
THE IMPACT OF OIL SPILLS ON THE ENVIRONMENT AND SURROUNDING COMMUNITIES: CASE OF SPAIN AND BRAZIL

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Abstract *Marine oil spills have been of tremendous concern due to their adverse impact on economic and ecological systems. Major oil spills triggered worldwide consciousness of marine spill response. In past decades, significant advances have been made in diverse aspects including prevention and preparedness, spill response and cleanup options, modelling of marine oil spills, and response decision support. Risk aversion was always a problem in the oil and gas business, but it has never been more serious. However, challenges remain particularly associated with cold and harsh environmental conditions. The research paper will explore how oil spills influence the environment and surrounding communities, as well as how this catastrophic issue causes the death of most marine species and threatens the sustainability of countries, with a focus on the Prestige and Northeast Brazil oil spills. The paper urges more organizations is needed to follow accessible standards to improve their operating performance and overcome technical uncertainty. Oil and gas companies collaborate with their peers to build transparent platforms that guarantee that automated production projects can be carried out at low cost and with relatively little interruption.*

Keywords: *Oil spill, Environment, Life below Water, sustainability.*

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Introduction:

An oil spill is a sort of pollution that occurs when a liquid petroleum hydrocarbon is released into the environment, particularly the sea. Oil is the primary pollutant of the water. Each year, more than three million tons of oil are released into the ocean. Most oil pollution in the oceans occurs on land. Through runoff and garbage from towns, industries, and rivers, oil enters the oceans. When ships empty their tanks or release their bilge water, they account for approximately one-third of the oil pollution in the oceans (Teal & Howarth, 1984). Typically, when thinking about an oil spill, people envision the accidental or intentional release of petroleum products into the environment as a result of human activity (drilling, manufacturing, storing, transporting, and waste management), which floats on the surface of water bodies as a discrete mass and is carried by the wind, currents, and tides. All of these factors have negative effects on coastal ecosystems. The oil spill in the water is a negative consequence of offshore oil drilling and shipping. Spill control companies are experts at preventing, containing, and cleaning up industrial oil spills. In the 1960s, oceanic oil spills developed into a significant environmental issue. This was primarily the result of increased petroleum exploration and production on continental shelves, as well as the utilization of oil tankers that were able to transport more than 500,000 metric tons of oil (Bakke, & Sanni, 2013).

Today, oceanic oil spills continue to be a significant environmental concern. As a result of increasingly severe shipping and environmental rules, instances of spectacular oil spills caused by ships carrying supertankers that have run aground or been destroyed are becoming increasingly uncommon. However, each year there are hundreds of smaller oil spills and a few significant oil spills that are publicized. These oil spills are related to good discharges and tanker activities. The total quantity of oil that is spilled annually into the world's oceans exceeds one million metric tons. The spill of old gasoline solvents and crankcase lubricants into the environment, whether unintentionally or through negligence on the part of businesses or individuals, significantly enhances the overall environmental problem. Large oil spills are conspicuous examples of large-scale disturbance pulses in marine ecosystems because they increase marine species' exposure to toxic compounds across a wide area (Salomone, 2002).

The environment has been recognized as a crucial component in reaching or not achieving optimum health.. The quality of the environment affects man's behaviours and inactions, and vice versa (Oluwafolahan et al, 2012).

On November 13, 2002, the single-hulled tanker Prestige in Spain, flying the Bahamas flag and carrying 77,000 tons of heavy petroleum, sent an SOS signal off Cape Tourina, Galicia. The tanker broke in two and sank at 428150 N and 128080 W, 260 km west of Vigo on the Galicia Bank .The oil spill damaged a coastline from Portugal to France. At least three oil pollution pulses containing 60,000 tones hit Galicia's coastline (Montero et al. 2003). First oil reached the coast on 16 November, six days after the ship sank. The ship sank and hit the coast on December 1, causing a second big spill. Once any oil split reaches the marine environment, it is subjected to a number of processes known as weathering, including, dissolution, emulsification, microbial degradation, photo-oxidation, adsorption to suspended matter, and deposition on the sea floor. These processes help to determine the oil's ultimate fate and the impact it has on the environment.

The primary processes and the broad patterns they follow are common knowledge, and a vast number of models have been developed to forecast the paths and behaviors of spills in the ocean as well as to analyze the effects of these spills on the species and habitats found in aquatic environments.

On August 30, 2019, a crude oil spill was detected on the Brazilian coast; as of November 22, 2019, it had touched 4,334 km of coastline in 11 Northeast and Southeast states, 120 municipalities (counties), and 724 locations. This oil spill is one of the worst in recorded history. The sequence of phenomena cannot be attributed to randomness, but rather to an unsustainable development model, environmental crisis, institutional unpreparedness for the prevention of expanded social and technical events, outdated legal frameworks that rarely punish large conglomerates responsible for them, and discriminatory policies against vulnerable populations, among other weaknesses.

This research paper will explore how oil spills influence the environment and surrounding communities, as well as how this catastrophic issue causes the death of the majority of marine species and threatens the sustainability of countries, with a focus on the Prestige and Northeast Brazil oil spills.

Literature review and hypotheses development:

The relationship between economic growth and the environment has always been and will continue to be a subject of debate. Some people believe that the emergence of new environmental issues, the inability to prevent global warming, and the continued increase in the number of people living in the Third World are all evidence that humans are short-sighted and greedy. However, others see the glass as merely half empty. They discuss the progress that has been done in urban sanitation and how the air quality in large cities has improved. They also discuss how incredible it is that technology continues to improve people's lives. The first group examines the lingering and frequently severe environmental issues of the present day. The second group concerns the long, although the inconsistent, history of improved living conditions.

Every model that relates economic growth to emissions or environmental quality implicitly assumes the magnitude of scale, composition, and technique effects. These assumptions are frequently disguised by decisions on functional form, the number of commodities, the inclusion of limited resources, and assumptions regarding abatement. Since we have data on the composition of output, its scale, and emissions per unit of output, it is often useful to classify models based on their reliance on the scale, technique, and composition effects, as opposed to model specifics such as the number of goods, types of factors, or abatement assumptions.

By dividing the literature along these lines, we can evaluate the relative merits of models that rely solely on composition effects based on their strength in the data, as opposed to asking for less obvious questions such as whether capital and resources are good or poor substitutes or whether abatement yields increasing returns.

Beginning with very early work in the 1970s by Forster (1973), Solow (1973), Stiglitz (1974), Brock (1977), and others, and culminating with more recent work investigating the Environmental Kuznets Curve by Stokey (1998), Aghion and Howitt (1998), and Jones and Manuelli (2000). All models of economic growth must provide changes in scale, composition, or procedures that satisfy the underlying assumptions of previous and later works of literature addressing the driving force behind economic growth. Models that generate similar aggregate connections between income and pollution frequently rely on distinct methods to reduce pollution. Due to these distinctions, they have additional observable implications that can be used for evaluation.

The Green Solow benchmark

This theory demonstrates that the Environmental Kuznets Curve (EKC) and the Solow model, the fundamental model of contemporary macroeconomics, are intimately connected. Once the Solow model is modified to integrate technological development in mitigation, the EKC is a required by-product of convergence on a path of sustainable growth. This modified model, which is referred to as the "Green Solow," creates an EKC link between the flow of pollution emissions and per capita income, as well as the stock of environmental quality and per capita income. The resultant EKC could be humped or purely decreased (Brock & Taylor 2010). To investigate the many strategies authors have used to achieve sustainable growth or an EKC prediction, an expanded Solow model was built in which exogenous technical improvement in both goods production and abatement leads to continuous growth accompanied by growing environmental quality. This is the simplest model to examine the significance of technical advancement in reducing emissions per unit of output. As economic expansion continues, there are many different opportunities to get away from a deteriorating environment. The Green Solow model illustrates one possibility, which is that technological advancement in pollution control will reduce pollution levels.

Another potential involves intensified pollution control, which is illustrated by the Stokey alternative and the third and last approach is Altering the composition of outputs or inputs so that they are comprised of less pollutant-intensive activities. Due to its close relationship with Solow, the Green Solow model is also related to a number of other theoretical contributions. Its aim is similar to that of Stokey (1998), however, it varies in that Stokey does not account for technical advancement in abatement. It relates to the new growth theory model of Bovenberg and Smulders (1995) since these authors permit "pollution-enhancing technology development," which, under certain conditions, is similar to our technological advance in abatement.

In the same sense, we add that Kijima et al. (2010) define the Green Solow model like "a macroeconomic dynamic model in which total production is allocated to consumption and abatement expenditure" (Kijima et al., 2010, p. 1193). In others words, the Green Solow model is consider like a simple dynamic model that may give a strong rationale behind the EKC hypothesis, and an adapted empirically testable convergence equation for emissions per capita.

Among the authors who have invested in this direction, we propose Ordás Carido et al. (2011) who they developed the Green Solow

model and provide a theoretical framework in which the reduction in pollution is endogenously determined. In particular, the theoretical predictions formulated by authors suggest that through the scale (defensive) effect, the growth rates in pollution are associated positively (negatively) with GDP growth (emissions levels). The theoretical model introduced by Ordás Carido et al. (2011) is opposed to the model of Brock and Taylor (2010), who link CO₂ emissions (a global stock pollutant) with economic growth. Their model is designed for local flow pollutants, such as SO₂ and NO_x emissions.

Stokey alternative: intensifying abatement

In a significant study, Stokey (1998) introduced a set of basic growth and pollution models to examine the connections between growth limits and industrial pollution. She analyzed the capacity of these models to mimic the results of empirical research establishing an Environmental Kuznets Curve, as well as how an active environmental policy might limit growth. An essential aspect of Stokey's analysis was its reliance on increased abatement and stricter restrictions to reduce pollution. Stokey's analysis contributes in two ways. The first is a straightforward explanation for the observed Environmental Kuznets Curve (EKC). Stokey also demonstrates how an income-elastic demand for environmental protection can lead to stricter laws and, ultimately, a decline in pollution levels similar to Lopez (1994) and Copeland and Taylor (2003)

This assumption about preferences, in conjunction with some assumptions about pollution reduction, results in a deterioration of the environment, followed by an improvement in it, all while economic growth continues.

Stokey (1998) assumed zero population increase, exogenous technological advancement in goods production, a Cobb–Douglas aggregator over capital and labour in final products production, and a Copeland and Taylor-derived abatement function (1994). In Stokey's analysis, savings and abatement decisions are determined by an optimal representative agent.

The source and sink Model (composition shifts)

Here are ways to prevent an economic downturn. The Green Solow model illustrates how technological, progress in pollution control can reduce pollution levels. The Stokey Alternative proposes intensified mitigation. Change to less polluting outputs or inputs. This

section explores changes in production's energy consumption. If the economy conserved energy, environmental quality would be improved. Because energy is a valuable input and its use is limited, increasing energy efficiency per unit of output incurs expenses. If growth is not to decline, these losses must be compensated for through additional capital, efficient labour, or innovative technology.

Changing the input composition of an economy to reduce pollution may be inefficient. These growth concerns are one of the reasons why so many countries have delayed ratifying the Kyoto Protocol, and why so many developing nations refuse to sign the deal. Few models of the growth-pollution relationship explicitly account for energy's function. Copeland and Taylor (2003) present a "Sources of Growth" explanation for the Environmental Kuznets Curve, arguing that if the development process relies heavily on capital accumulation in the early stages and human capital formation in the later stages, then these changes will alter the pollution intensity of production, causing the environment to initially deteriorate and then improve over time. Antweiler, Copeland, and Taylor (2001) find that growth fueled by capital accumulation increases pollution, but neutral technological

progress decreases pollution. This indicates a connection between growth, energy consumption, and emissions. Similarly, in Aghion and Howitt's (1998) examination of long-term growth and environmental outcomes, their clean capital – knowledge – plays an ever-increasing role in long-term growth, resulting in an improving economy. However, as they adopt the same abatement assumptions as Stokey (1998), even with a shifting composition of output, substantial increases in abatement are required to maintain acceptable levels of pollution.

In the majority of these formulations, the connection to energy use is at best implicit, requiring the reader to define capital or other productive components broadly so as to include energy or other natural resources. One of the key achievements of early resource literature was the identification of how and where finite resources affect the growth process. By disregarding the role of depletable resources in generating pollution, they run the risk of making pollution reductions appear comparatively painless, as these studies will fail to account for the economic growth drag that is created.

Combining older models of growth and depletable resources with modern models addressing the pollution and growth link, this section clarifies the relationship between energy use, economic growth, and environmental impacts. By doing so, this section demonstrates that several findings from the 1960s and 1970s literature on natural resources and economic growth are still relevant today. The previous

"limits to growth" literature investigated how exhaustible natural resources affected expansion.

Solow (1974) and Stiglitz (1974) demonstrated that growth with nonrenewable was possible, but that it required regulating population increase, technological progress, and natural resource usage. Two results are well-known. Solow (1974) argues that constant consumption is possible even with limited exhaustible resources and a constant population if the share of capital in production surpasses the share of resources in final output. This insight led to the optimal savings rate to maximize continuous consumption.

John Hartwick (1977) supplied the answer in the now-famous Hartwick's rule: invest all rents from exhaustible resources in capital, and future generations will be as well off as the currently alive notwithstanding the asymptotic extinction of natural resources. Stiglitz (1974) found that per capita consumption can grow with positive population growth if technological advancement outpaces population growth. Our formulation likewise restricts technical progress to create positive per capita output growth, but we also require environmental improvement. Even if expansion with exhaustible resources can generate positive output growth Stiglitz (1974), it may not be sustainable since it increases pollution.

Methods

Descriptive Analysis

On November 13, 2002, the single-hulled tanker Prestige, flying the flag of the Bahamas and carrying 77,000 tons of heavy petroleum, transmitted an SOS signal 15 nautical miles off Cape Tourin ana, Galicia (southeast North Atlantic). Following an erratic path to the north and south, the tanker finally broke in two and sank at 42°15' N and 12°08' W, some 260 kilometers west of Vigo on the southwestern flank of the Galicia Bank. The oil spilt into the ocean polluted a wide coastline stretching from northern Portugal to France. At least three huge oil pollution pulses containing more than 60,000 tons of oil hit Galicia's shores (Montero et al. 2003). The initial spill occurred between 13 November and the ship's sinking six days later, with the first oil reaching the coast on the morning of 16 November. The second (major) spill happened after the ship sank and struck the coast on December 1. On 3 January, the last spill consisted of oil that poured through the tanker's hull breaches and washed ashore.

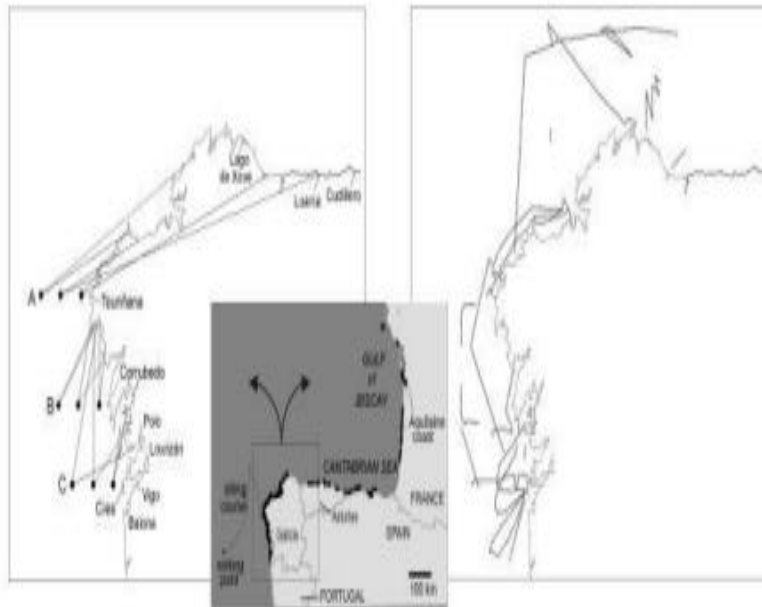


Figure 1: Prestige Tanker Path in Spain

Source: Munilla Rumbao, I., Arcos, J. M., Oro, D., Álvarez Fernández, D., Leyenda, P. M., & Velando Rodríguez, A. (2011). Mass mortality of seabirds in the aftermath of the Prestige oil spill.

As shown in the previous figure the prestige tanker following an erratic path to the north and south, the tanker finally broke in two and sank at 42°15' N and 12°08' W, some 260 kilometers west of Vigo on the southwestern flank of the Galicia Bank. The oil spilt into the ocean polluted a wide coastline stretching from northern Portugal to France. At least three huge oil pollution pulses containing more than 60,000 tons of oil hit Galicia's shores (Montero et al. 2003).

Mortality of sea Birds in Spain due to prestige oil spill

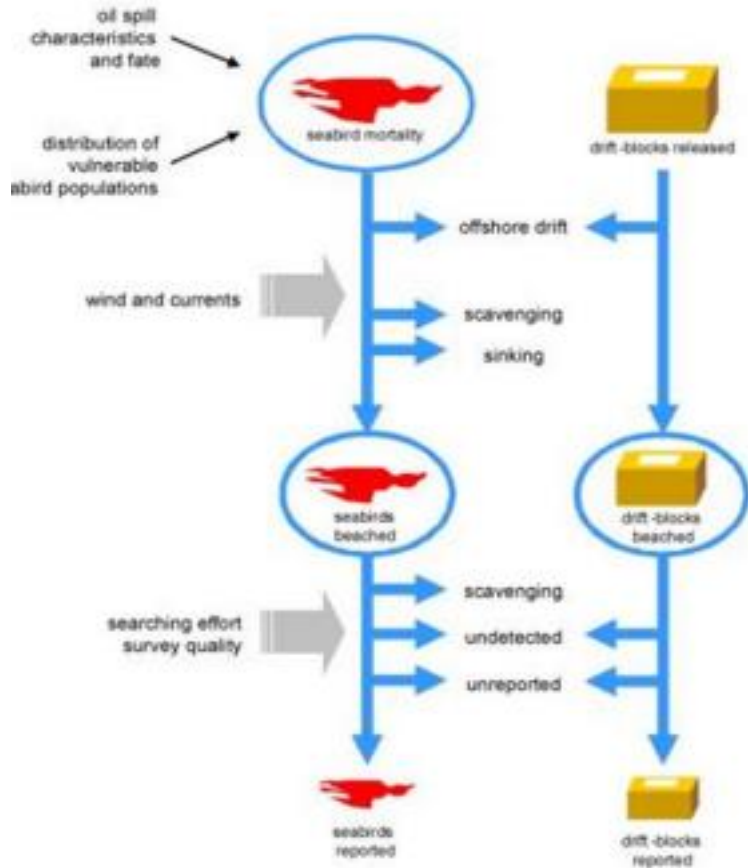
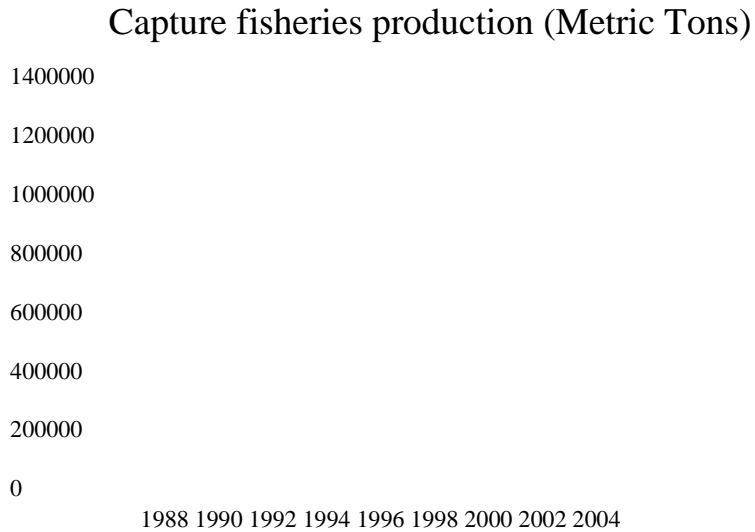


Figure 2: Sea-Bird Mortality in Spain *Source: Munilla Rumbao, I., Arcos, J. M., Oro, D., Álvarez Fernández, D., Leyenda, P. M., & Velando Rodríguez, A. (2011). Mass mortality of seabirds in the aftermath of the Prestige oil spill.*

Figure 2 is a diagram that shows the primary sources of variance in drift tests that were conducted to calculate the number of seabirds who died at sea as a result of oil spills. Although the actual seabird mortality is determined by the characteristics of the oil spill as well as the location of vulnerable seabird populations, the number of seabirds that are reported to be oiled is determined by the conditions of the ocean as well as the level of searching effort at beaches. Drift blocks are meant to simulate the drifting behaviour of handicapped oiled seabirds and

seabird carcasses. However, drift blocks do not sink and are not preyed upon by marine or terrestrial scavengers. Drift blocks were released at sea in the aftermath of the spill. A further point to consider is that the detectability and reporting probability of drift blocks and beach-washed seabirds are likely to be different from one another.

Losses in Spain attributed to the Oil Spill



Source: data.worldbank.com

Figure 3: Capture fisheries production (Metric Tons) in Spain

This graph illustrates Capture fisheries production, which counts the quantity of fish caught for commercial, industrial, recreational, and subsistence reasons. In this graph, it is evident that there are fluctuations, but the overall trend is upward. Beginning in 1990, there is an increase in the capture fisheries production, followed by a slight decline in the years that followed, and then a return to growth until 2002, when there was a precipitous decline due to the catastrophic accident of the prestige oil spill, which caused the death of many marine species and ended up causing environmental damage.

According to published death numbers from other marine oil spills that utilized similar estimation methodologies, there were a total of 8 oil spills. These figures imply that the amount of oil leaked didn't have an impact on the mortality of seabirds ($F_{1, 7} = 0.01$, $P = 0.99$); *Munilla ET AL. (2011)*. The numbers from the Prestige are in the same range as the highest seabird mortality estimates ever reported after an oil spill anywhere in the world; moreover, the estimated mortality was higher than expected based on the number of carcasses that were retrieved.

Areas damaged in Brazil due to Oil Spill

The natural disaster affected eleven Brazilian states from Maranhão to Rio de Janeiro, nine in the Northeast and two in the Southeast. This region possesses unique demographic characteristics, such as a dense population distribution in the coastal zones (10 of 11 state capitals are located along the coast), as well as natural characteristics. These factors combine to make this location extremely fascinating (owing to the diversity of the tropical ecosystems in this region). Moreover, a variety of human activities in this region, such as tourism, artisanal fisheries, nautical sports, and fishing/aquaculture, are highly dependent on natural resources. In addition, this region is plagued by high levels of social inequality and poverty, which impede its ability to pursue legal action and seek compensation for losses.

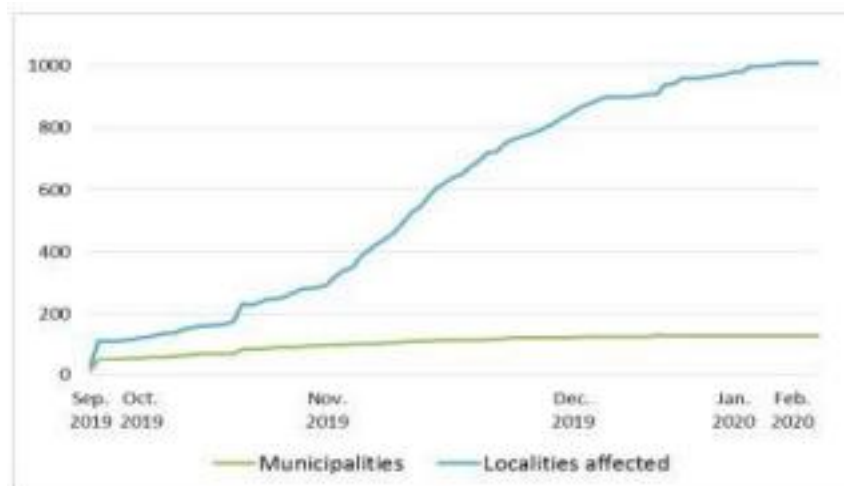


Figure 4: Temporal and quantitative development of oil-impacted coastal areas in Brazil

Source: Disner, G. R., & Torres, M. (2020). The environmental

impacts of 2019 oil spill on the Brazilian coast: Overview. *Revista Brasileira de Gestão Ambiental e Sustentabilidade*, 7(15), 241-256.

Figure 4 illustrates that there is a strong increasing trend and curve toward the locations that were considerably impacted by the oil leak that happened in Brazil between September 2019 and February 2020, indicating that places were significantly affected.

Birds and animals Mortality in Brazil due to oil spill

According to IBAMA estimates, 11 states (9 in the Northeast and 2 in the Southeast) and 130 localities were affected till February 2020. As stated in, 1009 locations have reported oil contamination to date. The mapping notion of locality is restricted to an area of one kilometre along the coast. Therefore, a 10- kilometre-long beach contains ten spots. Regarding affected fauna, IBAMA is currently aware of 159 affected species (112 dead and 47 alive but oiled) In Bahia and Sergipe, 2,814 young turtles were proactively captured. At least 14 conservation units on the Northeastern coast and over 55 marine protected areas in the Tropical Atlantic have already been impacted by pollution (Soares et al., 2020).

Brazil has a 7,367-kilometer coastline, of which approximately 4,000 kilometres were damaged by oil at some point during this period (Marinha do Brasil, 2019). River mouths, water catchment points, mangroves, conservation units, and rhodolith beds are among the sensitive environments that have been damaged (Nasri Sissini et al., 2020; Soares et al., 2020).

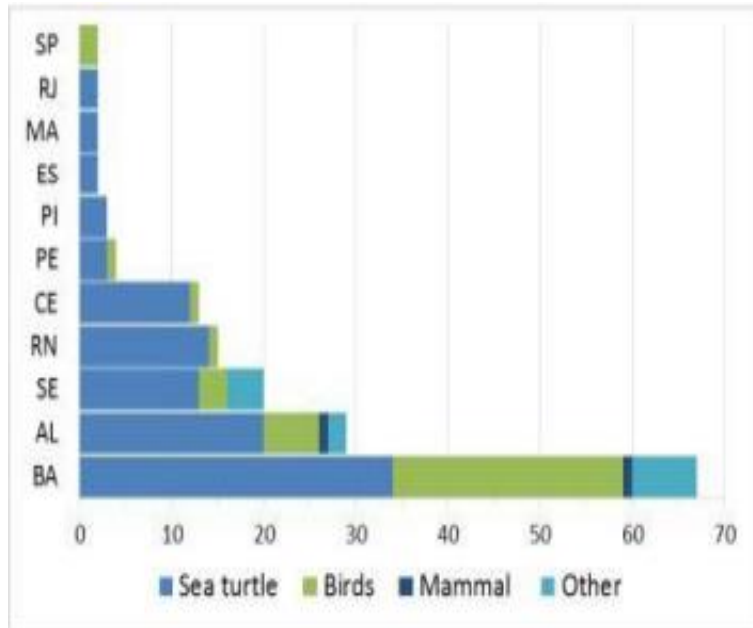


Figure 5: Number of oiled animals per state, of which 70.4% were determined to be killed in Brazil.

Source: Disner, G. R., & Torres, M. (2020). The environmental impacts of 2019 oil spill on the Brazilian coast: Overview. *Revista Brasileira de Gestão Ambiental e Sustentabilidade*, 7(15), 241-256.

Figure 5 depicts the percentage of seabirds that died in each state, including sea turtles, birds, mammals, and other marine species. The seabird turtle has the largest percentage of deaths, followed by birds and mammals.

Conclusion

In conclusion, marine oil spills have the potential to have devastating effects not just on marine life but also on the economic activities that take place along the coast and the populations who depend on the sea's resources. In general, the consequences of oil toxicity rely on a wide variety of parameters. These aspects include the oil's composition and properties (both physical and chemical), condition (i.e., whether it has been weathered or not), exposure routes and routine, and the oil's bioavailability.

Oil dispersants, a frequent tool used after oil spills, are also hazardous and pose a threat to pelagic creatures, benthic organisms, and fish. Oil dispersants are commonly employed after oil disasters. Cleanup

activities and the direct or indirect destruction of the environments in which plants and animals have their natural homes both have the potential to have an impact on marine life.

Communities that are in danger of being contaminated by oil spills in marine environments are aware of the risk, and as a result, they have devised their plans and policy problems to mitigate the threat posed by oil in marine environments.

In addition to the natural environmental pressures that are already present in the Gulf region, several human activities that are anthropogenic, such as oil spills, are expected to affect the region's economy. These are summed up by the fact that the fish business and desalination plants, which provide the vast majority of the residents in the Gulf region with freshwater, are in danger, in addition to the tourism industry that relies on scuba diving.

Recommendation

Many municipalities have responded to the threat posed to marine ecosystems by petroleum oil spills by drafting their plans and addressing related policy concerns. These have included everything from building infrastructure to dealing with oil spills to deciding whether or not to allow more oil to be transported. Given the likelihood of such catastrophes, the government's response, especially the health sector, must be evaluated to minimize the population's health worries and plan appropriate solutions. There are many recommendations and they are categorized into so many different types.

Oil spills caused by human Fault

These guidelines emphasize management support for spill prevention programmes, sufficient resources, meeting or exceeding regulatory criteria, implementing redundant safety systems, discouraging risk-taking, and creating annual performance targets. Implement formal risk assessment and correction processes, employee involvement, accountability, and performance rewards.

Oil spills caused by Boat Owners, Marinas, and Boatyards

Proper storage and disposal of wasted oil and oily wastes are emphasized, as well as frequent and thorough boat maintenance. In this area, we also urge that marinas construct effective runoff measures, educate their boat owners, and have them sign written agreements committing them to use best management practices.

Oil spills caused by tankers and Tank Barges

This set of guidelines includes monitoring operations, maintenance, personnel policies, health and safety, waste management systems, and spill and near-miss accidents. Reliable safety systems and annual performance benchmarks are suggested. Management policies and programmes are certified using international standards. We recommend watch practices for navigation, anchor, engineering, and security rounds. For both tankers and tank barges, the vessel master should prepare written emergency protocols to cover all possible emergency scenarios and necessary actions. We propose that tanker and tank barge crew members participate in a thorough personnel training programme that covers vessel orientation, particular position requirements, regular refresher training, and periodic safety and reaction drills. We recommend crew fitness checks and annual performance reviews. Keep training, drill, and performance records. We propose that tanker owners and operators follow OPA 90's work hours and navigation watch rules in West Coast waters. We also recommended that all licensed deck officers and the vessel's Person in Charge of oil transfers speak English and that multinational crews employ a common language understandable by both officers and unlicensed crew. We recommend that tanker or tank barge owners/operators demand frequent health checkups and a policy requiring notification of prescription medication use. Tank barge tow vessel masters shall keep a record of all crew members and have three licensed officers or tow operators on board during coastal transit.

All of these recommendations may serve as guidance before an oil spill occurs, but there are further recommendations when oil spills occur. Oil Boom is the most common and extensively used equipment for oil cleanup. These are also known as containment booms because they inhibit the spread of oil inside a limited region.

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