

Perception of threats and related management measures: the case of 32 marine protected areas in West Africa

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Abstract

This paper presents the results of surveys conducted with managers of West African Marine Protected Areas (MPAs) and focuses on the threats and the extent to which they are taken into account in the management process. The data and information derived from the surveys are used to provide a reference situation and to develop a complete inventory of threats faced by MPAs in the region. MPA managers identified unmanaged fisheries, coastal erosion, overexploitation of natural resources and pollution as the main threats to the sustainability of MPAs in the region. Climate change, although considered to be diffuse, is also a concern for managers. However, management measures are aimed (predominantly) at preventing overfishing and the overexploitation of terrestrial natural resources. Therefore, coastal erosion, pollution and climate change are only indirectly (and marginally) targeted by these management measures. Moreover, the management measures implemented i.e. monitoring, awareness raising and surveillance are insufficient and mainly aligned with the capacity of the local institutions. However, what is actually needed is more far reaching and adaptive actions to mitigate the current threats. The low financial, technical and human resources largely explain the limited scope of management actions taken. Coupled with the information and data deficit, which increases the inertia regarding threats that have been recurrent for more than a decade, management measures have not been sufficient in managing MPAs in the region. This paper recommends that the links between pressures on MPAs, technical recommendations and resulting management actions must be reinforced.

Keywords

West Africa; MPA; Fishing; Overexploitation; Pollution; Climate Change

1. Introduction

The West African coastline benefits from a variety of ecosystems and biodiversity [1]–[3]. Coastal areas, however, face significant and increasing anthropogenic pressures, which are exacerbated by aspirations for economic development [4]. Supporting the majority of the population, the coastal environment is particularly disturbed and its sustainable functioning is at risk from human impact [2], [5]. In this context, a network of MPAs have been designated in the region with the objective of conserving natural resources and habitats, such as fish fauna, iconic marine mammals and natural areas (including mangroves and beaches), as well as acting as a vector for local development. Most of the MPAs have been implemented since the 2000s. They are operated and managed by national institutions, although some community-managed MPAs are developing, particularly in Senegal. Overall, the MPAs are not meeting their conservation objectives [6]–[9]. This is largely because human and institutional capacities

are insufficient [10]–[13] and financial resources are lacking [6], [14], [15]. Furthermore, communication within the network of MPAs is not well developed [14], [16], [17] despite the work undertaken by the Network of MPAs in West Africa (RAMPAO). RAMPAO, which has been in operation since 2010, is tasked with enhancing and facilitating conservation initiatives and the visibility of efforts undertaken in seven West African countries (Mauritania, Senegal, Cabo Verde, Gambia, Guinea, Guinea Bissau and Sierra Leone).

The purpose of this paper is to present the threats faced by West African MPAs, as perceived by their managers, and discuss how they are taken into account in the management process of protected marine and coastal areas. It further aims to develop recommendations for improving the management of the regions MPAs. Threats are divided according to their origin (anthropogenic or natural) implying they have a direct impact on the environment within MPAs, irrespective of whether the threats originated from inside or outside the MPA [18]. Managers identified these threats without the intervention of a third party. The data and information are derived from surveys conducted in 2017 and 2018 for the purpose of establishing a reference situation for the 32 MPAs of the RAMPAO [9]. While perception surveys have been carried out in East Africa [19], Europe [20], Australia [21] and the Philippines [22], this paper presents the results of the first perception surveys carried out in West Africa¹. Studies conducted since 2010 in the West African region have been limited to identification of threats and pressures, without involving the perception of managers [6], [14]–[17]. Rather, they focused on the effectiveness of site management. Consequently, when threats have been acted upon (including threats to management), they have been addressed in a rapid and incomplete manner.

This article contributes to broadening the geographic scope of threat perception analysis by MPA managers. It also provides, through the approach adopted in this research - namely a perception survey that concerns all managers at the innovative scale of an MPA network in West Africa - a contribution to the study of the formulation of management actions in the context of a constant shortage of human, technical and financial resources in the region. Indeed, identifying the threats to MPAs, as well as the perception of these threats by MPA managers, is essential to better understand the management actions needed, and to increasing their effectiveness. More broadly, understanding stakeholders' perceptions of protected areas is critical to the formulation and direction of public policies, including the development of management measures [21], [23], [24], although this paper is focused on MPA managers' perceptions only. Such research is critical to understand the effects of global changes induced by modernisation, demography and climate change etc. on the West African coastline.

The paper is organised as follows. The method is described in the next section. The different threats identified by the managers, as well as the related management measures, are described in the third section. A review of threats, based on scientific work undertaken in the region, is discussed in the final section, which also considers the coherence of threat-based management measures and the opportunities that are discussed by managers to improve the effectiveness of the MPAs studied here.

2. Methods

2.1. Data gathering

Managers perceptions of threats were recorded as part of the study of the State of Reference for the 32 RAMPAO MPAs (see Figure 1) between June 2017 and May 2018 [9]. All managers of MPAs within the network were contacted to complete a questionnaire, which was designed to define the health of the protected ecosystems, the threats to their sustainable functioning and the opportunities to better maintain them (see Supplementary Material). Managers completed the questionnaire without the intervention of a third party. The questionnaires were distributed via e-mail and postal mail and the managers were

¹ Network MPAs are regularly subject to participatory assessments of management effectiveness, as part of an internal diagnosis. These, however, follow a fixed protocol (RAPPAM), based on a "dot map". These answers must be based on quantitative data or, where appropriate, on managers' impressions. The aggregation of these results determines the state of management of the site.

informed by phone calls. Reminders to the few managers who had not responded after a few weeks were done by phone and e-mails.

Managers are usually executive employees from the administration in charge of managing marine and coastal resources and they have robust field experience. Normally, they are based and work for several years at the same site, with their management team, before moving to another location. However, employees generally work at the same MPA for most of their careers. Therefore, managers who were relatively new to a particular MPA, rely on their team to be informed about past events, in order to discuss perceptions over the last 5 years or so. To identify the threats that managers face in the MPAs they are in charge of, the questionnaire allowed them to freely list threats, following the approach of Forster et al. [25]. However, it was dictated that threats were to be listed according to two categories: threats of anthropic origin and threats of natural origin. The criterion that defines a threat is simply that it impacts negatively upon natural resources and habitats within the MPA. In addition to mentioning these threats, managers were requested to specify the degree of severity according to the following qualitative scale - light, severe or very severe. Furthermore, managers were asked to freely list the management and protection measures they undertake, and to specify the issues these measures are trying to act on. Thus, through the questionnaires, it was possible to identify the threats (both anthropogenic and natural) perceived by MPA managers, the issues they are facing and the management measures in place to address them. The phenomena the management measures aim to address may differ from the identified threats.

Questionnaires were returned from 28 of the 32 RAMP AO MPAs, representing an 87% response rate². For the four MPAs that did not return questionnaires, the perception of the threats by the managers and their degree of severity could not be defined and included in this study. However, the management measures undertaken in these MPAs could be taken into account using available documentation (e.g. management plans, RAMSAR report, etc.).

2.2. Study sites

RAMP AO MPAs are located along the coast and near coastal islands, with the exception of MPAs in Cabo Verde (see Figure 1). There are no MPAs offshore, and most MPAs are at the interface between land and sea. The first MPAs were implemented during the 1970's (Saloum National Park, Banc d'Arguin, for example.) while the most recently implemented MPAs are only few years old (e.g. Kawawana and Gandoul). Key features of the MPAs are presented in the Supplementary Material.

Here Fig. 1

2.3. Classification of responses

Since managers were asked to freely enumerate the different threats, the responses showed a high degree of heterogeneity in both the quantity and quality of information provided. As a result, the different responses were coded to divide the threats into several categories, following Wallner-Hahn's method [26]. This classification was based on the responses of the managers, in order to correspond as closely as possible to the data collected. Thus, threats have been categorised according to their natural or human origin. However, it is important to keep in mind that these two aspects are linked (threats of natural origin may, for example, be exacerbated by human threats). The various responses relating to anthropogenic threats were divided into 11 areas (cited in order of recurrence): uncontrolled fishing, overexploitation of terrestrial natural resources, pollution, industry, agriculture (mainly extensive), hunting, loss of habitats, infrastructure, demography, tourism and transport. Natural threats were

² Questionnaires for the Djoudj and Saloum Delta National Parks (Senegal), the Cap-Blanc satellite reserve (Mauritania) and the Orango National Park (Guinea-Bissau) have not been returned.

classified according to management responses in 8 areas: erosion, climate change, invasive species, salinisation, silting, habitat modification, marine intrusion and bush fires. The direct or indirect nature of the threat (depending on whether the threat originates from inside or outside the MPA) [18] has not been taken into account, since the goal is only to compile a list.

Management measures have also been listed freely by managers, instead of being listed according to “incentives” categories, following Jones’ model [27], [28], in order to best match the managers’ responses. However, they had to specify on which issues these measures were focused. Then, these measures and the issues they have been implemented to counteract have been classified into several distinct domains, following as precisely as possible the answers of the managers (so as not to distort the content of the answers). The management measures were classified into 14 types (also cited in order of recurrence): monitoring, awareness raising, supervision, biological measures, space regulation, reforestation, contact with local communities, infrastructure, physical measures (maintenance and small infrastructure), tourism, resource management, fencing, consultation and others (the main management measures are defined in the “Results” section). The phenomena these management measures are trying to counteract on are classified into 11 types: unmanaged fishing, habitat loss, overexploitation of terrestrial resources, loss of biodiversity, erosion, agriculture (mainly extensive), pollution, habitat modification, industrial exploitation, transport and others. This last classification is logically close to the classifications of the threats, although there are still some differences.

In summary, four groups of answers have been classified: anthropogenic threats (see Figures 2, 3 and 6), natural threats (see Figures 4 and 5), the phenomena on which management measures are trying to act (see Figure 7) and the measures themselves (also see Figure 7). It is important to note that the phenomena on which management measures are trying to act, are something different from the identified threats.

2.4. Data processing

The threats were listed for each site by their domain and importance. It was then possible to identify the most recurrent threats, as well as to visualise their level of severity according to the managers (see Figure 2 for anthropogenic threats and Figure 4 for natural threats). Since the threats are distributed in a globally homogenous way, no typology has been developed in this work. However, the severity of anthropogenic threats was compared between Senegal and other countries, because of the significant difference between these two similarly sized samples. This trend, which is the only one shown in this work, is illustrated in Figure 6. The severity level was calculated by assigning a score for each threat to each site (0 for a non-existent threat; 1 for a light threat; 2 for a severe threat and 3 for a very severe threat). A Wilcoxon-Mann-Whitney’s Mean test was then performed between the two samples using R to evaluate if the differences between their means were significant. Links between threats were also tested following their score using Pearson’s correlation, but it has been set aside since no robust associations were identified.

Management measures were also listed and sorted according to their field of application and also to the issues on which they are trying to act. This made it possible to quantify which types of measures were the most recurrent. The main links between these measures and the issues they are attempting to counter were also quantified by crossing them. A network-wide aggregation was then drawn to provide a comprehensive picture of threats perception and responses in terms of management (see Figure 7). As stated previously, it is important to note that this figure does not illustrate the main threats that managers identified. Instead of these threats, Figure 7 shows the links between the phenomena the management measures try to act on and these measures themselves.

Managers’ perceptions were then compared to the results of assessments of the management effectiveness of MPAs in the region, carried out between 2010 and 2017. The first assessment was undertaken by RAMP AO in 2010 on the 19 RAMP AO member MPAs [6]. The second assessment was conducted by the WWF in 2011 on 12 Senegalese MPAs [15]. The third assessment was of the Go-Wamer program in 2014 on 23 RAMP AO MPAs [14] and the fourth assessment in 2017 was on the same MPAs [16], [17]. The first three assessments used *Rapid Assessment and Prioritisation of Protected Areas Management* (RAPPAM), which is based on questionnaires covering all phases of site

management³. The fourth used the « rose of the winds » tool to understand the state of maturity of a protected area, supplemented by the tools RAPPAM and IMET (*Integrated Management Effectiveness Tool*)⁴.

3. Results

3.1. Threats of anthropic origin

Unmanaged fishing is the threat that affects the greatest number of MPAs (see Figure 2): 86% of the managers consider that their MPA is affected by fishing practices that are illegal. Incursions of migrant fishing units into MPAs, or even industrial fishing vessels and nets in “bolongs” (mangrove inlets) and other channels, seem to be the most common forms of illegal fishing [4].

After overfishing and illegal fishing, overexploitation of other natural resources (especially wood), pollution, agriculture and industries (factories, but also mobile oil and gas exploitation) are considered as strong threats. Mangroves of MPAs localised in the coastal and estuarine network are cut for wild wood for domestic purposes (various construction types, cooking and preservation of food by smoking) [29], [30]. They are also damaged by fishermen who cut oyster-covered mangroves to facilitate harvesting [31], [32]. Moreover, the growing demand for food has resulted in an increase in extensive agriculture which endangers natural habitats. In addition to these long-standing threats [33], new threats related to the exploitation of hydrocarbon deposits of the West African coast is growing due to recent exploration [16].

Here Fig. 2

In terms of severity, pollution received the highest number of mentions as a 'very severe' threat, probably because of its visible and short-term impact on habitats, fauna and flora [34], and indirectly because of its effects on populations who depend on the affected resources and can suffer from intoxication and contamination [35], [36]. Infrastructure, especially dams on rivers, and tourism, although being relatively rare threats, are considered to have a tangible impact on the sites exposed to them.

According to the managers, the sites that suffer the most severe pollution are MPAs that are located close to major cities (see Figure 3): the Îles de la Madeleine National Park located along the coast of Dakar (Senegal), Tanbi and Tanji near Banjul (Gambia), and finally the Bao Bolon Reserve, bordered by a national road close to Farafenni (Gambia). For the Abéné MPA, the double threat, described as very severe by the manager, is linked to the polluted water flowing into the protected area from a nearby industrial zone, which continues to expand. The Diawling National Park, due to the Diama anti-salt dam downstream, has, since 1988, progressively seen a proliferation of invasive species, such as water hyacinth [37]. The APAC of Kawawana/Mangagoulack is currently the only site whose manager does not report any threats, probably because of its remote location.

Here Fig. 3

³ These six steps include: Context, Planning, Inputs, Process, Results, and Outcomes [82]. The pressures and threats are analysed in the preamble to the evaluation of the management cycle.

⁴ The RAPPAM, IMET and « rose of the winds » methods are tools for evaluating the effectiveness of protected area management. They are conducted by external consultants in collaboration with the management team of a protected area. They are in the form of questionnaires covering the entire management cycle of a protected site.

3.2. Threats of natural origin

The natural threats, which have the highest occurrence according to managers, are erosion and climate change (Figure 4). As MPAs are all located along the coast, in insular areas or in estuaries, erosion of shorelines or banks is a systematic threat. Its effect is accelerated by the multiplicity of aggravating causes, operating in cascade. For example, climatic change induces a decrease in precipitation [29], [38], responsible, in turn, for the sedimentary deficit that weakens the coastline [39] and promotes marine water intrusion into land. Salinisation and habitat modification in turn lead to the arrival of new species, some invasive, modifying the environment. Finally, threats of human origin also amplify the effects of those of natural origin.

Here Fig. 4

Among the MPAs most affected by erosion, Sangomar is in a critical position because of an increasing breach in a sandy spit. In the same way, Palmarin is located close to a sandy spit which is shrinking while its vegetation becomes less dense (Figure 5). Globally, the sites least affected by the natural threats identified are the island MPAs (Urok, Loos, Santa Luzia; Figure 5) and those sheltered in the estuaries' bottom and consisting of mangroves (Bamboung, Kawawana). The strong sedimentary supply of some big rivers such as the Rio Geba, Saloum and Casamance still guarantee a certain stability for the coastline. In addition, because of their locations in sparsely populated areas, they remain sheltered from the other threats identified by managers of other MPAs.

Here Fig. 5

3.3. Country differences

The distribution and level of severity of threats are globally homogeneous. However, MPAs in Senegal have lower levels of perception of anthropogenic threats than in other countries (see Figure 6). It appears that Senegalese MPAs have generally lower threat scores particularly in the category "overexploitation of terrestrial resources". This is partly because some of the MPAs in Senegal are mainly (or exclusively) marine, unlike the ones in the other countries. It is also due to the strong involvement of local communities in the management process (community MPAs) that leads to better use of mangroves, such as in the Saloum Estuary [40].

Here Fig. 6

The distribution of anthropogenic threats for countries other than Senegal is globally homogeneous. In addition, threats from natural origin are distributed in a relatively balanced way. Thus, the fact that MPA managers in Senegal perceive threats of human origin to a lesser degree than those in other countries, is the most obvious trend.

3.4. Management measures

Management measures are more or less linked to the threats of human and natural origin that they aim to counteract. Apart from the routine measures related to monitoring (evaluation) and awareness, the most common measures are to regulate fishing activity. The establishment of biological rest periods (for example, by restricting fishing seasons) and the regulation of marine and terrestrial space (for instance, zoning and buffer zones) are common management measures. More specifically:

- **Monitoring:** is essentially an inventory of fauna or flora. It can be based on indicators such as the number of birds, number of nests, abundance of fish, the trophic level, or the surface of a

type of habitat, for example. When this monitoring takes place over a fairly long time scale (10 years and more), it is possible to detect trends.

- **Supervision:** certain entities carrying out surveillance have the power to arrest people engaged in illegal activity, to confiscate their equipment, to give fines, etc. Where appropriate, state agencies may be notified when an offence is detected.
- **Awareness:** it is an essential and basic activity conducted by the managers. It is widespread because of its low cost. Some MPAs invest in advanced means of communication and awareness (community radios, websites, etc.). However, such measures, although necessary, should be supported by more stringent actions.
- **Improvement of knowledge:** many managers regret the lack of knowledge related to certain key habitats or species [10], [41]. The lack of a baseline is also detrimental to them, because management actions cannot be undertaken on the basis of robust databases. The lack of education of some management staff also complicates their appropriation of documents produced to date in the region [15]. As a result, some managers do not hesitate to host scientists or students, in order to produce scientific reference documents for the MPA. This helps improve the quality of monitoring.
- **Biological measures:** These are multiple: temporal restrictions (biological rest periods), restrictions on certain species or methods of sampling and control of invasive species (harvesting, hunting / fishing).
- **Reforestation:** This type of measure mainly concerns the mangrove areas, but also the sandy areas (Langue de Barbarie, Cayar, Saint-Louis, for example).

These measures are mainly aimed at combating uncontrolled fishing, overexploitation of terrestrial resources and habitat loss. Thus, the number of measures dedicated to each threat is illustrated in Figure 7 by the size of the circle representing the threat (orange), while the number of each type of measure is illustrated by the size of the circle representing the management measure (blue). Although being the target of a large number of management measures (Figure 7), habitat loss has not yet been identified by managers as a severe threat (Figure 2). Furthermore, some threats such as erosion and pollution are only rarely addressed by management measures, which explains their relatively small circles in the Figure 7. The threat constituted by climate change is not the subject of any specific management measure (which explains the absence of a circle representing it in Figure 7, where circles only highlight the main phenomena to be counteracted by the most common management measures). Capturing the full attention of West African MPA managers, the fight against unmanaged fishing leaves little room for management measures to counteract threats as important as the effects of climate change, pollution and erosion.

Here Fig. 7

4. Discussion

To understand the issues related to MPAs in West Africa, perception surveys are valuable tools providing fine scale information [42], complementary to traditional quantitative analyses and monitoring [43], [44]. *In situ* stakeholder expertise (in this case from the MPA managers) is indeed essential for improving knowledge [12], [15] and valuing their work, as well as their effective integration into the broader process of governance of West-African MPAs is needed [23], [45]. Furthermore, it would be interesting in subsequent analyses to compare managers' perceptions with different groups of users to have a broader view, since opinions may differ among stakeholders groups [24], [46].

The previously stated results, however, may be biased because of the subjective aspect of the perceptions of interviewed stakeholders [47], [48]. For example, the prioritisation of threats may be influenced by how questions are asked or by different factors such as inadequate time scales [19], location, or backgrounds of managers and investigation officers [42], [48], [49]. In addition, the lack of correlation between threats could demonstrate a relatively low reliability. On the other hand, the homogeneity of

the answers obtained in the present study for all the MPAs may indicate the contrary. But most importantly, managers' perception are further corroborated by the management effectiveness assessments conducted in the region since 2010⁵.

Overall, among the Protected Areas Management Effectiveness Evaluations carried out recently [6], [14]–[17], all indicate unmanaged fishing, wood cutting (both mangroves and coastal forests), habitat modification and erosion as the most common sources of nuisance (Table 1). They also quantify these four threats as major, in line with managers' perceptions, reinforcing their recurring character over time. While overfishing is a recurring threat in MPAs worldwide, one of the particularities of the network is to find erosion and logging as predominant threats.

Here Table 1

The main reason for the recurrence of unmanaged fishing among the main threats identified, is the lack of substantial measures taken against illegal fishermen. In West Africa, where 70% of the population lives close to the coast [50] and relies heavily on fishing to meet nutritional needs [7], [13], [51], unmanaged fishing is particularly perennial [36]. The entire shoreline of the study area is undergoing a massive influx of fishermen, sometimes coming from far away (for instance, from Liberia and Ghana) [4], [52]. Generally poor, and driven by the depletion of their usual resources, these fishermen have only limited local ecological knowledge and lack consideration for the local coastal populations and ecosystems [17], [53]. Nevertheless, overfishing is a recurring threat to MPAs networks even in rich countries that suffer little from illegal fishing [42].

Mangrove and forest logging within the MPAs is common practice in coastal West African populations. Particularly controlled in Senegalese MPAs according to the managers in this country, this activity would justify the average lower threat score in Senegal (see Figure 6) compared to other countries in the study area. A change in these practices implies the establishment of alternatives with inertia over time. Reforestation activities are widespread often with mixed results [40], [41], [54], [55] and the state of the forests seems to improve slightly in the region [54]. Mangroves remain subject to localised surface losses [56], although at the West African scale, their surface area is expanding [57], [58].

Desertification following a rainfall deficit in the 1970s and 1980s [59] has led to a drastic change in ecosystems within certain MPAs: forest surface losses, mangrove losses and the drying of some mudflats [60]. In addition, the reduction in freshwater inputs, accentuated by the construction of dams and dikes [61], has resulted in a sedimentary deficit and salinisation of certain areas at the interface between marine and inland waters. The sedimentary deficit is expressed by an erosion of the banks and adjacent coastline. In response to these structural changes in habitats, network MPAs attempt to contain this phenomenon by planting mangrove stands. However, this is insufficient in view of the increasing progress of salinisation. Considering that these threats are occurring in a geographic scale higher than MPAs, the latter are not sufficient to counter the threats. However, replantation projects have also been launched outside of the MPAs, with limited effects. Public policies are more likely to be effective in addressing these phenomena [28].

In the absence of precise and localised knowledge of the consequences of climate change, managers attribute the phenomenon of erosion to the sediment deficit resulting from hydraulic structures and the decrease in rainfall [62]. The lack of information is important since none of them can characterize the direct effects of climate change on the coastline and marine and coastal habitats (increase in the frequency of storms, sea level, etc.) [63]–[65]. In addition, climate change has not been mentioned in the MPA management effectiveness assessments carried out between 2010 and 2017, although climate change is the root of many sources of nuisance (erosion, desertification, invasive species, etc.). The regular mention of climate change by managers during the present survey indicates that awareness is being raised because, in their view, climate change induces more diffuse effects, whereas their origin is

⁵ These studies were based on the completion of questionnaires by the MPA management team, supervised NGOs and UNDP representatives. They covered management efficiency of MPAs and although threats were considered, they were superficially addressed.

often difficult to identify. In any case, this late awareness contrasts with other networks in the world, such as the Great Barrier Reef [66] or the Caribbean UK overseas territories [25].

Managers also mention pollution as a general threat. Following the absence of containment measures for domestic discharges linked to rapid population growth [67], [68] and industrial discharges related to the development of raw and manufacturing materials processing [31], [69], [70], this phenomenon seems as diffuse as erosion. The information deficit is just as significant, perhaps even more so, because the pollution caused by macro and micro plastics, present all along the coast, is causing major disruptions, which are ignored by the managers [40].

Management measures focused on those phenomena that are generated within the MPA and that are easier to counter with relatively small means (unmanaged fishing, overexploitation of terrestrial natural resources and habitat loss), neglecting diffuse and global threats like climate change, erosion and pollution (despite their very high degree of occurrence and severity). Management measures do not always follow management objectives, and do not coincide optimally with the threats and issues present. Overall, the most commonly cited protective measures are those associated with the "basic work" of any MPA. When Jones' classification of incentives [28] is considered in the present work, it appears that "interpretative" outcomes are predominant, while the other four categories of incentives (legal, knowledge, economic and participative) are generally under-represented. This was already noted by Jones in his analysis, at the scale of 20 MPAs distributed worldwide [27], [28]. Managers in the present network usually try to prepare in a hurry with limited resources. The multiple causes (most often coming from outside the MPAs) and the diffuse damage of pollution and climate change are difficult to apprehend, particularly in a context of weak human, logistical and financial capacities [7], and especially since human capacities and budget are deemed to be limiting factors in the effectiveness of MPAs [71]. Finally, direct threats are generally perceived as being more severe than latent threats, the effects of which are only visible in the long term [19].

Although the issues of fishing and logging seem accessible, these issues are noted year after year among the most consistent threats, raising the question of the effectiveness of MPAs, both in terms of management effectiveness [72], [73] and in terms of global effectiveness (ecological and social outcomes) [28], [71], [74]. Several studies have already been carried out in protected areas of the network about the positive evolution of fisheries resources [75], [76]. However, the state of forests and mangroves seems to vary greatly from one MPA to another [9]. It appears that increasing pressures on these MPAs is exceeding their ability to respond.

Despite the pessimistic observation of the lack of management capacity with regard to threats, the identification of certain opportunities for MPAs in the region mitigates this finding. According to the managers, the main opportunity is, above all, the ecological wealth of the sub-region. The MPAs in the region also induce positive effects on the environment within their borders [4], [64], [76]. Reasoned eco-tourism - in the opinion of the managers - could also boost local capacity building [10], [77], [78], providing it is closely controlled [79], by asserting itself as an alternative means of generating income and thus allowing people to protect themselves, or even to overcome threats. Consisting of non-governmental organisations, supported by several cooperation agencies, (RAMPAO, PRCM, Wetland International, etc.), national research centres and projects, as well as programmes funded by international cooperation, the community devoted to conservation constitutes a decisive lever for improving the condition of MPAs in West Africa [3]. This channel could be used to improve the overall effectiveness of MPA management measures by paying more attention to the rigor of planning, the institutional and political environment and the engagement of local people. It would also have the advantage of being able to carry out large-scale actions in order to maintain the resilience capacity of MPA ecosystems [80].

The network's MPAs seem, on their own, to be unable to fight against the threats occurring along the West African coast. Too few and generally undersized, they cannot counter the phenomena whose origins lie outside their contours. Alternatively, these MPAs must be integrated into a more global conservation dynamic, of which transnational public policies would be the initiating lever. If the benefits of MPAs are widely recognised [66], [71], [74], [81] (although restricted in this case due to the limited capacity for action), they depend on their environment. Coastal conservation mechanisms aiming to mitigate threats and to improve resiliency in the face of global changes should be proportional to these

threats. Therefore, they must be made up of a resilient "institutional ecosystem" [28], including MPAs geared towards adapting to global change, as is already done in other networks [66]. In addition, more resources (technical, human, financial) should be allocated to MPAs in the area, in order to carry out appropriate actions on a larger scale. Finally, management teams should be able to rely on up-to-date and relevant management plans. They could, moreover, benefit from external audits through advanced management effectiveness analyses (PAME), including perceptions from all stakeholders. Consequently, the management teams could have sufficient room to maneuver in order to act efficiently on the threats that they would have identified in collaboration with the other stakeholders and the scientific community.

5. Conclusion

This research concludes that unmanaged fishing, erosion, pollution, overexploitation of terrestrial natural resources and climate change are the most important threats identified by MPA managers in the RAMPAO network. Their recurring nature raises the question of the effectiveness of management measures implemented to contain and counter them in recent years. Oriented to uncontrolled fishing and overexploitation of non-fishing biological resources, management measures are neglecting erosion, pollution and climate change, being limited only to monitoring, surveillance and awareness-raising activities. Straightforward to implement, they are more similar to the basic functioning of MPAs, rather than actions adapted to the current situation that require a much more sustained and coordinated effort at the network level to maintain ecosystem resilience capacity in the face of climate change.

Supplementary Material

- Questionnaire template
- Table listing the key features of the studied MPAs
- Table listing the weight for each phenomena to be counteracted and the number of mention of their relationships with the management measures

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