

**Assessment of management effectiveness for the Marine Protected Areas at the 'Rosario and San Bernardo Corals National Park' (Cartagena): towards an adaptive management of Colombia's first coral reef protected area.**

**NOAA-Coral Grants- Project No. NA05NO54631013**

**FINAL REPORT**

**1. GENERAL CONSIDERATION**

Coral reefs are one of the most diverse and complex ecosystems in the earth surface, they also provide vital economic services for millions of people in coastal communities, especially in developing countries. Despite comprising less than 0.5% of the ocean floor, coral reefs harbor almost a third of all marine fish species (Samoilys 2007). However, on a global scale, coral reefs face diverse anthropogenic threats including overexploitation of resources, habitat destruction, pollution and climate change (Wilkinson 2004). This situation makes necessary to take actions to preserve marine habitats and resources of the world, under these circumstances the Sustainable Development Summit aims to establish, by 2012, an effectively managed, representative, global system of marine protected areas (MPAs) covering 10% of all marine ecological regions, comprising both multiple use areas and strictly protected areas (Wells 2007).

The marine protected area concept (MPA) arises to protect species, marine habitats, biodiversity conservation, fisheries restoration, tourist activities management and reduction of conflicts among resource users, among others (Pomeroy, 2004). There are several scientific papers showing benefits of MPAs accomplishment (Watson 2004; Gjertsen 2004; Kamukuru 2004; Cho 2005; Claudet 2006; Branch 2006; Pérez-Ruzafa 2006; Shears 2006; Aguilar-Perea 2006 and Hiddink 2006); improvements in fish assemblage (sizes, diversity and abundance on commercial species Halpern 2003), enhancing production of eggs and larvae inside reserves due to increase biomass of spawners (Castilla & Bustamante 1989; Jennings 2000) and by improving fisheries yields outside reserves due to the spillover of adults emigrating from the protected area (Sluka et al 1997; Branch & Odendaal 2003).

In developing countries it is very important to search the relationship between conservation actions and human welfare. One way in which marine protected areas, coral reef health, and human welfare in fishing communities might be linked is that by protecting the coral reef, coral cover and fish abundance inside the MPA can be maintained or increased, which leads to an increase in fish abundance outside the MPA and thus higher catches for fishermen (Gjertsen 2004). Consequently MPAs are used both for habitat protection and as a fishery management tool (Campbell, 2006). Larger catches can result in increase fish consumption in fishing families and higher incomes from fish that are sold.

An increasing need exists for the evaluation and understanding of the effectiveness of marine protected areas (Allison et al 1998; Boero et al 1999; Halpern & Warner 2002; Palumbi 2001 and Faschetti et al 2005). To meet this need, in 2000 The World Conservation Union (IUCN's) World Commission on Protected Areas—Marine and the World Wide Fund for Nature jointly initiated the MPA Management Effectiveness Initiative (MEI), an international project designed to create a methodology for planning and conducting performance evaluations of MPA management effectiveness (Pomeroy 2005). The guidebook, *How is your MPA doing?*, identifies and describes a set of biophysical, socioeconomic, and governance indicators that can be selected and adapted to fulfill requirements in every specific territory.

Management effectiveness evaluation introduces objective elements to assess future needs and turn current practices into adaptable management measures. It is necessary to evaluate if actions are producing the expected results according to their initial definition; previous evaluations show how they can allow for improvement of protected area management actions through learning, adaptation, and the diagnosis of specific issues influencing whether goals and objectives are being achieved (Pomeroy 2004). This method will allow staff administrators to learn of their successes and failures.

In 1978, the Rosario and San Bernardo Corals National Park was created in Colombia, to allow the conservation and the sustainable development of reef resources. In spite of being the oldest marine national park, this is the first management effectiveness evaluation with biological, socioeconomic and governance components. Evaluation must be a routine part of the management process and is something that, in some way, managers already do. It is also necessary to recommend new actions and conservation policies to preserve the marine biodiversity.

This project followed such approach, which consisted in:

1. Initial meeting, to identify and prioritize the relevant MPA effectiveness indicators. During three days of academic discussion a group of participants including government authorities, conservationists, academicians, researchers, stake-holders and managers was gather in a workshop to reviewed the MPA objectives as well as to chose indicators (three types: socio-economic, biophysical, and governance) for the evaluation process.
2. Planning and work plan for the evaluation, a smaller meeting with investigators/team leaders conducting the project took place in order to assess methodologies, teams and resource needed.
3. Several months were taken to collect data according to the work plan. Teams in each area carried out analyses.
4. Final meeting, to conduct the evaluation with team leaders of each area.

## 2. METHODOLOGY

### Biophysical indicators

A team of 12 biologists from different institutions (University of the Andes, University Jorge Tadeo Lozano, INVEMAR and Special Unit of National Natural Parks– UAESPNN- Unidad Administrativa de Parques Nacionales Naturales) carried out a survey to collect the biophysical data. Each of these institutions provided their experience in the field creating a work team that made possible the sampling of different indicators, which had a specific methodology that ensures the accuracy of the information. Sampling sites were geo-referenced and located in maps. Two field trips were made, one during May were 19 stations where surveyed, 10 outside the park and 9 inside it in San Bernardo area. In September another 8 station were surveyed inside the park in the Rosario islands area. The 10 stations outside the park allowed to have control sites were there was no management unlike the MPA area. The survey ensured that all the MPA area was covered. In order to increase the informativeness of the biophysical indicators but facilitating enough simplicity for management interpretation all the indicators were grouped in two groups (see table below): Focal species and community structure. Methods for the biophysical indicators are explained in detail below (justifications for chosen each indicator are presented in the previous project reports). As a result of the information gathered and the analysis of the indicators, a classification in groups is proposed following common observed characteristics. Thus, in the case of the socio-economic indicators, five groups of indicators were created as observed in the following table:

Groups of biophysical indicators

Group	Associated indicators
B1. Focal species	Ind 3. Fish commercial interest species and trophic structure Ind. 3. Abundance of focal species ( <i>Acropora palmata</i> , <i>A. cervicornis</i> , <i>D. labyrinthiformis</i> and <i>S.siderea</i> ) habitats Ind 3. Size-structure of the populations Ind 9. Area showing signs of recovery. Partial Mortality
B2. Community structure	Ind 4. Composition and structure of the community. New Indicator. Diversity and distribution of the zooxanthella

Group B1. Focal species abundance and structure:

- Reef Fish: Fish populations (key families: Acanthuridae, Scaridae, Lutjanidae and Serranidae) were estimated by visual surveys (including size estimates, e.g., Friedlander et al., 2004). In each of the 29 sampling stations two observers traced two 50 m transect for performing the fish survey. Percentages of commercial families were calculated per station inside and outside the park. Ordination and classification analyses were made.
- Coral Species: For determine and monitor distribution of *Acropora palmata* and *A. cervicornis*, listed as critically endangered, photo-transect data already available and new photo belt-quadrants (30 m long and 2 m wide, 1x1 m) were made in 20 stations in Rosario and San Bernardo islands. On each quadrant the number of individuals was counted, measured (diameter and height) and the percentage of dead tissue was estimated. Photographs were analyzed using Adobe Photoshop 7.0 and Image J. measurements of surface area were made. Also the area of live vs. dead tissue was estimated to the nearest

- cm. Size of colonies was used to construct frequency distribution histograms. Skewness and kurtosis were used as an indication of population status (e.g., Meesters et al. 2001).
- Other coral species: *Siderastrea siderea* and *Diploria labyrinthiformis* were chosen as indicators of sedimentation. Same methods as above were done (Lewis 1997; Ginsburg et al. 2001) (Focal species in figure 1).
- Group B2. Community composition and structure:
- Coral Reefs: Coral cover and community structure were evaluated with BIOMMAR photo transect data taken during 2005 and new photo belt-quadrants taken during the two field trips. Cover percentages, each quadrant and station, were estimated. Cluster analysis and PCA Ordination techniques were used to see relations between stations. This information was used to determine relative abundance, diversity, richness and dominance in each station (e.g., Garzón-Ferreira and Díaz 2000; Friedlander et al. 2003; Sánchez et al. 2005).
  - Diversity and distribution of the zooxanthellae: Coral samples from corals in and out the MPA were screened using molecular techniques to identify zooxanthellae types (e.g., LaJeunesse 2002, Rowan and Powers 1991).

### Socioeconomic and Governance indicators

To evaluate the achievement of these goals and objectives, we proposed 16 socio-economic indicators and 16 governance indicators. For the construction of these indicators, a research work was performed which was composed by rural participative activities together with surveys (See figure 2).

In the first place, gray literature from texts published by public and private entities related with the management of the RSBC-NNP was reviewed and analyzed. In addition, a review of scientific literature was directed towards topics such as the existing relationships between the socio-economic conditions and the use of natural resources, the economic environmental valuation, and experimental economic games. Based on the information collected in this stage, the other research activities were designed.

The next stage of the research consisted in the elaboration of a participative rural diagnostic, PRD, with the cooperation of the main communities inhabiting the study area.

In parallel, personal semi structured interviews aimed to the staff of the Rosario and San Bernardo Corals Natural National Parks Unit (RSBC-NNPU) were conducted. Interviews included open and multiple-choice questions regarding their perception about each of the governance indicators proposed in the reference guide (Pomeroy et al., 2004).

In addition, an environmental economic valuation of the park took place, using contingent valuation and travel cost methodologies, in which we not only built the basis to determine the economic value of the Park, but also obtained the socioeconomic and governance information from tourists visiting the RSBC-NNP.

Finally, economic experimental games (EEG) were made in five of the most representative communities in the Park and its area of influence. The games let us observe the behavior of the resource users under different management alternatives for the MPA, while compiling socio-economic and governance information for those communities.

From the information collected in each of the above mentioned activities, the socio-economic and governance indicators proposed were constructed. As a result of the information gathered and the analysis of the indicators, a classification in groups is proposed following common observed characteristics. Thus, in the case of the socio-economic indicators, five groups of indicators were created as observed in the following table:

Groups of socio-economic indicators

Group	Associated indicators
S1. Local marine resource use patterns and socioeconomic conditions	Ind. 1. Local marine resource use patterns Ind. 4. Perception of seafood availability Ind. 9. Household income distribution by source Ind. 10. Household occupational structure Ind. 12. Number and nature of markets
S2. Impact on resources	Ind. 3. Level of understanding of human impacts on resources Ind. 5. Perception of local resource harvest
S3. Formal and informal knowledge about resources	Ind. 13. Stakeholder knowledge of natural history Ind. 14. Distribution of formal knowledge to community
S4. Leadership in	Ind. 15. Percentage of stakeholder group in leadership

environmental management	positions
S5. Associated values to the park	Ind. 2. Local values and beliefs about marine resources Ind. 6. Perception of non-market and non-use value

Indicators 7, 8 and 16 were not analyzed in this exercise, due to the high cost required for collecting that information in a statistically significant mode.

In a similar way, for the analysis of the governance indicators, groups or categories of indicators were created as observed in the table below:

#### Groups of governance indicators

Group	Associated indicators
G1. Institutions, administrative resources, and existence and knowledge of a EMP	Ind. 2. Existence of decision-making and management body. Ind. 3. Existence and adoption of an environmental management plan (EMP) Ind. 6. Availability and allocation of MPA administrative resources
G2. Scientific research	Ind. 7. Existence and application of scientific research and input
G3. Legislation, norms, rules and enforcement	Ind. 4. Local understanding of MPA rules and regulations Ind. 5. Existence and adequacy of enabling legislation Ind. 14. Clearly defined enforcement procedures Ind. 15. Enforcement coverage
G4. Resource conflict	Ind. 1. Level of resource conflict
G5. Participation	Ind. 8. Existence and activity level of community organizations Ind. 9. Degree of interaction between managers and stakeholders Ind. 10. Proportion of stakeholders trained in sustainable use Ind. 11. Level of training provided to stakeholders in participation Ind. 12. Level of stakeholder participation and satisfaction in management processes and activities Ind. 13. Level of stakeholder involvement in surveillance, monitoring and enforcement Ind. 16. Degree of information dissemination to encourage stakeholder compliance

### 3. RESULTS

#### Biophysical indicators

##### Group B1. Focal species

##### Indicator 1. Fish commercial interest species and trophic structure

Fish density, abundance, and frequency were overall low, both inside and outside the MPA. Instead, diversity and richness showed a pattern slightly higher outside the MPA. The main trophic roles (e.g., herbivorous and carnivorous) were present in high number inside the park. Classification and ordination analysis showed cluster patterns independent of the geographic position with respect to management inside or outside the MPA (figure 3A y 3B). Although not significant, the largest sizes were observed inside the park, but smallest sizes were predominant. In order to obtain more accurate mean values with the data with or without management, a bootstrap resampling approach was done for the stations at each case. Data was transformed ( $\log^{10}$ ) and a Kruskal Wallis test was done, no differences between manage and no manage areas was found ( $p < 0.412$ ).

##### Indicator 3. Abundance of focal species (*Acropora palmata*, *A. cervicornis*, *D. labyrinthiformis* and *S. siderea*) habitats

The number of colonies of the focal species *Acropora cervicornis*, *Diploria labyrinthiformis* y *Siderastrea siderea* were greater within the zones that traditionally have had management (Rosario Islands for more than 30 years) than in zones without management (San Bernardo Islands). However, *Acropora palmata* was only found in San Bernardo, see table 1.

Table 1. The Rosario Island area has traditionally been managed as a National Natural Park (since 1978), and San Bernardo Islands were included in the last decade in the National Reserve.

	Number of colonies observed	
	Stations with management (Rosario islands)	Stations without management (San Bernardo area)
<i>Acropora cervicornis</i>	14	1
<i>Acropora palmata</i>	0	23
<b><i>Diploria labyrinthiformis</i></b>	<b>72</b>	<b>19</b>
<b><i>Siderastrea siderea</i></b>	<b>191</b>	<b>105</b>

*Acropora cervicornis* was one of the least abundant in most stations (5/17 in Rosario Islands and 1/10 in San Bernardo). *A. palmata* was found just in one station in the San Bernardo area. *Diploria labyrinthiformis* was present in almost all the studied area (16/17 at Rosario and 5/10 at San Bernardo). *Siderastrea siderea* was the most abundant of the four focal species and was present in all the sampling sites.

### Indicator 3. Size-structure of the populations

For *Acropora cervicornis* in Rosario Islands there was a dominance of small sized colonies but a wide range of sizes (skewness 0,62; kurtosis -0,94). *Acropora palmata* presented mostly large size colonies (skewness -0,34, kurtosis -1,05). *Diploria labyrinthiformis* presented smaller colonies at Rosario islands whereas at San Bernardo large colonies were dominant. Even so, there was no dominance of a given class size (skewness 0,73 and -0,68; kurtosis -1,4, -0,72, respectively). *Siderastrea siderea* also presented differences between sites, (Rosario: sk= 1,16; K= -0,65; San Bernardo, sk= 0,35; K= 0,17) (figure 4).

### Indicator 9. Area showing signs of recovery. Partial Mortality

In general partial mortality was higher in areas with no management (San Bernardo than at Rosario). Nevertheless the averages were never above 40% of dead tissue in any species at any zone. In *A. cervicornis* and *A. palmata* only the bigger colonies showed partial mortality, colonies of *D. labyrinthiformis* showed mortality both in big and middle size. *S. siderea*, was the only species that showed partial mortality, regardless their size.

Table 2. Average percentage of partial mortality present in any colony of a given species in the two studied zones within the Marine Protected Area. SCM (size classes in cm).

SCM	Rosario Islands			San Bernardo Islands		
	0 -60	60 – 150	> 150	0 -60	60 - 150	> 150
<i>A.cervicornis</i>			5.33			
SCM	0 - 100	100 – 300	300 - 500	0 - 100	100 - 300	300 - 500
<i>A. palmata</i>					16.66	
<i>D.labyrinthiformis</i>		4.08	17.91			
SCM	0 - 250	250 – 500	> 500	0 - 250	250 - 500	> 500
<i>S. siderea</i>	14.13	16.37	12.16	11.77	29.77	31.06

## Group B2. Community structure

### Indicator 4. Composition and structure of the community.

Abundance, richness and diversity were overall higher in managed areas than in areas with no management at all, but differences were not statistically significant (ANOVA,  $p > 0.05$ ). In regard to percentage of dead and live coral cover, algae, sponges, gorgonians and type of substrate (sand, rubble and coral skeletons) the stations did not show significant differences, as 60% of the stations were dominated by dead coral and rubble while the rest were dominated by algae cover. Classification and ordination analyses were done with stations inside and outside the park (figure 5). Data was transformed ( $\log^{-10}$ ) and Kruskal Wallis test was done, no differences between manage and no manage areas was observed ( $p < 0.912$ )

Resampling percentage was obtained to analyze if observed values have some inner variation, figure 6 shows that here were no differences between observed data and resampled data suggested that the pooled data were homogeneous.

### **New Indicators. Diversity and distribution of the zooxanthella**

Zooxanthellae classification showed results similar to that obtained with coral cover, this shows that knowing the composition and diversity of symbionts it is possible to infer, in an indirect way, the structure and healthy in the ecosystem. It's important that inside the park there was a bigger frequency of corals which have polytypic symbiosis, it means that they have different kind of symbionts. This is an important characteristic in term of resilience and resistance to environmental changes such as bleaching events. Each cluster analysis (figures 7 A and B) showed a division of the 28 sampled stations in 5 groups with a minimum of 50% similarity. In the cluster with only coral cover information 2 stations (LC and PBU, figure 7 A) did not cluster with any other station. The cluster containing holobiont information, on the other hand, (figure 7 B) grouped these two stations separately. The formed groups between each cluster were not identical (i.e. stations IN and SN which were separated in the first cluster, falls into group A when holobiont information was included), but the resolution of the second analysis shows better similarity percentage in all formed groups.

### **B. Socioeconomic indicators**

The main results of this stage were: the construction of a productive profile, social cartography of productive activities and places of natural-resources harvest, a seasonal analysis of activities, a historical analysis of the main events that have shaped the evolution of the area, a submarine profile, the characterization of the main problems and potentialities for each community, and an analysis regarding the relationships between the community and the different institutions who intervene the area of influence of the RSBC-NNP.

### **Group S1. Local marine resource use patterns and socioeconomic conditions**

#### **Indicator 1. Local marine resources use pattern**

To estimate this indicator we used gathered information from the literature review, the participative rural diagnostic, PRD, the economic valuation, and the experimental economic games. Fishing, tourism and recreation are the main activities done in the RSBC-NNP the involve use of natural resources. Those resources were mainly used to satisfy the demand for seafood of tourists visiting the park and, in a smaller degree, for the subsistence of the people who live in the area. Resources could also be used for recreational and resting activities, as well as harvested for craftsmanship and souvenirs.

#### **Indicators 4, 9, and 10. Local seafood availability, household occupational structure and income distribution**

According to the information gathered during the economic experimental games, EEG, the main source of income for the stakeholders is fishing, that mostly seeks to supply the demand of tourists who visit the MPA; consequently, about 72% of the household income comes from the fishing activity. Additionally, there are other important sources of income which in descending order are: tourist services 8%, craftsmanship 7%, commerce 7%, surveillance 3%, construction activities 2%, and other activities 1%.

The level of monthly income is low and very low. Over 56% of households earn less than the equivalent to a monthly minimum salary (about US\$180). Around 34% of households receive between 1 and 2 monthly minimum salaries (from US\$180 to US\$360). Having in mind that the average family size is 5.5 persons, it is possible to realize that most of families (90%) are living below the line of poverty and 56% below the line of extreme poverty, according to the criteria of one dollar daily per capita, established by the World Bank. This calculation previously done regarding the household income is, however, only monetary. It is important to note that fishing is an important source of non-monetary income for the population, since it happens to be the primary source of protein to the people in the region. In fact, most of the interviewed people admit to obtain their daily protein requirement from own fishing. That implies that the calculated income could be sub valued since it did not include this non-monetary source of consumption.

#### **Indicator 12. Nature of markets**

According to the information gathered during the PRD, in the region of the Park next to the Rosario archipelago there existed important markets coming from tourism, that mostly demanded recreational sites like beaches, snorkeling and scuba diving sites, and seafood, specially fine snapper (known locally as pargos) and shellfish (lobster, queen-conch and crab). In this area of the MPA, there is also a market for providing seafood to Cartagena city, sent

daily and done personally by fishermen; these characteristics imply that they do not need any special equipment for commercialization.

In the area next to the San Bernardo archipelago we can find the same kind of markets, but there is less tourism pressure, and in consequence, there is a better established storage and commercialization infrastructure. In this area of the MPA, there are fish and shellfish storage facilities in the Mucura, Santa Cruz del Islote and Ceicen islands, where different groups of fishermen can take their products to be commercialized from there, in continental markets located mainly in the city of Tolu.

## **Group S2. Impact on resources**

### **Indicator 3. Level of understanding of human impacts on resources**

This indicator was constructed from the interviews done to the participants of the experimental economic games. In general, we could observe the awareness by the community of the environmental problems existing in the zone and that they realize that the main problems are associated with fishing (mainly the use of inadequate techniques and overfishing). They also recognized the harm done to coral reefs as an important problem. Impact on non-marine areas like erosion in islands, deforestation, and pollution were also perceived by the community as important human impacts on the area (See Figure 8).

Figure 6. Main problems associated with natural resources identified by the community

### **Indicator 5. Perception of local resource harvest**

This indicator was created with the information gathered during the PRD, the experimental economic games, and the interview with the RSBC-NNPU staff. According to the perception of the stakeholders and the MPA staff, there were some human related events that have altered in a negative way the availability of natural resources and they mainly are: increase in the arrival of new settlers to the MPA, construction of recreational houses and hotels, pollution of marine waters, use of dynamite, powder and other types of inadequate fishing techniques, industrial fishing and non-industrial overfishing, extraction of biologic material for commercialization and craftsmanship, and the increase and disorganization of tourism.

## **Group S3. Formal and informal knowledge about resources**

### **Indicator 13. Stakeholder knowledge of natural history**

People from communities inhabiting on the RSBC-NNP have been living on the area from many years ago, so that multiple generations of inhabitants have already grown there. Since main activities of the inhabitants are fishing and extraction of biological material for commercialization, they were in permanent contact with the natural resources of the MPA and therefore, they are aware of their evolution. For at least 60 years, the communities recognized the main events that have altered in a positive and negative way the natural history of the zone.

Additionally, the community was aware and clearly recognized the behavior, patterns and location of the marine resources during each season of the year, as well as shortage times, migratory movements, and reproduction seasons. In other words, community –especially fishermen- were able to do an adequate compilation of the natural history, for the majority of natural resources used with commercial purposes (See Figures 9 to 11).

### **Indicator 14. Distribution of formal knowledge to community**

According to the interviews done to the staff in charge of the MPA, the dissemination of formal knowledge to the communities was mainly performed by a team in charge of communitarian education and training. More than half of the surveyed staff declared having meetings with the community at least once a month. On the other hand, 56% of the staff members recognized the existence of mechanisms for the diffusion of scientific knowledge toward the community, and 19% of the staff has involved the community in participation on scientific activities. 70% of staff members acknowledge the existence of training courses or workshops to improve the MPA management. The RSBC-NNPU had an environmental educational program in order to spread formal knowledge to community.

## **Group S4. Leadership in environmental management**

### **Indicator 15. Participation in Leadership Positions**

Given the close relation with some of the governance indicators related with community participation, this indicator clusters with the group of participation in the governance indicators.

### **Group S5. Values associated to the Park**

#### **Indicator 2. Local values and beliefs about marine resources**

This indicator was estimated from information gathered during the EEG. The stakeholders of the RSBC-NNP give great importance to the marine resources offered by the MPA. In general, most of the communities considered corals, mangroves, and beaches very important and exhibit a high degree of intergenerational altruism since almost 100% of the respondents consider these resources important to their next generations.

#### **Indicator 6. Perception of non-market and non-use values**

In general, all surveyed stakeholders recognize the biological and ecological importance of the MPA. Similarly, RSBC-NNP staff confers great value to its existence, recognizing the value of amenities such as the landscape, the biodiversity associated and the protected ecosystems, among others. Tourists also perceived the benefits of the MPA and –in a first approach to a question about the willingness to pay for enjoying it- they declared to be able to pay an average entrance fee twice the current value.

### **C. Governance indicators**

#### **Group G1. Institutions, administrative resources and existence and knowledge of an environmental management plan, EMP**

##### **Indicator 2. Existence of a decision-making and management body**

This indicator was created from secondary information and was complemented with information from the interview to staff, game participants and tourists. In Colombia, the *Environment, Housing and Territorial Development Ministry* (EVTDM) is in charge of the management of the protected natural areas in Colombia. For the case of the RSBC-NNP the institution representing the EVTDM is the *Rosario and San Bernardo Corals Natural National Park Unit* (RSBC-NNPU), which is supported institutionally by the *Canal del Dique Autonomic Regional Corporation* (CARDIQUE) and the *Marine Research Institute* (INVEMAR). The Unit staff adds up to a group of 15 persons, who are in charge of formulating and making operative an Environmental Management Plan (EMP) according to the current environmental legislation. The stakeholders in the MPA recognize the presence of the governmental agency as well the existence of the MPA. On the other hand, three of every four tourists recognize that they are entering to a MPA, but in most of the cases, do not identify the agency in charge of the management.

##### **Indicator 3. Existence and adoption of a management plan, EMP**

For the establishment of this indicator secondary information was used, interviews were done to the RSBC-NNPU staff as well as the gathering of results from the rural participatory diagnostic. Presently, the RSBC-NNP had an EMP with a diagnostic of the area, conservation objectives for the most important ecosystems in the MPA, and ordering guidelines and management rules for the users of the MPA resources. Additionally, a strategic plan of action was established, defining projects, objectives, and goals for five years starting in 2007. The EMP is known by all of the RSBC-NNPU staff, but most of the inhabitants in the region declare not to know its existence.

##### **Indicator 6. Availability and allocation of MPA administrative resources**

There were 25 questions in the staff interviews formulated in order to answer this indicator, complemented with information in the current EMP. Additionally, surveys made to the game participants were useful to value their perception about the agency capacities. In order to perform its management tasks, the RSBC-NNPU currently has two boats, an administrative office in Cartagena and two operative offices in the Rosario archipelago (soon a new operative office will be build at the San Bernardo archipelago). The operative offices have been installed with the basic radio communication equipment for control and surveillance, office equipment, lodging infrastructure, and specialized equipment for scuba activities. At that moment, this equipment was in good shape, but it requires constant maintenance, and communication equipment requires a periodic upgrading; the staff workers believe that it would be useful to

acquire additional computers, energy generator plants for the operative offices on the island, at least another boat, GPS receptors, digital photography cameras and video cameras, binoculars, and more diving equipment. Human capital at the Unit includes a professional interdisciplinary team which consists of an Oceanographer, a Lawyer, two Fishery Engineers, three Administrative Technicians, four Natural-Resource Technicians, and four qualified workers for the communication equipment and boat operation. This team is relatively young, with an average specific experience managing protected natural areas over 10 years, and more of 4.5 years in average working for this MPA. The work team constantly participates in training activities, in order to improve their labour performance related to the management of the MPA.

## **Group G2. Scientific research**

### **Indicator 7. Existence and application of scientific research and input**

The sources for this indicator were the institutional analysis from the RPD and the interview to staff, in which 12 of the questions are aimed to answer this indicator. Although the RSBC-NNPU did not have a scientific research implemented program, it does support initiatives from research entities interested in working in the MPA. That support to research was mainly represented by the participation of RSBC-NNPU team members, from logistic technical to professional collaboration. Research activities have dealt primarily with quantification, characterization, evolution and behavior analysis of the main ecosystems and species in the MPA, such as coral reef, fish, mangroves, birds and other relevant species. For the dissemination of research results, sometimes meetings or training activities with community were used; nonetheless, the best communication channel with the community is getting them involved in researching processes. In accordance to the staff, the scientific research should be mainly directed in two work lines: biological, that includes monitoring of coral reef, fishing resources, mangrove, forest, birds, and turtles; and social, that includes working with communities in training, environmental education, tourism and fishing resources management, among others. In a minor proportion, there were new lines of research suggested specifically in climatology and the effects of the sediment produced by the pollution coming from the Dique Channel.

## **Group G3. Legislation, rules and enforcement**

### **Indicator 4. Local understanding of MPA rules and regulations**

This indicator was created with information gathered during the interviews to MPA staff, tourists and participants of the games, and participative diagnostic. In general terms, stakeholders did not identify explicit informal norms for the natural resources management in the MPA. At the same time, they do recognize some formal regulations for the management of the MPA, such as minimum catch sizes, prohibitions on hydro-biological resources harvesting or building restrictions. Besides, stakeholders consider that this regulation must be enforced. However, due to the nature of common pool resources, stakeholders did not find incentives to protect natural resources. On the tourists' side, even though 74% of visitors recognize the existence of the Park as a protected area, just a 35% admit knowing that there is some legislation for them visiting the park, and just 24% admit knowing these rules. In other words, there was a gap in the information for the tourists in terms of what they are allowed to do when they enter to the MPA, behaviour that is sometimes reinforced by tour operators.

### **Indicator 5. Existence and adequacy of enabling legislation**

Besides of the collected secondary information regarding current and enabling legislation of the MPA, we included eight questions in the interviews to MPA staff. Main rules and laws used by the staff to regulate and guide the management of the Natural Park were: Decree number 2811 of 1974<sup>1</sup>, Decree number 662 of 1977<sup>2</sup>, Agreement 076 of 1985 from the Inderena<sup>3</sup>, Law 99 of 1993<sup>4</sup>, and Agreement 1425 of 2002<sup>5</sup>. The management of the RSBC-NNP included additional rules regarding on permitted fishing arts, minimum catch sizes required for fishing, harvest of timber resources, vessel transit, and restrictions on the extraction of

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<sup>1</sup> Natural Resources Code

<sup>2</sup> States the different functions on protected areas

<sup>3</sup> States some of the activities that can be developed in the Park

<sup>4</sup> Creation of the Environmental Ministry

<sup>5</sup> States the possibilities of buildings in the Rosario archipelago

biologic materials. Staff in charge of the MPA estimated that the legislation, above mentioned, was useful (65%) and that rules were enough for regulating the MPA (50%). However, a 78% perceived that the legislation is not adequate and 85% that those norms were not easily executable because of difficulties for enforcement. As a result, staff managers perceived that regulation had a low or very low acceptance by the community in a 46%, normal in a 39%, and only 15% in a high level.

#### **Indicators 14 and 15. Clearly defined enforcement procedures and its coverage**

The Park Unit has established a control and surveillance program that consisted in diverse patrol routes. In order to execute this task, there is a group of four trained employees with good knowledge of the zone, supported by two boats with enough autonomy to cover most of the Park, area and two building facilities in the area for stops and refueling. Patrol activities were programmed on a daily basis and recorded on a register book that is filled after each visit, and where anomalies should be registered. Even though there is a well established program, there are budget restrictions that limit the acquisition of enough fuel to cover all the programmed activities. In consequence, the enforcement of the program will always be depending on the access to fuel, so nowadays is only done sporadically. In the case of detecting an illegal activity, the penalties procedures vary from preventive and definitive decommissions, construction suspensions and demolitions, written and oral warnings, and ecosystem repositions to fines. However, an 80% of the staff thinks that the penalties mechanisms are hard to enforce, due to the juridical process slowness, the insecurity conditions when facing the community, the lack of technical and administrative resources, and the difficulty of doing ecological restoration. Finally, is worthy to highlight that 80% of the stakeholders consider that is important to implement the current legislation, because it would help doing fishing harvest sustainable, and a 70% think that the authority has enough capacity to enforce the legal framework.

#### **Group G4. Resource conflict**

##### **Indicator 1. Level of Resource Conflict**

The construction of this indicator was based in questions on the interview to the staff and in the survey done to the participants of the economic games, as well as from the information coming from the productive profiles and issues identification of the participative rural diagnostic. As mentioned before, communities living in the area of influence of the MPA were composed of people with low income and education levels, depending in a significant way of the natural resources for their livelihood, through the harvest and commercialization of marine products (fish, corals, shellfish, etc), destined to tourists and resellers. This harvest generates some of the most important threats to the MPA, due to the use of inappropriate fishing arts, coral reef affectation and overharvesting. Communities were aware of these issues. Additionally, stakeholders identify issues related to their own socioeconomic conditions (solid wastes, lack of potable water, and low access to education and health services) and governance conditions (conflicts with authorities, community problems, tourism, among others). MPA staff perceive that the main conflicts that threat natural resources of the MPA are: governance issues (difficulty to enforce the EMP, lack of environmental education, lack of dissemination, lack of joint work with communities, lack of law compliance, lack of income-generating alternatives for the communities), pollution issues (water pollution due to the *Canal del Dique*, solid wastes disposal, and water pollution due to the Cartagena industry park at Mamonal), besides of issues associated with inadequate fishing arts and overfishing, massive and disorganized tourism, deforestation and global warming, the latter seeming to be responsible of two important recent events of coral bleaching. Finally, there are other issues affecting the MPA resources such as: lack of ownership sense of communities with the MPA, excessive use of tourism areas, inadequate use of natural resources and great openwork ships transit.

#### **Group G5. Participation**

The results for this indicators group were obtained from the staff and participants of games interviews, institutional analysis, and community leader's identification of the PRD.

##### **Indicator 8. Existence and activity level of community organization**

In this region, we could find some communitarian organizations each one with different purposes: There were organizations for fishermen, environmental education, management of

tourist, and solid waste management. Some of them have been supported by the RSBC-NNPU, mainly those located at Barú and Isla Grande. Some of the current active organizations are:

- Fishing: Pesbaru Fishermen Association, Pesbosque Fishermen Association, Islote Fishermen Association.
- Environmental education: Environmental Interpreters.
- Ecotourism: Ecohotel The Blue House, Blue Crabs.
- Management of solid waste: Associative Work Enterprise Isla Limpia, Baru's Tidiness and Cleaning Committee Liribar, Little Beach, Clear Sea, Blue Sea.

#### **Indicators 9 and 16. Degree of interaction between managers and stakeholders**

In order to create these indicators, 9 questions in the staff interview were included that are complemented with questions of the experimental games survey. According with the new guidelines of the social policy of the National Parks Unit, the interaction with community must be one of the most important strategies, in order to achieve the conservation goals for the natural protected areas. However, in the RSBC-NNPU the process of relationship with community is just in an early stage, reflected in a low degree of community participation in the planning of the EMP. According to surveyed RSBC-NNPU staff, in the process of making the EMP, only 15% of them recalls having consulted or jointly designed it with any kind of stakeholder and just in 20% of the answers there were proposed some kind of community endorsement.

On the other hand, the RSBC-NNPU carried out meetings with the community on a regular basis, so that 55% of staff meets the community at least once a month. Additionally, there was a daily interaction with stakeholders that participate in the research programs and staff tries to meet the community at least once a week to carry out meetings regarding environmental education. With tourists there was a daily approach on the deck, where they are informed of some basic aspects about their visit to the MPA. Two years ago, there used to be periodical meetings with the owners of recreational houses in the influence area of the MPA; however, those meetings do not happen anymore and contact with the owners is sporadic. There were monthly meetings with tour operators of the Rosario archipelago area, and actually there is an effort to open a communication channel with the tourism operators of the San Bernardo archipelago.

#### **Indicator 10. Proportion of stakeholders trained in sustainable use**

As mentioned at Indicator 8, there are multiple local organizations that in some ways support the RSBC-NNPU labours of conservation and sustainable use of natural resources of the MPA. Those organizations are in charge mainly of solid waste management, environmental education, tourist management, and management of fishing resources. Some of these organizations have emerged or consolidated thanks to the RSBC-NNPU support at different levels, from creation, to training in natural resources management and sustainable use, organization and participation, environmental education, rules compliance (specially fishing ones) and solid waste management. Unfortunately, they have reached just a small amount of stakeholders.

#### **Indicator 11. Level of training provided to stakeholders in participation**

RSBC-NNPU did not have an established program to provide stakeholders specific training in participation. However, the Unit has established strategic alliances with different public institutions in order to organize meetings and conferences in the areas of communitarian organization and participation. Unfortunately, there were no records of the activities carried out, and is not possible to quantify those activities. Nevertheless, it is important to highlight that recently some communitarian organizations have appeared, especially fishermen groups, environmental education groups, and solid waste management groups.

#### **Indicator 12. Level of stakeholder participation and satisfaction in management processes and activities**

According to the surveyed staff, the elaboration of the EMP counted on with the indirect participation of the community; however, the EMP did not have a direct or joined elaboration with the community. Once the EMP was finished, results were presented to the community but there are no records of a formal accepting endorsement. Survey of game participant's answers showed that near 60% of the surveyed stakeholders manifested voluntary work participation for the MPA at some time. Even though the absence of direct participation channels, approximately

half of the stakeholders surveyed think that their opinion as inhabitant or fisherman is taken into account by the authorities when making decisions on the MPA.

#### **Indicator 13. Level of stakeholder's involvement in surveillance, monitoring and enforcement**

The set of norms enabled to the MPA did not include any kind of mechanisms to include the participation of the community in the surveillance and monitoring; however, the RSBC-PNNU through education programs tries to incentive this participation. Community, valuing greatly the natural resources, shows an increasing concern for their preservation and declares their willingness to meet other community members to discuss issues related with these resources. In fact, more than 70% of the stakeholders surveyed during the games admitted the importance of denouncing illegal activities in the AMP, but they admitted –in a 50%- that this action is not necessary well accepted by the community. Additionally, over 95% of the community members reveal their willingness to share the management responsibilities of the MPA with the government, specially committing in rules compliance, helping in surveillance, contributing in new rules definition, doing voluntary work and reducing the actual levels of fishing.

#### **4. CONCLUSIONS AND RECOMMENDATIONS**

In general, the biophysics indicators showed a deficiency at the ecosystemic level, management actions still don't have the expected impact in the natural coral reef communities. The fish assemblage analysis showed random aggregations of stations, suggesting the same phenomena describe above. Herbivorous fish such as parrot and surgeonfishes have low values in and out the MPA and that could be link to overall low coral cover values and high algae cover. It is important to note that some community features (such as coral sizes and trophic structure) confirmed the presence of management policies but they need to be applied in a longer period to have some significant effect. That's why this information must be observed with caution, as sampling sites were limited to a few stations and at a single date due to logistic limitations. To prove the effectiveness through these indicators, monitoring activities for longer periods (5-10 years) must be done before attempting to conclusively interpret the results (Pomeroy *et al.* 2004). The zooxanthellae community analysis placed these symbionts as an important tool of evaluation, because they provide finer community structure definition than their coral hosts. It is the first time that holobiont is used as unit in the evaluation of a coral reef community structure (Grajales and Sanchez, submitted).

Vulnerable focal species of *Acropora* spp. with a low number of individuals and presence in few localities in the MPA confirmed its status in the category of endangered species for Colombia (Ardila *et al.* 2002). On the other hand, the relative abundance of individuals of the other two studied species as well as its presence in the MPA along with low mortality could be seen as an indication of population growth in the habitat once known for having *Acropora palmata* and *Acropora cervicornis* as dominant species. Results suggested that the abundance and size structure of *D. labyrinthiformis* and *S. siderea* in some of the stations (Tesoro and San Martin in Rosario Islands and Punta Norte and Mangle in San Bernardo) could be used as indicators of healthy reef status. By comparing between sites in time, these could also be used as indicators of management effectiveness. The first station mentioned in each zone presents large colonies and a wide range of sizes, whereas the second presents large colonies with a few ranges of size. According to Bak & Meesters (1999) the first represent non-degraded zones, while the second degraded zones. As to the community, the dominance of dead coral cover can be explained as a consequence of the mass mortality of the *Acropora* species in the 80's, whereas the high algae cover can be due to the colonization of dead portions of coral in a highly degraded habitat (Knowlton *et al.* 1990). The protection of habitats where relicts of endangered species are still found can be considered a good management action and could be subject to evaluation of management effectiveness. Therefore, we suggest that any station where *A. palmata* and *A. cervicornis* are found, be closed to any activity. Moreover, protection of parrot and surgeonfish must be urgently enforced. A more accurate relationship between coral-fish community structure is undergoing analyses and will be submitted to peer review in a few weeks.

In accordance with the different research done in the area and the EMP, during the last years, the natural resources provided by the RSBC-NNP have been threatened and diminished for different reasons. The most important threats recognized are overfishing, use of inadequate

fishing arts, high and uncontrolled tourism, global warming, biological material extraction, the sedimentation and drainage of industrial residual waters, uncontrolled marine transit, constructions, mangrove and forest extraction, and inadequate solid waste and residual domestic waters management. With exception of global warming the indicators previously described bring clear explanations to the MPA's problematic and their consequences on management.

The main conflict related with MPA natural resources is the one of conservation vs. use of goods and services provided by the MPA:

- Use by communities from inside and outside the MPA
- Use by tourists, tour operators, hotels, occupants, etc.
- Industrial fishing in areas near the MPA

On the one hand, high poverty levels of the stakeholders and lack of alternative possibilities of income generation compel community to guarantee their sustenance mainly from the environmental services supply of the MPA. If one adds the increasing demand of tourism services to the stakeholder's characteristics, and the lack of alternative development opportunities, the result is overharvesting of the marine resources, as it is actually happening in the MPA of the RSBC-NNP, making unsustainable the marine resources harvesting. However, is important to highlight that inside the community there is an increasing awareness around the diminishing in the supply of natural resources and its consequences for the next generations, and this can be a starting point for the generation of solutions to the current problematic.

On the other hand, the governance indicators show that the MPA staff is making decisions to improve its performance in managing the park. In first place, it has been achieved a formal Environmental Management Plan with strategic and conservation goals well defined for the next five years, and it is backed by a sufficient legal frame. Additionally, the RSBC-NNPU relies on a well-trained personal in the management tasks, with sufficient experience in the area, and an infrastructure useful to enforce surveillance, control, and environmental education tasks, at least in the northern zone of the MPA. However, the current infrastructure does not ensure the appropriate institutional presence in the MPA southern area.

Additionally, there are gaps in two ways: on one hand, the decision making is disperse along the local, regional, and national level, what can generate conflicts or difficulties in the execution at a local level; on the other hand, communication channels with community are in some cases weak. As a result, the management and conservation goals proposed in the EMP are neither totally understood nor fully supported by the community, so more joint work between authority and community is a primary necessity for the management of the park. Finally, the RSBC-NNPU does not count on actually with a budget large enough to ensure the achievement of all the goals for which it was created, although it is the natural park that generates the highest income in the country.

The RSBC-NNP relies on an institutional arrangement and normative frame good enough for achieving all the conservation goals for the MPA. However, there is a conflict between the conservation of the MPA and its particular socioeconomic conditions. Communities know and understand relevant aspects of legislation; however, "de facto" it is not accomplished due to economic and behavioral reasons in the presence of common pool resources (CPR)

In other words, the conflicts in resource use, from the institutional point of view, are related with:

- Regulation "de jure" vs. compliance "de facto"
- Restrictive conservation vs. participative conservation in the context of CPR
- Appropriation of the MPA by the community vs. implications on the allocation of property rights in the MPA.

Starting from these results, some alternatives appear to contribute in improving the management and conservation in the MPA. On one hand, there is a need for devoting research efforts, not only to biological and ecological subjects, but also to socio-economic and communitarian topics. Themes like socio-economic conditions of inhabitants, additional income-generation alternatives, MPA tourism ordering, among others, have become a priority to understand and solve important institutional issues.

In the process of indicators estimation, it has been possible to identify that the problem regarding the management of the MPA can be attenuated by diversifying the activities that generate income to the stakeholders, making that tourism dependence decreases and harvesting of resources could be sustainable.

The main recommendation to look for sustainable use of natural resources in the MPA points to the involvement of community in MPA management responsibility. Keeping this goal in mind, the first step is to improve the communication channels between authorities and community, in order to establish rights and duties for each of the involved parts in the MPA management, so conservation objectives can be achieved and people inhabiting the MPA can improve their welfare and social conditions. This would be the next phase in the work at the Park.

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