Management effectiveness of a large marine protected area in Northeastern Brazil

Júlio Lustosa Araújo, Enrico Bernard[*]

Laboratório de Ciência Aplicada à Conservação da Biodiversidade, Departamento de Zoologia, Universidade Federal de Pernambuco, Rua Nelson Chaves s/n, Recife, PE 50670-420, Brazil

ABSTRACT

Brazil has one of the largest protected areas (PA) systems in the world but just a small fraction is devoted to the protection of marine habitats. The effectiveness and integrity of PA are being challenged and questioned worldwide and this situation is not different in Brazil. Poorly managed PA are more vulnerable to habitat loss, poaching and other threats. Alarmingly, studies have shown that just a fraction of the current PA can be considered effectively managed. Facing such scenario, studies on the effectiveness of the management of PA — and especially marine PA (MPA)- become essential to enhance the role these areas play in biodiversity conservation, as well as provide useful tools for managers and decision-makers. Using the Rapid Assessment and Priorization of Protected Area Management (RAPPAM) methodology, we evaluated the management effectiveness of the largest MPA in Brazil, the Environmental Protected Area Costa dos Corais (APACC, IUCN category V). In a rare opportunity in the context of Brazil's PA system, we were able to access the management effectiveness of APACC over a 15-year period, tracking progresses, identifying strengthens and weaknesses experienced. The overall management effectiveness of APACC has improved over the last 15 years. Although there were variations, five out of 14 indicators analyzed presented improvements while nine remained stable over the years. Finance was the module that contributed the most for the general improvement of APACC. Contrary to many other PA worldwide, which face budget restrictions, APACC's financial situation is currently stable and such stability may have had a positive effect on other management modules, like Infrastructure and Outputs. Research, Monitoring and Evaluation was among modules with slower progress, which is a contradiction considering APACC is amongst the Brazilian MPA with more research. The feedback from researchers is considered poor and most of the research conducted considered not useful for management purposes. Tourism has the highest increase in criticality, being not only the biggest pressure, but also the main threat. Considering that there were improvements in other areas, increasing APACC's limited staff should be a priority for the coming years. RAPPAM proved to be a quick and easy-to-apply methodology, making it effective for temporal analysis on the management of MPA. However, caution is necessary when analyzing some of RAPPAM results. Frequent changes in the management staff, poor records of the management process and the activities adopted, and incomplete transference of information between staff members inevitably compromises the answers and the overall accuracy. RAPPAM needs *in loco* validation of the answers and this could be a time consuming process for large PA. For better results, RAPPAM could and should be applied together with other evaluation methods.

1. Introduction

In a fast changing world, the conservation of marine and terrestrial environments has become a major challenge (Balmford et al., 2005; Pimm et al., 2014; Ceballos et al., 2015; Haddad et al., 2015). There are many strategies and approaches for the conservation of the world's biodiversity (CBD, 2014) and many international commitments were set (e.g Aichi Targets). However, despite all the problems and criticism, protected areas (PAs) are still considered one of the most efficient strategies for *in situ* biodiversity conservation (Palumbi, 2004; Chape et al., 2005; Sale et al. 2005; Watson et al., 2014).

* Corresponding author.
  E-mail address: enrico.bernard@ufpe.br (E. Bernard).

Although there is a high number of protected areas on the planet (~162,000) covering a considerable area (~5.6% of planet's surface — Watson et al., 2014), they are spatially biased towards terrestrial ecosystems and the nearly 7.300 marine PAs (hereafter MPA) cover only about 3% of ocean's surface (Watson et al., 2014). Expanding the extension and coverage of MPA is an actual challenge (Halpern et al., 2008; Veitch et al., 2012). Such scenario is beginning to change since MPA are seen today not only as a tool for the conservation of marine biodiversity, but also for the management of fish stocks (Gell and Roberts, 2003; Sale et al., 2005; Lester et al., 2009), with many studies pointing out to an increase of fisheries in and around MPA (Halpern and Warner, 2002; Claudet and Guidetti, 2010; Edgar et al., 2014).

Brazil has one of the largest PA systems in the world (WDPA, 2015) but just a very small fraction is devoted to the protection of marine habitats. The establishment of MPAs in the country had a late start and the first Brazilian MPA (Atol das Rocas Biological Reserve) dates from 1979 (Prates, 2007). Today, Brazil has ~1.8% of its marine area covered by approximately 300 MPAs in both coastal and marine zones (Magris et al., 2013; Schiavetti et al., 2013), being 62 of them federal (Gerhardinger et al., 2011). Although a signatory of global agreements committed to the expansion of its MPA network by 2020 (Magris et al., 2013), in the last years the creation of marine and terrestrial PAs in the country has stagnated (Bernard et al., 2014).

The effectiveness and integrity of PA are being challenged and questioned worldwide (Dowie, 2009; Fuller et al., 2010; Mascia and Pailler, 2010; Rife et al., 2012) and this situation is not different in Brazil (Magris et al., 2013; Bernard et al., 2014; Ferreira et al., 2014; Araújo et al., 2015). Poorly managed PA are more vulnerable to habitat loss, poaching and other threats (Watson et al., 2014). Alarmingly, studies have shown that just a fraction of the current PA can be considered effectively managed (e.g. Craigie et al., 2010; Leverington et al., 2010; Clark et al., 2013). The few studies on the effectiveness of PA in Brazil highlight a critical scenario: An assessment conducted in 2005 and 2006 in 245 Brazilian federal PA showed that only 13% of them were highly effective (Onaga and Drumond, 2007). In fact, the latest CBD targets calls for PA to be effectively managed, but MPA present unique challenges for managers, like border delimitation and enforcement (Brock et al., 2012).

Against a scenario of increasing pressures, scarcity of financial resources and declining political support (Watson et al., 2014), studies on the effectiveness of the management of PA — and especially MPAs- become essential to enhance the role these areas play in biodiversity conservation, as well as provide useful tools for their managers and decision-makers (Day et al., 2012). The study presented here aimed to contribute on filling such a gap. Using the Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) methodology (Ervin, 2003), we evaluated the management effectiveness of the largest MPA in Brazil, the Environmental Protected Area Costa dos Corais (hereafter APACC), one of the most prolific sites for marine research in the country (e.g. Ferreira et al., 2001; Frédou and Ferreira, 2005; Ferreira and Maida, 2006). In a rare opportunity in the context of Brazilian's PAs, we were able to access the management effectiveness of APACC over a 15-year period, tracking progresses, identifying strengthens and weaknesses experienced, as well as forecasting important features for APACC over the next 5 years, as predicted by the methodology.

2. Materials & methods

2.1. Study area

The Environmental Protected Area Costa dos Corais is an IUCN category V MPA established in 1997 by federal decree (Brasil, 1997).

APACC covers an area of ~413,000 ha, from the maximum high tide line up to 20 miles into the ocean (Fig. 1), bordering 12 cities between Maceió, in Alagoas State (9°32′51″ S, 35°36′59″ W) and Tamandaré, in Pernambuco State (8°42′16″ S, 35°04′40″ W) (ICMBio, 2012). With the exception of Maceió, all the cities covered by APACC rely on fishing and/or tourism as main income source. Those 12 cities have a total population of 1.064.718 people, with a *per capta* income of approximately U$ 1600.00 (IBGE, 2014).

APACC was created for the conservation of a large coral reef present in the area, as well as to protect local mangroves and one of the last populations of the marine manatee (*Trichechus manatus*) in the Brazilian coast (ICMBio, 2012). Until 2007, APACC was managed by Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), when this responsibility changed to Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio). Currently, APACC has two offices (Tamandaré and Maceió) and a technical staff of one manager (in charge since 2012) and three environmental analysts (the oldest since 2009).

APACC's management council was set in 2011, with 27 seats representing different sectors that have a direct or indirect influence in the area (ICMBio, 2011a). In 2012, its management plan was concluded and a zoning system proposed with seven different classes: Sustainable Use Zone; Beach Zone; Conservation Zone; Fishing exclusive Zone; Marine Life Preservation Zone; and Transition Zone.

2.2. RAPPAM — methods and application

RAPPAM is a methodology designed to offer managers and decision makers a quick and direct identification of management weaknesses and strengths, as well as tendencies, pressures and threats to a given area or protected area's system (Ervin, 2003). This method has been applied in over 53 countries and 1600 PAs (Leverington et al., 2010). In Brazil, RAPPAM was used for the first time in 2004, for the evaluation of 32 state PA in São Paulo (Instituto Florestal, 2004), and later applied in 2005 and 2010 for the evaluation of federal PA (ICMBio, 2011).

We used the same RAPPAM questionnaire (See Supplementary Material Tables S1 and S2) applied in Brazil by ICMBio with 94 questions in 16 modules covering five elements developed by the World Commission on Protected Areas (WCPA, 2014): 1) Context, 2) Planning, 3) Input, 4) Process and 5) Outcomes (Hockings, 2003). Answers for the questionnaire were obtained during an interview with APAAC's manager in April 11th, 2014. A second interview to review all the answers occurred in July 8th, 2014.

RAPPAM Module 1 (Profile) consists of questions on the identification and characterization of the PA and is not included in the effective analysis of management effectiveness. Module 2 (Pressures and Threats) consists of 16 activities previously identified by ICMBio as the most striking to PAs in Brazil (ICMBio, 2011 — Supplementary Material Table S1) and aims to evaluate the criticality, i.e., the severity of the different pressures and/or threats on a given PA. *Pressures* are defined as activities that have been present in the area for the last five years, while *Threats* are activities that have the potential to affect the area over the next five years. Pressures and Threats are evaluated individually, and four aspects are analyzed for the first: Tendency, Coverage, Impact and Permanency. In Threats, the analyzed aspects are Probability, Coverage, Impact and Permanency. Tendency and Probability were scored from −2 to 2, while Coverage, Impact and Permanency were given scores from 1 to 4 (see Supplementary Material Table S3). Criticality equals Coverage × Impact × Permanency, with scores ranging from 1 to 64. Results for Criticality were transformed to percentage in order to rank different activities based on their severity.

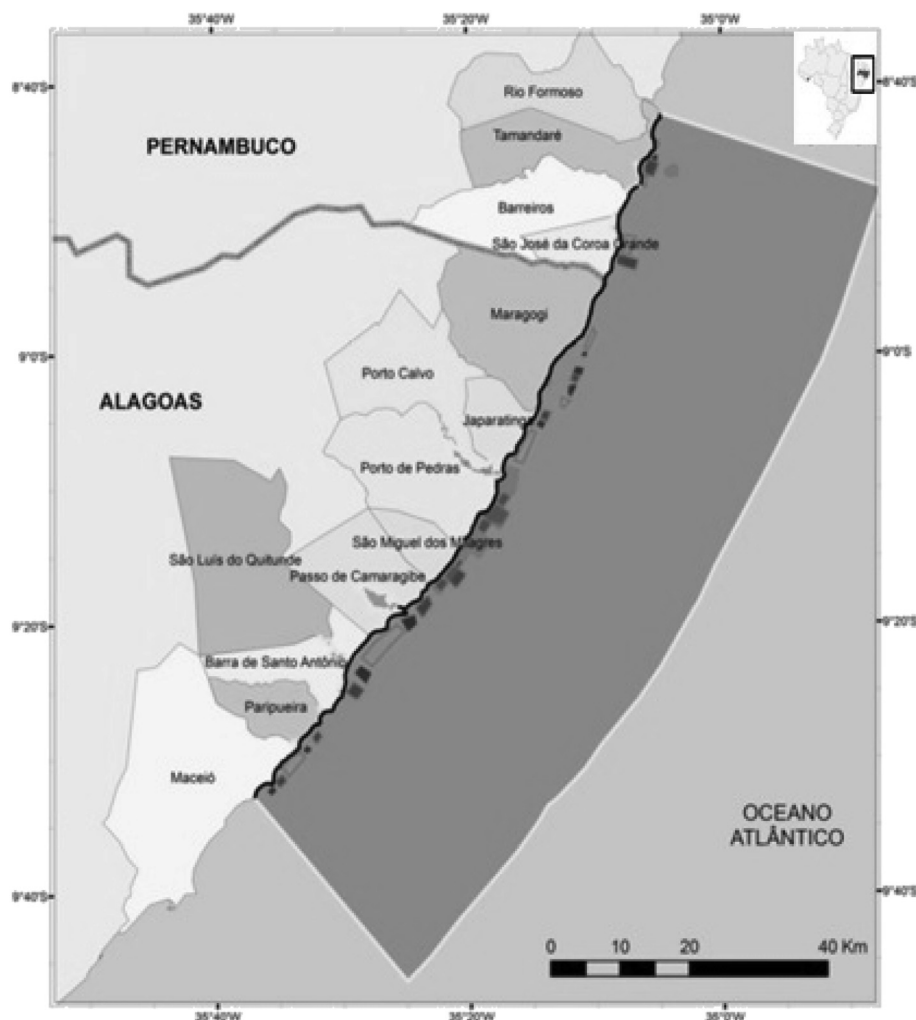Modules 3 to 16 contain questions regarding management

Fig. 1. Location of the *Área de Proteção Ambiental Costa dos Corais* (Environmental Protected Area Costa dos Corais — APACC), between Pernambuco and Alagoas States, in Northeastern Brazil.

effectiveness, so they were analyzed as a group. Four possible answers are considered for those questions: *Yes*, *Partially Yes*, *Partially No* and *No*, accounting for 5, 3, 1 or 0 points, respectively. Management Elements and Modules can be evaluated individually, based on their scores, allowing the identification of those that contributed most or least for improvements in the PA management effectiveness. Final scores were again transformed in percentage, in order to rank modules and elements. Three management effectiveness classes were adopted: *High effectivity* (for scores > 60% of the maximum), *Medium effectivity* (scores between 40% and 60%), and *Low effectivity* (scores < 40%).

2.3. Temporal evaluation

Our results from 2014 were compared with the results from two previously RAPPAM questionnaire applied in APACC in 2005 (for data between 2000 and 2005) and 2010 (for data between 2005 and 2010) so we could evaluate the progress of the management in the area along a 15-years period, as well as forecasts a scenario for the following 5 years. Positive and negative variations were taken in consideration. Thus, an increase >60% in a given score was categorized as *Dramatic Improvement*, between 40% and 60% as *Slight Improvement*, and between 0% and 40% as *Stability*. Similarly, a decrease >60% was categorized as *Dramatic Worsening*, and

between 40% and 60% as *Slight Worsening*. A system of color and arrows was adopted to facilitate the visualization of patterns and tendencies: green represents improvement, yellow stability and red worsening, whilst the direction of the arrows represents the intensity of variations. This scheme was also applied for the analysis of Pressures and Threats, however red was used to represent an increase in scores (higher criticality) and green a decrease in scores (lower criticality). Overall scores for all years were again transformed in percentages and classified in the categories already described. RAPPAM is flexible regarding removal, adding and modification of questions amongst years and different PAs. In our analysis we considered only questions common to the three evaluations conducted in APACC.

3. Results

3.1. RAPPAM 2014 findings

In our evaluation, the top 3 modules with higher scores were Socioeconomic Importance (100%), Management Decision-making Practices (100%), and Biological Importance (96%), while the bottom 3 with lowest scores were Infrastructure (56%), Legal Security (48%), and Research, Monitoring and Evaluation (43%) (Table S3). On the elements' level, Context had the highest score (87%), while

Input the lowest (68%) (Table 1).

The most concerning pressures pointed in 2014 were Tourism and Recreation (100%), Fishing (75%), and Use of Resources by Local Population (56%), while Semi Natural Processes (6%), Mineral Extraction (4%), and Construction and Operation of Infrastructure (1%) had the lowest scores (Table S4). Tourism and Recreation (100%), Fishing (75%), and External Influences (56%) had the highest scores for threats, while Timber Extraction (18%), Semi Natural Processes (14%) and Non-Timber Collection (6%) the lowest (Supplementary Material Table S4).

3.2. Temporal evaluation of RAPPAM

There was a large variation (from 12% up to 100%) in the management effectiveness scores obtained in the three evaluations conducted in APACC (2005, 2010 and 2014), (Supplementary Material Table S5). Five modules remained stable over the whole period analyzed (Fig. 2), of which four remained in the High Effectivity class (Biological Importance, Objective, Management Decision-making practices, and Vulnerability) and one in the Medium Effectivity class (Legal Security). Of the nine modules that presented fluctuations, four improved over the years (Site Design and Planning, Socioeconomic Importance, Communication and Information, and Research, Monitoring and Evaluation) and five varied inconsistently (Staff, Finances, Outputs, Infrastructure, and Management Planning) (Fig. 2).

3.3. Temporal evaluation of management's elements

The five management's elements analyzed also presented fluctuations during the study period (Table 1). One remained stable in the High Effectivity class (Context). Two improved their management effectiveness: Planning, from Medium Effectivity in 2005 to High Effectivity afterwards; and Process, from Medium Effectivity in 2005 and 2010 to High Effectivity in 2014. The remaining two elements (Inputs and Outputs) presented inconstant variations over the three evaluations (Table 1), being currently classified as High Effectivity.

3.4. Overall management effectiveness evaluation

APACC's overall management effectiveness varied over the 15 years analyzed, from 58% (Medium Effectivity) in 2005, to 39, 5% (Low Effectivity) in 2010, to 72% (High Effectivity) in 2014.

3.5. Pressures

Of the 16 possible pressures evaluated, three were not identified in APACC, there was a slight increase in one, dramatic increase in five, and seven others remained stable (Table S4). Some pressures presented large oscillations between evaluations, such as Tourism and Recreation, which achieved the maximum score in 2005 and

2014, but only 18% in 2010. Others presented stability, like Poaching, with only 1, 56% in 2005 and 0 in 2010 and 2014 (Supplementary Material Table S4).

3.6. Threats

Of the 16 activities, two were not identified as possible threats in APACC, six had a dramatic increase in criticality, and eight remained stable. Among the last eight, one had a small decrease in its criticality (Anthropogenic fire), one stayed completely stable (Fishing) and six had small increases in criticality (Table S6).

4. Discussion

The overall management effectiveness of the Environmental Protected Area Costa dos Corais (APACC), Brazil's largest MPA, has improved over the last 15 years. Although there were variations, five out of 14 indicators analyzed presented improvements while nine remained stable over the years. Finance was the module that contributed the most for the general improvement of APACC. This is an important achievement, since financial resources are identified as essential for the management of both terrestrial and marine PAs (Leverington et al., 2010). Contrary to many other MPAs worldwide, which face budget restrictions (Lacerda, 2004; Gerhardinger et al., 2011), APACC's financial situation is currently stable and such stability may have had a positive effect on other management modules (e.g. Infrastructure and Outputs). Since 2011, financial resources from a private foundation (Toyota Foundation) supplements the budget provided by the federal agency (ICMBio), with an extra income of U$125,000.00/year for 10 years, plus another U$125,000.00,/year as a trust fund (P. de Sousa Jr. *pers. comm.*). Considering that the Brazilian Ministry of Environment has one of the five smallest budgets among Brazilian ministries and since 2006 it has undergone consecutive budget cuts (Bernard et al., 2014), this extra income highlights how alternative sources can improve the management of protected areas, especially those with intensive human use (Chapin et al., 2010).

On the other hand, modules with the lowest improvement were Objectives, Legal Security and Research, Monitoring and Evaluation. Objective was constantly in the High Effectivity class. Legal Security — which is related with the legal status of the PA — was affected due to the *absence of border limitation* (maximum score of one, in 2005) and *unresolved issues related to land ownership*, which is closely related to a lack of enforcement in APACC. Research, Monitoring and Evaluation in APACC was among modules with slower progress. If correctly conducted, research, monitoring and evaluation could be used to supply managers with information useful for the PA's management. Moreover, researchers have a key-role helping managers in better estimating pressures and threats. However, frequently, there is a disconnection between the information produced and the PA's needs (Lacerda, 2004). In the case of APACC, this is mainly caused by 1) a lack of research priorities clearly set and presented by the managing staff, and 2) a lack of feedback from researchers with the results already obtained in APACC. In fact, APACC is amongst the Brazilian MPAs with more research, but the feedback from researchers is considered poor and most of the research conducted considered not useful for management purposes (P. de Sousa Jr. *pers. comm.*). A research agenda for APACC was already identified as a priority by the staff but while it is not available, it is up to the staff to establish a better communication with the scientific community about the research conducted in the area.

The observed progress in Management Planning is associated with an important achievement by APACC's staff in 2011: the completion of its Management Plan. This is a basic tool for the

Table 1
Percentage scores obtained in the RAPPAM evaluation of the management effectiveness of the Environmental Protected Area Costa dos Corais (APACC) in 2005, 2010 and 2014. Balance represents the difference between scores in 2005 and 2014.

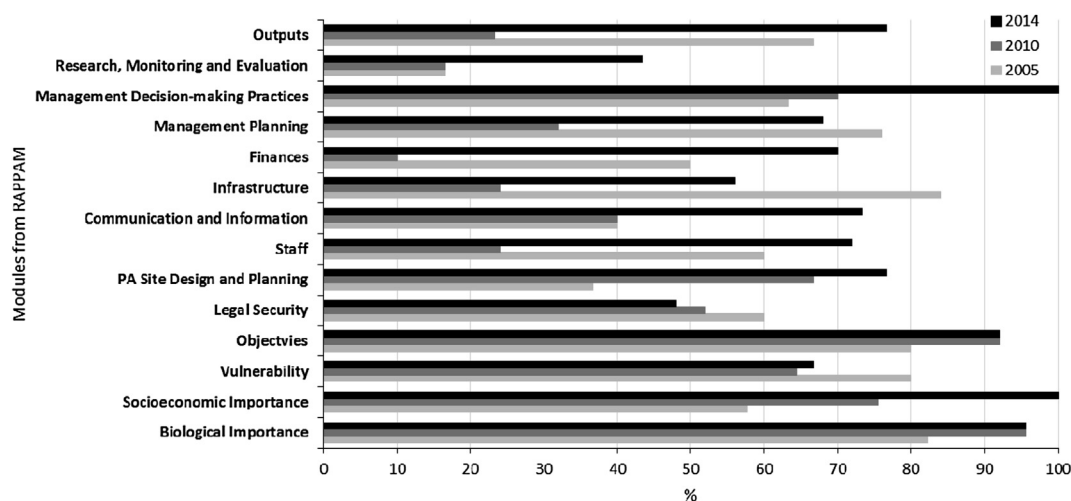| Element	Year			Balance
	2005	2010	2014	
Context	73.33	78.52	87.41	14.08
Planning	57.50	70.00	72.50	15.00
Inputs	57.27	24.55	68.18	10.91
Process	50.59	40.00	70.59	20.00
Output	66.67	23.33	76.67	10.00

Fig. 2. Temporal evaluation of 14 modules adopted in the RAPPAM evaluation of the management effectiveness of the Environmental Protected Area Costa dos Corais (APACC) in 2005, 2010 and 2014. Modules were classified as High Effectivity (>60%), Medium Effectivity (≥40% and ≤60%), or Low Effectivity (<40%).

proper management of PAs (Leverington et al., 2010; Gerhardinger et al., 2011), however, in Brazil many PAs still do not have such document (Veríssimo et al., 2011), compromising the application of basic strategies necessary for more effective management. Further improvements are expected with the publication of APACC's management plan, including, for example the designation of new no-take zones and the establishment of priority research lines.

APACC is a IUCN Category V MPA (Protected landscape/seascape), and such category is oriented to conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems (Dudley, 2008). Some decisions adopted in APACC, such as the regularization of diving activities, reef visitation and the prohibition of provisioning (effective as of 2012) are fundamental for the protection of the reef environment (Van Treeck and Schuumacher, 1998; Tratalos and Austin, 2001; Zakai and Chadwick-Furman, 2002). In addition, APACC's Management Plan foresees the establishment of *Marine Life Protection Zones*, no-take zones that would provide full protection for the coral reefs and their species. To date, there are plans for the implementation of three such zones, but when fully implemented and functional, such areas may have the potential to significantly improve the protection of the local marine biota.

Tourism has been a constant pressure at APACC since the first RAPPAM evaluation in 2005. Currently, this activity has the highest increase in criticality (162.6% — Table S4), being not only the biggest pressure, but also APACC's main threat. In fact, tourism was also pointed in other studies as a major challenge to APACC (Feitosa et al., 2012) and the zoning of the area will be very important to regulate tourism-related activities. Moreover, the area around APACC is experiencing an intense economic growth due to the expansion of the Port of Suape (50 km north, currently one of the main ports in Brazil), the beginning of activities by the Oil Complex Abreu & Lima, and impactful activities like diving and coral reef visitation associated with tourism. Other pressures and threats may also arise, such as an increase in fishing in order to supply the demand for seafood in local restaurants.

APACC was created for the conservation of a large coral reef present in the area. Corals are fragile ecosystems that are under constant and increasing pressures worldwide like ocean acidification and changes in the sea surface temperature (Pandolfi et al., 2003, 2011; Carpenter et al., 2008). However, there is a lack of *in situ* studies regarding those issues in APACC and assessments of coral reef health status are absent in the location (P. de Sousa Jr.,

pers. comm.). Considering the status of corals has worsened worldwide (IUCN, 2015), and coral bleaching was already detected in the nearby Paraíba coast (Dias and Gondim, 2016), APPAC should establish long-term monitoring sites to assess the status of the local corals. Therefore, the future scenario points to the necessity of a better-managed area to face current pressures and future threats.

The improvements we detected are very important for a better management of any given PA. However, even well-funded PA may still fail if they experience other restrictions, like small-sized staffs, for example. Human resources represents a great challenge for many PAs (Gerhardinger et al., 2011; Magris et al., 2013; Schiavetti et al., 2013) and it is not different in APACC, which is understaffed. The currently four staff should be increase to at least 10 to achieve the PA's basic needs (P. de Sousa Jr. *pers. comm.*). Therefore, considering that there were improvements in other areas, increasing APACC's staff should be a priority for the coming years.

4.1. Comparing APACC with other MPA

In Brazil, MPAs are divided into two groups: coastal and oceanic. APACC is in the first group and there is only another one IUCN category V MPA in the same category for which RAPPAM has been applied, the Extractive Reserve Prainha do Canto Verde (hereafter ERPCV), in 2010. Comparing the management status between APACC and other coastal MPAs in Brazil is therefore, compromised by the lack other study cases. But, like APACC, *Socioeconomic Importance*, and *Decision-making Practices* also had higher scores in ERPCV (WWF, 2016). However, ERPCV had several modules that scored lower than APACC, such as *Finances* (16% *vs*. 70%, respectively), *Infrastructure* (20% *vs*. 56%) and *Research, Monitoring and Evaluation* (14% *vs*. 43%). Like APACC, ERPCV is also understaffed, but had a smaller budget when compared with the first. Such results again highlight the importance of the additional financial resource obtained by APACC, which was indirectly responsible for improvements in different modules.

Few international IUCN category V MPA have been analyzed with RAPPAM. In St. Vincent and the Grenadines, RAPPAM was applied in combination with other methodologies to assess the status of the local MPA network (Leod, 2007). Although this analysis was taken in a system level, some results were similar to the ones found for APACC. Overall, MPA are also usually understaffed, funding over the past five years was identified as grossly inadequate to effectively manage the protected areas, and illegal fishing,

tourism, and poor enforcement were also recognized as major threats (Leod, 2007). Research has been conducted, with the participation of external universities and researchers. However, like in APACC, research priorities have not been identified, and research results are not always readily available, and often include only raw data rather than analyzed findings. In another study, in the Gulf of California, Wong-Pérez & Thaler (2012) have found that financial planning, studies on sustainable fisheries and monitoring tools are the most deficient points in the local MPA system. Therefore, APACC's threats and weaknesses seem to follow a global trend amongst MPA, with the exception of its financial situation.

4.2. Pros, cons and limitations of RAPPAM

RAPPAM is a quick and easy-to-apply methodology, making it effective for temporal analysis on MPA management. However, as any other methodology that relies on third party information, the accuracy of answers is a key-factor for the quality of the final output. As detected, frequent changes in the MPA's management staff, poor records of the management process and the activities adopted, and incomplete transference of information between staff members will inevitably compromise the answers and the overall accuracy. Discrepant answers or abrupt changes between evaluations must be better analyzed since they could be much more related to different personal opinions, not necessarily reflecting the PA reality. Therefore, despite being a simple, effective and quick methodology, caution is necessary when analyzing some of RAPPAM's results. Moreover, apart from the implicit subjectivity, RAPPAM needs *in loco* validation of the answers and this could be a time consuming process.

Nevertheless, RAPPAM becomes especially handy for the evaluation of large PA systems, like in Brazil, where in-depth studies are expensive and logistically unfeasible. RAPPAM could and should be applied together with other evaluation methods (e.g. World Bank/WWF Management Effectiveness Tracking Tool; Nature Conservancy's Five-S Framework; PROARCA, or the WWF/CATIE Evaluation Methodology — see De Figueiredo, 2007). Once in combination, such methods could produce more robust results, better reflecting the real world, and this is quite necessary considering that protected areas are centerpieces for biodiversity conservation, with ambitious PA targets as part of the 2020 Strategic Plan for Biodiversity (Watson et al., 2015).

Acknowledgments

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ocecoaman.2016.05.009.

References

Araújo, E., Barreto, P., Martins, H., 2015. Áreas Protegidas críticas na Amazônia no período de 2012 à 2014. Imazon, Belém, PA.

Balmford, A., Bennun, L., Brink, B.T., Cooper, D., Côté, I.M., Crane, P., Dobson, A., Dudley, N., Dutton, I., Green, R.E., et al., 2005. The convention on biological diversity's 2010 target. Science 307, 212—213.

Bernard, E., Penna, I.A.O., Araújo, E., 2014. Downgrading, Downsizing, Degazettement and Reclassification of Protected Areas in Brazil. Conservation Biology. http://dx.doi.org/10.1111/cobi.12298.

Brasil, 1997. Decreto de 23 de Outubro de 1997. Dispõe sobre a criação da Área de Proteção Ambiental Costa dos Corais, nos Estados de Alagoas e Pernambuco, e dá outras providências. http://www.planalto.gov.br/ccivil_03/dnn/Anterior%20a%202000/1997/Dnn5976.htm.

Brock, R.J., Kenchington, E., Martínez-Arroyo, A., 2012. Scientific Guidelines for Designing Resilient Marine Protected Area Networks in a Changing Climate. Commission for Environmental Cooperation, Montreal, Canada.

Carpenter, K.E., Abrar, M., Aeby, G., Aronson, R.B., Banks, S., Bruckner, A., Chiriboga, A., Cortés, J., Delbeek, J.C., DeVantier, L., et al., 2008. One-third of reef-building corals face elevated extinction risk from climate change and local impacts. Science 321, 560—563.

Ceballos, G., Ehrlich, P.R., Barnosky, A.D., García, A., Pringle, R.M., Palmer, T.M., 2015. Accelerated modern human-induced species losses: entering the sixth mass extinction. Sci. Adv. 1 (5) http://dx.doi.org/10.1126/sciadv.1400253.

Chape, S., Harrison, J., Spalding, M., Lysenko, I., 2005. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. Philos. Trans. R. Soc. B 360, 443—455.

Chapin, F.S., Carpenter, S.R., Kofinas, G.P., Folke, C., Abel, N., Clark, W.C., Olsson, P., Smith, D.M.S., Walker, B., Younq, O.R., et al., 2010. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. Trends Ecol. Evol. 25, 241—249.

Claudet, J., Guidetti, P., 2010. Fisherman contribute to protection of marine reserves. Nature 464, 673.

Clark, N.E., Boakes, E.H., McGowan, P.J., Mace, G.M., Fuller, R.A., 2013. Protected areas in South Asia have not prevented habitat loss: a study using historical models of land-use change. PLoS One. http://dx.doi.org/10.1371/journal.pone.0065298.

Convention on Biological Diversity (CBD), 2014. http://www.cbd.int/ [15 December 2014].

Craigie, I.D., Baillie, J.E.M., Balmford, A., Carbone, C., Collen, B., Green, R.E., Hutton, J.M., 2010. Large mammal population declines in Africa's protected areas. Biol. Conserv. 143, 2221—2228.

Day, J., Dudley, N., Hockings, M., Holmes, G., Laffoley, D., Stolton, S., Wells, S., 2012. Guidelines for Applying the IUCN Protected Area Management Categories to Marine Protected Areas. IUCN, Gland, Switzerland.

De Figueiredo, C.C.M., 2007. From Paper Parks to Real Conservation: Case Studies of National Park Management Effectiveness in Brazil (PhD thesis). The Ohio State University, Canada.

Dias, T.L.P., Gondim, A.I., 2016. Bleaching in scleractinians, hydrocorals, and octocorals during thermal stress in a northeastern Brazilian reef. Mar. Biodivers. 46 (1), 303—307.

Dowie, M., 2009. Conservation Refugees: the Hundred-year Conflict between Global Conservation and Native Peoples. MIT Press, Cambridge, MA.

Dudley, N., 2008. Guidelines for Applying Protected Area Management Categories. Gland, Switzerland.

Edgar, G.J., Stuart-Smith, R.D., Willis, T.J., Kininmonth, S., Baker, S.C., Banks, S., Barret, N.S., Becerro, M.A., Bernard, A.T.F., Berkhout, J., et al., 2014. Global conservation outcomes depend on marine protected areas with five key features. Nature. http://dx.doi.org/10.1038/nature13022.

Ervin, J., 2003. WWF: Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) Methodology — WWF. Gland, Switzerland.

Feitosa, C.V., Chaves, L.C.T., Ferreira, B.P., De Araújo, M.E., 2012. Recreational fish feeding inside Brazilian MPAs: impacts on reef fish community structure. J. Mar. Biol. Assoc. U. K. 92, 1525—1533.

Ferreira, B.P., Maida, M., Cava, F., 2001. Características e perspectivas para o manejo da pesca na APA Marinha Costa dos Corais. In: Anais do II Congresso Brasileiro de Unidades de Conservação. Campo Grande, Brasil.

Ferreira, B.P., Maida, M., 2006. Monitoramento dos recifes de coral do Brasil. Brasília, Brasil.

Ferreira, J., Aragão, L.E.O.C., Barlow, J., Barreto, P., Berenguer, E., Bustamante, M., Gardner, T.A., Less, A.C., Lima, A., Louzada, J., et al., 2014. Brazil's environmental leadership at risk. Science 366, 706—707.

Frédou, T., Ferreira, B.P., 2005. Bathymetric trends of Northeastern Brazilian Snappers (Pisces, Lutjanidae): implications for the reef fishery dynamic. Braz. Arch. Biol. Technol. 48, 787—800.

Fuller, R.A., McDonald-Madden, E., Wilson, K.A., Carwardine, J., Grantham, H.S., Watson, J.E.M., Klein, C.J., Green, D.C., Possingham, H.P., 2010. Replacing underperforming protected areas achieves better conservation outcomes. Nature 466, 365—367.

Gell, F.R., Roberts, C.M., 2003. Benefits beyond boundaries: the fishery effects of marine reserves. Trends Ecol. Evol. http://dx.doi.org/10.1016/S0169-5347(03)00189-7.

Gerhardinger, L.C., Godoy, E.A.S., Jones, P.J.S., Sales, G., Ferreira, B.P., 2011. Marine protected dramas: the flaws of the Brazilian National System of Marine Protected Areas. Environ. Manag. 47, 630—643.

Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzales, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Dollins, C.D., et al., 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Sci. Adv. 1 (2) http://dx.doi.org/10.1126/sciadv.1500052.

Halpern, B.S., Warner, R.R., 2002. Marine reserves have rapid and lasting effects. Ecol. Lett. 5, 361—366.

Halpern, B.J., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., et al., 2008. A global map of human impact on marine ecosystems. Science 319, 948—952.

Hockings, M., 2003. Systems for assessing the effectiveness of management in protected areas. Biosci. J. 53, 823—832.

Instituto Brasileiro de Geografia e Estatística (IBGE). 2014. http://cidades.ibge.gov.br/xtras/home.php [03 December 2014].

Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), 2011. Avaliação comparada das aplicações do método Rappam nas unidades de conservação federais, nos ciclos 2005—06 e 2010. WWF-Brasil, Brasília, Brasil.

Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), 2011a. Portaria nᵒ 62, de 21 de Julho de 2011.

Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), 2012. Plano de Manejo da APA Costa dos Corais. ICMBio, Tamandaré, Brasil.

Instituto Florestal, 2004. Implementação da avaliação rápida e priorização do manejo de unidades de unidades de conservação do Instituto Florestal e da Fundação Florestal de São Paulo. Instituto Florestal, Fundação Florestal, WWF-Brasil, São Paulo, Brasil.

IUCN (International Union for Conservation of Nature), 2015. IUCN Red List of Threatened Species [12 May 2016]. www.iucnredlist.org.

Lacerda, L., 2004. Are Protected Areas Working? an Analysis of Forest Protected Areas by WWF. WWF International, Gland, Switzerland.

Leod, P.M., 2007. St. Vincent and the Grenadines National Protected Area System Capacity Development Final Draft Plan. USAID, TNC, Parks in Peril.

Lester, S.E., Halpern, B.S., Grorud-Colvert, K., Lubchenco, J., Ruttenberd, B.I., Gaines, S.D., Airamé, S., Warner, R.R., 2009. Biological effects within no-take marine reserves: a global synthesis. Mar. Ecol. Prog. Ser. 384, 33—46.

Leverington, F., Costa, K.L., Courrau, J., Pavese, H., Nolte, C., Marr, M., Coad, L., Burgess, N., Bomhard, B., Hockings, M., 2010. Management Effectiveness Evaluation in Protected Areas — a Global Study. The University of Queensland, Brisbane, Australia.

Magris, R.A., Mills, M., Fuentes, M.M.P.B., Pressey, R.L., 2013. Analysis of progress towards a comprehensive system of Marine Protected Areas in Brazil. Braz. J. Nat. Conserv. 11, 81—87.

Mascia, M.B., Pailler, S., 2010. Protected area downgrading, downsizing, and degazzettement (PADDD) and its conservation implications. Conserv. Lett. 4 (1), 9—20.

Onaga, C.A., Drumond, M.A., 2007. Efetividade de gestão em unidades de conservação federais do Brasil. Implementação do método RAPPAM — Avaliação Rápida e Priorização da Gestão de Unidades de Conservação. Edição IBAMA, Brasília, Brasil.

Palumbi, S.R., 2004. Marine reserves and ocean neighborhoods: the spatial scale of marine populations and their management. Annu. Rev. Environ. Resour. 29, 31—68.

Pandolfi, J.M., Bradbury, R.H., Sala, E., Hughes, T.P., Bjorndal, K.A., Cooke, R.G., McArdle, D., McClenachan, L., Newman, M.J.H., Paredes, G., et al., 2003. Global trajectories of the long-term decline of coral reef ecosystems. Science 301, 955—958.

Pandolfi, J.M., Conolly, S.R., Marshall, D.J., Cohen, A.L., 2011. Projecting coral reef futures under global warming and ocean acidification. Science 333, 418—422.

Pimm, S.L., Jenkins, C.N., Abell, R., Brooks, T.M., Gittleman, J.L., Joppa, L.N., Raven, P.H., Roberts, C.M., Sexton, J.O., 2014. The biodiversity of species and their rate of extinction, distribution and protection. Science 344. http://dx.doi.org/10.1126/science.1246752.

Prates, A.P.L., 2007. Plano Nacional de Áreas Protegidas: O Contexto das Áreas Costeiras e Marinhas. In: Prates, A.P.L., Blanc, D. (Eds.), Áreas aquáticas protegidas como instrumento de gestão pesqueira. MMA-SBF, Brasília, Brasil.

Rife, A.N., Erisman, B., Sanchez, A., Aburto-Oropeza, O., 2012. When good intentions are not enough… insights on networks of "paper park" marine protected areas. Conserv. Lett. 6 (3), 200—212.

Sale, P.F., Cowen, R.K., Danilowicz, B.S., Jones, G.P., Kritzer, J.P., Lindeman, K.C., Planes, S., Polunin, N.V.C., Russ, G.R., Sadovy, Y.J., Steneck, R.S., 2005. Critical science gaps impede use of no-take fishery reserves. Trends Ecol. Evol. 20, 74—80.

Schiavetti, A., Manz, J., dos Santos, C.Z., Magro, T.C., Pagani, 2013. Marine protected areas in Brazil: an ecological approach regarding the large marine ecosystems. Ocean Coast. Manag. 76, 96—104.

Tratalos, J., Austin, T., 2001. Impacts of recreational SCUBA diving on coral communities of the Caribbean island of Grand Cayman. Biol. Conserv. 102, 67—75.

Van Treeck, P., Schuumacher, H., 1998. Mass diving tourism — a new dimension calls for new management approaches. Mar. Pollut. Bull. 37, 499—504.

Veitch, L., Dulvy, N.K., Koldewey, H., Lieberman, S., Pauly, D., Roberts, C.M., Rogers, A.D., Bailie, J.E.M., 2012. Avoiding empty ocean commitments at Rio+20. Science 336, 1383—1385.

Veríssimo, A., Rolla, A., Vedoveto, M., Futada, S.M., 2011. Áreas Protegidas na Amazônia Brasileira: Avanços e Desafios. IMAZON-ISA, Belém/São Paulo, Brasil.

Watson, J.E.M., Darling, E.S., Venter, O., Maron, M., Walston, J., Possingham, H.P., Dudley, N., Hockings, M., Barnes, M., Brooks, T.M., 2015. Bolder science needed now for protected areas. Conserv. Biol. http://dx.doi.org/10.1111/cobi.12645.

Watson, J.E.M., Dudley, N., Segan, D.B., Hockings, M., 2014. The performance and potential of protected areas. Nature 515, 67—73.

Wong-Pérez, K.J., Thaler, C.L., 2012. Measuring the success of the management capacity building program for marine protected areas in the Gulf of California. Knowl. Manag. Dev. J. 8, 93—104.

World Commission on Protected Areas (WCPA). 2014. http://www.iucn.org/about/work/programmes/gpap_home/gpap_wcpa/ [15 January 2015].

World Database on Protected Areas (WDPA), 2015. World Database on Protected Areas. http://www.protectedplanet.net/ [15 January 2015].

World Wildlife Fund Brasil. (WWF-Brasil) 2016. Observatório de UCs. http://observatorio.wwf.org.br/unidades/cadastro/860 [13 May 2016]..

Zakai, D., Chadwick-Furman, N.E., 2002. Impacts of intensive recreational diving on coral reefs at Eilat, northern Red Sea. Biol. Conserv. 105, 179.