Since 1998 the project has been funded by CARE International. There is an interpretive center on the island and six full time rangers.

MIMCA is considered a successful example of co-management. Illegal and destructive fishing has largely been stopped. A recent initiative to incorporate Islamic ethics into environmental conservation led to higher community awareness of the relevance of environmental issues in their lives.

The administration of MIMCA is currently in flux. Work is under way to develop a much larger protected area, the Pemba Channel Conservation Area, which will likely incorporate MIMCA as one core zone. Probably the greatest challenge currently facing the area is to maintain or enhance management in the context of a much larger PECCA project.

Timeline 7: Misali/PECCA

Before the MMA was initiated	*In the early phases of the MMA*	*During implementation of the MMA*	*Today*
Socioeconomic variables			
Proposal to lease the island to a private investor		MICODEP begins support for project – focus on culturally appropriate livelihoods	Islamic conservation program seems to be effective – fishers have learned to relate their religious beliefs to conservation measures
			400 people have obtained loans and received capacity training
Governance variables			
	Proposal to manage the island as a community managed ecotourism site	Marker buoys installed but removed by fishers for their own use	Misali incorporated into the much larger Pemba Channel Conservation Area. World bank/MACEMP project. Significant influx of resources.
	Misali Island Conservation Association established with 95 members	Weak capacity noted esp. with regard to Rangers	Misali Island Conservation Association now has 1385 members
Ecological variables			
Reefs are in relatively pristine condition – 51% coral cover		Only 17% live coral cover after bleaching event	Recovery is underway; less damage in deeper waters
			Little difference in fish populations between core zones and fishing zones – perhaps attributable to illegal fishing?

SMMA

Soufriere Marine Management Area (SMMA) is on the southwest coast of Saint Lucia. It extends along 11 km of coastline to a depth of 75m. This area comprises very well-developed fringing reef, which are part of the healthiest and most biologically diverse corals in St. Lucia. Soufriere, the closest community to SMMA, is a traditional fishing community located on the coastal border of the Soufriere Bay. According to the Statistical Department of Saint Lucia (2006), the estimated population was 7,935 inhabitants in 2005.

The marine management area was legally established in 1994 after a long consultation process with communities and institutions initiated in 1992. Earlier protection initiatives had been in place since 1985 as tools to solve conflicts over competing uses (recreation and fishing), but those earlier initiatives did not succeed, reportedly due to the lack of involvement of communities into the process. The management authority of SMMA includes the Department of Fisheries, the Soufriere Development Foundation, and the Soufriere Marine Management Association.

A particularly interesting element of SMMA is its adaptability. When the original plans for a Marine Managed Area didn't work out, the management authority went back to the community for an additional round of consultations, resulting in the present configuration of the MMA. In the face of severe economic difficulties, the MMA instituted a program to ease the transition of older fishers out of the industry. The management authority recruited a vocal opponent of the MMA as a ranger. This individual is now one of SMMA's most ardent advocates.

This MMA is self-financed through user fees, which are collected on a daily basis by rangers who simultaneously conduct patrols of fishing and divers.

In the 12 years since the establishment of SMMA, some benefits have been identified. For instance, key informants and published reports note an increase in fish production and enhanced environmental awareness. The most pressing concern at the moment is damage from inland pollution and sedimentation.

Timeline 8 - SMMA

Before the MMA was initiated	*In the early phases of the MMA*	*During implementation of the MMA*	*Today*
Socioeconomic variables			
Doubling of dive tourism leads to user conflicts		Fishers report declining catch and apparently resent being "over-promised Factory closes, hotel closes, unemployment >50% One year buy-out program met with limited success	
Governance variables			
Reserve was declared but without enforcement – conflicts escalate	1994 – SMMA plan developed by stakeholders	New government Adjustments and modifications to zoning met resistance initially; went back to the stakeholders and redesigned the management plan	Reserve gets user fees from yachters and divers – these cover operating expenses Researchers promoted the positive ecological effects with community – this built support
Ecological variables			
Additional conflict – uncontrolled and uncoordinated scientific research		Hurricane causes flooding, sedimentation threatening reefs Improvements in biophysical indicators noted quickly	Waste management and pollution a huge problem

5.0 RESULTS

Analytic approach: grouping the data

The nineteen MMA sites included in this study are quite diverse, ranging from tiny, community based *tabu* sites with no tourism or outside influence, to large, established MMAs with multiple users including a large tourism base. Some of them are world-renowned examples of successful marine conservation, and some are barely more than "paper parks". A one size-fits-all analytic approach would not be appropriate for this sample of MMAs. Therefore, the study sites were divided into subsets using a number of different grouping schemes, based on 1) the availability of data and the analytic options associated with it, and 2) the socioeconomic profile of the communities included in the study.

The first grouping scheme entailed subdividing the MMAs according to whether or not the MMA was one of Conservation International's node sites (Table 3). Although the number of non-node sites was small – only eight – these MMAs were chosen for this study because they have reliable ecological data associated with them. Therefore, it was possible to incorporate the ecological data into the analysis in ways that were not possible for the other sites. For these MMAs, we used a multilevel mixed effects statistical model to incorporate site-level effects into the logit regression analysis, reported in section 5.3.

In addition, some of the node sites included ecological data on the fish biomass and/or coral cover inside the MMA vs. in a control site. This group of MMAs (non-node sites plus the node sites with ecological data) was used for the detailed correlation analysis reported in section 5.2 (Table 4). In this way, we were able to gain some insight from the relationships among Critical Determining Factors that were associated with both the key socioeconomic and governance outcomes, and the ecological outcome indicating a positive difference in fish biomass inside the MMA vs. at a control site.

The third grouping scheme involved segregating the MMAs based on their socio-economic profile and the perceived level of success of the MMA (Table 5). Within this scheme, Group 1 includes traditional fishing communities with minimal tourism and high levels of "success" reported by survey respondents (or, in the case of Apo Island, where the MMA is widely considered a success by the scientific community). Group 2 includes highly successful MMAs located in or near communities in which fishing is not a major economic activity. Group 3 includes MMAs with lower levels of reported success, or in which poverty is and remains a serious concern[9]. We used forward logit regression to elucidate the most critical factors associated with perceived improvements in various MMA effect indicators, as reported in section 5.3.

[9] [9] The question of "poverty" in this case was either determined via a review of the secondary literature (see the case studies for El Nido and Hon Mun, above) or through "expert opinion" and/or discussions with people working in the communities in question (

Table 3. MMA grouping scheme 1

Socioeconomic profile of respondents: Group 1

	Pct. Fisher	Pct. Tourism	Pct. Reporting "successful"
Apo	67%	12%	69%
Hon Mun	82%	0%	84%
Kubulau	31%	0%	100%
Lighthouse Reef	41%	18%	67%
Menai	57%	5%	82%
Navakavu	72%	0%	82%
Misali/PECCA	63%	0%	95%

Table 4. MMA grouping scheme 2

Socioeconomic profile of respondents: Group 2

	Pct. Fisher	Pct. Tourism	Pct. Reporting "successful"
Gladden Spit	19%	27%	94%
Laughing Bird	10%	40%	92%
Mabini	13%	19%	94%
SMMA	15%	15%	84%

Table 5. MMA grouping scheme 3

Socioeconomic profile of respondents: Group 3

	Pct. Fisher	Pct. Tourism	Pct. Reporting "successful"
Coiba	56%	10%	58%
El Nido	38%	3%	91%
Mafia	52%	5%	61%
Malolo	0%	87%	39%
Port Honduras	31%	22%	78%
Sapodilla Caye	18%	14%	86%
South Water Caye	24%	20%	78%
Waitabu	4%	0%	84%

5.1 WHAT ARE THE EFFECTS OF MARINE MANAGED AREAS?

Analysis of the household survey data indicates that there was a statistically significant but small increase in perceived levels of all of the impact indicators (p<0:01) (Table 6). The full set of 19 MMAs indicated that the highest levels of improvement were perceived in biodiversity and ecological health, and the least improvement was perceived in conflict levels. For the non-node sites, there were large positive changes perceived in compliance, and in perceptions of ecological health and biodiversity (Table 7). The next highest positive change was in livelihoods, with the smallest changes reported for conflict levels and food security.

Table 6
Perceived pre-project to post-project changes in indicators: all MMAs

Indicator	T2-T1	P
Livelihoods	.933	<.001
Food security	.472	<.001
Resource conflicts	.403	<.001
Participation	.896	<.001
Influence	.953	<.001
Compliance	1.07	<.001
Ecological health	1.27	<.001
Biodiversity	1.30	<.001

Table7
Perceived pre-project to post-project changes in indicators: non-node sites

Indicator	T2-T1	P
Livelihoods	1.348	<0.01
Food security	.973	<0.01
Resource conflicts	1.054	<0.01
Participation	1.143	<0.01
Influence	1.233	<0.01
Compliance	2.247	<0.01
Ecological health	2.294	<0.01
Biodiversity	2.126	<0.01

Among the MMA sites with positive differences in fish biomass inside the MMA vs. in a control area, the same pattern is observed – the largest differences were in perceived improvements reported for ecological health and biodiversity, and the smallest improvement was perceived for conflict levels (Table 8). This pattern does not hold, however, for those MMAs which show a positive difference in coral cover inside vs. outside the protected area (Table 9). In this group, although some of the governance variables

indicate a positive change over time, neither biodiversity nor ecological health was perceived to have improved by a significant amount.

Table 8
Perceived pre-project to post-project changes in indicators: MMAs with positive i/o fish

Indicator	T2-T1	P
Livelihoods	0.98	<.001
Food security	0.51	<.001
Resource conflicts	0.48	<.001
Participation	0.95	<.001
Influence	1.02	<.001
Compliance	1.00	<.001
Ecological health	1.35	<.001
Biodiversity	1.34	<.001

Table 9
Perceived pre-project to post-project changes in indicators: MMAs with positive i/o coral

Indicator	T2-T1	P
Livelihoods	0.39	<.001
Food security	-0.27	.02
Resource conflicts	-0.06	.31
Participation	0.68	<.001
Influence	0.72	<.001
Compliance	0.32	<.001
Ecological health	0.26	.03
Biodiversity	0.22	.06

Grouping the MMAs by their socioeconomic profile provides a different picture of the effects of MMAs. Survey respondents in the first group of MMAs perceive substantial improvements in ecological health and biodiversity, as well as compliance, and a significant but not as large improvement in livelihoods and food security (Table 10). Respondents in the second group perceive improvements in both livelihoods and the ecological indicators that are more even (Table 11). Respondents in the third group do not perceive significant improvements in any indicators, and in fact the most significant T2-T1 difference in that group is a significant worsening of resource conflict levels from before the MMA was established until now (Table 12).

Table 10
Perceived pre-project to post-project changes in indicators: Group 1

Indicator	T2-T1	P
Livelihoods	1.36	<.001
Food security	1.00	<.001
Resource conflicts	0.84	<.001
MPA conflicts	0.77	<.001
Participation	1.76	<.001
Influence	1.65	<.001

Compliance	1.94	<.001
Ecological health	2.19	<.001
Biodiversity	2.27	<.001

Table 11
Perceived pre-project to post-project changes in indicators: group 2

Indicator	**T2-T1**	**P**
Livelihoods	1.68	<.001
Food security	0.78	<.001
Resource conflicts	1.20	<.001
Participation	0.67	<.001
Influence	0.85	<.001
Compliance	1.21	<.001
Ecological health	1.78	<.001
Biodiversity	1.68	<.001

Table 12
Perceived pre-project to post-project changes in indicators: group 3

Indicator	**T2-T1**	**P**
Livelihoods	0.05	.346
Food security	-0.25	.047
Resource conflicts	-0.55	<.001
Participation	0.13	.166
Influence	0.28	.016
Compliance	0.09	.264
Ecological health	.049	.384
Biodiversity	.148	.182

Ecological data:

Ecological outcomes of MMAs were determined using a quantitative approach whereby quantitative differences in key ecological variables were compared within the MMA area and nearby control areas (open access areas) using the most recent data available. The assessment of ecological outcomes was based on previously collected data available in published and unpublished literature. Thus, the data used in the ecological analyses were necessarily different from those used in the socioeconomic analyses in several fundamental ways: they are quantitative, objective (i.e., not based on opinion), and reliant on the availability of previously collected data (i.e., it was not possible to collect new field data to fulfill data requirements).

For inside/outside comparisons, negative values indicate that values for the control site were greater than for the MMA site at the time of comparison. Positive inside/outside comparisons indicate variables having greater values in MMA sites (Table 13).

Table 13
Ecological outcome values for each MMA.

	Difference in coral cover		Difference in fish	
	BACI	Inside/outside	BACI	inside/outside
Apo	-0.27	0.07	17.14	0.91
El Nido	-0.37	-1.00	3.05	-3.17
Hon Mun	0.70	-0.30	n/a	0.00
Mabini	-0.79	-0.23	-0.44	0.88
Mafia	-0.75	0.00	n/a	0.80
Menai	-0.11	-1.74	-2.78	0.82
Misali	0.00	-0.25	n/a	0.34
SMMA	0.31	0.38	0.92	0.29
Laug bird		0.16		0.12
Port hon		0		-0.31
Malolo		0.3		-0.18
Navakavu		0		0.11
Waitabu		0.05		0.41

Because before-after data were only available for non-node sites, ecological data across all sites was limited to comparisons of outcomes inside and outside MMAs. One outcome compared across all sites, the difference in coral cover within versus outside MMAs, varied among sites with approximately half of the study sites (n = 7) showing no difference between MMA and control sites or greater coral cover in control sites, and approximately half of sites (n = 8) having higher coral cover within MMAs. Because we do not know the starting conditions at any of the node sites and how coral cover changed within these sites compared to control sites, it is difficult to say how MMA management has affected coral cover, but clearly, any positive MMA effects are limited.

There was a greater occurrence of potentially positive MMA effects on the abundance and/or biomass of key fishery species, with 10 MMA sites reporting greater abundance or biomass than their controls and only 4 sites reporting no difference or greater abundance or biomass at control sites. Again, because time series data does not exist for node sites, we cannot correlate changes in biomass or abundance of key species with the implementation of MMA protection, however the high frequency of occurrence of cases where abundance or biomass is greater within MMA sites is suggestive of a positive effect of MMA management. Sites for which abundance or biomass was lower within MMAs or no difference occurred between MMAs and control sites were not outliers with respect to any of the ecological CDFs, but a combination of ecological, socioeconomic, and governance CDFs may have influenced these outcomes

5.2 WHAT ARE THE CRITICAL FACTORS DETERMINING MMA EFFECTS?

ECOLOGICAL FACTORS

For this study, qualitative and quantitative data associated with each indicator variable were gathered from secondary data, and the level of each variable was scaled as described in detail in Appendix B and C. In keeping with the scales employed throughout the GME project, low values for a variable indicate a situation with a negative connotation (in this case, a negative impact on habitat, water quality, or MMA effectiveness) while high values have a more positive connotation (except for the *characteristic of fisheries* CDF).

1. Life history characteristics of key species

Several characteristics of a species life history can influence the extent to which its population is likely to respond to MMA protection. Species with rapid reproductive rates, mature rapidly, are sessile, or have limited home ranges, and have a short larval duration, may rapidly increase in abundance, even within a small MMA These species may be limited in their export to fished areas, however. Species that have greater movement rates, extended larval durations, are slow to mature and have low reproductive outputs may not increase much within MMAs. While movement, age at maturity, reproductive output and planktonic larval duration are not the only life history characteristics that affect how a species may respond to MMA protection, they are some of the more important characteristics and ones for which data was available for key fishery species within each MMA. Since most fishery species examined were members of the fish families *serranidae* and *lutjaniudae*, values do not vary much between sites, however, since different species within those families do show some variability in each characteristic and because the multi-species fishery at each site also included other species, values calculated for each site ranged by 1 or 2 points for each characteristic (Table 14).

Table 14: Life history characteristics of key species (Fishery Species)

	Movement	Age at Maturity	Reproductive output	Planktonic Larval Duration
Apo	0.8	0.8	0.9	0.9
El Nido	0.6	0.6	0.8	0.6
Hon Mun	0.8	0.8	0.8	0.9
Mabini	0.7	0.55	0.8	0.7
Mafia	0.7	0.6	0.9	0.8
Menai	0.7	0.6	0.9	0.8
Misali	0.7	0.6	0.9	0.8
SMMA	0.8	0.8	0.9	0.86
Half moon		(average life history value)		0.85
Laug bird				0.85

Port hon	0.85
Malolo	0.805
Navakavu	0.805
Waitabu	0.805

2. Habitat characteristics

All sites studied included coral reef areas, but the amount of seagrass and/or mangrove habitats varied among sites (Table 15) to some degree, producing indices that ranged from 0.4 to 1.0.

3. Incidence and severity of storms

The frequency with which tropical cyclones impacted sites varied considerably, as did the severity of those storms. Some sites, such as those in Africa are outside the path of tropical cyclones, while others, such as those in the Philippines, are frequently impacted by tropical cyclones. While coral reef ecosystems have evolved in areas frequently impacted by tropical cyclones, and some level of impact may actually enhance diversity on coral reefs, tropical cyclones increasingly appear to have a negative impact as human activities reduce the resiliency of coral reefs.

Table 15: Habitat characteristics and Incidence of storms

	Habitat characteristics	Incidence of storms		
		Beg	**Imp**	**today**
Apo	0.6	0.9	0.75	0.23
El Nido	1	0.2	1	0.15
Hon Mun	0.5	0.58	1	0.83
Mabini	0.6	0.45	0.5	0
Mafia	1	1	1	1
Menai	1	1	1	1
Misali	0.4	1	1	1
SMMA	0.4	0.85	0.5	0.4
Half moon	0.4	0.95	1	0.35
Laug bird	0.4	0.95	1	0.15
Port hon	1	0.95	1	0.25
Malolo	0.6	0.1	0.33	0.4
Navakavu	0.6	0.1	0.33	0.4
Waitabu	0.6	0.4	0	0.6

4. Outbreaks of disease or harmful algal blooms

Diseases, such as those affecting corals or the apparent pathogen which killed off *Diadema antillarum*, a key herbivore species in the Caribbean, and harmful algal blooms, which result in fish kills and other mass die-offs, have been reported from a number of MMA

sites. At some sites, like Mabini, harmful algal blooms have resulted in massive die-offs of fish. At most sites, however, impacts have been limited to outbreaks of coral disease that have resulted in partial of total death to colonies of several coral species (Table 16).

5. Frequency and degree of coral bleaching

Coral bleaching has been reported locally, regionally and globally on a number of occasions over the past two decades. In 1998 a massive global bleaching event affected nearly all of the MMAs in this study. How this event is recorded in our analyses depends primarily on when the MMA was created. For those created after 1998, the mass bleaching event will be reported as at the beginning of the MMA. For long established MMAs, that event will be averaged in the today time category. While local and regional bleaching events have been reported since 1998, their severity is not likely to have been as great since coral levels reduced in the 1998 event are not likely to have rebounded prior to these later bleaching events for large impacts to be reported.

Table 16: Outbreaks of disease and coral bleaching

	Outbreaks of disease or harmful algal blooms			Frequency and degree of coral bleaching		
	Beg	imp	today	Beg	imp	today
Apo	1	1	0.6	1	1	0
El Nido	1	1	1	1	1	0
Hon Mun	0.8	0.8	0.8	0.8	1	1
Mabini	0	1	1	0	1	1
Mafia	1	1	1	1	1	0
Menai	1	1	1	1	1	0
Misali	1	1	1	0	1	1
SMMA	0.8	0.8	0.2	0.8	0.8	0.2
Half moon	1	1	1	1	1	0.6
Laug bird	1	1	1	0.6	1	0.6
Port hon	1	1	1	0.6	0.5	0.6
Malolo	1	1	1	0.5	1	1
Navakavu	1	1	1	0.5	1	1
Waitabu	1	1	1	1	1	0.5

6. Impact of land use and human activities on habitat and water quality[10]

[10] These two CDFs were only able to be calculated for the non-node sites.

The impact of land use and human activities on habitat and water quality CDF is presently conceived as a weighted average of the rankings of the five subcomponents of this metric, divided by the maximum value, to give a ranking on a scale of 0 to 1. At present, the weights are equal at 20%.

This indexing scheme shows Misali as the area with the least human impact on habitat and water quality in the MMA (which makes sense, since the island is uninhabited), while Hon Mun comes out as the area with the greatest human impact on the MMA (which also makes sense, as that MMA receives over 400,000 visitors per year and has significant aquaculture activities) (Table 17).

Table 17: Impact of human activities and land use on habitat and water quality

	Population	Tourism levels	Land uses	Aqua-culture	Coral mining	Weighted average	*CDF value (divide by max)*
Weight	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*		
Apo	4	3	3	5	1	3.2	**0.94**
El Nido	2	2	2	5	1	2.4	**0.71**
Hon Mun	3	1	3	1	1	1.8	**0.53**
Mabini	1	2	2	5	1	2.2	**0.65**
Mafia	2	3	3	3.5	0	2.3	**0.68**
Menai	2	2	3	2.5	0	1.9	**0.56**
Misali	4	3	4	5	1	3.4	**1.00**
SMMA	3	1	1	5	1	2.2	**0.65**

7. Characteristics of fisheries

The characteristics of fisheries CDF is presently conceived as the gear rankings (as described in Appendix C), adjusted for the number of fishers in the area. This rating scheme gives us an index with El Nido as the highest impact fishery, followed closely by Misali, and with the fisheries at Hon Mun and Mafia having the least environmental impact (Table 18).

Table 18: Characteristics of fisheries

MMA	Simple average of gear ratings	Adjusted rating	*CDF (divide by max)*
Apo	8.833	6.18	**0.70**
El Nido	8.875	8.88	**1.00**
Hon Mun	**6.75**	6.08	**0.68**
Mabini	8.85	7.08	**0.80**
Mafia	6.75	6.08	**0.68**
Menai	8.333	8.33	**0.94**
Misali	9.6	8.64	**0.97**
SMMA	9.25	7.40	**0.83**

5.3 WHAT ARE THE CRITICAL FACTORS DETERMINING MMA EFFECTS?

DIRECT CORRELATIONS BETWEEN CDFS AND PERCEPTIONS OF MMA EFFECTS

For the purpose of correlation and econometric analysis, we define a binary variable indicating a positive change in perceptions of the effect indicators. This binary variable is coded "1" if the difference in the before/after indicator level on the 10 point ladder scale is 2 or greater. ***include something about this being a much higher hurdle than the statistical significance The following set of tables contains the most significant direct correlates of MMA effects. Indirect correlations, and cross-correlations between the CDFs are addressed in the next section.

These correlations are for the set of (14) MMA sites which have ecological effect data (i.e. which have data on the difference in fish or coral density inside vs. outside a protected area). This gives us a way to show the relationships between socioeconomic, governance, and ecological factors and effects as originally envisioned in the study design. The coefficients and their statistical significance are reported at the site level. In order to emphasize only the important factors, coefficients are only reported if their significance is 5 percent or better. Coefficients with two asterisks indicate a statistical significance of one percent.

Table 19shows the strongest correlations between perceived socioeconomic effects of MMAs and various determining factors. The most striking pattern in these correlations is that there is little overlap between the factors significantly associated with the two MMA effects. The only factors with significant correlations to both livelihood and food security improvement were storms during implementation (negatively related), benefits exceeding costs, and shared benefits during implementation.

Table 19 Correlations on socioeconomic MMA effects

	Improvement in livelihoods	Improvement in food security
Storms – During implementation	-0.574	-0.727
Community influence – at the beginning		0.554
- During implementation		0.579
Leadership – today		0.535
Supportive local government – during implementation	-0.569	
- Today	-0.522	
Accountable management style – at the beginning		0.579
Conflict management mechanism – at the beginning		0.596
Benefits exceed costs – during implementation		
-today	0.739	0.753
Shared benefit from the MMA to the community - during implementation	0.578	0.659
-today		0.597

Table 20 shows the correlations between improvements in the governance outcomes and the critical determining factors. There was quite a lot of overlap between the significant correlates of improvement in both conflict levels and community influence, and several of the correlates were highly significant ($p<.01$). As before, storms during implementation were negatively associated with these outcomes, and benefits exceeding costs and shared benefits were positively associated with them. In addition, accountable management style, community influence, and conflict management mechanism were strongly correlated with more than one of these governance outcomes.

Table 20: Correlations on improvement in governance MMA effects

	Improvement in levels of		
	Conflict	Participation	Influence
Storms- during implementation	-.628		-.663**
Disease – at the beginning	-.532		
Bleaching – at the beginning	-.562		
Community influence - at the beginning	.665**		.633
- during implementation	.705**		.603
- today	.636**		.637
Leadership - at the beginning	.631		
- during implementation	.608		.547
- today	.544		
Accountable management style - at the beginning	.702**	.536	.657
- during implementation		.558	.616
- today			.564
Conflict management mechanisms - at the beginning	.725**	.635	.727**
- during implementation		.573	.541
Benefits exceeding costs - at the beginning	.608		
- during implementation	.743**	.549	.640
- today	.674**		.589
Shared benefits - at the beginning	.630		
- during implementation	.723**	.646**	.679**
- today	.537		.542

Table 21 shows the correlations between improvements in perceptions of improvements in ecological outcomes, ecological data indicating a positive difference in fish abundance and coral cover inside vs. outside the MMA, and the critical determining factors. Very few socioeconomic and governance factors have high correlations with these outcomes. However, shared benefits and an accountable management style were associated with positive values for the difference in fish biomass inside vs. outside the MMA.

Table 21: Correlations on ecological MMA effects

	Inside vs. outside MMA differences in		Improvement in perceptions of	
	Fish abundance	Coral cover	Ecological health	Biodiversity
Storms – during implementation			-.581	-.543
Life history metric		.600		
Habitat metric		-.552		
Community influence – at the beginning	.544			
Leadership – at the beginning	.554			
Accountable management style – during implementation	.617			
Benefits exceeding costs – at the beginning	.535			
Shared benefits – during implementation	.751**			
-today	.587			

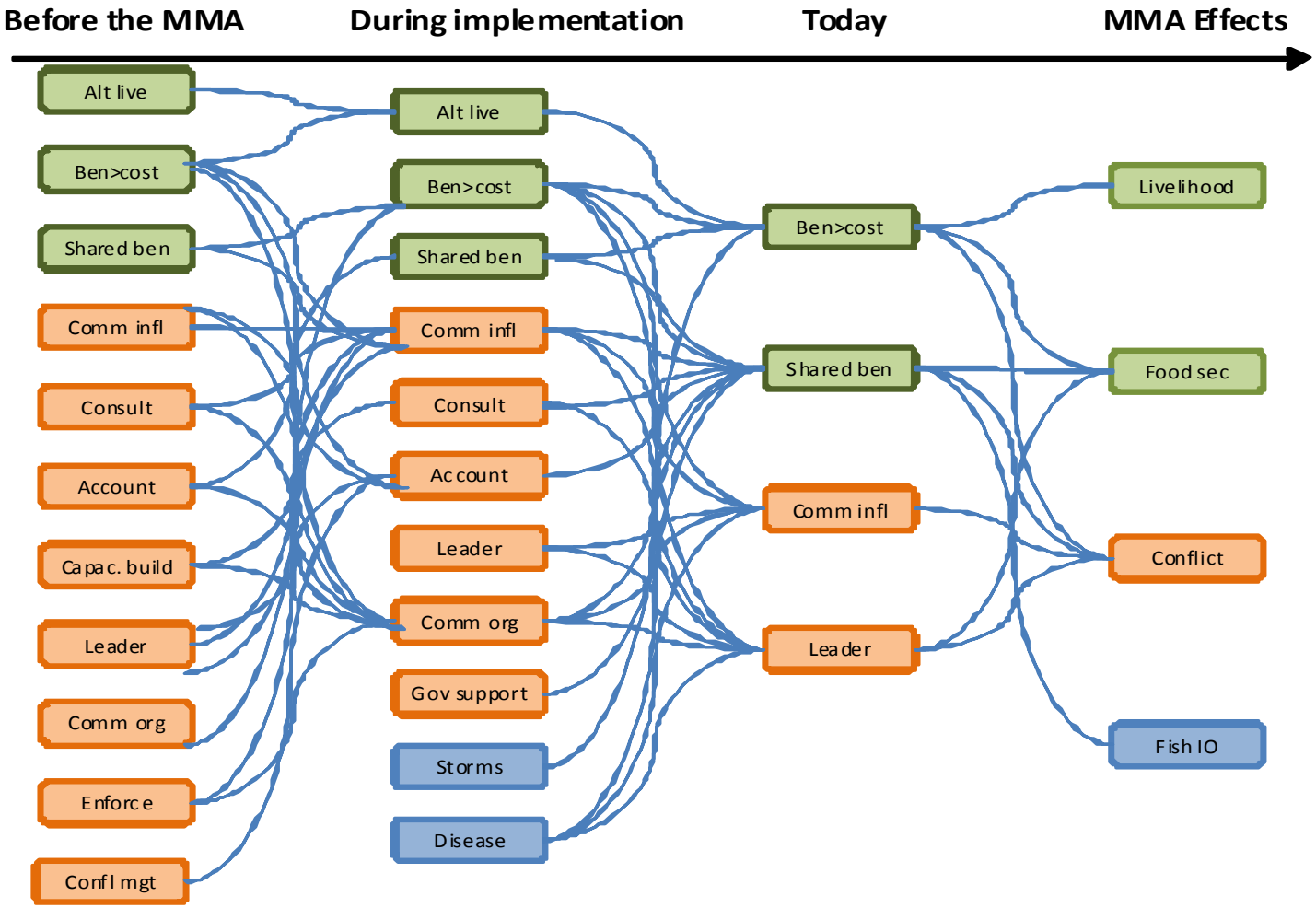
TIMELINES AND INDIRECT CORRELATES

The significant correlates of MMA effects can be placed into a timeline in order to gain additional insights. If we look at not only direct, but also indirect correlates (i.e. what factors in prior time periods are related to factors occurring in the future), and correlates that appear as direct influencers of multiple MMA effects, some interesting patterns emerge.

Figure 2, below, is the timeline for correlates of four MMA effects – improvements in livelihoods, food security, conflict levels, and a positive differential in fish biomass inside vs. outside the MMA. Clearly it is impossible to dissect all those relationships at once, but it is interesting to see the strong interrelationships among a fairly finite set of CDFs. Arrows indicate correlations between factors and across time.

First, note that of the universe of 20+ possible socioeconomic and governance CDFs, only four (from today) are strong, direct correlates of these four MMA outcomes. These are shared benefits from the MMA to the community, benefits exceeding costs, community influence, and strong leadership. For the most part, these current-period CDFs are factors that MMA management can control. The list grows to 11 CDFs during implementation with the addition of alternative livelihood projects, accountability in MMA management, and several CDFs associated with participation and a supportive local government. In addition, two ecological factors (storms and disease) occurring during implementation are associated with the four key current-period CDFs. In the early periods before the MMA, enforcement and capacity building activities become important correlates to later period factors.

Figure 2:


Before the MMA
During implementation
Today
MMA Effects
Alt live
Ben>cost
Shared ben
Comm infl
Consult
Account
Capac. build
Leader
Comm org
Enforce
Confl mgt
Alt live
Ben>cost
Shared ben
Comm infl
Consult
Account
Leader
Comm org
Gov support
Storms
Disease
Ben>cost
Shared ben
Comm infl
Leader
Livelihood
Food sec
Conflict
Fish IO

5.3 PREDICTING MMA OUTCOMES

This section addresses the third objective of the GME study, that is, to use the data we have gathered to *predict* MMA effects based on ecological, socioeconomic and governance variables. To begin this section, we will discuss the implications of our (statistical) model specification for predictions of MMA effects.

Recall that we have defined the effect of an MMA as an improvement in the perceived levels of several indicator variables such as livelihood, food security, conflict, ecological health, etc.[11] We model a latent variable, y^*, which can be thought of as a respondent's belief that there has been an improvement in the level of a particular MMA effect indicator. This latent variable is defined by a linear regression relationship:

$$y^* = \sum_{k=1}^{k} \beta_k x_k + \varepsilon$$

In practice, y^* is unobserved. We cannot measure peoples' beliefs directly. What we do observe is a dummy variable y, which takes the value of 1 if y^* is positive, and 0 otherwise. This distinction (between the latent variable and the realization of that variable) is important because it determines how we can interpret the coefficients of a multiple regression with binomial outcomes. The probability that y=1 is a function of the independent variables times their coefficients, but it is not a linear function.

In order to understand the effect of a change in an independent variable on a binary outcome, we first must introduce the concept of the odds ratio. It is defined in this case as the ratio of positive responses to negative responses for MMA effects. As an example, refer to Table 22 below. For the first MMA outcome, there are 212 positive responses out of a total of 446. This implies that the probability of a respondent indicating an improvement in livelihoods is 47.5% (212/446=.475). We calculate the odds by dividing the number who reported an improvement in livelihoods by the number who did not (212/234=.906). The odds of this event occurring are .906 – that is, 90 respondents indicated an improvement in livelihoods for every 100 who did not.

We focus on the odds ratio here because exponentiation of the coefficients in a logit model gives the expected change in the odds of having an event occur, per unit change in an explanatory variable, other things being equal. The same interpretation applies to both dummy and continuous variables[12].

[11] Note that this discussion only pertains to the perceived effects of MMAs. The sample size (8 MMAs) is too small to do a multivariate regression of this type on the quantitative ecological effects of MMAs.

[12]It is much more complicated to address the incremental impact of a change in a dummy independent variable on probabilities directly, and that is why we are looking at odds ratios.

Table 22: Odds ratios for survey responses (non-node sites)

Indicator	Positive responses*	Probability	Odds
Livelihoods	212	0.475	0.906
Food security	186	0.417	0.715
Resource conflicts	177	0.397	0.658
MPA conflicts	167	0.374	0.599
Village conflict	137	0.307	0.443
Participation	165	0.370	0.587
Influence	168	0.377	0.604
Compliance	262	0.587	1.424
Ecological health	265	0.594	1.464
Biodiversity	269	0.603	1.520

*N=446

The following table (Table 23) is a summary of the top positive regressors, by group, for all MMA outcomes. The detailed regression results tables follow.

Table 23. Summary of top positive regressors, by group, for all MMA

Perceived improvement in:	**Non-node sites**	**Group 1**	**Group 2**	**Group 3**
Livelihoods	• Alt lives – today • Shared benefits – during implem. • Community organizations – during implem.	• Capacity building - at the beginning • External agents - - today • • Alternative livelihood projects - during implementation	• Benefits exceed costs - - today • Accountable management style - during implementation • Shared benefits - during implementation	• Adequate funding - during implementation • Strong leadership - during implementation
Food security	• Leadership – at the beginning • Enforcement – at the beginning • External agents involved – today	• Community can influence - today • Accountable management style - during implementation • External agents - during implementation	• Shared benefits - at the beginning • Strong leadership - at the beginning • External agents - at the beginning	• Adequate funding - during implementation • Strong leadership - at the beginning

Perceived improvement in:	**Non-node sites**	**Group 1**	**Group 2**	**Group 3**
Ecological health	• Accountable management – during implem. • Enforcement – today • Community influence – at the beginning	• Adequate funding - during implementation • Community can influence - at the beginning • Supportive local government - during implementation	• Conflict management mechanisms - during implementation • Supportive local government - during implementation • Enforcement - today • Adequate funding - during implementation • External agents - at the beginning	• Shared benefits - during implementation • Enforcement - during implementation • Community organizations - during implementation
Biodiversity	• Shared benefits – at the beginning • Capacity building – at the beginning • Religious heterogeneity	• Accountable management style - during implementation • Capacity building - at the beginning • Conflict management mechanisms - today	• Conflict management mechanisms - during implementation • Shared benefits - at the beginning • External agents - at the beginning	• Accountable management style - today • Shared benefits - during implementation • Enforcement - today
Resource conflict	• Conflict management – during implementation • Adequate funds – today • Leadership – during implementation	• Benefits exceed costs - today • Community can influence - at the beginning • Strong leadership - during implementation	• Benefits exceed costs - today • Community can influence - at the beginning • Enforcement - during implementation • Strong leadership - during implementation	• Adequate funding - today • Strong leadership - during implementation

Perceived improvement in:	**Non-node sites**	**Group 1**	**Group 2**	**Group 3**
Participation	• Capacity building – today • Accountable management – during implem. • Community influence –today	• Accountable management style - today • Alternative livelihood projects - at the beginning	• Accountable management style - today • Alternative livelihood projects - at the beginning	• Accountable management style - today • Adequate funding - today • Strong leadership - during implementation
Influence	• Shared benefits – today • Socioeconomic heterogeneity • Consultations – during implementation	• Accountable management style - today • Adequate funding - during implementation	• Accountable management style - today • Conflict management mechanism - at the beginning • Shared benefits - today	• Accountable management style - today • Adequate funding - today • Shared benefits - today
Compliance	• Accountable management – during implementation • Socioeconomic heterogeneity • Shared benefits - today	• Legislation - at the beginning • Enforcement - during implementation • Capacity building - at the beginning	• Conflict management mechanisms - during implementation • Enforcement - today • Supportive local government - at the beginning	• Accountable management style - today • Adequate funding - today • Shared benefits - during implementation

NON-NODE SITES: MULTILEVEL REGRESSION ANALYSIS

The first step in the analysis was to reduce the number of explanatory variables to be included in the final regressions to a manageable number via a forward regression, with the cutoff for inclusion in the model a probability of less than 20 percent. This forward regression included ecological variables, which effectively serve as proxies for the site-level grouping variable to be included in the final analysis. The individual level variables were then subjected to a mixed logit regression, grouped at the MPA level. The conceptual difference between this type of analysis and the correlations discussed above is that the (exponentiated) coefficients here indicate a change in the odds of encountering a positive outcome, holding all other variables constant, and taking into

account the site-level effects. Therefore, although we would expect the results of the econometric analysis to be broadly consistent with the correlations described above, we are also hoping for some new insights beyond the simple bivariate correlations.

Table 24 displays the results from the multilevel logit regression on improvement in livelihoods. As expected, being a fisher is negatively related to improvements in livelihoods. Socioeconomic heterogeneity is positively related to this MMA effect, which may reflect the increase in opportunities that some fortunate stakeholders can take advantage of. Other significant regressors that did not appear in the bivariate correlations include the ongoing support of the implementing organization (today), a supportive local government (today), and education and training programs at the beginning. The remainder of the significant regressors did appear in the correlation matrix, although the timing of those was not always identical.

As noted above, exponentiating the coefficients in a logit model gives the expected change in the odds of having an event occur, per unit change in an explanatory variable, other things being equal. Therefore, the odds for fishers to indicate an improvement in their livelihoods are .542 times as high as non-fishers, other things being equal. The same type of interpretation can be applied to the remainder of the statistically significant regressors. The odds of a respondent indicating an improvement in livelihoods are twice as high if there is socio-economic diversity in their community, and almost four times as high if there are shared benefits from the MMA to the community during the implementation process.

Table 24: Dependent variable - improvement in livelihoods (non-node sites)

	Coef.	Std. err	z	P>|z|	exp(β)
Subject is a fisher	-0.612	0.263	-2.33	0.02	0.542
Socioeconomic heterogeneity	0.741	0.306	2.42	0.015	2.098
Alternative livelihood projects					
– during implementation	-0.603	0.378	-1.6	0.111	0.547
-today	1.008	0.369	2.73	0.006	2.740
Benefits exceeding costs					
– during implementation	-0.659	0.409	-1.61	0.107	0.517
-today	0.806	0.399	2.02	0.043	2.239
Shared benefits					
– at the beginning	-0.451	0.389	-1.16	0.246	0.637
-during implementation	1.374	0.386	3.56	0	3.951
Leadership					
– during implementation	0.802	0.34	2.36	0.018	2.230
External agents					
– during implementation	-0.59	0.372	-1.58	0.113	0.554
- today	0.708	0.363	1.95	0.051	2.030
Supportive local government					
– during implementation	0.68	0.443	1.53	0.125	1.974
-today	-1.011	0.44	-2.3	0.022	0.364
Community consultations					
– at the beginning	0.658	0.344	1.91	0.056	1.931
- today	-0.666	0.324	-2.05	0.04	0.514
Community organizations					
– during implementation	0.843	0.286	2.95	0.003	2.323

Capacity building – at the beginning	0.599	0.323	1.86	0.063	1.820
_cons	-2.798	0.507	-5.52	0	0.061

Wald chi²=73.99, Log likelihood=231.934, Prob>chi²=0

Table 25displays the results from the multilevel logit regression on improvement in food security. Here the differences between multivariate regression and bivariate correlations are even more pronounced. Of the eight statistically significant regressors, only two are found on the list of significant correlates reported previously. The remainder, including continuing advice from the implementing organization, enabling legislation, a supportive local government, and conflict management mechanisms today, and enforcement in the beginning, do not appear in the list of significant direct correlates reported above.

Table 25: Dependent variable - improvement in food security (non-node sites)

	Coef.	Std.	z	P>|z|	exp(β)
Subject is a fisher	-0.415	0.253	-1.64	0.101	0.660
Benefits exceeding costs					
– at the beginning	-0.375	0.280	-1.34	0.18	0.687
Leadership					
– at the beginning	0.832	0.392	2.12	0.034	2.298
External agents					
- today	0.641	0.263	2.44	0.015	1.898
Enabling legislation					
- today	-0.735	0.413	-1.78	0.075	0.480
Supportive local government					
– during implementation	0.687	0.450	1.53	0.127	1.988
- today	-0.852	0.439	-1.94	0.052	0.427
Community has influence					
– at the beginning	0.551	0.324	1.7	0.088	1.735
– during implementation	-0.538	0.344	-1.56	0.118	0.584
Community organizations					
– at the beginning	-0.388	0.313	-1.24	0.216	0.678
- today	0.417	0.319	1.31	0.19	1.517
Enforcement					
– at the beginning	0.898	0.301	2.98	0.003	2.455
Conflict management					
- today	0.652	0.291	2.24	0.025	1.919
Management is accountable					
– during implementation	0.669	0.310	2.16	0.031	1.952
_cons	-1.971	0.575	-3.42	0.001	0.139

Wald chi^2=45.81, Log likelihood=242.339, Prob>chi^2=0

Table 26 displays the results from the multilevel logit regression on conflict over resources. Again, there are significant differences between the regression results and the bivariate correlations. Interestingly, all three types of heterogeneity that we measure are significant, but religious diversity is negatively related to resource conflict while the two other types of diversity are positively related. Enabling legislation throughout the life of the MMA is also significant, as are alternative livelihoods, enforcement, and adequate funds today, as well as having adequate funds at the beginning of the MMA project.

Table 26: Dependent variable - conflict over resources (non-node sites)

	Coef.	Std.	z	P>|z|	exp(β)
Alternative livelihood projects					
– during implementation	-0.644	0.408	-1.58	0.115	0.525
-today	0.683	0.386	1.77	0.077	1.980
Ethnic heterogeneity	0.913	0.416	2.2	0.028	2.492
Socioeconomic heterogeneity	0.789	0.404	1.95	0.051	2.201
Religious heterogeneity	-0.667	0.402	-1.66	0.097	0.513
Benefits exceeding costs					
– during implementation	0.458	0.297	1.54	0.123	1.581
Shared benefits					
– at the beginning	0.832	0.322	2.59	0.01	2.298
Leadership					
– during implementation	1.081	0.421	2.57	0.01	2.948
External agents					
– during implementation	0.457	0.387	1.18	0.237	1.579
-today	-0.518	0.379	-1.37	0.171	0.596
Enabling legislation					
– at the beginning	-1.180	0.475	-2.48	0.013	0.307
– during implementation	1.538	0.602	2.55	0.011	4.655
-today	-1.644	0.615	-2.67	0.008	0.193
Community consultations					
– at the beginning	0.802	0.373	2.15	0.032	2.230
Community has influence					
– at the beginning	0.610	0.352	1.73	0.083	1.840
– during implementation	-0.611	0.379	-1.61	0.107	0.543
Enforcement					
-today	0.789	0.333	2.37	0.018	2.201
Conflict management					
– during implementation	0.812	0.318	2.55	0.011	2.252
Adequate funds					
– at the beginning	-1.088	0.327	-3.33	0.001	0.337
-today	1.163	0.330	3.53	0	3.200
_cons	-3.629	0.777	-4.67	0	0.027

Wald chi^2=53.27, Log likelihood=212.118, Prob>chi^2=.0001

Table 27 displays the results from the multilevel logit regression on increases in participation. Leadership at the beginning and enabling legislation today have negative coefficients in this regression. This might reflect the idea that an autocratic leader could discourage participation, and enabling legislation might also discourage participation in coastal resource projects. We also see supportive local government during project implementation, and education and training programs today turning up as significant regressors when they were not particularly strong correlates in bivariate correlations.

Table 27: Dependent variable – participation (non-node sites)

	Coef.	Std.	z	P>|z|	exp(β)
Benefits exceeding costs – at the beginning	-0.254	0.266	-0.96	0.339	0.776
Shared benefits -today	0.934	0.292	3.2	0.001	2.545
Leadership – at the beginning	-0.757	0.394	-1.92	0.055	0.469
Enabling legislation -today	-0.813	0.413	-1.97	0.049	0.444
Supportive local government – during implementation	0.432	0.250	1.73	0.084	1.540
Community has influence -today	0.778	0.290	2.68	0.007	2.177
Community organizations – during implementation	0.366	0.270	1.35	0.176	1.442
Enforcement – at the beginning	-0.503	0.326	-1.54	0.123	0.605
– during implementation	0.443	0.372	1.19	0.233	1.557
Capacity building -today	0.542	0.262	2.07	0.038	1.719
Management is accountable – during implementation	1.210	0.314	3.85	0	3.353
_cons	-1.803	0.446149	-4.04	0	0.165

Wald chi^2=50.27, Log likelihood=253.307, Prob>chi^2=0

Table 28 displays the results from the multilevel logit regression on increased influence on the MMA. This regression has particularly unexpected results, in that a number of the coefficients on significant regressors (namely, benefits exceeding costs during implementation, supportive local government at the beginning, community consultations today, and accountable management at the beginning) are negative, contrary to expectations.

Table 28: Dependent variable – influence (non-node sites)

	Coef.	Std.	z	P>|z|	exp(β)
Socioeconomic heterogeneity	1.019	0.286	3.57	0	2.770
Benefits exceeding costs					
– during implementation	-0.731	0.270	-2.7	0.007	0.481
Shared benefits					
-today	1.267	0.282	4.5	0	3.550
Enabling legislation					
– during implementation	-0.609	0.396	-1.54	0.124	0.544
Supportive local government					
– at the beginning	-0.984	0.503	-1.96	0.05	0.374
– during implementation	1.190	0.495	2.4	0.016	3.287
Community consultations					
– during implementation	1.257	0.435	2.89	0.004	3.515
-today	-0.812	0.405	-2	0.045	0.444
Community has influence					
– at the beginning	0.455	0.287	1.58	0.113	1.576
-today	0.553	0.298	1.86	0.064	1.738
Community organizations					
– during implementation	0.534	0.259	2.06	0.039	1.706
Conflict management					
-today	0.531	0.255	2.09	0.037	1.701
Capacity building					
– during implementation	0.786	0.349	2.26	0.024	2.195
-today	-0.499	0.314	-1.59	0.112	0.607
Management is accountable					
– at the beginning	-0.769	0.320	-2.4	0.016	0.463
-today	0.710	0.320	2.22	0.027	2.034
_cons	-3.205	0.474	-6.76	0	0.041

Wald chi^2=72.91, Log likelihood=241.695, Prob>chi^2=0

Table 29 displays the results from the multilevel logit regression on improvements in compliance. These results are striking because there were very no significant direct bivariate correlations on perceptions of improvements in compliance, yet there are several significant regressors here. Alternative livelihood projects today and adequate funds in the beginning are negatively related to perceived improvements in compliance. Socioeconomic heterogeneity, shared benefits from the MMA to the community, the involvement of external agents today, government support and enforcement during implementation, and accountability during implementation are all positively related to improvements in compliance.

Table 29: Dependent variable – compliance (non-node sites)

	Coef.	Std.	z	P>|z|	exp(β)
Subject is a fisher	-0.337	0.261	-1.29	0.197	0.714
Alternative livelihood projects – during implementation	0.545	0.376	1.45	0.147	1.725
-today	-0.758	0.370	-2.05	0.04	0.469
Ethnic heterogeneity	0.313	0.401	0.78	0.436	1.368
Socioeconomic heterogeneity	1.151	0.362	3.18	0.001	3.161
Religious heterogeneity	0.603	0.368	1.64	0.101	1.828
Shared benefits -today	0.643	0.312	2.06	0.039	1.902
External agents -today	0.448	0.270	1.66	0.097	1.565
Enabling legislation -today	-0.476	0.411	-1.16	0.247	0.621
Supportive local government – during implementation	0.621	0.296	2.1	0.036	1.861
Community organizations – during implementation	-0.398	0.295	-1.35	0.178	0.672
Enforcement – during implementation	0.623	0.319	1.95	0.051	1.865
Adequate funds – at the beginning	-0.827	0.421	-1.97	0.049	0.437
– during implementation	0.689	0.431	1.6	0.11	1.992
Management is accountable – during implementation	0.717	0.300	2.39	0.017	2.048
_cons	-1.711	0.740	-2.31	0.021	0.181

Wald chi^2=56.40, Log likelihood=235.806, Prob>chi^2=0

Table 30 displays the results from the multilevel logit regression on improvement in perceptions of ecological health. Here we have several CDF with negative coefficients, including some that are positively related to other outcomes. Benefits exceeding costs and strong enforcement at the beginning, alternative livelihoods during implementation, and community organizations today all have negative coefficients, while a supportive local government and community influence at the beginning, shared benefits, external agents involved, and accountability during implementation, and enforcement today all have positive coefficients.

Table 30: Dependent variable - perception of ecological health (non-node sites)

	Coef.	Std.	z	P>|z|	exp(β)
Subject is a fisher	-0.380	0.283	-1.34	0.18	0.684
Alternative livelihood projects – during implementation	-0.579	0.306	-1.89	0.058	0.560
Ethnic heterogeneity	0.629	0.404	1.56	0.12	1.876
Socioeconomic heterogeneity	-0.430	0.374	-1.15	0.251	0.651
Benefits exceeding costs – at the beginning	-0.887	0.324	-2.74	0.006	0.412
Shared benefits – during implementation	0.893	0.331	2.7	0.007	2.442
External agents – during implementation	0.750	0.303	2.47	0.013	2.117
Supportive local government – at the beginning	0.663	0.300	2.21	0.027	1.941
Community has influence – at the beginning	1.172	0.357	3.28	0.001	3.228
– during implementation	-0.492	0.361	-1.36	0.173	0.611
Community consultations -today	-0.437	0.326	-1.34	0.18	0.646
Community organizations -today	-0.732	0.304	-2.41	0.016	0.481
Enforcement – at the beginning	-0.603	0.362	-1.66	0.096	0.547
-today	0.891	0.363	2.45	0.014	2.438
Capacity building – at the beginning	0.513	0.360	1.42	0.154	1.670
Management is accountable – at the beginning	-0.770	0.446	-1.73	0.084	0.463
– during implementation	1.229	0.444	2.77	0.006	3.418
_cons	-0.315	1.020	-0.31	0.757	0.730

Wald chi^2=50.12, Log likelihood=207.224, Prob>chi^2=0

Table 31 displays the results from the multilevel logit regression on improvement in biodiversity. Here we see very different results from those for ecological health. Only two CDF are negatively related to this MMA outcome: community consultations and community organizations today. Religious heterogeneity, shared benefits and empowerment/capacity building programs at the beginning, enabling legislation and a supportive local government during implementation are all positively related to improvements in perceptions of biodiversity.

Table 31: Dependent variable - perception of biodiversity (non-node sites)

	Coef.	Std.	z	P>|z|	exp(β)
Ethnic heterogeneity	0.390	0.397	0.98	0.326	1.477
Religious heterogeneity	0.928	0.391	2.37	0.018	2.529
Benefits exceeding costs – during implementation	-0.354	0.294	-1.2	0.229	0.702
Shared benefits – at the beginning	1.111	0.319	3.48	0	3.037
Leadership – at the beginning	-0.610	0.421	-1.45	0.147	0.543
Enabling legislation – during implementation	0.809	0.431	1.88	0.061	2.246
Community has influence – during implementation	-0.525	0.341	-1.54	0.124	0.592
Supportive local government – at the beginning	-0.879	0.567	-1.55	0.121	0.415
– during implementation	1.180	0.594	1.99	0.047	3.254
Community consultations – during implementation	0.708	0.467	1.52	0.129	2.030
-today	-1.164	0.415	-2.8	0.005	0.312
Community organizations -today	-0.636	0.310	-2.05	0.04	0.529
Conflict management -today	0.490	0.324	1.51	0.13	1.632
Capacity building – at the beginning	0.785	0.372	2.11	0.035	2.192
Management is accountable -today	0.505	0.352	1.44	0.151	1.657
_cons	-0.809	1.023	-0.79	0.429	0.445

Wald chi^2=45.49, Log likelihood=202.879, Prob>chi^2=.0001

ALL MMA SITES; GROUPED: FORWARD LOGIT REGRESSION ANALYSIS

This section presents tables of regression results for the full set of MMAs, grouped by socioeconomic characteristics. In all cases, the predictive power of the statistical model for the whole data set and for Group 3 was quite low. Therefore, this section emphasizes the results for Groups 1 and 2 – two different types of successful MMAs. The tables showing results for the whole data set and for Group 3 are provided for comparison purposes only.

Table 32 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in livelihoods, for the full set of 19 MMAs. Here we have several CDF with negative coefficients, including some that are positively related to other outcomes.

Table 32: Dependent variable - improvement in livelihoods (whole data set)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - - today	0.325	0.166	1.96	0.051	1.384
Alternative livelihood projects - at the beginning	-0.524	0.258	-2.03	0.042	0.592
Benefits exceed costs - - today	0.505	0.246	2.05	0.040	1.656
Benefits exceed costs - at the beginning	-0.581	0.254	-2.29	0.022	0.559
Capacity building - - today	-0.437	0.248	-1.76	0.078	0.646
Community can influence - during implementation	0.323	0.226	1.43	0.153	1.381
Community organizations - during implementation	0.360	0.211	1.71	0.088	1.433
External agents - during implementation	0.493	0.218	2.26	0.024	1.638
Shared benefits - during implementation	0.776	0.176	4.41	0.000	2.172
Strong leadership - at the beginning	0.437	0.166	2.63	0.009	1.548
Supportive local government - - today	-0.787	0.219	-3.60	0.000	0.455
_cons	-1.340	0.304	-4.41	0.000	0.262

Pseudo R2 = 0.1133, Log likelihood=-553.800

Table 33 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in livelihoods, for Group 1 ("successful" MMAs located near traditional fishing communities). The predictive power of this model was somewhat better than that for the group as a whole, but still not particularly high. The CDFs with the highest regression coefficients were capacity building at the beginning, external agents involved today, and alternative livelihood projects during implementation.

Table 33: Dependent variable - improvement in livelihoods (Group 1)

	Coef.	Std. err	z	P>|z|	exp(β)
Alternative livelihood projects - at the beginning	-0.364	0.178	-2.05	0.041	0.695
Alternative livelihood projects - during implementation	0.685	0.269	2.54	0.011	1.984
Benefits exceed costs - - today	0.310	0.164	1.89	0.058	1.363
Capacity building - - today	-0.452	0.160	-2.83	0.005	0.636
Capacity building - at the beginning	0.776	0.214	3.62	0.000	2.173
Community organizations - at the beginning	0.564	0.323	1.75	0.081	1.757
Conflict management mechanisms - during implementation	-0.849	0.308	-2.76	0.006	0.428
Conflict management mechanisms - today	0.686	0.442	1.55	0.121	1.986
External agents - - today	0.940	0.245	3.84	0.000	2.560
External agents - during implementation	-0.416	0.324	-1.28	0.199	0.660
Legislation - during implementation	-0.765	0.350	-2.19	0.029	0.466
Shared benefits - during implementation	0.546	0.301	1.81	0.070	1.727
Strong leadership - - today	0.281	0.241	1.16	0.245	1.324
Supportive local government - - today	-0.697	0.244	-2.85	0.004	0.498
_cons	-0.631	0.372	-1.70	0.090	0.532

Pseudo R2 = 0.1728, Log likelihood=-210.62

Table 34 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in livelihoods, for Group 2 (established and successful MMAs located near communities with a diverse economic base including tourism). The predictive power of this model was much stronger. The CDFs with the highest coefficients were benefits exceeding costs today, community influence during impmlenetation, and conflict management mechanisms at the beginning.

Table 34: Dependent variable - improvement in livelihoods (Group 2)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	-1.676	0.730	-2.29	0.022	0.187
Accountable management style - during implementation	1.883	0.284	6.63	0.000	6.574
Adequate funding - - today	-0.664	0.510	-1.30	0.193	0.515
Adequate funding - at the beginning	-0.779	0.423	-1.84	0.066	0.459
Age of respondant	-0.021	0.008	-2.67	0.008	0.979
Alternative livelihood projects - - today	-1.627	0.989	-1.65	0.100	0.197
Alternative livelihood projects - at the beginning	1.018	0.423	2.41	0.016	2.767
Alternative livelihood projects - during implementation	-2.802	0.649	-4.32	0.000	0.061
Benefits exceed costs - - today	4.637	0.648	7.16	0.000	103.187
Benefits exceed costs - at the beginning	-0.519	0.257	-2.02	0.043	0.595
Benefits exceed costs - during implementation	-5.258	0.580	-9.07	0.000	0.005
Capacity building - - today	-1.336	0.822	-1.63	0.104	0.263
Capacity building - at the beginning	-0.742	0.495	-1.50	0.134	0.476
Community can influence - at the beginning	-2.312	0.410	-5.64	0.000	0.099
Community can influence - during implementation	3.227	0.884	3.65	0.000	25.210
Community consultations - during implementation	-0.481	0.471	-1.02	0.307	0.618
Conflict management mechanism - at the beginning	4.035	1.124	3.59	0.000	56.568
Conflict management mechanisms - during implementation	-3.708	1.137	-3.26	0.001	0.025
Enforcement - - today	-1.762	0.636	-2.77	0.006	0.172
Enforcement - during implementation	2.573	0.721	3.57	0.000	13.101
Ethnic heterogeneity	-1.643	1.100	-1.49	0.135	0.193
External agents - at the beginning	4.025	0.783	5.14	0.000	55.971
Legislation - - today	2.143	0.894	2.40	0.016	8.526
Legislation - at the beginning	-3.571	2.085	-1.71	0.087	0.028
Legislation - during implementation	2.783	1.592	1.75	0.080	16.171
Religious heterogeneity	9.886	2.473	4.00	0.000	19645
Respondent is a fisher	-0.678	0.380	-1.78	0.074	0.508
Shared benefits - during implementation	2.201	0.080	27.59	0.000	9.031
Shared benefits - today	-0.812	0.353	-2.30	0.021	0.444
Strong leadership - - today	2.234	0.413	5.41	0.000	9.333
Strong leadership - at the beginning	-4.096	1.238	-3.31	0.001	0.017
Strong leadership - during implementation	1.319	0.653	2.02	0.043	3.741
Supportive local government - - today	-0.879	0.561	-1.57	0.117	0.415
_cons	-8.020	2.160	-3.71	0.000	0.000

Pseudo R2 = 0.4404, Log likelihood=-76.68

Table 35 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in livelihoods, for the Group 3 (less successful MMAs, or those where poverty is a serious concern). The predictive power of this model is very low.

Table 35: Dependent variable - improvement in livelihoods (Group 3)

	Coef.	Std. err	z	P>|z|	exp(β)
Adequate funding - during implementation	0.693	0.229	3.03	0.002	2.001
Alternative livelihood projects - during implementation	-1.089	0.254	-4.29	0.000	0.337
Capacity building - during implementation	-0.470	0.221	-2.13	0.034	0.625
Community organizations - at the beginning	-0.602	0.283	-2.12	0.034	0.548
Religious heterogeneity	1.006	0.673	1.49	0.135	2.734
Shared benefits - during implementation	0.732	0.388	1.89	0.059	2.080
Strong leadership - during implementation	0.944	0.308	3.06	0.002	2.570
_cons	-2.100	0.663	-3.17	0.002	0.122

Pseudo R2 = 0.0970, Log likelihood=-182.60

Table 36 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in food security, for the full set of 19 MMAs. The predictive power of this model is somewhat higher than that for the equivalent model of improvement in livelihoods. The CDFs with the highest coefficient values are strong leadership at the beginning and external agents involved during implementation.

Table 36: Dependent variable - improvement in food security (whole data set)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - during implementation	0.332	0.297	1.12	0.263	1.394
Accountable management style - today	0.578	0.267	2.16	0.030	1.783
Age of respondant	0.023	0.005	4.61	0.000	1.023
Benefits exceed costs - at the beginning	-0.733	0.182	-4.02	0.000	0.480
Benefits exceed costs - during implementation	0.393	0.233	1.69	0.092	1.481
Capacity building - today	-0.612	0.282	-2.17	0.030	0.542
Conflict management mechanism - at the beginning	0.205	0.148	1.38	0.168	1.227
Enforcement - at the beginning	0.358	0.229	1.57	0.117	1.431
Ethnic heterogeneity	-0.769	0.338	-2.28	0.023	0.464
External agents - at the beginning	0.322	0.264	1.22	0.224	1.379
External agents - during implementation	0.701	0.322	2.18	0.029	2.017
Legislation - today	-0.704	0.252	-2.79	0.005	0.495
Shared benefits - during implementation	0.637	0.174	3.66	0.000	1.891
Strong leadership - at the beginning	1.031	0.286	3.60	0.000	2.803
Supportive local government - today	-0.683	0.299	-2.28	0.022	0.505
_cons	-2.614	0.435	-6.01	0.000	0.073

Pseudo R2 = 0.2110, Log likelihood=-474.53

Table 37 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in food security, for Group 1 ("successful" MMAs located near traditional fishing communities). The CDFs with the highest value coefficients are an accountable management style and external agent involvement during implementation and shared benefits from the MMA to communities today.

Table 37: Dependent variable - improvement in food security (group 1)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - during implementation	1.302	0.359	3.63	0.000	3.676
Adequate funding - today	-0.379	0.280	-1.36	0.175	0.684
Age of respondant	0.022	0.014	1.56	0.119	1.023
Benefits exceed costs - at the beginning	-0.445	0.170	-2.62	0.009	0.641
Capacity building - at the beginning	0.714	0.481	1.49	0.137	2.043
Capacity building - during implementation	0.426	0.315	1.35	0.176	1.532
Capacity building - today	-0.567	0.311	-1.82	0.068	0.567
Community can influence - during implementation	-0.416	0.212	-1.96	0.050	0.660
Community can influence - today	0.830	0.253	3.28	0.001	2.292
Ethnic heterogeneity	-0.746	0.412	-1.81	0.070	0.474
External agents - during implementation	1.072	0.195	5.49	0.000	2.922
Legislation - today	-1.197	0.370	-3.24	0.001	0.302
Shared benefits - today	0.645	0.106	6.08	0.000	1.905
Strong leadership - today	0.655	0.268	2.45	0.014	1.925
_cons	-2.756	0.758	-3.63	0.000	0.064

Pseudo R2 = 0.3196, Log likelihood=-173.53

Table 38 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in food security for Group 2 (established and successful MMAs located near communities with a diverse economic base including tourism).. The CDFs with the highest regression coefficients are strong leadership, external agents, and community consultations at the beginning.

Table 38: Dependent variable - improvement in food security (group 2)

	Coef.	Std. err	z	P>|z|	exp(β)
Adequate funding - at the beginning	-2.493	0.414	-6.03	0.000	0.083
Adequate funding - during implementation	1.232	0.461	2.68	0.007	3.430
Age of respondant	0.055	0.021	2.60	0.009	1.057
Alternative livelihood projects - at the beginning	1.066	0.338	3.15	0.002	2.904
Alternative livelihood projects - today	0.450	0.224	2.01	0.045	1.568
Capacity building - during implementation	-0.986	0.732	-1.35	0.178	0.373
Capacity building - today	-2.154	0.609	-3.54	0.000	0.116
Community consultations - at the beginning	1.222	0.628	1.95	0.052	3.395
Community consultations - during implementation	-2.296	0.417	-5.51	0.000	0.101
Conflict management mechanisms - during implementation	-0.402	0.172	-2.33	0.020	0.669
Enforcement - at the beginning	1.067	0.600	1.78	0.075	2.906
Enforcement - during implementation	-1.364	0.338	-4.04	0.000	0.256
Enforcement - today	0.926	0.520	1.78	0.075	2.524
Ethnic heterogeneity	1.346	0.533	2.52	0.012	3.840
External agents - at the beginning	2.490	0.688	3.62	0.000	12.065
External agents - today	1.430	0.567	2.52	0.012	4.180
Legislation - at the beginning	-0.796	0.306	-2.60	0.009	0.451
Legislation - today	0.539	0.393	1.37	0.170	1.714
Respondent is a fisher	-0.971	0.230	-4.22	0.000	0.379
Shared benefits - at the beginning	0.983	0.206	4.77	0.000	2.671
Strong leadership - at the beginning	2.842	0.530	5.36	0.000	17.157
Strong leadership - during implementation	-1.437	0.068	-21.11	0.000	0.238
Supportive local government - today	-0.371	0.281	-1.32	0.186	0.690
_cons	-6.469	1.177	-5.50	0.000	0.002

Pseudo R2 = 0.3790, Log likelihood=-80.67

Table 39 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in food security, for Group 3 (less successful MMAs, or those where poverty is a serious concern). The CDFs with the highest regression coefficients are adequate funding and shared benefits during implementation, and strong leadership at the beginning.

Table 39: Dependent variable - improvement in food security (group 3)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	0.244	0.132	1.84	0.066	1.276
Accountable management style - today	0.525	0.297	1.77	0.077	1.691
Adequate funding - during implementation	1.136	0.324	3.50	0.000	3.114
Adequate funding - today	0.248	0.350	0.71	0.478	1.281
Age of respondant	0.030	0.011	2.66	0.008	1.031
Capacity building - during implementation	-0.392	0.256	-1.53	0.126	0.676
Community organizations - at the beginning	-0.695	0.101	-6.90	0.000	0.499
Conflict management mechanisms - today	0.794	0.403	1.97	0.049	2.212
External agents - today	-0.966	0.376	-2.57	0.010	0.381
Legislation - today	-0.947	0.456	-2.07	0.038	0.388
Shared benefits - during implementation	0.863	0.570	1.52	0.130	2.371
Shared benefits - today	-1.427	0.487	-2.93	0.003	0.240
Strong leadership - at the beginning	1.315	0.361	3.64	0.000	3.723
Strong leadership - today	0.067	0.315	0.21	0.831	1.070
_cons	-2.870	0.613	-4.68	0.000	0.057

Pseudo R2 = 0.1935 Log likelihood=-155.99

Table 40 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in ecological health, for the full set of 19 MMAs.. The CDFs with the highest regression coefficients are shared benefits during implementation, and external agent involvement during implementation and today.

Table 40: Dependent variable - improvement in ecological health (whole data set)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	-0.354	0.243	-1.46	0.145	0.702
Accountable management style - during implementation	0.800	0.275	2.91	0.004	2.226
Age of respondant	0.015	0.009	1.73	0.083	1.015
Benefits exceed costs - at the beginning	-0.813	0.278	-2.92	0.003	0.444
Benefits exceed costs - during implementation	0.543	0.311	1.75	0.081	1.722
Capacity building - today	-0.600	0.392	-1.53	0.125	0.549
Community consultations - at the beginning	0.401	0.237	1.69	0.091	1.493
Community consultations - during implementation	-0.602	0.234	-2.57	0.010	0.548
Enforcement - at the beginning	-0.558	0.248	-2.25	0.025	0.572
Enforcement - during implementation	0.430	0.332	1.30	0.194	1.538
Enforcement - today	0.510	0.225	2.26	0.024	1.665
Ethnic heterogeneity	-1.172	0.535	-2.19	0.029	0.310
External agents - at the beginning	0.735	0.342	2.14	0.032	2.084
External agents - during implementation	0.800	0.324	2.47	0.013	2.225
External agents - today	-0.635	0.413	-1.54	0.124	0.530
Legislation - at the beginning	0.524	0.311	1.69	0.092	1.689
Shared benefits - during implementation	1.279	0.273	4.70	0.000	3.595
Socioeconomic heterogeneity	-0.620	0.463	-1.34	0.180	0.538
_cons	-1.360	0.481	-2.83	0.005	0.257

Pseudo R2 = 0.2293, Log likelihood=-488.69

Table 41 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in ecological health, for Group 1 ("successful" MMAs located near traditional fishing communities). The CDFs with the highest regression coefficients are capacity building at the beginning, adequate funding and a supportive local government during implementation, and an accountable management style today

Table 41: Dependent variable - improvement in ecological health (Group 1)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	0.712	0.421	1.69	0.091	2.038
Adequate funding - during implementation	0.714	0.210	3.41	0.001	2.042
Age of respondant	0.009	0.006	1.64	0.102	1.009
Alternative livelihood projects - today	-0.525	0.247	-2.13	0.034	0.592
Benefits exceed costs - at the beginning	-0.935	0.181	-5.17	0.000	0.393
Capacity building - at the beginning	1.052	0.389	2.70	0.007	2.863
Capacity building - today	0.337	0.259	1.30	0.192	1.401
Community can influence - at the beginning	0.763	0.220	3.46	0.001	2.145
Community consultations - during implementation	-0.752	0.311	-2.41	0.016	0.472
Community organizations - at the beginning	0.490	0.305	1.61	0.108	1.632
Community organizations - today	-0.999	0.311	-3.21	0.001	0.368
Ethnic heterogeneity	-1.395	0.607	-2.30	0.022	0.248
External agents - at the beginning	0.884	0.422	2.10	0.036	2.421
Shared benefits - during implementation	-0.026	0.277	-0.09	0.926	0.975
Shared benefits - today	0.742	0.256	2.89	0.004	2.101
Strong leadership - at the beginning	-0.977	0.328	-2.98	0.003	0.376
Supportive local government - at the beginning	0.342	0.511	0.67	0.504	1.408
Supportive local government - during implementation	1.116	0.448	2.49	0.013	3.052
_cons	-0.305	0.738	-0.41	0.679	0.737

Pseudo R2 = 0.3094, Log likelihood=-164.49

Table 42 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in ecological health, for Group 2 (established and successful MMAs located near communities with a diverse economic base including tourism). The CDFs with the highest regression coefficients are external agents at the beginning, adequate funding and an accountable management style during implementation, and strong leadership today.

Table 42: Dependent variable - improvement in ecological health (Group 2)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	1.775	0.933	1.90	0.057	5.898
Accountable management style - during implementation	4.518	2.272	1.99	0.047	91.652
Accountable management style - today	-2.230	0.702	-3.18	0.001	0.108
Adequate funding - at the beginning	-6.829	2.758	-2.48	0.013	0.001
Adequate funding - during implementation	5.351	2.079	2.57	0.010	210.910
Adequate funding - today	-1.123	0.892	-1.26	0.208	0.325
Age of respondant	0.034	0.048	0.72	0.474	1.035
Alternative livelihood projects - at the beginning	-2.381	1.086	-2.19	0.028	0.092
Alternative livelihood projects - during implementation	1.352	0.790	1.71	0.087	3.867
Benefits exceed costs - at the beginning	-5.619	1.510	-3.72	0.000	0.004
Benefits exceed costs - during implementation	1.197	3.355	0.36	0.721	3.309
Benefits exceed costs - today	3.005	2.270	1.32	0.185	20.191
Capacity building - during implementation	-0.323	0.721	-0.45	0.654	0.724
Capacity building - today	-5.243	1.624	-3.23	0.001	0.005
Community consultations - at the beginning	0.602	1.421	0.42	0.672	1.826
Community consultations - during implementation	-4.338	0.848	-5.12	0.000	0.013
Community organizations - during implementation	3.683	1.399	2.63	0.008	39.759
Community organizations - today	-2.007	0.528	-3.80	0.000	0.134
Conflict management mechanisms - during implementation	2.873	0.224	12.84	0.000	17.688
Conflict management mechanisms - today	-4.073	1.127	-3.61	0.000	0.017
Enforcement - at the beginning	3.041	1.500	2.03	0.043	20.920
Enforcement - during implementation	-3.855	2.038	-1.89	0.059	0.021
Enforcement - today	2.880	0.908	3.17	0.002	17.814
External agents - at the beginning	5.059	1.408	3.59	0.000	157.365
External agents - during implementation	0.569	0.798	0.71	0.476	1.766
Legislation - today	4.119	0.820	5.02	0.000	61.528
Respondent is a fisher	-4.085	2.684	-1.52	0.128	0.017
Shared benefits - today	2.300	1.691	1.36	0.174	9.975
Strong leadership - during implementation	-6.576	5.051	-1.30	0.193	0.001
Strong leadership - today	7.993	3.371	2.37	0.018	2959.744
Supportive local government - during implementation	7.175	1.338	5.36	0.000	1306.066
Supportive local government - today	-10.027	2.971	-3.38	0.001	0.000
_cons	-6.516	1.681	-3.88	0.000	0.001

Pseudo R2 = 0.6974, Log likelihood=-40.20

Table 43 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in ecological health, for Group 3 (less successful MMAs, or those where poverty is a serious concern). The CDFs with the highest regression coefficients are leadership at the beginning, and shared benefits and community organizations during implementation.

Table 43: Dependent variable - improvement in ecological health (Group 3)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	0.770	0.474	1.62	0.105	2.159
Adequate funding - today	0.509	0.253	2.01	0.044	1.664
Benefits exceed costs - at the beginning	-1.300	0.378	-3.44	0.001	0.272
Benefits exceed costs - during implementation	0.492	0.346	1.42	0.155	1.636
Capacity building - today	-0.414	0.202	-2.05	0.040	0.661
Community can influence - during implementation	-0.380	0.242	-1.57	0.117	0.684
Community organizations - at the beginning	-0.305	0.226	-1.35	0.177	0.737
Community organizations - during implementation	1.105	0.437	2.53	0.012	3.018
Community organizations - today	-2.430	0.607	-4.00	0.000	0.088
Conflict management mechanisms - during implementation	0.342	0.498	0.69	0.492	1.408
Conflict management mechanisms - today	0.582	0.405	1.44	0.150	1.789
Enforcement - during implementation	0.421	0.161	2.62	0.009	1.524
Ethnic heterogeneity	-1.056	0.789	-1.34	0.181	0.348
External agents - during implementation	1.036	0.288	3.60	0.000	2.817
External agents - today	-1.086	0.782	-1.39	0.165	0.338
Legislation - at the beginning	1.539	0.414	3.72	0.000	4.658
Legislation - during implementation	-0.781	0.189	-4.13	0.000	0.458
Legislation - today	-0.863	0.523	-1.65	0.099	0.422
Shared benefits - during implementation	1.990	0.526	3.78	0.000	7.315
Socioeconomic heterogeneity	-0.745	0.477	-1.56	0.119	0.475
Strong leadership - at the beginning	1.248	0.623	2.00	0.045	3.484
Supportive local government - today	0.003	0.207	0.02	0.988	1.003
_cons	-1.865	0.788	-2.37	0.018	0.155

Pseudo R2 = 0.3389, Log likelihood=-132.29

Table 44 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in biodiversity, for the full set of 19 MMAs. The CDFs with the highest regression coefficients were legislation at the beginning, and shared benefits and external agents involvement during implementation.

Table 44: Dependent variable - improvement in biodiversity (whole data set)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	0.616	0.284	2.17	0.030	1.851
Age of respondant	0.025	0.006	4.13	0.000	1.026
Benefits exceed costs - at the beginning	-0.555	0.247	-2.25	0.024	0.574
Community consultations - today	-0.674	0.328	-2.05	0.040	0.510
Community organizations - during implementation	0.630	0.334	1.89	0.059	1.878
Enforcement - at the beginning	-0.476	0.295	-1.61	0.106	0.621
Enforcement - during implementation	0.636	0.336	1.89	0.059	1.888
Ethnic heterogeneity	-1.636	0.498	-3.28	0.001	0.195
External agents - during implementation	0.819	0.358	2.29	0.022	2.269
Legislation - at the beginning	0.898	0.300	2.99	0.003	2.456
Shared benefits - at the beginning	0.292	0.221	1.32	0.185	1.340
Shared benefits - during implementation	1.071	0.260	4.11	0.000	2.919
Supportive local government - today	-0.493	0.344	-1.43	0.152	0.611
_cons	-2.161	0.705	-3.06	0.002	0.115

Pseudo R2 = 0.2413, Log likelihood=-482.80

Table 45 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in biodiversity, for Group 1 ("successful" MMAs located near traditional fishing communities). The CDFs with the highest regression coefficients are capacity building at the beginning, community organizations during implementation, and conflict management mechanisms today.

Table 45: Dependent variable - improvement in biodiversity (Group 1)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - during implementation	1.245	0.310	4.02	0.000	3.474
Age of respondant	0.032	0.012	2.56	0.010	1.032
Alternative livelihood projects - at the beginning	0.838	0.238	3.53	0.000	2.313
Alternative livelihood projects - today	-1.087	0.191	-5.69	0.000	0.337
Benefits exceed costs - at the beginning	-0.785	0.330	-2.38	0.017	0.456
Benefits exceed costs - during implementation	-0.409	0.293	-1.40	0.162	0.664
Capacity building - at the beginning	1.431	0.270	5.30	0.000	4.185
Capacity building - during implementation	-0.464	0.326	-1.42	0.155	0.629
Community consultations - during implementation	-0.482	0.314	-1.53	0.125	0.618
Community consultations - today	-1.565	0.693	-2.26	0.024	0.209
Community organizations - during implementation	1.124	0.287	3.92	0.000	3.077
Community organizations - today	-1.577	0.419	-3.76	0.000	0.207
Conflict management mechanism - at the beginning	-0.939	0.293	-3.21	0.001	0.391
Conflict management mechanisms - today	1.474	0.290	5.08	0.000	4.365
Ethnic heterogeneity	-2.495	0.702	-3.56	0.000	0.082
Legislation - at the beginning	0.666	0.323	2.06	0.039	1.946
Religious heterogeneity	0.793	0.468	1.70	0.090	2.211
Shared benefits - during implementation	0.934	0.320	2.92	0.003	2.544
_cons	0.068	0.864	0.08	0.937	1.071

Pseudo R2 = 0.3960, Log likelihood=-140.13

Table 46 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in biodiversity, for Group 2 (established and successful MMAs located near communities with a diverse economic base including tourism). The CDFs with the highest regression coefficients are a conflict management mechanism, community influence, and supportive local government during implementation, and benefits exceeding costs today.

Table 46: Dependent variable - improvement in biodiversity (Group 2)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	3.455	3.462	1.00	0.318	31.654
Accountable management style - during implementation	1.082	0.896	1.21	0.227	2.950
Accountable management style - today	-2.542	2.447	-1.04	0.299	0.079
Adequate funding - during implementation	1.258	2.375	0.53	0.596	3.518
Benefits exceed costs - at the beginning	-5.082	1.611	-3.15	0.002	0.006
Benefits exceed costs - during implementation	0.139	1.610	0.09	0.931	1.149
Benefits exceed costs - today	3.488	1.913	1.82	0.068	32.720
Capacity building - at the beginning	-1.243	0.506	-2.46	0.014	0.289
Capacity building - during implementation	0.778	0.548	1.42	0.156	2.177
Capacity building - today	-3.158	1.484	-2.13	0.033	0.042
Community can influence - at the beginning	-4.207	1.050	-4.01	0.000	0.015
Community can influence - during implementation	4.327	2.228	1.94	0.052	75.680
Community consultations - at the beginning	1.604	0.738	2.17	0.030	4.971
Community consultations - during implementation	-1.725	0.992	-1.74	0.082	0.178
Community consultations - today	-2.636	1.058	-2.49	0.013	0.072
Community organizations - today	1.502	0.829	1.81	0.070	4.492
Conflict management mechanism - at the beginning	2.813	0.905	3.11	0.002	16.667
Conflict management mechanisms - during implementation	3.832	1.000	3.83	0.000	46.152
Conflict management mechanisms - today	-6.297	1.619	-3.89	0.000	0.002
Enforcement - during implementation	-1.234	0.590	-2.09	0.037	0.291
Enforcement - today	4.043	1.389	2.91	0.004	56.970
External agents - at the beginning	2.559	0.850	3.01	0.003	12.924
External agents - during implementation	0.950	0.964	0.99	0.324	2.587
Legislation - today	5.089	1.565	3.25	0.001	162.180
Religious heterogeneity	1.628	1.451	1.12	0.262	5.095
Respondent is a fisher	-3.748	3.278	-1.14	0.253	0.024
Shared benefits - at the beginning	5.611	1.158	4.85	0.000	273.550
Shared benefits - during implementation	-7.205	4.664	-1.54	0.122	0.001
Shared benefits - today	3.129	3.279	0.95	0.340	22.843
Strong leadership - at the beginning	-2.736	1.163	-2.35	0.019	0.065
Strong leadership - during implementation	-3.326	3.741	-0.89	0.374	0.036
Strong leadership - today	5.208	2.209	2.36	0.018	182.804
Supportive local government - at the beginning	-3.771	1.375	-2.74	0.006	0.023
Supportive local government - during implementation	11.041	2.118	5.21	0.000	62381.872
Supportive local government - today	-8.821	1.710	-5.16	0.000	0.000
_cons	-8.342	1.966	-4.24	0.000	0.000

Pseudo R2 = 0.6420, Log likelihood=-48.81

Table 47 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in biodiversity, for Group 3 (less successful MMAs, or those where poverty is a serious concern). The CDFs with the highest regression coefficients are legislation at the beginning, and shared benefits and strong leadership during implementation.

Table 47: Dependent variable - improvement in biodiversity (Group 3)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	1.221	0.233	5.24	0.000	3.389
Adequate funding - today	0.144	0.358	0.40	0.688	1.155
Age of respondant	0.034	0.015	2.26	0.024	1.035
Benefits exceed costs - today	-0.833	0.517	-1.61	0.107	0.435
Capacity building - today	-0.237	0.379	-0.62	0.533	0.789
Community can influence - today	-0.421	0.252	-1.67	0.094	0.656
Community organizations - today	-0.982	0.466	-2.11	0.035	0.375
Enforcement - today	0.376	0.163	2.30	0.021	1.457
Ethnic heterogeneity	-1.906	0.778	-2.45	0.014	0.149
External agents - during implementation	0.679	0.321	2.11	0.035	1.971
External agents - today	-0.869	0.363	-2.39	0.017	0.419
Legislation - at the beginning	1.758	0.741	2.37	0.018	5.802
Legislation - during implementation	-0.442	0.380	-1.16	0.245	0.643
Legislation - today	-0.801	0.528	-1.52	0.129	0.449
Religious heterogeneity	1.345	0.887	1.52	0.130	3.837
Respondent is a fisher	-0.526	0.380	-1.38	0.166	0.591
Shared benefits - during implementation	1.768	0.452	3.91	0.000	5.857
Socioeconomic heterogeneity	-0.906	0.553	-1.64	0.101	0.404
Strong leadership - during implementation	1.563	0.790	1.98	0.048	4.773
Supportive local government - at the beginning	0.468	0.345	1.36	0.175	1.596
_cons	-4.073	1.022	-3.99	0.000	0.017

Pseudo R2 = 0.3250, Log likelihood=-137.18

Table 48 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in resource conflict, for the full set of 19 MMAs. The CDFs with the highest regression coefficients are external agent involvement and shared benefits during implementation.

Table 48: Dependent variable - improvement in resource conflict (whole data set)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	0.342	0.219	1.57	0.117	1.408
Age of respondant	0.033	0.008	4.10	0.000	1.034
Capacity building - today	-0.747	0.256	-2.92	0.003	0.474
Community can influence - at the beginning	0.611	0.280	2.18	0.029	1.842
Community consultations - today	0.351	0.213	1.65	0.099	1.421
Community organizations - at the beginning	0.433	0.282	1.54	0.124	1.542
Enforcement - during implementation	0.389	0.179	2.18	0.029	1.476
Enforcement - today	0.346	0.262	1.32	0.186	1.414
External agents - during implementation	0.797	0.330	2.42	0.016	2.220
External agents - today	-0.773	0.266	-2.90	0.004	0.462
Legislation - today	-0.655	0.273	-2.40	0.016	0.519
Shared benefits - at the beginning	-0.440	0.241	-1.82	0.068	0.644
Shared benefits - during implementation	0.722	0.238	3.04	0.002	2.059
Shared benefits - today	0.645	0.349	1.85	0.065	1.906
Strong leadership - at the beginning	0.397	0.340	1.17	0.243	1.488
Strong leadership - during implementation	0.644	0.378	1.70	0.089	1.903
Supportive local government - at the beginning	-0.539	0.282	-1.91	0.056	0.583
_cons	-4.230	0.584	-7.24	0.000	0.015

Pseudo R2 = 0.2013, Log likelihood=-453.77

Table 49 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in resource conflict, for Group 1 ("successful" MMAs located near traditional fishing communities).The CDFs with the highest regression coefficients are adequate funding and benefits exceeding costs today, ethnic heterogeneity, and legislation and enforcement during implementation.

Table 49: Dependent variable - improvement in resource conflict (Group 1)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	1.380	0.893	1.55	0.122	3.975
Adequate funding - at the beginning	-2.661	0.786	-3.39	0.001	0.070
Adequate funding - today	2.395	1.174	2.04	0.041	10.973
Age of respondant	0.028	0.015	1.88	0.061	1.029
Benefits exceed costs - during implementation	-4.405	1.138	-3.87	0.000	0.012
Benefits exceed costs - today	2.701	0.710	3.80	0.000	14.888
Capacity building - today	-2.719	0.331	-8.21	0.000	0.066
Community can influence - at the beginning	1.385	0.224	6.18	0.000	3.995
Community can influence - today	0.963	0.264	3.64	0.000	2.621
Conflict management mechanism - at the beginning	1.370	0.803	1.71	0.088	3.934
Conflict management mechanisms - during implementation	1.081	0.603	1.79	0.073	2.946
Conflict management mechanisms - today	-2.333	0.881	-2.65	0.008	0.097
Enforcement - at the beginning	-1.721	0.617	-2.79	0.005	0.179
Enforcement - during implementation	3.318	0.833	3.98	0.000	27.614
Enforcement - today	1.309	0.354	3.70	0.000	3.704
Ethnic heterogeneity	4.942	2.140	2.31	0.021	140.080
External agents - during implementation	2.820	0.988	2.85	0.004	16.773
Legislation - at the beginning	-5.605	2.365	-2.37	0.018	0.004
Legislation - during implementation	4.352	1.470	2.96	0.003	77.619
Shared benefits - at the beginning	2.205	1.349	1.63	0.102	9.069
Shared benefits - today	-1.108	1.087	-1.02	0.308	0.330
Strong leadership - during implementation	2.035	0.436	4.67	0.000	7.652
Strong leadership - today	-2.079	0.707	-2.94	0.003	0.125
Supportive local government - today	-2.303	1.106	-2.08	0.037	0.100
_cons	-10.096	1.981	-5.10	0.000	0.000

Pseudo R2 = 0.3167, Log likelihood=-169,54

Table 50 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in resource conflicts, for Group 2 (established and successful MMAs located near communities with a diverse economic base including tourism). The CDFs with the highest regression coefficients are ethnic heterogeneity, enforcement during implementation, and benefits exceeding costs and adequate funding today.

Table 50: Dependent variable - improvement in resource conflict (Group 2)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	1.380	0.893	1.55	0.122	3.975
Adequate funding - at the beginning	-2.661	0.786	-3.39	0.001	0.070
Adequate funding - today	2.395	1.174	2.04	0.041	10.973
Age of respondant	0.028	0.015	1.88	0.061	1.029
Benefits exceed costs - during implementation	-4.405	1.138	-3.87	0.000	0.012
Benefits exceed costs - today	2.701	0.710	3.80	0.000	14.888
Capacity building - today	-2.719	0.331	-8.21	0.000	0.066
Community can influence - at the beginning	1.385	0.224	6.18	0.000	3.995
Community can influence - today	0.963	0.264	3.64	0.000	2.621
Conflict management mechanism - at the beginning	1.370	0.803	1.71	0.088	3.934
Conflict management mechanisms - during implementation	1.081	0.603	1.79	0.073	2.946
Conflict management mechanisms - today	-2.333	0.881	-2.65	0.008	0.097
Enforcement - at the beginning	-1.721	0.617	-2.79	0.005	0.179
Enforcement - during implementation	3.318	0.833	3.98	0.000	27.614
Enforcement - today	1.309	0.354	3.70	0.000	3.704
Ethnic heterogeneity	4.942	2.140	2.31	0.021	140.080
External agents - during implementation	2.820	0.988	2.85	0.004	16.773
Legislation - at the beginning	-5.605	2.365	-2.37	0.018	0.004
Legislation - during implementation	4.352	1.470	2.96	0.003	77.619
Shared benefits - at the beginning	2.205	1.349	1.63	0.102	9.069
Shared benefits - today	-1.108	1.087	-1.02	0.308	0.330
Strong leadership - during implementation	2.035	0.436	4.67	0.000	7.652
Strong leadership - today	-2.079	0.707	-2.94	0.003	0.125
Supportive local government - today	-2.303	1.106	-2.08	0.037	0.100
_cons	-10.096	1.981	-5.10	0.000	0.000

Pseudo R2 = 0.5634, Log likelihood=-57.98

Table 51 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in resource conflict, for Group 3 (less successful MMAs, or those where poverty is a serious concern). The CDFs with the highest regression coefficients were benefits exceeding costs and strong leadership during implementation, and adequate funding today.

Table 51: Dependent variable - improvement in resource conflict (Group 3)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	-0.611	0.319	-1.91	0.056	0.543
Adequate funding - today	1.058	0.322	3.28	0.001	2.881
Age of respondant	0.045	0.010	4.30	0.000	1.046
Benefits exceed costs - during implementation	1.641	0.573	2.86	0.004	5.162
Benefits exceed costs - today	-1.875	0.790	-2.38	0.018	0.153
Capacity building - today	0.351	0.167	2.10	0.036	1.421
Community organizations - today	-0.543	0.384	-1.42	0.157	0.581
Conflict management mechanism - at the beginning	0.473	0.348	1.36	0.175	1.605
External agents - today	-0.814	0.295	-2.76	0.006	0.443
Respondent is a fisher	-1.590	0.480	-3.31	0.001	0.204
Shared benefits - at the beginning	-0.668	0.406	-1.65	0.100	0.513
Shared benefits - during implementation	1.150	0.459	2.50	0.012	3.158
Strong leadership - during implementation	1.541	0.497	3.10	0.002	4.667
Supportive local government - at the beginning	0.522	0.329	1.59	0.113	1.685
Supportive local government - during implementation	-1.100	0.345	-3.19	0.001	0.333
_cons	-4.104	0.939	-4.37	0.000	0.017

Pseudo R2 = 0.2362, Log likelihood=-121.51

Table 52 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in participation, for the full set of 19 MMAs. This regression provided very little predictive power.

Table 52: Dependent variable - improvement in participation (whole data set)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	0.792	0.244	3.24	0.001	2.207
Age of respondant	0.026	0.006	4.57	0.000	1.026
Alternative livelihood projects - at the beginning	-0.281	0.195	-1.44	0.150	0.755
Community can influence - today	0.470	0.140	3.35	0.001	1.601
Enforcement - at the beginning	-0.433	0.243	-1.78	0.075	0.648
Enforcement - during implementation	0.882	0.272	3.24	0.001	2.415
Enforcement - today	-0.283	0.176	-1.61	0.107	0.753
Ethnic heterogeneity	-0.477	0.317	-1.50	0.133	0.621
Shared benefits - during implementation	0.546	0.215	2.54	0.011	1.726
_cons	-2.657	0.293	-9.07	0.000	0.070

Pseudo R2 = 0.1090, Log likelihood=-513.25

Table 53 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in participation, for Group 1 ("successful" MMAs located near traditional fishing communities). This regression provided very little predictive power.

Table 53: Dependent variable - improvement in participation (Group 1)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	1.135	0.246	4.61	0.000	3.110
Adequate funding - during implementation	0.453	0.211	2.14	0.032	1.573
Age of respondant	0.014	0.005	2.62	0.009	1.014
Alternative livelihood projects - at the beginning	0.462	0.151	3.05	0.002	1.587
Benefits exceed costs - during implementation	-0.559	0.318	-1.75	0.079	0.572
Community can influence - at the beginning	0.469	0.338	1.39	0.165	1.598
Conflict management mechanisms - during implementation	0.175	0.092	1.91	0.056	1.192
Enforcement - during implementation	0.618	0.345	1.79	0.073	1.856
Enforcement - today	-0.482	0.283	-1.70	0.089	0.618
External agents - today	0.444	0.253	1.76	0.079	1.559
Shared benefits - today	0.707	0.374	1.89	0.059	2.028
_cons	-2.913	0.718	-4.06	0.000	0.054

Pseudo R2 = 0.1530, Log likelihood=-215.92

Table 54 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in participation, for Group 2 (established and successful MMAs located near communities with a diverse economic base including tourism). The CDFs with the highest regression coefficients are enforcement and strong leadership during implementation.

Table 54: Dependent variable - improvement in participation (Group 2)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	1.110	0.702	1.58	0.114	3.035
Age of respondant	0.025	0.006	4.06	0.000	1.025
Alternative livelihood projects - during implementation	0.729	0.227	3.21	0.001	2.073
Benefits exceed costs - during implementation	-1.676	0.906	-1.85	0.064	0.187
Benefits exceed costs - today	0.774	0.625	1.24	0.215	2.169
Community organizations - at the beginning	-1.130	0.431	-2.62	0.009	0.323
Community organizations - today	-0.454	0.155	-2.93	0.003	0.635
Enforcement - at the beginning	-1.261	1.184	-1.06	0.287	0.283
Enforcement - during implementation	2.872	0.915	3.14	0.002	17.680
Ethnic heterogeneity	-1.307	0.742	-1.76	0.078	0.271
External agents - today	1.309	0.489	2.67	0.008	3.701
Legislation - during implementation	1.337	0.530	2.52	0.012	3.808
Respondent is a fisher	0.518	0.323	1.60	0.109	1.679
Shared benefits - today	0.205	0.525	0.39	0.697	1.227
Strong leadership - during implementation	2.444	0.949	2.58	0.010	11.515
Strong leadership - today	-1.789	0.121	-14.76	0.000	0.167
Supportive local government - today	-1.148	0.173	-6.65	0.000	0.317
_cons	-4.462	1.169	-3.82	0.000	0.012

Pseudo R2 = 0.2143, Log likelihood=-89.88

Table 55displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in participation, for Group 3 (less successful MMAs, or those where poverty is a serious concern). The CDFs with the highest regression coefficients were an accountable management style and adequate funding today, and strong leadership during implementation.

Table 55: Dependent variable - improvement in participation (Group 3)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	-0.810	0.415	-1.95	0.051	0.445
Accountable management style - today	1.160	0.354	3.28	0.001	3.190
Adequate funding - at the beginning	-0.763	0.516	-1.48	0.139	0.466
Adequate funding - today	1.672	0.209	7.99	0.000	5.325
Age of respondant	0.037	0.008	4.59	0.000	1.038
Benefits exceed costs - today	-0.534	0.337	-1.59	0.113	0.586
Capacity building - at the beginning	-1.300	0.294	-4.42	0.000	0.273
Capacity building - today	0.340	0.252	1.35	0.177	1.405
Community can influence - during implementation	0.692	0.305	2.27	0.023	1.997
Community organizations - at the beginning	-0.799	0.339	-2.36	0.018	0.450
External agents - at the beginning	0.609	0.400	1.52	0.128	1.838
External agents - during implementation	0.498	0.239	2.08	0.037	1.645
External agents - today	-1.234	0.400	-3.09	0.002	0.291
Legislation - today	-0.441	0.247	-1.79	0.074	0.643
Religious heterogeneity	0.695	0.512	1.36	0.175	2.004
Shared benefits - during implementation	0.892	0.391	2.28	0.023	2.439
Socioeconomic heterogeneity	0.627	0.236	2.66	0.008	1.872
Strong leadership - during implementation	1.349	0.434	3.11	0.002	3.855
Strong leadership - today	-0.655	0.495	-1.32	0.186	0.519
_cons	-4.790	0.437	-10.96	0.000	0.008

Pseudo R2 = 0.2084, Log likelihood=-133.39

Table 56 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in influence, for the full set of 19 MMAs. This regression provided little predictive power.

Table 56: Dependent variable - improvement in influence (whole data set)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	-0.486	0.242	-2.01	0.044	0.615
Accountable management style - today	0.874	0.151	5.79	0.000	2.397
Adequate funding - during implementation	0.257	0.198	1.30	0.194	1.294
Age of respondant	0.034	0.007	4.57	0.000	1.035
Alternative livelihood projects - at the beginning	-0.491	0.227	-2.16	0.031	0.612
Alternative livelihood projects - during implementation	0.158	0.125	1.26	0.207	1.171
Benefits exceed costs - at the beginning	-0.270	0.305	-0.88	0.376	0.764
Benefits exceed costs - today	-0.488	0.272	-1.79	0.073	0.614
Capacity building - during implementation	0.265	0.216	1.23	0.219	1.303
Capacity building - today	-0.536	0.278	-1.93	0.053	0.585
Community can influence - today	0.416	0.174	2.39	0.017	1.517
Conflict management mechanisms - during implementation	0.386	0.209	1.85	0.065	1.472
Ethnic heterogeneity	-0.599	0.288	-2.08	0.038	0.549
Shared benefits - during implementation	0.266	0.201	1.32	0.186	1.305
Shared benefits - today	0.719	0.345	2.09	0.037	2.053
Strong leadership - at the beginning	0.478	0.250	1.92	0.055	1.613
Strong leadership - during implementation	0.520	0.293	1.77	0.076	1.682
Supportive local government - today	-0.288	0.180	-1.60	0.109	0.750
_cons	-3.160	0.450	-7.02	0.000	0.042

Pseudo R2 = 0.1648, Log likelihood=-489.63

Table 57 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in influence, for Group 1 ("successful" MMAs located near traditional fishing communities).This regression provided little predictive power.

Table 57: Dependent variable - improvement in influence (Group 1)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - during implementation	0.116	0.253	0.46	0.647	1.123
Accountable management style - today	0.958	0.248	3.87	0.000	2.605
Adequate funding - at the beginning	-0.232	0.102	-2.28	0.023	0.793
Adequate funding - during implementation	0.426	0.186	2.29	0.022	1.531
Age of respondant	0.017	0.010	1.76	0.078	1.018
Benefits exceed costs - at the beginning	-0.594	0.417	-1.43	0.154	0.552
Benefits exceed costs - during implementation	-0.344	0.194	-1.78	0.076	0.709
Community can influence - at the beginning	0.645	0.474	1.36	0.173	1.905
Community can influence - today	0.302	0.330	0.92	0.359	1.353
Community organizations - during implementation	0.569	0.411	1.39	0.166	1.766
Enforcement - today	0.337	0.215	1.56	0.118	1.400
Shared benefits - during implementation	0.637	0.305	2.09	0.037	1.891
Strong leadership - at the beginning	0.116	0.099	1.17	0.243	1.123
Strong leadership - during implementation	0.542	0.199	2.72	0.007	1.720
_cons	-3.684	0.886	-4.16	0.000	0.025

Pseudo R2 = 0.1966, Log likelihood=-203.46

Table 58displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in influence, for Group 2 (established and successful MMAs located near communities with a diverse economic base including tourism). The CDFs with the highest regression coefficients are enabling legislation during implementation and today, and a conflict management mechanism during implementation.

Table 58: Dependent variable - improvement in influence (Group 2)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	-0.869	0.275	-3.16	0.002	0.419
Accountable management style - during implementation	-1.232	0.220	-5.59	0.000	0.292
Accountable management style - today	1.227	0.445	2.76	0.006	3.410
Age of respondant	0.034	0.008	4.34	0.000	1.035
Benefits exceed costs - at the beginning	-0.284	0.802	-0.35	0.723	0.752
Benefits exceed costs - during implementation	-1.556	0.900	-1.73	0.084	0.211
Capacity building - today	-1.542	0.735	-2.10	0.036	0.214
Community organizations - today	-1.129	0.314	-3.60	0.000	0.323
Conflict management mechanism - at the beginning	1.564	0.290	5.39	0.000	4.779
Enforcement - at the beginning	-1.483	0.843	-1.76	0.078	0.227
Enforcement - during implementation	1.853	0.852	2.17	0.030	6.376
Ethnic heterogeneity	1.904	0.501	3.80	0.000	6.713
Legislation - at the beginning	-2.660	1.059	-2.51	0.012	0.070
Legislation - during implementation	2.139	0.626	3.42	0.001	8.487
Legislation - today	3.441	1.072	3.21	0.001	31.222
Shared benefits - today	0.646	0.183	3.52	0.000	1.908
Supportive local government - today	-0.430	0.505	-0.85	0.394	0.650
_cons	-4.725	1.114	-4.24	0.000	0.009

Pseudo R2 = 0.2793, Log likelihood=-81.54

Table 59 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in influence, for Group 3 (less successful MMAs, or those where poverty is a serious concern). This regression provided little predictive power.

Table 59: Dependent variable - improvement in influence (Group 3)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	0.802	0.209	3.83	0.000	2.231
Adequate funding - today	0.456	0.139	3.28	0.001	1.578
Age of respondant	0.045	0.019	2.43	0.015	1.046
Alternative livelihood projects - at the beginning	-0.519	0.254	-2.04	0.041	0.595
Benefits exceed costs - today	-0.943	0.462	-2.04	0.041	0.390
Capacity building - at the beginning	-0.649	0.338	-1.92	0.054	0.522
Community can influence - today	0.377	0.341	1.11	0.269	1.457
Community consultations - during implementation	0.721	0.361	2.00	0.046	2.057
Community organizations - at the beginning	-0.886	0.443	-2.00	0.045	0.412
Community organizations - during implementation	0.199	0.158	1.26	0.209	1.220
Enforcement - during implementation	-0.138	0.327	-0.42	0.673	0.871
Enforcement - today	-0.553	0.318	-1.74	0.082	0.575
Ethnic heterogeneity	-0.917	0.605	-1.51	0.130	0.400
Respondent is a fisher	-0.554	0.267	-2.07	0.038	0.574
Shared benefits - today	1.080	0.274	3.94	0.000	2.945
Strong leadership - at the beginning	0.625	0.444	1.41	0.159	1.868
_cons	-2.860	0.847	-3.38	0.001	0.057

Pseudo R2 = 0.1993, Log likelihood=-154.87

Table 60 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in compliance, for the full set of 19 MMAs. This regression provided little predictive power.

Table 60: Dependent variable - improvement in compliance (whole data set)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	0.340	0.237	1.44	0.151	1.405
Alternative livelihood projects - at the beginning	-0.575	0.234	-2.46	0.014	0.563
Benefits exceed costs - at the beginning	-0.286	0.213	-1.34	0.180	0.752
Community consultations - today	-0.572	0.228	-2.50	0.012	0.565
Enforcement - at the beginning	-0.604	0.276	-2.19	0.028	0.547
Enforcement - during implementation	0.871	0.240	3.63	0.000	2.389
Enforcement - today	0.474	0.217	2.19	0.029	1.606
Ethnic heterogeneity	-0.612	0.423	-1.45	0.148	0.542
External agents - at the beginning	0.319	0.245	1.30	0.194	1.376
External agents - during implementation	0.397	0.192	2.07	0.039	1.487
Legislation - at the beginning	0.708	0.289	2.44	0.014	2.029
Shared benefits - during implementation	0.700	0.214	3.27	0.001	2.014
Strong leadership - during implementation	0.553	0.406	1.36	0.173	1.738
Strong leadership - today	-0.866	0.274	-3.16	0.002	0.420
_cons	-1.221	0.439	-2.78	0.005	0.295

Pseudo R2 = 0.1264, Log likelihood=-547.67

Table 61 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in compliance, for Group 1 ("successful" MMAs located near traditional fishing communities).The CDFs with the highest regression coefficients are legislation at the beginning, adequate funding and enforcement during implementation.

Table 61: Dependent variable - improvement in compliance (Group 1)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - today	0.540	0.314	1.72	0.085	1.717
Adequate funding - during implementation	0.706	0.344	2.05	0.041	2.025
Alternative livelihood projects - during implementation	0.344	0.157	2.19	0.028	1.410
Alternative livelihood projects - today	-0.827	0.430	-1.92	0.055	0.438
Capacity building - at the beginning	0.789	0.292	2.70	0.007	2.201
Capacity building - today	-0.417	0.224	-1.86	0.062	0.659
Community can influence - today	-0.822	0.490	-1.68	0.094	0.439
Community consultations - during implementation	-0.652	0.281	-2.32	0.020	0.521
Community organizations - during implementation	0.276	0.295	0.93	0.350	1.317
Enforcement - at the beginning	-0.687	0.343	-2.00	0.045	0.503
Enforcement - during implementation	1.053	0.448	2.35	0.019	2.867
Enforcement - today	0.624	0.371	1.68	0.093	1.866
External agents - during implementation	-0.097	0.222	-0.44	0.661	0.907
External agents - today	0.590	0.342	1.73	0.084	1.805
Legislation - at the beginning	1.151	0.340	3.38	0.001	3.163
Strong leadership - today	-0.627	0.359	-1.75	0.081	0.534
Supportive local government - at the beginning	-0.510	0.302	-1.69	0.091	0.601
_cons	-0.826	0.607	-1.36	0.173	0.438

Pseudo R2 = 0.2034, Log likelihood=-199.15

Table 62 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in compliance, for Group 2 (established and successful MMAs located near communities with a diverse economic base including tourism). The CDFs with the highest regression coefficients are a supportive local government at the beginning, community influence and an accountable management style during implementation, and enforcement today.

Table 62: Dependent variable - improvement in compliance (Group 2)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	0.251	0.754	0.33	0.739	1.286
Accountable management style - during implementation	1.187	0.768	1.55	0.122	3.277
Capacity building - at the beginning	-1.603	0.564	-2.84	0.004	0.201
Capacity building - today	-1.077	0.356	-3.03	0.002	0.341
Community can influence - at the beginning	-1.564	0.668	-2.34	0.019	0.209
Community can influence - during implementation	1.655	0.664	2.49	0.013	5.232
Community consultations - today	-0.391	0.233	-1.68	0.092	0.676
Conflict management mechanism - at the beginning	0.672	0.341	1.97	0.049	1.958
Conflict management mechanisms - during implementation	1.160	0.405	2.87	0.004	3.190
Conflict management mechanisms - today	-1.953	0.219	-8.92	0.000	0.142
Enforcement - at the beginning	-0.233	0.617	-0.38	0.705	0.792
Enforcement - during implementation	0.258	0.245	1.05	0.294	1.294
Enforcement - today	1.831	0.152	12.06	0.000	6.240
External agents - at the beginning	0.803	0.609	1.32	0.187	2.232
External agents - during implementation	1.070	0.799	1.34	0.180	2.917
External agents - today	-0.773	0.373	-2.08	0.038	0.461
Religious heterogeneity	1.287	0.681	1.89	0.059	3.623
Strong leadership - at the beginning	-0.368	0.665	-0.55	0.579	0.692
Supportive local government - at the beginning	2.217	0.563	3.94	0.000	9.181
Supportive local government - today	-3.264	0.295	-11.07	0.000	0.038
_cons	-2.725	1.099	-2.48	0.013	0.066

Pseudo R2 = 0.3764, Log likelihood=-83.10

Table 63 displays the results from the forward logit regression (with standard errors adjusted for clustering at the site level) on improvement in compliance, for Group 3 (less successful MMAs, or those where poverty is a serious concern). The CDFs with the highest regression coefficients are strong leadership during implementation, adequate funding today, and a heterogeneous population.

Table 63: Dependent variable - improvement in compliance (Group 3)

	Coef.	Std. err	z	P>|z|	exp(β)
Accountable management style - at the beginning	-1.272	0.266	-4.79	0.000	0.280
Accountable management style - today	1.485	0.464	3.20	0.001	4.416
Adequate funding - during implementation	-0.732	0.408	-1.79	0.073	0.481
Adequate funding - today	1.171	0.232	5.04	0.000	3.226
Age of respondant	0.029	0.012	2.48	0.013	1.029
Alternative livelihood projects - during implementation	-0.798	0.465	-1.72	0.086	0.450
Benefits exceed costs - at the beginning	-0.977	0.568	-1.72	0.086	0.377
Capacity building - during implementation	0.556	0.376	1.48	0.139	1.744
Community can influence - at the beginning	0.771	0.334	2.31	0.021	2.162
Community consultations - today	-0.643	0.434	-1.48	0.139	0.526
Community organizations - at the beginning	-0.893	0.281	-3.18	0.001	0.409
Community organizations - today	-0.817	0.428	-1.91	0.056	0.442
Conflict management mechanisms - today	-1.158	0.367	-3.15	0.002	0.314
Ethnic heterogeneity	-0.963	0.507	-1.90	0.058	0.382
Religious heterogeneity	2.625	0.931	2.82	0.005	13.799
Respondent is a fisher	-0.696	0.365	-1.90	0.057	0.499
Shared benefits - during implementation	0.748	0.215	3.48	0.000	2.113
Shared benefits - today	0.761	0.411	1.85	0.064	2.141
Strong leadership - during implementation	1.866	0.673	2.77	0.006	6.464
Strong leadership - today	-1.191	0.477	-2.50	0.013	0.304
Supportive local government - at the beginning	0.698	0.345	2.02	0.043	2.010
Supportive local government - today	0.420	0.308	1.37	0.172	1.522
_cons	-4.178	1.087	-3.84	0.000	0.015

Pseudo R2 = 0.2821, Log likelihood=-145.90

6.0 LESSONS LEARNED

To reiterate, the objectives of this project are to:

1. determine the socioeconomic, governance and ecological ***effects*** (outcomes and outputs) of MMAs;

2. determine the ***critical factors*** (ecological, socioeconomic and governance) affecting MMA outcomes and outputs, as well as the impact of the ***timing*** of those factors on the outcomes and outputs of the MMA;

3. provide management tools for ***predicting*** MMA outcomes based on ecological, socioeconomic and governance variables.

The nineteen MMA sites included in this study are quite diverse, ranging from tiny, community based *tabu* sites with no tourism or outside influence, to large, established MMAs with multiple users including a large tourism base. Some of them are world-renowned examples of successful marine conservation, and some are barely more than "paper parks". A one size-fits-all analytic approach would not be appropriate for this sample of MMAs. Therefore, the study sites were divided into subsets using a number of different grouping schemes, based on 1) the availability of data and the analytic options associated with it, and 2) the socioeconomic profile of the communities included in the study. Discussion of the merits vs. negatives of the grouping scheme

The first grouping scheme entailed subdividing the MMAs according to whether or not the MMA was one of Conservation International's node sites. Although the number of non-node sites was small – only eight – these MMAs were chosen for this study because they have reliable ecological data associated with them. Therefore, it was possible to incorporate the ecological data into the analysis in ways that were not possible for the other sites. For these MMAs, we used a multilevel mixed effects statistical model to incorporate site-level effects into the logit regression analysis, reported in section 5.3.

In addition, some of the node sites included ecological data on the fish biomass and/or coral cover inside the MMA vs. in a control site. This second group of MMAs (non-node sites plus the node sites with ecological data) was used for the detailed correlation analysis reported in section 5.2. In this way, we were able to gain some insight from the relationships among Critical Determining Factors that were associated with both the key socioeconomic and governance outcomes, and the ecological outcome indicating a positive difference in fish biomass inside the MMA vs. at a control site.

The third grouping scheme involved segregating the MMAs based on their socio-economic profile and the perceived level of success of the MMA. Within this scheme, Group 1 includes traditional fishing communities with minimal tourism and high levels of "success" reported by survey respondents. Group 2 includes highly successful MMAs located in or near communities in which fishing is not a major economic activity. Group 3 includes MMAs with lower levels of reported success, or in which poverty is and remains a serious

concern. We used forward logit regression to elucidate the most critical factors associated with perceived improvements in various MMA effect indicators, as reported in section 5.3.

As noted above, the first objective of this study is to understand the effects of MMAs. In terms of the effects measured via household surveys (perceptions of improvements in various social and ecological indicators), the data indicate statistically significant (but not large) difference in before/after levels of all MMA performance indicators. Discussion of whether this matters or not; "rosy picture" issues.

When the survey respondents were subdivided according to the schemes noted above, most subsets perceived the greatest improvements in ecological health and biodiversity. The survey respondents in "Group 2", (MMAs near communities with a diverse economic base) reported a more even improvement of social and ecological indicators. Survey respondents at MMAs with ecological data indicating a positive differential in coral cover inside the MMA vs. at a control site, as well as those in "Group 3" (less successful) MMAs, do not perceive any improvements in MMA effect indicators and in fact reported statistically significant (but small) worsening of conflict levels. So therefore we see that the "rosy picture" is not even across all subgroups.

Because before-after data were only available for non-node sites, our assessment of the ecological effects across all sites was limited to comparisons of outcomes inside and outside MMAs. One outcome compared across all sites, the difference in coral cover within versus outside MMAs varied among sites with approximately half of the study sites (n = 7) showing no difference between MMA and control sites or greater coral cover in control sites, and approximately half of sites (n = 8) having higher coral cover within MMAs. Because we do not know the starting conditions at any of the node sites and how coral cover changed within these sites compared to control sites, it is difficult to say how MMA management has affected coral cover, but clearly, any positive MMA effects are limited.

There was a greater occurrence of potentially positive MMA effects on the abundance and/or biomass of key fishery species, with 10 MMA sites reporting greater abundance or biomass than their controls and only 4 sites reporting no difference or greater abundance or biomass at control sites. Again, because time series data does not exist for node sites, we cannot correlate changes in biomass or abundance of key species with the implementation of MMA protection, however the high frequency of occurrence of cases where abundance or biomass is greater within MMA sites is suggestive of a positive effect of MMA management.

For the second objective of the study, we determine the critical factors affecting MMA success through a correlation analysis similar to what has been done in many prior studies. However, in this study we drill a bit deeper to try to understand the cross-correlations between factors over time. There are several patterns in the correlations and regression coefficients that are useful for managers and policy makers to understand:

- There are a finite number of actions that can be undertaken by MMA management that are directly related to improvements in perceptions of several key indicators of MMA effects. These include a situation where the *benefits exceed the cost* of the MMA, an equitable *sharing of benefits* from the MMA to the community, *community influence* over the MMA, *accountable management* of the MMA, and *conflict management mechanisms*.

- Perceptions of improvements in biological indicators do not have as many direct correlates as the socioeconomic and governance indicators. A positive differential in fish biomass inside vs. outside the MMA was related to *leadership* and *community influence* at the beginning, as well as *shared benefits* and *benefits exceeding costs* now.

- If we look at the prior period correlates of the important CDFs occurring today, we see that the same set of CDFs is strongly correlated across time not only with MMA effects, but also with each other. There are interesting and statistically significant relationships between ecological CDFs and socioeconomic/governance CDFs occurring in later periods, but it is probably not realistic to ascribe any meaning to those relationships.

- The inferences on CDFs that arise from analyzing secondary literature are broadly consistent with the results of the analysis of survey data, but they are incomplete. The two CDFs that show up most strongly in the literature are *shared benefits* from the MMA to the community (equity), and *accountability* of management. These are two CDFs that appear as both bivariate correlates and significant regressors on multiple MMA outcomes. On the other hand, reading the literature would have led us to believe that *adequate financial resources* was a significant CDF. This factor did not appear as a positive correlate for very many MMA outcomes. This absence probably implies that community perceptions are not the most reliable measurement of the financial resources of an MMA.

- On the topic of the financial resources of an MMA, we did see that perceptions of MMA *financial resources* at the beginning of the project were negatively related to conflict and compliance levels for the non-node sites, and with conflict levels for Groups 1 and 2. This finding aligns with anecdotal reports that a new MMA entering an area with lots of money is likely to generate resentment and resistance among the communities affected.

- The predictive power of the regression model for the 19 MMAs as a whole was generally weak – the forward logit regressions generally had pseudo R^2s on the order of .15 to .25. These improved greatly when we subdivided the data into groups, but the regressions for Group 3 (the less successful MMAs) consistently exhibited the least predictive power of the three groups. The R^2*s* associated with the regressions on perceptions of improvements in ecological health and biodiversity were by far the most satisfactory, even for Group 3. More discussion here.

- There was some consistency in terms of important regressors for multiple governance outcomes across groups. Leadership, conflict management mechanisms, and accountable management style were strong predictors of several governance outcomes.

- There were some surprising results in terms of what was NOT important in the regression models. *Enforcement* and *enabling legislation* did not appear as strong

regressors for many outcomes, which was surprising given the emphasis on these two factors in policy and the operations of MMAs.

- There was not a great deal of overlap in the most significant regressors for socioeconomic and ecological outcomes of MMAs for the three groups. For example, *capacity building, external agents*, and *alternative livelihood projects* were the most important determinants of improvements in livelihoods for Group 1, benefits *exceeding costs , accountable management*, and *shared benefits* were important for Group 2, and *adequate funding* and *leadership* were important for Group 3.

For the third objective, predictions of changes in MMA outcomes arise directly from the interpretation of the coefficients in the multilevel logit regression. Exponentiating the coefficients on CDFs gives the change in the odds ratio for a particular outcome associated with a unit change in the CDF.

Another CDF with a strong relationship to multiple MMA outcomes is *shared benefits* from the MMA to the community. This finding has important implications for MMA managers, policy makers, and donors. MMAs are more likely to encounter positive community perceptions and consequent support for their projects if they share the benefits of conservation with the community in a meaningful way. This is logical and expected. At the same time, however, MMAs are increasingly being expected to be self-funding; to be financially sustainable. Given the imperative of financial sustainability, then, how is an MMA manager to distribute the proceeds of user fees, for example? Should he distribute those fees to the community and be left without enough money to buy gas for patrol boats or pay rangers? Should he pay rangers more because they have to enforce regulations among a hostile and impoverished populace? This is a real challenge and one that merits further study. What is the relationship between enforcement expenditures and shared benefits to the community?

Finally, there are tradeoffs between socioeconomic, governance, and ecological effects of MMAs. Actions taken by management that may have a positive effect on one suite of outcomes may have a negative effect on others. For instance, *alternative livelihood* projects, which are positively related to improvements in livelihoods, are negatively related to improvements in compliance (in the multiple regression analysis for the non-node sites). This actually makes sense in the context of a comprehensive economic model of MMAs, but it is disheartening for conservationists who want to be able to say that MMAs can help alleviate poverty, but who also want ecosystem protection rules to be complied with.

Several important limitations of this study should be highlighted. The study cannot claim to be a globally representative evaluation of all MMAs worldwide. It evaluates only a small sample of MMAs, and those MMAs were not sampled at random. The evaluation was conducted without controls for either MMAs (i.e. looking at "unsuccessful" vs. "successful" MMAs) or the local context (i.e. looking at areas not under any kind of management vs. these managed areas[13].) Therefore, it was not possible to conduct the evaluations using an

[13] We did use control data for the ecological effects wherever possible.

experimental research design of before/after, control/impact (or "differences in differences") data generation. Biophysical impacts of MPAs are generally recorded as treatment-control (for example, biomass inside vs. outside an MPA); reliable before-after ecological data are rare. Although household surveys will generate before-after values, they will not be conducted in communities unaffected by MMAs – that is, there are no directly comparable treatment-control data.

In summary, MMAs do lead to positive outcomes and changes for marine resources and users, specifically large positive changes perceived in compliance, and in perceptions of ecological health and biodiversity. It should be noted that while community members may feel good about the changes the MMA has brought, they don't feel equally good about everything.

The more important CDFs affecting MMA outcomes identified include:

- Community influence – As has been reported in many publications, participation of community members in the MMA project design and implementation provides them with a sense of 'ownership' over the MMA.

- Accountable management – The MMA has a management process in which business is conducted in an open and transparent manner. All MMA partners must be held equally accountable for management. Without strong accountability, decision making can become corrupt and arbitrary.

- Conflict management mechanism - Arbitration and resolution of disputes are imperative when conflicts arise over MMA management and institutional arrangements. If resource users are to follow rules, a mechanism for discussing and resolving conflicts and infractions is a must. There is a need for a forum for resource users to debate and resolve conflicts and to appeal decisions.

Benefits exceed costs - Individuals must feel that the benefits to be obtained from participation in the MMA, including compliance with rules, will be greater than the costs of such activities.

- Sharing of benefits – The perception of benefits from the MMA, as well as sharing of economic benefits for participants and non-participants resulting from the MMA. Real or perceived economic benefits from the MMA influence participants to sustain the MMA.

However, it should be noted that there was not a great deal of overlap in the most significant regressors for socioeconomic and ecological outcomes of MMAs for the three groups. This may be the most important result coming out of this work – that there is no single recipe for success with marine conservation, but that it is important to understand the circumstances of the local community before deciding on the appropriate policy mix to meet conservation or development objectives.

APPENDIX A: GME HOUSEHOLD SURVEY

RESP#_____ START TIME_____:_____ GIS lat_____: long_____

DATE _____,_____ INTERVIEWER _____

LOCATION _____, COUNTRY _____

Section 1: Demographics and community questions

1.1. What is your age _____? Male or Female? _____

1.2. Years of formal education_____

1.3 Are you married? Y____ N _____

1.4. How many people live in your household? ____

1.5. How many years have you lived here/there? _____ years

1.6. What is your (the respondant's) main occupation? _____

1.7. What are the top two main occupations in this household?

#1 _____

#2 _____

1.8. What are the top two main sources of household income?

#1 _____

#2 _____

1.9. Is there more than one ethnic group living in this community?

(Check one) Y____ N _____

1.10.Are there certain people in this community who have a lot more money/wealth than others?

(check one) Y____ N _____

1.11. Is there more than one religious group present in this community?

(check one) Y____ N _____

1.12. Do you feel that the MPA has been successful?

(check one) Y____ N___

1.13. If yes, what have been the successes?

1. 2.

1.14 If no, what were the failures?

1. 2.

1.15 Did you support the MPA?

In the beginning or early phases of the MPA Y____ N _____

During implementation of the MPA Y____ N _____

Today Y____ N _____

1.16. If you supported the MPA in the beginning, why did you support it? (You can choose more than one of the following)

— Expected economic benefits
— Increase the number of fish
— Make the marine life better
— Minimum sacrifice
— Provide for alternative livelihoods (from tourism, etc.)
— Having conservationists out there and with good policing solves a totally unrelated problem in a novel way (e.g. drug beach, squatters driven off)
— Other reasons _____

1.17. If you didn't support the MPA in the beginning but supported it later, what changed your mind?

— Expected economic benefits
— Increase the number of fish
— Make the marine life better
— Minimum sacrifice
— Provide for alternative livelihoods (from tourism, etc.)
— Having conservationists out there and with good policing solves a totally unrelated problem in a novel way (e.g. drug beach, squatters driven off)
— Other reasons _____

1.18.Has the availability of fish from local waters increased/decreased/stayed the same since five years ago?

— Increased
— Decreased
— Stayed the same

If there has been an increase or decrease, what is the reason?_____

_____

1.19.Has your household's quality of life (health, household assets) increased/ decreased/stayed the same since five years ago?

— Increased
— Decreased
— Stayed the same

If there has been a change, what is the reason?_____

_____

Section 2(a): Critical success factors

If you answered "yes" to number 1.12 above, in your opinion, what were the most important factors affecting the success of the MPA? (Note: interviewer will ask open ended question, what were the most important factors? Interviewer will tick off the top 3 responses from the list.)

— There was legislation to support the MPA's implementation

— External help in planning and implementing the MPA (NGO, Academic, etc.)

— Continuing advice from implementing organization

— The size of the MPA is appropriate to enable effective management

— It is clear who can participate in decision making

— Tangible increase in fish

— Those who are impacted by the MPA can participate in decision making

— Leadership

— There was training and education provided

— Community organizations

— Long term support of local government

— Adequate financial resources

— Accountable management within the MPA

— Small population size

— Conflict management mechanism

— Clear objectives

— Management rules enforced

— The benefits exceed the costs

— Successful alternative livelihoods

— Benefits are shared

— There was a perceived crisis in the resource

— Other (specify)

Section 2(b): Questions checking/probing on the CDFs and their timing

The next set of questions asks about the timing of factors that might be important in establishing and managing an MPA. (Check appropriate box if "yes")

	In the beginning or early phases of the MPA	During implemen-tation of the MPA	Today
1. Were community members able to influence the size and location of the different reserve areas?			
2. Did the MPA receive any advice or support from external groups or organizations in planning or implementing the MPA?			
3. Does the MPA have sufficient funds to achieve its objectives?			
4. Was there a community education and training program associated with the MPA?			
5. With respect to the development of the MPA, were there community consultations?			
6. Were alternative/supplemental income opportunities developed or promoted by the MPA?			
7. Are there or were there clear leaders who pushed this project forward?			
8. Did the project receive financial inputs from the local government?			
9. Is there legislation in place that supports the MPA?			
10. Are there any community organizations (formally or informally) associated with the MPA?			
11. Are the managers of the MPA accountable to community members?			
12. Is there conflict management mechanism?			
13. Is there effective enforcement of the MPA rules and regulations?			
14. Do the benefits to community members arising from the MPA exceed the costs?			
15. Are there shared benefits from the MPA to community members?			

Section 3: Perception questions

Please use the 1 to 10 ladder diagram to respond to the following questions:

	Before the MPA	Today
1. ***Livelihoods:*** The lowest step indicates the worst possible existence, little or no food, inadequate furnishings and shelter, and sickness. The highest step indicates the best possible house, fully furnished, more than enough food, and everyone healthy.		
2. ***Food security***: The lowest step indicates a situation where seafood is never available. The highest step indicates a situation where there is always locally harvested seafood available in the markets		
3. ***Resource use conflicts***: The lowest step indicates a situation where people are always arguing and fighting over coastal marine resources. The highest step is a situation where everyone is friendly and cooperates together like one family.		
4. ***MPA conflicts:*** The lowest step represents a situation where the MPA has brought about high levels of conflict and the highest step is a situation where there is no conflict caused by the MPA.		
5. ***Participation in MPA management:*** The lowest step in the ladder indicates a situation where you cannot join any meeting on the MPA management. The highest step represents a situation where you can join all meetings on the MPA management.		
6. ***Influence on MPA management:*** The lowest step indicates a situation where whatever you say or do it makes no difference with respect to activities in the MPA. The highest step indicates a situation where your opinion has influence on the MPA activities		
7. ***Peace and order:*** The lowest step indicates a situation where the peace and order situation is very bad. The highest step indicates a situation with the best possible level of peace and order.		
8. ***Crime:*** The lowest step indicates a situation with the highest possible amount of crime in the area. The highest step indicates a situation with no crime at all in the area.		
9. ***Village-level conflict:*** The lowest step indicates a high degree of disputes or conflict in the village/town, and the highest step indicates no disputes or conflict at all.		
10. ***Compliance:*** The lowest step shows a situation where no-one obeys the resource management rules. The highest step shows a situation where everyone obeys the rules.		
11. ***Ecological health:*** The lowest step indicates a situation with no fish or other resources, that the water is so foul nothing could live in it. The highest step is described as rich, clean water, filled with fish and other wildlife.		
12. ***Biodiversity:*** The lowest step indicates a situation with only one or a few different types of fish or corals. The highest step indicates a situation with many different kinds of fish and other wildlife.		

APPENDIX B: ECOLOGICAL CDFS

Overview

As part of the Global Management Effectiveness study, various ecological outcomes (MMA effects) and ecological factors (Critical Determining Factors or CDFs) are being assessed for an integrated analysis of how ecological and socioeconomic factors combine to influence MMA success. This report is intended to provide an update on the data collection and analysis methods used for assessing ecological CDFs and outcomes and how these outcomes and factors are being integrated with socioeconomic factors for analysis. Detailed discussions of the overall project and approach used to assess the relationship between CDFs and MMA outcomes have been provided in previous reports (see Interim report on Social Data for further information). The ecological component is described briefly below.

Several ecological MMA effects or outcomes were selected *a priori* as a means of evaluating MMA success. These outcomes include:

1. Percent Cover of Coral, Seagrass and Mangrove Habitats
2. Size and Abundance of Fishery Species
3. Abundance of Ecologically Important Species
4. Recruitment Rates of Ecological Engineers
5. Species richness Diversity and Evenness

These outcomes are likely to be influenced by a wide range of ecological socioeconomic and governance factors. Ecological factors likely to influence these outcomes were also selected *a priori*, and include:

1. Life History Characteristics of Key Species
2. Functional redundancy within Ecosystems
3. Trophic structure
4. Habitat Characteristics
5. Incidence and Severity of Storms
6. Outbreaks of Disease or Harmful Algal Blooms
7. Frequency and Degree of Coral Bleaching

Ecological outcomes of MMAs were determined using quantitative approach following a Before-After Control-Impact or BACI-style comparison whereby quantitative changes in key

ecological variables were compared within the MMA area and nearby control areas (open access areas) over a time period extending from before MMA regulations were implemented (i.e., when both MMA and control areas were subject to the same level of management) to recent times after MMA regulations have been implemented. Since this approach relies on historical information on the status of marine resources and ecosystems within and outside of the MMA areas, the assessment of ecological outcomes was based on previously collected data available in published and unpublished literature. Thus, the data used in ecological analyses were necessarily different from those used in socioeconomic analyses in several fundamental ways: they are quantitative, relatively objective (i.e., not based on opinion), and reliant on the availability of previously collected data (i.e., it was not possible to collect new field data to fulfill data requirements).

Various ecological outcomes will be used in an analysis of the influence of specific CDFs (or combinations of CDFs) and their timing (e.g., before MMA designation, during the MMA implementation process, following MMA implementation) on MMA outcomes as described in other reports. Quantitative assessment of ecological CDFs followed a combination of approaches. Some CDFs for a particular location did not vary in space and time (e.g., life history characteristics of key species). In these cases, CDF data does not follow the BACI-style approach described for the ecological outcomes and is independent of space and time. In other cases CDF data was highly variable temporally (e.g. incidence of storms, disease outbreaks, coral bleaching events), but varied spatially on scales larger than that used for MMA vs. control area comparisons. In these cases, only the temporal component is used in analyses for individual sites; however comparisons between MMA sites (e.g., between individual MMAs in a country or between MMAs in different countries or regions) was possible. Only a few of the CDFs from specific sites varied spatially and temporally on scales appropriate for BACI-style comparisons.

The sites selected for analysis are described in detail in previous reports (see Interim Report on Social Data), and were selected based on the ability to collect socioeconomic data in the area and the number of ecological studies conducted in the area. While not all sites selected met both criteria, a balance was struck between these two differing needs. Preliminary studies during Phase 1 of this project, however, suggested that ecological data was readily available for several MMA sites (although those sites differed from those selected for Phase 2 of this project).

Study sites included:

Philippines:

Apo Island Protected Landscape and Seascape

El Nido-Taytay Managed Resource Protected Area

Mabini-Batangas Marine Reserve Area

St Lucia

Soufriere Marine Management Area

Tanzania

Mafia Island Marine Park

Menai Bay Conservation Area Misali

Island Marine Conservation Area

Vietnam

Hon Mun Marine Protected Area

MMA sites varied in the amount and quality of data available for determining Ecological CDFs and Outcomes. While some data from each site was readily available in the primary scientific literature, other data was available only in obscure reports that could only be obtained from local management agencies or directly from the researchers. Other data were entirely unavailable. Table 1 shows the data availability for MMA and control sites. As evident from this table, there were several issues that hindered efforts. The first was the lack of any data from many sites before an MMA was created. While the improvement in data collection following the creation of an MMA shows one value of creating an MMA, it does little to help our analyses. The second issue was the failure of many MMA assessment and monitoring programs to include control sites outside the MMA. In addition to hindering our analyses, this points to a critical shortcoming in MMA monitoring and evaluation programs, since conclusions drawn about MMA effects or "successes" are suspect with no contextual basis from control sites. Finally, a third issue is that little, if any data has been collected on several important aspects of evaluating MMA success.

D**etermining Quantitative Values for Ecological Outcomes**

Following the approach described above, data was collected to determine a "Success Index" (note - this is a temporary term used to describe this index until we finalize the integrated analyses) for each MMA with respect to individual outcomes. Success indices were developed to facilitate use of quantitative ecological outcome data in integrated analysis of both ecological and socioeconomic CDFs. The development of each success index followed the same approach. The change in each ecological outcome from before the implementation of the MMA to a point in time after the MMA was implemented for each MMA site and its control site(s) were calculated independently as a percentage. This percentage was either a positive or negative value depending on whether the change was an increase or decrease in the amount of the outcome. Following an approach used by Pollnac et al. (2001), the success index was developed for each site by calculating the difference in percent change between each MMA site and its control site(s). The ecological success indices will be refined further

as necessary (e.g. expressed as a decimal instead of a percentage) to facilitate integrated analyses with socioeconomic outcomes and CDFs. These refinements will be made following our meeting on August 26 to discuss the final details of the integrated analyses. Details of individual outcome values are presented below.

% Cover of Coral, Seagrass and Mangrove Habitats - Values were based entirely on coral cover. There are several reasons for this including, the fact that all MMAs included coral reef area, but some did not include both of the other habitats. Furthermore, with few exceptions, coral cover data was the only data available showing change to benthic communities or habitat characteristics.

Size and Abundance of Fishery Species – The suite of species used for calculating these values were site-specific, as was the type of data used (e.g. abundance, biomass), based on available data for both MMA and control sites. Similarly, it is important to note that not all fishery species were included in these values. Based on data availability, the values for fishery species reflect some of the most important species (or families) in finfish fisheries, such as serranids and lutjanids. Invertebrate fishery species are underrepresented in these values based on a lack of data.

Abundance of Ecologically Important Species – There was little before data on the abundance of ecologically important species. Because ecologically important species can have positive (e.g., herbivores such as parrotfish and sea Urchins) and negative (e.g. crown of thorns starfish) impacts on coral reefs, this outcome may have 2 different success indices to reflect the MMA effect on species with positive and negative effects on reefs. The lack of quantitative data, particularly data from before MMAs were created, however, has limited our ability to calculate any success indices for this outcome.

Recruitment Rates of Ecological Engineers – Only 1 or 2 studies provide any data on recruitment rates of corals (or other ecological engineers) within MMAs. Thus, this outcome will be excluded from analyses.

Species Richness/Diversity/Evenness – Very few studies from before MMAs were created have collected any data necessary for this analysis. Those that have collected data only report species richness and/or a diversity index. These data will be used to calculate the success index for this outcome.

Success index values for each MMA and outcome are presented in Table 2. Additional success index values may be calculated as new data is obtained. Because there is little to no

site specific data for Recruitment Rates of Ecological Engineers, this outcome will not be included in analyses.

D**etermining Values for Ecological CDFs**

To facilitate integrated analyses with socioeconomic data, it was decided that ecological CDF data should be presented as ordinal data on a scale from 0-1. To accomplish this, a combination of quantitative and ordinal data was used and then scaled appropriately. Site specific values for each Ecological CDF are presented in Table 3. A detailed explanation of how values were determined is provided below.

Life History Characteristics of Key Species – In this CDF, life history characteristics of were limited to those key fishery species to address factors that contribute to ecological Outcome 2 in particular. While adding analysis of life history characteristics of coral species (Ecological Outcome 1) and/or ecologically important species (Ecological Outcome 3) may be useful, they were not included for several reasons. The fact that the general life histories of corals found at MMAs and control sites are not likely to vary much means that their addition would contribute little to our analyses. Thus, they were excluded. Ecologically important species were not explicitly included in this CDF since there is some overlap between some ecologically important species and fishery species for several MMAs (e.g., parrotfish) and for other MMAs, no data provided on ecologically important species.

Life history characteristics were broken down into four key characteristics: Movement; Age at Maturity; Reproductive Output; and Planktonic Larval Duration (PLD). Ordinal values for each of these characteristics were on a scale of 1-5 (Table 4), and then converted to a 0-1 scale by dividing by the maximum value (5). Ordinal values included decimal to encompass a range in each characteristic for individuals or when several species (or families) were averaged together to come up with the final value.

Functional Redundancy within the Ecosystem – There was insufficient data to accurately assess this for any sites. Furthermore, since all MMA sites are primarily coral reef areas, this CDF will vary little between MMA sites (with the possible exception of comparisons across regions between MMAs in the Indo-Pacific and Atlantic). Thus this CDF will be dropped or included as an ordinal value based on “expert opinion”.

Trophic structure – There was insufficient data to accurately assess this for most sites. Thus this CDF will be dropped or included as an ordinal value based on “expert opinion”.

Habitat Characteristics – Since all MMAs are in coral reef areas, the critical aspect of habitat characteristics to be captured in this CDF is the connectivity among different habitats in the MMA area (within and outside the MMA). Thus, habitat maps and published descriptions were used to rank habitats and their connectivity following a modification of the ranking system used by Stoner et al. (1999) for evaluating MPA sites. A value of 1 was assigned to MMA sites containing coral reef only. A value of 2 was assigned to MMAs containing reef and seagrass. MMAs with reef and seagrass with mangrove habitats outside the MMA by nearby were assigned a value of 3. A value of 4 was assigned to MMAs containing all three habitat types. A value of 5 was assigned to MMAs containing all three habitats plus terrestrial areas. Values were then converted to a 0-1 scale by dividing them by the maximum value (5).

Incidence of Storms - This CDF accounted for both the frequency and intensity of tropical cyclones likely to affect each MMA (i.e. those whose center tracked within approximately 50 km of the MMA). Since the incidence of storms is highly variable temporally, this is the first CDF to incorporate a temporal component in its values (i.e., different values for before MMA implementation, during implementation process, and after implemented). Since most control sites were located near MMA sites, there was insufficient spatial variability to include separate values for control sites. Incidence of storm values were calculated by assigning each storm passing within approximately 50 km a number from 0-5 based on its rating on the Saffir-Simpson scale (Tropical Depressions receiving a 0 and Tropical Storms receiving a 0.5) adding up the values for each year and calculating the average value over the specified time period. For the before MMA implementation time period a 10 year average was used. Values were then converted to a 0-1 scale by dividing them by the maximum value (5).

Outbreaks of Disease or Harmful Algal Blooms – This CDF included outbreaks of coral diseases, die-offs of key ecological species, fish kills and documented cases of algal blooms (e.g. red tides). To calculate an index for disease and harmful algal blooms, the severity of episodes during each specified time period (up to 10 years before, during and after MMA implementation) was rated on a scale of 1-5, and then converted to a 0-1 scale by dividing them by the maximum value (5). A value of 0 was assigned when no reports of disease or algal blooms were reported. While this may lead to a bias of low scores before the MMA was implemented, enough cases of fish kills, coral disease or harmful algal blooms were reported from time periods prior to MMA implementation (primarily 1980's and 1990's) that any major episodes are likely to have been reported. A value of 1 was assigned if coral disease or other episode was reported in the literature but not thought to have had an impact on ecological communities. A value of 2 was assigned when partial mortality was documented for some species. A value of 3 was assigned to incidences when there was some widespread mortality (or total mortality of individual coral colonies) was observed in a few species. A value of 4 was assigned to incidences where widespread mortality was reported for a few species. Incidences where there was widespread mortality of many species received a value of 5.

Frequency and degree of coral bleaching – Similar to the past few CDFs, this CDF had a temporal component for analyzing events before, during and after MMA implementation. Since some control sites and MMA sites also differed in severity of bleaching (e.g., due to local upwelling around Hon Mun Island in Vietnam), a spatial component is also included for this CDF. To calculate an index for coral bleaching, the severity of episodes during each specified time period (up to 10 years before, during and after MMA implementation) was rated on a scale of 1-5, and then converted to a 0-1 scale by dividing them by the maximum value (5). Values were assigned based on a scale identical to that of Outbreaks of disease and harmful algal blooms (see above).

Table 1. Current data availability for ecological analysis of outcomes for each MMA site. BACI = a full set of before and after data from MMA and control sites; MB = data from the MMA site before implementation; MA = data from MMA site after implementation; CB = data from control site(s) before the nearby MMA was implemented; CA = data from control site(s) after the MMA was implemented; 0 = no data from control or MMA sites. Note: in some cases before and after and/or MMA and control data are available but are not comparable (i.e., density of species A from one site/time and density for species B at another site/time) – in these cases only one of these datasets is shown in the table.

	% cover of live coral, seagrass and mangrove habitats(1)	Size and abundance of fishery species(2)	Abundance of ecologically important species(3)	Recruitment rates of ecological engineers(4)	Species richness diversity and evenness(5)
Tanzania					
Mafia Island Marine Park	BACI	MA,CA	MB,MA	MA,CA	MB,MA
MBCA, Zanzibar	BACI	MB	MB,MA	0	MB
Misali Conservation Area, Pemba	BACI	MA,CA	0	MA	MB,MA
Vietnam					
Nha trang	BACI	MB,MA	MB,MA	0	MB,MA
St Lucia					

Soufriere Marine Management Authority	BACI	BACI	BACI	0	CB
Philippines					
Apo Island	BACI	BACI	0	0	BACI
El Nido	BACI	BACI	0	0	BACI
Mabini	BACI	BACI	0	0	0

Table 2. Outcome values for each MMA. Note that MMA outcomes marked in red with the letters N/A do not have sufficient before and/or after data from the MMA and/or control site. The outcome marked in yellow will not be included in analyses based on insufficient data from study sites.

	% cover of live coral, seagrass and mangrove habitats(1)	Size and abundance of fishery species(2)	Abundance of ecologically important species(3)	Recruitment rates of ecological engineers(4)	Species richness diversity and evenness(5)
Tanzania					
Mafia Island Marine Park (1995)	-75%	N/A	N/A		N/A
MBCA, Zanzibar (1997)	-11%	N/A	N/A		N/A
Misali Conservation Area, Pemba (2000)	0%	N/A	N/A		N/A
Vietnam					
Nha trang (2002)	70%	N/A	N/A		N/A
Saint Lucia					
Soufriere Marine Management Authority (1995)	31%	92%	-41%		N/A
Philippines					
Apo Island	-27%	1714%	N/A		27%
El Nido	-37%	305%	N/A		-77%
Mabini	-79%	-16%	N/A		N/A

Table 3. Vales of Ecological CDFs for non-node MMA study sites and control sites (when appropriate). CDFs highlighted in yellow will not be addressed in analyses.

	Movement	Life history characteristics of key species (Fishery Species)			Functional redundancy within the ecosystem	Trophic structure	Habitat characteristics	Incidence of storms			Outbreaks of disease or harmful algal blooms			Frequency and degree of coral bleaching		
		Age at Maturity	Reproductive output	Planktonic Larval Duration												
Tanzania								*BEG*	*IMP*	*NOW*	*BEG*	*IMP*	*NOW*	*BEG*	*IMP*	*NOW*
Mafia Island Marine Park	0.70	0.60	0.90	0.80			1.00	1.00	1.00	1.00	1	1	1	1	1	0
MBCA, Zanzibar	0.70	0.60	0.90	0.80			1.00	1.00	1.00	1.00	1	1	1	1	1	0
Misali Conservation Area, Pemba	0.70	0.60	0.90	0.80			0.40	1.00	1.00	1.00	1	1	1	0	1	1
Vietnam:								*BEG*	*IMP*	*NOW*	*BEG*	*IMP*	*NOW*	*BEG*	*IMP*	*NOW*
Hon Mun MPA, Na Trang	0.80	0.80	0.80	0.90			0.50	0.58	1.00	0.83	0.8	0.8	0.8	0.8	1	1
Control											0.8	0.8	0.8	0.4	1	1
Saint Lucia:								*BEG*	*IMP*	*NOW*	*BEG*	*IMP*	*NOW*	*BEG*	*IMP*	*NOW*
SMMA	0.80	0.80	0.90	0.87			0.40	0.85	0.50	0.40	0.8	0.8	0.2	0.8	0.8	0.2
Philippines:								*BEG*	*IMP*	*NOW*	*BEG*	*IMP*	*NOW*	*BEG*	*IMP*	*NOW*
Apo Island	0.80	0.80	0.90	0.90			0.60	0.90	0.75	0.23	1	1	0.6	1	1	0
El Nido	0.60	0.60	0.80	0.60			1.00	0.20	1.00	0.15	1	1	1	1	1	0
Mabini	0.70	0.55	0.80	0.70			0.60	0.45	0.50	0*	0	1	1	0	1	1
										* negative value						

Table 4. Life History Characteristics and basis for ordinal values.

Characteristic	1	2	3	4	5
Movement (including home range size and periodic migrations)	<10 m	10-100m	100m-1km	1-10km	>10km
Age at Maturity	<1 yr.	1-2 yrs.	2-3 yrs.	3-4 yrs	>4 yrs.
Reproductive Output (no. offspring per year)	<100	100-1,000	1,000-10,000	10,000-100,000	>100,000
PLD	<1 week	1-2 weeks	2-3 weeks	3-4 weeks	>4 weeks

APPENDIX C: SOCIO/ECOLOGICAL CDFS

Critical Determining Factors: Ecological CDFs built on social data

Two of the ecological Critical Determining Factors depend upon social data for their values. These are ecological CDF #8: *Impact of land use and human activities on habitat and water quality*, and ecological CDF #9: *characteristics of fisheries*. Each of these CDFs is a composite of a number of measurable variables thought to impact the marine environment and the effectiveness of MPAs. As with the other ecological CDFs, these socio/ecological CDFs will be presented as ordinal data on a scale from 0-1.

The general methodology for constructing each of these CDFs follows that used in Yale University's "Environmental Performance Index" and others (for example, Pollnac et al, 2001). These indices are essentially a hierarchy of weighted averages at increasing levels of aggregation which are combined to generate a composite score.

Impact of land use and human activities on habitat and water quality –The metrics underlying this CDFs encompass 8 indicators chosen through a broad based literature review and consultation with experts in the field. Humans can impact habitat and water quality through both the number of people in the area and the activities that they engage in, including tourism, aquaculture, various types of land use and coral mining. A schematic of the relationship between indicator variables and this composite CDF is presented as figure 1.

Characteristics of fisheries – This CDF is defined as a combination of the effort expended in the fishery and the types of fishing gear used. A schematic of the relationship between indicator variables and this composite CDF is presented as figure 2.

Figure 1:Variables included in the "Impact of land use and human activities" CDF

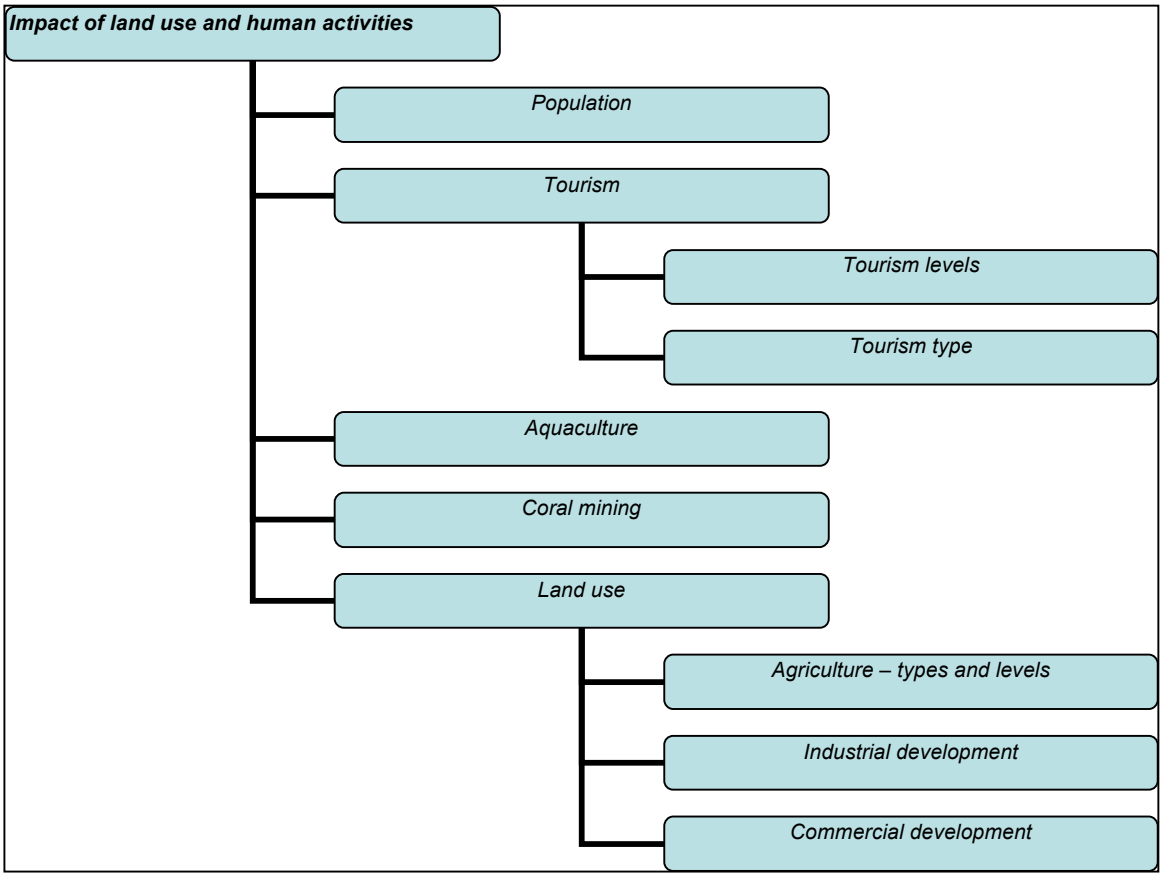
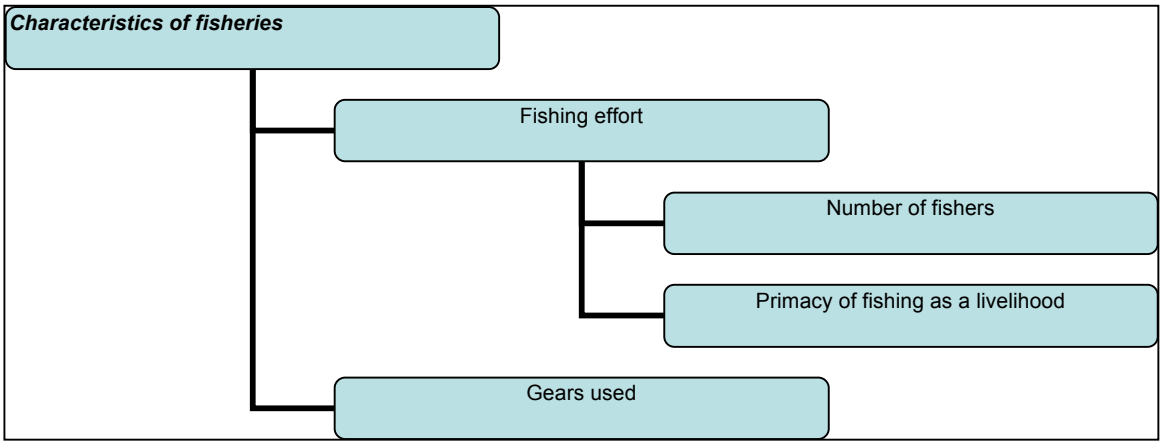


Figure 2: Variables included in the "Characteristics of fisheries" CDF



Determining values for the indicator variables:

For the present project, qualitative and quantitative data associated with each indicator variable were gathered from secondary data, and the level of each variable was scaled as described in detail below. In keeping with the scales employed throughout the GME project, low values for a variable indicate a situation with a negative connotation (in this case, a negative impact on habitat, water quality, or MPA effectiveness) while high values have a more positive connotation.

Population

This variable defines the number of inhabitants that are permanent residents in the areas around the MMA. Heavily populated areas such as Mabini, Philippines, have 42,000 people residing near the MMA while some isolated islands such as Apo and Misali have a few hundred (Apo) or none (Misali).

The number (and density) of people living near the MMA will affect both environmental conditions and social/governance conditions of the MMA. Low levels of population have been found to be a positive correlate of successful MMAs (Pomeroy, 1997) in social-science based analyses, and high population density is related to negative environmental impacts (Mora, 2008). Therefore, the sample of MMAs for this survey was ranked on a 1-4 scale with the lowest rank associated with high population levels.

Population level	Rank	MMA
>40k	1	Mabini
10-40K	2	Mafia, El Nido, Menai
1000-10K	3	Hon Mun, SMMA
<1000	4	Misali, Apo

Tourism

This variable captures the level and type of tourism, if any, occurring in or near the MMA. Tourism can have both positive and negative affects on the success of an MMA. From an ecological perspective. higher level of tourism activities are a bigger threat to coastal and marine ecosystems. Coral damage due to boat anchors, physical contact by divers with the corals and waste generated via tourism are major concerns that may also affect the protected areas. In many of the regions studied in this project,, the level of tourism is only increasing over time and thus more damage is being done to the marine areas. At a limited level of tourism, best practice strategies such as limiting access from sensitive habitats and resource components creates a more positive impact on the MMA. (Neto, 2003; Hawkins et al, 1999)

These negative environmental impacts may be mitigated by the (potential) positive social impacts associated with tourism activities. As an alternative source of livelihoods, tourism may reduce fishing pressure and indirectly benefit the ecosystem. Tourism development can be a driver for a more diversified economic base in an area, and the realization that tourists will pay to see the fish in situ may foster a different kind of respect for the environment. Tourism must be planned in such a way that the benefits from tourism accrue to the local population, however. The social impacts of tourism are captured through survey responses regarding the social impacts of MMAs.

Annual visits	Rank	MMA
>100k	1	SMMA, Hon Mun
10-100K	2	Menai, Mabini, El Nido
<10,000	3	Misali, Mafia, Apo

Land Use

Various land use activities can affect the success of an MMA. Coastal construction can create a number of negative environmental impacts (Chua, 2000) Sedimentation both from logging and urban development can smother coral (Cesar, 2000). In addition, industrial and domestic wastes are frequently discharged directly into waterways, generating an additional threat. Land uses in the sample of MMAs in this study range from a totally undeveloped, uninhabited island (Misali) to a bustling town with a diversity of economic activities (SMMA).

The scale for land use is as follows:

Dominant land uses	Rank	MMA
Near - urban development	1	smma
commercial agriculture, some industry	2	el nido, mabini
subsistence or less agriculture, forest	3	menai, hon mun, apo, mafia
unpopulated	4	misali

Coral mining

Coral mining is a particularly damaging activity that can directly impact the ability of an MMA to provide the kinds of benefits it was designed for. Coral mining not only destroys the reefs but also leads indirectly to logging of forests, which is used for lime burning. (Cesar, 2000).

Following the convention of using low values for negative connotations, MMAs in which coral mining is present are ranked as 0, and MMAs with no noted coral mining are ranked as 1.

Existence of coral mining	Rank	MMA
Coral mining is present	0	Mafia, Menai
Coral mining is not present	1	Apo, El Nido, Hon Mun, Mabini, Misali, SMMA

Aquaculture

Aquaculture can impact the environmental health of a marine area. Not all aquaculture activities are created equally however (Wu, 1995). Their environmental impacts vary depending on the technology used. Some aquaculture technologies can negatively impact wild fish populations through habitat modification, wild seed stock collection and other ecological impacts, while others are more benign. Naylor et al, 2000)

Correspondingly, and in conjunction with expert opinion (Dahlgren, pers. comm.) the following ranking system is employed for aquaculture:

Aquaculture activity	Rank	MMA
Shrimp	1	
Lobster	n/a (1?)	hon mun
Bivalve	2	menai
Seaweed	3	mafia, menai
Pearl oysters	4	mafia
None	5	SMMA, El Nido, Mabini, Misali

Fishing pressure

Fishing pressure can impact the productivity of reef ecosystems (McClanahan, 1995) and thereby affect the performance of an MMA. In this application, fishing pressure is modeled as the approximate number of full-time fishermen operating in the vicinity of an MMA.

At present, we are using an estimation of the number of full-time fishers in the area around the MMA as a measure of fishing pressure. The percentage column was based on a reading of the qualitative data that gives a sense of the number of households engaged in fishing full time (vs. occasional or part-time fishing*).*

Estimation of the number of full-time fishers in or near the MMA

	Population	Households (pop/5)	Percentage (approx)	Number of fishers (assume 1 per hh)
Apo	700	140	100%	140
El Nido	16000	3200	70%	2240
Hon Mun	6000	1200	100%	1200
Mabini	42000	8400	10%	840
Mafia	18000	3600	50%	1800
Menai	16000	3200	90%	2880
Misali				1640
SMMA	8000	1600	40%	640

Number of fishers	Rank	MMA
>2000	1	El Nido, Menai
1000-2000	2	Hon Mun, Mafia, Misali
500-1000	3	Mabini, SMMA
<500	4	Apo

Fishing gears used

The basis for this metric was a scale modified from an article entitled "Shifting gears: assessing collateral impacts of fishing methods in US waters". (Chuenpagdee et al, 2003) The scale presented in that publication needed to be modified because that rating system was not really designed with coral reef fisheries in developing countries in mind. The shifting gears article also weighs bycatch much more heavily than habitat impacts and in a way that is not very relevant to reef fisheries. The overall score for a particular type of fishing gear is a summation of the impacts on various aspects of ecosystem health. The summed values associated with the gears mentioned in the secondary literature for our set of MMAs range

from 5 (for dip nets) to 20 (for blast fishing). The detailed scores are presented in Table 7 of Appendix A, below.

Simple average of the impact ratings of fishing gears mentioned in secondary literature. (Please note that no specific gears were mentioned for Mabini, so we extrapolated that it would approximate the other gears used in the Philippines.) It is important to note that these rankings do not follow the "higher is better" scheme we have been using until now. In this case, a lower ranking means a lower impact on the ecosystem.

MMA	Simple average of gear ratings
Apo	8.833
El Nido	8.875
Hon Mun	**6.75**
Mabini	8.85
Mafia	6.75
Menai	8.333
Misali	9.6
SMMA	9.25

Creating the Indices

The *impact of land use and human activities on habitat and water quality* CDF is presently conceived as a weighted average of the rankings of the five subcomponents of this metric, divided by the maximum value, to give a ranking on a scale of 0 to 1. At present, the weights are equal at 20%.

This indexing scheme shows Misali as the area with the least human impact on habitat and water quality in the MMA (which makes sense, since the island is uninhabited), while Hon Mun comes out as the area with the greatest human impact on the MMA (which also makes sense, as that MMA receives over 400,000 visitors per year and has significant aquaculture activities).

	Population	Tourism levels	Land uses	Aqua-culture	Coral mining	Weighted average	*(divide by max)*
Weight	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*		
Apo	4	3	3	5	1	3.2	0.94
El Nido	2	2	2	5	1	2.4	0.71
Hon Mun	3	1	3	1	1	1.8	0.53
Mabini	1	2	2	5	1	2.2	0.65
Mafia	2	3	3	3.5	0	2.3	0.68
Menai	2	2	3	2.5	0	1.9	0.56
Misali	4	3	4	5	1	3.4	1.00
SMMA	3	1	1	5	1	2.2	0.65

The *characteristics of fisheries* CDF is presently conceived as the gear rankings as described above, adjusted for the number of fishers in the area.

Number of fishers	adjustment	MMA
>2000	1	El Nido, Menai
1000-2000	0.9	Hon Mun, Mafia, Misali
500-1000	0.8	Mabini, SMMA
<500	0.7	Apo

MMA	Simple average of gear ratings	Adjusted rating	*(divide by max)*
Apo	8.833	6.18	0.70
El Nido	8.875	8.88	1.00
Hon Mun	**6.75**	6.08	0.68
Mabini	8.85	7.08	0.80
Mafia	6.75	6.08	0.68
Menai	8.333	8.33	0.94
Misali	9.6	8.64	0.97
SMMA	9.25	7.40	0.83

This rating scheme gives us an index with El Nido as the highest impact fishery, followed closely by Misali, and with the fisheries at Hon Mun and Mafia having the least environmental impact.

Qualitative data on indicator variables

Table 1: Population

Apo Island	460 people resident on the island at the beginning, 700 people now in 170 households.
El Nido	16,000 people associated with the MMA and a high rate of population growth noted
Hon Mun	5000 people in several villages ranging in size from very small to much larger
Mabini	High rate of population growth noted through the 1980's and 90's, current population is 42,000 in the vicinity of the MPA
Mafia	18,000 people within the jurisdiction of the MPA
Menai Bay	16,000 people within the jurisdiction of the MPA
Misali	Misali Island is uninhabited
SMMA	7,900 residents in town of Soufriere

Table 2: Tourism

Apo Island	Most tourism is beach/snorkeling activities. There are two resorts on the island with a total of 30 rooms. Total visits at present are approx. 10,000. Increasing dive tourism during the November to April season is perceived to be a threat to the ongoing success of the MMA.
El Nido	Overall tourism levels have grown from a few hundreds before the MMA was implemented to about 20,000 today. Concern noted about damage due to anchoring, fin damage, pollution etc.
Hon Mun	400,000 tourist visits per year at present
Mabini	Tourism levels growing significantly – there were 74 beach resorts in 2005, up from 63 in 2001. The top three resorts had a total of over 10,000 visitors in 2004. The location is only 3 hours from Manila.
Mafia	Three ecotourism type resorts in the area. Relatively low levels of tourism overall. No firm numbers, but less than 5000 visitors per year.

Menai Bay	15-20,000 visitors, mostly day trippers from Zanzibar town. Most concentrated in one or two areas. Mostly dolphin viewing.
Misali	Diving is the main activity for visitors. Visitors arrive by boat. In 2004 there were about 4700 visitors.
SMMA	Yachting is the main tourism activity, and there are also several resorts in the area. Runoff related to construction and sewage from the resorts are cited as major environmental threats

Table 3: Land use

Apo Island	Agriculture is minimal – not even at a subsistence level. some concern noted over the use of wood for fuel and building
El Nido	fairly large scale commercial agriculture, more important than fishing. forested land cleared regularly for agriculture; concern noted due to deforestation and associated water flow problems
Hon Mun	No specific data; the region is identified as "rural"
Mabini	30% of land is used for agriculture, 50% is forest. Substantial land has been cleared for tourism activities. Some industrial development
Mafia	Small scale and subsistence agriculture. The main island has one sizeable town, otherwise traditional villages.
Menai Bay	Minimal agriculture. Subsistence reliance on mangrove resources noted.
Misali	None – the island is uninhabited

SMMA	Plantation agriculture diminishing in importance on the Island; some agriculture continues. sedimentation and upstream development is a huge issue at SMMA; pollution is identified as the main threat

Table 4: Aquaculture

Apo Island	None noted
El Nido	None noted
Hon Mun	Cage culture is used rather than pond and tanks. Aquaculture is a relatively new activity but is rapidly becoming very important in the economy. 10% of HHs engage in lobster culture full time and up to 30% are involved in aquaculture on a part-time basis. Concern noted due to pollution.
Mabini	Not mentioned
Mafia	Seaweed farming becoming more important; some culture of pearl oysters
Menai Bay	Seaweed farming is important; trying to get bivalve cultivation started
Misali	None
SMMA	none

Table 5: fishing activity levels

Apo Island	Fishing is still the main livelihoods for most families on Apo. About 90% of community members are engaged in fishing. Even those families who are now engaging in other livelihoods still fish

	occasionally
El Nido	2/3 of households fish, 1/3 of those fish fulltime
Hon Mun	At the beginning the population was almost entirely fishers, now fishing is being replaced by aquaculture and tourism for some residents
Mabini	Fishing is not the primary livelihood – overseas remittances and tourism are much more important to the local economy
Mafia	About half of households name fishing as their primary livelihood; its relative importance varies among the different communities within the MPA.
Menai Bay	Fishing is the main activity for men in the area
Misali	There are alternative livelihoods available but no data on whether fishing families rely entirely on fishing
SMMA	Formerly the major source of income in the area; now being supplanted by tourism esp. for younger fishermen

Table 6: gears employed

Apo Island	60% of fishing boats are non-motorized. Among the three principal fishing gears, most fishing effort was spent with hook and line, followed by gill nets, then with spear guns (Table 1). Hook-and-line fishing, therefore, contributed the greatest yield and highest income, accounting for 66% of the total yield and 72% of the total income recorded. Bamboo fish traps contributed the least yield and income. All types of fishing occurred mainly on the northern fishing grounds. The northern fishing grounds accounted for 92%, 52%, 63%, and 100% of the total effort for hook-and-line gear, gill nets, spear guns, and fish traps, respectively.
El Nido	commercial fishing is banned within the PA hook and line, squid and octopus jibs, gill nets, spear gun some illegal fishing continues small mesh nets becoming the norm

Hon Mun	Their main fishing practices are anchovy purse seine, lift net, lift net with light, squid hook & line (day and night), push net with light, diving and some other practices. Also fixed net fishery. Most of these fishing practices operated in the core zone and have existed for many years.
Mabini	No specific data on gears used
Mafia	Observed hook and line, purse seine. Destructive fishing reduced.
Menai Bay	The most common fishing gears are gill nets, shark nets, small-scale purse seine and a variety of fishing lines.
Misali	A total of 13 distinct gear types are used in MIMCA, of which the main ones are hand-spears for octopus, hand lines, *kigumi* nets, traps, beach seining, gill netting, seine netting. *Kigumi* nets, used for fishing around coral patches, account for 25% of the total catch and are the most destructive
SMMA	Main fishing gears are large traps set overnight and small traps set for 1-2 hours, beach seines, gill nets, fish pots, and trolling

Table 7: impact of various gears

Fishing gears/technologies	**Seafloor structure**	**Benthic organisms**	**Target Species impacts**	**Non-target species impacts (bycatch)**	**TOTAL**
1-5 scale with 1 = low impact; 5 = high impact;					
Hook and line(1)	1	1	3	2	7
Gill net (1)	2	2	4	3.5	11.5
Spear gun	1	1	4	2	8
Traps on reefs (2)	3	3	3	3	12
Small mesh nets	2	2	3	2	9
Dip net	1	1	2	1	5
Trammel net	2	2	4	3.5	11.5
Purse seine (1)	1	1	2	2.5	6.5

Longline (1)	2	2	4	2	10
Hooka diving (will add 0.5 to impact on target fish to fishing gear type used - cyanide, spear, etc.)					0
Lift net catching fish	1	1	2	2	6
Lift net catching lobster seed	1	1	2	2	6
Fixed net (may vary based on type of net)	2	2	3	3	10
Drift gillnet (1)	1	1	4	4.5	10.5
Bottom set gillnet (1)	3	2	4	3	12
Squid jig	1	1	3	2	7
Kigumi (that's where a bunch of people bang on the reefs with sticks)	4	5	3	3	15
Deep sea fishing	1	1	3	2	7
Blast fishing	5	5	5	5	20
Cyanide fishing for aquarium fish	2	4	5	5	16
Cyanide for food fish	2	4	4	5	15

(1) directly from shifting gears pub

(2) modified from shifting gears pub

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