



Research

A comparative case study of multistakeholder responses following oil spills in Pointe d'Esny, Mauritius, and Huntington Beach, California

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ABSTRACT. Oil spills generate negative ecological, societal, economic, and public health impacts, and require rapid response to contain and mitigate damages. Prompt and effective emergency management of acute events like oil spills is highly dependent on the social, institutional, and ecological context. In August 2020, the wreckage of the MV Wakashio spilled 1000 tonnes of fuel oil along an ecologically sensitive coastline in Pointe d'Esny, Mauritius. In October 2021, an offshore pipeline split and released 78 tonnes of crude oil off the coast of Huntington Beach in California. We compare responses among three sets of stakeholders (government, non-governmental organizations, and local residents) during the first 10 days of both oil spills, which also occurred during the COVID-19 pandemic. In Mauritius, unfavorable weather conditions and COVID-19-related border closures that delayed international support impeded government action, creating a leadership and trust vacuum among residents regarding the immediate cleanup response. This perceived gap was subsequently complemented by NGOs coordinating improvised artisanal boom production and local volunteer cleanup efforts, with limited protection or public health training. By contrast, prompt state and local government intervention in Huntington Beach created a clear chain of command with NGOs and residents deferring to official guidance. In both cases, the oil spills created new policy opportunities to improve emergency management plans and reduce future risks. Our results demonstrate the influence of prior local expertise in managing earlier disasters and resources on governmental and organizational capacity. Incorporating and ensuring on-the-ground disaster expertise in response activities improves government-led crisis response, subsequently protecting ecosystems and residents. Effective multi-level crisis response helps address a range of environmental and social justice concerns related to negative impacts of spills on local communities. Our study discusses how learnings from disaster management can reinforce social-ecological resilience in coastal communities dealing with increasing anthropogenic stressors.

Key Words: *California; disaster response; emergency management; environmental justice; Mauritius; oil spill*

INTRODUCTION

Oil spills affect both natural processes and social systems (Webler and Lord 2010). Major oil spills can constitute enormous ecological, societal, economic, and public health disasters that require immediate and organized cross-sectoral responses to contain damages and begin their cleanup (Chang et al. 2014). The impact of oil spills on natural ecosystems, including marine and coastal areas, depends on local weather conditions, the amount and chemistry of the oil, and how and where the oil spreads (Saadoun 2015). Social factors such as regulations, pre-disaster contingency plans, and strong relationships and engagement between response teams and the local community can also mitigate the impact of an oil spill (Walker 2014). Oil spills can cause significant decline in or damage to zooplankton, invertebrate, bird, and marine mammal populations (Saadoun 2015, Beyer et al. 2016). In terms of public health, proximity to oil spills, whether through vapors, direct contact, or consumption of affected animals, is associated with nausea, short-term respiratory health impacts, psychological stress, compromised immune systems, and potential long-term neurological damage (Institute of Medicine 2010). Affected individuals may experience anxiety, depression, and post-traumatic stress disorder, with more extreme impacts among those with greater societal and personal disruptions associated with the oil spill (Osofsky et al. 2011). From an economic perspective, oil spills affect tourism revenue, oil and gas industries, recreational and commercial fisheries, and other local businesses (Cheong 2012, Taleghani and Tyagi 2017).

Investigating oil spill responses from a social-ecological and governance lens is paramount to understanding these interrelated impacts on affected communities (Ostrom 2009, Hur 2012).

Disaster governance encompasses collaborative approaches between governmental and non-governmental actors, which influence the management of oil spills (Hur 2012, Sandoval and Voss 2016). Oil spill emergency management emphasizes minimizing the loss of and damage to social-ecological systems by making emergency plans prior to an oil spill in anticipation of such emergency situations (Keramitsoglou et al. 2003, Krohling and Rigo 2009). Such plans help improve response and recovery (Banerjee and Gillespie 1994, United States Environmental Protection Agency 1999). Cleanup should follow a contingency plan that efficiently and rapidly coordinates across the response community to prevent accidental exacerbation of negative impacts or delays in oil recovery (Chen et al. 2019a), with the initial emphasis on containment and then recovery. The U.S. Environmental Protection Agency recommends starting control and cleanup immediately to reduce ecological impacts. Oil spill cleanup frequently involves mechanical containment such as booms or skimmers, chemical and biological dispersing agents, and physical washing and wiping, with reduced negative impacts when equipment is correctly and quickly used (United States Environmental Protection Agency 2020).

Oil spill preparedness and response plans are deeply enmeshed within social and institutional systems, and hence should include

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input from local stakeholders such as government agencies, civil society and non-governmental organizations (NGOs), residents, and local businesses (Hur 2012, Walker et al. 2015, Swanepoel 2020). Higher perceptions of preparedness and better coordinated responses are associated with higher levels of trust in government among residents (Longstaff and Yang 2008, Basolo et al. 2009); pre-disaster collaboration with local NGOs (Brudney and Gazley 2009); and strategic, transparent, and responsive leadership (Gilstrap et al. 2016). Disaster response plans often include consulting with situation-specific experts (Perry and Lindell 2003, Bharosa et al. 2010, Stoepel and Ludwig 2015), because professional and scientific expertise may be crucial for managing disaster responses effectively (Lidskog and Sjödin 2016, Mease et al. 2017, Albris et al. 2020), including after oil spill events (Jones 2013). Government responsibilities and expertise vary across countries and levels of government (e.g., national, state, local; Xiong et al. 2015). In addition, governments within the same region may have differing levels of preparedness. For example, only one of five coastal cities threatened by the 1990 American Trader oil spill had an oil spill contingency plan, slowing and inhibiting adequate overall response (Fischer and Martinet 1993). Civil society and NGOs may also participate in oil spill cleanup. For example, the Oiled Wildlife Care Network (OWCN) is a veterinary care NGO affiliated with the University of California at Davis. After the M/V Cosco Busan oil spill in San Francisco Bay in 2007, OWCN coordinated with the state's oil spill response agency to organize 1850 volunteers to find, clean, and rehabilitate oiled wildlife (Ziccardi et al. 2011). Residents often play important roles as cleanup volunteers. After the 2011 MV Rena oil spill in New Zealand, the local Maori community coordinated cleanup with more than 450 volunteers over several weeks, drawing on traditional ecological knowledge and respect and guardianship of the local ecosystems (Smith et al. 2014). Frontline responders should have adequate equipment and resources and be familiar with incident response following scenarios and regular drill practices (Swanepoel 2020), although local volunteers may not be recognized as official frontline workers (Guevarra 2008). Coordination across multiple stakeholder groups improves emergency management for acute events like oil spills.

Coastal communities are now more than ever facing a multitude of climatic and non-climatic stressors (Badjeck et al. 2010, Kalikoski et al. 2010, Barange et al. 2014). Understanding how coastal communities are reacting, coping, adapting, and enhancing their resilience to a range of anthropogenic stressors is fundamental to understanding responses to growing Anthropocene risks (Martins and Gasalla 2020, Green et al. 2021). Social-ecological resilience refers to the ability to adapt to and improve from change, and particularly unexpected change (such as a disaster), across intertwined societies and ecosystems (Folke et al. 2016), as well as to manage future shocks more effectively. Disaster recovery also offers opportunities for sustainability science to guide societal changes to improve social and environmental equity, justice, and well-being, often drawing from community and stakeholder input (Redman 2014). After a major disturbance like a disaster, communities (composed of governments, civil society, and individuals) may mobilize resources and social capital to respond. Effective disaster response involves strong leadership, flexibility, and cooperation across

multiple management levels and organizations (Adger et al. 2005). Social-ecological resilience is strengthened under polycentric governance, in which many actors have various levels of decision-making power, thus creating a more flexible and adaptable response (Cinner and Barnes 2019). As such, social-ecological vulnerabilities and impacts caused by disasters are shaped by a community's resilience before and after disaster occurrence (Adger et al. 2005) and require an understanding of how resilience is achieved through social learning through both informal collaborative partnerships and formal, post-disaster policy processes (de Kraker 2017).

The COVID-19 pandemic has presented new and compounding challenges for coastal communities (Campbell et al. 2021, Love et al. 2021, Sowman et al. 2021). Several studies have examined oil spill-related decision making and response, and those impacts on social-ecological systems and oil spill consequences (Webler and Lord 2010, Liubartseva et al. 2016). However, although there have been several experiences gained in oil spill preparedness during the pandemic, shared through networks such as the Oil Spill Response Limited (OSRL) dashboard (<https://www.oilspillresponse.com/readiness-dashboard/>), there is minimal research examining the compounding responses to both oil spills and the COVID-19 pandemic (Hebbar and Dharmasiri 2022). By contrast, emerging research reveals compounding challenges for crisis management for hurricanes, extreme heat, war, and wildfires during the ongoing pandemic (Martinez et al. 2020, Collins et al. 2021, Harutyunyan et al. 2021, Hutton et al. 2021, Thompson et al. 2021). We build on existing literature to further the understanding of the complexities in how governments and communities respond to oil spills during a pandemic, which may inform future cleanup plans and efforts, particularly as the pandemic continues to evolve with new variants and compounding climatic and non-climatic disasters are increasing in frequency.

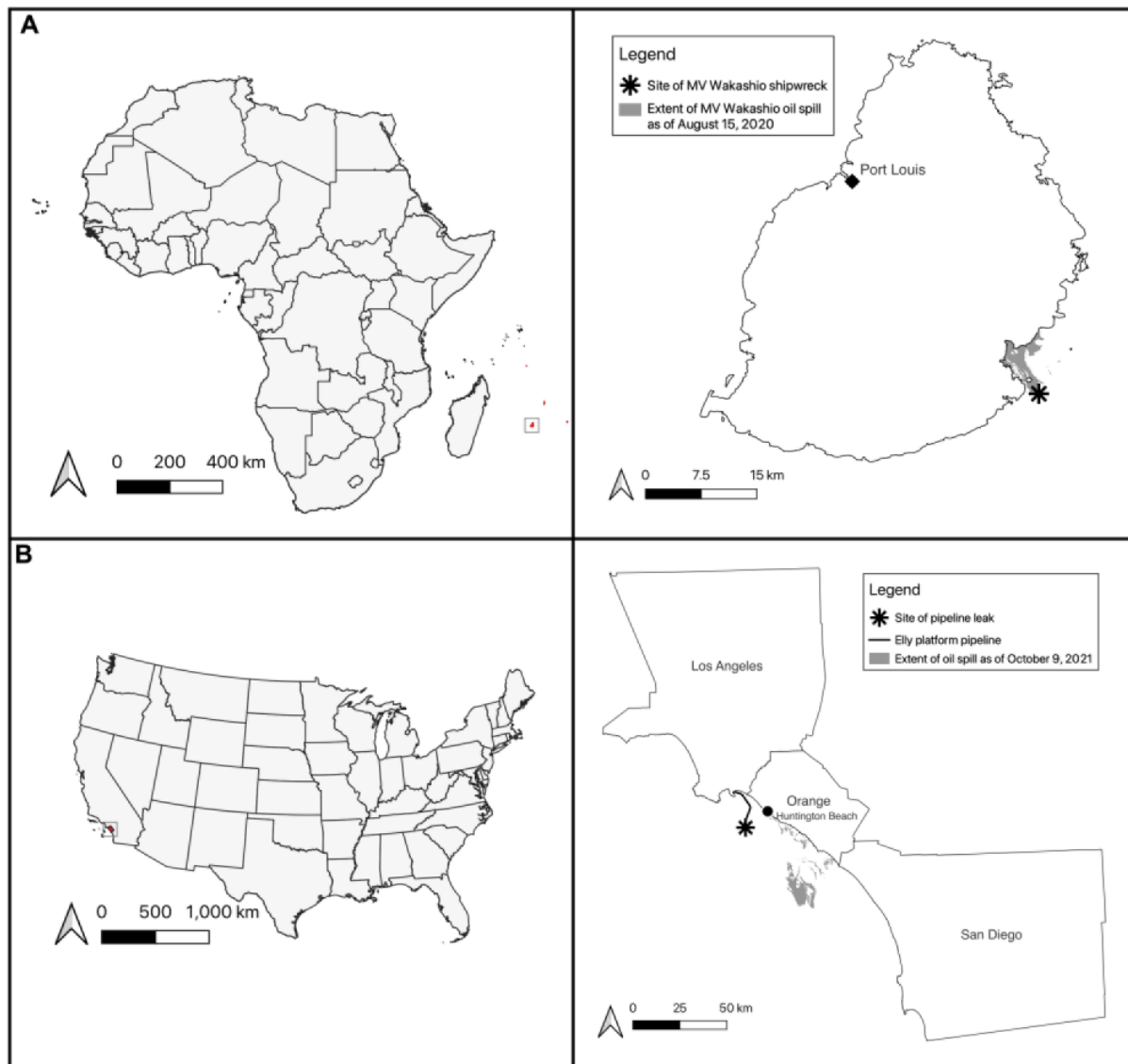
Here we use a comparative case study to explore disaster responses following recent oil spills in Pointe d'Esny, Mauritius, and Huntington Beach, California, which both occurred during the COVID-19 pandemic. In this research, we examine how government agencies, NGOs, and residents responded within the first 10 days of the oil spills. We first provide background information on the two oil spills and their locations before reconstructing timelines of the first 10 days of disaster response based on government documents, post-spill reports, and media coverage. We find important differences in stakeholder involvement within these two disparate social-ecological systems following the two oil spills. Our results demonstrate the influence of social learning on disaster management, locally available cleanup resources, and expertise on governmental and organizational capacity, with subsequent impacts on NGO and resident responses following ecological disasters.

BACKGROUND

MV Wakashio oil spill

On 25 July 2020, the Panama-flagged bulk carrier vessel MV Wakashio, owned by Japanese company Okiyo Maritime Corporations/Nagashiki Shipping Company, Limited, ran aground off the southeastern coast of Mauritius, a small island nation in the Western Indian Ocean (Fig. 1A). The vessel, which

Fig. 1. Maps displaying (A) Mauritius shown in red within Africa (left) and the extent of the oil spill in Pointe d'Esny, Mauritius (right) and (B) Orange County shown in red within the United States (left) and the extent of the oil spill in Orange County, California (United Nations Institute for Training and Research, 2020; GISGeography, 2021; DOI - Bureau of Safety and Environmental Enforcement, 2014; DOI - Bureau of Safety and Environmental Enforcement, 2011; National Environmental Satellite, 2021).



was not carrying any cargo, had departed from Lianyungang, China, on 4 July 2020 and was on its way to Tubarão, Brazil, after stopping in Singapore with 200 tonnes of diesel and 3800 tonnes of bunker fuel. Twelve days after the grounding, on 6 August 2020, approximately 1000 metric tonnes (318,000 gallons) of fuel oil leaked from the vessel along 30 km of ecologically sensitive coastline (Table 1). The MV Wakashio oil spill affected multiple conservation sites, including two internationally recognized Ramsar sites and fishing and nature reserves. In addition, the oil spill was the first to involve a new type of very low sulphur fuel oil (VLSFO) designed to reduce air pollution, resulting in many uncertainties on the ecological and health effects of the VLSFO

(Lewis 2020, de Rosnay et al. 2021, Scarlett et al. 2021). Nagashiki Shipping and the Japan P & I Club (Japan's primary private ship insurer) contracted specialist oil response and salvage teams to help mitigate the pollution impacts. In addition, the ship's charterers (Mitsui O.S.K. Lines, Limited) committed to providing support to the Mauritian government (Asariotis and Premti 2020).

When the oil spill occurred, Mauritius was also managing the impacts of the COVID-19 pandemic that had prompted border closures and strict quarantine rules, negatively impacting its critical tourism sector (de Rosnay et al. 2021). Direct and indirect tourism contributed to 8.2% and 23.8% of Mauritius' GDP in

Table 1. Characteristics of oil spills in Pointe d'Esny and Huntington Beach.

	Pointe d'Esny, Mauritius	Huntington Beach, California
Fuel type	Very low sulfur fuel oil (VLSFO)	Crude oil
Date of first spill/leak	6 August 2020	1 October 2021
Cause of leak	Ship fuel leak after ship ran aground a coral reef	Pipeline break; cause unknown (possibly anchor-related)
Amount of oil spilled	1000 tonnes (318,000 gallons)	78 tonnes (24,696 gallons)
Source of oil	MV Wakashio fuel oil	Offshore oil platform in Beta Field
Details of oil transport	Ship sailing from Lianyungang, China, to Turbarão, Brazil	Transported from offshore oil platform Elly to the Beta pump station in Long Beach, California
Responsible company	Okiyo Maritime Corporations/Nagashiki Shipping Company, Limited. Headquarters: Okayama, Japan	Amplify Energy, Beta Offshore (division of Amplify Energy). Headquarters: Houston, Texas, USA
Prior oil spill in region	None	1990: American Trader (1312 tonnes; 417,000 gallons)

2019, respectively (United Nations Development Programme Mauritius 2020), generating more than 63 billion Mauritian rupees (\$1.45 billion USD) in gross earnings in 2019 from nearly 1.4 million tourists (Ministry of Tourism 2019); for context, 1.27 million people live in Mauritius (The World Bank Group 2021). The pandemic and border closures caused a 78% drop in tourist visitation in 2020 compared to 2019 (United Nations Conference on Trade and Development 2021). In addition, the Blue Economy (referring to fisheries, port infrastructure, shipping, cultural heritage, and marine renewable energy) contributes to 10.5% of Mauritius' GDP (Nairobi Convention 2019). The oil spill directly affected 631 (33.2%) registered fishers, who were unable to fish both during the COVID-19 lockdowns and for up to a year after the oil spill in certain areas (de Rosnay et al. 2021).

Mauritius had never experienced a major oil spill prior to the 2020 spill, although the government has previously acknowledged the country's high risk for an oil spill given petroleum shipping routes near Mauritian waters. Mauritius faced two recent threats of an oil spill when MV Angel and MV Benita wrecked on its reefs in 2011 and 2015, respectively (Raghoo 2021). Mauritius developed its first oil spill contingency plan in 1990 after an influx of tar balls along the coast in the 1970s. Its revised 2003 National Oil Spill Contingency Plan was designed to manage minor oil spills (fewer than 10 tonnes), with any larger spills requiring international aid. Practice drills during the 2000s revealed poor coordination and communication, limited in-country expertise and cleanup equipment, and slow emergency response (Republic of Mauritius 2010). The last national oil spill drill was held in April 2012; the Wakashio spill occurred shortly before another drill that had been planned for August or September 2020 (Luximon et al. 2020).

Orange County oil spill (Pipeline P00547 incident)

On 1 October 2021, a 13-inch tear in an underwater offshore pipeline owned by Houston-based company Amplify Energy Corporation (and its subsidiary Beta Offshore) caused an estimated 24,696 gallons (78 tonnes) of crude oil to escape into the coastline of Huntington Beach in Orange County, California (Winton et al. 2021), near the Bolsa Bay and Bolsa Chica Basin State Marine Conservation Areas (Table 1, Fig. 1B; California Department of Fish and Wildlife 2021). The leak causing the oil spill stemmed from a pipeline that was transporting oil from nearby offshore drilling platforms to a pump station (Winton et al. 2021). Estimates from Day 2 indicated at least 126,000 gallons (396 tonnes) of oil had escaped, with revised estimates of 24,696

gallons released on Day 6 (Mejia and Do 2021). Amplify Energy agreed within days to pay the cleanup costs associated with the oil spill, although the formerly bankrupt company had financial struggles affecting its ability to cover all associated costs (Gerda 2021). The oil spill was likely caused by a passing ship's anchor that may have hit and torn the pipeline, possibly months before the spill occurred (Winton et al. 2021). Supply chain delays caused by COVID-19 precautions and insufficient personnel had slowed the loading and unloading of cargo ships, leaving them stranded offshore and possibly contributing to the Orange County oil spill (Curwen et al. 2021).

Government agencies were first notified of a possible oil spill after resident complaints about the smell of oil on 1 October; the U.S. Coast Guard opened a formal investigation into the spill the next day (Chabria et al. 2021). Officials delayed alerting the public until the evening of 3 October after shifting winds began moving the oil spill toward the beach and the Pacific Airshow (1–3 October) and Afterburner Music Festival (1–2 October; Fry et al. 2021). Huntington Beach has hosted the Pacific Airshow annually since 2016, drawing millions of spectators, the largest airshow by attendance in the United States. The 2021 airshow featured civilian and military flight performances, including the U.S. Navy Blue Angels, the U.S. Air Force Thunderbirds, and the Canadian Forces Snowbirds. However, the oil spill forced the cancellation of the third day of the airshow (<https://pacificairshowusa.com/>), likely producing significant economic losses. The 2019 airshow generated \$3.4 million in taxes and \$68.1 million in direct spending (Destination Analytics 2020).

The oil spill was expected to cause additional negative economic impacts in Huntington Beach, compounding the impacts of the ongoing COVID-19 pandemic (Smith et al. 2021). Tourism in Huntington Beach supported nearly 7000 jobs and generated \$91 million in tax revenues and \$736 million in total business sales in 2018 (Tourism Economics 2019, Smith et al. 2021). Downtown Huntington Beach features more than 250 businesses, including restaurants, recreational shops (e.g., fishing, surfing, biking), professional services, and wellness and fitness establishments, among others (see, e.g., Huntington Beach Downtown Business Improvement District, <https://www.hbdowntown.com/member-directory>). Lawsuits filed against Amplify Energy alleged anticipated damages for businesses such as surf and bike rental shops, wildlife and recreation guides, whale watching, and small-scale commercial fishing (Beyond Business Incorporated v. Amplify Energy Corporation 2021, Justia 2021, Straus 2021).

Huntington Beach has a long history with oil; extraction of oil was integral to the city's early economic development in the 1920s and 1930s (Higgins 1976). In addition, Huntington Beach previously experienced an oil spill in 1990 after the American Trader oil tanker ran over its anchor, spilling nearly 417,000 gallons (13,132 tonnes) of crude oil and killing an estimated 3400 birds (American Trader Trustee Council et al. 2001). The 1990 oil spill affected much of the Huntington Beach coastline, including the Talbert Marsh, a refuge for native plants and 90 species of shorebirds. The Huntington Beach Wetlands Conservancy subsequently invested millions of dollars in restoration; unfortunately, oil from the 2021 spill also penetrated the Talbert Marsh (Becker 2021).

California has contingency plans in the event of an oil spill, with the latest recommendations for spills in Orange County released in 2020. The Orange County plan details available resources, local contacts, resources at risk, site strategies, and logistics for specific shorelines (including the Talbert Marsh) to guide the first 24 hours of response until additional, real-time information becomes available (California Department of Fish and Wildlife and Office of Spill Prevention and Response 2020). However, upon learning that the city did not have adequate equipment in the event of a large spill, the Huntington Beach fire chief applied for grants to fund the equipment in 2020. The necessary equipment arrived a few months before the oil spill (Fry and Estrin 2021).

METHODS

This is an empirical study of multistakeholder responses in the first 10 days after oil spills in Pointe d'Esny, Mauritius, and Huntington Beach, California, focusing on responses by government agencies and officials, NGOs, and residents and how these groups influence each other. Here, we use the term "government" to refer to the national government in Mauritius and to Unified Command (a collection of federal, state, county, and city government agencies involved in disaster response) in Orange County, unless otherwise noted. We selected the first 10 days to examine the immediate oil spill responses on the basis of guidelines recommending rapid and organized cleanup (United States Environmental Protection Agency 2020). The empirical results draw on document analyses of media coverage, NGO social media communication, official press conferences and press releases, and follow-up reports. Data are limited to publicly available information and may not capture all activities (Appendix 1). In addition, these data do not capture the politics and power dynamics that shaped responses, which may have influenced specific responses, including cleanup decisions and actions.

We selected the oil spills in Mauritius and Orange County as critical comparative case studies. These two oil spills were among the 10 spills of at least seven tonnes in 2020 and 2021 that occurred during the COVID-19 pandemic (International Tanker Owner's Pollution Federation Limited [ITOPF] 2022), and thus offer important insights into the compounding effects of the ongoing pandemic on oil spill emergency management. Whereas the pandemic slowed the arrival of international aid in Mauritius, residents in Huntington Beach blamed the pandemic for slowing cargo ship unloading, leading to the oil spill. In addition, these two incidents represent extremes in oil spill preparedness. Prior to the Pointe d'Esny spill, Mauritius had never experienced a major oil spill. Local emergency management was equipped to

handle small spills, but larger incidents would require significant reliance on international aid and expertise. By contrast, Huntington Beach had previously experienced an oil spill in 1990 in a similar location to the 2021 spill. The State of California organizes regular oil spill practice drills and has extensive resources and expertise available to respond to oil spill crises. The disparities in these locations' oil spill preparedness allow us to examine both how pre-disaster preparedness influences how major stakeholder groups respond during a disaster and the critical role of local, on-the-ground expertise in guiding cleanup. As such, we chose these cases to highlight how differing levels of government preparedness influence the actions of major stakeholder groups (government, civil society, and residents).

We did not include the private sector in our analysis because it did not come up substantially as a major stakeholder group within the first 10 days of either disaster. In Mauritius, private companies donated materials for boom production and refreshments, allowed workers to participate in artisanal boom production, and offered space for decentralized boom production. In Huntington Beach, the Unified Command included Amplify Energy. In the immediate aftermath of the oil spills, the responsible companies primarily focused on damage control. In both locations, the primary drivers of cleanup activities centered on government, civil society, and resident-led action.

Here, we compare responses from these three sets of stakeholders in two locations to examine how differences in institutional and multistakeholder organizational capacity influence disaster preparedness and response. We recognize the considerable differences between the two contexts, as Mauritius is a highly isolated small island nation whereas the United States is a global power with tremendous facilities, expertise, and funds available. By comparing oil spills with such critical differences in pre-disaster resources and post-disaster response, we aim to highlight factors that may contribute to these differences, which can help support rapid response to future oil spill scenarios across a diverse range of social-ecological and political settings. Because this research examines two specific oil spills in a comparative case study, these results may not be applicable beyond Mauritius and Orange County, but they may reflect broader implications in preparedness, impacts, and stakeholder responses to disasters.

Data collection: Mauritius and Orange County

First, we tracked official press releases and communiqués related to each spill. For Mauritius, we first accessed documents through the reliefweb.int website. For Huntington Beach, we also tracked local newspaper coverage of the oil spill from three local newspapers that covered the incident extensively: Los Angeles Times, The Orange County Register, and Voice of OC. We reviewed articles to construct a timeline of oil spill activities conducted by government agencies, NGOs, and residents within the first 10 days: 6–16 August 2020 for Mauritius (Fig. 2) and 1–11 October 2021 for Huntington Beach (Fig. 3). We also monitored coverage of the oil spills within the first three months to identify major events related to cleanup and recovery operations, although our findings primarily focus on the first 10 days.

Second, for Mauritius we reviewed government press releases, press conferences, and local government websites between 25 July and 20 August to encompass ongoing cleanup efforts. We

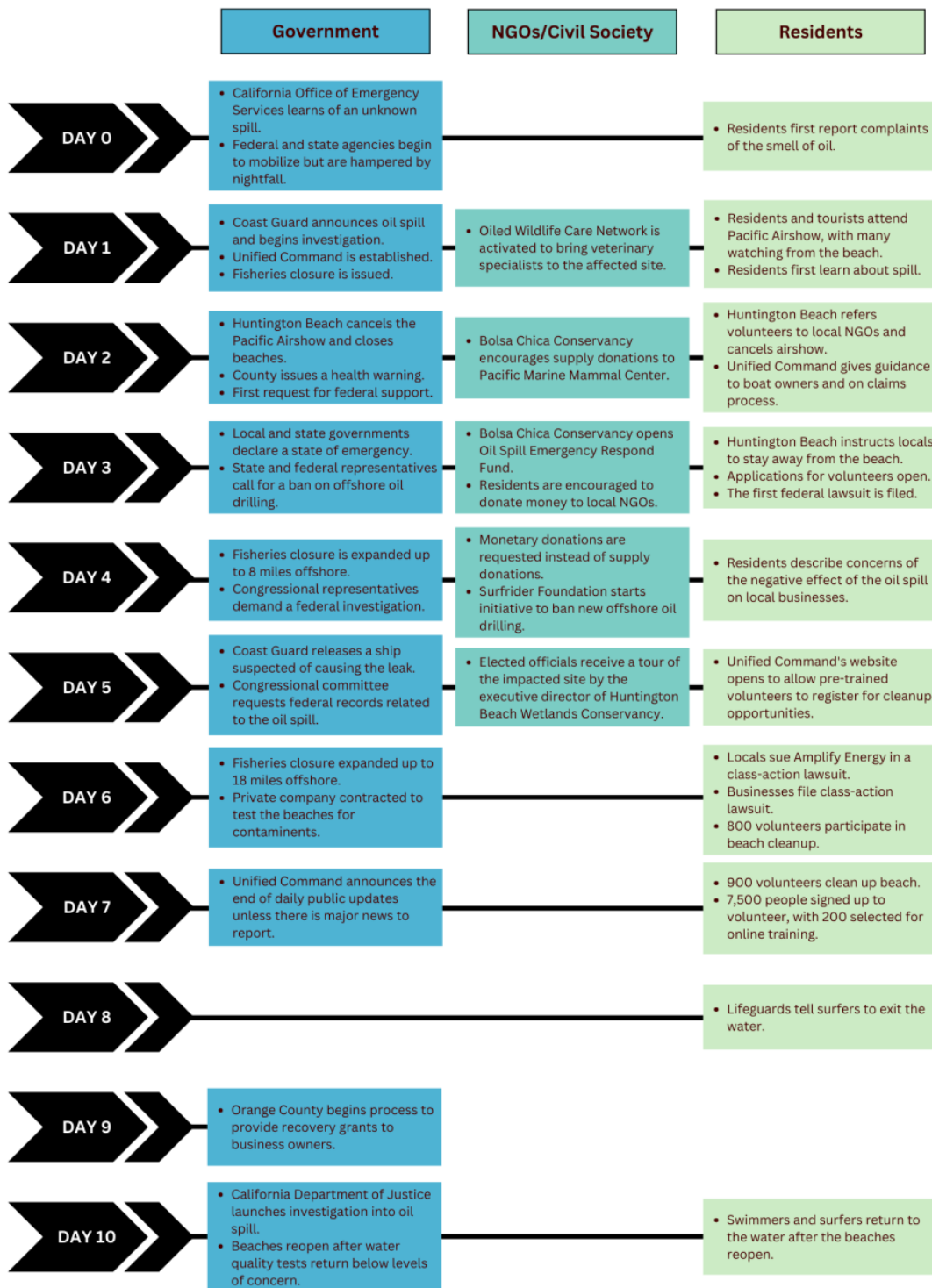
Fig. 2. Timeline of major government, NGO/civil society, and local resident activities during the first 10 days of the oil spill in Pointe d'Esny, Mauritius. Citations and additional information are available in Appendix 1.

Pointe d'Esny Timeline: August 6-16, 2020

	Government	NGOs/Civil Society	Residents
DAY 0	<ul style="list-style-type: none"> Mauritian government issues strict restrictions on access to affected areas. First appeal for international aid. 	<ul style="list-style-type: none"> Mauritian Wildlife Foundation begins emergency response measures to rescue affected endemic species. Boom creation experiments begin. 	<ul style="list-style-type: none"> Government instructs public, including boat operators and fishers, not to go to the beach.
DAY 1	<ul style="list-style-type: none"> State of emergency declared. Mauritian government establishes multiple coordination mechanisms and committees. 	<ul style="list-style-type: none"> NGOs share links to raise funds for cleanup and safety equipment. NGOs partner with volunteers to construct artisanal booms. 	<ul style="list-style-type: none"> Residents join local NGOs to build and place makeshift booms from leaves, straw, and hair. Locals and Mauritian diaspora donate hair.
DAY 2	<ul style="list-style-type: none"> National crisis meetings continue. 	<ul style="list-style-type: none"> NGOs continue coordinating artisanal boom production. Mauritian Wildlife Foundation continues rescuing endemic species. 	<ul style="list-style-type: none"> Residents continue volunteering to make artisanal oil booms. Mauritian diaspora raises money for cleanup and lagoon rehabilitation.
DAY 3	<ul style="list-style-type: none"> National Parks and Conservation Service supports Mauritian Wildlife Foundation in rescuing endemic species. 	<ul style="list-style-type: none"> NGOs continue coordinating artisanal boom production. Mauritian Wildlife Foundation removes endemic species. 	<ul style="list-style-type: none"> Residents continue volunteering to make artisanal oil booms.
DAY 4	<ul style="list-style-type: none"> Prime Minister warns of vessel breaking. International experts begin consulting with government. 	<ul style="list-style-type: none"> NGOs continue coordinating artisanal boom production. Mauritian Wildlife Foundation continues rescuing endemic species. 	<ul style="list-style-type: none"> Thousands of volunteers continue to make artisanal oil booms.
DAY 5	<ul style="list-style-type: none"> United Nations and Japanese experts arrive. The COVID-19 pandemic constrains international travel and expert arrival. 	<ul style="list-style-type: none"> NGOs continue coordinating artisanal boom production with thousands of volunteers. 	<ul style="list-style-type: none"> Residents continue volunteering to make artisanal oil booms.
DAY 6	<ul style="list-style-type: none"> Prime Minister thanks stakeholders for roles in cleanup. International experts continue to support oil spill cleanup. 	<ul style="list-style-type: none"> Prime Minister thanks NGOs. NGOs coordinate boom production. United Nations provides funding to support NGOs and communities. 	<ul style="list-style-type: none"> Residents continue volunteering to make artisanal oil booms. Prime Minister thanks volunteers for response efforts.
DAY 7	<ul style="list-style-type: none"> National Parks and Conservation Service supports additional Mauritian Wildlife Foundation efforts to rescue endemic species. 	<ul style="list-style-type: none"> NGOs advised to stop assisting cleanup. 	<ul style="list-style-type: none"> Government advises public to stop visiting impacted sites and instead clean public debris from the beaches.
DAY 8	<ul style="list-style-type: none"> Government advises the public to stop visiting impacted sites. Professionals and experts take over oil spill cleanup efforts. 	<ul style="list-style-type: none"> United Nations hosts a civil society dialogue with NGOs to produce spill action items and recommendations. NGOs advised to end cleanup. 	<ul style="list-style-type: none"> Government advises public to stop visiting impacted sites and instead clean public debris from the beaches. Artisanal boom production ends.
DAY 9	<ul style="list-style-type: none"> French experts approve plan to tow the broken vessel away from reefs. Government oversees environmental surveys to assess the spill's size. 	<ul style="list-style-type: none"> NGOs participate in National Technical Coordination meetings. 	<ul style="list-style-type: none"> Future cleanup plans with input from NGOs will be communicated to the public, including information on the need for more artisanal booms.
DAY 10	<ul style="list-style-type: none"> Additional international experts and resources arrive to support cleanup and restoration. 	<ul style="list-style-type: none"> NGOs continue crowdfunding to support ecological restoration and community recovery. 	<ul style="list-style-type: none"> Artisanal booms are replaced. Professional cleaning begins, with 516 local fisherman hired for beach cleanup.

Fig. 3. Timeline of major government, NGO/civil society, and local resident activities during the first 10 days of the oil spill in Huntington Beach, California. Citations and additional information are available in Appendix 1.

Huntington Beach Timeline: October 1-11, 2021



examined press releases and reports from the Mauritian Government Information Service (<https://gis.govmu.org/SitePages/Index.aspx>), ITOPF (International Tanker Owner's Pollution Federation Limited), and the United Nations (UN) offices, which included activities undertaken by the UN Office for the Coordination of Humanitarian Affairs (OCHA), International Maritime Organization (IMO), UN Environment Programme (UNEP), UN Resident Coordinator's Office (UNRCO), International Organization for Migration (IOM), UN Office on Drugs and Crime, UN Development Programme (UNDP), and the World Health Organization (WHO). For Huntington Beach, we reviewed government press releases and press conferences, local government websites, and elected officials' websites between 1–11 October. We examined press releases issued by Unified Command's official website (<https://socalspillresponse.com>) and press conferences via Facebook Live. The Unified Command website provided information on beach and fisheries closures, calls for volunteers, and updates on cleanups. Local government websites included official websites for the City of Huntington Beach and the County of Orange. We monitored the official websites of Senator Dianne Feinstein, Senator Alex Padilla, Representative Michelle Steel, State Senator David Min, and State Assemblywoman Cottie Petrie Norris, all of whom represent Huntington Beach in federal or state legislative bodies.

Third, we examined websites and social media pages of NGOs involved in the oil spill response. In Mauritius, we focused on the Facebook pages of the two primary local NGOs operating in the oil spill-impacted region: Eco-Sud and the Mauritian Wildlife Foundation (MWF). We also reviewed annual reports, oil spill-related reports, press releases, and blogs published by NGO and civil society actors involved in the oil spill response. The constructed timelines were shared with NGO actors and the UN Resident Coordinator's Office in Mauritius to confirm the chronology of events. For Huntington Beach, we examined websites and Twitter pages of four local NGOs dedicated to wetland conservation and ocean protection: Surfrider Foundation, Bolsa Chica Conservancy, Oiled Wildlife Conservation Network (OWCN), and HB Wetlands and Wildlife. We updated our timeline every day on the basis of stakeholder activities.

Data analysis

After constructing timelines of the two oil spills, we next used an inductive approach to coding activities for each oil spill within each stakeholder group by using qualitative content analysis (Hsieh and Shannon 2005, Elo and Kyngäs 2008). We started with all observations from our timeline and began identifying patterns by oil spill and individual stakeholder group. Appendix 1 provides a detailed list of and citations for all major activities detailed in the Results section. The coding occurred through thematic association to identify preliminary themes, followed by a recoding of activities thematically and by oil spill in an iterative process. We grounded themes in specific observations from the timelines. Each author served as a primary coder for one oil spill and a secondary coder for the other oil spill to check all codes and ensure coder reliability. We reviewed and resolved all discrepancies between coders to ensure consistency of findings. Table 2 lists the major differences between responses at the two sites.

RESULTS

Responses to Mauritius oil spill

Government response

Government efforts in the immediate aftermath of the oil spill concentrated on (1) activating its national oil spill contingency plan, including the actors who are parties of the international conventions related to spills that Mauritius has ratified, declaring a state of environmental emergency and calling for international help; (2) cautioning residents against visiting the spill site and prohibiting access to ecologically sensitive areas; and (3) assessing and mitigating both immediate and long-term environmental and societal impacts (Fig. 2).

First, under the IMO's International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) Convention, Mauritius has an obligation to establish a national response system. Although the government remained at the forefront of all oil spill-related response action and coordination, the national government delayed taking sufficient rapid-response actions (e.g., requesting international aid) to protect ecosystem and human health after the initial MV Wakashio was grounded on 25 July, 12 days before the oil leak began. The prime minister cited bad weather conditions and lack of local expertise and equipment to effectively stabilize the vessel and pump out the oil to avoid the oil spill and highlighted how actions had been undertaken following the expert advice of the salvage team (Smit Salvage Pty Ltd). While Nagashiki Shipping and P & I Club, the Japanese owners and managers of the MV Wakashio, contracted specialist oil response and salvage teams to help mitigate the effects of pollution, Tokyo-Mitsui O.S.K. Lines, Limited, the vessel's time-charterers, extended their support to the cleanup and recovery operations (Asariotis and Premti 2020). When oil began leaking on Day 0 (6 August 2020), the prime minister declared a "state of environmental emergency" and requested immediate international assistance. Authorities from Réunion, a French overseas department and island located 226 km from Mauritius, were the first to arrive with pollution control equipment. Beginning on Day 1, the Mauritian government established multiple coordination mechanisms, including daily crisis meetings and oil spill committees. COVID-19 travel restrictions, combined with the decision to request help after the spill occurred, delayed expert arrival to the island, with oil spill experts from the United Nations arriving on Day 5, although some started providing remote assistance from Day 1. Experts from Japan, France, the United Kingdom, and India also responded to the government's appeal for help, with other countries providing equipment and remote technical support. The National Crisis Committee finally approved the cleanup action plan on Day 11. The government also began revising its National Oil Spill Contingency Plan for potential future spills.

Second, the government issued access restrictions around the spill sites, including ecologically sensitive areas like the Blue Bay Marine Park and the Pointe d'Esny wetlands. However, the constrained emergency response from the government prompted environmental activists, NGO staff, and residents to mobilize to produce artisanal booms and contain the oil spill. The government eventually supported the community-driven initiatives by providing amenities in affected locations. The waste management company Polyecco was also involved in the early stages of the cleanup and worked in

Table 2. Major differences between oil spill responses in Pointe d'Esny and Huntington Beach.

	Pointe d'Esny, Mauritius	Huntington Beach, California
Restrictions	Government issued access restrictions to affected sites, including fishing and recreational activities. Volunteers continued producing artisanal booms and supporting cleanup initiatives despite restrictions.	Government paused recreational and commercial fishing and closed beaches.
Impact of COVID-19 pandemic	Pandemic delayed arrival of international aid and expertise due to international border closures.	Pandemic had minimal impact on cleanup activities.
Access to information	The government provided information via press releases and daily press conferences during the first 10 days. NGOs shared regular updates mostly via social media.	Unified Command provided regular updates and press conferences, although residents complained about amount of information shared.
Public health	Health warnings were issued to public to avoid contaminated areas. Protective equipment was not always available for volunteers involved in cleanup activities. Affected coastal residents reported challenges receiving medical certificates despite physical and mental health impacts experienced.	Health warnings were issued to public to avoid contaminated areas. Crews wore protective equipment during cleanup.
Role of untrained volunteers	Residents actively constructed artisanal booms using locally sourced raw materials and donated hair in support of cleanup efforts.	Untrained volunteers were not permitted to help with cleanup.
Economic impacts	Residents lost tourism- and fishing-related income because of the oil spill. Government created a special cell to identify beneficiaries for compensation.	Local business owners anticipated losing income associated with fishing, tourism, and beach events. Residents documented economic losses with Unified Command.
Long-term policy changes	Government started working on an updated contingency plan. Government instituted a new shipping regulation to protect the Mauritian coastline.	Elected officials and NGOs called for bans on offshore drilling.

collaboration with coastal residents (<http://www.polyeco.mu/news/polyeco-join-forces-with-local-community-to-combat-oil-spill/>). On Day 6, after international experts had arrived, the prime minister thanked participants and acknowledged the role of civil society, specifically the NGOs and Mauritians who supported cleanup efforts daily by producing booms or bringing food to volunteers. Authorities and NGOs subsequently advised volunteers to refrain from visiting affected areas as experts started coordinating and overseeing subsequent oil spill response. In the months after the spill, the government also demarcated restrictions for shipping activities around the Mauritian coastline.

Finally, government authorities oversaw assessments examining the ecological and socioeconomic impacts of the oil spill on coastal communities. Initial reports from Day 8 revealed that 13 villages were negatively affected by the spill and required immediate and long-term assistance. On Day 9, the Ministry of Environment, Solid Waste Management and Climate Change conducted environmental surveys to determine the size of the oil spill, with heavy impacts estimated along at least 30 km of coastline. On Day 10, experts from the ITOPE and Le Floch Depollution (a French oil spill cleanup company mobilized by the Japan P & I Club) prepared action plans for cleanup and restoration, with active cleanup approved by the Mauritian government beginning on Day 13. These cleanup operations were handled jointly by the companies Le Floch Depollution and Polyeco who employed and trained coastal residents to clean the contaminated shoreline in a coordinated, supervised, and safe manner using techniques such as flushing, high pressure washing, and sorbent wiping.

Non-governmental organization response

NGO efforts in the immediate aftermath of the oil spill concentrated on (1) reducing the environmental impacts of the spill by protecting wildlife and containing the oil with artisanal

booms, and (2) coordinating cleanup activities with government and international authorities (Fig. 2).

First, NGOs rapidly responded to protect the local ecosystems. For example, MWF produced and finalized an oil spill contingency plan for Ile aux Aigrettes following the grounding of the vessel and immediately implemented Tier Three of its action plan upon the initial oil leak. Tier Three involved emergency response measures to protect the native and endemic biodiversity of affected islets by relocating species to the mainland in biosecure facilities. On the evening of Day 0, NGOs and civil society groups such as Eco-Sud, CARES, and Resistanz ek Alternativ (ReA) experimented with different locally available materials, such as dried sugar cane leaves, and items available from hardware stores to create artisanal booms. After successful tests of the artisanal booms, local activists and NGO staff instructed residents to gather supplies and meet the next morning (Day 1) to build more booms. NGOs and civil society groups partnered with tour operators and local volunteers to make more booms from sugar cane leaves, straw, and hair donations. In addition, MWF and Eco-Sud used crowdfunding to raise money for on-the-ground actions and adequate personal protective equipment to ensure public safety during cleanup operations.

Second, NGOs worked with government authorities and international organizations like the United Nations to support cleanup efforts and mitigate socioeconomic impacts. The National Coast Guard and cleanup contractor Polyeco helped deploy booms in and transport oil waste out of the affected lagoons. In addition, government authorities invited NGOs to National Technical Coordination meetings starting on Day 6. Among other actions to support critical ecosystems and affected communities, MWF worked with the National Parks and Conservation Service to collect native and endemic species to capture genetic variance from affected islet reserves. On Day 8, the UNDP-Global Environment Facility (GEF) Small Grants

Programme hosted a civil society dialogue in coordination with the UN Resident Coordinator's Office at Eco-Sud's office in Pointe d'Esny. The dialogue resulted in a list of action items and recommendations agreed upon jointly by civil society groups and international experts to clean up the sites while reducing local exposure to the oil spill.

Local resident response

Local responses in the immediate aftermath of the oil spill concentrated on (1) producing artisanal booms and (2) demanding prompter government action (Fig. 2).

First, residents supported artisanal boom production from Day 1 through Day 6, with volunteers using small tourist boats and fishing boats to place the booms in strategic locations. Residents donated materials for the booms or provided refreshments for volunteers. When social media accounts spread the information that hair could help absorb oil, prompting a nationwide call for hair donations, barbershops offered free haircuts for people who wanted to support the initiative. In addition, thousands volunteered to create artisanal oil booms, with many learning about the efforts from Mauritian press and social media. When oil spill experts and professionals arrived by Day 5 and sufficient equipment reached the island around Day 8, boom production subsided. Separately, the Mauritian diaspora across North America, Europe, and Australia mobilized funds and equipment to support action in Mauritius through several fundraising campaigns to provide personal protective equipment for volunteers and money to support NGO cleanup, lagoon rehabilitation efforts, and alternative livelihood programs for affected communities. The NGO Eco-Sud reported receiving 21 million Mauritius rupees (approximately \$480,000 USD) in donations through its crowdfunding platforms.

Second, residents expressed anger and frustration with the government for its delay in responding to the oil spill threat from the ship grounding. Locals viewed the inaction during the 12-day gap between the grounding incident and the oil spill disaster as government negligence. This frustration ultimately manifested in the largest march in Mauritius' history on Day 23, when 150,000 people marched in the capital of Port Louis (representing over 10% of the Mauritian population), with hundreds of the Mauritian diaspora joining around the world, demanding prompter response to such incidents in order to better protect local ecosystems, biodiversity, and associated livelihoods.

Responses to Huntington Beach oil spill

Government response

Government activities in the immediate aftermath of the oil spill concentrated on (1) Unified Command organizing rapid response coordination of emergency management across multiple agencies and levels of government, (2) Unified Command hiring expert consultants, and (3) legislators demanding additional government action and policy change (Fig. 3).

First, on Day 1 (2 October 2021), Huntington Beach officials preemptively placed booms along sensitive areas to protect the wetlands. A Unified Command was organized on Day 2, consisting of the Coast Guard, California Department of Fish and Wildlife's Office of Spill Prevention and Response, and Beta Offshore, with additional support from local cities including

Huntington Beach, Newport Beach, Long Beach, and the Orange County Sheriff's Department. Unified Command created the website www.SoCalSpillResponse.com to detail news releases, fishery closure information, and response imagery by Day 2. The State of California and local affected cities issued states of emergency, closed beaches for cleanup indefinitely, paused recreational and commercial fishing indefinitely, and provided public health warnings. Federal, state, county, and city government resources coordinated according to jurisdictional authority and oil spill-related expertise.

Second, Unified Command hired and contracted experts to support cleanup and disaster response. OWCN specialists arrived by the evening of Day 1 to rescue oiled animals. By Day 2, Unified Command had contracted with Patriot Environmental Services for their expertise in environmental cleanup, specifically for toxic spills and disaster response. Similarly, only pre-trained volunteers were eligible for initial cleanup and animal rescue support; Unified Command declared that untrained volunteers could hinder or harm cleanup efforts.

Finally, local, state, and federal elected officials toured affected sites and demanded policy changes and financial support both formally and verbally. On Day 2, Congresswoman Michelle Steel, representative for the coastline along Orange County, formally requested that the Biden Administration issue a Major Disaster Declaration to protect the vulnerable ecosystems. State senators and assembly members, federal senators, and city council members visited affected areas like the Talbert Marsh and called for new bans on offshore drilling. Several elected officials introduced new bills intended to prevent new construction for offshore drilling and close current drill sites, citing the 2021 oil spill as evidence of their danger.

Non-governmental organization response

NGO efforts in the immediate aftermath of the oil spill concentrated on (1) receiving and organizing material and monetary donations, (2) political lobbying for bans on offshore oil drilling, and (3) organizing volunteers (Fig. 3).

First, NGOs requested material and monetary donations in the initial aftermath of the oil spill. For example, Bolsa Chica Conservancy posted on Twitter a list of specific supplies needed by the Pacific Marine Mammal Center, including nitrile gloves, N-95 masks, Tyvek hazmat suits, syringes for feeding, small red rubber feeding tubes, and animal carrying cases. Local NGOs such as the Surfrider Foundation, HB Wetlands & Wildlife, and California Coastkeeper Alliance also requested monetary donations to support oil spill emergency response efforts.

Second, NGOs used the oil spill as an opportunity to lobby against offshore drilling. On Day 4, Surfrider Foundation started a petition calling on congressional leaders to pass bills banning new offshore oil and gas drilling sites. Leaders of NGOs such as the Huntington Beach Wetlands Conservancy met with local, state, and national representatives to tour affected areas and discuss the threat of offshore drilling on local ecosystems.

Finally, NGOs directed and organized volunteers, following official guidance from Unified Command. Unified Command initially permitted only pre-trained volunteers to support cleanup efforts, with untrained volunteers instructed to contact local

NGOs and wait for training opportunities. When Unified Command allowed volunteers to register for oil spill cleanup training on Day 5, NGOs directed interested volunteers for both animal rescue and oil and tar pickup to sign up for training via the Unified Command's official website.

Local resident response

Local responses in the immediate aftermath of the oil spill concentrated on (1) volunteering and donating to protect the local ecosystem and (2) expressing concern about and suing responsible parties for the economic damages from the oil spill (Fig. 3).

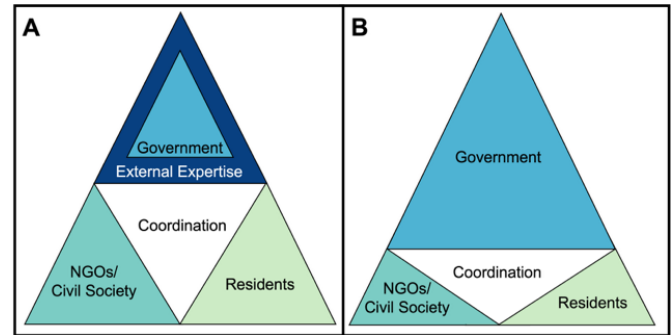
First, local interest in volunteering and donating prompted government agencies and NGOs to direct residents to local NGOs for volunteer and donation opportunities. Unified Command's daily updates and website repeatedly included information on volunteer needs (initially only for pre-trained volunteers), indicating overall interest from the public to help. Online trainings for volunteers became available on Day 5; 7500 people had signed up for training by Day 7, with 200 people ultimately being selected. Trainings lasted four hours rather than the traditional 16 hours because of the COVID-19 pandemic. Newspaper reports describe conversations with residents worried about the long-term impacts on wildlife and coastal ecosystems. In addition, locals signed petitions created by local NGOs to ban offshore oil drilling and protect the coastline.

Second, residents recognized the economic impact of the oil spill, with several suing Amplify Energy and other responsible parties for monetary damages, cleanup costs, and long-term health effects. Residents expressed concerns of the economic impacts to the profitable beach tourism, recreation, surfing and volleyball competitions, and fishing industries. Disc jockey Peter Moses Gutierrez Jr filed a federal lawsuit on Day 3 for alleged economic damages to his business that relies on beach events and for his own exposure to toxic oil. Separately, lawyers filed a class-action lawsuit on behalf of Orange County businesses on Day 6, with preliminary plaintiffs including a surf school and an oceanside rental shop. Residents frequently cited the oil spill as another economic stressor on top of the ongoing impacts of the COVID-19 pandemic.

DISCUSSION

Here, we compare oil spills that differ in size, cause, location, and jurisdictional oversight (Table 1, Table 2) using an inductive approach, highlighting the influence of local context and organizational capacity on disaster response. We highlight the social learnings, the need for multistakeholder collaboration, and the environmental justice and policy implications based on the analysis of these case studies. Successful responses require clearly defined leadership with expert guidance and material resources to quickly begin cleanup, recruit experts, and provide regular and reliable updates to the public. Lack of prior experience with oil spills and deferral in requesting for assistance, combined with delays in experts arriving in Mauritius because of COVID-19-related border closures, prompted local NGOs, civil society groups, and residents to self-organize and begin cleanup, often through trial and error and likely risking both ecosystem and human health (Fig. 4A). The grassroots, community-led efforts were acknowledged and supported by the authorities until formal cleanup agencies took full control of the situation. By contrast, the prompt government-led response in Huntington Beach (the

Fig. 4. Representative diagrams of coordination and power dynamics among government, NGO/civil society, and resident stakeholder groups in (A) Pointe d'Esny, Mauritius, and (B) Orange County, California. Delayed government action and reliance on external expertise in Mauritius resulted in an outsized role for NGOs/civil society and residents in the response. By contrast, robust government action and access to expertise in California resulted in a smaller role for NGOs/civil society and residents in the response.



result of available resources, expertise, and prior oil spill experience) reduced the need for untrained residents to directly participate in cleanup operations (Fig. 4B).

Multistakeholder collaboration

The overlapping priorities and responses of the three stakeholder groups in Mauritius further illustrate the importance of incorporating civil society into disaster response plans (Walker et al. 2015, Swanepoel 2020). Civil society groups emerge as powerful leaders during disasters, organizing both response efforts and retaining a significant role in long-term community recovery (Miller and Mach 2022). Local private sector stakeholders should also be included in the formulation of contingency plans, as is the case in countries like South Africa (Swanepoel 2020). Private companies could provide support after an oil spill in locations with limited expertise such as Mauritius and should be called upon to support rapid response actions (e.g., oil and gas companies with expertise in managing oil spills). The reliance on international expertise continues the concerning precedent already in place in vulnerable small island developing states like Mauritius before the MV Wakashio spill: dependence on external expertise following a disaster rather than consolidating, acknowledging, or calling upon either local or diaspora expertise and resources.

However, it is important to note that this was the first oil spill of this magnitude in Mauritius, whereas the United States has experienced multiple significant oil spills and has a thriving oil and gas industry. Prior oil spills have enabled improvement of emergency management and coordination protocols. In 1989, the Exxon Valdez supertanker spilled 37,000 tonnes of oil in Alaska, devastating the local shoreline and ecosystems. The Exxon Valdez spill contributed to enormous policy shifts in the United States, particularly the Oil Pollution Act of 1990 that established penalties and liability for oil spillers, provided resources for cleanup, and created new expectations for the federal government to respond to oil spills (Birkland and Lawrence 2002). Furthermore, the Oil Pollution Act of 1990 required all petroleum companies in the

United States to prepare for possible oil spills by submitting contingency plans to the Environmental Protection Agency and the U.S. Coast Guard. The Exxon Valdez oil spill and subsequent disasters such as the Deepwater Horizon spill have significantly altered how the United States pursues oil spill preparedness and response; only after experiencing such severe disasters did the United States enact significant policy changes to respond proactively to oil-related threats and spills (Sylves and Comfort 2012). These policy changes are examples of post-disaster social learning and efforts to enhance resilience, which highlighted the need for multistakeholder coordination and created opportunities to strengthen policies to better protect coastal ecosystems and residents from oil spill risks.

Environmental justice challenges and implications

These oil spill case studies raise important environmental justice challenges related to knowledge and expertise in disaster management and highlight the opportunity to pursue sustainability and justice efforts alongside resilience after a disaster (Redman 2014). Inadequate in-country expertise (largely owing to a lack of oil production and of any spill history) coupled with inadequate resources for major spills led the Mauritian government to rely heavily on international oil spill experts to support cleanup. Pandemic-related travel restrictions further slowed response efforts. Although we cannot expect the complete suite of oil spill expertise to be found within a small island nation like Mauritius, Swanepoel (2020) argues that rapid responses could be organized and activated on a regional level. This could be achieved through the establishment of a “Regional Co-ordination Centre (RCC) for Marine Pollution Preparedness and Response in the Western Indian Ocean.” Nations could request and accept help from nearby countries of the region. In March 2020, the Nairobi Convention and the International Maritime Organization (IMO) conducted a regional workshop in Zanzibar, Tanzania, to promote regional cooperation for preparedness and response to marine pollution incidents (Nairobi Convention 2020). In the case of Mauritius, earlier support could have been sought from neighboring Réunion island. By contrast, the Huntington Beach oil spill involved a robust, well-trained, and coordinated response across multiple levels of governments and NGOs such as OWCN; California also has prior experience with oil drilling and oil spills and a comprehensive, funded response system in place.

These divergent responses reflect a parachute support model akin to parachute science when researchers from higher-income countries conduct research in lower-income countries but fail to fully engage with locals (Stefanoudis et al. 2021). For example, the majority (58%) of research publications discussing deadly disasters in developing countries were led by authors in Western, developed countries (Gaillard and Gomez 2015). Vulnerable countries such as Mauritius that rely on external experts during environmental crises may lack the logistical capacity and institutional knowledge to manage low-frequency, high-risk disasters like oil spills by themselves. Such roadblocks and constraints are ubiquitous in small island developing states like Mauritius (Hebbar and Dharmasiri 2022), which further exacerbate the environmental injustices that compounding disasters create for vulnerable nations. Such practices may also inhibit social learning after these disasters. Although oil spills may

be unpredictable, countries should invest collectively in local knowledge, resources, and organizational infrastructure to identify potential impacts and response scenarios in anticipation of a disaster or worst-case scenario (Stoepler and Ludwig 2015), in addition to reliance on external assistance by UN agencies and international aid for more vulnerable nations.

Not all communities benefit from oil or shipping industries in a similar way, creating an additional layer of injustice among at-risk communities. The damage from an oil spill can happen overnight, but reparations and compensation may take months to years to arrive, if they ever do. Huntington Beach has a long history of oil extraction and associated economic benefits (Higgins 1976), whereas Mauritius has not benefited historically from oil extraction but is exposed to 30% of the world’s crude oil supply as it passes its coastlines (United Nations Development Programme 2021). In addition, delayed cleanup action prompted locals to engage in cleanup themselves, often without adequate protective equipment (de Rosnay et al. 2021). The Mauritian government created a special cell to identify beneficiaries for compensation of lost income as a result of the oil spill using a top-down and bottom-up approach, a positive attempt to decentralize recovery efforts (Mannakkara and Wilkinson 2015). Because the cell’s initial focus was on providing financial support to members of the formal economy (who tend to be predominantly men) identified through governmental departments, it inadvertently overlooked the important but informal economy that included vulnerable groups like female gleaners (Nagea et al. 2021). The Mauritian government launched a claims e-program on Day 14 (Government Information Service 2020), although many unregistered fishers likely did not apply, believing they were ineligible (de Rosnay et al. 2021). As of April 2022, more than one year after the spill, the Mauritian government was still working through the claims process with the insurer to provide compensation.

Mauritius is also party to IMO conventions relating to oil spill compensation, namely the International Convention on Civil Liability for Oil Pollution Damage (CLC) and the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND) for tankers (amended in 1996; Asariotis and Premti 2020). Bunker oil spills from non-oil tanker vessels, like the MV Wakashio spill, are covered by the Bunkers Convention (International Maritime Organization 2001) that has been ratified by Mauritius, Panama, and Japan. With the gross tonnage of the MV Wakashio reported as 101,932, any liability for the incident under the Bunkers Convention would be capped at approximately \$65 million USD (Asariotis and Premti 2020). Future research should also explore the socioeconomic and political implications of oil spills caused by international actors in both the affected country and abroad, such as from the Japanese-owned, Panama-flagged MV Wakashio in Mauritius.

Health-related issues related to oil exposure also differ across the two contexts. Those involved in the cleanup operations in Mauritius reported a range of acute symptoms potentially linked to the oil spill, including breathing difficulties, irritated eyes from fumes, and neurological symptoms such as dizziness and nausea (Barmania 2020). Six months after the spill, following

consultations set up by a medical team facilitated by the NGO Eco-Sud, one-sixth of locals examined, who had been exposed to the oil, reported having experienced oil-related health issues (Le Mauricien 2021). In addition, residents reported experiencing difficulties obtaining medical certificates attesting to the impact of the oil spill fumes on their health (de Rosnay et al. 2021). Such incidents, along with delayed response actions, ultimately contributed to greater health and economic damages, with a considerable burden on community members who engaged in cleanup operations, despite health warnings, because they felt adequate actions were not being taken by the authorities (de Ferrer 2020, Rambaree and Rambaree 2021). The psychological impacts of the oil spill on coastal residents who faced uncertainty in light of the disaster, including those who scrambled to participate in the initial clean-up efforts and those who lost their livelihoods, are also not insignificant, ranging from sadness and anxiety to post-traumatic stress disorder (Barmania 2020).

In California, government agencies issued health warnings, started cleanup operations, and provided compensation information at earlier stages of the response, as is standard procedure based on the California State Oil Spill Contingency Plan (California Department of Fish and Wildlife and Office of Spill Prevention and Response 2019). Public health officials warned residents to avoid the beaches and other contaminated areas (Orange County Health Care Agency 2021). Unified Command and NGOs redirected untrained volunteers away from the beaches to ensure public safety, following the state's oil spill contingency plan (California Department of Fish and Wildlife and Office of Spill Prevention and Response 2020). A study of mental health impacts associated with the 2010 Deepwater Horizon demonstrated that individuals engaged in oil spill response and cleanup activities were linked with a higher prevalence of depression and post-traumatic stress disorder (Kwok et al. 2017). Where institutional capacity and leadership are weaker, affected communities ultimately face the burden of the immediate response and cleanup (Fig. 4), often associated with both physical and psychological distress.

Marginalized and socially vulnerable groups, such as small-scale fishing communities and tourism-dependent residents, are at the greatest risk of long-term damages and impacts from oil spills (Andrews et al. 2021). In Huntington Beach, as in Mauritius, environmental damages are major stressors and have the potential to negatively impact small businesses that depend on healthy marine ecosystems, including restaurants, equipment renters, wildlife guides, and fishers (Beyond Business Incorporated v. Amplify Energy Corporation 2021, Justia 2021, Straus 2021).

Policy implications

The Pointe D'Esny and Huntington Beach oil spills occurred during the COVID-19 pandemic and offer preliminary insights into the pandemic's influence on oil spill emergency management and disaster governance. The compounding nature of the oil spill and pandemic in Mauritius resulted in exacerbated negative impacts from the second disaster (the oil spill). By contrast, higher levels of institutional expertise and resources reduced the compounding nature of the oil spill in California. In this case, higher levels of oil spill preparedness, perhaps also in conjunction with the oil spill's timing during a later period of the pandemic, resulted in fewer pandemic-specific impacts on the oil spill

response. These two cases demonstrate how institutional factors and prior experience affect response to compounding disasters, and how social learning can help foster resilience to disasters within coastal social-ecological systems (de Kraker 2017) and shape adaptive capacity in society (Gupta et al. 2010, Green et al. 2021). The improvisation and innovation in making artisanal oil booms and grassroots mobilization observed in Mauritius stemmed from perceived weaker institutional response (Gupta et al. 2010, Glantz and Ramírez 2018). When faced with disasters, residents and local groups often turn into zero-order responders, survivors who must improvise in response to ongoing, changing circumstances to protect lives and property, such as the artisanal boom producers in Mauritius. The Mauritian case study highlights the need for decision makers to include community-level actors in pre-disaster preparedness and the importance of compiling case studies of such grassroots improvisation for their potential contribution to risk prevention, response, and recovery with regard to these growing disasters (Glantz and Ramírez 2018, Peek et al. 2021).

However, the public health burden on residents involved in an oil spill cleanup poses important environmental justice and sustainability concerns, which need to be addressed not only through policy interventions to support impacted communities but also through increasing preparedness for future disasters in vulnerable contexts. Social learning after disasters, beyond improving disaster resilience, is also paramount to enhancing sustainable development (Brundiers and Eakin 2018) and overall improvement of quality of life for people and nature, particularly for risk reduction, coined by the notion of "building back better" (Cutter et al. 2015). This phrase has also been used widely to refer to post-pandemic improvements to human systems, from health care to sustainable societies and economies (Bolton 2020, Jenkins and Smith 2021). Our study posits that we need to prepare for compounding disasters to build back better for people and nature (Andraka et al. 2020, Martinez et al. 2020, Mangubhai et al. 2021, Sultana 2021).

After both oil spills, elected officials and residents demanded and proposed more stringent environmental protections (Figs. 2 and 3), possibly indicating the opening of a policy window, with potential to improve response and resiliency to disasters. Given the political nature of most disaster responses, this is a common occurrence after oil spills that leads to the development of policies and regulations targeting prevention and response actions (Olson and Gawronski 2010, Chen et al. 2019b). Policy windows form when problems occur (such as an oil spill) with viable solutions (such as bans on offshore oil drilling) and both public and political support (such as calls from both politicians and locals to act; Kingdon 1995, Birkland 1996). New calls to ban offshore oil drilling in the United States after the Huntington Beach oil spill are the latest example of decades-long political lobbying to end offshore oil drilling (Tostevin 1987). In Mauritius, a context where political protests are culturally rare (Nagea 2021), thousands of residents came together to protest in demand of better environmental governance and disaster management. Additionally, policy changes in Mauritius included reworking the National Contingency plan building on experience gathered from the Wakashio oil spill (Government Information Service 2021), and instituting a new shipping regulation ("Establishment of Recommended Areas To Be Avoided [ATBAs] around

Mauritius”) to protect the Mauritian coastline (Ministry of Blue Economy, Marine Resources, Fisheries and Shipping 2020). In the same way that Exxon Valdez and the Deepwater horizon spills forced the United States to rethink its oil spill response (leading to clearer responsibilities, resources, and expertise available in the event of an oil spill), Mauritius, which never before had an oil spill, is now responding to its worst environmental crisis by establishing new policies.

Beyond a contingency plan, practice drills are also needed to ensure organized and effective disaster response. In Mauritius, government agencies had not been able to practice through drills for an oil spill emergency of this extent and ultimately struggled to respond quickly and effectively to the nation’s first oil spill (Swanepoel 2020). In addition, cleanup operators in Mauritius had minimal experience with the new type of VLSFO carried by the MV Wakashio that spilled near critical ecosystems such as mangroves, which required specialized cleaning techniques and also created more perceptions of uncertainty around cleanup operations (de Rosnay et al. 2021, Scarlett et al. 2021). By contrast, multiple government agencies in Orange County were experienced with oil spill cleanups. Huntington Beach had a major oil spill in 1990 that affected many of the same ecological reserves as the 2021 spill (American Trader Trustee Council et al. 2001). The California Department of Fish and Wildlife organizes drills for its Office of Spill Prevention and Response (California Department of Fish and Wildlife 2021). Given the unpredictable nature of oil spills, institutions and coastal communities should actively prepare for a potential spill by both crafting plans and practicing responses that incorporate multiple stakeholders who would participate in the actual response. Such low-frequency, high-risk situations require in-country and regional expertise and experience to protect ecosystems and communities most effectively and to address the critical environmental justice issues related to public health, loss of livelihoods, and food security emanating from such disasters. This comparative case study offers a critical lens to understanding how in-country expertise, prior experience, and resources shape multistakeholder responses in socio-political and ecological systems, which in turn impact communities and ecologically sensitive ecosystems at risk from disasters such as oil spills.

Author Contributions:

J.N. and R.K.M. conceived of and designed the research, collected and analyzed the data, and wrote the paper.

Acknowledgments:

We would like to thank Tim McClanahan, Vikash Tatayah, Pierre Fallavier, Krish Seetah, Jennifer K. O’Leary, Larry Crowder, and Emilie Wiehe who provided comments on draft versions of this manuscript. This research was supported by the Emmett Interdisciplinary Program in Environment and Resources, the Stanford HAAS Center for Public Service Graduate Summer Fellowship for Community Engaged Research, the Huntington-USC Institute on California and the West, and the Stanford Center for Ocean Solutions.

Data Availability:

The data/code that support the findings of this study are openly available in Appendix 1.

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Appendix 1. Pointe d’Esny Oil Spill Timelines from August 6-16, 2020

Government Timeline:

Day	Activity
Day 0 (8/6)	Oil begins to leak from the MV Wakashio vessel at 11am. Mauritian authorities mobilize on site to contain the spill. All MV Wakashio crew members have been evacuated (Ministry of Environment, 2020).
	The Mauritian government issues strict restrictions on access to affected areas, including Blue Bay Marine Park and the Grand Port Fishing Reserve. Booms are deployed in highly sensitive areas including the Ramsar site of Pointe d’Esny and the Blue Bay Marine Park (Ministry of Environment, 2020).
	The Ministry of Foreign Affairs, Regional Integration and International Trade makes an appeal for international aid to support cleanup efforts (Ministry of Environment, 2020).
	Authorities from Reunion Island (one of the two primary islands in the Republic of Mauritius) begin providing cleanup assistance (Ministry of Environment, 2020).
Day 1 (8/7)	Republic of Mauritius declares a “state of environmental emergency,” emphasizing concern about damages to the country’s coastal waters and marine wildlife (The Editorial Team, 2020b).
	The Mauritian government establishes multiple coordination mechanisms including: Daily National Crisis Management Committee meetings led by the Prime Minister to review and make decisions on strategic and technical issues; the National Oil Spill Coordination Committee chaired by the Director of Environment to meet every morning to review progress, assess the situation, and plan the next 24 hours of work; and the National Emergency Operations Command chaired by the Commissioner of Police and a dedicated Coordination Committee for the Salvaging of the Vessel chaired by the Director of Shipping (United Nations Office for the Coordination of Humanitarian Affairs, 2020c).
	The Union Civil Protection Mechanism is activated following the Republic of Mauritius’ request for equipment and experts in oil spills, pollution monitoring, environmental protection, and environmental damage evaluation (United Nations Office for the Coordination of Humanitarian Affairs, 2020b).
Day 2 (8/8)	The Prime Minister chairs daily national crisis meetings (UN Office for the Coordination of Humanitarian Affairs, 2020).
Day 3 (8/9)	The Prime Minister chairs daily national crisis meetings (UN Office for the Coordination of Humanitarian Affairs, 2020).
	The Mauritian Wildlife Foundation visited the southeast islet nature reserves (Ile de la Passe, Ilot Vacoas, Ile aux Fouquets, and Ile Marianne) with the National Parks and Conservation Service. The presence of oil prompts a decision to remove a small number of reptiles from each island to capture their genetic diversity and establish captive assurance populations. Reptiles remained in a biosecure facility in Mauritius until they could be transported to the Jersey Zoo on the island of Durrell in the English Channel on September 14, 2020, by private jet (Mauritian Wildlife Foundation, 2021).

Day 4 (8/10)	Current cleanup involves floating dams, oil booms, oil pumps, skimmers, and vessels to carry collected oil sludge to shore and then recycling centers. However, additional booms, barges, lorries, and intermediary storage containers are needed to support cleanup. Sea boom placement prioritizes environmentally sensitive areas (United Nations Mauritius, 2020b).
	High waves from difficult weather conditions threaten to break the MV Wakashio vessel. The Prime Minister announces concerns of a “worst case scenario” in anticipation of the vessel falling apart “at some point” (United Nations Office for the Coordination of Humanitarian Affairs, 2020c).
	The Mauritius Oceanographic Institute conducts oil slick movement modeling with support from the Government of France, a local university, and an Indian Center collaborating with UNESCO (United Nations Office for the Coordination of Humanitarian Affairs, 2020c).
	The Ministry of Health prepares health messaging for affected communities based on guidelines from the World Health Organization (WHO) (United Nations Office for the Coordination of Humanitarian Affairs, 2020c).
	France sends a team of ten French specialists from Reunion Island. The Indian government provides technical support for environmental and pollution control and cleanup. The European Union announced support for the ongoing environmental crisis. The United Kingdom’s Maritime and Coastguard Agency begins discussions with local authorities on what expertise and equipment are required, including how to prepare for the worst-case scenario. Mauritius continues consulting with other countries considering providing support (United Nations Office for the Coordination of Humanitarian Affairs, 2020c).
Day 5 (8/11)	Oil spill response, legal support, and coordination experts arrive in Mauritius from an interagency United Nations team. They had previously provided support remotely to local authorities. Expert teams have been organized by the International Maritime Organization (IMO), UN Environmental Programme (UNEP), UN Office for the Coordination of Humanitarian Affairs (OCHA), International Organization for Migration (IOM), and UN Office on Drugs and Crime (UNODC) (United Nations Mauritius, 2020c).
	Japan sends experts to help with cleanup logistics (United Nations Office for the Coordination of Humanitarian Affairs, 2020c).
	COVID-19 pandemic constrains international travel and expert arrival (Ighobor, 2021).
Day 6 (8/12)	The Prime Minister continues to chair daily crisis meetings and thanks government departments, international organizations, friendly countries, NGOs, the private sector, and local communities for their roles in the response, acknowledging the hundreds of Mauritians who have joined clean-up efforts, including crafting and deploying booms and bringing food for volunteers (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).
	Japanese, French, and United Nations experts organize into four groups: Strategic and Coordination, Operations and Response; Social and Environmental Impacts Evaluation; and Forensic, Claims and Finance (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).

	<p>The Government of Mauritius receives additional technical support from UNDP, UNESCO's Oceanographic Institute, WHO, IOM, UNODC, UNOSAT, Office for the Coordination of Humanitarian Affairs (OCHA), the African Development Bank, World Bank, and International Monetary Fund (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).</p> <p>International experts continue to support cleanup. Australia sets up a virtual panel of technical and scientific experts with experience in oil spill response and tropical ecosystems. The United States National Oceanic and Atmospheric Administration (NOAA) provides satellite analysis and imagery to the Mauritius Ministry of Environment, Solid Waste Management and Climate Change, in coordination with United Nations Satellite Centre (UNOSAT). The Government of India announces intent to provide additional booms and skimmers. The United Kingdom continues conversations on providing assistance to Mauritius (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).</p>
Day 7 (8/13)	<p>Mauritian government continues national crisis meetings, with guidance from international experts. Every morning, a technical coordination meeting is organized with the participation of the technical stakeholders actively involved in marine pollution control and disposal to fine-tune the planning and response strategy (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).</p> <p>The National Parks and Conservation Service, Forestry Services, in collaboration with the NGO Mauritian Wildlife Foundation, collect young adult Bojer's skinks (with a roughly equal ratio of male and female) from Ile de la Passe, Ilet Vacoas, and Ile aux Fouquets to capture genetic variance (Mauritian Wildlife Foundation, 2021).</p>
Day 8 (8/14)	<p>The Ministry of Environment, Solid Waste Management and Climate Change thanks NGOs and residents for their rapid response in support of oil spill cleanup but advises the public to stop visiting the impacted sites. Professionals and experts are now on the ground managing the oil spill response to support and take over efforts previously undertaken by cleanup volunteers (Ministère de l'Environnement, 2020).</p> <p>The Ministry of Environment, Solid Waste Management and Climate Change reports that approximately 13 villages are affected by the spill and require immediate and long-term assistance (International Organization for Migration, 2020). IOM begins deploying resources and expertise to support government efforts to reduce the impacts of the oil spill on livelihoods and potential displacement (United Nations Office for the Coordination of Humanitarian Affairs, 2020a, International Organization for Migration, 2020).</p>
Day 9 (8/15)	<p>The MV Wakashio vessel breaks into two pieces, with 90 tonnes of oil still aboard the vessel, and is closely monitored, with teams and materials in place in case of a potential spill (United Nations Office for the Coordination of Humanitarian Affairs, 2020e). An estimated 40 tonnes are removed on Day 9 with ongoing efforts to pump the remaining oil from the ship and extract it via helicopter in order to reduce oil spillage from the vessel (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).</p> <p>French experts validate and approve a plan to tow the vessel's bow away from the reefs to eight nautical miles from the outer limit of the reef at 2,000 metres depth (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).</p>

	Shoreline clean-up continues, with over 880 metric tonnes of oil waste collected across 14 sites (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).
	The Ministry of Environment, Solid Waste Management and Climate Change begins conducting environmental surveys to evaluate the size of the oil spill. An estimated 30 km of the coastline have been heavily impacted (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).
	The National Environment Laboratory, along with the Ministry of Health and Wellness, Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping, and Ministry of Agro-Industry and Food Security, oversee the monitoring of air quality and marine resources. No volatile organic compounds are detected (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).
Day 10 (8/16)	Field information, combined with satellite observations, indicates that the Wakashio spill came to a halt on Day 10 (Centro euro-Mediterraneo sui Cambiamenti Climatici, 2020).
	India sends 30 tonnes of technical equipment and ten members of the Indian Coast Guard with expertise in oil spills to support the Mauritian government (Sandhu, 2020).
	Environmental experts from the International Tanker Owner's Pollution Federation Limited (ITOPF) and Le Floch Depollution arrive in Mauritius to begin preparing action plans for cleanup and restoration (United Nations Office for the Coordination of Humanitarian Affairs, 2020e). The cleanup action plan is approved by the Mauritian government at the National Crisis Committee meeting on Day 11 (August 17), with active clean-up starting on Day 13 (August 19) (International Tanker Owners Pollution Federation Limited, 2020).

Non-Governmental Organization Timeline:

Day	Activity
Day 0 (8/6)	The Mauritian Wildlife Foundation (MWF), upon gauging the severity and speed of the leakage, initiates tier three of their contingency plan. A substantial spill could threaten native and endemic biodiversity on the Ile aux Aigrettes (IAA) island reserve, situated close to the shipwreck and spill site, through fire risks, toxic fuel fumes, and exposure to toxic chemicals. The field station is closed immediately, with all visitors and nonessential staff evacuated (Mauritian Wildlife Foundation, 2021).
	MWF begins emergency response measures to protect the native and endemic biodiversity on Ile aux Aigrettes (IAA). Staff relocate 21 young giant tortoises <i>Aldabrachelys gigantea</i> , one captive Bojer's skink <i>Gongylomorphus bojerii</i> , and invertebrate colony to the Mauritius mainland. Fifty additional young giant tortoises are relocated to mainland tortoise enclosures. Thirteen Telfair's skinks <i>Leiopisma telfairii</i> in a skink nursery could not be removed due to biosecurity risks. Live IAA crickets, an undescribed endemic type of cricket, were placed in an enclosure (Mauritian Wildlife Foundation, 2021).
	During the evening, ecosocialist activists of CARES Mauritius, leftist political party Resistanz ek Alternativ (ReA) and other solidarity leaders and partners, including local NGOs, begin building and testing an artisanal boom made of dried sugar cane

	leaves (an easily available by-product of the local sugar industry) and ordinary materials available from hardware stores. Upon the successful test of the boom, activists alerted local residents through social media to begin gathering supplies to build more booms the next morning (August 7) (Ngam, 2021, Rungoo, 2021).
Day 1 (8/7)	The Mauritian Wildlife Foundation and Eco-Sud establish crowdfunding links to raise funds for on-the-ground actions and begin coordination efforts to collect and distribute adequate safety equipment (PPE) to ensure public safety during cleanup operations (Tibaldeschi, 2020, Eco-Sud, 2020b).
	NGOs and civil society groups partner with tour operators and local volunteers across Mauritius to help build booms from dried sugar cane leaves, straw, and hair. This leads to nationwide hair donations among residents (Trends Desk, 2020). Volunteers use small tourist boats and fishing vessels to place the booms in the water to prevent oil from reaching the shore (Tibaldeschi, 2020).
	The Mauritian Wildlife Foundation continues its efforts to rescue endemic plants and animals from Ile aux Aigrettes (Tibaldeschi, 2020).
Day 2 (8/8)	NGOs and civil society groups continue to coordinate artisanal boom production (Rungoo, 2021).
	The Mauritian Wildlife Foundation continues its efforts to rescue endemic plants and animals from Ile aux Aigrettes (Tibaldeschi, 2020).
Day 3 (8/9)	NGOs and civil society groups continue to coordinate artisanal boom production (Rungoo, 2021).
	The Mauritian Wildlife Foundation continues its efforts to rescue endemic plants and animals from Ile aux Aigrettes (Tibaldeschi, 2020).
Day 4 (8/10)	NGOs and civil society groups continue to coordinate artisanal boom production (Rungoo, 2021).
	The Mauritian Wildlife Foundation visited the southeast islet nature reserves (Ile de la Passe, Ilot Vacoas, Ile aux Fouquets, and Ile Marianne) with the National Parks and Conservation Service. The presence of oil prompts a decision to remove a small number of reptiles from each island to capture their genetic diversity and establish captive assurance populations. Reptiles remained in a biosecure facility in Mauritius until they could be transported to the Jersey Zoo on the island of Durrell in the English Channel on September 14, 2020, by private jet (Mauritian Wildlife Foundation, 2021).
	Aerial imagery reveals that artisanal booms protected the oceans and coral reefs. More than half of the oil that had leaked from the MV Wakashio was collected and removed by artisanal booms (Ngam, 2021).
Day 5 (8/11)	NGOs and civil society groups continue to coordinate artisanal boom production (Rungoo, 2021). Thousands of community volunteers and members of the private sector mobilize daily to support NGOs in making artisanal booms (United Nations Office for the Coordination of Humanitarian Affairs, 2020d). The private sector (e.g., grocery chains) contributed raw material, refreshments, and transport to support NGOs and volunteers (Trends Desk, 2020).
Day 6 (8/12)	The Prime Minister thanks government departments, international organizations, friendly countries, NGOs, the private sector, and local communities for their roles in the response, acknowledging the hundreds of Mauritians who have joined clean-up

	efforts, including crafting and deploying booms and bringing food for volunteers (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).
	Community-driven clean-up activities continue across multiple affected locations. Volunteers included local residents, private sector entities, and NGOs working every day to mitigate damages (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).
	The Mauritian Red Cross join in artisanal boom production. (Croix-Rouge de Maurice, 2020).
	United Nations experts meet with civil society organizations (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).
	United Nations Development Programme (UNDP) allocates \$200,000 USD through the Global Environmental Facility (GEF) Small Grants Programme (SGP) to support government institutions and NGOs working on oil spill response and communities affected by the disaster (United Nations Mauritius, 2020a).
	MWF continues its efforts to rescue endemic plants and animals from Ile aux Aigrettes. Young adult Bojer's skinks (with a roughly equal ratio of male and female) are collected from Ile de la Passe, Ilot Vacoas, and Ile aux Fouquets to capture genetic variance, along with the National Parks and Conservation Service, Forestry Services. Thirty young adult lesser night geckos <i>Nactus coindemirensis</i> (with a roughly equal ratio of male and female) are also collected from Ilot Vacoas and Ile Marianne to capture genetic variance. Animals are transferred to a biosecure holding facility where they underwent health checks. Geckos remained under the care and management of Durrell and MWF staff (Mauritian Wildlife Foundation, 2021).
Day 7 (8/13)	NGOs and civil society groups advise volunteers not to participate in clean -up activities anymore, as experts and specific private companies are now handling the clean-up operations including removal of artisanal oil booms set up in the earlier days of the spill (Eco-Sud, 2020c).
Day 8 (8/14)	The UNDP GEF SGP hosts a civil society dialogue in collaboration with the United Nation Resident Coordinator's Office at Eco-Sud's office in Pointe d'Esny. The dialogue produced a list of action items and recommendations agreed upon jointly by NGO/civil society groups and UN experts. UN experts provided updates on cleanup efforts, including recommendations to stop volunteer community cleanup efforts to reduce local exposure to oil spill sites (United Nations GEF Small Grants Programme Office, 2020).
	The Ministry of Environment, Solid Waste Management and Climate Change thanks NGOs and residents for their rapid response in support of oil spill cleanup but advises the public to stop visiting the impacted sites. Professional oil spill clean-up experts (Le Floch Dépollution) appointed by the vessel's are now on the ground managing the oil spill response to support and taking over efforts previously undertaken by cleanup volunteers (Ministère de l'Environnement, 2020, International Tanker Owners Pollution Federation Limited, 2020).
Day 9 (8/15)	NGOs participate in National Technical Coordination meetings (Eco-Sud, 2020a).

Day 10 (8/16)	Crowdfunding appeals by NGOs via platforms like Crowdfund.mu and Gofundme.com are ongoing to support ecosystem restoration and alternative livelihood programs for affected individuals (Eco-Sud, 2020b).
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Local Resident Timeline:

Day	Activity
Day 0 (8/6)	Residents first informed about oil spill (Ministry of Environment, 2020). The Ministry of Environment, Solid Waste Management and Climate Change requests that the public, including boat operators and fishers, not go to the beach and lagoons of Blue Bay, Pointe d'Esny, and Mahebourg. Fishers and boat operators are asked to remove their boats from the listed beach and lagoons (Ministry of Environment, 2020).
Day 1 (8/7)	After successful testing of artisanal booms, activists send word early in the morning for more activists and locals to gather materials and build booms. Residents joined local civil society organizations and tour operators across Mauritius to build booms from dried sugar cane leaves, straw, and hair. Approximately 1,000 activists arrive and begin stuffing sugarcane leaves, straw, and human hair into green mesh bags, then linked together to form long booms. Plastic bottles placed under the booms ensured they would float (Ngam, 2021). Residents used small tourist boats and fishing vessels to place the booms in the water to prevent oil from reaching the shore (Tibaldeschi, 2020). Local residents and Mauritians living abroad start donating hair. Hair packed in pantyhose are being used as a makeshift boom to absorb the oil (Tibaldeschi, 2020, Mossae and Rana, 2020).
Day 2 (8/8)	Residents continue volunteering to make artisanal oil booms (Tibaldeschi, 2020). Over 100,000 people volunteer to create more artisanal oil booms, many learning about the efforts from Mauritian media. Barbershops offer free haircuts to collect hair, while locals collect straw from nearby farms (Ngam, 2021). Mauritian diaspora in North America and Europe fundraise to provide personal protective equipment for volunteers and money to support NGO cleanup and lagoon rehabilitation efforts (Nguyen, 2020).
Day 3 (8/9)	Residents continue volunteering to make artisanal oil booms (Tibaldeschi, 2020).
Day 4 (8/10)	Residents continue volunteering to make artisan oil booms, now led by NGO and civil society organizations. Thousands of community volunteers and members of the private sector have mobilized to create artisan booms to mitigate the damages (United Nations Office for the Coordination of Humanitarian Affairs, 2020d). Aerial imagery reveals that artisanal booms protected the oceans and coral reefs. More than half of the oil that had leaked from the MV Wakashio was collected and removed by artisanal booms (Ngam, 2021).
Day 5 (8/11)	Residents continue volunteering to make artisanal oil booms (Tibaldeschi, 2020).
Day 6 (8/12)	Residents continue volunteering to make artisanal oil booms (Tibaldeschi, 2020). The Prime Minister thanks government departments, international organizations, friendly countries, NGOs, the private sector, and local communities for their roles in

	<p>the response, acknowledging the hundreds of Mauritians who have joined clean-up efforts, including crafting and deploying booms and bringing food for volunteers (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).</p> <p>Community-driven clean-up activities and artisanal boom production continue across multiple affected locations involving hundreds of volunteers. Volunteers include private individuals, private sector entities, and NGOs coming every day to mitigate damages (United Nations Office for the Coordination of Humanitarian Affairs, 2020d).</p>
Day 7 (8/13)	Residents advised by NGOs to stop participating in boom production as professional clean up experts are now on the ground (Eco-Sud, 2020c).
Day 8 (8/14)	<p>The Ministry of Environment, Solid Waste Management and Climate Change thanks NGOs and residents for their rapid response in support of oil spill cleanup but advises the public to stop visiting the impacted sites. Professionals and experts are now on the ground managing the oil spill response to support and take over efforts previously undertaken by cleanup volunteers (Ministère de l'Environnement, 2020).</p> <p>On expert advice, artisanal boom production ends. The Ministry of Environment, Solid Waste Management and Climate Change promises to keep the public informed of the ongoing cleanup situation in case new booms become needed (Ministère de l'Environnement, 2020).</p>
Day 9 (8/15)	Artisanal boom production stops based on advice from experts (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).
Day 10 (8/16)	<p>Authorities oversee shoreline cleanup by volunteers, civil society organizations, fishers, fish mongers, and boat operators in affected regions (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).</p> <p>Artisanal booms created and deployed by volunteers will be replaced with new booms (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).</p> <p>Professional cleaning begins. Local residents, more specifically fishers, fish mongers and boat operators in the affected regions are recruited to support the cleaning the shorelines, under the supervision of the authorities (United Nations Office for the Coordination of Humanitarian Affairs, 2020e). The Ministry of Blue Economy supervises the recruitment of 516 local fishers to conduct beach cleanup across 15 sites (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).</p>

Major events following Day 10:

Day 11 (8/17)	The National Crisis Management Committee announces that 884 tonnes of oil liquid waste, 524 tonnes of solid waste sludge and contaminated debris, and 416 cubic meters of saturated artisanal booms were collected. Professional companies begin cleanup following clear guidelines (United Nations Office for the Coordination of Humanitarian Affairs, 2020e).
Day 12 (8/18)	Mauritius police authorities arrest captain of MV Wakashio and charge him with endangering the safe navigation of a vessel (The Editorial Team, 2020c).
Day 13 (8/19)	Mauritius government decides to sink the MV Wakashio's bow. Greenpeace Africa and Greenpeace Japan warn of the potential negative consequences to biodiversity due to contamination (The Editorial Team, 2020a).

Day 14 (8/20)	Mauritius government launches an E-platform to facilitate claims for which the ship owner and insurer will be held liable (Government Information Service, 2020).
Day 16 (8/22)	Mauritius government sinks MV Wakashio's bow despite biodiversity concerns (The Editorial Team, 2020d).
Day 18 (8/24)	The United Nations Recovery Fund provides \$2.5 million USD to establish a fund to help minimize socioeconomic and environmental impacts of the oil spill. Additional seed funds of \$250,000 USD from the Regional UN Sustainable Development Group will assist in community disaster prevention, risk management, and recovery (Government of Mauritius, 2020b).
Days 20-22 (8/26- 8/28)	An estimated 40 dead cetaceans wash ashore. Greenpeace claims the dead cetaceans are linked to the oil spill and calls for an investigation into their deaths (The Editorial Team, 2020e). The Minister of Blue Economy, Marine Resources, Fisheries and Shipping denies a connection between the animal deaths and the oil spill, referring to the deaths as a "sad coincidence" (Anna, 2020a).
Day 23 (8/29)	Mauritians protest the government's slow response to the MV Wakashio oil spill and recent discovery of dead dolphins (Anna, 2020b). Activist Bruneau Laurette, political party Reziztans ek Alternativ, CARES, and other members of the solidarity assembly (composed of activists, political parties, and civil society) organize the largest march in Mauritius' history. At least 150,000 people march in Port Louis, the capital, with millions of other Mauritians and activists joining in solidarity marches around the world (Ngam, 2021).
Day 25 (8/31)	A tugboat involved in the MV Wakashio salvage operations sinks after colliding with a barge, killing at least three sailors. The tugboat was towing the barge from the hull of the MV Wakashio (Meldrum, 2020).
Day 26 (9/01)	Fishers, fishmongers, and pleasure craft workers begin receiving a monthly solidarity grant of Rs 10,200 (\$235 USD) as compensation for the oil spill's economic and marine impact (Government of Mauritius, 2020a).
Day 32 (9/07)	The NGO Eco-Sud sets up a cell to provide psychological and physical health support to residents of affected areas, which ran until Dec 3, 2020. The initiative supported 277 patients from 9 villages of the affected shoreline (Eco-Sud, 2021).
Day 33 (9/08)	The Panama Maritime Authority (AMP) issues its first official statement and confirms that the MV Wakashio diverted from its original navigation plan (The Editorial Team, 2020f).
Day 77 (10/21)	The Ministry of Environment, Solid Waste Management and Climate Change organizes a Review of the Draft National Oil Spill Contingency Plan to identify lessons learned from recent oil spills, including the MV Wakashio spill (United Nations Development Programme, 2021).
Day 118 (12/1)	Shipping restrictions issued by the Ministry of Blue Economy, Marine Resources, Fisheries and Shipping are enacted on ships with at least 150 gross tonnage (Ministry of Blue Economy, Marine Resources, Fisheries and Shipping, 2020).

Huntington Beach Oil Spill Timelines from October 1-11, 2021

Government Timeline:

Day	Activity
Day 0 (10/1)	California Office of Emergency Services (CalOES) receives a call regarding an unknown spill at 8:22pm (Chabria et al., 2021a).
	The Office of Spill Prevention and Response (OSPR) within the California Department of Fish and Wildlife, learns of an “observed sheen in federal waters several miles off the coast of Huntington Beach” at 10:22pm. Federal and state agencies begin to mobilize in response to an oil spill but are hampered by darkness (Chabria et al., 2021a).
Day 1 (10/2)	National Oceanic and Atmospheric Administration (NOAA) reports oily anomaly around 2am from a satellite image (Cain, 2021).
	The U.S. Coast Guard receives report of oil sheen at 9:10am. The Coast Guard issues a public announcement on Twitter (Chabria et al., 2021a).
	Unified Command is established in the afternoon. Unified Command includes the U.S. Coast Guard, OSPR, and Amplify Energy Corp. (Southern California Spill Response, 2021a).
	The California Department of Fish and Wildlife issues a fisheries closure for all fish and shellfish up to six miles from shore in the affected area based on recommendations from the Office of Environmental Health Hazard Assessment (OEHHA). The fisheries closure is established based on concerns about public health (State of California - Natural Resources Agency, 2021c).
	Huntington Beach proactively deploys booms at the Talbert Inlet Channel, the Warner Bridge off Pacific Coast Highway, and the Warner Fire Station, and the entrance to Talbert Marsh to protect the Bolsa Chica Wetlands (Fry and Estrin, 2021).
Day 2 (10/3)	Huntington Beach cancels the third and final day of the Pacific Airshow. Beaches in Huntington Beach and Newport Beach are closed. Officials urge residents to stay off the beaches (Rong-Gong Lin and Watanabe, 2021).
	Orange County Health Care Agency issues a health warning urging people who have had exposure to seek medical attention and for residents to stay away from the coastline (Orange County Health Care Agency, 2021).
	Congresswoman Michelle Steel issues a request for a Major Disaster Declaration by the Biden Administration to access federal resources and financial support for emergency response (Steel, 2021).
Day 3 (10/4)	Orange County, the City of Huntington Beach, and the State of California declare a state of emergency (Office of Governor Gavin Newsom, 2021, City of Huntington Beach, 2021b, Elattar, 2021).
	State Senator Dave Min calls on federal representatives to pass legislation that formally bans offshore oil drilling (Dave Min Representing Senate District 37, 2021). Senator Dianne Feinstein and Senator Alex Padilla reference the “West Coast Ocean Protection Act” which would place a permanent ban on offshore oil and gas drilling. Both senators are sponsors (United States Senator for California: Dianne Feinstein, 2021, Alex Padilla: U.S. Senator for California, 2021).

	An Orange County representative joins the Unified Command as a local government on-scene coordinator (Southern California Spill Response, 2021a).
Day 4 (10/5)	The California Department of Fish and Wildlife expands the fisheries closure of both recreational and commercial fishing based on recommendations from OEHHA. The closure extends from Huntington Beach to San Clemente, eight miles offshore (State of California - Natural Resources Agency, 2021a).
	Four Congressmembers representing Southern California (Michelle Steel, Ken Calvert, Young Kim, and Darrell Issa) demand a federal investigation by the Biden Administration into the causes of the spill and any federal delays in the response (Michelle Steel, 2021).
Day 5 (10/6)	U.S. Coast Guard investigates and releases the Rotterdam Express, a cargo ship in Oakland, in anchor theory probe. The Rotterdam Express was the closest anchored ship to the burst pipeline (Chabria et al., 2021b).
	The House Oversight and Reform Committee requests records from federal agencies to determine if regulatory failings may be linked to the oil spill (McCaskill and Sheets, 2021).
Day 6 (10/7)	The California Department of Fish and Wildlife expands the fisheries closure of both recreational and commercial fishing based on recommendations from OEHHA. The closure includes the shorelines, bays and harbors, and offshore areas extending up to 18 miles offshore (Robinson, 2021, State of California - Natural Resources Agency, 2021b).
	Private Orange County-based company Moffat & Nichol begins testing beaches for contaminants (Connelly, 2021).
Day 7 (10/8)	Unified Command announces the end of public updates without major news to report (Pho and Custodio, 2021).
	A San Diego County representative joins the Unified Command as a local government on-scene coordinator (Southern California Spill Response, 2021a).
Day 9 (10/10)	The Orange County government is starting the process of providing recovery grants of \$5,000-\$20,000 to affected business owners. The county government recommends that residents should document their losses and file claims with Unified Command (Estrin and Gerber, 2021).
Day 10 (10/11)	The California Department of Justice launches investigation into oil spill response and cause (Estrin and Fry, 2021).
	State and city beaches in Huntington Beach reopen at 6am after water quality tests return at below levels of concern (Estrin, 2021).

Non-Governmental Organization Timeline:

Day	Activity
Day 1 (10/2)	The Oiled Wildlife Care Network (OWCN) is activated to bring veterinary specialists to the affected site (Southern California Spill Response, 2021b).
Day 2 (10/3)	Bolsa Chica Conservancy encourages donations of supplies to Pacific Marine Mammal Center. Supply requests include nitrile gloves of all sizes, N95 masks, Tyvek suits, feeding syringes, small red rubber feeding tubes, and collapsible plastic or cardboard animal carrying cases (@BolsaChicaCon, 2021).
	OWCN teams deploy to find and clean affected wildlife (Bolsa Chica Conservancy, 2021a).

Day 3 (10/4)	Bolsa Chica Conservancy starts the Oil Spill Emergency Response Fund to raise money that will subsequently be transferred to one or more emergency response organizations (Bolsa Chica Conservancy, 2021a).
	Concerned residents are encouraged to donate money to local NGOs including the California Coastkeeper Alliance, Surfrider Foundation, and Huntington Beach Wetlands (Amato, 2021).
Day 4 (10/5)	The Bolsa Chica Conservancy announces that supply donations are no longer needed at the Wetlands & Wildlife Care Center. Monetary donations are requested instead (Bolsa Chica Conservancy, 2021b).
	Surfrider Foundation starts initiative encouraging people to petition their representatives to ban new offshore oil drilling (Surfrider Foundation, 2021).
Day 5 (10/6)	Executive director of the Huntington Beach Wetlands Conservancy gives a tour to elected officials, including state legislators, an Orange County supervisor, and the mayor of Huntington Beach (Szabo, 2021).

Local Resident Timeline:

Day	Activity
Day 0 (10/1)	Residents in Huntington Beach and Newport Beach first complain about oil smells. Residents called the Newport Beach Police Department concerned about the smell of gas (Fry et al., 2021a, Chabria et al., 2021a).
Day 1 (10/2)	Residents and tourists attend the Pacific Airshow, with many attendees watching from the beach (Fry et al., 2021a).
	The Coast Guard issues the first public announcement of the oil spill on Twitter (Chabria et al., 2021a).
Day 2 (10/3)	The City of Huntington Beach refers interested volunteers to the Surfrider Foundation and Huntington Beach Wetlands & Wildlife. The City of Huntington Beach provides contact information for individuals with questions about health, the oil spill, and affected wildlife (City of Huntington Beach, 2021a).
	Unified Command provides a phone number for individuals and businesses affected by the oil spill to begin the claims process (Southern California Spill Response, 2021b).
	Unified Command instructs boat owners not to clean their boats and not to use soaps or dispersants (Southern California Spill Response, 2021b).
	Huntington Beach cancels the third and final day of the Pacific Airshow (Rong-Gong Lin and Watanbe, 2021). Residents express suspicion that they were not initially informed about the oil spill because of the city did not want to cancel the Pacific Airshow (Fry et al., 2021a).
Day 3 (10/4)	City of Huntington Beach instructs locals interested in supporting cleanup efforts to stay away from the beach. Interested volunteers are encouraged to register with the Surfrider Foundation and await next steps (City of Huntington Beach, 2021b).
	OSPR accepts volunteer applications for assistance with cleanup (Amato, 2021).
	Peter Moses Gutierrez, a Huntington Beach-based business owner, files the first federal lawsuit against Amplify Energy Corp. and its Beta Offshore division. The lawsuit alleges lost wages and potential exposure to health hazards for the beach DJ company (Smith et al., 2021).

Day 4 (10/5)	Residents describe concerns of the negative effect of the oil spill on local businesses, such as tourist attractions, fishing industries, and surf shops (Smith et al., 2021).
Day 5 (10/6)	Unified Command website opens to allow interested pre-trained and affiliated volunteers to register for cleanup opportunities (Southern California Spill Response, 2021e).
Day 6 (10/7)	Laguna Beach locals sue Amplify Energy in a class-action lawsuit alleging damages to public health and property values and seeking unspecific monetary damages (Emery, 2021).
	Residents file the first class-action lawsuit on behalf of Orange County businesses affected by the oil spill, including those related to tourism and recreation, fishing, and restaurants. Banzai Surf School is the first plaintiff (Fry et al., 2021c).
	More than 800 people are cleaning up the beaches (Fry et al., 2021c).
Day 7 (10/8)	More than 900 people are cleaning up the beaches, with hopes of 1,500 people total in the next few days (Fry et al., 2021b). More than 7,500 people signed up to volunteer with the California Department of Fish and Wildlife, 4,000 of whom come from Orange County. The department selected 200 people to participate in cleanup (Estrin, 2021).
	Government officials express frustration on behalf of residents over limited information during Unified Command press conferences, exacerbated when Unified Command ends daily public updates (Pho and Custodio, 2021).
Day 8 (10/9)	Lifeguard tells surfers to get out of the water due to hazardous conditions (Estrin and Gerber, 2021).
Day 10 (10/11)	Surfers and swimmers return to water after beaches in Huntington Beach and Newport Beach reopen (Estrin and Fry, 2021).

Major events following Day 10:

Day 17 (10/18)	Speakers (including actress and activist Jane Fonda), legislators, and hundreds of protestors attend a news conference calling for an end to offshore oil drilling (Turner, 2020).
Day 27 (10/28)	The California State Senate's Natural Resources and Water Committee holds an oversight meeting to discuss offshore drilling and the oil spill. Legislators and official testifying recognize the financial and legal challenges of ending offshore drilling while also acknowledging the environmental risks of continuing offshore oil drilling (Willon, 2021).
Day 50 (11/20)	Morning reports of an additional oil sheen approximately 70 ft x 30 ft (21m x 9m) near the original pipeline prompt new investigations (Mozingo, 2021). However, later observations reveal no additional oil sheen and that the sheen was "likely residual" (Southern California Spill Response, 2021c, Ormseth, 2021).
Day 60 (11/30)	The California Department of Fish and Wildlife reopens previously closed areas as of 11:59am based on recommendations from OEHHA that determine no more public health hazards from the consumption of seafood from the affected area (State of California - Natural Resources Agency, 2021d).
Day 75 (12/15)	Amplify Energy Corp. and two subsidiary companies are charged by a federal grand jury with illegally discharging oil due to extensive negligence. Pipeline crews were aware of and failed to respond adequately to leak detection alarms, allowing oil to

	continue to pump through the pipeline. These events contradict statements by Amplify Energy leaders that no one was aware of an oil leak at the time (Winton et al., 2021).
Day 88 (12/28)	Unified Command declares that affected shorelines have been returned to their original condition. Unified Command transitions to monitoring tar ball and oiling incidents (Southern California Spill Response, 2021d).

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