An Acad Bras Cienc (2022) 94(Suppl. 2): e20210320 DOI 10.1590/0001-3765202220210320
Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences*
Printed ISSN 0001-3765 I Online ISSN 1678-2690
www.scielo.br/aabc | www.fb.com/aabcjournal

ECOSYSTEMS

Assessing the actions of the Brazilian Federal Government to respond to the 2019 mysterious oil spill: a perpective of the national environmental agency

PHILIPE P. BARBEIRO & FERNANDA C.P. INOJOSA

Abstract: On August 30, 2019, in the state of Paraíba, an oil spill of unprecedented characteristics reached Brazil, affecting 1009 coastal locations, in eleven states (from Maranhão to Rio de Janeiro). The objective of this paper is to present a description of the incident scenario from the perspective of the Brazilian Federal Government. Furthermore, the analysis of its performance regarding the actions and tools employed focuses on the role of the Federal Environment Agency (Ibama). Ibama led the Federal Government's initiatives for managing the spill when its true scale was yet unknown. Once the emergency was officially recognized, the Government acted through the implementation of the National Contingency Plan for Oil Pollution Incidents in Waters Under National Jurisdiction. From then on, the spill management was under the command of the "Grupo de Acompanhamento e Avaliação" (composed of Ibama, the Brazilian Petroleum Agency, and the Navy). The performance of other entities was crucial to make response actions feasible. Management tools were added to help the standardization, speed, and consolidation of the information collected in the field. Considering the specificities and limitations imposed by this event, we conclude that the Federal management of the spill was adequate, although opportunities for improvement were identified.

Key words: Oil spill response, disaster, crisis management, government actions, environmental agency.

INTRODUCTION

On August 30, 2019, the Brazilian coast became affected by oil fragments from an undetermined origin. Starting in Paraíba state, these fragments were eventually observed in eleven Brazilian states, in different periods, frequency, and volumes. (Ibama 2019, MB 2019a). beginning on this date, Ibama 2019 confirms that 1009 localities were affected with various levels of severity, until the demobilization of the emergency state, which occurred on March 20, 2020 (Figure 1). The Brazilian Federal Government, through its environmental agency, "Instituto Brasileiro de Meio Ambiente e Recursos Naturais Renováveis" - Ibama, responded to the event since its beginning, according to available information, as is demonstrated in this study. Ibama is an independent federal agency, linked to the Ministry of the Environment ("Ministério do Meio Ambiente" - MMA). Its headquarters are in Brasília, and each Brazilian state has an Ibama Regional Office, called a Superintendency. All Superintendencies have a team dedicated to environmental emergencies, all of which were part of the response to the 2019 oil spill incident response.

As the situation worsened throughout the following months, the Brazilian National

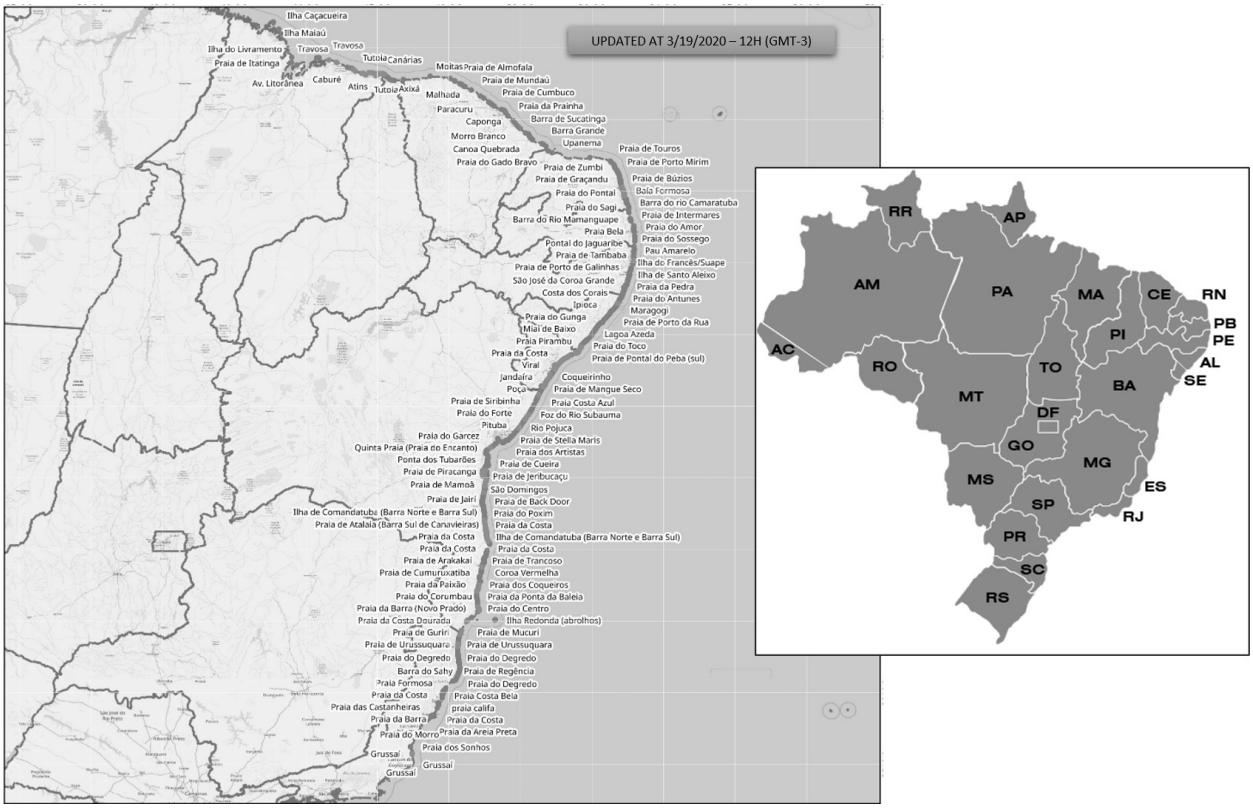

Figure 1. Geographical view of affected locations (Ibama 2019, adapted).

Contingency Plan for Oil Pollution Incidents in Waters Under National Jurisdiction – NCP, instituted by Federal Decree 8,127/2013, was activated (Brazil 2013).

The NCP establishes guidelines, methodologies, and management structure for the Federal Government in relevant emergency situations involving oil. Activation of the NCP occurs through a structure of monitoring and assessment, called a "Grupo de Acompanhamento e Avaliação" - GAA, integrated by Ibama, Brazilian Navy (Marinha do Brasil) – MB and Brazilian National Petroleum, Gas and Biofuels Agency (Agência Nacional de Petróleo, Gás e Biocombustíveis) – ANP. A GAA is responsible for operational management of incidents, with support from a "National Authority", represented by the MMA, and a "Support Committee", which is a joint body formally extinguished by Decree 9.759/2019 (Brazil 2019a).

When a GAA is formed, according to Brazil 2013, one of its three forming institutions is defined to be an Operational Coordinator. MB assumed this role, because the origin of the oil was the territorial sea. Ibama´s individual role was to monitor the performed actions, to provide guidelines relating to environmental issues and to evaluate the results based on technical criteria.

This incident was considered unprecedented in the world, because the responsible party was unidentified, the extension of the affected area, and its recurrence at some localities (Agência Brasil 2019, MB 2019a, Ibama 2020). According to Decree 8,127/2013, the polluter, "regardless of the actions for controlling the incident, must communicate, immediately" with Ibama, the corresponding state environmental department, the corresponding Port or Fluvial Captaincy, and ANP (Brazil 2013) - which never occurred.

Brazilian environmental law assimilates and adopts the polluter-pays principle (Brazil 1988); introduced by European community in 1987 (Aragão 2014). This principle imposes on the polluter (the one[s] responsible for the pollution incident) civil liability for mitigation actions, compensations for damage or, eventually, criminal liability. In this scenario, the first great challenge was the necessity of public administration to take on and manage a disaster with no identified polluter-payer.

Considering it was an unexpected event and the Brazilian NCP was activated for the first time, this paper details and describes the oil spill event along the Brazilian coastline, focusing on the methods and actions performed by the Federal Government, related to the technical management of the incident. Thus, it presents a detailed description of the event and response management actions, especially Ibama´s, from the first oil record until March 20, 2020, when the NCP was formally deactivated.

Tools that enabled monitoring and oil spill response are presented and analyzed. In the discussion, the effectiveness of the adopted tools and management techniques are assessed, including a critical analysis of the global management context of the incident by the Federal Government.

This study does not include the analysis of documents referring to personnel and movement of materials. Logistics is addressed only when it is necessary for the technical management context.

ABBREVIATIONS LIST

Aquasis: Association for Research and Aquatic Ecosystem Preservation
AL: Alagoas (Brazilian state)
ANP: Brazilian National Petroleum, Gas and Biofuels Agency
BA: Bahia (Brazilian state)
CE: Ceará (Brazilian state)
ESA: European Space Agency
IBAMA: Brazilian Institute for the Environment and Renewable Natural Resources
ICMBio: Chico Mendes Institute for Biodiversity Conservation
IPC: Incident Command Post
ICS: Incident Command System
IEAPM: Almirante Paulo Moreira Marine Study Institute
INPE: National Institute for Space Research
GAA: Monitoring and Evaluation Group
GPS: Global Positioning System
MB: Brazilian Navy
MA: Maranhão (Brazilian state)
MMA: Brazilian Ministry of Environment
NCP: National Contingency Plan for Oil Pollution Incidents in Waters Under National Jurisdiction
NGO: Non-profit organization
OSRV: Oil Spill Response Vessel
PA-BTS: Baía de Todos os Santos Area Plan
PA-BAAR: Baía de Aratu Area Plan
PA-ES: Espírito Santo Area Plan
PAE: Emergency Action Plan
PB: Paraíba (Brazilian state)
PE: Pernambuco (Brazilian state)
PEI: Individual Emergency Plan
PETROBRAS: Petroleo Brasileiro S.A.
PNRS: National Policy for Solid Waste
PPE: Personal Protective Equipment
RJ: Rio de Janeiro (Brazilian state)
RN: Rio Grande do Norte (Brazilian state)
SCAT: Shoreline Cleanup and Assessment Technique
SE: Sergipe (Brazilian state)
SEI: Electronic Information System
SIPAM: Amazon Protection System
WG: Working Group

MATERIALS AND METHODS

In this paper, actions performed by the Federal Government, especially by Ibama, were identified. The execution method and results of each action were also studied. In addition, this work explores how the incident was managed, initially by Ibama, and later by the GAA. To understand and evaluate the agility of the Government response, the actions were arranged chronologically.

The work consisted initially in gathering the documentation produced by Ibama and the GAA – such as Technical Notes, Letters, and Reports, many of which were produced to meet judicial demands, which provides strength to their legitimacy.

Consulted documentation was obtained through Ibama´s virtual environment for documental management ("Sistema Eletrônico de Informação" or "SEI-Ibama") (Ibama 2020). When documents were not available on SEI-Ibama, information was obtained via official websites, through e-mail from the official source and by direct contact with strategic public agents involved in management and response (e.g., instant messengers file trading). Once received, these files/documents were formally registered on SEI-Ibama. Finally, Brazilian regulations associated with this event and the intended analysis were also consulted.

Documents gathered and consulted from SEI-Ibama (detailed expansion of the reference "Ibama 2020") are listed in Table I.

Once all the essential information was gathered, a descriptive report of the disaster was built, in which the actions were classified by topics and chronology. Thus, creating a report with the most complete possible scenario of the event from official documentation, considering the Federal Government actions since it started.

After this step, a critical conclusive analysis about the effectiveness of each performed action was possible and accomplished, assessing the managing options by the incident command according to available resources. Although this work was conducted through the perspective of one national agency (Ibama), it is based on official information of several institutions involved in the response management actions. These conditions permitted an objective critical analysis, even though it was centered on one specific angle.

RESULTS

Timeline

The timeline was built according to available documentation collected from SEI-Ibama (Ibama 2020) presented in Table I.

On August 27, 2019, Ibama was informed about an accident the occurred the day before, at "Abreu & Lima" Refinery, in the state of Pernambuco. Once aware, Ibama inspected the area next to the refinery and moved an oil spill detection aircraft to the region. The airplane departed from the southeast region of Brazil and, on August 31, Ibama started aerial monitoring of the northeastern Coast, with this fixed-wing aircraft specialized in oil spill detection.

When the first oil fragments came ashore, they were thought to be related to this incident at the refinery, but this hypothesis was subsequently discarded, as clarified in technical reports included on SEI (Ibama 2020). On September 3 at dawn, the emergency team of Ibama in Pernambuco recorded oil spots at "Boa Viagem" beach, Recife, PE. On September 5, Ibama started analyzing satellite images, to investigate suspicious features possibly related to the incident. Thus, satellite imagens started to be analyzed specifically for this incident,

Table I. Official documents obtained through SEI-Ibama (Ibama 2020).

Identification	Description
02001.024716/2019-36	Communication from Abreu & Lima Refinery - PE
02001.029046/2019-44	Aerial monitoring reports
5880064	Oil records at Pernambuco
5887072	Internal request for satellite monitoring
02001.031437/2019-29	Cosmo Skymed images
5919275	Oil records at Rio Grande do Norte
02016.001532/2019-39	Oil records at Paraíba
02007.003125/2019-75	Oil records at Ceará
02003.002120/2019-65	Oil records at Alagoas
5923360	Support request from Ibama to Petrobras
5933364	"Administrative Requisition" from Ibama to Petrobras
6012416	Documents from video conference of Ibama's inspection teams
6031656	Technical guidelines distributed to municipalities
7156700	Technical guidelines distributed to municipalities - send to Public Prosecutor's Office
6233676	NCP activation communication Letter (Ibama)
7636972	NCP demobilization Letter (GAA)
9354682	Ibama's documentation worksheet generated from the incident
6326154	Technical Note about Federal actions in response to Public Civil Action
6350220	Technical Note about consolidated actions until November 6, 2019
7140873	Technical Note about consolidated timeline until March 3, 2020
6898984	Technical Report of Incident
6281409	Technical Note about Ibama's satellite monitoring
02001.030383/2019-84	ICS 209 forms and maps, after NCP activation
02021.001671/2019-93	ICS 209 forms and maps, before NCP activation (Ibama)
02019.003440/2019-63	ACCEL ® remediation request
2808447	NCP Manual

in addition to the routine aerial and on-land monitoring.

On September 2, Ibama in the state of Paraíba (Ibama-PB) was contacted through telephone by the Municipality of Conde, communicating the presence of oil on its beaches. On the same date, Ibama contacted the Navy, which collected the first samples and inspected the coast of Paraíba for the first time. Ibama-PB maintained contact with the Port Captaincy and environmental departments of the municipalities to obtain information about the event, starting its own inspections on September 11.

On September 7, Ibama in the state of Rio Grande do Norte recorded oil fragments on the "Via Costeira" beaches. On this date, collecting of samples was required by the Navy.

On September 18, Ibama-PB received a Letter from the Municipality of Cabedelo, communicating oil fragments recorded since September 1. On September 23, the Municipality of Conde sent a document to Ibama-PB, formally

communicating that they first recorded oil on August 30.

In the state of Ceará, the emergency team of Ibama – Ibama-CE was contacted by the "Association for Research and Aquatic Ecosystem Preservation" - Aquasis, reporting the occurrence of an oiled marine turtle on Sabiguaba beach, Fortaleza. The event occurred on September 1st, according to the communication (dated September 10). On the communication date, Ibama inspected the area and confirmed the presence of oil.

In the state of Alagoas, the first communication about oil on the beaches was on September 8th, by a team of "Chico Mendes Institute for Biodiversity Conservation" - ICMBio, which sent documentation about these first records to Ibama.

As can be observed, the first communications about records of oil were sent to Ibama dispersedly and through several different means, and not by formal communication from the polluter, as it should have been. Additionally, it was not possible to conclude, at that point, that all these records were related to a single event, instead of from several simultaneous occurrences, from different origins, as it originally seemed to be.

According to consulted documentation, "The first observations of oil on the coast did not produce to immediate response, either because it was only about some oiled carcasses, or by the disperse distribution of these oil spots. In touristic locations, the first fragments were removed by the local merchants, as later reported to the inspection teams" (Ibama 2020).

Ibama noticed the need to involve other institutions in the oil removal when the beaches of the state of Rio Grande do Norte were affected, which happened with a substantially greater volume of oil than previous records. It was also observed that the Municipalities, which are responsible for the waste collection in their jurisdiction (Brazil 2010), did not have sufficient experience in managing oil waste and did not act promptly. Around September 9, the states of Ceará, Alagoas, and Pernambuco also registered difficulties in removing the oil, which was gradually reaching the coast in greater volumes.

Thus, Ibama initially required support from the state oil company – Petróleo Brasileiro S.A. (Petrobras), on September 10. The next day, the first Administrative Request was sent from Ibama to Petrobras, requiring beach cleaning. The "Administrative Request" is provided for in article 27 of Decree 8,127/2013, as follows: "The GAA may require from the responsible of any facility the goods and services listed on the corresponding Individual and Area Emergency Plans which are necessary for response actions, besides other available goods and services." (Brazil 2013).

On September 12, the various teams of Ibama which had inspected the beaches held a video conference, aiming to organize the available information at each state. From this date on, Ibama partially adopted the Incident Command System (ICS) as a management tool, using its standardized forms to gather information about the actions of Ibama teams in all localities.

Aiming to guide the actions of municipalities for oil removal, Ibama created a technical guideline document and distributed it to municipalities at several states, and to the Federal Prosecutor's Office on September 19, as a public and legal formalization of this action.

On September 16, Ibama contacted ITOPF (ITOPF 2020) for the first time due to specificities (continuous and increasing volumes of oil arriving at the coast) of the incident which required technical advisory. Ibama was remotely assisted by ITOPF professionals until September 27, when its first expert came to Brazil to assist Ibama.

As shown, from September 2 on, Ibama started the necessary articulation at the local level, as it was not yet possible to predict the behavior of the oil or the dimensions of the event.

Incident Command Posts – IPCs were set up beginning on September 9 on, through the initiative of Ibama, located as follows:

- 09/12/2019 - Ibama adopts ICS and installs an IPC at Natal, RN;
- 09/25/2019 - Ibama's IPC is transferred to São Luís, MA, due to the severity and ecological importance of the incident in that state;
- 10/02/2019 - Ibama's IPC is transferred to Aracaju, SE, due to the severity intensification of the incident in that state.

As the oil observations intensified across the northeastern coast, Ibama, MB, and ANP decided to join response structures, activating the GAA on October 14th, at the Second Naval District Command, Salvador, BA, considering that the state of Bahia, at that time, was the most severely affected location. The GAA was also joined by the National Civil Defense and ICMBio, enabling strategy definitions and operational actions. On October 26, the GAA was transferred to the Ministry of Defense headquarters in Brasília, DF, and to the First Naval District Command in Rio de Janeiro, RJ on November 29, always aiming to have the most feasible structures for the current defined priorities.

In addition to the requisitions from Petrobras since the incident started, once the GAA was activated in Salvador, the following additional resources were required from the company:

- The available resources from the Area Emergency Plan of Baía de Todos os Santos (PA-BTS) on October 17 (this plan was still under approval);
- Specialized offshore vessels for oil containment (OSRVs) on October 17;
- Equipment from the Manati Individual Emergency Plan - PEI of Petrobras on October 20.

Two Area Emergency Plans (PA)[1] of impacted areas were also triggered: PA of Baía de Aratu (PA-BAAR), on October 11, and PA of Espírito Santo (PA-ES), on November 13.

Throughout the response, specific tools to help facilitate and standardize the actions were used or even developed, such as the online form "JotForm" and the application "Olhos de Águia", which are addressed later in this work.

Starting at the end of December 2019, a decreasing curve in the relation of cleaned versus still oiled locations could be observed, implying the emergency was finally coming to an end.

On March 20, 2020, the Operational Coordinator formally demobilized the unified coordination involved in response and monitoring actions, as (in his words) "the emergency actions at the affected states were effective, the environmental damages remediated, and the final disposal of the oil wastes is flowing in an environmentally proper way." (Ibama 2020).

Figure 2 shows a timeline which includes the first records, the main actions performed by Ibama (or later by the GAA), and the IPC transfers, due to the emergency context.

[1] The PA, according to Decree 4,871/2003, is "a document or set of documents which contains information and actions referring to an area where organized ports, harbors, pipelines, or oil rigs are concentrated, aimed to integrate the several PEIs of the area to combat oil pollution incidents, as well to as facilitate and expand the response capacity of these plans and guide the necessary actions when the incidents do not have a known origin" (Brazil 2003). Brazil 2013 states that the PA activations are possible through the NCP, as a role of the Operational Coordinator.

Incident management

Incident Command System - ICS

ICS (which is a simpler adaptation but maintains its main principles) was implemented as the incident management tool, (Deal et al. 2006, FEMA 2017), due to its international consolidation and large usage among private institutions. It is also a common procedure for some Brazilian institutions, such as the Military Fire Department and the Civil Defense (Oliveira 2009, Defesa Civil – PR 2009, Sejusp – MS 2016, CBM-GO 2017, CMB-DF 2020, Defesa Civil – ES 2020). ICS is the standard managing tool defined in the Brazilian NCP, according to the article 21 of Decree 8,127/2013 (Brazil 2013).

The incident response was organized at three levels: national, regional, and local. The GAA occupied ICP at the national level, articulating the regional coordinators – located

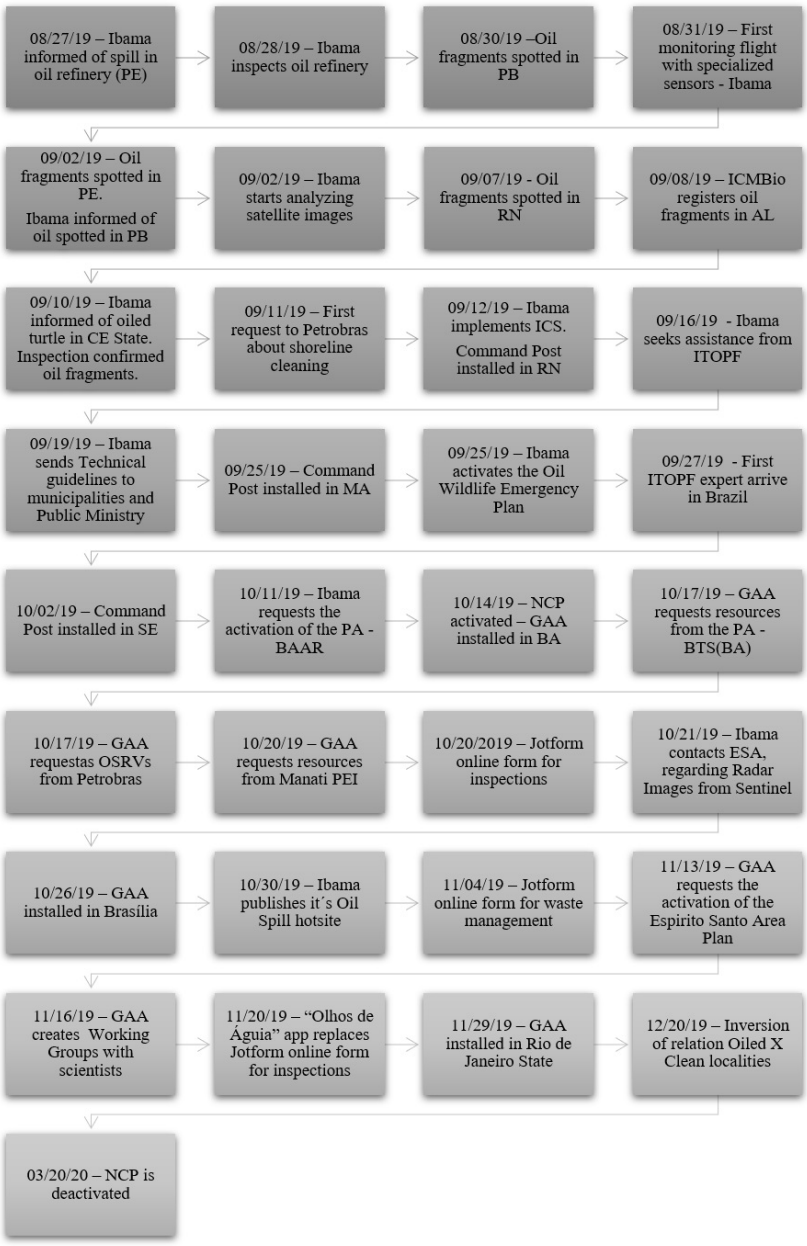

Figure 2. Oil spill timeline.

at the Naval Districts – which in turn articulated the local commands – usually located at the Port Captaincies. In general, federal institutions joined their actions with the GAA; state institutions joined the regional commands (including each state representations of Ibama); and, finally, the departments of municipalities joined the local commands.

In each operational cycle, the regional commands, through the Naval Districts, were required to send information to the GAA to plan for the subsequent cycle, as it is the protocol of the ICS and the Brazilian NCP Manual (Deal et al. 2006, Oliveira 2009, Brazil 2013, Ibama 2020). The operational cycles were defined as the situation required: in the most intense working periods, it used 24 h; in a less intense context, 72 h for instance, starting and ending at 12 pm (Ibama 2020).

Documentation and Communication

During the incident, documents were produced through three means: according to preexisting protocols from the individual institutions, whenever the requirements were specifically directed to each of them; through standardized ICS forms; and though NCP Manual forms.

Although the NCP manual was still not officially published until the end of this study, it was instituted by Decree 8,127/2013 and approved by the "Executive Committee" in March 2018 (Ibama 2020).

Specifically, at Ibama the official documents are produced and registered in SEI-Ibama, which is the standard environment for official documentation of the Federal Government, even though federal institutions have not adopted the SEI yet. SEI-Ibama is a public-access, but regulated, system: external access to documents is granted for a determined time as formally required, through a temporary link sent to the specific e-mail address (Ibama 2020).

For the writing of multiagency documents, such as the GAA, the ICS, and NCP Manual forms were used, eventually adapted to the situation needs, as well as Letters identified and signed by the GAA, even if they were not created in any of these systems. They were later inserted into SEI-Ibama, from where they could be more easily obtainable (Table I).

The main communication channel to civil society were the official websites, where the institutions published their updated information. Ibama created its own oil spill website, which included: updated map of affected localities, technical guidelines, informational material about safety, and others.

Besides the necessity to provide information to civil society, the incident managers were also required to respond to demands of several judicial and regulatory institutions. By the end of the emergency, 56 administrative document processes were registered with such requests (Ibama 2020). This situation imposed an extra workload on an already overloaded team. According to the document identified as 6326154 in Table I (originally in Portuguese), "It should be noted that the countless judicial or civil demands are overloading the technical team of Ibama, which have been working exhaustively for more than forty days, 12 h per day, to solve an unprecedented and extremely complex problem. Unfortunately and perceptibly, Ibama has been charged as a polluter, instead of the technical institution heading all this response work, guiding actions based on the best feasible practices applicable. The required deadlines for returning these demands end up taking away personnel from the technical area, which is detrimental to the already intense and continuous work performed" (Ibama 2020).

Technical and Scientific Advice

The Unified Command demanded an advisory body from Academia and experts from ITOPF (Ibama 2020, ITOPF 2020). ITOPF is an international organization which, among other things, offers training and expert advice in the field of oil spills and provided the Command at least one expert for each operational cycle, until December 10, 2019. One of the most relevant products of this partnership was the technical guidelines for clean-up operations. ITOPF also provided valuable decision-making assistance and in-field training and advice (Ibama 2019).

On November 16, 2019, the GAA created seven Working Groups – WGs under the coordination of Professor Dr. Ricardo Coutinho, from "Almirante Paulo Moreira Marine Study Institute" - IEAPM: WG1 – Numerical modeling and remote sensing; WG2 – Evaluation of Biotic and abiotic factors; WG3 – Evaluation of Socioeconomical impacts; WG4 – Protected areas; WG5 – Beaches; WG6 – Mangroves; and WG7 – Reefs. These WGs aimed to propose alternatives for monitoring, remediation, and recovery of the ecosystems affected by the spill, in the short, medium, and long terms (MB 2019b, MB 2019c).

Academia was also requested to analyze specific actions, such as testing of containment booms and other cleaning techniques applicable for those localities where the ongoing methods were not feasible or efficient. Several Brazilian Universities as well as national and international companies were involved in research and oil sample analysis to investigate its origin (Ibama 2020).

Human and material resources management

For personnel management, each involved institution was accountable for its own mobilization, including transportation and accommodation. Typically, this team organization took place at the local level, prioritizing the available workers near the targeted localities and mixed teams with people from all the institutions, aiming to meet the GAA planed actions. In the ICS, the Logistics Section is responsible for controlling and distributing the personnel in each operational cycle (Oliveira 2009, Ibama 2020).

Equipment and materials were allocated according to demands of regional and local coordinators. Once available at these local commands, the equipment was directed to the Port Captaincy or Civil Defense facilities for distribution. The equipment acquisition took place by different means, including, direct buying with GAA institutions own resources; administrative requisition from Ibama to Petrobras; and donations.

Developed actions and tools

Under the coordination of Ibama at the very start of the event and, after October 14, under the GAA and the operational coordinator, several actions were performed, targeting different defined goals according to each ICS operational cycle, as stated in the documents studied for this paper. Besides the coordination and management actions already described in the earlier the GAA articulated the following field activities:

- Monitoring and inspecting: aimed to identify the status of the affected or potentially affected localities, including on-land, aerial, aquatic, and subaquatic operations;
- Cleaning: direct combat in the affected areas, through oil removal as technically feasible, which varied for each environment;
- Waste management: to provide environmentally proper temporary storage, transportation, and final disposal.

Monitoring and Inspections

Planning and execution

Monitoring and inspection activities started in September, 2019, in a decentralized way, with no unified standard protocol or tool common to all institutions and localities. This situation generated a large volume of information, which demanded detailed analysis and organization, costing the teams unplanned extra time to put data into worksheets, publish, and even using it as a base for decision-making. Thus, there was a need to implement some unified instrument for standardizing all the field-collected information.

Considering the difficulty of predicting the behavior of the oil, information about its occurrence on beaches were first obtained through diverse channels, such as the press, social media, and complaints. With such information, the GAA was able to designate teams to inspect the area, aiming at first to confirm the existence of oil fragments and estimate, if applicable, the necessary cleaning efforts. If the presence of oil was confirmed, the proper response technique was then defined, based on the technical guidelines produced by Ibama and ITOPF; the necessary equipment and resources were identified; and a cleaning up team was designated (Ibama 2019). All these actions were recorded on the specific ICS form.

Thus, for monitoring and inspecting activities, two different tools were adopted: "JotForm" and "Olhos de Águia" (Ibama 2020). Both platforms were accessible to all institutions of the Unified Command. Their main function was to feed and update the map of affected localities, helping to direct combat efforts to the most severely impacted or strategically important areas.

JotForm

JotForm[2] was an online fill-in form to be used during monitoring/inspection visits. It was accessible through a website which demanded on-time internet access for synchronizing the recorded information. JotForm was implemented on October 20, 2019, after continuous efforts started by ITOPF to systematize information gathered from field.

JotForm permitted the attachment of up to three photographs of the oil record, which should be made through auxiliar georeferencing application for the camera, and the information was downloaded as a custom spreadsheet (the user could manually choose the columns of interest). Besides the georeferenced pictures, this form included qualitative information such as: name and institution, inspection date and place, contaminated area extension, the existence (or not) of clean-up teams on site, amount of removed waste, and the classification of the oil distribution according to the Shoreline Cleanup and Assessment Technique – SCAT methodology (NOAA 2020).

The SCAT technique was simplified for the conditions and the diversity of institutions involved, the familiarity with the related terminology, the scope of the method, and the technical abilities of the available personnel. This method considered the conditions of the oil occurrence according to the following categories:

- Oiled Locality with stains/patches, when more than 10% of the area is contaminated with oil;
- Oiled Locality with traces, when less than 10% of the area is contaminated with oil;
- Locality with no observed oil.

This same methodology professes the segmentation of affected areas into monitoring

[2] https://www.jotform.com/pt/

zones. Thus, based on the official shoreline procedure as published by IBGE 2017, consulted documentation states that zones of 1000 meters long to 500 meters wide were generated, which were periodically inspected.

For instance, the most affected areas were inspected daily, whereas the less accessible areas could be inspected in more spaced time periods. The local toponymy was attributed to each defined zone.

Olhos de Águia

Olhos de Águia is an application available for Android and IOS systems that was developed by the "Amazon Protection System" - SIPAM, from the Ministry of Defense. It stores local information regardless if internet access is available or not at the location. This application has already been used for forest fire control and was specially adapted to oil spots monitoring, within an articulation between the GAA and SIPAM, during this emergency state. It was instituted to replace the JotForm on November 20, 2019.

It was limited as only one picture could be uploaded on each record, but it automatically georeferenced the points through the GPS of the device, and stored information offline, for synchronizing whenever internet access is available. It includes field for free-writing additional information on its recording form, besides three mutually exclusive markable options related to the same SCAT classification which was used on JotForm. Once the information is synchronized, the outcome because a data spreadsheet on which a search filter may be applied.

Information synchronizing should preferably take place until 11h59min on the last day from the operational cycle, so the information could be used to compose the updated map of affected locations, to be published at the end of the same day (18h00min).

At the beginning, the general guidelines oriented records to be made only in locations where oil was observed. Later, once Olhos de Águia was already instituted as the registry tool, the GAA decided that all inspections should be standardized, so the records must be made in every "SCAT situation" (oil stains, oil traces, no oil) and at each 1 kilometer of shoreline. The record should include a measurement instrument for the spots or vestiges: whenever possible, a pachymeter or measuring tape; if these are not available, a comparative object as a pen or even body parts (hand or foot overlapping the oil without touching).

The related map was produced with the Desktop Geographical Information System –QGIS and enabled the automatization of mapping based on the processing models of the system, which collected information from the field reports recorded on JotForm or Olhos de Águia. (QGIS 2020).

Remote Sensing

According to article 12, item XII-a of Decree 8,127/201, it is up to the "National Institute for Space Research" – INPE "to provide information obtained through satellites and space technology, about weather forecast, climate, oceanography, and water resources for environmental protection and other legitimate interests eventually affected by oil spill events" (Brazil 2013).

Additionally, the GAA, through Ibama, performed remote sensing across Brazilian waters aiming to detect in advance any oil pollution features. All northern, northeastern, and southeastern coasts were monitored by optical and radar imaging from satellites since July 1, 2019. This analysis was done to the geographic (easternmost) limits of the satellite

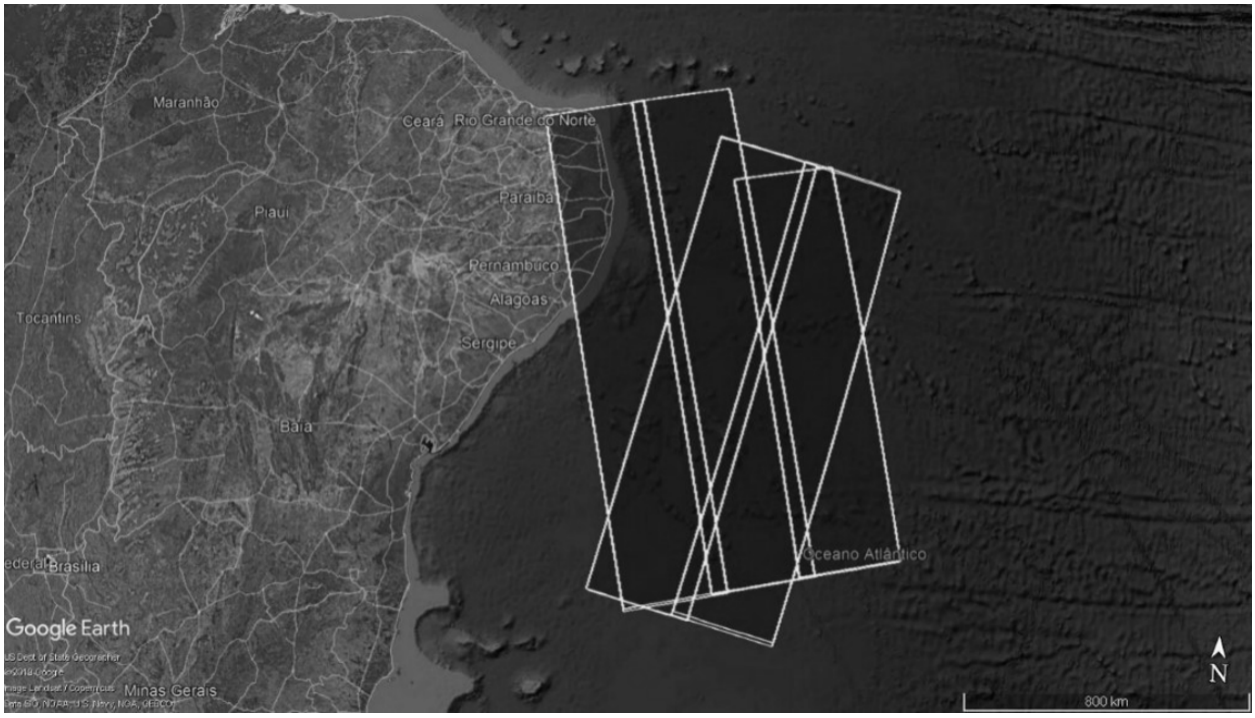

Figure 3. Sentinel 1 expanded covered area (Ibama 2020, Source: ESA).

imagery available at the time, and the produced information was sent daily to the GAA to assist decision-making. As the origin of the oil could be away from the area covered by the satellites, Ibama contacted the European Space Agency – ESA to expand the area covered by satellite Sentinel 1. The ESA promptly responded to Ibama´s request, with no costs for Ibama as shown in Figure 3 (Ibama 2020).

Besides free available satellite imagery and ESA contribution[3], Ibama also required Petrobras to move the satellite CosmoSkymed northeast, which started monitoring the affected area on October 30, 2019. Ibama has commercial access to these images due to a commitment term signed with Petrobras. This term also grants Ibama the use of a specialized aircraft named Poseidon, aimed at detecting oil on the sea surface. Starting on August 31, 2019, Poseidon flew 141 hours through northeastern and southeastern coasts, and 59 reports were produced (Ibama 2020).

The absence of detected oil spots on the sea surface by all these sensors suggested that the oil did not drift on the water surface, but under it.

Cleaning

Coastal environments cleaning

It is important to highlight that cleanup actions were the only feasible combat technique due to the peculiarities of the event. As the under-surface drifting of the heavily weathered oil led to ineffective results from containment booms, dispersants, and specific remediators tested (Ibama 2019, 2020).

The cleaning techniques varied according to the affected environment, which were previously listed by the MMA 2020, so the scientific and

[3] Complete specification of all the satellites used in this event is available at the document identified by "6281409" in Table I. They are Sentinel 1A, 1B, 2A, 2C, and 3 (from ESA); CBERS 4 (from INPE and Chinese Academy of Spatial Technology – CAST); Landsat 7 and 8 (from NASA); Terra/Modis and Aqua/Modis (from NASA).

expert advice was a determining factor in the decision-making. The cleanup actions were mainly executed by teams from the military sector (army and navy) coordinated by the GAA, Petrobras personnel, civil community volunteers (NGOs, companies, and independent civilians), personnel of municipalities, trained personnel hired from specialized response companies by local governments and firefighters from Ibama and ICMBio.

The materials used in these actions were mainly related to the manual removal of oil, eventually assisted by machinery, such as shovels, rakes, spatulas, brushes, buckets, big bags, canvas, absorbent blankets, pick-up trucks, excavators, cranes, fine mesh nets, and small vessels. Designated personnel were required to use proper PPE according to the situation (Ibama 2019).

The role of Ibama in the clean-up actions was supervising and technically guiding the workers, as well as indicating environmental priority areas. Besides the availability of resources (equipment and trained personnel), the guiding criteria for decision-making about the applicability and feasibility of cleaning techniques was the optimal minimization of environmental and socioeconomic impacts. Some environments, such as mangroves, should preferably not undergo any intervention due to the sensitivity of contamination, meanwhile fishing and tourism-based regions could not remain under only natural oil depletion due to their economic importance, demanding some cautious actions (Gundlach & Hayes 1978, Cantagallo et al. 2007, Ibama 2019).

When cleaning was done by companies or hired personnel, the financial costs were covered by local governments and eventually entrepreneurs, or through administrative request from the Federal Government to properly train and equipped companies. According to Brazil 2013, NCP professes that it is up to the Federal Executive Branch to fund cleaning actions for as long as the polluter is still unknown (but counting on later identification and refund). The NCP Manual additionally states that the National Authority is responsible for determining expenses and providing refunds to the non-polluter actors. (Ibama 2020).

Wildlife

On September 25, as oiled animals and carcasses continuously washed ashore on the northeastern coast, the National Emergency Plan for oiled wildlife was activated (Ibama 2016, 2020).

Consulted documentation reveals that, initially, teams from Ibama acted in gathering information about the institutions and structures available for receiving these demands. Six institutions were identified as possibly actionable for monitoring, rescuing, stabilization, decontamination, and rehabilitation of oiled wildlife. As scenarios were frequently altered and the oil kept moving to other regions, other institutions voluntarily joined Ibama and ICMBio.

Ibama 2016 describes how actions to protect vulnerable or affected wildlife should be driven. Therefore, actions were performed as follows, according to documentation made available by Ibama 2020.

"Primary actions", aiming to prevent the arrival of oil at locations were wildlife occur: installation of booms at manatees (*Trichechus manatus*) enclosures, located in the river Tatuamunha (Porto de Pedras – AL);

"Secondary actions", aimed to prevent animals from being touched by the oil or contaminated areas: preventive capture of 3862 oil-free turtles hatchlings from nests located in the states of Bahia and Sergipe (which were later freed on secure areas) by ICMBio and partners; manatee monitoring in the states of

Sergipe and Alagoas by volunteer institutions in partnership with Ibama and ICMBio; collection of oiled animals and carcasses to prevent further contamination, and, whenever possible, submitting these animals and carcasses for investigation of *causa mortis* and oil sample analysis;

"Tertiary actions", aimed to manage the oiled animals: capture of live oiled animals for stabilization, cleaning, rehabilitation, and release (whenever possible) by several partner institutions.

Besides these operational actions, Ibama produced guidelines for civil society, local environmental departments, and wildlife rescuing teams about how to proceed with oiled wildlife (Ibama 2019).

Remediators

During the emergency, several manufacturers were interested in testing and/or applying products that aimed to remove oil from the environment, through physical, chemical, or biological processes.

According to Brazil, 2014, remediators are regulated. Prior to use of the product in the natural environment, the company must obtain specific registration at Ibama and authorization from the competent environmental state agency.

To allow the test/application of products in an environmentally safe way, but faster than the usual bureaucratic procedure for registration, Ibama published a Normative Instruction (Brazil 2019b) that created a "Special Temporary Registry" for remediators. Such possibility was created exclusively for the 2019 oil spill incident, considered a critical and exceptional situation (Ibama 2019). Ibama supervised some tests with these products. However, effectiveness in oil removal was not observed.

Training

Apart from personnel from Petrobras, in general, the workers who carried out the cleaning did not have specific training on oil removal. Therefore, training was provided by Ibama, ITOPF, and Petrobras (Ibama 2020). The formal trainings occurred on the following dates and places: Ilhéus, BA - 11/07/2019; Porto Seguro, BA - 11/09/219; Salvador, BA - 11/13/2019; Aracaju, SE - 11/11/2019; Maceió, AL - 11/14/2019; Recife, PE - 11/11/2019; João Pessoa, PB - 12/11/2019; Natal, RN - 11/13/2019; and Fortaleza, CE - 15/11/2019.

Basic training was also carried out during the service transition between the Petrobras teams and the military forces.

Waste management

First, it is important to define that the term "waste" refers to the oil contaminated waste generated after the cleaning efforts. This waste consisted of oil, as well as oiled sand, earth, rock fragments, PPEs, seaweed, etc. The volume of oil in the total waste varied with the response technique and the efficiency of the response teams in each location.

As described in Ibama 2020, the final waste disposal was carried out by local administrations; partnerships with private companies interested in receiving the waste for productive purposes (e.g., cement plants); Petrobras, following a request by the GAA.

According to the National Solid Waste Policy - PNRS, Municipalities are responsible for the integrated management of solid waste generated in their territories, supported by States (Brazil 2010). Therefore, role of the GAA was technical guidance, articulation, and information about waste handling.

During the emergency, approximately 5,000 tons of oily waste were collected and monitored by the GAA during the entire period and in all stages, from the collection on the beaches to

their final disposal, in partnership with the responsible entities.

To promote and update the record of waste volume collected in the Brazilian states, the GAA provided a spreadsheet that was filled out by the state environmental agency and sent to a specific GAA waste management e-mail. On the spreadsheet, the state reported daily the volume of waste collected and sent to final disposal per day (in tons). The total volume was published periodically by the GAA on the SCI 209 form (Deal et al. 2006, Oliveira 2009, Ibama 2020).

The monitoring of temporary waste storage was carried out through site inspections, registered in a specific online form (JotForm), as of November 2, 2019. The inspecting agent should enter the location, storage condition, local structure (floor, roof, insulation), deadline for transportation, probable destination, and pictures. The GAA monitored the waste JotForm on a daily basis and the survey updates were disclosed on maps created by GAA's own geoprocessing team.

DISCUSSION

Management actions

Although there was criticism about a supposed delay in the federal government actions, as in Soares et al. 2020, the timeline (Figure 1) and the documents referenced in this paper suggest that Ibama was proactive from first communication, even before the dimensions and characteristics of the event were known. Therefore, it is possible to consider that any ineffectiveness eventually pointed out by external observers must be attributed to the characteristics of the event itself, and not to the lack of sufficient action by the environmental institutions.

Another possible explanation for the negative public impression about the government´s performance was a deficiency in communications. Although there were earlier interviews and press releases, the regular publicity began only on October 30, 2019, with the creation, by Ibama, of a specific website in which all the consolidated information about the oil spill response was available. Once the site was online, public information became transparent and materialized as a reliable source of updated information on the spill.

The use of ICS since the beginning of the emergency - on 9/12/19 - was assertive, given it allowed organized documentation through predefined forms. Some forms of the NCP Manual were added to the management, such as the so-called "NCP-14", when the plan was formally activated. The ICS procedures, even if simplified and adapted, from the beginning, allowed the integrated management to move forward in operational actions, with less impasses on how to manage the situation.

Forms ICS 202 and 209 (Deal et al. 2006, Oliveira 2009) contained planning and actions for each operational period. As a result, activities were prefixed to avoid randomness or loss of information. The use of ICS, however, needs to be better understood by institutions, even within the Federal Government. For example, the "Administration and Finance" section of the ICS, an important function to keep track of the expenses, did not have a person responsible for it during almost the entire emergency. Such a person could have made a great contribution to both organization and systematization of financial accountability.

Still in this context, the first major difficulty observed in dealing with the multilevel character of this incident was the flow of information between federal entities. While the Federal Government had a command flow due to the use of the ICS, there was no early integration of local and state authorities in the same flow, which occurred after an adaptation

period that varied between locations. Some Brazilian institutions already do or intend to implement the system as a managerial tool (Civil Defense - PR 2009, Brazil 2013, Sejusp - MS 2016, CBM-GO 2017, CMB-DF 2020, Civil Defense - ES 2020). However, local administrations and some state institutions were not familiar with ICS, its principles, and documents. If this tool had already been implemented and practiced at the national level, some constraints would have been avoided.

The GAA had some difficulties obtaining regional information on affected areas, which was an obstacle to define strategy and the needed to be worked around in each location. Communication by official documents was often not effective due to bureaucratic issues, and the local administration was often intensely dedicated to the emergency itself, sometimes without available staff for the simultaneous and routine administrative work.

The scientific community was also involved in an organized manner only after the creation of the Working Groups, on November 16, 2019. The involvement of the scientific community, under the command of IEAPM, organized previously dispersed initiatives from academia, bringing together a large group of researchers with a single objective (MB 2019a). The availability of advisors with technical expertise and the scientific community were fundamental to the technical quality and effectiveness of fieldwork and reinforced positive public impression of each strategic decision.

Most of the GAA technical guidelines were possible and produced with the support of the international partner ITOPF, which accompanied and provided technical guidance on strategic decisions, when needed.

In a second stance, some local administrations alleged that they could not continue to respond to the emergency, due to lack of financial resources, and requested aid from the federal government. This situation imposed an even greater responsibility on the federal level (GAA). In fact, Decree 8,127/2013 addresses, by competence, only the actions of the Federal Government, leaving gaps in the responsibilities of the other entities and in the mechanisms to promote training and prior interaction between the three levels (Brazil 2013).

The participation of Ibama officials in the local coordination forums was decisive to promote mutual solidarity, increasing the concept in which the federal government was a partner, not an observer or the only responder, as was a frequent misconception.

The effectiveness of this dialogue can be best observed in waste logistics, a situation in which the federal government, for instance, provided big bags and basic equipment, local administrations provided temporary storage, and the transport to the final disposal site was shared with the federal government (Ibama 2019).

The continued need to answer to and comply with numerous legal orders was a challenge and a burden on Ibama´s technical team. Some determinations, usually local and decentralized, did not correspond to the reasonableness or technical proportionality of the resources available and were even out of technical context, considering the nature of the incident. Professionals who could be better employed in priority actions had to be detached from the management team to respond to such requests.

Tools and actions performance

The GAA encouraged joint inspections and standardized data collection, first without a specific software, then using Jotform and, later, with the Olhos de Águia application. Until the

widespread use of Jotform, data collected in inspections varied from day to day and had no standard collection procedure among institutions, or even among teams from the same institution. This brought difficulties for incident management, reflected in technical difficulties to produce the daily map accurately. There was a daily flow of information about places surveyed via electronic messaging applications, which, although agile, were difficult to compile and represented a very informal (not standardized) communication.

In addition, if different organizations inspected individually the same location, the information would diverge at various levels, generating conflicts. Then, Ibama 2019 standardized the classification that should be attributed to the visited beaches according to technical criteria and defined the geographical space in which the records should be taken.

Exact data collection location was a limitation in JotForm: the location information would be linked to the place where synchronization was possible, through wi-fi or mobile network. This caused location errors that, if not corrected manually by the map editing team, could render the information invalid. Manual correction depended on the user's proactivity in using an accessory camera application that recorded the date, time, and coordinates of the photo. Otherwise, for example, a register in a location with no data network available, when synchronized in an urban center, ended up reporting the occurrence of oil in that urban center. This was the major bottleneck that demanded the shift to the Olhos de Águia Application.

JotForm use was then ended and a note in the current link guided the users to Olhos de Águia application. The shift date was also publicized beforehand through the GAA electronic communications groups.

The Olhos de Águia application, although limited to only one photo per record (whereas JotForm allowed three), saved the registration according to GPS information, even in places where upload was not possible. When synchronization was performed, the information collected contained the location saved at the time of registration. The limitation in the number of photos was overcome with the formalization of the monitoring and inspection protocol established by the GAA (at least one record in each 1 km range). Therefore, the quality of information and the reliability of the map of affected locations improved after these adaptations were implemented.

The consolidating trajectory was long, but the periodic map finally presented solid information, becoming the main general reference to the affected locations situation.

With Olhos de Águia, the panoramic view of the situation was presented through a simple but effective key (Figure 4 a, b, c and d). The spot-shaped icon varied between green, gray, and black, meaning, respectively, clean, oiled - fragments, and oiled - patches. Ibama 2019 presents the technical distinction between fragments and patches for registration purposes.

Cleaning effectiveness

The main cleaning technique was manual collection of oil. Occasionally, scrapping was suggested, in situations where the rocky environment would withstand the intervention and the permanence of the oil was more harmful than its removal. When possible, sunken oil removal was desirable, as the stranded oiled could become a source of potentially continuous beach pollution. For submerged removal, a specialized workforce (divers) was required.

The use of machinery was strongly advised against, except in specific situations. The wide spread use of heavy machinery could increase

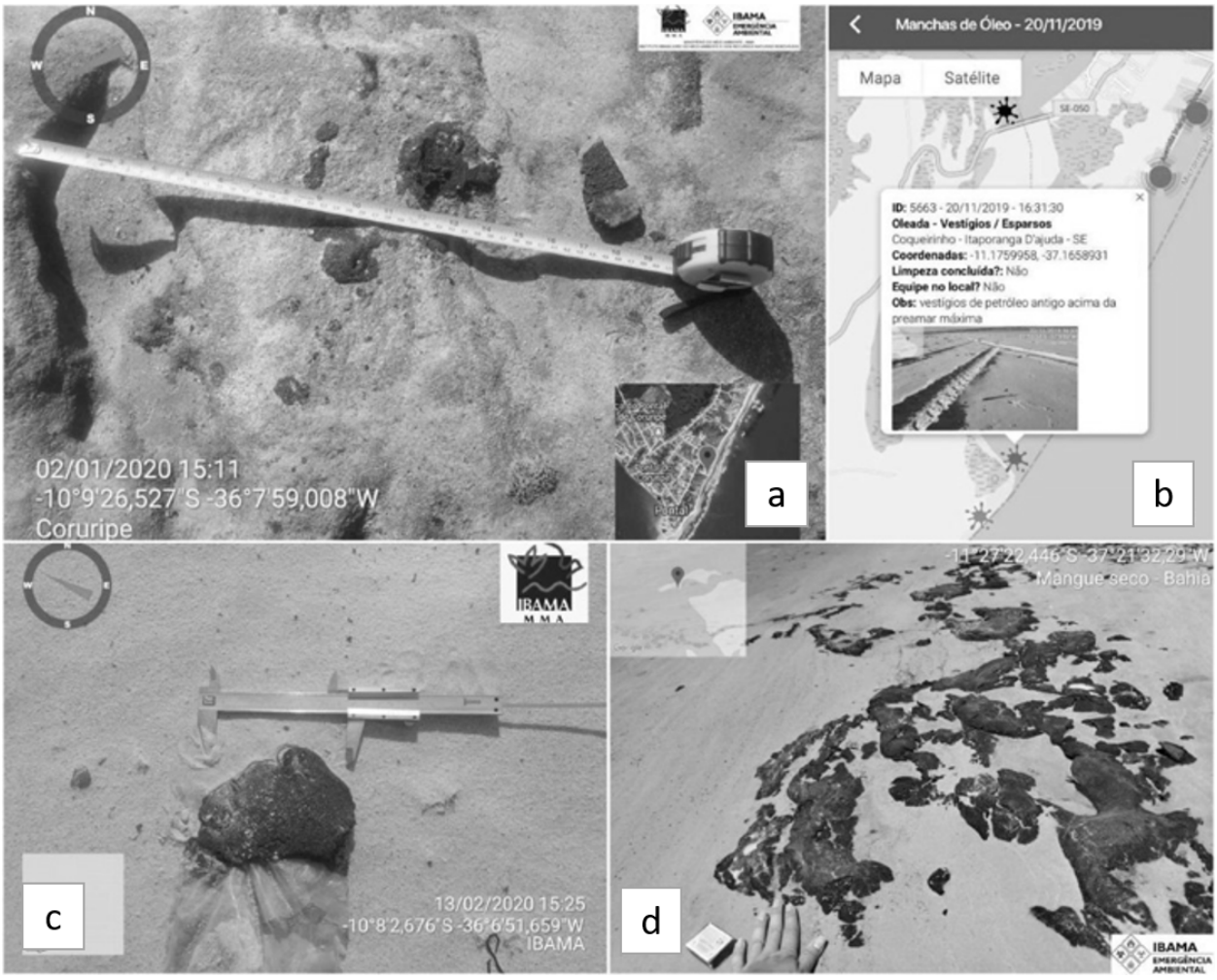

Figure 4. Examples of data in Olhos de Águia application (a - oil fragments compared to a measuring tape; b - view of the application's output data; c – oil fragment measured with a caliper; d – oil stains compared to the recorder's hand).

the amount of oil contaminated waste, as well as the impacts of opening the access. Moreover, it meant a level of intervention in the environment that could permanently impair its capacity for regeneration, especially in areas close to mangroves. In these areas, any intervention was totally unsuitable (Gundlach & Hayes 1978, Cantagallo et al. 2007).

Ibama was often questioned by the civil community, including in court, about the use of booms to collect oil at sea or to protect sensitive areas. The scientific support of the advisors was decisive for this clarification. Tests were conducted, and the results were unsatisfactory, due to the peculiarities of this incident, such as the weathered oil moving in the subsurface, crossing the booms with ease, among other technical issues (Ibama 2020).

In the first weeks of the emergency, oil reached the beaches daily and in great volume. At that time, the response was intense, but still disorganized. The presence of volunteers was a factor of great effectiveness to the cleaning effort. However, the lack of guidance and previous training left critical gaps, such as occupational hazards and lack of precision

and standard in the oil collection. Because protocols were not easily available or were not used at first, collectable oil was sometimes left in the environment. After this period of reactive combat, Ibama and ITOPF (and Petrobras, as requested by the GAA) trained joint companies, NGOs, and local governments, on how to collect oil safely and more effectively.

The Civil Defense played an important role in the management of volunteers from various institutions or even individual civilians. The participation of the National Secretariat for Civil Defence and Protection in the GAA, as of 10/16/2019, contributed to the creation of a link with local authorities (Ibama 2020). One of the first actions of this entity was a daily contact with the municipalities, which helped to bring together actions of federal and local governments. The management of volunteers, in fact, is a point that needs to be developed in a future revision of Decree 8,127, considering that the topic is not even addressed in the current regulation.

In some locations, recurrent records of oil in areas which had already been cleaned triggered a new alarm in public opinion about the effectiveness of the action. The reasons for recurrences were diverse, such as natural movement of tides and re-emerging buried waste, situations that were already expected. This generated weariness both for the cleaning teams – repeatedly sent back to areas that had already been cleaned – and for the management– which faced an external critical eye without, but could only act by directing personnel to local clean up whenever the presence of oil was verified.

As a general result, in December 2019 the reduction of tourism and the primary environmental impacts were already reversed in several locations. Thus, the cleaning efforts came to an end at each site, after 21 days without observation of newly arrived oil, or considering the environmental cost-benefit of further cleaning to each environment (Ibama 2019, 2020).

The volume of waste generated demanded special logistics. The main problems for local administrations were the lack of a location for correct disposal ("Class 1" landfills); unavailability of regular transport for the destination; lack of protocols for controlling temporary disposal sites and accounting of the amounts; lack of standard information about the waste still to be collected; and delays in providing information to the GAA.

At first, some local administrations were responsible for the waste logistics. However, in addition to some mistakes such as the destination to regular landfills, the municipalities declared economic unsustainability, passing on the task to the federal government. There was a period of "wear and tear" dialogues between local and national authorities aiming for proper integration, since continuous solidarity action was essential. The municipalities should have locations suitable for the temporary storage of waste, properly accommodated in big bags wrapped in canvas to prevent leakage. This protocol was encouraged with the dissemination of the official technical guidance (Ibama 2019). Local teams should also share the temporary storage location, so that the cleaning teams could transport the volumes collected daily, and the GAA (federal government) could provide the transport to a suitable final disposal site, complementarily.

For locations where there were no "Class 1" landfills or any other suitable destination, the GAA was able to partner with private companies interested in receiving the waste (usually cement plants). As long as each local administration controlled the waste generated and disposed of it properly, most of this transport was provided by the GAA via an administrative request to the

company Petrobras to schedule the collection route.

Global results

The incident was brought to an acceptable level of control, due to the efforts achieved and reported in the previous sections of this study. After that, the reversal of the scenario between oiled versus cleaned locations was finally visible, and the response structure could gradually be retracted, with continued routine cleaning, monitoring, and inspection actions, as needed.

Figure 5 charts the evolution of the emergency up to 03/19/2020, one day before demobilization. The oiled areas significantly increase between 11/07/2019 and 11/20/2019, due to the overlap of intensification of the oil patches coming ashore. Increased monitoring and inspections allowed more rapidly identification of new affected areas, and register standardization added accuracy and agility to the information flow.

The dissolution of NCP groups in January 2019, and consequently the halt in the NCP Manual publication, may have caused a less agile interaction between the GAA and Support Committee (Brazil 2019a). The fact that the manual was not published also created public uncertainty about the actions that were being developed. With the NCP fully institutionalized and periodically exercised, the origin and distribution of resources and services would occur in a more efficient and controlled manner.

Another consideration is that, from a popular perspective, civil society had difficulties visualizing the performance of Ibama, MB, and other institutions integrated in the GAA as the Federal Government. In this context, the executing agencies were deficient in their disclosure. Although the ICS structure provides for an external communication officer, this team was possibly undersized. Thus, the undesirably negative public view of government performance (represented by the GAA) may have been essentially due to lack of public communication, since the limitations imposed on the acting agencies were contextual and not necessarily internal and managerial (Soares et al. 2020).

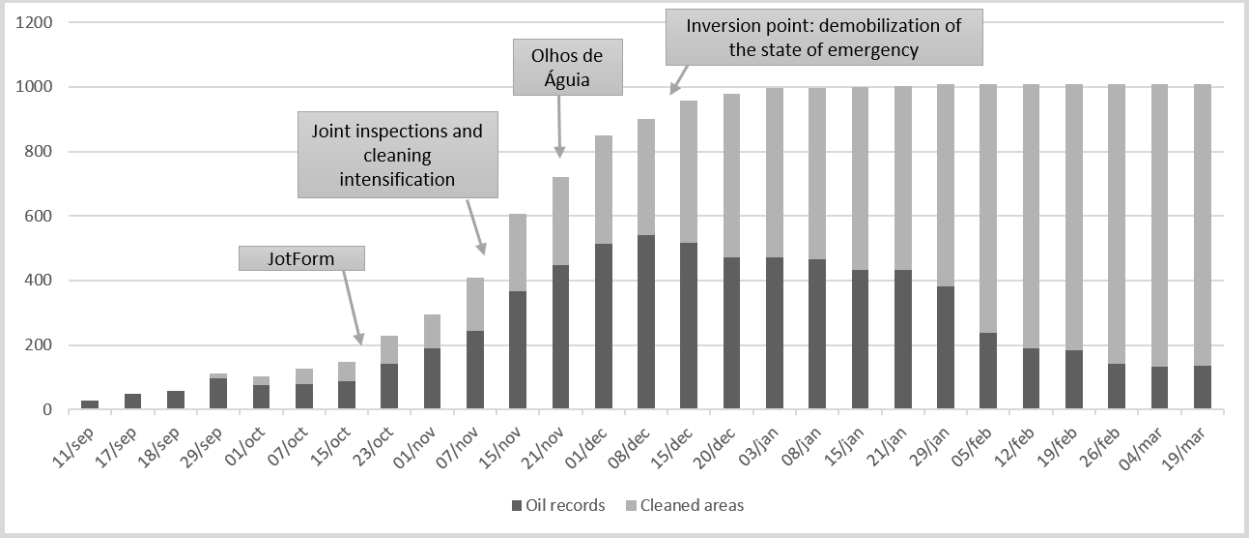

Figure 5. Clean vs oiled localities – 09/11/2019 to 03/19/2020. Chart elaborated with data from the "Oiled Areas" maps (Ibama 2019).

Given the large number of external demands, there was an overload on Ibama's technical team, with possible loss of service to the public. More than seventy lawsuits with judicial determinations or public inquiries with tight deadlines, subliminally attributed to Ibama a negative image, as if the environment institute was the responsible party, and not an emergency facilitator and manager (Ibama 2020). This context led to a need to improve its public image through these official responses and a greater effort in the dissemination of results.

Other limitations may also have jeopardized the combat efficiency. In addition to the difficulty in obtaining and distributing PPE and basic cleaning equipment quickly, there was a lack of training to the first responders (from the government or volunteers), given the unprecedented nature of this incident. As a result, waste management and public health issues added challenges to the emergency response. The training and distribution of PPE for safe and efficient action depended in most cases on partnerships with institutions and companies with this proactivity, which in part brought a solution, but also created a dependency factor for the continuity of activities.

Horizontal cooperation (between institutions at the federal level) and vertical cooperation (between the Federal Government and the federated entities: States and Municipalities) contributed to definitive and faster results. At first, there was some response action, although insufficient, by some of the local administrations. As the emergency took on greater proportions, however, some municipalities began to leave the combat actions entirely to the Federal Government, either due to depletion of resources or, possibly, for political reasons.

There was also a mistaken perception of the Federal Government's role in the emergency, and this may have caused a sense of abandonment on the part of local governments that did not occur. The cooperation challenges had to be managed to structure the response at all levels. The GAA´s communication policy and the presence of Ibama in each local coordination promoted such cooperation. Major gains in this area included the standardization of monitoring and inspection records and the integrated waste management.

The development of the Olhos de Águia application was another definite gain. As it is the property of the Federal Government, the application should be improved and incorporated as a routine useful tool, either for future oil spills or even other emergency scenarios.

Finally, the demobilization of the NCP was possible on March 20, 2020, due to the control of the situation that the integrated actions allowed (Ibama 2020). The GAA institutions continued to act less intensively, supporting the final actions that were still necessary at the local level.

An online "lessons learned" form was developed by the GAA, so that the participants (workers) could register voluntarily and anonymously the response failures and successes, which can be studied to further improve NCP.

The intense management work, therefore, was what transformed, over time, an atypical, disorganized scenario, in an organized, uniform, and standardized structure that finally culminated to the end the state of emergency. In this regard, it is possible to say that there was no omission or serious failure in Ibama's performance, since the limitations, as brought together in this study, were external.

One may argue that the specificities of the event may not be such a problem or an overall explanation for the performance limitations, but rather the lack of experience in managing these

situations due to the absence of an exercising routine for the emergency plans, especially NCP.

In addition, Pena et al. 2020 supports the thesis that the apparent unpreparedness for large emergencies is a global and persistent phenomenon in history, which proposes an extensive demand on organizations and world governments: the urgent empowerment of environmental institutions.

Another important observation refers to the structure and effectiveness of the NCP. The 2019 incident was the first occasion when the plan needed to be triggered and, immediately, it ran into some limitations. The first major obstacle was the applicability of the decree to an incident with an undetermined source, since every previous strategy was based on polluter accounting for financial, civil, and eventually criminal responsibility.

CONCLUSIONS

This study contributes to future research, in which science depends on the sequence of facts, the actions developed by Ibama, the characteristics of the event collected to date, and the reported experience as a whole. The experience elucidated the need to better coordinate information, and the interaction with the public and public administration, either with a dedicated team, a systematic protocol for public communication, or another especially applicable strategy. The studied incident had various official information sources; however, the Federal Government could have centralized information in only one website. Although the information disseminated bore no contradictions and the sites had links for the other sources, the disclosure efforts could have been better optimized.

Regarding the gaps in the legal framework, a review of Decree 8,127/2013 should be a priority, to better share roles and responsibilities, avoiding any possible conflicts or delay in a future NCP activation if the polluter is undetermined. The associated NCP Manual must be published and periodically exercised, after the needed assessment and adaptations, to guarantee a similar event would meet all the necessary technical and administrative safety requirements.

Studies on specific and applicable cleaning techniques, as well as a detailed survey regarding the logistics of the incident, could enhance the content of the Manual. Research on waste characterization could also contribute to possible adjustments in the National Waste Policy, avoiding clashes over proper treatment and administrative responsibilities.

The adoption of a national event management system, to all administrative entities, is urgent in many aspects, from strategy standardization to unified documentation. In this matter, ICS has the advantage of being used internationally and already widespread. Moreover, there is national capacity to propagate ICS training, without the need to spend extra budget on the development of a whole new system. The integrated efforts of the Federal Government represent a positive legacy, and ICS was an important part of such success

Further studies focusing on the impacts to wildlife as well as waste management should be conducted to complement these data.

Finally, the need for mutual cooperation between academia and public administration is evident to proper disseminate the present event and acquisition of practical experience. Similarly, environmental institutions in Brazil must be enhanced, which not only were success determinants, but also protagonists in this incident.

Acknowledgments

Special thanks be granted for the members of all institutions and sectors which collaborated to accessing all needed documentation. Namely, we thank George Porto Ferreira (Ibama official), for the information about the applications used in the event; Commander Alvaristo Nagem Dair Junior (Brazilian Navy) for the GAA documents which were not included at SEI-Ibama yet; and Frederico Medeiros Vasconcelos de Albuquerque (Brazilian Navy) for recovering and sharing JotForm data.

REFERENCES

AGÊNCIA BRASIL. 2019. Salles: manchas de óleo em praias são caso de poluição sem precedente. Available at: <https://agenciabrasil.ebc.com.br/geral/noticia/2019-10/salles-manchas-de-oleo-em-praias-sao-caso-de-poluicao-sem-precedente>. Access: May 7th, 2020.

ARAGÃO MA. 2014. O Princípio do Poluidor Pagador: Pedra Angular na Política Comunitária do Ambiente, São Paulo: Inst. O Direito por um Planeta Verde, 317 p.

BRAZIL. 1988. Constituição Da República Federativa Do Brasil – 1988, Brasília: D. O. U. (oct 5th) Sec I: 1-32.

BRAZIL. 2003. Decreto nº 4.871 de 6 de novembro de 2003. Planos de Áreas para o combate à poluição por óleo em águas sob jurisdição nacional, Brasília: D. O. U. Sec I: 88-89.

BRAZIL. 2010. Lei nº 12.305 de 2 de agosto de 2010. Política Nacional de Resíduos Sólidos, Brasília: D. O. U. Sec I: 3-7.

BRAZIL. 2013. Decreto nº 8127 de 22 de outubro de 2013. Plano Nacional de Contingência para Incidentes de Poluição por Óleo em Águas sob Jurisdição Nacional, Brasília: D. O. U. Sec I: 4-8.

BRAZIL. 2014. Resolução nº 463, de 29 de julho de 2014. Controle ambiental de produtos destinados à remediação, Brasília: D. O. U. (jul 30th) Sec I: 85-86.

BRAZIL. 2019a. Decreto nº 9.759 de 11 de abril de 2019. Extinção e diretrizes, regras e limitações para colegiados da administração pública federal, Brasília: D.O.U. Sec I – Extra:5-6.

BRAZIL. 2019b. Instrução normativa nº 25, de 2 de dezembro de 2019. Registro Temporário Especial – RTE de remediadores, Brasília: D. O. U. (dec 24th) Sec I – extra: 264-265.

CANTAGALLO C, MILANELLI JCC & DIAS-BRITO D. 2007. Oil spill cleanup on Brazilian coastal environments: a review. Pan Am J Aquat Sci 2: 1-12

CBM-DF - CORPO DE BOMBEIROS MILITAR DO DISTRITO FEDERAL. 2020. Manual SCI: Livro de Sistema de Comando de Incidentes - versão 6. Available at:<https://www.cbm.df.gov.br/component/edocman/?view=document&id=755>. Accessed: May 6th, 2020.

CBM-GO - CORPO DE BOMBEIROS MILITAR DO ESTADO DE GOIÁS. 2017. Manual Operacional de Bombeiros: Sistema de comando de incidentes – SCI. Available at: <https://www.bombeiros.go.gov.br/wp-content/uploads/2015/12/Manual-SCI-do-CBMGO-final.pdf>. Accessed: May, 06th 2020.

DEAL T, BETTENCOURT M, HUYCK V, MERRICK G & MILLS C. 2006. Beyond Initial Response: Using the National Incident Management System's Incident Command System. 1st Ed., Bloomington: Author House, 432 p.

DEFESA CIVIL DO ESTADO DO ESPÍRITO SANTO (Defesa Civil - ES). 2020. Sistema de Comando em Operações - SCO. Available at: <https://defesacivil.es.gov.br/Media/ defesacivil/Capacitacao/Apostila%20de%20SCO.pdf>. Accessed: May 6th, 2020.

DEFESA CIVIL DO ESTADO DO PARANÁ (Defesa Civil - PR). 2009. Sistema de Comando de Incidentes – Nível Operações. Available at: <http://www.defesacivil.pr.gov.br/sites/defesa-civil/arquivos_restritos/files/documento/2018-12/ManualSCI.pdf>. Accessed: May 6th, 2020.

FEMA - FEDERAL EMERGENCY MANEGEMENT AGENCY. 2017. National Incident Management System, 3rd ed., Washington DC: US Department of Homeland Security, 123 p.

GUNDLACH E & HAYES MO. 1978. Vulnerability of coastal environments to oil spill impacts. Mar Technol Soc J 12: 18-27.

IBAMA - INSTITUTO BRASILEIRO DE MEIO AMBIENTE E RECURSOS NATURAIS RENOVÁVEIS. 2016. Manual de Boas Práticas: Manejo de Fauna Atingida por Óleo, Brasília: Ibama, 74p.

IBAMA - INSTITUTO BRASILEIRO DE MEIO AMBIENTE E RECURSOS NATURAIS RENOVÁVEIS. 2019. Manchas de Óleo. Available at: <http://www.ibama.gov.br/manchasdeoleo>. Accessed: February 24th, 2021.

IBAMA - INSTITUTO BRASILEIRO DE MEIO AMBIENTE E RECURSOS NATURAIS RENOVÁVEIS. 2020. Documentos e processos eletrônicos - Sistema Eletrônico de Informações (SEI!). Available at: < https://www.ibama.gov.br/sei >. Accessed: February 24th, 2021.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. 2017. Atlas Mar – Linha de Costa. Available at: <http://www.metadados.geo.ibge.gov.br/geonetwork_ ibge/srv/por/

metadata.show?id=22358&currTab=simple>. Accessed: May 6th, 2020.

ITOPF. 2020. About us. Available at: <https://www.itopf.org/about-us/>. Accessed: May 7th, 2020.

MB - MARINHA DO BRASIL. 2019a. Combate ao óleo: Sobre. Available at: <https://www.marinha.mil.br/combate-ao-oleo/sobre>. Accessed:August 14th, 2020.

MB - MARINHA DO BRASIL. 2019b. Nota à imprensa: criação dos GTs. Available at: < https://webcache.googleusercontent.com/search?q=cache:aEa0CGGBNTUJ:https://www.marinha.mil.br/sites/default/files/nota_gaa_16nov_-_coordenacao_cientifica_do_gaa_1.pdf+&cd=7&hl=pt-BR&ct=clnk&gl=br&client=firefox-b-d >. Accessed: February 25th, 2021.

MB - MARINHA DO BRASIL. 2019c. Nota à imprensa: reunião dos GTs. Available at: < https://www.marinha.mil.br/sites/default/files/nota_a_imprensa_05dez_comunidade_cientifica.pdf >. Accessed: February 25th, 2021.

MMA - MINISTÉRIO DO MEIO AMBIENTE. 2020. Cartas de Sensibilidade ao Óleo. Available at: <https://www.mma.gov.br/seguranca-quimica/cartas-de-sensibilidade-ao-oleo>. Accessed: May 7th, 2020.

NOAA - NATIONAL OCEANIC AND ATMOSPHERE ADMINSTRATION. 2020. Shoreline Cleanup and Assessment Technique (SCAT). Available at: <https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/shoreline-cleanup-and-assessment-technique-scat.html>. Accessed: May 6th, 2020.

OLIVEIRA M. 2009. Livro Texto do Projeto Gerenciamento de Desastres - Sistema de Comando em Operações. Florianópolis: Ministério da Integração Nacional, Secretaria Nacional de Defesa Civil, Universidade Federal de Santa Catarina, Centro Universitário de Estudos e Pesquisas sobre Desastres, 82 p.

PENA PGL, NORTHCROSS AL, LIMA MAG & RÊGO RCF. 2020. The crude oil spill on the Brazilian coast in 2019: the question of public health emergency. Cad Saúde Pública 36: 1-5.

QGIS. 2020. Um Sistema de Informação Geográfica livre e aberto. Available at: <https://qgis.org/pt_PT/site/about/index.html>. Accessed: May 6th, 2020.

SECRETARIA DE ESTADO DE JUSTIÇA E SEGURANÇA PÚBLICA DO MATO GROSSO DO SUL (Sejusp-MS). 2016. Corpo de Bombeiros institui o Sistema de Comando de Incidentes na "Caravana da Saúde" em Dourados. Available at: <http://www.sejusp.ms.gov.br/corpo-de-bombeiros-institui-o-sistema-de-comando-de-incidentes-na-caravana-da-saude-em-dourados/>. Accessed: May 6th, 2020.

SOARES MO ET AL. 2020. Oil spill in South Atlantic (Brazil): Environmental and governmental disaster. Mar Policy 115: 1-7.

How to cite
BARBEIRO PP & INOJOSA FCP. 2022. Assessing the actions of the Brazilian Federal Government to respond to the 2019 mysterious oil spill: a perspective of the national environmental agency. An Acad Bras Cienc 94: e20210320. DOI 10.1590/0001-3765202220210320.

Manuscript received on February 28, 2021;
accepted for publication on November 11, 2021

PHILIPE P. BARBEIRO
https://orcid.org/0000-0001-7061-4110

FERNANDA C.P. INOJOSA
https://orcid.org/0000-0003-1312-6262

Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), Diretoria de Proteção Ambiental (DIPRO), Coordenação Geral de Emergências Ambientais (CGEMA), SCEN, Trecho 2, Ed. Sede do Ibama, Bloco C, 70818-900 Brasília, DF, Brazil

Correspondence to: **Philipe P. Barbeiro**
E-mail: Philipe.Barbeiro@ibama.gov.br

Author contributions

Philipe Pontes Barbeiro: gathering of external documents (out from SEI-Ibama) by contacting respective institutions, SEI-Ibama documents organizing and consulting, writing of the first complete version in Portuguese of the paper, compilation of data in graphic, translating, and formatting.
Fernanda Cunha Pirillo Inojosa: scope and methodology proposal, revision and textual contributions to the first and later versions in Portuguese of the paper, timeline constructing, translating, and formatting.