



Short communication

Oil and plastic spill: 2021 as another challenging year for marine conservation in the South Atlantic Ocean

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ABSTRACT

After two years of the most extensive (2890 km of coastline affected) oil spill on the Brazilian coast (2019), a new event of unknown origin brought about 1.3 tons of plastics and oil to the Fernando de Noronha Archipelago; formed by 21 oceanic islands with high endemism, productivity and unique ecosystems such as rich seagrass and rhodolith beds and the only insular mangrove ecosystem in the South Atlantic. The no-take marine protected area of the Fernando de Noronha National Park has been affected by marine debris from Africa and weathered oil that brings ecological risks to biodiversity and ecosystems services in the only pristine seagrass beds and mangrove in Brazil. In this note, we describe this novel event and argue that the maritime surveillance system of the Brazilian coast remains non-operational, making it challenging to find the responsible parties for such a recent accident (2021) and the extensive event beginning in 2019. This new event shows that past mistakes have not been learned and that the Brazilian federal government continues to have a low capacity in detecting environmental accidents in its Exclusive Economic Zone and potential polluters. Moreover, this new event in unique insular marine environments shows how vulnerable the South Atlantic coastline and islands are to the growing impacts of increasing plastics in the ocean basin and accidents involving the fossil fuel production chain, shipwrecks, and shipping lines, especially when extreme climate events are expected due to global environmental change.

Almost two years (September 2019) after the first mysterious registers of oil stains on the Brazilian coast [1], which caused the most extensive oil spill event in the Atlantic Ocean Basin and tropical oceans worldwide [2], new oil stains (now together with marine debris) reached Brazil. This time (August 2021), the affected area is the Archipelago of Fernando de Noronha (Fig. 1); a unique cluster of 21 islands (26 Km²) with high rates of endemism, productivity, a hotspot of marine biodiversity, and a UNESCO Natural World Heritage [3,4].

This scientific note is the first preliminary assessment of an

unprecedented event in the history of these South Atlantic islands, which have never before been hit by a disaster involving oil and plastic at the same time, mainly considering the quantity found. Given its oceanic position (Fig. 1) and the South Atlantic surface current system, this Archipelago has already been affected by marine debris and microplastics [5–7], showing its vulnerability to acute events of low predictability as the one described in this article. Between August 13 and 16, 2021, ~ 1.3 tons of marine debris (mostly plastics) and oil stains were collected from around 3.6 km of the windward coast of the main

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island, distributed at four different beaches and the insular mangrove ecosystem [8] (Fig. 2). The area affected by the oil and debris may be larger since there are inaccessible areas in the Marine Park of Fernando de Noronha [9,10], making it impossible to clean these areas. In this Marine Protected Area (MPA) occurs 40 threatened species [8], endemic species (e.g., *Elaenia ridleyana*, Shaper, 1888 and *Vireo gracilirostris*, Sharpe, 1890) [11], large concentrations of the spinner (*Stenella longirostris*, Gray, 1828), and spotted dolphins (*S. attenuata*, Gray, 1846) [12], and some areas are used by humpback whales (*Megaptera novaeangliae*, Borowski, 1781) [13] and sea turtles (*Chelonia mydas* Linnaeus, 1758 and *Eretmochelys imbricata* Linnaeus, 1766) as breeding or feeding grounds [14]. Furthermore, the affected areas have extensive rhodolith beds [4], pristine seagrass meadows, and the only mangrove on the South Atlantic islands [15–17].

In the 2021 event, the response to the arrival of oil and plastics on the beaches in Fernando de Noronha was quick and efficient, appearing that we have learned so much from the 2019 disaster since, in the latter case, the response was very slow, disjointed, and inefficient [2,16,18,19]. Even considering that the 2021 event in the oceanic Archipelago affected a smaller area (~ 18.3 km) than the 2019 event, which affected 2890 km along the Brazilian coast [2,20]. The rapid response in 2021 took dozens of ICMBio servers, Navy personnel, Island Administration technicians, and volunteers to do the initial cleaning that involved collecting debris and scraping the oil off of volcanic stones in the oceanic islands. Although the source of this oil and plastic spill in Fernando de Noronha is still under investigation and it is probably not related to the 2019 oil spill [1,2], in June 2021 (a few months previous to the events here described), oil stains from the same origin as the 2019 event arrived

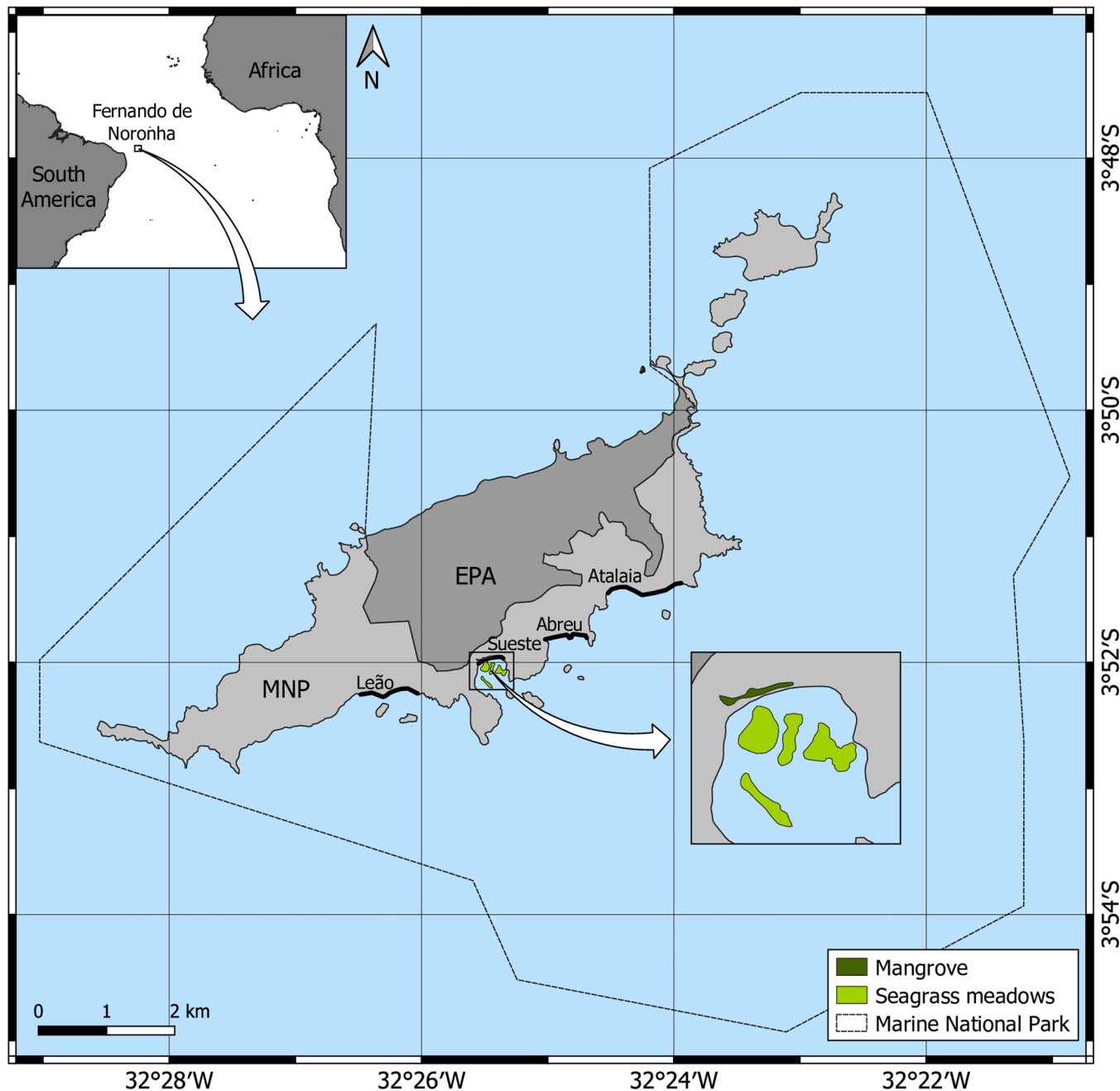


Fig. 1. Primary sites of debris and oil collection (highlighted by the black lines on the beaches) in the Fernando de Noronha Archipelago (3°51' S, 32°25' W) in August 2021. Marine Protected areas: multiple-use Environmental Protection Area (EPA), no-take Marine National Park (MNP) with its marine boundaries. Highlighted the Sueste bay location for the unique mangrove area and seagrass meadows on the archipelago.



Fig. 2. Debris and oil collection in the Fernando de Noronha Archipelago (South Atlantic, Brazil). A) Collection effort at Leão beach, the most affected area; b) Insular mangrove at Sueste bay with debris deposition; c) Fauna (crustacean *Johnnarthia lagostoma*) affected by the oil stains at Abreu's beach; d) Bird affected by the debris and oil; e) Aspect of the debris deposited in the mangrove; f) Oil sample containing mangrove seeds from plants (*Dioclea* sp.) not established in the South Atlantic archipelago. Photos: Cláudio Bellini (a, b, and e); Ana Marinho (c and d); Clemente Coelho (f).

in Bahia coast [21].

While we wait for further analysis of the oil samples collected in Fernando de Noronha, this new event in 2021 shows us how vulnerable are the Brazilian marine ecosystems and protected areas to acute events. The surface circulation (0–100 m) in the Tropical South Atlantic Ocean is driven by the westward South Equatorial Current System (SEC) that bifurcates, forming the north-flowing North Brazil Under-current (NBUC) and North Brazil Current (NBC) and the south-flowing Brazil Current (BC) (Fig. 3). The SEC current system has three different branches (north, central and south) that transport debris [22] and pollutants [23] present in the tropical area between Brazil and Africa toward the Brazilian shelf. Those materials can then be transported northward by the NBUC and NBC and/or southward by the BC, along the Brazilian continental slope from where they can enter the shelf due to eddies, meanders, upwelling events, and other cross-shore circulation mechanisms [23]. Due to the absence of a unified ocean surveillance system in the South Atlantic [2,18], many acute environmental events such as oil and plastic spills occurring in international (or national) waters will impact the tropical Southwest Atlantic coast [24].

The mangrove ecosystems, rhodolith, and seagrass beds of the Fernando de Noronha Archipelago were affected by the 2021 event. About 500 kilos of plastic waste and oil were removed from the Sueste bay area, being ~200 kilos inside the mangrove [8]. Although mangroves are usually driven by tides, this unique insular mangrove is regulated by the rainfall regime, as it is isolated from the beach by a vegetated dune system that is open to the Sueste bay (Fig. 1) only for short periods of time in the rainy season [25]. Plastic residue is often seen in the

mangrove lagoon as it reaches the island transported by the South Equatorial Current central branch (cSEC) (Fig. 3) and is trapped inside the mangrove forest, staying there as long as the connection to the bay is closed [25]. Litter deposited in this mangrove can have a strong and long-lasting impact, given the low predictability of when it will be washed from there. As there is no systematic monitoring program of residues in the mangrove, we cannot be sure that all the debris collected after this new event was recently deposited, but the oil stains are the first major event of mangrove deposition in Fernando de Noronha.

In 2020 we argued that Fernando de Noronha sheltered the only seagrass meadows not touched by the oil in 2019 [26] because that extensive event mainly affected the coast and not the oceanic islands [2, 19,20]. The ecological damage extension to ecosystem services and biodiversity is still to be accessed and monitored, but with this 2021 event, these meadows are added to the ~325 km² seagrass area affected by some oil after 2019 [27]. As for the subtidal rhodolith beds, damages are still not reported as the first resources were directed to mechanical clean the visible residues in the intertidal zone.

Now, three years after the first large-scale accident, we still do not know the source of the 2019 oil (e.g., shipwreck or dumping vessel) [20, 28], but its origin is a Venezuelan sedimentary basin [27], and all oil comes from the same source [29]. Even though ~5379 oil tons were collected from the 2019 event, the volume leaked is still unknown [2] and estimated between 5000 and 12,000 m³ [30]. We still do not know how much oil is still out there on the seafloor or trapped in marine and mangrove sediments. Without knowing the source of this recent leak in 2021, despite the gigantic proportion of the 2019 disaster, it is not

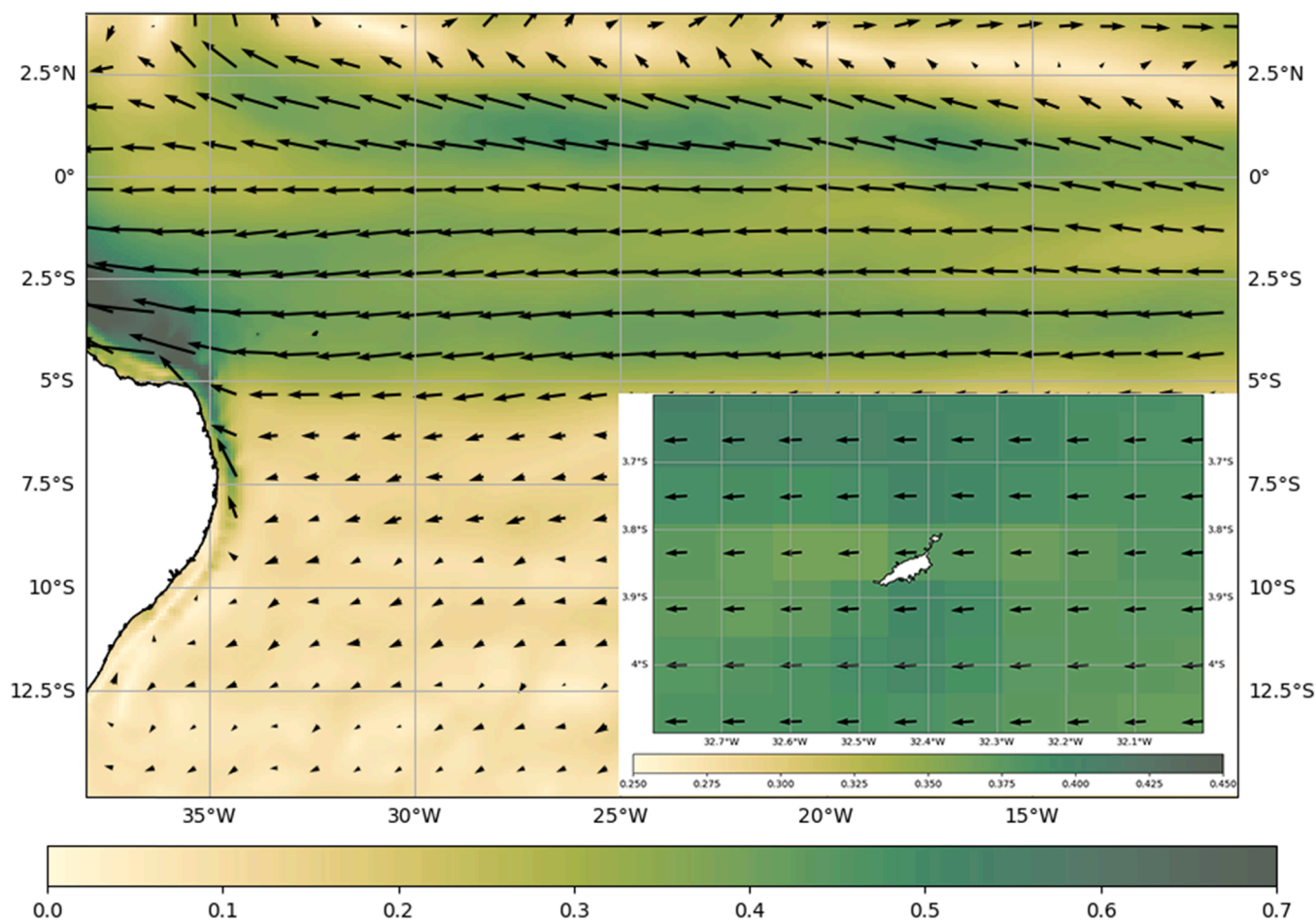


Fig. 3. Tropical South Atlantic Surface Circulation averaged for 2021. Currents data from the Operational Mercator Global Ocean Analysis and Forecast System Model. Colors denote currents speed (m/s). The small panel in the right corner shows the surface circulation around FN.

possible to hold anyone responsible or determine who should pay for cleaning, environmental remediation, and the economic damage to the tourist sector [31] and, most importantly, to mitigate the public health and economic damage on the artisanal fishers involved in cleaning processes and food security also affected in 2019 [32,33]. It is also important to remember that these social, economic, and environmental consequences were amplified by Brazil's still not controlled COVID-19 pandemic [16].

The Brazilian Navy and scientists have organized online meetings to discuss: (1) the possible origin of the materials; (2) physicochemical characteristics of the collected samples, the synthesis of the knowledge acquired about this event, and what are the resulting propositional actions. However, multiple stakeholders have not yet been involved in the discussions. Understanding the impacts of this recent 2021 accident on the oceanic and insular environment will require efforts including multidisciplinary teams that consider the effects on chemical, physical and biological characteristics. It will be necessary to monitor medium and long-term changes in the characteristics of water and sediments and the structure and functioning of biological communities. This 2021 accident should also be an opportunity to propose protocols to identify and monitor the impacts of high intensity and low predictability events on tropical oceanic islands already affected by other impacts such as climate change [10] and invasive lionfish [34]. In addition to monitoring changes in the environment, the cumulative impacts on island communities, mainly on social and economic activities, should be considered since Fernando de Noronha is one of the most important tourist destinations on the Brazilian coast, and tourism is the primary source of income for islanders [35,36].

While we are preparing to monitor the area and wait to know the fingerprint of the oil, this recent event shows us that even after the 2019 oil accident on the Brazilian coast, we still are not prepared to anticipate or prevent new events. The current event shows that past mistakes have not been learned and that the Brazilian federal government continues to have a low capacity in detecting accidents in its Exclusive Economic Zone and potential polluters. Despite global needs regarding the urgent mitigation of the climate change crisis, the Brazilian federal government signalize bidding 92 blocks of oil and gas exploitation in their Economic Exclusive Zone [36]. The potential oil production from these new marine areas will add to the pre-salt reserves already contracted, multiplying the fossil fuel emissions up to the beginning of 2030 [37]. Moreover, the dismantling of environmental laws and interference in Federal Government agencies fosters disasters such as futures oil spills [2]. The government action to put down the contingency plan to manage the extensive 2020 oil spill [18,19] exposed critical vulnerabilities concerning the increases in oil exploitation areas and volume as suggested by new oil and gas blocks offered [37].

This new event in unique insular ecosystems shows how vulnerable the South Atlantic marine protected areas and islands are to the ongoing impacts of increasing marine debris in the ocean basin and events involving the fossil fuel production chain, shipwrecks, and shipping lines. Monitoring and observational systems [24] are crucial as these events may end without a responsible party to pay for the cleaning and restoration of impacted environments in this unique South Atlantic archipelago.

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