

Initial Steps of an Adaptive Management Exercise to Strengthen Puerto Rico's Coral Reef Monitoring Program

Inicio de un Ejercicio de Manejo Adaptativo para Fortalecer el Programa de Monitoreo de Arrecifes de Coral de Puerto Rico

Premières Étapes d'un Exercice de Gestion Adaptative pour Renforcer le Programme de Surveillance des Récifs Coralliens de Porto Rico

MARIANA C. LEÓN-PÉREZ^{1*}, TANIA M. METZ-ESTRELLA², and ERNESTO L. DÍAZ-VELÁZQUEZ³

¹*National Coral Reef Management Fellow FY16-17,
Department of Natural and Environmental Resources,
P. O. Box 366147, San Juan, Puerto Rico 00936 USA.*

**mariana.leonperez@tamucc.edu*

²*Coral Reef Conservation and Management Program,
Department of Natural and Environmental Resources,
P. O. Box 366147, San Juan, Puerto Rico 00936 USA.*

³*Office of Coastal Zone Management Program and Climate Changes,
Department of Natural and Environmental Resources, P. O. Box 366147,
San Juan, Puerto Rico 00936 USA.*

ABSTRACT

The Puerto Rico Coral Reef Monitoring Program (PRCRMP) was established in 1999 by the Department of Natural and Environmental Resources, with the responsibility of assessing the condition and trends of jurisdictional coral reefs. Although the PRCRMP has collected and analyzed this data, its implementation on management decisions has been limited. Therefore, an assessment was commissioned to identify needs and courses of action to strengthen the PRCRMP. After reviewing the PRCRMP's historical data and its possible audiences, key stakeholders were inquired about their experience and understanding of the PRCRMP, as well as perceived limitations, and recommendations for improvement. Scientists, managers and collaborators that were consulted agreed on the importance of the information gathered by the PRCRMP for the conservation of coral reefs. However, limited data accessibility and lack of collaboration within and between agencies and other entities were considered the main issues impeding the application of this information. To strengthen the PRCRMP, participants highlighted the value of promoting collaborative agreements with other agencies, academia and non-governmental organizations, especially considering Puerto Rico's fiscal constraints. Recommendations also included new monitoring parameters and the expansion of monitoring efforts in assessing the effectiveness of management actions. Validating findings and recommendations through an inclusive and objective process improved the stakeholders' approach and willingness to cooperate in this effort. Implementing this exercise as an initial step of an adaptive management effort assisted in overcoming communication challenges between managers and scientists, resulting in recommendations with strong support for implementation.

KEYWORDS: Coral reef ecosystems, coral reef management, long-term monitoring program, adaptive monitoring, coral reef monitoring

INTRODUCTION

The Puerto Rico Coral Reef Monitoring Program (PRCRMP) represents the longest ongoing shallow coral reef monitoring program in Puerto Rico (García-Sais et al. 2008). Established in 1999, this program has the objective of assessing the conditions and trends of coral reef ecosystems in Puerto Rico. The PRCRMP is part of the Coral Reef Conservation and Management Program (hereinafter referred to as Coral Reef Program) of the Department of Natural and Environmental Resources of Puerto Rico (DNER) and is funded through Cooperative Agreements with the US National Oceanic and Atmospheric Administration (NOAA). Though the PRCRMP, DNER collects and analyzes data on coral reef community structure's temporal and spatial patterns around jurisdictional waters. For example, this program has documented the impacts and lingering effects of the 2005 regional coral bleaching event (García-Sais et al. 2017a), the overgrowth of the algae *Ramificrusta textilis* (Williams et al. in preparation), as well as the presence and persistence of coral diseases affecting Elkhorn coral within a Marine Protected Area (García-Sais et al. 2017b).

Long-term data are important for assessing ecological responses to natural and anthropogenic disturbances, providing baselines to evaluate change, and for assessing the ecological responses to management interventions (Lindenmayer and Likens 2009). The PRCRMP has been able to document the ecological response of coral reefs to natural disturbances, and provided a baseline to evaluate any change. However, it has been challenging to link this 19-year monitoring dataset and its results with management decisions. As part of the adaptive management process initiated by the Coral Reef Program, an assessment of the PRCRMP was commissioned to the National Coral Reef Management Fellow during fiscal years 2016 - 2017. The findings of this assessment were consistent with its objectives of identifying monitoring needs, recommending courses of action, and improving data accessibility. Herein we present the most relevant results of the assessment, and discuss its implications and collateral results on the PRCRMP and the Coral Reef Program.

ASSESSMENT OF THE PRCRMP

The assessment of the PRCRMP began with a thorough literature review about coral reef monitoring efforts in Puerto Rico and other countries with tropical coral reef ecosystems. Stakeholders were informally interviewed to gather historical

data and create a timeline of the PRCRMP milestones and modifications since it was established in 1999.

Subsequently, a series of surveys, meetings, and presentations were conducted to collect information from primary sources (Figure 1). The first questionnaire focused on gathering the perceptions and recommendations about the PRCRMP from local coral reef scientific community, natural reserve managers, and representatives of federal and state agencies. The results of these first steps were presented and discussed with the DNER Coral Reef Advisory Committee (hereinafter referred to as Coral Committee), a group of agency representatives designated by the DNER Secretary to respond to coral reef matters.

After incorporating the recommendations of the Coral Committee, a last round of interviews was conducted to validate the interpretation of the information gathered and the strategies considered for the action plan. Interviews to key informants were conducted in person from May to June 2017. This information, together with an action plan, was also presented to the Coral Committee and other stakeholders.

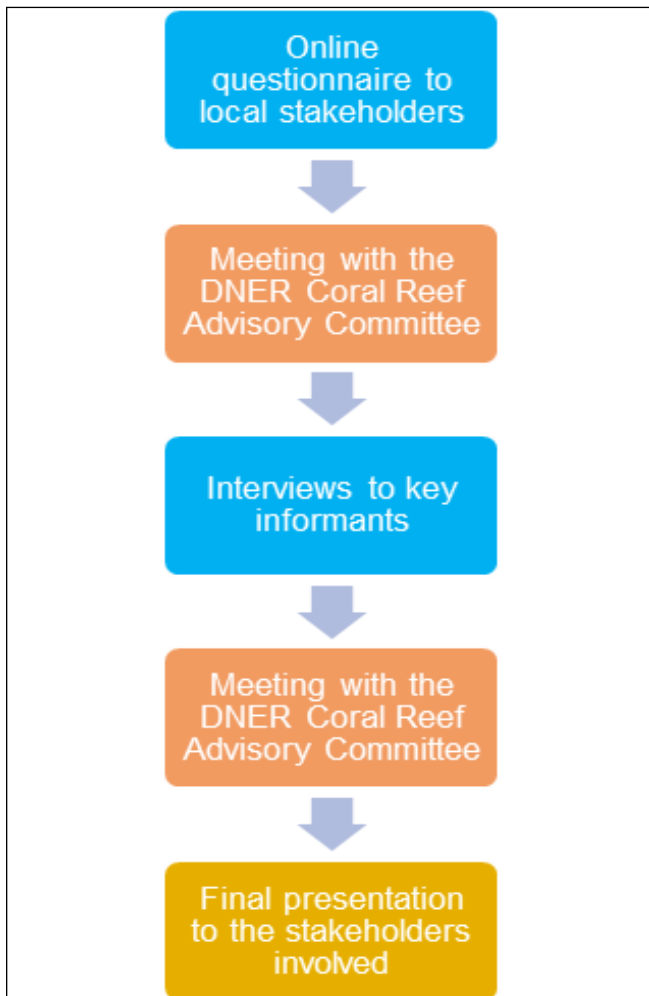


Figure 1. Summary of the data gathering and validation

Results and Recommendations to Strengthen the PRCMRP

Recommendations were developed considering the information gathered from the literature review and following leading examples, such as the Coral Reef Monitoring Program of the Great Barrier Coral Reef in Australia. These were presented and validated with a diverse group of more than 40 stakeholders who participated in several data gathering exercises conducted as part of this evaluation. The process was designed to be inclusive with inputs from representatives from the scientific community, state and federal agencies, non-governmental organizations and natural resources managers. Their contributions were analyzed and applied in the design of the action plan.

The majority of the stakeholders agreed that the information already collected and analyzed through the PRCRMP is important for the conservation and management of coral reef ecosystems in Puerto Rico. Nonetheless, throughout the process there were some repetitive recommendations to improve the program:

- i) Incorporating new monitoring parameters (water quality and coral recruitment, among others),
- ii) promoting more collaborative agreements with other agencies, academia and non-governmental organizations,
- iii) completing a database and statistical analyses to determine which of the current management questions can or cannot be addressed with the existing data, and
- iv) improving data accessibility.

These assessment tasks included the identification of the needs of the PRCRMP and questions that it should be answering for the DNER. It was initially found that some stakeholders expected that the long-term data collected by the PRCRMP and its analysis would be able to answer a wide range of questions. By reviewing the PRCRMP's original objectives and methodology, among other factors, it was found that some of these questions and needs can be addressed, while others cannot be addressed with the available data and analyses. For example, the PRCRMP can analyze temporal trends in the composition and abundance of herbivorous fishes within the monitoring sites. However, it may not be able to assess the effectiveness of a best management practice implemented to reduce sediment runoff reaching coral reefs, since this would require applying a different sampling design for data collection. Ultimately, an adaptive monitoring approach can be used to adapt existing questions and pose new questions, although any change conducted to the program must ensure that the integrity of the long-term data is not compromised (Lindenmayer and Linkens 2010).

In order to use this approach and incorporate stakeholders' recommendations, a program reorganization and expansion was proposed, allowing the PRCRMP to include new monitoring efforts while maintaining the integrity of the long-term data. The proposed framework consists of organizing the program in the following units:

- i) Long-Term Monitoring Unit – Assesses the

conditions and trends of coral reef communities around Puerto Rico and provides the historical context to differentiate between localized and regional changes.

- ii) Management Monitoring Unit – Assesses the impacts of specific anthropogenic and natural events on coral reef communities in Puerto Rico, as well as the effectiveness of localized management actions.
- iii) External Monitoring Unit – Develops and maintaining strong partnerships with other entities and/or individuals that are conducting coral reef and/or water quality monitoring efforts in Puerto Rico and the region.

Participants agreed that this new framework proposes a robust yet flexible program structure that enables resource managers to not only know the status and trends of coral reef resources, but also to utilize the data to learn, adjust and implement different management strategies. It also provides an official platform to establish partnerships with other agencies, academia and non-governmental organizations where shared objectives are identified and aligned to contribute to the adaptive management process.

Efforts to Improve the PRCRMP Data Accessibility

While this assessment was conducted, several efforts were carried out simultaneously to address the needs of improving the PRCRMP data accessibility and outreach. These initial efforts included gathering and publishing all the PRCRMP annual reports on the DNER webpage, together with a description of the program and a map showing the location of each coral reef site which has been

visited (characterized and/or monitored) by the PRCRMP (Figure 2). Educational materials were also uploaded to the webpage and promoted to be used in outreach activities conducted by the Coral Reef Program and others.

IMPLICATIONS AND COLLATERAL RESULTS OF THE ASSESSMENT

The outcomes of this assessment went beyond making recommendations to strengthen the PRCRMP and to improve its data accessibility. The exercises conducted triggered a series of collateral consequences that directly and indirectly assisted in the adaptive management process of the Coral Reef Program.

For example, the meetings held as part of this assessment and other participatory exercises conducted simultaneously by the Coral Reef Program, provided a forum to share and become aware of the different Island-wide efforts related to coral reef ecosystem research, restoration, monitoring and education. Discussions of needs in these meetings have promoted collaborations with the academia and other agencies leading to the development of research projects aligned with shared interests that will benefit the PRCRMP and Coral Reef Program. Overall, the process facilitated improved communication between resource managers and scientists, and positively modified attitudes towards collaborating throughout this adaptive management process.

Almost one year after this effort, the assessment process continues yielding results. A momentum of collaborations and willingness to cooperate in the next steps has been observed. For example, a new partnership with the Caribbean Fisheries Management Council has been created to develop a georeferenced database that will expand the application of the PRCRMP data among

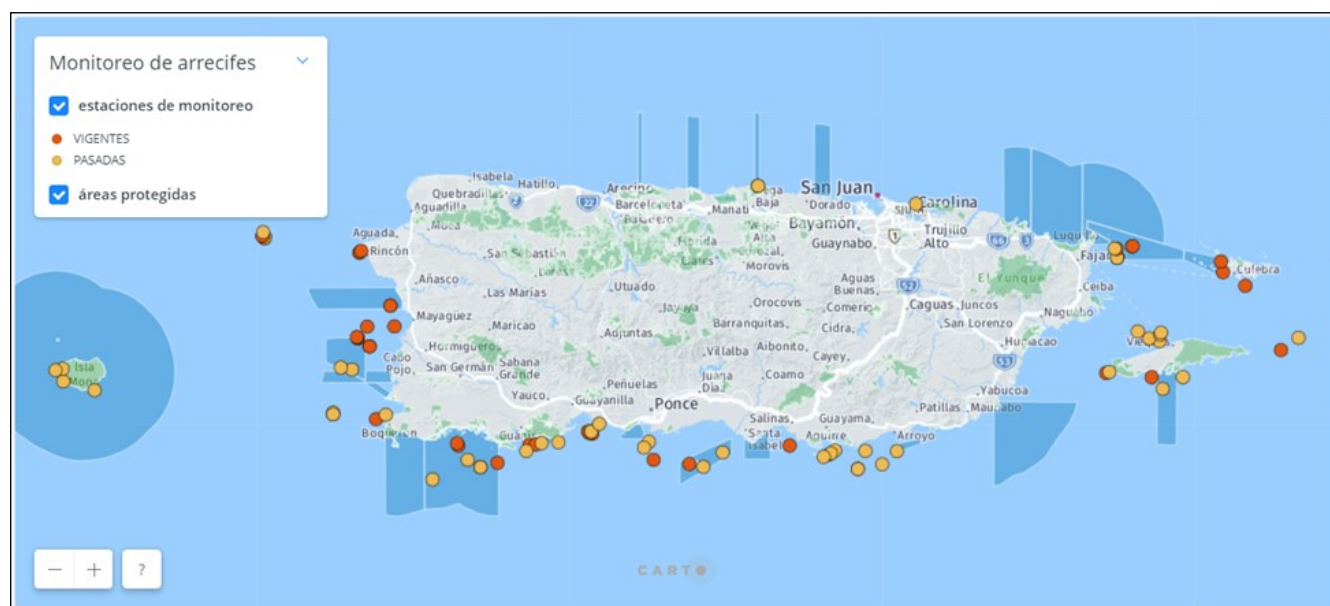


Figure 2. Interactive map published under the Coral Reef Program section of the DNER webpage, showing the location of the reef sites which have been visited by the PRCRMP since 1999. Orange dots represent the sites that are currently monitored by the program and yellow dots represent sites that are no longer visited. Note: At this map scale reef sites that are closer together seems to be one. Visit www.drna.pr.gov/coralpr and click the Monitoring tab to access the map and the PRCRMP annual reports.

stakeholders. Meanwhile, there has been an increase in outreach efforts to promote the use and application of the PRCRMP data. Another achievement has been the involvement of more DNER staff in the reviewing process of the annual report of the PRCRMP. In addition, the DNER is using the PRCRMP results to guide future management projects under the Coral Reef Program. A key achievement has been the creation of a new contract position, the PRCRMP coordinator, whose main responsibility will be to coordinate the implementation of the recommendations of this assessment.

Obstacles Identified and Lessons Learned

This process made evident some of the barriers that were hindering the adaptive process of the PRCRMP. These barriers have been previously defined by Lindenmayer and Likens (2010) and Rist et al. (2013) as reasons for failure and/or ineffectiveness of adaptive monitoring and adaptive management, respectively. These barriers are:

- i) Disagreement among stakeholders on what entities to monitor
- ii) Issues with data management
- iii) Limitations in funding
- iv) Limitations in building shared understanding and joint decision-making between stakeholders
- v) Conflicts among stakeholders have restricted communication and joint action
- vi) Information have been limitedly used to modify management and policy

However, it is important to highlight the factors that contributed to overcoming some of those barriers and to the previously mentioned achievements. First, validating findings and recommendations through an inclusive and objective process is a key factor. Considering the diverse groups involved and previous conflicts in defining the program's needs, it was strategic to provide an environment where participants felt that their opinions were equally and objectively valued. In addition, facilitating an open exchange of ideas between stakeholders and decision-makers such as the Coral Reef Committee and backing-up arguments and recommendations with facts and science-based data, improved people's preconceptions about the program and this assessment process. Another important factor in this process was that this assessment was assigned to the Coral Fellow, who has an academic background in marine sciences and is external to the DNER. This provided objectivity throughout the process and the position worked as a mediator between the agency and the rest of the stakeholders. Together, all of these factors helped to strengthen the stakeholders' trust in the DNER, initiating the adaptive management process and their willingness to participate in it, and creating an environment in which new collaborations and ideas can flourish.

FINAL REMARKS

The implementation of monitoring data into management decisions can be hindered by barriers in the planning and decision-making process (Rist et al. 2013). In the case of PRCRMP, some of these barriers consisted in divergent ideas and/or conflicts within stakeholders that limited the decision-making process. It is crucial to recognize that any management framework is encompassed by the social, political and institutional realities of the entity (Rist et al. 2013). Therefore, a good exercise to initiate an adaptive management process is to recognize these realities and to identify strategies to overcome barriers that may be present. The experience presented here may serve as a reference for similar situations, however each management scenario has its own particularities that must be considered.

ACKNOWLEDGMENTS

We would like to thank all the participants for their time and dedication during this assessment. This assessment was conducted thanks to the National Coral Reef Management Fellowship Program which is a partnership between Nova Southeastern University's National Coral Reef Institute, NOAA's Coral Reef Conservation Program, the U.S. Department of Interior Office of Insular Affairs, and the U.S. Coral Reef All Islands Committee.

LITERATURE CITED

- García-Sais, J.R., R. Appeldoorn, T. Batista, L. Bauer, A. Bruckner, C. Caldwell, L. Carrubba, J. Corredor, E. Díaz, C. Lilyestrom, G. García-Moliner, E. Hernández-Delgado, E. Menza, J. Morell, A. Pait, J. Sabater-Clavell, E. Weil, and E. Williams. 2008. The State of Coral Reef Ecosystems of the Commonwealth of Puerto Rico. Pages 75-116 in: J. Waddell and A.M. Clark (Eds.) *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States*. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NOS/NCCOS. Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, Maryland. 569 pp.
- García-Sais, J.R., S.M. Williams, and A. Amirrezvani. 2017a. Mortality, recovery, and community shifts of scleractinian corals in Puerto Rico one decade after the 2005 regional bleaching event. *PeerJ* 5:e3611 <https://doi.org/10.7717/peerj.3611>
- García-Sais, J.R., S. Williams, R. Esteves, J. Sabater-Clavell, and M. Carlo. 2017b. *Monitoring of Coral Reef Communities from Natural Reserves in Puerto Rico 2017*. Final Report submitted to the Department of Natural and Environmental Resources (DNER), U. S. Coral Reef National Monitoring Program, NOAA. 311 pp.
- Lindenmayer, D.B. and G.E. Likens. 2009. The science and application of ecological monitoring. *Biological Conservation* 143:1317-1328.
- Rist, L., A. Felton, L. Samuelsson, C. Sandström, and O. Rosvall. 2013. A new paradigm for adaptive management. *Ecology and Society* 18 (4):63.