An Acad Bras Cienc (2022) 94(Suppl. 2): e20210309 DOI 10.1590/0001-3765202220210309
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

SOCIAL SCIENCES

Lessons learned from a mystery oil spill that hit the Brazilian coast in 2019

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Abstract: The oil spill of unknown origin that hit the Brazilian coast in 2019 led to the first activation of the National Contingency Plan, outside the scope of an exercise. The Brazilian Navy, the Environmental Agency and the Oil Agency worked together during the oil spill emergency at the Federal level, as the plan´s Monitoring and Evaluation Group. However, the distinctive characteristics and proportions of the incident demanded unanticipated actions. Therefore, this work aims to analyze the response actions, to evaluate policies and procedures in place and to propose improvements for the future. The paper discusses the anonymous and voluntary feedback from 150 professionals, obtained during the event, through a structured online form. The results of the survey are compared to findings in official documents, especially the Incident´s Final Report, prepared by the Brazilian Navy. The conclusion is that the Incident Command System, used to manage and coordinate clean-up operations, provided a swift and coordinated response as the oil reached the shore of 11 states. In contrast, there is a need to review the legal framework, including the Decree that established the National Contingency Plan, revisit response manuals, improve liaison and enhance communication channels among different authorities in the Brazilian Government.

Key words: lessons learned, oil spill, National Contingency Plan, perception research.

INTRODUCTION

Brazil has been affected by oil spills in the recent decades, such as the 1,300 m³ bunker oil spill from a pipeline, in Rio de Janeiro State (RJ) in 2000 (Milanelli et al. 2000), the 350 m³ crude oil and 1,200 m³ diesel oil spill due to the explosion and sinking of an oil rig in 2001, in Campos Basin (ANP 2001), or the 588 m³ crude oil spill from an underground blowout, also in Campos Basin, in 2011 (ANP 2012).

All the incidents mentioned above, however, share the fact that the oil source and the polluter were known, and, therefore, there was a responsible party to provide the oil spill response.

Mystery oil spills do happen around the world, such as in 2007, when 50-200 t of crude oil reached Argentina´s coastline (IOPC 2013). Argentina was also impacted by a mystery oil spill in 2006, when several hundred oiled Magellanic penguins washed ashore in Cabo Virgen (Ruopollo et al. 2007); In 2021, oil tars from an unknown source reached Israel and Lebanon, affecting over 170 km of the coastline (Rinat & Zikri 2021).

According to the the National Contingency Plan for Oil Pollution Incidents in Waters under National Jurisdiction ("Plano Nacional de Contingência para Incidentes de Poluição por Óleo em Águas sob Jurisdição Nacional" – PNC), the Brazilian government´s main role is

to supervise the oil spill response, to be held by the polluter. The PNC was first mentioned in Federal Law nº 9,966/2000 (Brasil 2000), and was later detailed by Federal Decree nº 8,127, in 2013 (Brasil 2013). In January 2022, the Decree nº 8,127 was replaced by the Federal Decree nº 10,950 (Brasil 2022).

The Federal Decree nº 8,127 defined how the Federal Government was to be organized to monitor and, if necessary, to coordinate an oil spill response when the responsible party´s actions were inadequate. The PNC does not embody for oil spills to be responded to directly by the Brazilian Government, and that was the main challenge faced by Brazilian Authorities in the mystery oil spill that reached the Brazilian coastline in 2019, and which is studied in this paper.

From August to December 2019, oil patches came ashore in 1,009 km of Brazilian coastline, distributed into 3,500 km of 11 Brazilian states (Ibama 2020). Despite all investigation efforts from the Brazilian Federal Police and the Brazilian Navy ("Marinha do Brasil" – MB), the source of this vast oil spill remains unknown (MB 2020b). Consequently, all the oil spill response had to be provided by the Brazilian Government, which led to the first activation of the PNC (excluding exercises) in an unprecedented organizational arrangement. Altogether, 5,300 tons of oiled waste were collected from various environments, such as sandy beaches, rocky shorelines and mangroves.

The Brazilian Navy ("Marinha do Brasil" – MB), the Brazilian Institute for the Environment and Renewable Natural Resources ("Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis"- Ibama) and the National Agency of Petroleum, Natural Gas and Biofuels ("Agência Nacional do Petróleo, Gás Natural e Biocombustíveis" – ANP), integrate the PNC Monitoring and Evaluation Group ("Grupo de Acompanhamento e Avaliação" – GAA). According to the PNC, these three institutions are to work together in cases of relevant oil spills.

In September 2019, MB and Ibama professionals started informally to share information on the oil patches that gradually reached the shoreline, first in Paraiba State (PB), then Pernambuco (PE) and Sergipe States (SE) and so forth spreading to the other northeast states. Then, a WhatsApp group was specifically created to spread information and discuss the incident within the GAA representatives (MB 2020a).

It is important to register that the responsible party should have reported the incident to Ibama, MB and ANP, in accordance with Brazilian regulations (Brasil 2013, Brasil 2022). Without a formal report, the oil was considered of unknown origin.

To corroborate this hypothesis, due diligence was carried out with Brazilian oil companies, that reported absence of incident or any operational anomaly in their activities (Nogueira et al. 2019).

Conforming to Brazilian regulations, specifically the Federal Decree 4,871/2003 (Brasil 2003), oil spills of unknown source are to be responded to by the Area Plans. An Area Plan is an operational document for oil spill response, produced by a group of neighboring oil facilities, such as ports or oil rigs. However, there is only one approved Area Plan at the northeast region of Brazil, in Bahia State (BA), which was activated when the oil reached that location.

Initially, only small amounts of oil reached the coastline, with no hint that the spill could correspond to a large volume of discharged oil, or even that it could reach vast extensions of the coast. Throughout September 2019, the beaches were monitored and cleaned by different entities (public and private) and less oil arrived onshore

daily, what suggested the situation was returning to normal by the end of that month (MB 2020a).

By the apparent reduction of oil spots along the beaches in late September, GAA estimated that the incident was coming to an end. However, in early October 2019, oil stains started to resurge in Sergipe state, in larger quantities.

With this, on October 11th, 2019, the Ministry of the Environment triggered the PNC. As the incident was probably unrelated to an oil producer company, and happened in open waters, the Ministry assigned the role of Operational Coordinator to the Brazilian Navy, in consonance with the Federal Decree that stablishes the PNC (MB 2020a).

The polluter is responsible for providing equipment, resources, and materials to respond to any incident, according to the polluter-pays principle (Brasil 1981). Such principle, applied to the PNC, means the GAA is not expected to perform operational activities. In this context, the evaluation of the clean-up response provided by the public institutions, to an event of unprecedented characteristics, is of great importance, not only to the GAA, but to national services such as public health, tourism and fishing. The GAA coordinated and performed numerous activities, like oil removal, waste management, monitoring, oil sampling and analysis, technical advice, development of data collection tools, acquirement and distribution of resources, among others.

In this article, the actions performed in the PNC are critically assessed and lessons learned about the incident management are presented, focusing on the GAA performance and further management actions.

During the emergency phase of the response, Ibama´s agents who were participating in the command center in Maranhão State (MA) verified the need to gather feedback from the Ibama´s employees who were performing field actions. Thus, an Office Word document was produced and shared online with Ibama personnel in September. Few comments were registered in this document, probably due to the overload of work at the time.

In November 2019, after the PNC was activated, Ibama´s servers at GAA suggested the creation of an online form, aiming to gather feedback from the public servants who were participating at the response (from federal, state or local levels), being at the command centre on the field, from all the institutions involved. The online form was then created and shared through the WhatsApp groups related to the response.

Procedures to gather feedback were not included in the PNC, nor in the PNC Manual (Ibama 2018), so there was no formal template or reference as to what questions should be on the form. Although there is research documenting the perceptions and human behaviors during emergencies, such as in Poffo (2011), it was the first time the Federal Government included a feedback collection tool in an oil spill response. Hence, this paper brings important contributions to the Academy and to the Public Sector, regarding the understanding of positive/negative aspects of the first PNC activation.

List of Abbreviations and Acronyms

ANP – *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis* - National Agency of Petroleum, Natural Gas and Biofuels

BA – Bahia State

CLC – International Convention on Civil Liability for Oil Pollution Damage

FAB – *Força Aérea Brasileira* – Brazilian Air Force

Ibama - *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* - Brazilian Institute for the Environment and Renewable Natural Resources

ICMBio – *Instituto Chico Mendes de Conservação da Biodiversidade* – Chico Mendes Institute for Biodiversity Conservation

MB – *Marinha do Brasil* – Brazilian Navy

PB – Paraíba State

PE – Pernambuco State

PNC – *Plano Nacional de Contingência para Incidentes de Poluição por Óleo em Águas sob Jurisdição Nacional* - National Contingency Plan for Oil Pollution Incidents in Waters under National Jurisdiction.

RJ – Rio de Janeiro State

SE – Sergipe State

SEDEC – National Secretariat for Civil Defense and Protection

MATERIALS AND METHODS

Online Form

The perceptions of the participants who were involved in the first real activation of the PNCwere gathered through an online form, of voluntary completion, available from 11/16/2019 to 04/04/2020, via GAA WhatsApp communication groups.

The questionnaire was designed and elaborated by the GAA during the emergency response phase, with the objective of gathering experiences that could be transformed into "lessons learned", which in the future would lead to changes in the existing protocols or regulations, ifapplicable.

The form was prepared using Microsoft Forms software and contained the following questions (Figure 1):

1) In which sector did you engage? (Objective answer with the following options, being possible to choose only one alternative: i. GAA - National Operational Coordination GAA; ii. Regional Operational Coordination - Naval Districts; iii. Local Operational Coordination – Naval Agencies; and v. I did not participate in management activities, only field actions, required by my institution);
2) What is your institution? (Objective answer with the following options, being possible to choose only one alternative: i. Ibama; ii. MB; iii. Civil Defense; iv. ANP; v. ICMBio (Chico Mendes Institute for Biodiversity Conservation); vi. Army; vii. Air Force; and

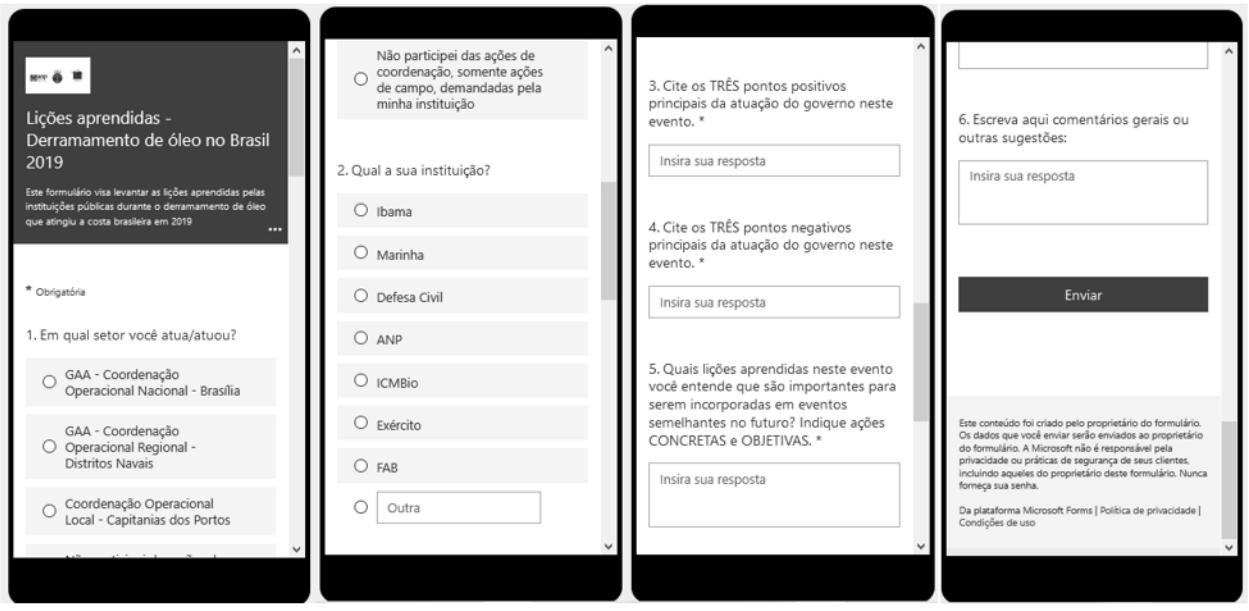

Figure 1. Online form.

viii. Other - in this case the participant could name the institution);

3) Name THREE main positive points of government's performance in this event (free text response); Name THREE main negative points of government's performance in this event (free text response);
4) What lessons learned from this event do you understand are important to be incorporated into similar events in the future? Indicate CONCRETE and OBJECTIVE actions (free text response);
5) Write here general comments or other suggestions (free text response);

Access to the form expired on 4th April 2020 and 150 answers were compiled in an Excel spreadsheet (Inojosa et al. 2021). In this article, the answers are not differentiated by institution, nor by sector of activity, since they do not bring additional information to the objective of this study.

The fact that the responses are anonymous allows for free expression of the items covered. On the other hand, it prevents the verification of the respondent's actual participation in the event and makes it impossible to check any points filled out incorrectly.

For the systematization of information, subjective responses were evaluated and, when they had a common subject, they were grouped into categories, which will be described later in this paper. The number of similar responses were counted, to compare the importance of different aspects addressed.

The answers for the 6th question: "general comments or other suggestions" were not grouped into categories, due to the asymmetry of the contributions. However, such answers were studied and taken into consideration in Table II.

Subjective responses bring rich individual experiences in content. For the GAA, the free text format was deemed necessary to register innovations and criticism of procedures. However, compilation is challenging, and its findings are subject to the analysts' reasoning. Considering the authors of this paper were involved in the oil spill response, mainly in GAA, Table II – Lessons Learned - incorporates the authors' experience in managing the 2019 oil spill.

Operational Coordinator's Report

In the present paper we also assessed the Final Operational Coordinator Report (MB 2020a), prepared in compliance with section VIII, Art. 10, of Decree n° 8,127/2013 (Brasil 2013). Such document brings the official version of the oil spill incident, which was compared to the comments of the online survey participants.

Lessons learned

The form collected 482 contributions related to "Lessons Learned" (344 answers – question5) and "Comments / General Suggestions" (138 answers – question 6). From this total, we extracted those that presented concrete, relevant proposals, that are within the scope of GAA's work or that may have their execution stimulated by GAA.

In addition to the identified lessons learned, the GAA manifestations in the Operational Coordinator's Report were also evaluated.

As a result, fourteen "lessons learned" are presented at the end of this article (Table II). The lessons are arranged in tables, which include "What happened", "Why it occurred", "What was the consequence" and "Suggestions for the future".

RESULTS

Participation in the questionnaire

The form was answered by 150 people, with the following distribution by institution: Ibama (88

people – 58%); ICMbio (21 people – 14%); MB (21 people – 14%); ANP (07 people – 5%); Civil Defence (07 people – 5%) and Other Institutions (06 people – 5%). There were no answers from the Army or the Brazilian Air Force ("Força Aérea Brasileira" – FAB), although such military forces participated in the clean-up operations.

The engagement of the various collaborators during the response to the oil spill occurred in different sectors and, according to the data obtained in the online form, the survey participants performed as follows: 44 people at GAA- 29% (National Operational Coordination or Regional Operational Coordination), 32 – 21% people in the Local Operational Coordinationand 71- 47% people in the field actions (03 people did not answer this question).

Note that the survey results reflect solely the views of the employees who accepted to fill it out. The representativeness of the institutions in the questionnaire was not proportional to the number of employees from each institution that were involved in the response. Ibama servants, for example, were less numerous than the military during the actions. However, there were far more responses from representatives of Ibama than from the MB or other military forces. Ibama had a leading role in GAA and a supervisory role in field operations, so the answers will reflect such positions predominantly, in comparison to agents involved directly in the clean-up activities.

Positive aspects

The positive aspects presented in the free-text format totaled 376 responses and were organized into seven categories: Successful response, Dedication/Commitment, Coordination by GAA Availability of Resources, Training and Knowledge, Waste Management and Others (Figure 2).

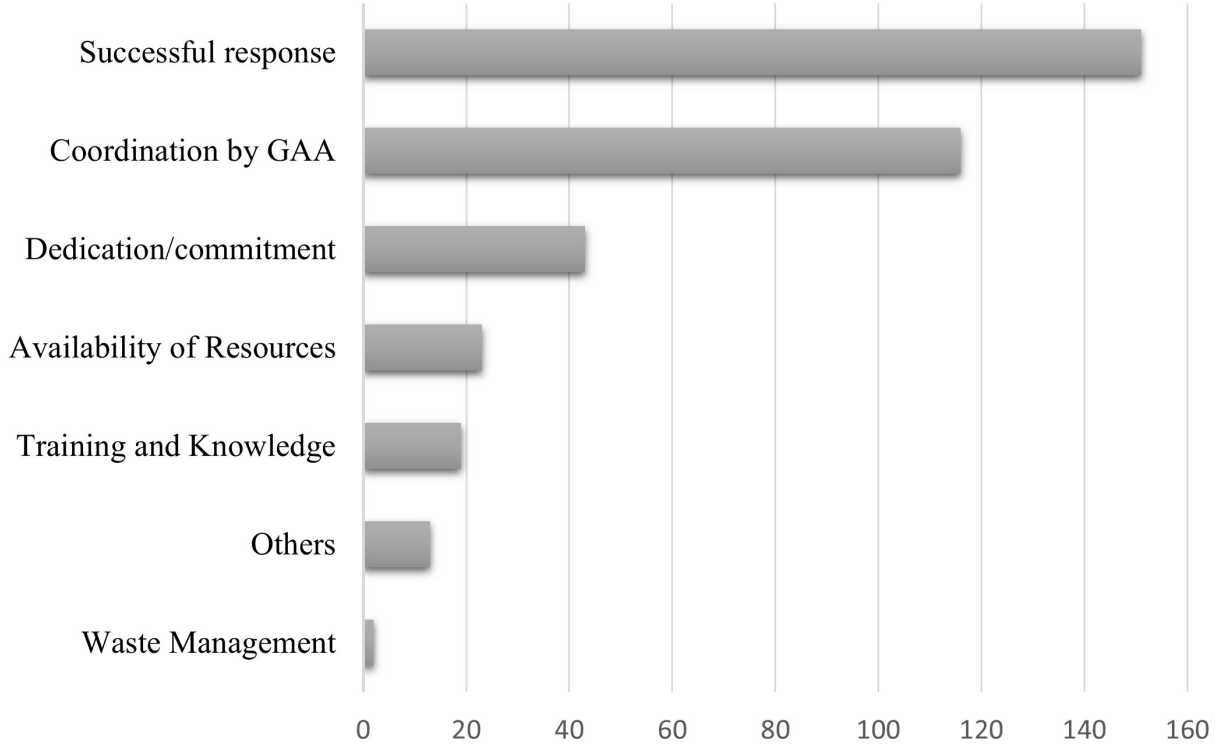

Figure 2. Categories of positive answers.

"Successful Response" was the category that grouped the largest number of positive comments, adding up to a total of 151 answers (40%). The main issues discussed, followed by quantitative quotes, were: efficiency in the mobilization of the institutions, the speed to respond to the incident and the organization's response (112 answers – 29%); the scope of response actions along the vast affected areas (18 answers – 5%); the effectiveness of fieldwork (07 answers -2%); use of tools to help data collection (Jotform online form, "Eyes of the Eagle" Application, etc.) (14 answers – 4%).

"Coordination by GAA" was the second category with the highest number of positive comments, totaling 116 (30%). The answers mentioned different aspects of the effectiveness of GAA coordination. Considering the relevance this category, it was decided to subdivide it into the subcategories "Collaboration/Integration", "Incident Command System (ICS)" and "Communication" (Figure 3).

In the subcategory "Collaboration / Integration", 64 (46%) answers mentioned aspects about integration, interaction, and cooperation, among the various institutions that acted in the response.

In the "ICS" subcategory, 32 (27%) citations were grouped. In relation to the number of positive citations, the majority referred to the use of the system and the effectiveness of the logistics developed for the response.

ICS is a standardized management tool, which includes common structure, language, communications, operating picture and planning process. It can be used for military orcivilian use, considering no single agency has the expertise, authority or resource to manage a complex situation (Deal et al. 2010). In the studied oil spill response, ICS was adopted partially by the Brazilian authorities.

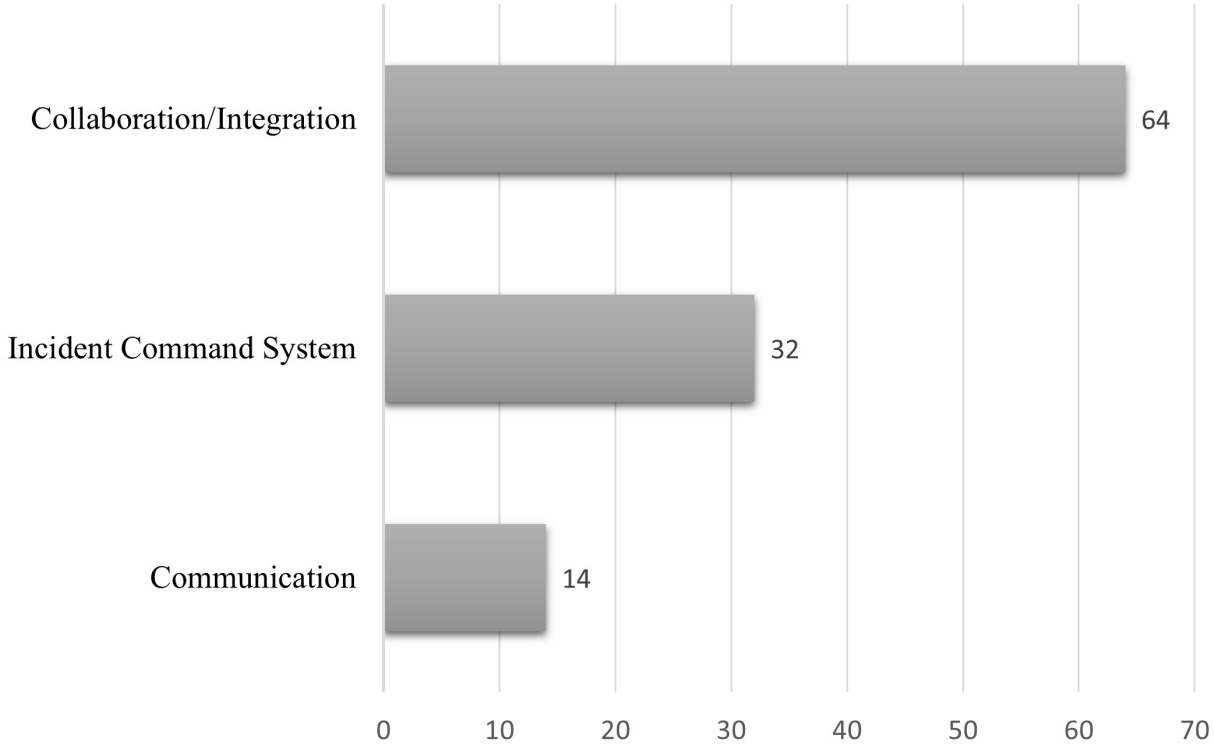

Figure 3. Number of positive answers, in each "GAA Coordination" subcategory.

In the subcategory "Communication", 14 (12%) responses were grouped with aspects relating to risks communication; social communication; transparency of information and the disclosure of the actions. Other positive points, mentioned once, were satisfactory interaction with the press and general publicity.

The "Availability of resources" brought together 23 answers. The positive points mentioned, followed by the number of answers were: availability of material resources, without specifying the type (16 responses); availability of human resources, vehicles / aircraft / infrastructure and Personal Protection Equipment - PPE's (04 responses) and the availability offinancial resources (03 responses).

The "Training and Knowledge" category grouped 19 responses (5%). Positive aspects mentioned the knowledge / qualification / technical capacity of the professionals (07 responses); the learning opportunity (03 responses); the decision to seek support from international ITOPF specialists (05 responses) and universities (04 responses).

The category "Waste Management" gathered only 02 positive responses, one referringto the correct disposal of waste and the other to the monitoring of collection, transport and disposal of oil-contaminated waste.

There were 13 answers (3%) which did not fit in the categories. Therefore, they were grouped in the "Other" category. As examples, the answers addressed aspects as follows: citation of negative points of the work performed; isolated acclamation of some institution in GAA; statement that there are no positive aspects or that the responder did not know how to answer.

Negative aspects

The negative points presented in free-text format totaled 367 responses, which were distributed in eight categories: Coordination by GAA, Delay of the PNC activation, Availability of Resources, Polluter Identification, Training and Knowledge, Political and Judicial Interference, Waste Management and Others (Figure 4).

The category "Coordination by the GAA" received the largest number of contributions - 147 responses (40%). As proposed for the equivalent category (positive points), it was subdivided it into the subcategories: ICS, Collaboration / Integration and Communication (Figure 5).

The subcategory "ICS" grouped 75 responses (51%) which presented criticisms about: logistics section; questions about conflict / overlapping functions or absence of an integrated protocol; difficulties in operationalizing the ICS (no knowledge of the tool; document organization; absence of planning meetings and lack of planning). There were also criticisms directed at the coordination of field work, the delay in implementing actions, the lack of recognition and appreciation of the work carried out, among others.

In the "Collaboration / Integration" subcategory, 39 answers (26%) indicated the difficulty of articulation, integration, and dialogue among the institutions. This subcategory includes aspects related to the lack of articulation, coordination and support by the Federal Government in relation to state, municipal entities, or non-profit organizations, as well as the difficulty of communication between GAA and field teams and / or operational bases.

In the subcategory "Communication", 33 answers (22%) were grouped. Most of the negative points were related to the way in which communication with society occurred, as well as the lack of adequate disclosure of the work carried out by the Federal Government. Other negative points sparsely recorded were criticisms of the work of the press office and the difficulty of internal dialogue, among others.

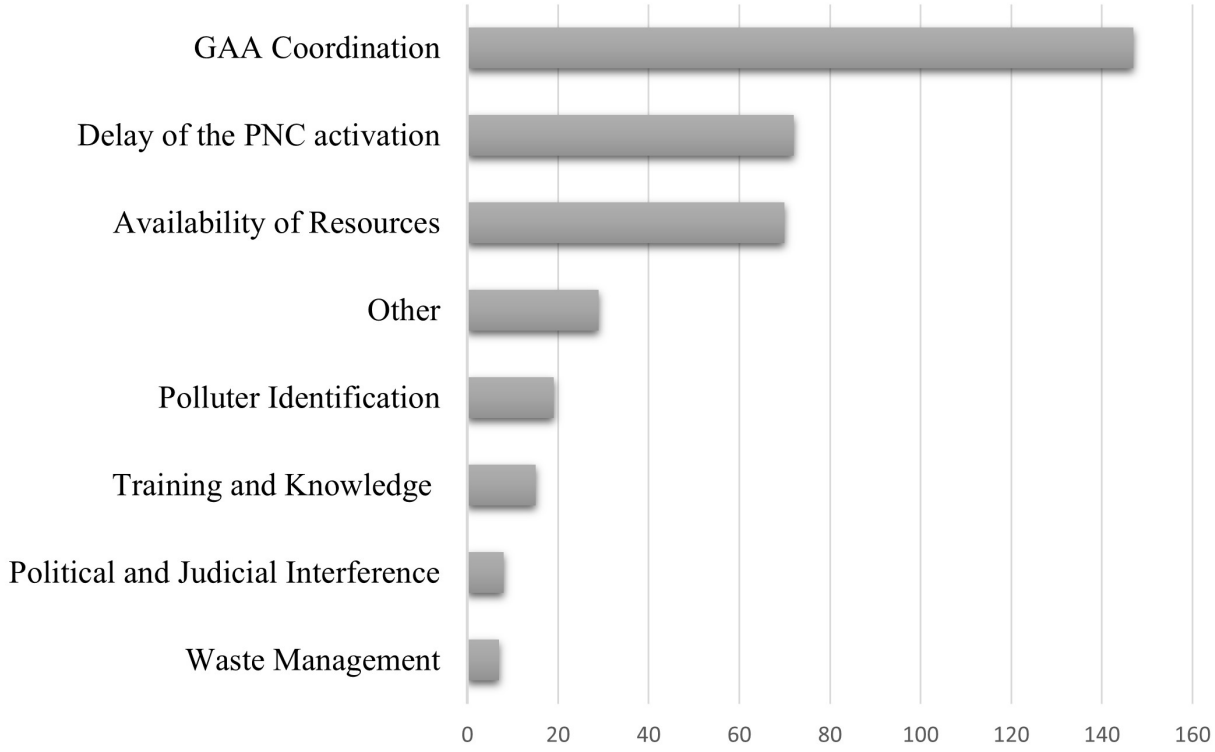

Figure 4. Categories of negative answers.

The category "Delay of the PNC activation" brought together a total of 72 answers (20%) that mentioned the delay in triggering the PNC or the total absence of public policies related to the oil spill. The main issues addressed in this category, followed by the approximate number of responses were: delay in triggering the PNC and / or delay in recognizing the severity and / or delay in the performance of any institution (59 responses); criticisms to the Ministry of Environment, due to absence or inefficiency (07 responses). Other answers were directed to aspects that indicate lack of public policies, lack of economic support, a lack of local support and a delay or lack of support / compensation for artisanal fishing communities (06 responses).

In the category "Availability of resources", 70 answers (19%) mentioned negative aspects such as the lack of resources (material, human or financial) or the delay in their availability. The negative points mentioned were: lack of material resources (computers, telephones, response equipment, among others) (24 answers); problems related to financial resources (12 answers); missing or delayed availability of PPE (11 answers); lack / insufficiency of human resources (07 answers). Also, 16 responses indicated bad managementof human resources, distributed in criticisms about how to replace teams, not inviting volunteers or lack of control over volunteers, the need to hire specialized personnel, among others.

In the category "Identification of the polluter and type of oil", 19 answers (5%) mentioned issues related to the difficulty in identifying the origin of the oil spill, and difficulties to carry out laboratory analysis of oil samples. The subjects and number were: criticisms about the investigation (07 answers); failure to identify the oil source (08 answers); delay in obtaining

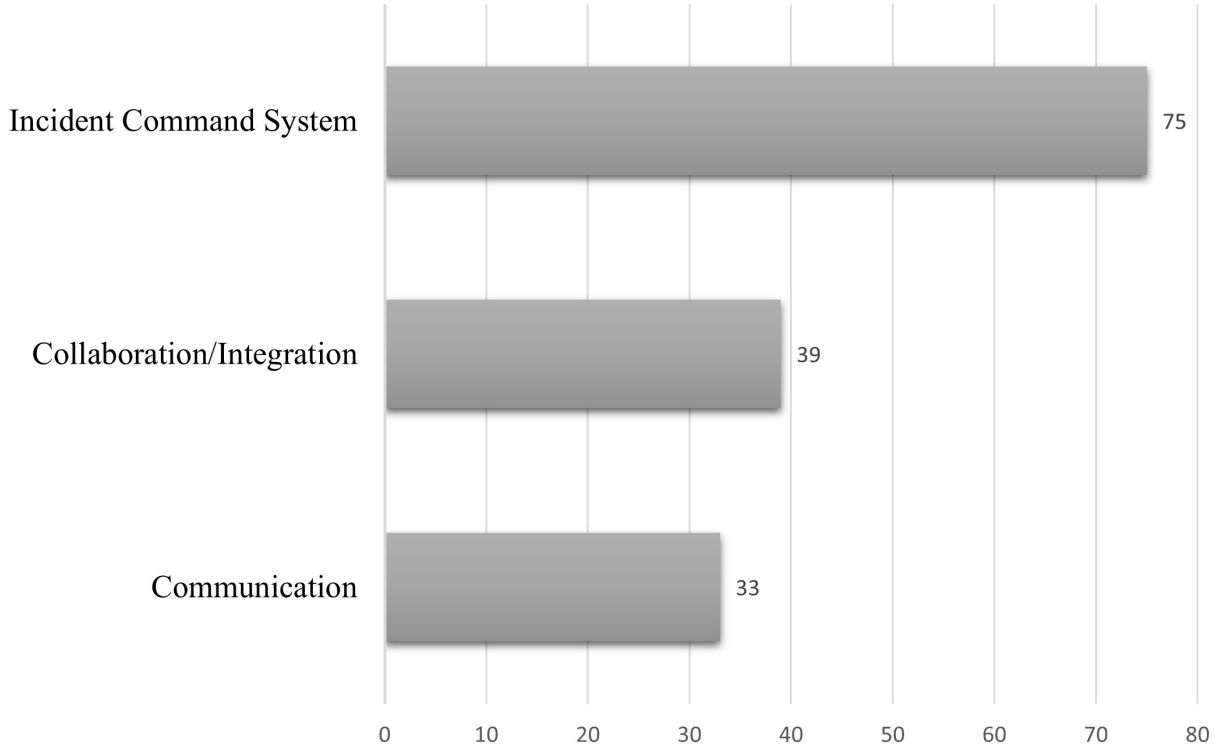

Figure 5. Number of negative answers in each "GAA Coordination" subcategory.

laboratory results (03 answers); and difficulty in sending samples for analysis, which depended on third parties to be performed (01 answer).

About the "Qualification/knowledge" category, 15 answers (4%) mentioned: lack of training / knowledge / experience in different areas of the environmental emergency; lack of knowledge on emergency plans, including area plans; lack of training for volunteers, among others.

The category "Political and judicial interference" grouped 08 answers (2%), which mentioned as negative aspects: the political interference in the development of the GAA's work (04 responses) and the interferences resulting from the judicial demands that, somehow, hindered the progress of the GAA's work (04 answers).

Regarding the topic "Waste management", 07 answers were collected (2%). They addressed questions about waste final disposal (04 answers); problems in collection and disposal (02 answers); and waste storage (01 answer).

In the "Others" category, 29 answers (7%) did not fit into the previous categories, for reasons such as difficulty in interpreting the answer; statement that there were no negative points in the work carried out by the Federal Government; among others.

Lessons learned

In summary, the form gathered 482 contributions related to "Lessons Learned" (344 answers - question 5) and "Comments / General Suggestions" (138 answers – question 6). Contributions were grouped into the following categories: Resources, PNC Review, Work Methodology, Communication, Collaboration/Integration, Knowledge/Training and Others.

Some categories were subdivided into groups, to better represent the variety of topics that were addressed.

The report of the Operational Coordinator (MB 2020a) addressed lessons learned in a specific chapter, with suggestions for management improvements, divided into: the creation of a National Sea Institute; PNC review; enhancement of the national and international legal framework.

Given the above, Table I presents the consolidation of topics identified in the online survey and in the Final Operational Coordinator Report (MB 2020a).

In the survey, the lessons learned gathered in the "Resources" category indicated primarily the need to acquire resources or to better manage them under the PNC. The need to create a Financial Fund was also mentioned.

A similar theme was treated as a suggested action in the Operational Coordinator's report (MB 2020a). The Executive Branch, under the coordination of the Ministry of Exterior, should proceed with the internalization of the Civil Liability Convention - CLC 1992, to safeguard national interests and claim compensations.

Regarding the category "Work methodology", the lessons learned that stood out with the highest number of records were of two types: improvement of response procedures and improvement of the ICS use, which was considered of great importance to the response. There were numerous citations regarding the need to improve mobilization / performance strategies when activating the PNC.

In the Operational Coordinator's report (MB 2020a), the need for harmonization and simplification of the templates and forms contained in the PNC Manual and ICS was suggested. The report also advocated the existence of a formal document to activate the PNC, in the form of a legal diploma, such as a Ministerial Ordinance. With this, greater legitimacy and support would be given to the acts and demands of the GAA / Operational Coordinator. Such an act would make public that there is an ongoing national environmental emergency and that all means must be mobilized to respond to it (MB 2020a).

About the "Communication" category, the lessons learned that were predominant in the online survey suggested the need to improve communication with the media / society, especially the need for agility and objectivity with the press, as well as the need to improve internal communication in GAA.

Report of the Operational Coordinator (MB 2020a) states that GAA maintained a close relationship with the communication officers of the various institutions involved, acting in a coordinated and cooperative manner. The unprecedented nature of the event, the complexity of the actions and the national repercussion of the subject required that social communication actions be conducted at the strategic, operational and tactical levels, in a harmonious way.

Also, according to the report, several tools have been developed for this purpose: a) press release; b) websites developed by MB and Ibama, c) social media; among others. In addition, when needed, press conferences and several interviews were conducted, through selected spokespersons. The Operational Coordinator's report (MB 2020a) mentioned the activities but did not present any improvement suggestion for the "Communication" topic.

In the "Collaboration / integration" category, the lessons learned most cited in the forms were those related to praise and / or demonstration of satisfaction with the joint work carried out by the Institutions. Another group of responses, registered within this category, was relatedto the

Table I. Categories and Topics of the Lessons Learned.

Category	Topics	
	Online Survey	**Operational Coordinator Final Report (MB 2020a)**
Resources	- Acquisition and better management of resources (material, human, financial); - Creation and management of a Financial Fund for the PNC; -Better infrastructure.	- Internalization of the International Convention on Civil Liability for Oil Pollution Damage.
PNC Review	- To review / improve the PNC regulation.	- To review / improve the PNC regulation.
Work Methodology	- The need to improve response procedures in areas impacted or likely to be impacted; - Improvement of response strategies; - The need to improve ICS use; - Recognition of the ICS as an effective tool in responding to environmental emergencies; - Recognition of the importance and / or the need for the development / improvement of tools that facilitate data collection and systematization. - To establish criteria / rules for the management of human resources; - To develop/improve clean-up protocols; - Criticisms regarding Emergency Plans (PNC, Area Plan, among others); - To seek solutions / support to meet legal demands; - To improve mobilization and action strategies, when activating the PNC ; - Criticisms to some institutions which participated in the PNC activation; - Recognition of the PNC efficient clean-up response; - Criticism to the efforts spent by GAA, regarding the identification of the responsible party; - Waste management.	- The need to improve ICS use;
Communication	- The need to improve the communication with the media and the society; - The need to improve the communication flow within the GAA and between the GAA and field teams; - The need to improve the GAA's communication flow with local governments and / or affected communities.	No comments on communication aspects
Collaboration / integration	- Satisfaction with the joint work; - Improvement needed in articulation / integration among institutions.	No comments on collaboration/ integration
Knowledge and training	- The need for the various collaborators to be better qualified.	- Training of local teams; - Formal cooperation agreements with training providers; - Creation of the Readiness Monitoring Group to Combat Environmental Crimes.

need for improvement in the articulation and integration between the entities.

The Operational Coordinator's report (MB 2020a) remarks that the GAA adopted procedures that allowed coordinated action, such as articulation with state and municipal authorities responsible for emergency response at the local level. However, there were no allusions to lessons learned on the topic collaboration/ integration.

At the online form, many answers mentioned the need for more training in general. In this category "Knowledge and training", the Operational Coordinator Report (MB 2020a) suggeststhe training of local teams, to enable a more efficient response. In this regard, the role of the National Secretariat for Civil Defense and Protection - SEDEC is fundamental. The report also reinforces the maintenance of the regular exercises that have been carried out annually by ITOPF with the GAA, preferably through a formal agreement (MB 2020a).

Finally, there is a proposal to set up a Readiness Monitoring Group to Combat Environmental Crimes - GAP to oversee the processes of conducting GAA / PNC exercises and simulations, among other objectives (MB 2020a).

DISCUSSION

In total, 376 answers mentioned positive aspects, while 367 answers mentioned negative ones. Although with asmall difference, the perception of the participants waspredominantly positive.

The significant number of positive comments registered in the category "Success in the Response" (151 answers), can be interpreted as satisfaction with the work developed and the results achieved. This positive perception in relation to the success of the response may be a consequence of the prior preparation of the main institutions in the PNC, which managed to adapt to the unusual scenario.

In addition to the number of positive aspects in the "Successful response" category, the significant number of positive comments registered in the "Coordination by GAA" category (116 answers), is a result that corroborates the understanding of satisfaction with the work performed, since a direct relationship can be established between the success achieved in the response and the appropriate coordination by the GAA. In addition, as identified in the "dedication / commitment," third category with the highest number of positive comments (43 answers), the perception that those who acted in response works were committed people may indicate that there was a common interest in developing activities successfully.

However, the category " GAA Coordination ", subdivided into " ICS ", "Collaboration / Integration" and "Communication", despite the high number of positive responses, was the one that received the highest number of negative comments as well (147 answers). We suppose the negative comments related to the coordination by the GAA may be related to the delay to disclose consistent information in the first month of the incident.

In the subcategory "ICS", the number of positive points (38 answers) is lower than the negative comments (75 answers). Nonetheless, these aimed the need for improvement in the tool and did not criticize the choice to adopt the ICS. Therefore, considering the results presented in Table I, the Institutions approve the ICS and consider its importance, but understand the need for developments that would improve efficiency.

In the subcategory "Collaboration / Integration" the results indicated a higher number of positive aspects (64 answers), when compared to the negative aspects (39 answers).

Regarding the positive comments, there was a perception that the different institutions working together promoted the successful response to the incident. As for the negative points mentioned, many answers pointed out the difficulties and challenges to develop integrated work.

The subcategory "Communication" indicated greater number of negative points (33 answers) in relation to the positive points (14 answers). The criticisms related to the media deserve due attention, because they indicate the need for communication strategies and appropriate dissemination of the work carried out by the GAA.

One preponderant category, being the second with the highest number of negative points (72 answers), was the "Delay in activating the PNC", for which no similar category was formed in the positive scope. The Operational Coordinator was formally asked to present documentation to prove when the PNC was activated (GAA 2020). In fact, the document that activated the PNC was classified, which was confusing to the press and to the society.

Whereas the negative criticism addresses the delay in the PNC activation, it means a review of the Decree nº 8,127/2013 was necessary, to qualify the criteria used to decide if the plan should be activated or not. Moreover, it supports the need for a formal instrument to trigger the PNC, as indicated in the Operational Coordinator report (MB 2020a).

In the category "Resources," positive comments (32 answers) were less numerous than negative ones (70 answers). Although positive contributions have highlighted aspects that indicate that the resources were satisfactorily available, negative contributions, with more than double the responses, indicate mainly the lack of resources for the shoreline clean- up activities.

As it was noticeable in Decree nº 8,127/2013 (Brasil 2013), there was no specific budget or equipment to be maintained by the Federal Government to respond to an oil spill. Thus, it is relevant to make prior agreements with companies and institutions that can add resources and services in the case of relevant incidents, especially those of unknown origin. The possibility of previous agreements is already provided in Art. 7, item V, of Decree nº 8,127/2013 (Brasil 2013).

In the context of "Resources", suggestions comprise the creation of a financial fund and the adherence to international conventions related to civil liability that would make claimspossible, including compensations for government costs. Such instruments are widely used by countries that operate in the oil sector, but they are not yet practiced or are outdated in Brazil (Pedrosa 2012).

The 1969 International Convention on Civil Liability for Oil Pollution Damage – CLC was internalized in Brazil through Federal Decree 79,437/1977 (Brasil 1977). The CLC was later reformulated, and a new protocol was added in 1992 (1992 Fund Convention); in consequence, the 1969 Convention fell partially into disuse (Silva 2019). Most members of the 1992 Convention ratified the Protocol which created the International Oil Pollution Compensation Funds (IOPC). In 2003, a Supplementary Fund Protocol was adopted, providing additional compensation over and above that available under the CLC 1992 (IOPC 2021).

Although the incident involved a mystery oil spill, if Brazil was a party to the Funds Convention, and if later proved that the incident involved a tanker, compensation would be available to governments which have incurred costs for clean-up operations and to companies/ individuals who have suffered damage, such as fishermen and hoteliers (IOPC 2021).

In the Operational Coordinator's report (MB 2020a), it is said that the institutions participating in the GAA sought various instruments to meet urgent demands for material resources. One of the solutions was the administrative request from Article 27 of Decree n° 8,127/2013 (Brasil 2013), to use resources from oil operating facilities. In this regard, Petrobras was formally requested by GAA to provide clean-up operations and to supply various materials and services. The GAA also requested resources and services from the "Todos os Santos" Bay Area Plan, Aratu Bay Area Plan and Espírito Santo Area Plan. The acquisition ofpersonal protective equipment was possible using the budget from GAA institutions, administrative requests to Petrobras and donations from various companies.

In the category "Knowledge and Training" positive comments (19 answers) exceeded slightly the negative ones (15 answers). The appreciation of specialists' support, whether international consultants or from universities, indicates the importance of technical collaboration, which needs to be mapped prior to the incident. In this sense, the option of establishing formal partnerships is emphasized, in this case, with institutions that can provide training. On the other hand, the survey results indicate that teams from local agencies still lack training related to oil spill emergencies. It is also important to provide training for volunteers, who were numerous in responding to this incident.

Basic training for shoreline clean-up is expected to happen during an oil spill response, not only to ensure that the response is effective but also do raise awareness of health and safety issues (ITOPF 2014a).

It is important to mention that the PNC 8,127 Decree did not even mention the use of volunteers, neither does the PNC Manual (Ibama 2018). Considering the classification by Tucker & O´Brien (2011), the volunteers in the 2019 Brazilian oil spill response were of all types: spontaneous, affiliated, professional or unskilled.

The category "Waste management" had little significance in the perception of the survey participants, even though a complex logistics to store, transport and dispose of the contaminated waste was reported by the Operational Coordinator (MB 2020a). In this context, it is relevant to understand the institutional roles and map the disposal and treatment options available, so the waste management does not become another emergency.

ITOPF (2014b) states that "the most time-consuming and costly component of a response to an oil spill is often the treatment or disposal of collected waste. The amount of waste generated is dependent on many factors, such as the type and quantity of oil, the extent to which the oil spreads and affects the shoreline and, most importantly, the methods employed to recover the spilt oil and oiled material from the sea surface and the shoreline".

The Operational Coordinator's Report (MB 2020a) highlighted that, according to Arts. 10 and 11 of the National Solid Waste Policy (Brasil 2010), it is up to the municipalities the integrated management of solid waste generated in their territories, supported by the states. In this regard, GAA's role was to provide technical advice, articulation, and organization of information. In places where waste management by the state itself was not possible, GAA also provided transport and final disposal. Upon administrative request from GAA, Brazilian oil company Petrobras carried out the proper transportation of waste, from temporary storage locations to final disposal in cement industries, which were willing to receive waste for coprocessing in furnaces.

The negative aspects related to the category "Political and Judicial Interference" demonstrate

the need to approach the control institutions during the emergency. A dedicated team to meet such demands is also needed. Requests for people with relevant functions, such as the Operational Coordinator, to participate in hearings and other meetings is in opposition to the ICS principles and can jeopardize response efforts.

The report of the Operational Coordinator (MB 2020a) says that five Public Civil Actions, one Popular Action, two Administrative Inquiries and an Administrative Proceeding were filed against the Federal Government, to compel the Union to implement the PNC. In addition to the judicial demands, the report also highlighted the demands of the Federal Court of Auditors, as well as from the Oil Parliamentary Commission of Inquiry, created specifically for this incident.

The register of "lessons learned" obtained from the survey in the "PNC Review" category did not bring many practical contributions. On the other hand, several "lessons learned" grouped in other categories indicated the need to alter Decree nº 8,127/2013 (Brasil 2013) and/or the PNC Manual. Although the publication of the PNC Manual was not mentioned, it is deemed necessary to provide transparency of the plan.

It is important to point out that many contributions recorded as "lessons learned" included aspects that cannot be considered good practices. Many participants registered only criticisms, praise, or generic needs, which could not be incorporated as learning opportunities without understanding the context in which they were placed. In fact, neither the Decree nº 8,127/2013 (Brasil 2013) nor its manual contained a methodology for the gathering and processing of lessons learned. This incident was the first time that the institutions involved used the feedback tool, and we recommend it to be incorporated as an official protocol.

From this discussion, the fourteen lessons learned listed below (Table II) should be evaluated by the PNC institutions, both individually and/or in a group.

CONCLUSIONS

Through an online survey, it was possible to identify and summarize the main lessons learned from the unprecedented 2019 mystery oil spill in Brazil, as well as it´s positive and negative aspects. The perception of the participants shares similarities with the official report (MB 2020a), although some perspectives were unique in the online survey results.

Despite being a simple method to obtain information, using a feedback form allowed the registry and systematization of lessons learned during the first PNC activation. Public Authorities should stablish protocols and encourage the gathering of feedback in future events, trying to reach equally all levels of professionals and entities involved.

The results obtained through the online survey highlighted positive and negative aspects that should be evaluated, to create a catalogue of best practices and to reduce mistakes. Decision-making in similar cases could benefit from the experiences described in this work.

The actions suggested at Table II should be addressed by Brazilian authorities, to improve the management procedures and skills of the involved entities, aiming to enhance national capacity in future events of PNC activation. Further study on lessons learned should be appraised individually by each participating institution, as the strengthening of their singular roles will contribute to the overall response performance in the future.

Table II. Lessons learned from the Brazilian mysterious oil spill in 2019.

Lesson Learned No. 1	Exercises
What happened?	The exercises carried out before the event did not include the participation of state and municipal institutions, nor did they foresee the use of resources exclusively from the government or a situation of national significance with an unknown polluter. Exercises in Brasil focus on at-sea response, and not at shoreline clean-up.
Why did it happen?	No scenarios for triggering the PNC were envisaged in these circumstances.
What was the consequence?	Interactions with other federative entities were developed during the emergency phase. There was no prior preparation for managing the response to a spill of national significance with unknown polluter.
Suggestions for the future	To practice complex scenarios in simulated exercises, including the involvement of other entities (at local and state levels) and considering the possibility of the polluter not being identified. To exercise scenarios which focus on shoreline clean-up, instead of at-sea response only.
Lesson Learned No. 2	Incident Command System - ICS
What happened?	The PNC Manual´s and the ICS´s forms were not used entirely. Data collection tools were generated throughout, and not prior, to the emergency.
Why did it happen?	Many participants were not familiar with the tools. There was an overlap between the ICS and the PNC forms. There was no previous development of tools (such as applications) for data collection and standardization.
What was the consequence?	Problems in the command flow, doubts about roles and how to fill out the forms. Application development during the emergency phase generated positive, but late results.
Suggestions for the future	To perform harmonization and simplification between the templates and forms contained in the PNC Manual and those provided in the ICS. To provide training in ICS, especially considering the roles of each section and the responsibility to fill out forms. To refine the tools created in this incident, so that they are ready for future events.
Lesson Learned No. 3	Legal framework
What happened?	There was no provision for tools/resources/structure to respond to an incident of this magnitude exclusively by the government.
Why did it happen?	Decree No. 8,127/2013 and its Manual did not provide guidelines for unusual incidents, such as the one experienced.
What was the consequence?	It was necessary to create flows and tools during the emergency phase, which impacted the agility of the response.
Suggestions for the future	To establish a Working Group, to be coordinated by the MMA, as National Authority of the PNC, and with the participation of the Brazilian Navy, Ibama, ANP, ICMBio and SEDEC, to revise Decree No. 8,127/2013, Decree 10.950/2022, the PNC Manual and Resolution n. 398/2008 (CONAMA 2008).
Lesson Learned No. 4	Interinstitutional articulation
What happened?	Difficulties in establishing articulations between GAA, entities that participated in the PNC Support Committee and local governments.
Why did it happen?	Institutions that participated in the Support Committee did not engage in responding to the incident. There was no tool for previous interaction between the Federal, State and Municipal levels.

Table II. Continuation.

What was the consequence?	Delay in response to specific demands, uncoordinated actions between Union and states.
Suggestions for the future	To establish, on the part of the National Authority, mechanisms for engaging the institutions that were in the Support Committee (or another group to be created), as well as state agencies, to improve the articulation, integration and interaction necessary to respond to an incident. To promote the implementation of the Area Plans.
Lesson Learned No. 5	Disclosure
What happened?	The information dissemination channels were not established immediately. There was no planning to reach all audiences, especially local communities.
Why did it happen?	Unpredictability of the incident escalation. Absence of prior communication plan.
What was the consequence?	It took time to provide regular information to the public at the first weeks of the emergency. Some local communities were not reached by official communication.
Suggestions for the future	To review the communication strategy, considering the need for agility and objectivity in the dissemination of information to the press and to the society. To provide training in conflict management and communications strategy for the GAA staff.
Lesson Learned No. 6	PNC activation
What happened?	Absence of transparency regarding the activation of the PNC. Absence of objective criteria for its activation.
Why did it happen?	The plan was activated by a document classified as confidential. Inability to predict the evolution of the incident. PNC Manual provides subjective criteria for triggering the plan. The PNC manual was not published, so it was not easily accessible to the public.
What was the consequence?	Public authorities, society and the press questioned the activation of the plan and the correct moment to activate it.
Suggestions for the future	To refine the criteria for triggering the PNC, to facilitate decision making. To formally trigger the PNC with a Ministerial Ordinance or superior document, to legitimize and support the acts and demands of GAA, as well as to inform the public that there is an emergency ongoing. To publish the PNC Manual, aiming to provide transparency of the planned actions to be implemented during an incident, to society and to the control agencies.
Lesson Learned No. 7	Resources
What happened?	GAA institutions did not have specific resources to respond to an incident of this magnitude. There were no agile mechanisms for hiring and purchasing materials in an emergency. The Government is not refunded when the polluter is unknown. Government formally requested services and equipment from oil companies.
Why did it happen?	There is no legal provision.
What was the consequence?	Public institutions spent their own resources for emergency response, impacting other actions under their responsibility. The hiring and purchasing process takes time in the public service, delaying the delivery of equipment. There is no compensation for the government. Oil companies that acted at the government´s request were not reimbursed yet.

Table II. Continuation.

Suggestions for the future	To assess the need to create a national fund (public or private) to compensate damages caused by oil spill pollution incidents and to provide financial resources to the response. To proceed with the internalization of international conventions dealing with liability (CLC 1992, Funds Convention, Bunker Convention). To detail the reimbursement process.
Lesson Learned No. 8	Local teams
What happened?	Cleaning was performed by local teams. However, the techniques were not adequate in some cases.
Why did it happen?	Lack of preparation of local teams to respond to oil spills.
What was the consequence?	Larger volume of contaminated waste, safety problems, secondary impacts of the response.
Suggestions for the future	Increase emergency response actions by training local teams to shoreline clean-up, in coordination with the National Secretariat for Civil Defence and State Agencies.
Lesson Learned No. 9	Volunteers
What happened?	High engagement of volunteers, whether from the community or from experts, however, in a disorganized manner.
Why did it happen?	Absence of established procedure for the management of volunteers of various types.
What was the consequence?	Available workforce and knowledge could have been better used.
Suggestions for the future	To register possible volunteers for beach cleaning. To create a standardized national register of voluntary companies and specialists, including international ones. To establish formal agreements with relevant partners.
Lesson Learned No. 10	Control Institutions
What happened?	Control and judicial interference in the emergency management. Absence of a specific group dedicated to answering such requests in the GAA.
Why did it happen?	Lack of proactive disclosure of ongoing actions. Lack of interaction with the control institutions.
What was the consequence?	Overload on technical teams to respond to demands. Need to carry out ineffective field actions to meet legal demands.
Suggestions for the future	To include in the organizational ICS chart, a unit dedicated to answering to the control units, preferably a multi-institutional one. To publicize GAA's actions from the first moment.
Lesson Learned No. 11	Feedback
What happened?	Federal government was not prepared to get feedback after oil pollution incidents.
Why did it happen?	The tool was not mentioned in the legal framework.
What was the consequence?	Specific form was generated by GAA during the emergency.
Suggestions for the future	To include the use of a feedback tool in the PNC Manual.
Lesson Learned No. 12	Inventory
What happened?	No information on the quantities of materials and resources available to be requested by the Federal Government.
Why did it happen?	Absence of national inventory of emergency response equipment.
What was the consequence?	Administrative requests could have been better programmed, speeding up the response.

Table II. Continuation.

Suggestions for the future	To have an inventory database of emergency plans, area plans and available resources.
Lesson Learned No. 13	Waste Management
What happened?	Difficulty identifying locations for final waste disposal. Absence of prior protocol for identifying temporary locations.
Why did it happen?	Lack of knowledge about places to receive oily residues in large quantities.
What was the consequence?	Final recipients were identified during the emergency, which delayed waste disposal. Waste was disposed of in inappropriate places, causing social and environmental impacts. Sending materials to cement companies proved to be an environmentally appropriate alternative.
Suggestions for the future	To develop a protocol to promote the prior identification of temporary and final disposal sites. Such protocol should be shared with the competent entities (states, through the State Environment Agency and municipalities).
Lesson Learned No. 14	Scientific Community/Tecnhical advisors
What happened?	In the early stages, the scientific community was not engaged with GAA in the emergency response. Researchers acted isolated and without knowledge of the context. Excellent experience with ITOPF advisors
Why did it happen?	There was no previous procedure for interaction with the academy.
What was the consequence?	Creation of Working Groups by GAA organized the participation of the scientific community.
Suggestions for the future	To create a previous channel of interaction with the scientific community, to assist in PNC situations. To encourage scientific research on topics of interest to the PNC.

Acknowledgments

We acknowledge Mr. Fabio Sobrinho, from Ibama, who worked on the online form responses.

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How to cite

INOJOSA FCP, PEDROSA LF, CASTRO MCT, AMORIM MN, FRANÇA MR & MOURA RN. 2022. Lessons learned from a mystery oil spill that hit the Brazilian coast in 2019. An Acad Bras Cienc 94: e20210309. DOI 10.1590/0001-3765202220210309.

Manuscript received on March 4, 2021;
accepted for publication on August 9, 2021

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