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Mitigation Actions by the Marine Epas Against the Oil Spill on the Northeast Brazilian Coast

Ações Mitigadoras das Apas Marinhas Frente o Derramamento de Óleo Na Costa do Nordeste Brasileiro

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Abstract

Brazil has established Marine Conservation Units to safeguard its biodiversity and regulate the use and occupation of these regions. They are considered a coastal zone, thereby being susceptible to disasters such as the oil spill that affected the Brazilian coast in 2019. Thus, the present research aimed to verify whether the management plans of the affected Environmental Preservation Areas (EPA) included contingency measures for chemical accidents involving oil, as well as the actions taken by government environmental agencies in terms of the assistance provided. Considering the organizations/institutions involved in the beach cleaning assistance, we sought to identify whether the actions taken for beach cleaning were related to tourism. To achieve this, we conducted searches on the platforms of the Socio-Environmental Institute (ISA), Chico Mendes Institute for Biodiversity Conservation (ICM-

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Bio), Brazilian Institute of Environment and Renewable Natural Resources - IBAMA, State Secretariats of Environment and Tourism, and the respective State Governments' portals. As a result, thirteen EPAs were found in the states of Bahia, Pernambuco, and Rio Grande do Norte. No management plans mentioned oil spills; however, the actions carried out during the incident were punctual and effective, mitigating major impacts on biodiversity and socio-economic aspects, as the beaches are tourist attractions and sources of income for the municipalities. This factor motivated quicker actions to prevent larger impacts on the municipalities' economy and environment. Therefore, revisions of the management plans should include provisions for such incidents, enabling decision-making to be more concise and even faster and effectively address the damages to these environments.

1. Introduction

Data from the largest international oil spill database, The International Tanker Owners Pollution Federation Limited - ITOPF, demonstrate that incidents involving oil spills have drastically decreased worldwide over the last decade. In 2010, 1,202,120 barrels of oil were recorded in the oceans, marking a 95% reduction compared to data from 1970 (ITOPF, 2020). The primary causes associated with these types of events include groundings, collisions, and strandings, accounting for half of the accident causes (ITOPF, 2020).

On a global scale, the most significant oil accidents occurred from the late 1960s through the late 1990s The two most notable examples are the grounding of the Torrey Canyon tanker off the coast of England in 1967, which released 900,000 barrels of crude oil into the sea, and the Exxon Valdez incident in 1989 off the coast of Alaska, spilling 258,000 barrels (O'Sullivan and Richardson, 1967; Wells, 2017). Looking at Brazil, the first accident occurred in Guanabara Bay, Rio de Janeiro state, in 1985, when the Tarik Ibn Ziyad tanker ran aground on sandbanks during low tide, resulting in a leak of 43,980 barrels (Soares and Irving, 2013; Lawand Junior *et al.*, 2021).

In 2019, Brazil experienced another major accident, considered the largest in national history (Carmo and Teixeira, 2020; Gonçalvez *et al.*, 2020; Pena *et al.*, 2020; Lawand Junior *et al.*, 2021). It is estimated that between 794.92 and 1,987.3 barrels of crude oil leaked (Zacharias *et al.*, 2021), affecting the nine states in northeastern Brazil (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Sergipe) and two in the southeast (Espírito Santo and Rio de Janeiro) (Carmo and Teixeira, 2020; Brito da Silva *et al.*, 2022).

With such extensive disaster implications, based on previous work (Rigotto *et al.*, 2018; Santos *et al.*, 2019), vulnerabilities, whether environmental, social, or economic, are substantially heightened in the affected areas, along with increased exposure to negative impacts on local traditional communities. Notable impacts include the presence of the oil itself (hydrocarbons), which possess mutagenic and carcinogenic properties, causing diverse harm to human health (Talaska *et al.*, 2014; Euzebio *et al.*, 2019), contaminating the soil and sediments even after the first contact with the contaminant, in addition to impacts on different scales on the fauna and flora of the region (Short, 2017; Ward *et al.*, 2017; Gutiérrez *et al.*, 2018). Regarding the socio-economic vulnerabilities, communities reliant on rivers, estuaries, and oceans suffer considerably due to reduced and contaminated fish stocks, a primary income source for these populations (Ramalho, 2019).

With an approximately 8,000 km coastline (Andrés *et al.*, 2018), susceptible to environmental vulnerabilities and disasters as mentioned, Brazil has a

coastal management approach to safeguard its environmental integrity. In line with this, Law No. 9.985/2000 established the National System of Conservation Units (SNUC), governing Conservation Units (CUs), whether terrestrial or marine, sustainable use or full protection, all aiming to protect the environment (Brasil, 2000).

To aid the management of Conservation Units (CUs), SNUC mandates the development of Management Plans for all CUs. This technical document, grounded in the general objectives of the CUs, establishes "zoning and rules governing the use of the area and the management of natural resources" (Law 9.985/2000, Chapter I, Article 2, XVII). Moreover, integrating the management of these units with the coastal region facilitates scenario projection regarding vulnerabilities in a coastal zone and allows for the formulation of management strategies to mitigate environmental impacts across various spheres and scales (Phillips and Jones, 2006; Moraes *et al.*, 2014).

Within the sustainable use category set by SNUC, the Environmental Protection Area (APA) is defined as "a generally extensive area with a certain degree of human occupation, endowed with abiotic, biotic, aesthetic, or cultural attributes that are especially important for the quality of life and well-being of human populations," with objectives including biodiversity protection, regulation of human occupation processes in the region, and the sustainability of natural resources (Law 9.985/2000, Chapter III, Article 15).

Many of these regions, when marine, possess extraordinary scenic beauty, promoting tourism development in the area. Consequently, traditional communities living there are directly impacted by tourism, whether positively (*e.g.,* income generation, overall community improvements) or negatively (*e.g.,* pollution, social inequality).

Thus, when a CU has its management plan in place, it is guided by its directives, strengthened by the foundation provided by the document. This document comprises management programs that, among other objectives, can contain guidelines within their scope to support decision-making in the face of environmental disasters. Additionally, when susceptible to major environmental impacts, such as oil spills, mitigation actions must be undertaken to reduce environmental, social, and economic disasters.

Therefore, this research aims to investigate whether Marine Conservation Units in the APA category, affected by the 2019 oil spill along the Brazilian coast, included oil spill contingency measures in their management plans, as well as the actions that government environmental agencies implemented to provide assistance. Furthermore, it seeks to identify the government bodies/institutions involved in the cleanup of the affected beaches and whether the actions taken in these areas were related to tourism.

2. Methods

Identification of Affected Marine Conservation Units

Firstly, Marine Conservation Units (CUs) were identified using the National Conservation Units Registry (CNUC), which, being an integrated database, encompasses all CUs managed by the three levels of government (municipal, state, and federal) as well as private entities.

Within the CNUC, filters were applied to select Marine CUs with management plans that were in the states affected by the oil spill, namely: Bahia, Ceará, Espírito Santo, Maranhão, Pernambuco, Rio

de Janeiro, and Rio Grande do Norte. The remaining states (Alagoas, Paraíba, Piauí, and Sergipe) yielded no results when the filter was applied. In the other words, there were no Marine CUs.

Once the units were identified, filters were set based on CU category, opting for Sustainable Use, and typology, choosing the Environmental Protection Area - APA. As not all units provided the initial and final coordinates of their coastal zones in their respective Management Plans, a survey of these coordinates for each CU was conducted on the website of the Socio-Environmental Institute - ISA, utilizing the available georeferencing tool to calculate the coastline extent of each unit.

With this information, coordinates were overlaid onto spreadsheets provided on the website of the Brazilian Institute of Environment and Renewable Natural Resources - IBAMA, which contained a weekly history of coordinates for the sighting of oil slicks.

Management Plan Analysis

After identifying all affected Marine EPAs, an assessment of their Management Plans (MPs) was conducted on digital platforms of state and federal agencies, ISA, the Chico Mendes Institute for Biodiversity Conservation (ICMBio), and the virtual archives of the environmental secretariats of each Federal Unit. Within the MPs, publication dates were analyzed, alongside the governmental level responsible for EPA administration, and the presence or absence of a contingency plan or program, particularly in the case of oil spills.

We manually conducted all searches for their respective MPs and performed individual analysis of each plan, aiming to carry out a thorough examination of the material.

Survey of Undertaken Actions

Following the compilation of information from all affected Marine EPAs and their respective beaches, we conducted a research using digital media archives to identify the actions taken by each CU. Primary official communication channels were utilized, including government websites, municipal websites, Environmental Secretariats, as well as major regional and national newspapers such as G1 and R7 News.

Upon accessing these websites, an active search was conducted for news related to the undertaken contingency actions, utilizing relevant keywords for the search, including oil spill, chemical accident, contingency, catastrophes, disasters, response, environmental impact, mitigation, oil, contingency action. This allowed us to identify results relevant to this study.

The active search for relevant information regarding actions following the oil spill became essential to understand the directed actions of each unit. Furthermore, due to the diverse area involved, the selection of the main communication channels in the regions ensured the accuracy and truthfulness of the obtained data.

Identification of tourist sites

Through the compilation and cross-referencing of all the aforementioned data in the methodology, we were able to identify which Marine EPAs and their respective beaches that experience a higher level of tourist demand. This assessment focus stems from tourism' direct influence on the conservation and preservation of natural areas, as they constitute the localities' source of income.

Thus, a hypothesis emerges suggesting that areas with greater infrastructure and tourism potential exhibit a more robust and effective response to contingency actions in the face of environmental disasters. In addition, throughout the research, it was possible to verify whether the suggested hypothesis is validated or not. In summary, the methodological steps undertaken in this article follow a logical order to systematically identify all essential elements for its execution, as exemplified in Figure 1.

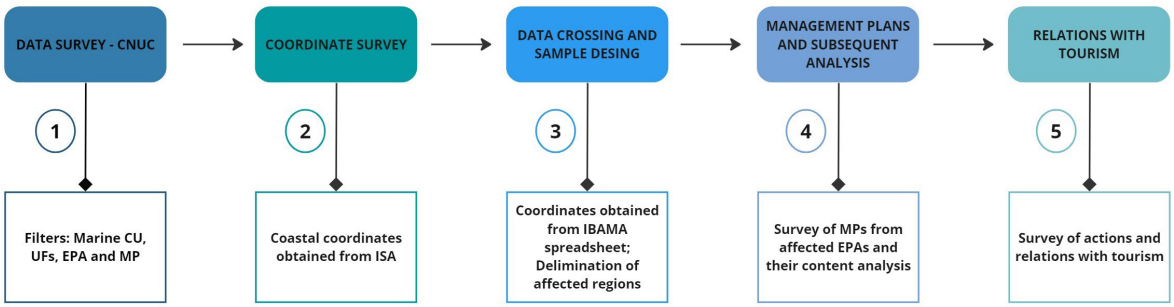

Figure 1. Exemplification of the methodological procedures performed in the execution of the article. Source: Authors, 2024.
Figura 1. Exemplificação dos procedimentos metodológicos realizados na execução do artigo. Fonte: Autores, 2024.

3. Results and Discussion

Management Plan Analysis

By applying the filters within the CNUC, a total of 13 EPAs and 48 beaches affected by the 2019 oil spill were identified (Figure 2). Among these EPAs, nine are situated in the state of Bahia, two in Pernambuco, and the remaining two in Rio Grande do Norte.

Upon analyzing the MPs of these units, it was observed that all of them are administered by the state level. In Bahia, management is related to the Tourism Development Committee (CODETUR), the Bahia State Tourism Promotion Authority (BAHIATURSA), and the Bahia Regional Administration Council (CRA). In Pernambuco, the State Government and the Pernambuco Environmental Agency (CPRH) are responsible for this management, while in Rio Grande do Norte, the State Government manages the areas (Table 1).

Analyzing the selected Protected Areas, it was possible to verify that the MPs of the EPAs located in Bahia show greater outdatedness when compared to those of the other states under study. The units had their MPs published in the 1990s, except for APA Pratigi, located in the municipalities of Igrapiúna, Ituberá, and Nilo Peçanha (Table 1), which had its document updated in 2004. APA Guadalupe, located in the state of Pernambuco, was the one with the most recently updated document, in 2011.

Law No. 9.985/2000 (Brasil, 2000) determined that MPs should be developed for all PAs (Protected Areas), establishing a deadline of 5 years from the date of creation of these Units (Article 27, § 3), to comply with this obligation. This Law, through Decree No. 4.340/2002 (Article 14), delegated to the administrative bodies of the PAs the task of carrying out the procedures related to the elaboration of these documents, through a methodological routing to standardize the methodologies and concepts addressed in the different categories of protected areas.

The EPAs in the state of Bahia were created between 1991 and 1998. In the states of Pernambuco and Rio Grande do Norte, in turn, they were created after the enactment of the SNUC. Most of the Bahia EPAs had already published their MPs before the obligation imposed by SNUC. Therefore, their plans do not follow an established methodological routing, as proposed by ICMBio (Brazil, 2001), nor is there a routing established by the State, as evidenced by the analysis of the respective MPs. However, it should be noted that APA Pratigi was updated in 2004, thus following the guidelines established by ICMBio

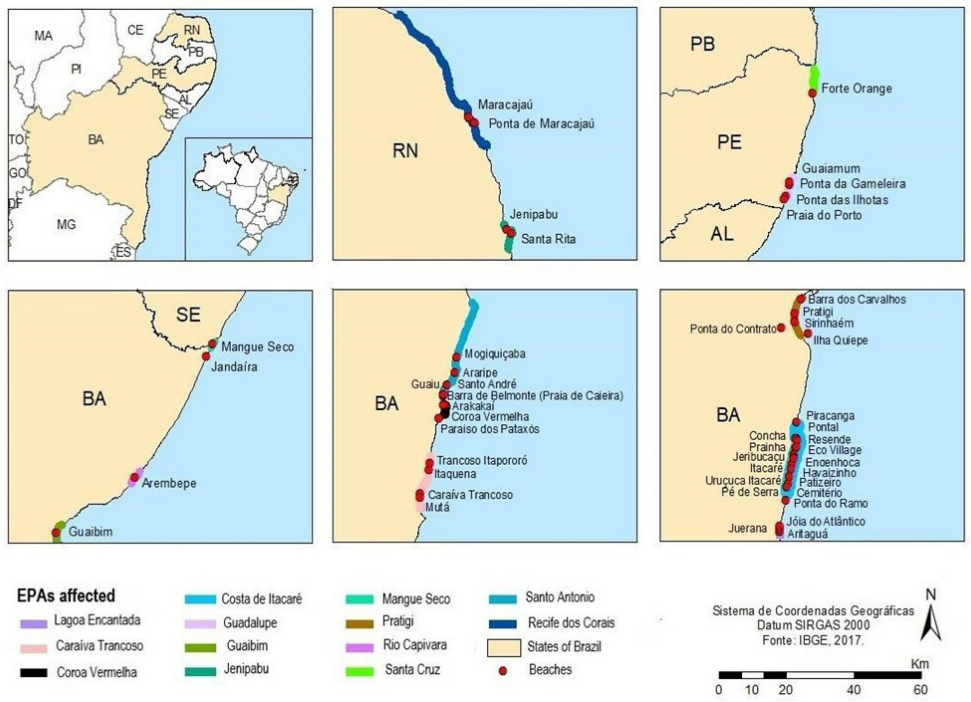

Figure 2. Environmental Protection Areas (EPAs) and beaches affected by the 2019 oil spill on the Brazilian coast in the states of Rio Grande do Norte (RN), Pernambuco (PE), and Bahia (BA). Source: Authors, 2023.

Figura 2. Áreas de Proteção Ambiental (APAs) e praias pelo derramamento de petróleo de 2019, na costa brasileira nos estados do Rio Grande do Norte (RN), Pernambuco (PE) e Bahia (BA). Fonte: Autores, 2023.

(2001). When observing the states of Pernambuco and Rio Grande do Norte, the MPs of their EPAs were published and updated according to the precepts and recommendations of ICMBio, following Decree No. 4.340/2002 (Article 14).

Although the MPs have great potential, according to data from ICMBio, only 155 of the 313 existing PAs in the country have this document, with approximately 6% of them having revisions to their plans (ICMBio, 2018). These data corroborate our findings, given the situation of the studied EPAs. Barros and Leuzinger (2018) state that updating becomes necessary to strengthen and readjust necessary points for the proper functioning of the PA.

Regarding the composition of the MPs of these EPAs, none of them included action plans or contingency plans for accidents involving chemical compounds, focusing on oil spills. The lack of information regarding this theme delays the planning of actions when facing the problem, requiring the formation of extraordinary committees to consider solutions that mitigate the impact. If these documents alluded to plans or contingency programs related to these possible events, et al.actions would be carried out more effectively, and the generated impacts would be substantially minimized (Nascimento et al., 2022).

Considering the context of outdated plans and the lack of investments in better routing and essential topics like contingency planning, reference is made to the National Environment Council - CONAMA, which establishes some guidelines. Action and contingency plans for oil incidents have been provided

Table 1. Overview of the Management Plans of the Marine CUs affected by the 2019 oil spill on the Brazilian coast.
Tabela 1. Panorama dos Planos de Manejo das UCs Marinhas afetadas pelo derramamento de óleo de 2019 na costa brasileira.

Management Plans						
EPA's	**State**	**Creation**	**Plan Date**	**Area of the CU (km²)**	**Administrative sphere**	**Cities affected**
Caraíva Trancoso	BA	1993	1988	319	CODETUR – State	Porto Seguro
Coroa Vermelha	BA	1993	1996	41	CODETUR – State	Porto Seguro
Costa do Itacaré	BA	1993	1998	149.25	CODETUR – State	Itacaré and Uruçuca
Guaiabim	BA	1992	1993	20	State	Valença
Lagoa Encantada	BA	1993	1996	1,577.45	BAHIATURSA- State	Ilhéus
Mangue Seco	BA	1991	1993	34	CRA – State	Jandaíra
Pratigi	BA	1998	2004	856.86	CRA and BAHIATUR-SA- State	Igrapiúna, Ituberá and Nilo Peçanha
Rio Capivara	BA	1993	2000	18	State	Camaçari
Santo Antônio	BA	1994	1996	23	CODETUR – State	Belmonte and Santa Cruz Cabrália
Guadalupe	PE	1997	2011	442.55	State	Barreiros and Sirinhaém
Santa Cruz	PE	2008	2010	386.92	CPRH – State	Itamaracá Island
Jenipabu	RN	1995	2009	17.35	State	Extremoz
Recife dos Corais	RN	2001	2007	1,363.44	State	Maxaranguape

for in Brazil since the 2000s with CONAMA Resolution No. 265, which, in Article 4, establishes the implementation of the National Contingency Plan and Regional, State, and Local Emergency Plans, providing for accidents focusing on oil industries. Subsequently, in 2001, CONAMA Resolution No. 269 highlighted oil spill incidents in oceans.

Actions taken by state after oil spill

Bahia

According to information from the Institute of the Environment and Water Resources (INEMA), government actions following the 2019 spill focused on removing oil stains by providing protective equipment for beach cleaning, as well as hiring a company responsible for collecting and disposing of the waste. Monitoring and cleaning of the beaches were carried out from the moment the stains appeared, with the support of the Secretariat of the Environment (SEMA), Civil Defense, and municipalities, as stated in official statements.

Regarding the chemical analyses carried out by the technical team of INEMA-BA, there was no contamination of the affected beaches in Bahia. Until then, no contingency or action plans had been verified in the respective MPs of the studied Bahia EPAs. All actions taken were elaborated by the municipalities or the state government for containment and disaster prediction.

Pernambuco

According to reports from the state government provided to the press, action plans were drawn up for the containment of the oil stain to prevent it from reaching estuaries (natural nurseries) using containment barriers at the exits of these estuaries. A total of 2,145 meters of containment barriers were installed (G1-Pernambuco, 2019).

The operational actions planned by the government were carried out by 400 people from various state agencies and 90 inmates allocated for removal, containment, and impact prevention. Additionally, the government received help from Non-Governmental Organizations (NGOs) such as Recife Sem Lixo and Salve Maracaípe. Furthermore, the state collaborated with the Federal Government through the institutions of the Northeastern Military Command and the Army, which provided equipment for oil removal (three helicopters, one plane, fifty-one vehicles, ten boats, and three ships for constant coastal monitoring).

The state's situation was one of the most critical: in just eight days of beach cleaning, 1,358 tons (9,954 barrels) of oil deposited in the sand were removed. All material was sent to the Pernambuco Waste Treatment Center, where it was transformed into fuel for cement industries. In addition, calls for research related to the prolonged impacts caused by the oil spill were made. Thus, all containment actions taken were elaborated by the government.

The protected areas in this state did not present actions involving any type of chemical disaster with hydrocarbons in their MPs. Therefore, after the accident on the coast, the actions were thought out and put into practice.

Rio Grande do Norte

With the oil spill incident, the government created the Disaster Response and Mitigation Plan, as the state's PAs did not have any proposed contingency or action in the context of chemical spills, specifically related to oil. The Plan established by the government consists of monitoring the coast in a joint action with volunteers, and interested parties were required to register with IDEMA (Institute of Sustainable Development and the Environment). According to the government, the partnership with society and municipalities enabled the effectiveness of any proposed action.

In addition to active monitoring, groups composed of researchers were created for long-term monitoring of the impacts generated by the oil. In total, the government counted 34 tons of oil (249 barrels) mixed with sand on its coast. Efforts of the Federal Government were not reported.

Concerning the actions taken by the states, NGOs, the third sector, and volunteers, they were essential for mitigating the environmental impact. In contrast, the Federal Government's lack of promptness in assisting the affected areas *et al.*led to a dual confrontation by the Public Prosecutor's Office to expedite decision-making, thus activating the Incident Contingency Plan with a 40-day delay (Mendes *et al.*, 2021).

This finding reiterated the importance of establishing guidelines regarding the handling of crude oil, due to its toxicity. Furthermore, these guidelines should be widely disseminated, as many volunteers, intending to help mitigate this impact, handle this material without even using personal protective equipment.

EPAs and Tourism: Intersection of data

Examining the location of the beaches (Figure 2) and the tourism potential of the regions where the studied Marine PAs are located, it was found that all of them have great tourist potential due to their scenic beauty. Data from the Ministry of Tourism (2020) highlight that the main segment of tourism demand in Brazil is sun and beach, and the states of Bahia,

Pernambuco, and Rio Grande do Norte are among the top ten most sought-after national destinations.

The state of Bahia receives an average of 11 million tourists annually, according to data from the Tourism Secretariat (Bahia, 2016), of which approximately 85% are Brazilian tourists and 15% are foreigners. The most visited beaches in the state are Porto Seguro (EPAs Caraíva do Trancoso and Coroa Vermelha) and Ilhéus (APA Lagoa Encantada). Together, they receive approximately 5,5 million tourists during their high season, according to data from the Bahia Tourism Secretariat in 2019, released to the media (G1-Bahia, 2019), generating around 6 billion reais/year.

The tourism planning involving these beaches is intense, given the income generation from tourism. Therefore, attention is drawn to the speed at which the state government planned and executed its actions to prevent further oil on the beaches. In addition to the imminent environmental impact on its beaches, significant financial losses from tourism were also at stake.

Similar examples are found on other beaches located in Pernambuco and Rio Grande do Norte. These regions rely on tourism, having significant local incentives for their development, as well as the maintenance of scenic beauty to attract more tourists annually. Pernambuco is expected to welcome around 10 million tourists annually, with beaches being the main destination (Pernambuco, 2008), while Rio Grande do Norte is projected to welcome around 230,000 tourists just during the year-end holidays, with 10% of them coming from abroad (Diário do Turismo, 2019).

Even with limited data regarding each studied APA, the projections established by each State Tourism Secretariat indicate that the beaches in these regions are the main destinations chosen by tourists, whether national or international, contributing to the income of the region. In addition, Mendes *et al.* (2021) state that the climate in the northeastern region further favors attracting tourists to the beaches. Thus, the impact of the oil accident on the coast directly affected business owners and traditional populations in the region connected to tourism. Therefore, the prompt removal of oil from the beaches is a crucial factor for maintaining the tourism sector in general, since, according to Mendes *et al.* (2021), tourists have great concerns about direct contamination from oil residues and consequently avoid visiting such regions.

According to Muler *et al.* (2011), beaches with high tourism potential tend to "exert greater pressure" regarding cleaning/removing oil from their coast due to the attractiveness of their scenic beauty inherent to tourism and, consequently, the generation of income for the region. In line with this, Brum *et al.* (2020) report that the affected states were able to act effectively, but the promptness of assistance at times could have been faster, which was not always possible as it often depended on the Federal Government.

Furthermore, Phillips (2019) informs that equipment for removing contaminating material from the beaches and personal protective equipment took a long time to arrive, requiring the involvement of private companies and volunteers to remove the oil from the beaches as soon as possible. According to Brum *et al.* (2020), this movement was crucial to mitigate the environmental and social impact of the region, given that tourism is the main source of income in the area. As oil stains appeared on the Brazilian coast, states and their respective municipalities began to act without waiting for guidelines from the Federal Government, which, according to Soares *et al.* (2020), failed to organize and coordinate decisive actions in the face of the environmental disaster under study.

Considering all the implications related to oil spills on the Brazilian coast, it is fundamental and imminent the need to establish preventive measures regarding these accidents. An important guideline refers to the detailing of guidance in the management

plans of the Marine UCs, since this is the official document of the units, and it is passed on regardless of the current administrations. It is possible to contain information related to monitoring, mitigation, and cleaning of the area so that the disaster does not worsen. Furthermore, it enables directions regarding the management care of this region, since crude oil is toxic at all ecological scales.

4. Conclusions

With the oil spill on the Brazilian coast, 11 coastal states suffered from the presence of crude oil on their beaches and PAs. In three of them, 13 EPAs that had MPs were affected. This paper helps and suggests guidelines for the respective PAs, providing relevant information on regional characterization and potential guidelines for addressing environmental impacts. The MPs of the studied EPAs presented, in general, significant outdatedness, with the state of Bahia having the oldest documentation. In the three observed states, the MPs of the EPAs were not developed according to the methodological routing suggested by ICMBio, nor did they include action or contingency plans for chemical accidents, focusing on oil. It is emphasized here the need to revise these documents, elaborating Contingency Plans as an integral part of their MPs, considering that incidents of oil spills on the coast are said by the literature to be common, as the coastal zone is vulnerable to these situations.

The EPAs include private properties as well as public ones, such as beaches and the waterfront. The beaches belong to the Union, although the studied PAs, whose beaches were affected by the oil spill, are managed by state governments. Therefore, it was expected that the Federal Government, through ICMBio, would offer support and provide emergency assistance to these and other units in case of incidents of this magnitude. However, efforts at this level fell short of expectations, requiring significant pressure from the population and media outlets to prompt any kind of aid.

Conversely, initiatives from private companies, NGOs, the population, and volunteers, along with municipalities and the State Government of the respective Federative Units, ensured that actions to clean and remove oil stains were promptly carried out. This prevented further damage to biodiversity and local tourism, as the latter relies directly on the local scenic beauty for income generation in the municipalities where they are located. It is worth noting that if guidelines related to these incidents were included in the existing MPs, actions would have been quicker and with more focused logistics.

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G1- Pernambuco. *Em oito dias, Pernambuco recolhe 1.358 toneladas de óleo em praias. Recife.* G1- Pernambuco.

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