Open University Cyprus Hellenic *Open University*

Faculty of Economics and Management

Enterprises Risk Management (ERM)

MASTER THESIS

Oil Spill Risk Analysis via Largest Oil Spill Accidents and their Effects in the Ecosystem and the Economy

Georgia Ioannou

Dr. Dionysios Gerontogiannis

May 2018

Blank Page

Table of Contents

Abstract 3

Acknowledgments 5

Introduction 7

Methodology 9

Chapter 1: Oil Spill Catastrophes 11

Major Oil Spill Accidents 11

Factors and Causes 17

Ecosystem and Societal Impact 19

Clean-Up Techniques 27

Current Status of the Gulf-Coast 33

Chapter 2: Crisis Management Models 37

Risk Management Process 37

Kash and Darling 39

Mitroff 41

Business Continuity Management 43

Chapter 3: Compliance and Regulations 47

Adoption of Regulations 47

Organizational Components 53

Chapter 4: Quantitative Analysis 59

Statistical Analysis based on Numerical Variables 59

Statistical Analysis based on Non-Numerical Variables 63

Chapter 5: Summary of Results 67

Conclusion 69

Appendix 71

Reference List 83

Abstract

Oil Spill catastrophes have been one of the largest concerns worldwide especially in the marine sector as they bring with them commercial and environmental problems. Also, such catastrophes when occurred, last long after the cleaning procedures are finalized.
Major oil spill catastrophes will be presented and some of the topics to be declared: Challenges facing the oil and gas industry in terms of health and safety along with prevention measures. In what way the oil spills are affecting the nature, the company and the economy and what is the current situation at the Gulf Coast. Compliance with relevant oil and gas regulations. What are the common causes of the oil spills? Reference to the cleaning procedures and their cost in regards to the oil spilled. Crisis Management models will be introduced through the Exxon Valdez oil spill disaster. The significance and non-significance between numerous factors concerning the clean-up costs after an oil spill will be tested.

Blank Page

Acknowledgments

I would like to express my gratefulness to Dr. Dionysios Gerontogiannis for providing me the opportunity to choose my own topic and believed on me. Also, I appreciate very much his excellent effort concerning his guidance on the way the thesis should be presented and written as well as his constant supervision, collaboration and support during the whole process of my master-thesis writing.

Blank Page

Introduction

Oil is a leading source of energy worldwide. It has an extensive usefulness, offering fuel for the industrial, residential and transportation sectors. Massive oil quantities are entering constantly each country via a pipeline or a vessel. To this extent, the oil spill accidents are inescapable not to happen with this extensive use and non-stop movement. The issue is whether each country has the necessary workforce and resources in place to act in response to major spills. A number of major oil spills in the U.S. have had long-lasting consequences that surpassed the economic and environmental effects. The greatest remarkable example is the Exxon Valdez spill in 1989 that resulted into the release of around 11 million gallons of crude oil into the Prince William Sound in Alaska (Ramseur 2010). As per National Academies of Science (2003), the mentioned accident caused ultimate changes within the U.S. manner of thinking about oil, the oil business, and the petroleum transport procedure (NRC 2003). It was seen as the 'necessary evil' and something not to be trusted and to be feared. Bearing in mind that oil imports and consumption have shown a major growth in the last decades, the incline of lessening spill accidents and volume in the past years is remarkable. Conversely, the risk of a massive oil spill remains on the surface. The oil spill threat questioned whether a country, the state or even oil companies worldwide have the required resources in place to respond to a spill catastrophe. Oil spills are not completely benign. It should be noted that even a minor spill can cause a major damage to an entire population. Sea and land based animals, birds, and other organisms in their initial developing stage (eggs, larvae) are extremely vulnerable to an oil spill. Yet, the oil spill effects can significantly vary as their impacts can range from few days to numerous years or even decades (Ramseur 2010).

This thesis is focused in major oil spill catastrophes, especially within U.S. coastal waters, including oil spill statistics and their potential impacts in the ecosystem and the economy. Such catastrophes when occurred, last long after the cleaning procedures are finalized and a reference will be made to the best and worst procedures used in each case. A risk analysis will also be included concentrating in the worst accident. Based on accidents, the thesis will give an emphasis to the legal framework which has been restructured as a direct response to these happenings. The first chapter introduces a number of major oil spill catastrophes, factors and main causes of these happenings along with their impact on the economy and the ecosystem. Also, the current status of the Gulf's coast ecosystem in regards to the Exxon Valdez and Deepwater Horizon accidents will be discussed as well. The second chapter will introduce three crisis management models applicable to the Exxon Valdez Oil Spill catastrophe with a reference to the Business Continuity Management. The legal framework within the oil industry will be discussed in the third chapter. A Quantitative analysis of the clean-up costs based on numerical and non-numerical variables will be presented on the fourth chapter in order to analyse their significance. This will be supported by statistical charts.

Methodology

The literature review is written based on information derived from journals, scientific articles, academic books, and websites. The methodology used for the quantitative analysis is based on a collection of data such as year, name, volume, oil type, location, weather condition, clean-up costs and causes, derived from the websites of International Tanker Owners Pollution Federation (ITOPF), Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE), National Oceanic and Atmospheric Administration and Joye Research Group. From the mentioned websites, the data collected are specifically for 23 major accidents from 1967 to 2014. Using the Excel, a statistical analysis is presented using numerical and non-numerical factors in order to test their significance and their correlation between the clean-up costs. All cost data are converted to USD, the oil spill volume in tons, the location of the accident into inshore and outshore, and the weather conditions into severe and not severe. The data is analyzed into a scatter plot graph, a histogram, pivot tables, pie charts, ANOVA testing and a regression analysis. Keywords used through the search engine (google scholar) 'oil spills', 'oil accidents', 'oil spill impacts', 'oil spill legislation', 'oil spill causes', ' oil spill risk analysis', and 'oil spill prevention'. The journal articles and books were collected from Google Scholar and from My Athens online library.

Blank Page

Chapter 1

Oil Spill Catastrophes

1.1. Major Oil Spill Accidents

An American multinational oil and gas corporation named Exxon Mobil Corp. was faced with a crisis on the 24th of March 1989 when one of its tankers Exxon Valdez, a 987 foot ship, struck Alaska's Bligh Reef, spilling more than 10.8 million gallons of crude oil into the waters of Prince William Sound. The vessel was sailing out of its shipping path with an attempt to avoid its meeting with icebergs. It was considered to be the worst oil leak in the waters of America as the land, sea life and the economy were dramatically affected. There were no human casualties as a direct consequence of the disaster, however 4 deaths were linked with the clean-up procedures. Consequently, the natural and human losses were massive to tourism, wildlife, fisheries, and subsistence livelihoods (ARLIS 1990). A workforce of more than 11,000 individuals, 1,400 ships and 85 planes were hired for the cleaning procedure (EVOSTC 2009). The ship's captain was blamed for alcohol consumption, deficient supervision of its crew, the engagement of the automatic pilot happened too soon and the efforts made to leave the accident place were too risky (CEDRE 2014). An oil spill crisis plan was not used as it was considered very expensive. The accident happened because of a number of mistakes, deficiencies and faults such as the 3rd mate has failed to maneuver the ship in the right direction, probably because of tiredness and a work overload, the captain was unsuccessful to provide an accurate navigation watch, probably due to the consumption of alcohol. The Exxon Shipping Company's operational process was unsuccessful as the company has failed to notice the Captain's drinking problem and failed to provide a rested crew on the ship. Exxon Valdez was a single hulled tanker that carried a full load of crude oil. These kinds of tankers pose a bigger threat to maritime environment during an accident than double hulled tankers as they can reduce the size and frequency of oil spills. An ineffective escort system was one of the main causes of the accident as it was not satisfactory as per risk assessment's review which concluded that Exxon should have used more escort tugs to depart Valdez. The US Coast Guard and the Alaska Department of Environmental Conservation were held liable for the cause of the accident as they failed to implement and impose proper response and prevention measures, as well as to provide an effective vessel traffic system. Due to the limited radar coverage and outdated communication equipment in Prince William Sound, the coast guard failed to detect the accident at Bligh Reef (ARLIS 1990).

The Deepwater Horizon oil spill, also referred as the 'Gulf of Mexico oil spill', said to be the biggest marine oil spill in history since its occurrence on the 20th of April in 2010 and sank two days later, darkening the 1989 Exxon Valdez spill several times over. It was caused by an explosion on the Deepwater Horizon oil rig which was located in the Gulf of Mexico. The rig was operated and owned by Transocean, an offshore oil drilling company, and leased by BP, an oil company, and was located in the Macondo prospect in the Mississippi Canyon, a valley in the continental shelf (Pallardy 2017). Hydrocarbons escaped from the Macondo well onto Transocean's Deepwater Horizon, causing explosions and fire on the rig. Estimates of the amount of oil released into the Gulf of Mexico and onto its beaches and seaside estuaries ranged between 35000-60000 oil barrels a day. As a result, seventeen workers were injured and eleven workers lost their lives (King 2010). As per BP's report, eight key causes were found which lead to the massive explosion. These are, a 'bad cement design' and shoe track barriers that did not isolate the hydrocarbons, the crew along with the BP's well site leaders reached the inaccurate view that the negative-pressure test was successful and that well integrity had been recognized, the rig crew didn't spot the influx and no action was taken to control the well till hydrocarbons had entered though the blowout preventer (BOP) and into the riser. Also, first well control actions failed to recover the control of the well by the crew members, alteration to the mud gas separator caused the gas venting onto the rig, the gas and fire system didn't stop hydrocarbon ignition and the BOP emergency mode didn't seal the well (BP 2010).

The 'giant oil tanker' Torrey Canyon, 974 feet in length, was the thirteenth largest merchant tanker worldwide, and on the 18th of March in 1967 ran aground on Pallard's Rock, sixteen miles west of Land's End in England (Wilson 1973). Thousands of oil tones were spilled from the wracked vessel's broken tanks and within the period of twelve days the whole cargo of around 119,000 tons of crude oil were lost (ITOPF 2014). The tanker's captain at that time has realized that they were east of the planned course and in order to save time he decided to go through a gab and to take a shortcut. Unluckily, the autopilot was disconnected due to a plotting error and resulted to the collision. The crew were saved by lifeboats. However, thousands of birds were killed and the livelihood of local people was threatened. The beaches of France and England were highly polluted, and it was said to be the worst oil accident at that time (Luoma 2009).

Prestige, a single-hull oil tanker, run by a Greek shipping company under the flag of Bahamas has suffered a severe accident 30 miles off the coast of Spain in Galicia on the 13th of November in 2002 while transferring 77,000 tons of heavy fuel oil. A structural failure of the starboard load tanks resulted to the leaking of the oil. Four thousand tons of fuel poured out from the tanker over the weekend. A day after the accident, the authorities have agreed to towage the ship away due to the high risk of serious contamination of the mussel producer regions, Rias Baixas and Costa da Morte. (Albaigés et al., 2006). As a result, on the 19th of November, the tanker sank after broking in two. The oil has affected more than 200 km of the Galician coast and the government has postponed the fishing activities along a 100 km of coastline. After its sank, the vessel is still carrying approximately 77,000 tons of heavy fuel oil and in that area the water is more than 3,000 m deep. The spill was a severe environmental catastrophe and the most severe in the Spanish waters (Luoma 2009).

The twenty five years old Maltese oil tanker, Erika, ran aground and smashed in two close to the coast of Brittany in France on the 12th of December in 1999. Stormy and extreme weather conditions, inefficient maintenance and repair resulting erosion, and the faults of the vessel's captain made in controlling the ship caused the accident. Twenty thousand tons of oil were leaked into the sea polluting France coast, around 400 km distance. From the spill, the fishing and tourism were adversely affected leading to economic and environmental consequences (Luoma 2009). French authorities have initiated the salvage procedure immediately and the crew was evacuated from the vessel in marine helicopters (Covic et al., 2013). Fourteen days after its sinking, Groix Island was affected and the pollution was reached the south and the north banks of the Loire River. As a result, a sticky oil layer had covered the coastline's parts (CEDRE 2012).

Under heavy weather conditions, the failure of the hydraulic steering gear of the tanker Amoco Cadiz on the 16th of March 1978 has caused the grounding off the coast of Brittany in France (Luoma 2009). Over a two-week period, the whole cargo of 227,000 tons of light Iranian and Arabian crude oil and 4,000 tons of bunker fuel were spilled into sea. A lot of tanks were destroyed and the whole cargo even 227,000 tons of oil was spilled into the sea. A considerable amount of the oil has rapidly formed a viscous water in oil emulsion and by the end of April the oil and emulsion had polluted 320km of the Brittany coast and has spread as far east as the Channel Islands (ITOPF 1978). It was the biggest oil tanker spill accident worldwide and it caused the biggest loss of marine life at that time and had seriously affected the oyster cultivation, tourism and fishery (Luoma 2009).

On the 19th of July in 1979 a Greek oil tanker, the Atlantic Empress collided with the Aegean Captain during a tropical rainstorm in the Caribbean Sea, 20 miles northeast of the Tobago Island. Both tankers were large crude carriers of Mobil oil carrying approximately 276,000 and 207,000 tons respectively. The fire on the Aegean Captain board was brought under control and the ship was towed to Curacao where the rest of its cargo was discharged. The other tanker was further towed out to sea on the 21st and 22nd of July. A large explosion was followed causing a massive damage to the ship and finally sank on the 2nd of August. The full capacity of both vessels, 3.5 million barrels of crude oil could probably be vanished in the nearest future. Approximately 287,000 tons of oil was leaked from the Atlantic Empress which makes this the biggest ship cause spill ever documented. The quantity of oil burned or sank is unknown as no impact studies were carried out (ITOPF 2014). The death casualties were 26 sailors from the Atlantic Empress and 1 sailor from the Aegean Captain. A minor coast pollution was present and all the oil has vanished from the surveillance by tug vessels on the 9th of August (Joye 2016).

ABT summer, a Liberian oil tanker, carried 260,000 tons of heavy Iranian crude oil has unexplained exploded on the 28th of May in 1991 and spilled approximately 57,000 tons of oil into the sea, 900 miles off the Angola coast. The vessel was burning for three days until it's sank on the 1st of June (ITOPF 2014). As a result, 27 crew members were rescued, one person has lost his life, and four went missing. There was a minor environmental impact as the accident occurred far from the coast (CEDRE 2010).

Blank Page

1.2. Factors and Causes

Even though oil is a required risk in society, latest oil spills have demonstrated that major improvements in the response process of oil spills are necessary to improve effectiveness. Companies have introduced maintenance and operating procedures to decrease the frequency of oil spill accident. The risk of an oil spill is high due to the frequent oil transportation from oil fields to the buyers among several diverse methods of transportation such as pipelines, railcars, tankers and tank trucks. The oil spill rate has decreased in the last ten years, regardless of the increased oil consumption, production and transportation, especially for sea tanker accidents. There is an estimation of 30%-50% of oil spills are caused by human error (directly/indirectly), and 20%-40% of all spills are caused by malfunction or equipment failure (Fingas 2012). According to NOAA (2018) oil spills can be caused from natural disasters such as typhoons, hurricanes and storms, from people in control such as captains being careless or making mistakes, equipment failure, and terrorist attacks (NOAA 2018). The circumstances and causes of oil spills differ, however they can have a major effect on the amount of oil spilt. Major causes as a result of the release of oil into the sea include allission/collision, grounding, hull failure, equipment failure, fire explosion, other/unknown causes. It should be noted that other/unknown causes for accidents of less than 7 tons comprise of ballasting, de-ballasting, at the time the vessel is moving, and for accidents over 700 tons are heavy weather damage and human error. According to the ITOPF statistics (2016) a database of oil spill accidents between 1967 and 2016 were recorded showing the main causes of oil spills. Allission/Collision and groundings were the main causes of incidents of more than 700 tons yet incidents of less than 7 tons were resulted from Other/Unknown causes having a 64% (Appendix: Chart 1a, Chart 1b) (ITOPF 2016). However, according to the statistical analysis of Chapter 4, 30% of oil spills (quantity not considered) were caused by structural damage in respect to the collision of 9% (Appendix: table 1, chart 1c).

Blank Page

1.3. Ecosystem and Societal Impact

Ecosystem and societal impacts can be affected by numerous factors after an oil spill? Ramseur (2017) has noted that oil spill impacts, short-term and long-term, depending on the rate, size, type and location of the spill. Subject on location and timing, even an insignificant spill can be the start up for causing a substantial damage to the ecosystem and the society. The impacts can last from days to weeks, months to years or even decades (Ramseur 2017). Oil contamination resulting from frequent sea transportation sources is considered as a vital threat to the aquatic environment. The contamination can take the form of huge spills resulting commonly from tanker cargoes (grounding, collision, explosion, structural damage etc.), or frequent minor spill incidents due to diverse ship operations (bunkering, loading, uploading, discharging etc.). Jernelov et al. (1975) has noted that short-term effects of oil spills can lead to long term effects that had not been observed in temperate or cold waters. For example, coral reefs which are built by small sized animals found in sea waters, are sensitive to oil and are frequently killed in the event of an oil spill close to the reefs (Jernelov et al. 1975). Another example are the mangroves, small tree species which grow in muddy areas along seashores and rivers. The mangroves can stabilize the shorelines, safeguard communities from rainstorms, provide home for a lot of animals, keep the mud away from the sea and store a massive quantity of carbon. If they blocked by oil, the mangroves might die causing damages to both the animals and humans. Also, re-colonization will be very slow since once the mangroves die, the mud will spread out into the ocean (Jernelov et al. 1976, Jernelov and Linde´n 1981).

Numerous oil spill accidents worldwide have occurred, some of them are larger than others. However, according to Walther III (2014), small sized oil spills can have a greater environmental impact rather than large ones (Walther III 2014). Aquatic ecosystems are complex structured, with a lot of interacting species, and an oil spill will have a dissimilar effect on each one of them. Peterson et.al (2003) declared that sea mammals and birds which are frequent passers through the air-water interface to inhale, are mainly vulnerable to the exposure of all the types of oil, whereas Paine et.al (1996) has noted that pelagic fish will have an insignificant oil exposure (Paine et. al 1996, Peterson et. al 2003). As per Erikson (1995), there is a minor significance between the number of sea-bird fatalities and the size of an oil spill. This is proven by the Exxon Valdez accident, which spilled approximately 35,000 tons of oil and from which more than 35K sea-birds had died in contrast to the Braer accident (85,000 tons) from which only 1,500 dead birds were counted (Heubeck 1997). The evidence of an injury is circumstantial. For instance, no killer whale corpses were found after the Exxon Valdez oi spill. However, scientists have noticed that fourteen out of thirty six killer whales have disappeared from the Prince William Sound in 1989 and 1990 (EVOSTC 2009). There is an estimated number of 250,000 bird casualties in the region of the accident however there are claims that the murre population might not be able to recover in the following 20 and 70 years (Kingston 2002). However, according to Wiens (1995), after the oil spill the sum of the murre presence at breeding locations in the spill area was parallel to the estimates in 1970 (Wiens 1995). Recent case study stated that in the next 9 years the bird population which has been affected from the Exxon Valdez spill has not recovered yet (Lance et.al 2001). These discrepancies and the numerous factors having a direct consequence on the statistics of the bird populace, makes it hard to evaluate the recovery and impact of an oil spill. However, there is a diminutive evidence that the seabirds undergo long-term effects from oil spills (Kingston 2002). Conversely, as per EPA (1999), birds can undergo short term and long term effects from the oil spill contamination such as lung, liver and kidneys damage and gastro-intestinal syndromes (EPA 1999). Oil might be transmitted from the plumage of the bird to their eggs, suffocating the eggs by closing the shells' pores and stopping the gases exchange (EPA 1999). It was also estimated that 300 harbor seals, 2,800 sea otters, 22 killer whales and an extensive number of salmon and herring eggs were found dead from the spill (Jernelov 2010 and Pegau, 2014). Nevertheless, the quantity of oil spilled and the location of the accident has made the Exxon Valdez the most 'damaging' of its time (Walther III 2014).

As per ITOPF (1993) study regarding the Braer accident, an excessive number of shellfish and fish were polluted with oil. Cultivated salmon, detained inside sea-cages in the water surface, couldn't avoid the oil and millions of them had to be exterminated (ITOPF 1993). Due to the reason that the death rate was low the spill's long-term impacts were difficult to be assessed (ITOPF 1993). According to Heubeck (1997), a decline in the bird populace could not be detected in the long-term and might be attributed to the oil spill (Heubeck 1997). Also, the breeding timing of sea-birds in the affected area was the same as in previous years, before the oil spill, and there was no indication of any delay (Monaghan, 1996). Twenty-two seals were found dead two weeks after the accident, most of them were severely decomposed and possibly died before the wreck of the tanker. As per Conroy et al. (1997), statistics of otter and seal populations in the oil spill area were slightly affected (Conroy et.al 1997).

The Amoco Cadiz accident has caused the biggest loss of sea life in contrast to other oil spills. Masses of dead sea urchins, molluscs, and other benthic kinds were found two weeks after the incident. Crustacean and echinoderm populations were nearly disappeared from the affected areas, populations of other species had recovered a year after. From the spill, 20,000 birds have died, and approximately 9,000 tons of oyster farming in the estuaries were destroyed as they were seriously contaminated (ITOPF 1978). Research studies showed that species populations might take three to six generations to get through, particularly mammal species and longer lived birds might recover in the next decades (Conan et.al 1982 and Matkin et.al 2008).

Ixtoc I and the Deepwater Horizon blows-out are similar events with dissimilar impacts. Deepwater Horizon was at 1500m water depth and Ixtoc at 50m, while the first one happened in Louisiana coastlines where there are sensitive wetlands and the other in the coast of Mexico where there are sandy beaches. Also, the Deepwater Horizon has spilled approximately 230,000 tons of oil in severe weather conditions and Ixtoc I around 476,190 tons in calm weather conditions. These differences are significant in regards to the environmental effects of the two oil spill accidents (Jernelov 2010). There is not much evidence of the impact of the Ixtoc I spill on the marine environment. According to studies on the Texas shoreline which was 1000km far from the oil spill, haustoriid and polychaetes amphipods were reduced in population due to the oil spill. However, there were suggestions that the reduction was caused by typhoons, seasonal changes and clean-up procedures (Thebeau et.al 1981). Also, around 3,000 bird casualties were reported, as most of the birds have escaped (Jernelov 2010). Scientists have found that four kinds of sea turtles and marine mammals and their homes were affected by the oil due to aspiration, inhalation, and absorption of toxins through their skin and consumption of polluted sediments. Researchers of marine mammals have concluded that oil exposure has caused a number of health impacts such as organ reproductive damages. Also, animals which have died by these effects have contributed to the lengthiest and largest marine mammal death occurrence ever happened in the Gulf of Mexico (NOAA 2017). Cetaceans which are aquatic mammals consisting of dolphins, whales and porpoises were extremely affected by the spill. Prior to the oil spill response, 89 cetaceans were stranded and during the initial oil spill response 119 cetaceans were stranded or reported dead offshore (NOAA 2016). Three years after the oil spill, Louisiana has stated that approximately 5 million pounds of oil had reached 55 miles of seashores which was double the quantity removed the prior year. Oil was also traced in sand in Florida (Venn-Watson et al. 2015). During the spill, more than 8,500 deceased and damaged birds were collected and more than 3,000 alive birds were transported to recovery centers where only half of them lived. A final damage assessment has estimated a range between 65,000 and 102,000 birds have died by the spill (U.S. Fish and Wildlife Service 2011). However, the Deepwater Horizon oil spill is said to be the biggest environmental catastrophe in the history of the United States and the second biggest in history. (Levy and Gopalakrishnan 2010).

As per National Research Council (1985), there are two ways to determine the oil spilled movement behavior onto the aquatic surface and these are advection and spreading (National Research Council 1985). According to Fay's theory (1969), spreading is controlled by viscous forces, gravity, surface tension and the balance between them but advection is subject on the wind and sea activity (Fay 1969). This is proven by the oil spill accident in 2001 with the tanker Jessica which ran aground at the Galapagos Islands and spilled 900 tons of bunker fuel and diesel into the ocean. It said to be the biggest oil spill that happened in that location and had the prospective to cause permanent damages to the marine fauna which are considered to be 'unique' to the isles. Luckily, with the benefit of the wind the oil was driven away from the island shores and the environmental impact was minimal (Gelin et al. 2003). A similar case happened with the Sea Empress vessel which had released 73,000 tons of oil at Milford Haven, a significant region of the Wales tourism industry due to its natural habitat and animal species. It has affected two National Nature areas, a Coastal National Park and a Marine Nature area. The 'assistance' of the wind moved the oil far away from the shore and leaving only 7% (White & Baker 1998). However, after the Torrey Canyon catastrophe, and having in mind the stable weather conditions, there was no quantification to the impairment done on the fishery populace but in general the oil spill effect was insignificant (Simpson 1968).

Is there a chain link of the impact of oil spills into the 'health and living status' of humans? Webler and Lord (2010) noted that people are affected by oil spills in three ways. The first one is that it can affect ecological procedures causing a direct damage such as health effects from the consumption of toxins found in seafood. The second way is the oil spill stressors which can modify the intermediary procedures such as the economic effects to fishers from oil spill influence to fish. The third way is that the oil spill can have a direct effect on humans such as health effects from the inhalation of oil vapors. All these, can lead to economic, health and social impacts (Webler and Lord 2010). The oil spill quantity and rate are said to be the key factors of the severity of the outcomes. It has been estimated that 1% rise in spill size can increase damages by approximately $0.718M (Alló and Loureiro 2013).

A scientific review of 130 catastrophes as per Picou et al. (2004) brought into light that US's technological disasters such as oil spills were more psychologically tense than natural tragedies (Picou et al. 2004). The entry of recovery money in the threatened livelihoods have been linked with stress and communal breakdown. The Exxon Valdez accident support this as an increased rate of drugs and alcohol consumption were connected with recovery employment which has resulted into an increase rate of domestic violence and crime. This has caused a higher demand on psychological health, clinics and rehabilitation courses (Rodin et al. 1992, Palinkas et al. 1993). Mentioned impacts had direct expenses through hospital bills, but had also a bigger societal cost through labor stoppages and shorter lifetime (Loureiro et al. 2005, Moore et al. 1998). The social life of the public can also be endangered by the involvement of third parties such as the unequal spreading of clean-up works and alterations in family and communal hierarchies (Palinkas et al. 1993). People from the affected Alaskan communities were hired by Exxon's contractors to work for the clean-up. This course of action perceived the attention of individuals from other Alaskan districts as there was a probability of a high payment for those worked on the oil clean-out (Russell et al. 2001). Social and moral conflicts emerged among the community members and the 'outsiders' between drift and set netters fishers and among those who worked on the clean-up and those who didn't (Picou et al. 2009). However, social impacts have been eased in the Hebei-Spirit and Prestige accidents by provisional support payments, government support, volunteer enrolment, assistance from the unaffected populaces and further efforts to offer the needed assistance to the affected populaces (Loureiro et al. 2005, Cheong 2011). Sabucedo et al (2009) found that the Prestige spill compared to the Valdez accident had no significant influence on mental health and social interactions because of the robust support of civic groups and proper levels of provisional financial help (Sabucedo et al. 2009). In regards to the Deepwater Horizon tragedy it should be noted that the oil spill has also affected the mental health of a number of people living near the Gulf coast. However, the impact level varies among the residents. Negative psychological health effects such as anxiety, depression and post-traumatic stress disorder were traced in individuals whose family, leisure life or work place was obstructed by the spill (Graham et al. 2016). Campbell et al (1993) had also concluded that during the first and second day after the Braer oil spill, people have reported headaches, itchy eyes and irritation of their throat. (Gampbell et al. 1993). In the case of Sea Empress oil spill, residents of the affected areas have also presented high levels of anxiety, depression, headaches, sore eyes and aching throat (Lyons et al. 1999). A different evaluation was performed by Baars (2002) in respect to the Erika oil spill. Baars (2002) examined the health status of people involved in the cleaning procedures after the spill and concluded that individuals who were in direct contact with the oil there was a greater risk of developing skin irritation, dermatitis, and skin tumors (Baars 2002). Morita et al (1999) had also concluded that people who joined the clean-up activities in the Nakhodka oil spill have suffered mainly from headaches and irritation of throat and eyes, alike to the results of Baars (2002) (Morita et al. 1999). A different study was performed on the psychological health of the wives of clean-up employees after the Deepwater Horizon accident; It was concluded that memory loss and depression were related with their contact to the pollutants and not to economic anxieties (Rung et al., 2015).

Oil spill accidents can be referred as a tourism crisis or a disaster? The word crisis was generated from the Greek word ''krisis'' which means judgement, choice or decision. The term crisis was well-defined by a lot of writers, however there is no communal definition yet

(Paraskevas 2006). Most definitions speak in terms of the crisis effects on organizations. Coombs (2007) defines crisis as ''a significant threat to operations that can have negative consequences if not handled properly'' whereas Lerbinger (1997) states that a crisis is "an event that brings, or has the potential for bringing, an organization into disrepute and imperils its future profitability, growth, and possibly its very survival" (Lerbinger 1997). Other writers argued that a crisis also affects the entire system of the organizations as well (Pauchant and Mitroff 1992, Fearn-Banks 1996 and Faulkner 2001). Fearn-Banks (1996) stated that crisis is a '' major occurrence with a potentially negative outcome affecting an organization, company or industry, as well as its publics, products, services, or good name'' whereas Pauchant and Mitroff (1992) agreed that a crisis is '' a disruption that physically affects a system as a whole and threatens its basic assumptions, its subjective sense of self, its existential core'' (Pauchant and Mitroff 1992 and Fern-Banks 1996). On the other hand, a disaster according to Faulkner (2001) is a "situation where an enterprise is confronted with sudden unpredictable catastrophic changes over which it has little control" (Faulkner 2001).

Oil spills indicate that a number of industries can end up to substantial losses that are caused by direct or market impairment. Aquaculture industries and fisheries are frequently affected by product losses caused by direct death, habitat damage or by a decline in market demand (Punzón et al. 2009). Likewise, the tourism business which can be harmed by the direct impact of oil to beaches, waterfront properties, decrease accommodation levels in hotels and decrease income in fisheries (U.S. Department of Commerce 1983 and Oxford Economics 2010). After the Exxon Valdez accident, 59% of tourism industries in the spill region have reported cancellations, and as a result the visitor spending has decreased by 35%. The nonexistence visitor services such as charter yachts, accommodations, excursions, etc. has also resulted to the reduction of visitors. The greatest effects were in fisheries which were exposed to damages of $287 million (McDowell Group 1990). Following the Braer accident, media releases had adversely affected the Shetland's image and contributed to visitor cancellations. Fishing zones were closed for an extensive period of time resulted to the economic losses of fishing industries (restaurant, fisheries) and as a result tourism damages were counted to £550,000 (Butler and Fennell 1994). Both, fishing and tourism industry were highly suffered, approximately £15 million, due to the customer's perceptions from the release of oil by the Sea Empress vessel at Milford Haven (White & Baker 1998). The affected coastlines after the Prestige accident (Galicia, Spain's north coast and the Atlantic coast of France) suffered around €719 million due to the oil spill impact to tourism and fishing business (Loureiro et al. 2005). Accommodation in these areas was decreased and had a direct consequence to the income loss of the fishing industry that was closed for health reasons (Loureiro et al. 2005). The oil released from the blowout of the Deepwater Horizon affected the tourism industry as well. Specifically, in 2010 in Louisiana, visitor expenses were decreased by $247 million and hotels nearby the Gulf Coast were facing cancellations. As a result, tourism interest in that area was declined after the accident having costs of $7.6 billion (Knowland Group 2010).

According to the above, oil spill accidents differ from one another. To this extent, their impact to the environmental and the ecosystem will vary as well. However, there is a significance between the impacts and the factors contributed at the time of the accident and after the accident. Also, both disaster and crisis represent chaotic occurrences in the tourism and fishing sectors. There is no right and wrong on how to call it as both terms involve a chain of threats for the fishing and tourism industry.

1.4. Clean-up Techniques

Numerous oil spill accidents have 'shocked' the marine industry and the ecosystem. There is a worldwide challenge, especially for those responsible such as the drilling companies, government, and emergency response teams, to effectively clean-up the oil after a disaster. According to Othumpangat and Castranova (2014), no cleanup methods have shown to be 100% effective and reliable even with the great improvements in technology (Othumpangat and Castranova 2014).The ecosystem is seriously affected by an oil spill and more specifically the fishing businesses, recreational zones and civic water supplies. Inadequate and poor clean-up procedures can cause long-term health impacts for people living in regions nearby oil spills. Spills that are not adequately cleaned up could enter into the soil and pollute layers close to water drinking supplies. However, repeatedly clean-ups after oil spills do not remove the toxins that pollute soil, water and air. Clean-up procedures have repeatedly proven costly, challenging, demanding and ineffective, and do not restore entirely the affected regions. To this extent, the oil spill prevention is the most significant part of controlling oil contamination (Onwurah et al 2007). There are two groups of clean-up methods when estimating the oil spill impact in water and land; the biological/chemical and mechanical/containment recovery. The first treatment of oil spill is occasionally used in conjunction with the mechanical process. Chemical methods aimed to dissolve the oil while biological methods aim to promote the development of microbes that can feed in oil remains. These techniques are more supportive and applicable in sea and coastlines as they are complex, sensitive and must be safeguarded. The second treatment is used more frequently, as it takes away the oil from the affected zones as fast as possible. Chemical methods include the use of dispersants, and burning oil from slicks, while mechanical methods include the use of booms, sorbents and skimmers (Walther III 2014).

According to Idris et.al (2014), the use of sorbent materials is proven to be effective and cost-effective for oil cleanups especially for large scale processes (Idris et. al 2014). This was also proven by Choi and Cloud (1992) as they have also found that in soil environments sorbents could be successfully used to absorb oil and to remove it from soils (Choi and Cloud 1992). This method can be used for spills in accessible locations, in order not to disturb the natural and marine environment. It has been proved that the method of dispersing the oil is effective when oil is stuck in coastal rocks, laying at the sea surface or in tiny ponds by the coastline (Walther III 2014). However, sorbents can cause a possible damage to the marine environment as when they are covered with oil they sink to the bottom of the sea (EPA 2014). The fastest and most successful technique to handle an oil spill is burning, as approximately 98% of the oil spilled can be took away by this method, but bearing in mind that the oil coating is at minimum 3mm thick and quite fresh. Conversely, this method causes health problems as it damages the airway from nose, lungs and moth and can present effects such as black mucous and coughing and also can cause wind pollution. Booms can be effective when the oil is concentrated in a particular location and are used to stop the oil from dispersal. They are float on the sea surface and are composed of a freeboard which enclose the oil and stopping it from spilling over the top, a 'skirt' under the surface that stops the oil from leaking under the booms and a chain that embraces the boom together (Wadsworth 1999). However, the use of booms cannot deliver effective oil spill control in windy weather conditions as it could turn away the oil to other areas and also will splash it above the boom (Robert et al., 1989). Skimmers can remove the oil after it has been controlled by booms. They can recover and spot the oil off the sea surface, or isolate the oil from the water. Not severe weather conditions are required in order for this technique to be effective and also cannot be applicable in outsized spills or in rough sea-waters (Walther III 2014).

Oil spills are contaminating the oceans, land, wildlife and human life for a lot of years and can increase the time of their recovery. In order to manage the oil spill, an important decision of the 'best solution' related to the clean-up method must be taken by the responsible persons in order to minimize the impact on the ecosystem and the environment. Also, upon the use of the best technique it should also be considered the aftermath of the clean-up method. Even the 'best technique' can have a negative impact to the ecosystem and the environment of the affected areas; this question will be answered through three major catastrophes, the Deepwater Horizon, the Exxon Valdez and the Torrey Canyon.

In the case of Deepwater Horizon, around 30,000 individuals had responded to the oil spill in the Gulf coast. A lot of techniques were used for the removal of oil such as booms, dispersants, burning and skimmers (Walther III 2014). According to Judson et al (2010) chemical dispersants are toxic however since the last decade these kind of dispersants have turned out to be less poisonous (Judson et al 2010). In the case of Deepwater Horizon, approximately 2 million gallons of chemical dispersants were used in both the oil slick surface and at a great depth beneath the surface close to the leak source. This technique reduced the direct contact of oil at the source which then lessened the oil's intact at the water's surface. It said that the shoreline damage was minimal (Kujawinski et al. 2011). As per findings of McCormick (2015), dispersants which can be stacked in the environment for a lot of years, can also escalate the exposure probability of corals, fish, and other water leaving organisms to the poisonous oil compounds. Also chemical dispersants can kill fish population within one week after chemical exposure. Sargassum, a type of algae, can be used as a habitat for a lot of fishes but sank after its direct contact with the chemical dispersants. In 2012, 80% of the white pelican's eggs were comprised of chemical dispersants (McCormick 2015). Walther III (2014) also proved that bluefin tuna, corals, reddish egret, brown pelicans, sea turtles, snowy plover, royal tern and whale's sperms were also affected from the chemical dispersants (Walther III 2014). Containment and sorbent boom were used although physical and weather forces destroyed the boom and as a consequence oil reached the shoreline. The implementation of the burning technique has removed only 5% of the oil from the sea surface but due to the release of smoke, carbon dioxide and monoxide into the water and air there are concerns of adverse health impact on humans especially to the workers. (Blum et al 2014). This was also proven by Walther III (2014) as he had concluded that the burning technique had a negative outcome on both the environment and the workers' health. Also, the reproductive behaviour of sea turtles was faced with alterations due to the use of skimmers, burning, booms, increase of light nearby the nesting shorelines and boat traffic in order to clean up the oil (Walther III 2014). Despite the numerous clean-up techniques used, there is no doubt that a great amount of oil is still under the ocean of the Gulf Coast and due to that the oil will be existing into the beaches and will continue affect the ecosystem. As a result the damage might take a lot of years to recover even centuries (Joye 2018).

Another huge catastrophe back in 1989 was the accident of the Exxon's tanker. Numerous methods were used to clean-up the oil such as burning, chemical dispersants, skimmers, booms, bioremediation, high pressure hot and cold water treatment, and explosion. Due to the adverse weather conditions and spill's location, burning process was stopped and booms and skimmers were used but also ceased due to the difficult transportation of oil into the containers for storage purposes for a later disposal of oil. Dispersants were used at the initial response phase but due to the calm sea-waters the process was stopped. The treatment of hot and cold water was also discontinued after it was concluded that the washing was causing a greater injury than the oil as it destroyed microbial populaces. Bioremediation was used effectively only to beaches that were little impacted with spilled oil. Lastly, only one trial of explosion was conducted in an early stage after the oil spill because it had reduced only an insignificant amount of oil and also weather conditions didn't allowed any additional trials (Walther III 2014, Joye 2018). According to Walther III (2014), the shoreline's ecosystem of Alaska has suffered because of the use of violent clean-up procedures such as hot and cold water treatment and as a result the beaches will face an extensive time of recovery (Walther III 2014). During the clean-up activities four people lost their lives and 6,722 incidents of respiratory claims (flue, cold) were reported from the clean-up employees. Until recently, a lot of them are still having respiratory issues, some of them are disabled and others have lost their lives because of their contact to the poisonous oil gases (Joye 2018). Following the study of EVOSTC (2009), the clean-up methods have a negative impact on the harvests by decreasing the disposal of wildlife and fish, and concerns were raised for probable health impacts from the consumption of lubricated wildlife and fish (EVOSTC 2009). Recent study stated that the residual oil in the Alaskan waters is hidden or sequestered and is not posing a threat to the ecosystem (NOAA 2018).

The wrecked of the Torrey Canyon supertanker in the southwest England has resulted in the release of the oil into the Atlantic Ocean which then reached the beaches of UK and France (Joye 2018). A lot of clean-up methods were used for the mitigation of the oil. Due to the unsuccessful attempt of burning off the slick, under the commands of the British government, 42 bombs were used to sink the tanker in order for the remaining oil to be burned. The operation was relatively successful as the oil was escaped and as a result a lot of areas of England's southwest were polluted, a massive number of seabirds have died, beaches and harbors were contaminated, and the livelihood of the locals was at stake especially within the tourist period (ITOPF 2014). Foam booms were also used but were not successful due to the aggressive sea waters (Joye 2018). Ten thousand tons of dispersants were applied without considering any threats to the ecosystem. It was found that the oil-dispersant combination was much more poisonous for the environment than the oil itself

(CEDRE 2014). According to Hawkins et al (2017) the dispersants usage was the reason of the oil to sink far away in a number of beaches and there was proof that the dispersants have destroyed the oil-degrading germs. Also, it was evidenced that at the areas where oil was not cleaned, there was a slightly death-rate of coastline plants and wildlife and impairment was insignificant on sloping rocks. In contrast to the areas where dispersants were applied there was an extensive death-rate of algae, snails, shore fish and crabs (Hawkins et al 2017). It took around 8 years for the 'light oily' rocky areas to recovered whereas regions that dispersants were used it took about 10 years to recover (Joye 2018).

According to the above case studies findings, even the best technique can be considered as the worst technique used for the ecosystem and environmental perspective. Numerous factors can turn the best technique as the worst one such as weather conditions, the type and amount of oil spilled and how effective the methods were used by the responders. Therefore, there is no assurance for the best and the worst clean-up technique to be used. It is all about preparedness.

Blank Page

1.5. Current status of the Gulf Coast

The process of restoring and evaluating environmental damages from hazardous oil substances is complex and time consuming. National Oceanic and Atmospheric Administration (NOOA), focusing on the protection and conditions of the atmosphere and the oceans, responds to approximately 150 oil spills every year. A lot of factors can affect the restoration process of an oil spilled area such as the location, the season, the type and amount of oil released, and the duration of the oil remained into the ocean. The Natural Resource Damage Assessment (NRDA) is a procedure that NOAA and other trustees such as federal agencies, states, government etc. have introduced in order to examine the impacts and the extent of the ecosystem and environmental damage from the oil spills and to state the time-period of restoration required, to quantify damages and to conclude which parts were most affected. Restoration actions include the creation of water-side habitats, improvements on coastlines and beaches, creation of shellfish homes and oyster reefs, restoration of seagrass beds and coral reefs, removal of obstacles from canals and rivers, construction of ship ramps, fishing docks and paths (NOAA 2018). Under the adoption of the Damage Assessment, Remediation and Restoration Program (DARRP), which was created following the Exxon Valdez oil spill, the trustees, public, attorneys, economists, scientists, restoration experts, and industries are working together in order to develop restoration plans and to look after shoreline and oceanic resources when damaged. Until today, $10.3 billion haven been recovered for restoration services from those accountable for ecological impairment (DARRP 2018). Can the responsible parties assure the public that they can restore the affected areas and the animal species in their original phase?

Following the oil spill catastrophe, Exxon Corporation has concurred to pay $900 million over a 10 year period to civil settlement. The Exxon Valdez oil spill trustee council was created for the restoration procedure of the ecosystem through the use of the payment. As a result, the adoption of a restoration plan in 1994 by the Trustee council was introduced. Meetings were arranged in 22 spill areas with more than 2,000 individuals present. However, despite the recovery efforts of the company, Holloway (1996) "stated that recovery will occur when the Sound looks as it would have if the spill had not occurred" (Holloway 1996). The oceanographer Pegau (2014) concluded that some of the marine species are completely recovered conversely to one out of eight inhabitant pods of orcas have no livable females and probably will disappear. The AB pod, a group of killer whales, had shown some recovery signs in regards to the AT1 pod that have shown no recovery signs at all (Pegau 2014). Few species were not recovering due to the presence of oil ten years later which was said to be as poisonous as it was the first days after the accident. In 2000, Littleneck clams have shown a slight increase and their quantities were equivalent to those in uncontaminated areas. The cause for their slow recovery was because of the trapped oil in the affected areas. According to EVOSTC (2009) recovery of seabirds will be challenging without the herring recovery and human services within the fishing industry will not be recovered until cutthroat trout, rockfish and herring will recovered. Additionally pacific herring and pigeon guillemots will not be recovered, archaeological resources, bald eagles, common loons, common murres, cormorants, harbor seals, pink salmon, sockeye salmon, dolly varden and river otters are among to those recovered (EVOSTC 2009). Until today, 111 acres of marshland habitat have been restored or improved and more than 80 acres were bought for protection. However, restoration effort is continuing (DARRP 2018). According to a recent study, the oil is decreasing approximately 0%-4% each year with only a 5% probability that oil will be at the highest percentage, and as a result the oil will take decades and probably centuries to vanish completely (Pegau 2014).

Regarding the Deepwater Horizon catastrophe, approximately $8.8 billion was agreed as a payment from BP to the Trustees for restoration purposes, mainly in Texas, Louisiana, Alabama, Mississippi and Florida (DARRP 2018). According to NOAA fisheries (2016), the investigations for the death of fetal dolphins and the oil spill effects to the ecosystem and the environment are still ongoing. Also, the long-term effects of the oil in regards to the dolphin reproduction are yet unidentified (NOAA 2016). Scientists have tracked a group of dolphins after the oil spill and have concluded that Dolphin Y35 has disappeared and Y12 which was a sixteen years old dolphin was never seen again (NOAA 2015). In 2017, the Deepwater Horizon Oceanic Fish Restoration Project was created as a supportive tool for the restoration of fish species. Its aim was to reduce fishing death throughout a six month period every year where contributing ship owners will hold back from fishing. This will be continued yearly for about five to 10 years. Specifically, the participants will be remunerated and will have an alternative process on the targeting of swordfish and yellowfin tuna in order to for the pelagic fish species to be reproduced (NFWF 2017). In 2012, researchers have found oil signs in the eggs of white pelicans in Minnesota, yet from 2011-2012 the reproduction population has fundamentally stabilized. Dramatic drops of seatrouts were detected in Mississippi and Louisiana, and oil spill remains in some marshes is setting seaside sparrows at continual danger from their contact with oil, from reduced or polluted food, and from loss of their habitat. A decline in the growing of red snappers was perceived between 2011 and 2013, in contrast to Auburn University study in 2014 which hasn't found any decline in red snapper. There was a decline of 64% in regards to the laughing gulls from 2011 until 2013, and the number of nests of a certain kind of sea turtles, Kemn's ridley, were also dropped in 2013 and 2014 and until now is seemed inescapable to recover. Additionally, coral reefs might take decades to recover due to their slowly growing. Due to that, the fish populace was dropped intensely in Roughtongue Alabama and Alps Reefs. The sandy beaches of Gulf Coast in 2013 were still contaminated as the oil was detected on approximately 300 miles of sea coastline. Yet, the recovery timeframe in the Gulf Coast areas is not determined. (McCormick 2015).

Blank Page

Chapter 2

Crisis Management Models

2.1. Risk Management Process

There is a great uncertainty when an oil spill accident will occur as its likelihood is not predictable. It is all about preparedness to prevent or mitigate the coming risks and threats. According to ISO (2018), ''We live in an ever-changing world where we are forced to deal with uncertainty every day, but how an organization tackles that uncertainty can be a key predictor of its success'' (ISO 2018). Risk is an essential part in any kind of organization, however the company's challenge is to detect it and mitigate it. ISO 31000 principle is applicable in every type of business, acting as a shield of numerous risk types through its guidance and assistance for each company for the development of a risk management plan. This will help the companies on the identification and mitigation part of risks, to increase their probability of accomplishing their goals and to protect their resources. Its aim is to expand the risk management culture within the organizations in order for the stakeholders and personnel to be alerted for any upcoming risks, how to monitor and manage them. Regarding the risk management process, ISO 31000 highlights the significance of establishing the context before the risk assessment, risk treatment, communication-consultation and monitoring- review phase (ISO 2018). In regards to the oil spill accidents, it is very important for each organization to be one step ahead and to have in mind the happening of 'the worst case scenario'. They will always be alerted. Some of the topics to be considered by each company when undertaking an oil spill risk assessment are:

- To question themselves if there are indicators for a possible oil release such as to identify and analyze probable risks that are linked to the vessel's activity such as grounding, collision, explosion, mechanical failure etc. This will assist the companies to create a scenario related to the likelihood of an oil spill and also to recommend ways to minimize or mitigate the risks.

- Prevention measures related to the likelihood of an oil spill accident resulted from the production or transport of oil. For example companies should invest to technology-based equipment for the prevention of a blowout such as blowout preventers, and employees should have a constant training for the detection of possible risks.
- What could possibly be happened after the release of oil? Companies should ensure that response programs are in place for the clean-up of the oil. The type and quantity of spilled oil, location of the accident and weather conditions should be highly considered before the clean-up activities in order to minimize the economic and environmental impacts.

2.2. Kash and Darling

Crises are unavoidable, and in many occasions are intense and constant. Most of the crises are unexpectedly occurring as their signals are usually preceded. A proposed methodological approach for a targeted management related to the Exxon Valdez oil spill is: (Kash & Darling 1998):

1. By *evaluating the data* for determining the nature of the crisis. Exxon should have prepared a proactive crisis plan to assist the managers to resolve a crisis.
2. By *presenting the anatomy* of the crisis schematically. Exxon failed to detect significant symptoms and signals in order to prevent or minimize the disaster. E.g. the vessel was fully loaded and unescorted, outdated and inadequate communication systems were used, and diminishing output per man hour pointed out the disaster.
3. By *recommending methods for prevention and intervention* prior to any crisis symptoms set in. Scenario analysis, contingency planning and strategic forecasting should have been implemented by Exxon's officials to prevent the disaster. E.g. overseeing industry spill drills, conducting facility inspections, monitoring radar coverage, ensuring that the personnel is trained effectively and the equipment/resources will be available to be activated quickly, ensuring that the personnel had practiced their job-tasks in training for a real spill.

   Refusing to accept a crisis situation is the worst action procedure to be taken by a company. Exxon's CEO did not respond promptly to the public/media and no communication plan/ team were in place to manage the situation. A public relations manager must be appointed and a crisis plan should be implemented to inform internal/external stakeholders. Exxon has appointed a public relations manager in 1993 that is 4 years after the disaster (Pauly & Hutchison 2005).

Blank Page

2.3. Mitroff

Crises can be identified at various stages, and allow the users to communicate about any upcoming changes, adjust interventions of what is required at each stage, and examine progress across stages (Jaques 2010). According to the model of Mitroff, there are five stages of crisis management that Exxon should have used in order to minimize the threats prior and after the catastrophe; these are (Mitroff et al 1996):

- *Signal detection* discovers the warning signs of possible crises within a business. Prior to the accident, Exxon failed to detect such signals and no active or well-developed programs were in place in order to allow them to spot emerging problems (Leacock 2005).
- *Probing and prevention* of risk factors. Exxon should have audited its external environment, operations, technologies and culture on a regular basis to detect probable vulnerabilities. This could be done by scrutinize earlier crises, audit the status of detection systems e.g. fire alarms, audit the recovery systems, create a crisis portfolio to ensure that Exxon will not only be prepared for fire/explosions but to be prepared for a wide variety of disasters that might occur (Mitroff et al 1996).
- *Damage containment.* Exxon should have taken appropriate actions for keeping the disaster from spreading to uncontaminated areas. Exxon used ineffective toxic dispersants to clean-up the oil spill. In-situ burning was used as well, but on the 2nd day of the clean-up instead on the same day (ARLIS 1990).
- *Recovery* from the disaster to return to normal operations faster. Exxon should have cooperated with other polluters, states and federal agencies to analyze the accident's damages. E.g. appointing scientists, restoration specialists, economists who will develop a restoration plan for coastal and marine habitats (Burger1994).
- *Learning* from a crisis. Exxon and major oil companies must consider that the best it can be done after a disaster is to protect a spill-damaged ecosystem and allowing it to recover naturally. Also, they shouldn't trust industry statements concerning the size and impact of a spill, as in most cases the size, risk and impact of oil spills are downgraded (Steiner 2014).

Blank Page

2.4. Business Continuity Management

Business Continuity (BC) and disaster recovery have appeared as critical parts of business planning over the past few years due to the reason that hundreds of companies every year are effected by natural and man-made disaster (Watters & Watters 2014). According to ISO (2012), BC can be defined as the ‘‘capability of the organization to continue delivery of products or service at an acceptable predefined level following a disruptive incident’’ (ISO 2012). A business continuity management procedure (BCM) aims to identify current or potential risks, threats and vulnerabilities that might impact the organization’s continued operations. The BCM lifecycle consists of four elements, all of which need to be undertaken in order to implement a BCM effectively (Hiles 2014). This is presented below in connection to the Exxon’s Valdez incident.

- Business Impact Analysis (BIA) is a systematic procedure for determining and evaluating probable consequences of an interruption to significant business operations derived from a disaster. It also includes an investigative component to disclose vulnerabilities and a planning component to create strategies for reducing risks. A BIA report is derived that describes the probable risks specific to the business, attempts to measure the financial and non-financial costs related with the disaster and focuses on the most crucial organization’s parts (Hiles 2014). Businesses that cause environmental damage will come upon a public relations nightmare and this can be confirmed in the Exons’ disaster. Even though there was no loss of human lives, the death of animals and the environmental damage was extensive. The negative media press releases were daunting the company as they had no crisis plan and a BIA in place (ARLIS 1990).
- A risk assessment (RA) procedure is used for the identification and evaluation of risks in the company’s vital activities. It also allows the company to act on proposals to lessen its exposure to risks and vulnerabilities. Based on the results of the RA a company will be able to identify mitigation and risk treatment methods that can reduce the possibility of disruption, lessen the period of disruption and limit its impact (Hiles 2011). Preventing oil spills is the best strategy for avoiding potential damage to the ecosystem. Exxon did not do that. A risk assessment was neither in

place, nor procedures in order to prevent the accident for happening. The crisis-management specialists have stated that the Exxon has failed to follow a number of well established procedures, and to audit on a regular basis its external environment (operation, technologies, culture) to detect probable vulnerabilities. Upon the direction of the ship out of the traffic lanes, both captain and the third mate were controlling it with misleading information as the vessel traffic center couldn't monitor the movement of the vessel due to limitations on the stations' radar. Information or warnings were not available from the station to the vessel in order to drive it in a safe position (ARLIS 1990).

- Plan development, implementation and documentation always take longer than originally estimated. It synthesizes the RA and BIA results to create a methodological and actionable plan such as obtaining executive sign-off of business impact analysis, developing department, division and site level plans, organize recovery teams, distributing and reviewing the plan to all key stakeholders, and conducting training sessions to help and ensure that the employees are comfortable with the steps outlined in the plan (Hiles 2014). A respond to an oil spill depends on planning and preparation. Exxon has failed to do that. No plan development was in place and neither the above mentioned activities were followed by the company. Exxon should have planned for such oil spill accidents by ensuring that their employees were trained effectively and oil spill response equipment will be available when needed. The third mate Cousins was unqualified to command the ship (ARLIS 1990).
- Plan testing and continuous improvement is the final and most critical stage in the BCP as a plan isn't actually a plan until it has been methodically tested. Such as, conducting periodic table top and stimulation exercises to ensure the key stakeholders are comfortable with the plan steps, executing bi-annual plan reviews, performing annual business impact assessments, through checklist tests and emergency evacuation drills. Once the testing is concluded, the cycle is then completed and begins again. On a regular basis risks, strategies and impacts must be reassessed, corrections to be made if necessary and re-test regularly to ensure the most effective plan is in place (Hills 2011). Due to the reason that the first 3 phases ere not followed by Exxon, this

phase was not carried out as well. The inaccessible location and the massive oil spill size has tested Exxon's spill preparedness and response capabilities which were poor and inadequate (ARLIS 1990).

The Exxon Valdez oil spill accident has caused the whole industry to review and to re-evaluate its response procedures with strategic and fundamental new ideas.

Blank Page

Chapter 3

Compliance and Regulations

3.1. Adoption of Regulations

During the last two decades, even though the oil consumption and imports in the USA have steadily increased, oil spill accidents and the volume of spilled oil have not followed a similar road and shown a decline. The Exxon Valdez spill in 1989 in the Alaskan waters was the 'start up' for stimulating actions that conducted to the lessening of the annual spill volumes. Specifically the mentioned accident, highlighted the necessity for a more robust legislation, inflamed the public sense, and induced the Congress to implement a comprehensive oil spill regulation (Ramseur 2010).

Oil tankers begin to operate since the 19th century, and worldwide 1,800 million tons of crude oil is transported by ships every year. It is the safest way for the transportation of crude oil to reach its destination. Conversely, there is always the risk of a huge oil spill (Luoma 2009). Historically, there have been massive oil ship accidents causing huge amounts of oil spills that have led to civic attention, political pressure and to an effort to find the right solutions to lessen the risks connected to such happenings. A number of accidents have caused environmental damages and immense financial losses. As a result, they had an impact on the development of maritime standards and safety regulation (Luoma 2009). In 1967, the Torrey Canyon oil accident was the first major happening that had an influence on the international legislation and subsequently has led to the adoption of Marpol 73/78. In 1978, the tanker Amoco Cadiz was the world's biggest oil spill accident that have led to the development of the first local port state control 'Paris MoU'. The OPA 90 was adopted in the USA after the Exxon Valdez accident in 1989 which was said to be the most costly oil accident (Luoma 2009). The Erika and the Prestige accidents in 1999 and 2000 respectively had a significant impact in the European legislation. The most vital factor in the prevention of oil spill accidents is the adoption of a safety culture within the maritime transportation (Luoma 2009).

The International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL) in 1954 was adopted and it was the first international convention to act as a guard for the protection of the aquatic environment from the contamination caused by oil tankers (Luoma 209). Due to the oil trading expansion, the OILPOL was inadequate (Luoma 2009). According to IMO (2018), MARPOL is the major international convention for the prevention of pollution of the sea environment by vessels from accidental or operational causes (IMO 2018). The adoption of the first convention was on the 2nd of November in 1973 at IMO (IMO 2018). The 1978 Protocol was adopted due to major vessel accidents happened within the period 1976-1977 such as the Torrey Canyon. As the first Convention in 1973 was not in action, the 1978 Protocol had absorbed it and entered into force on the 2nd of October in 1983. The adoption of another Protocol in 1997 arose to amend the Convention and also the joining of a new Annex VI in 19th of May 2005. MARPOL has a constant improvement throughout the years and has been revised quite a lot of times. The Convention consists of regulations with an aim to prevent and to minimize pollution from vessels and currently comprises of six technical Annexes such as (IMO 2018):

- Annex I Regulations for the Prevention of Pollution by Oil
- Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
- Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
- Annex IV Prevention of Pollution by Sewage from Ships
- Annex V Prevention of Pollution by Garbage from Ships
- Annex VI Prevention of Air Pollution from Ships

As per IMO (1998) MARPOL is seen "as the most important set of international regulations for the prevention of marine pollution by ships" (IMO 1998). Conversely, the issue of the IMO convention is that are not effective at all times. This is because a number of countries don't have the necessary expertise and resources to adopt the convention as a part of their domestic law (Scanlon 2001). For example, the Erika and Prestige vessels which broke into two due to their structural failure, were registered in countries with lessen ship safety principles (Luoma 2009).

In response to the Amoco Caidz oil spill accident and the political and civic concerns raised from that within Europe, the Paris Memorandum of Understanding on Port State Control was adopted in 1982 and fourteen European nations signed it (Paris MoU 2018). It ensures the international safety in the aquatic, prevention of contamination by vessels, security and environmental principles and the ship's crew team will have a satisfactory living and working conditions (Paris MoU 2018). The aim of the Paris MoU is to eliminate the shipping of sub-standard ships. This is done by aiming ships for inspection, conducting the inspections out and ceasing substandard ships (Sage 2004). Paris MoU has links with the European Commission Agency, International Maritime Organization (IMO), European Maritime Safety Agency (EMSA) and the International Labour Organization (ILO). It also follows a categorization system to rank the vessels in order to determine which vessels have to be inspected based on their risk factors such as vessel's flag/type/age, classification with a non-European society, more than 12 years old and number of deficiencies (Sage 2004). Following the Prestige and Erika accidents, high risk ships are inspected every 12 months. In this category are the vessels over 3000 GT and over 15 years old. Even though the Paris MoU was signed 27 years ago, insecure ships are still threatening the environment and to this extent the Paris MoU's members will continue to be competitive against sub-standard shipping (Luoma 2009).

Following the Exxon Valdez oil spill, it has been concluded that the accident could have been prevented. Due to the public anxiety and political pressure, the Oil Pollution Act of 1990 (OPA 90) was established in the US (Birkland & Lawrence 2002). Its aim was to minimize the volume and number of oil spills and reduce the environmental damage through an upgraded tanker design and better preparedness (Ketkar 1995). OPA 90 states that the vessel owners/operators will be held accountable for the cost of pollution accidents and not just for the clean-up cost but for the damage to the environment as well (Stopford 2008). Based on that, three minor spill clean-up funds were combined into one bigger fund, the Oil Spill Liability Trust Fund which reduces the environmental damages to by providing a prompt and an efficient clean-up (Birkland & Lawrence 2002). Also, it requires the development of thorough contingency oil spill response plans, establish double-hull requirements for new tankers, and phase out schedule and operational requirements for single-hull tankers

(Luoma 2009). OPA 90 is concentrating in five areas for an adequate and right response when an oil spill occurs. These are (Luoma 2009):

- Prevention which gives an emphasis on staff competence and double hulls
- Preparedness consists of Vessel Response Plans and Exercises, Contingency Plans, training requirements and qualifications of qualified employees in Oil Spill Response Organizations
- Response implies that the Coast Guard will be responsible to ensure an effective and safety response.
- Liability and Compensation regime
- Research and Development comprises of response and prevention procedures and hardware.

After the Exxon Valdez oil spill a lot of things have been improved, however the risk of an oil spill will be present at all times (WWF 2009).

The European Union has significant improvements on the maritime safety standards after the Erika oil spill from where important gaps in the maritime safety procedures have been discovered and indicated the need for harmonization (Luoma 2009). To this extent, the adoption of Erika I and Erika II packages were introduced and have set effective procedures to improve maritime safety and lessen the risks of oil spills (EC 2002). The Erika I package has reinforced the current Directive on Port State Control and every year more than 4000 ships are obligatory to be inspected for any structural problems and vessels that are discovered in a 'poor condition' are forbidden to enter the European ports (EC 2001). The 'Black list' of these kind of ships is been published every six months (EC 2001). The society's performance is strictly supervised and if not satisfactory, there is a permanent or a temporary removal to work on behalf of European Member States (EC 2002). Also, this package enhanced the procedure of phasing out of single hull oil vessels (EC 2002) The Erika II package offers solutions to support the Erika I such as the adoption of a new basis of ship traffic monitoring and information system, the introduction of the Compensation Fund for Oil Pollution in European Waters (COPE) which will pay an amount to the oil spill victims, and the creation of the European Maritime Safety Agency (EMSA) in 2003 in order to lessen the risk of marine accidents, sea pollution from vessels and human death at sea (EC 2001 and EC 2002). The European Parliament has adopted the Erika III package in 2009 and despite its name the Commission wanted to avoid the link between the Erika accident and this package (OSIR 2009). The Erika III package comprises of new regulations such as the permanent banning of unsafe vessels, repeated inspections, rigorous insurance requirements for vessel owners, improved compensation plans to passengers in the occurrence of an accident, and obligatory compliance with international safety principles (OSIR 2009).

All the above regulations have a positive effect in regards to the prevention of oil spills. As a consequence, 19 flags were included in the 'Black List' (Paris MoU 2007). The vessels that were black listed and have been 'arrested' twice in two years, cannot have the green light to enter into ports in Paris MoU region (Sage 2004). Devanney (2006) has stated that deficiencies cannot be noticed as the inspectors are not entering the tanks and the port state has not a direct impact on the construction and design of a tanker, and has concluded that these issues must be resolved(Devanney 2006). This was proven by the Erika and Prestige oil spills, the inspectors didn't entered into the tanks and as a result the deficiencies couldn't be traced (Devanney 2006). There was a 95% decrease in the volume of spilled oil from vessels after the adoption of OPA 90 (Knapp & Franses 2009). However, as per WWF (2009) the OPA 90 might not work effectively in the Arctic areas due to very low temperatures (WWF 2009). The removal of single-hull tankers according to OPA 90 has also prevented the happening of small oil spills (Devanney 2006). According to EVOSTC (2009), it is very important to regularly amend the conventions in order to improve maritime safety (EVOSTC 2009). The prevention measures can be considered 'expensive' in the eyes of the shipping industries however cannot be compared to the costs after the happening of an oil spill (Faure & Hui 2003).

Blank Page

3.2. Organizational Components

The Contingency Plans are the basic instruments for preparing and responding to US oil spills as they describe the organizational formation to deal with the contamination risk, the procedures to follow, and the available resources to achieve the work. There are six response and planning organizations in the U.S. (Tejedor & Spinosa 2004):

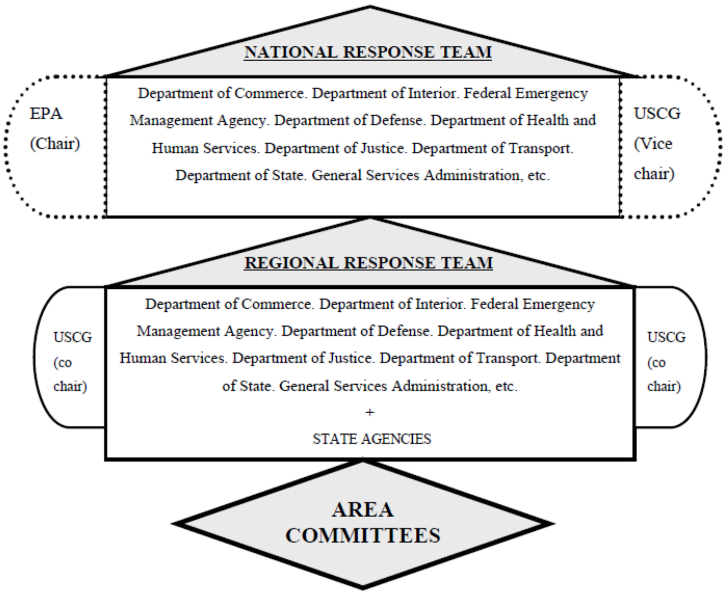
- National Response Team, accountable for its National Contingency Plan
- Regional Response Teams, accountable for their Regional Contingency Plans
- Area Committees, accountable for their Area Contingency Plan including local regions, parts of the regions, water/land areas
- States accompanied by their Emergency Response Commissions
- Local Committees along with their local crisis response procedures such as the appointment of a local emergency planning committee for the supervision and coordination of their actions, and for the reviewing of local emergency response procedures.
- A set up plan to be in place by each tank ship and onshore/offshore facility that may cause a significant damage to the environment by the release of oil.

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) was developed and published in 1968, and it is the federal government's plan for responding to oil spills and dangerous substance releases. It provides the guiding principles and procedures required to respond to oil spill releases, and likely dangerous substance releases, contaminants or pollutants. The NCP is the outcome of the attempts to develop a nationalized response capability and to encourage coordination between the contingency plans and the hierarchy of the responders. Pursuant to the NCP, three primary activities are carried out (Tejedor & Spinosa 2004):

- Preparedness development and coordination for oil spill response or dangerous substance releases, contaminants or pollutants
- Notifications and communications
- Response procedures at the scene of the release

The national Response Team (NRT), the Regional Response Team (RRT) and the Area Committees are the organizational components to perform the above mentioned activities (Figure 1) (Tejedor & Spinosa 2004).

Figure 1: Organizational Components



(Tejedor & Spinosa 2004).

The National Response Team (NRT) is responsible for the revision, elaboration and coordination of the NCP. Even though the NRT does not directly respond to accidents, it is in charge for distributing information (technical, operational, financial) regarding oil spills and dangerous substance releases to team members. Also, it makes sure that the federal agencies' tasks during a response disaster are clearly defined in the NCP. Once the disaster is finalized, the response effectiveness is cautiously assessed by the NRT. The NRT can use the data collected from the assessment to proceed with recommendations in order to upgrade the NCP and the National Response System (NRS). A reviewing procedure of the plans will be initiated to verify whether they act in accordance with federal regulations on emergency response. The NRT also develops training programs, synchronize federal training attempts and disclose information to local officials, district, and state about training needs and also supports the Regional Response Teams (RRTs) (EPA 2017).

The NRT membership composes of representatives for oil spills from various agencies such as (EPA 2017):

- The U.S. Coast Guard (USCG), an agency of the U.S. Department of Homeland Security, which serves as a Vice Chair for the NRT and co-chairs all the RRTs. Twenty-four hour a day staffed resources in forty-six 'Captain of the Port Zones' are sustained by the USCG for surveillance, control and command of releases in the coastal waters. It also direct the National Response Centre and retain a National Strike Force that is particularly equipped and trained for the response of major sea pollution accidents. The strike teams of the USCG are located on the Gulf and Pacific Coasts (EPA 2017).

  The USCG provides fast response assistance in incident supervision, safety site, contractor work monitoring, response strategy, risk assessment, oil spill dispersants and the use of in-situ burning and monitoring of the operational efficiency, through the National Strike Force that trains the coast guard units in ecological pollution response, check and appraise pollution response equipment, and cooperate with response agencies (EPA 2017)

- The Environmental Protection Agency (EPA) co-chairs with the USCG, the RRTs and chairs with the NRT. It provides scientific support coordinators for in-land spills, On-Scene Coordinators (OSCs), and Remedial Project Managers for dangerous waste remedial acts under Superfund. EPA offers support upon request or when country and local first responder abilities have been exceeded. Through the coordination and implementation of an extensive range of actions, EPA acts a shield for protecting human health and the environment by conducting removal actions (EPA 2017).

- The Department of Commerce (DOC), through the National Oceanic and Atmospheric Administration (NOOA), offers professional support contingency preparation and response in marine and coastal areas, consisting of risk assessments that might be involved, estimation of the movement and spreading of oil and dangerous substances, mitigation and clean up techniques, and providing expertise for the endangered animals and the ecosystem (Tejedor & Spinosa 2004).

Other major representative agencies include the Federal Emergency Management Agency which offers guidance, technical and policy assistance in crisis preparedness, training, planning and exercising procedures for local and state governments, the Department of Defence offering manpower and recovering equipment, the Department of Health and Human Services providing training and information on human health, the Department of Justice providing expert legal advice, the Department of Transport for the transportation of oil or dangerous substances, and the Department of State that leads the contingency plans (Tejedor & Spinosa 2004).

The Regional Response Teams (RRTs) developed the Regional Contingency Plans (RCPs) for Alaska, Oceania in the Pacific, and the Caribbean. The RRTs includes the standing team consisting of selected representatives from each contributing federal agency, local and state governments, the incident-specific team created from the standing team when the RRT mechanism is set in motion for a response. The objective of the RCPs is to organize timely and efficient response by different government agencies and other associations to clean oil or releases of dangerous substances, contaminants or pollutants. For this reason, RCPs contain information from commercial, government, academic and other sources, on all useful resources and facilities in each region. RCPs are synchronized with the Area Contingency Plans, state Emergency Response Plans and Local Emergency Response Plans (Tejedor & Spinosa 2004).

Blank Page

Chapter 4

Quantitative Analysis

4.1. Statistical Analysis based on Numerical Variables

The most frequent question related to oil spills is 'How much are the clean-up costs?' There is not a specific answer for that as there is a significant variation in respect to the clean-up costs of major oil spill accidents at a range of $100,000 to $12,000,000,000 (White & Molloy 2003). This variation is due to numerous factors such as the location of the accident, the type and the quantity of oil spilled, weather conditions at the time of the accident, and the response procedures. There is a complex interaction between the factors which makes cost estimation unreliable. These factors are explained below by reference to major oil spill accidents worldwide along with their impact in the economy and the environment (White & Molloy 2003). Also, a statistical analysis using the Excel is presented and giving an emphasis to 23 major accidents from 1967 to 2014 through a number of data (Appendix: table 1).

All types of oils are component mixtures with dissimilar properties. At the time the oil is spilled on the sea surface, it experiences numerous changes on its dissolution process. It is one of the most significant factors in clean-up costs. Light oil types such as diesel and gasoline, do not usually require a clean-up response as they do not stick on the sea surface for a certain time because of their fast evaporation (White & Nichols 1983). On the other hand, heavy oil types such as crude oil have the prospective to expand far away from the spill location causing an extensive pollution of the coastline. Their clean-up procedure is complex and costly especially in coastal waters and sea shores (White & Nichols 1983). As it can be seen from Figure 1a (Appendix), 90% of the total clean-up costs was spend for heavy crude oil spills, in contrast to the clean-up costs of light oil, for both inshore and outshore spills occurred in 1967-2014. There is a significance variation between the type of oil spilled and the clean-up costs. This can be seen from the Braer oil spill accident in 1993 at the Shetland Isles in UK. The vessel ran aground due to the entrance of sea water which had as a consequence the failure of its engine. The ship couldn't be towed out of the sea and as a result 84,500 tons of light oil were released causing a minor contamination as the oil was dispersed naturally (Cedre 2004). Therefore, clean-up costs were very low, approximately $500,000, in relation to the severe weather conditions and to the massive amount of oil spilled (White & Molloy 2003). In contrast, to the Nakhodka tanker, a Russian flag ship which ran aground and broke in two sections in 1997 under severe weather conditions. The vessel transported 19,000 tons of heavy fuel from which 6,240 tons were spilled into the Sea of Japan (Cedre 2000). The ship's bow part ran aground on the coastline, whereas its stern part sank with the rest of the tons 200 km off the shore. The expansion of the oil from the place of the incident has polluted a large swatch of the coastline causing significant economic and environmental damages. Approximately $71,000,000 were the costs of the 6,240 tons of oil spill (Appendix: table 1) (Moller 1997).

The high amount of the clean-up costs of heavy fuel oil is comparative to the quantity spilled and this is proven by the Tanio accident in 1980. Due to a structural failure the ship broke up off the northern coast Finistere in France spilling 6,000 heavy oil into the sea. As a result more than 200 km of the coastline was affected. Also, due to the severe weather conditions the clean-up was difficult to be executed and cost approximately $50,000,000 (Appendix: table 1) (Ganten 1985). A statistical method based on a regression analysis was used in order to test the significance between two variables, clean-up costs and the quantity of oil spilled from 23 oil spill accidents during the period 1967-2014. Regarding oil spilled (tons) the minimum quantity was 20 tons, Luno accident and the maximum was 476,190 tons, Torrey Canyon accident (Appendix: figure 2, table 1) (Cedre 2014). The average oil spill was 90,879.043 tons with a standard deviation of 110,436.90 (Appendix: table 2). As per Histogram (Appendix: Figure 3) it can be seen that 11 oil spill accidents (48%) have resulted from small quantity that is below 60,000 tons. According to the Regression Statistics table (Appendix: table 3), the Pearson's Correlation Coefficient (multiple R) that measures the strength of a linear association between the two variables is 0.34678. This indicates that as 0.34678 is closer to 0 there is no association between the clean-up costs and the quantity of oil spilled. Therefore, no linear relationship exists between these variables. R Squared is the square of the correlation coefficient (multiple r) and represents the percentage of how close the data is to the fitted regression line. A 12% indicates that there is no relationship between the two variables and therefore the clean-up costs does not depend on the quantity of oil spilled. This can be seen in the Scatter Plot (Appendix: figure 4) showing the relationship between the two sets of data. From the plot, it can concluded that the model has not a good fit to the regression line as the 12% is close to 0. Therefore there is a weak correlation between the two variables. According to the Anova testing results (Appendix: table 4), we can compare the alpha (0.05) with the p-value in order to conclude whether the observed data are statistically significant. In our case, the p-value which is the same as the significance F, that is 0.104983288 we can conclude that there is no significant relationship between the clean-up costs and the quantity of oil spilled as the p-value is greater than alpha.

Blank Page

4.2. Statistical Analysis based on Non-Numerical Variables

Despite the statistical way of determining whether there is a significant or no variation between the numerical variables as described above, the non-numerical variables are also important and must be considered in terms of the clean-up costs. Non- numerical variables in our case include the weather conditions, location and type of oil spilled for the 23 accidents (Appendix: Table 1). The oil spill location may have an extensive bearing on accident clean-up costs as it will determine the degree of damage to the economic and environmental resources (White & Molloy 2003). Both heavy and light oil types, if they remain in the ocean for a long time, will be dissolved naturally. The clean-up costs of oil spills from very large crude carriers (VLCC) that are situated far away from the coast may be lower than oil spills located near to the coast (White & Molloy 2003). This is proven by the outcome of the three biggest tanker spills of all time as shown in table 5, the Atlantic Empress in 1979 in West Indies, the Castillo De Bellver in 1983 in South Africa and the ABT Summer in 1991 in Angola. The Atlantic Empress has spilled approximately 145,238 tons of oil as a result of a collision with another vessel. The vessel was on fire, then exploded until it's sank few weeks later. No oil came on shore and no signs of any ecological damage were detected (Joy 2016). The quantity of oil spilled or burned is unknown and the clean-up cost was very low. No impact studies were performed on this case (Horn 1981). The oil spill resulted from the Castillo De Bellver (160,000 tons) and the ABT Summer (57,000 tons) have also resulted in minor clean-up costs and damages as there was no contamination of the coastlines (Cedre 2010). There is no statistical evidence that the offshore oil spills are cheaper than the inshore ones. This is proven by the Sea Empress oil spill incident in 1996 that ran aground at the entrance to Milford Haven Bay and realizing around 73,000 tons of light oil into the sea, in an area of a unique environmental significance for animal life, tourism and natural magnificence (White & Baker 1998). Despite the effective clean-up procedures, there were adverse effects on animal life, fisheries, and tourism and animal life. As a result of the evaporation, natural and chemically induced spreading at sea, only a minimal amount of tons has reached the shore but extended into a large quantity of emulsion over a 200km distance (White & Baker 1998). Clean-up costs were estimated at a total of 35,000,000 USD. The cleaning procedure required in response to a single large oil release may be significant but might be completed in few weeks (White & Baker 1998). Conversely, the same quantity of oil spilled over several months from a broken ship situated nearby to a coast may require an extended clean-up effort, with frequent cleaning of amenity areas with possible adverse effects on fishery and tourism (ITOPF 2014). This is proven by the Torrey Canyon oil spill in 1967 releasing 119,000 tons into the sea at a location off the western coast of Cornwall, in the UK, which is a fishing and a tourist area (CEDRE 2014). A lot of clean-up methods such as 10,000 tons of dispersants, 42 bombs to sink the ship, foam booms, manual removal and 3,000 tons of chalk comprising of stearic acid were used, with a total a cost of approximately 15,000,000 USD. As a result, it took 8 years for the coasts to be cleaned naturally (Appendix: table 1) (ITOPF 2014).

As already noted, at some point oil spills will be dissolved naturally and might not put in danger sensitive shore resources. However, in numerous occasions as illustrated in Table 1, little can be done due to severe weather conditions. People in charge in order to satisfy themselves that they have to do something despite the severe winds and rain storms, they will continue to respond with different ways of clean-up procedures for an extended period of time leading to expensive clean-up costs for little or no benefit at all (White & Molloy 2003).That was the case with the Amoco Cadiz accident which has released 227,000 tons of heavy crude oil into the sea. The remote position of the grounding and rough seas confine the clean-up attempts for the two weeks after the accident (ITOPF 1978). Also, strong winds prevented an effective offshore recovery process, and approximately 3,000 tons of dispersants and some chalk were used. As a result, 122,400,000 USD were spent for the cleaning operations of the accident (Grigalunas et al. 1986). Statistically though, as it can be seen from Figures 1b and 1c (Appendix), the sum of the total clean-up costs for heavy oil released in offshore and inshore locations are much more costly than the sum of the clean-up costs from light oil spilled. Therefore, there is a significant relationship of the location of the accident in regards to the type of the oil spilled into the ocean which then results to the increase of the clean-up costs. There is an exception though as in some cases the severe weather conditions, the location of the oil spilled and the type of oil might be significantly related to the clean-up costs. This was proven by the Odyssey spill accident in 1988 releasing 132,000 tons of light oil into the sea. It sank in heavy weather conditions, located 800 miles off the shoreline of Nova Scotia in the North Atlantic. There were no clean-up attempts as there was no concern for contamination due to the distance from the nearby shoreline (Joye 1988)

According to Chang et.al (2014), when an oil spill accident occurs, its location is said to be one of the most significant forecaster of impact. Spills occurred closer to seashores and human communities have higher financial impacts and are more costly to be cleaned. For example, the 1991 explosion of the ABT summer and the 1979 collision of the Atlantic Empress. Both oil spills were huge catastrophes with more than 250,000 tons of oil leaked into the ocean, however they hadn't any observed consequences on human communities, as they have happened hundreds of kilometers from the shoreline (Chang et.al 2014). Conversely, as per Kontavos et.al (2010), clean-ups of large oil spills located far away from shoreline may cost $300,000 per ton to clean, whereas small inshore spills may cost $29,000 per ton. This was the case in 1979 with Ixtoc I's offshore drilling rig in the Gulf of Mexico which was destroyed by an oil eruption causing a massive blow out, approximately 80km from the coast (Teal and Howarth 1984). The eruption was ceased after 295 days, and an estimation of 476,190 tons of oil spilled into the ocean. The worst scenario is said to be 1,500,000 tons. The extensive use of dispersants, containment booms were used as the oil had reached Texas and Mexican beaches having a total cost of about $1.5M (Teal and Howarth 1984). The quantity of oil spilled and the rate of spillage are also major contributing factors for the consequences of an accident. An increase of 1% in spill size is likely to raise damages by $0.718M (Chang et.al 2014). Spill incidents that leak oil slowly over a period of time, for example in cases oil immovable tankers, might increase the damages by imposing numerous response attempts such as the Prestige oil accident which has a continual releasing of oil for many months causing long-term costs (Loureiro et al. 2005).

Blank Page

Chapter 5

Summary of Results

According to the statistical analysis presented in Chapter 4, there are two ways to measure the clean-up costs of an oil spill. The first one is to compare the clean-up costs with the numerical variables such as the quantity of oil spilled, and the second one to compare the clean-up costs with the non-numerical variables such as weather conditions, location and type of oil spilled.

In order to test the significance or non-significance between the clean-up costs and the quantity of oil spilled, three statistical methods were used. The first method is the Pearson's Correlation Coefficient (multiple r) which proves that there is no association and no significance between the two variables. The result of 0.34678 indicates that there is no linear relationship between these variables as it is closer to zero. The second method is the R-squared which also proves that there is no relationship and no significance between these two variables as a 12% indicates that the clean-up costs do not depend on the quantity of oil spilled. From the scatter plot (Appendix: figure 4) the model has not a good fit to the regression line as the 12% is close to zero. Therefore there is a weak correlation between the two variables. The third method is the Anova Testing which confirms that there is no significant relationship between the two variables as the p-value (0.104983288) is greater than alpha (0.05). From the perspective of the non-numerical variables, there is indeed a significant relationship of the oil spill location, weather conditions, and type of oil spilled into the ocean between the clean-up costs. Specifically, severe weather conditions, offshore oil spills and heavy oil can result to higher clean-up costs. To this extent, there is a high influence of the non-numerical variables in regards to the clean-up costs and companies should consider them before the clean-up operations will be carried out. Even though there is no significance between the quantity and the clean-up costs, a minor amount of spilled oil can result to more expensive clean-up costs and to a massive catastrophe.

Blank Page

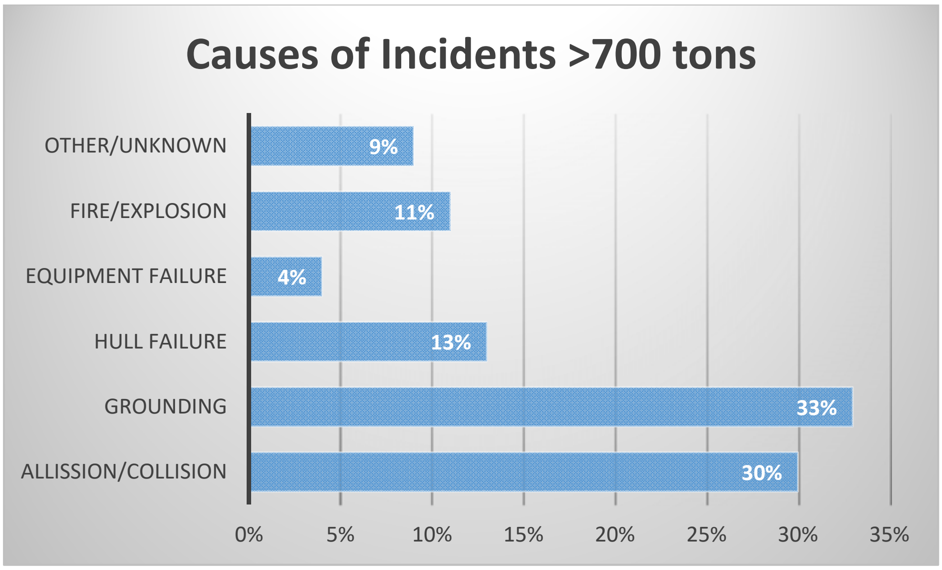
Conclusion

In previous years, oil spill accidents have caused massive environmental, societal and economic issues as there was a low uncertainty of the occurrence of oil accidents. Oil companies, and individuals especially those who were involved within the oil industry were not alarmed, not properly prepared and not informed for oil accidents. No attention was paid to prevent or to be prepare for an oil accident. This was due to the non-existence of regulations, standards and legislation. The continuing occurrence of oil spills and especially those with costly effects have created the need of harmonization between the countries, oil industries and individuals. Risk management process is a necessary tool for the prevention of an oil spill accident. By the adoption of this process, probable risks and threats can be identified at an early stage. This will help the companies to minimize the effects from an oil spill accident or even stop it from happening. Prevention is better than treatment. Nowadays, government and companies have invested a lot to prevent an oil spill by the adoption of regulations, introduction of new technology systems, updated equipment, day to day seminars for the workers, training and drilling procedures. Each ship is being monitored and inspected on a frequent basis as per mandatory legislation procedures. Significant progress on the aftermath of an oil spill accident has been achieved by the introduction of 'updated' techniques for the minimization of oil spill effects. However, clean-up procedures require a further progress especially the clean-up efforts in the ocean. Oil spill responders must find ways to minimize the environmental damage from an oil spill and to promote a faster restoration plan for the polluted areas. Exxon Valdez accident can support this as oil was found in the area 25 years later. Safest clean-up methods must be examined and updated and more efficient and safer methods related to the burning of oil from the sea surface must be introduced. Factors affecting the clean-up efforts such as the weather conditions, location and type of oil must be highly considered before the initiation of a clean-up technique as will result to worst impacts. In windy weather conditions the booms cannot be used as the oil will be spread to other areas. Inadequate clean-up will cause long-term environmental and health impacts especially to those leaving in oil spill areas. Chemical dispersants should be highly considered prior to its usage as this method might be fast to remove the oil but also can be fast to kill the sea populace especially species which are in danger to be disappeared.

Clean-up methods should be re-assessed and re-examined by the scientists and engineers in order to minimize the oil contamination. Up to date technologies must be tested in regards to the response procedures after an oil spill accident. Learning from a disastrous spill event can assist the companies to introduce new oil spill scenarios for the prevention of a similar accident. A cost effective plan should be introduced in order to minimize the clean-up expenses and should be in line with the factors affecting the clean-up costs such as the type of oil, quantity of spilled oil, location of the accident and weather conditions. Even though new regulations have enhanced the marine safety, alterations concerning the safety culture must be introduced in order to avoid oil spill accidents. Prevention costs are much cheaper than response costs. According to EVOSTC (2009) regardless the occurrence of oil spills, complacency will still be the most important threat to the prevention of an oil spill (EVOSTC 2009).

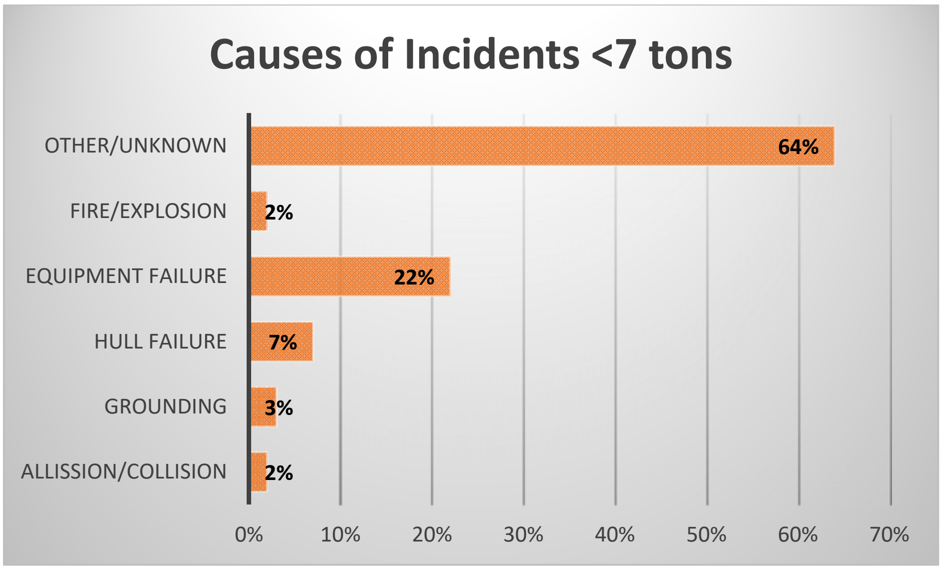
Appendix

Chart 1a: Causes of Incidents of more than 700 tons



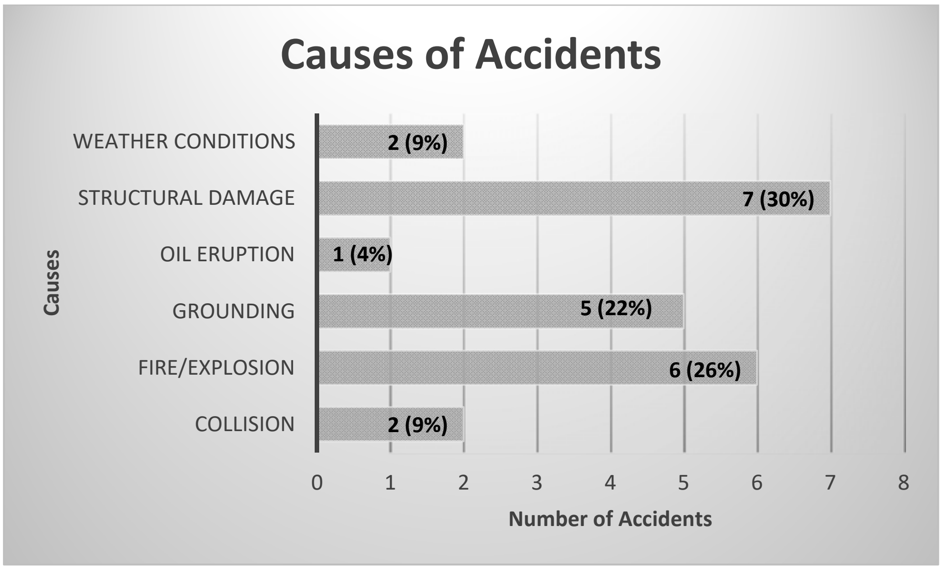
(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Chart 1b: Causes of Incidents of less than 7 tons



(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Chart 1c: Causes and Number of Accidents between 1967-2014



(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Table 1: Statistical Analysis of major oil spill accidents in 1967-2014

Year	Accident Name	Quantity (tons)	Type of Oil	Location	Weather & Sea Conditions	Clean-up Cost (USD)	Cause	Exception
1967	Torrey Canyon	119,000	Light oil	Inshore	Not Severe	15,000,000	Grounding	
1969	Santa Barbara	15,000	Heavy Crude oil	Inshore	Not Severe	25,000,000	Fire/Explosion	
1970	Nakhodka	6,240	Heavy Crude oil	Inshore	Severe	71,000,000	Grounding	
1978	Amoco Cadiz	227,000	Heavy Crude oil	Inshore	Severe	122,400,000	Structural Damage	
1979	Atlantic Empress	145,238	Light oil	Offshore	Not Severe	0	Collision	Unknown Costs-Minor effect
1979	Ixtoc I	476,190	Light oil	Offshore	Not Severe	1,500,000,000	Oil Eruption	
1980	Tanio	6,000	Heavy Crude oil	Offshore	Severe	50,000,000	Structural Damage	
1983	Castillo de Bellver	160,000	Light oil	Offshore	Not Severe	0	Fire/Explosion	Unknown Costs-Minor effect
1988	Odyssey	132,000	Light oil	Offshore	Severe	0	Fire/Explosion	
1989	Exxon Valdez	38,500	Heavy Crude oil	Offshore	Severe	2,500,000,000	Grounding	
1991	Haven	142,860	Heavy Crude oil	Inshore	Not Severe	60,000,000	Fire/Explosion	
1991	ABT Summer	57,000	Heavy Crude oil	Offshore	Not Severe	200,000	Fire/Explosion	
1992	Katina P.	66,700	Light oil	Inshore	Not Severe	4,500,000	Weather Conditions	
1993	Braer	84,500	Light oil	Offshore	Severe	500,000	Grounding	
1996	Sea Empress	73,000	Light oil	Offshore	Severe	37,000,000	Grounding	
1999	Erika	20,000	Heavy Crude oil	Offshore	Severe	122,256,000	Structural Damage	
2002	Prestige	77,000	Heavy Crude oil	Offshore	Severe	100,000,000	Structural Damage	
2006	Solar 1	800	Light oil	Inshore	Severe	12,000,000	Structural Damage	
2007	Hebei Spirit	10,900	Heavy Crude oil	Inshore	Severe	83,000,000	Collision	
2008	Ice Prince	2,000	Heavy Crude oil	Offshore	Severe	0	Structural Damage	Unknown Costs-Minor effect
2009	Pacific Adventurer	270	Heavy Crude oil	Offshore	Severe	25,000,000	Weather Conditions	
2010	Deepwater Horizon	230,000	Heavy Crude oil	Offshore	Severe	11,200,000,000	Fire/Explosion	
2014	Luno	20	Light oil	Inshore	Severe	5,000,000	Structural Damage	

(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Table 2: Analysis of Accidents in respect to Oil Spilled

	Quantity (tons) (x)	(x-mean)^2
Sum	2,090,218.000	2.68319E+11
Count (n)	23	23
Average (mean)	**90,879.043**	-
Variance (s^2)	-	12196309579
Standard Deviation (s)	-	**110,436.90**
Median	66,700.000	-

(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Table 3: Regression Analysis of the Quantity Spilled Vs Clean-up Costs

Regression Statistics	
Multiple R	0.346788656
R Square	12%
Adjusted R Square	0.078370104
Standard Error	106021.1466
Observations	23

(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Table 4: Anova Testing

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	32268656546	32268656546	2.87075342	**0.104983288**
Residual	21	2.3605E+11	11240483533		
Total	22	2.68319E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	79657.11137	23077.77766	3.451680337	0.002389442
Clean-up Cost (USD)	1.61995E-05	9.56101E-06	1.694329785	**0.104983288**

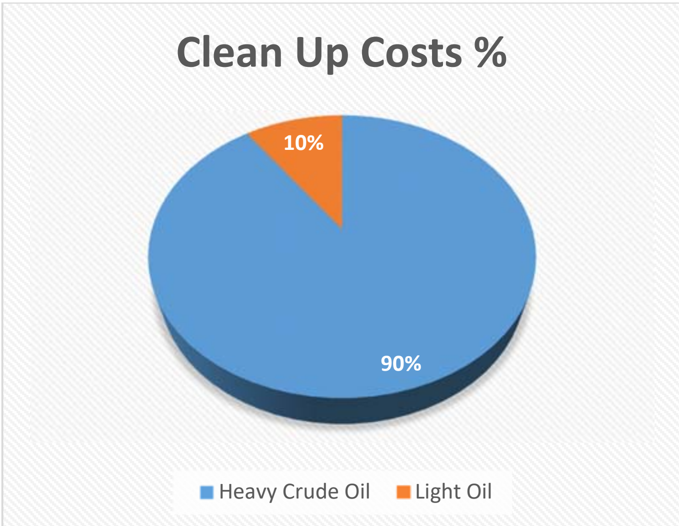
(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Table 5: Four Offshore Oil Spills

Year	Accident Name	Quantity (tons)	Location	Clean-up Cost (USD)	Exception
1979	Atlantic Empress	145,238	Offshore	0	Unknown Costs- Minor effect
1983	Castillo de Bellver	160,000	Offshore	0	Unknown Costs- Minor effect
1991	ABT Summer	57,000	Offshore	200,000	
1996	Sea Empress	73,000	Offshore	37,000,000	

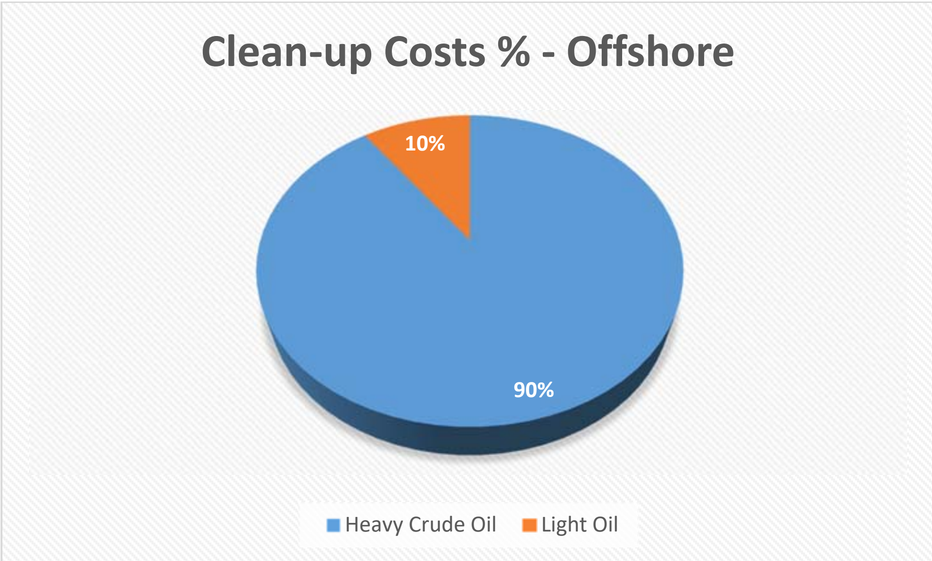
(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Figure 1a: Sum of the Total Clean-up Costs Vs Type of Oil



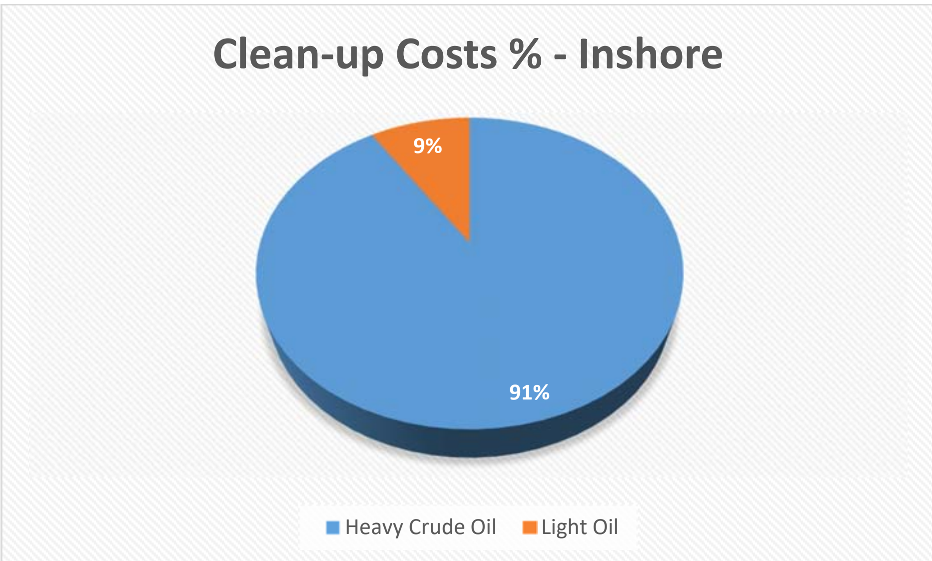
(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Figure 1b: Sum of Total Clean-up Costs for Offshore Spills Vs Type of Oil



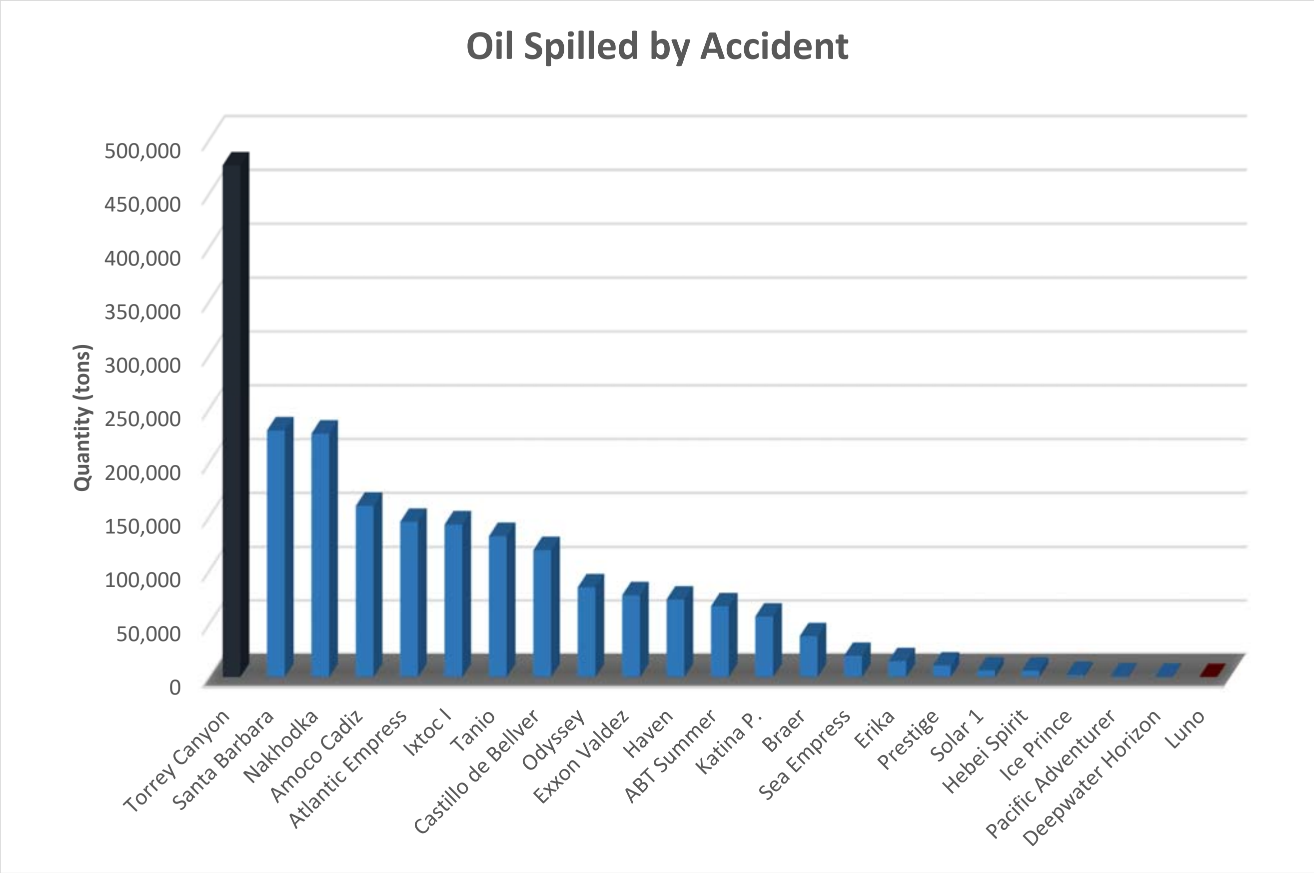
(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Figure 1c: Sum of Total Clean-up Costs for Inshore Spills Vs Type of Oil



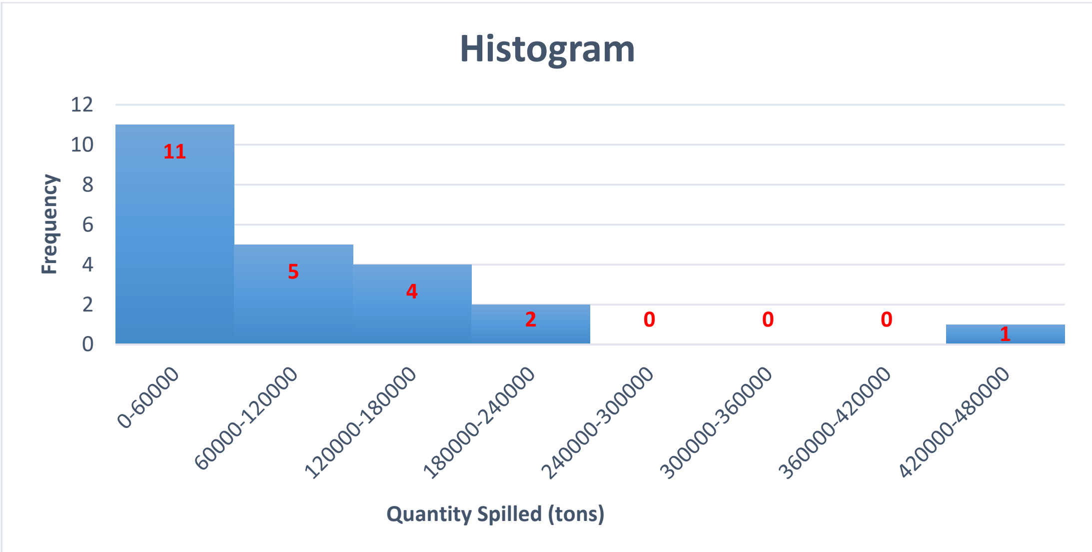
(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Figure 2: Quantity of Oil Spilled by Accident



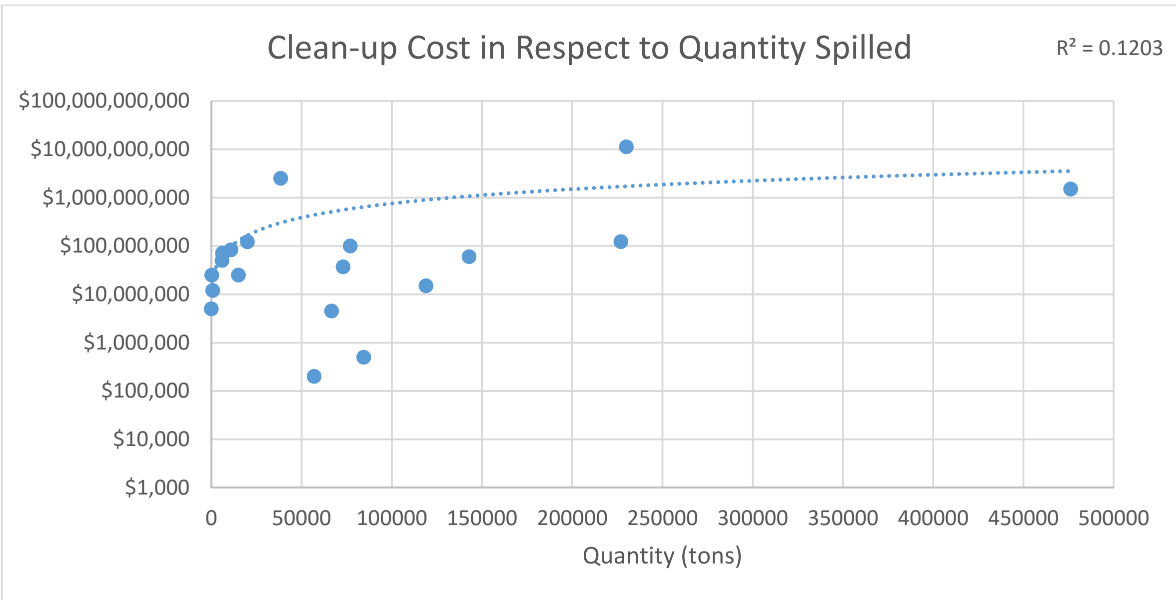
(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Figure 3: Frequency of Oil Spills Vs Quantity Spilled



(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

Figure 4: Scatter Plot- Clean- up Cost Vs Quantity Spilled



(ITOPF 2018, Cedre 2018, NOAA 2018, Joye 2018)

For Figures 1b and 1c a pivot and a summary table was used in Excel:

Sum of Clean-up Cost (USD)	Location		
Type of Oil	**Inshore**	**Offshore**	**Grand Total**
Heavy Crude oil	361,400,000.00	13,997,456,000.00	14,358,856,000.00
Light oil	36,500,000.00	1,537,500,000.00	1,574,000,000.00
Grand Total	**397,900,000.00**	**15,534,956,000.00**	**15,932,856,000.00**

Inshore- Total Clean Up Costs	Total %
Heavy Crude Oil	91%
Light Oil	9%

Offshore- Total Clean Up Costs	Total %
Heavy Crude Oil	90%
Light Oil	10%

For Figures 2 and 3 the following method was used using Excel:

Accident Name	**Quantity (tons) (x)**	**(x-mean)**	**(x-mean)^2**
Torrey Canyon	476,190	385,311	1.48465E+11
Santa Barbara	230,000	139,121	19354640544
Nakhodka	227,000	136,121	18528914804
Amoco Cadiz	160,000	69,121	4777706630
Atlantic Empress	145,238	54,359	2954896154
Ixtoc I	142,860	51,981	2702019841
Tanio	132,000	41,121	1690933065
Castillo de Bellver	119,000	28,121	790788195.7
Odyssey	84,500	-6,379	40692195.7
Exxon Valdez	77,000	-13,879	192627847.9
Haven	73,000	-17,879	319660195.7
ABT Summer	66,700	-24,179	584626143.5
Katina P.	57,000	-33,879	1147789587
Braer	38,500	-52,379	2743564196
Sea Empress	20,000	-70,879	5023838804
Erika	15,000	-75,879	5757629239
Prestige	10,900	-79,979	6396647396
Solar 1	6,240	-84,639	7163767681
Hebei Spirit	6,000	-84,879	7204452022
Ice Prince	2,000	-88,879	7899484370
Pacific Adventurer	800	-90,079	8114234074
Deepwater Horizon	270	-90,609	8209998760
Luno	20	-90,859	8255365782

Sum	2,090,218.000	1.16E-10	2.68319E+11
Count (n)	23	23	23
Average (mean)	**90,879.043**	-	-

Variance (s^2)	-	-	12196309579
Standard Deviation (s)	-	-	**110,436.90**
Median	66,700.000		-

Bins(Quantity)	**Bins quoted for Formula**	**Frequency**	**%**
0-60000	60,000	11	48%
60000-120000	120,000	5	22%
120000-180000	180,000	4	17%
180000-240000	240,000	2	9%
240000-300000	300,000	0	0%
300000-360000	360,000	0	0%
360000-420000	420,000	0	0%
420000-480000	480,000	1	4%

Count	23
Min	20
Max	476,190
Range	476,170
Bin width	60,000
Number of Bins	8

For the Scatter Plot the following method was used using Excel:

Quantity (tons)	Clean-up Cost (USD)
476,190	1,500,000,000
230,000	11,200,000,000
227,000	122,400,000
160,000	0
145,238	0
142,860	60,000,000
132,000	0
119,000	15,000,000
84,500	500,000
77,000	100,000,000
73,000	37,000,000
66,700	4,500,000
57,000	200,000
38,500	2,500,000,000
20,000	122,256,000
15,000	25,000,000
10,900	83,000,000
6,240	71,000,000
6,000	50,000,000
2,000	0
800	12,000,000
270	25,000,000
20	5,000,000

	Quantity (tons)	*Clean-up Cost (USD)*
Quantity (tons)	1	
Clean-up Cost (USD)	0.346788656	1

Correlation	0.34678866
Coefficient Correlation	0.34678866

Blank Page

Reference List

- Alaska Resources Library & Information Services. (1990). Spill: The Wreck of the Exxon Valdez Implications for Safe Transportation of Oil. Alaska Oil Spill Commission Report. USA
- Albaigés, J., Morales-Nin, B., & Vilas, F. (2006). The Prestige oil spill: A scientific response. Marine Pollution Bulletin, 53, 205–207. Elsevier. Spain.
- Alló, M. and Loureiro, M. L. (2013). Estimating a meta-damage regression model for large accidental oil spills. Ecological Economics 86:167-175
- Baars, B. J. (2002). The wreckage of the oil tanker 'Erika' human health risk assessment of beach cleaning, sunbathing and swimming. Toxicol. Lett. 128: 55–68.
- Birkland, T. A. & Lawrence, R.G. (2002). The Social and Political Meaning of the Exxon Valdez
- Blum, M. J., Bernik, B. M., Azwell, T., and Hoek, E. M. V. (2014). Remediation and restoration of northern Gulf of Mexico coastal ecosystems following the Deepwater Horizon event. John Wiley & Sons. 2014; pp 59–88.
- British Petroleum (2010). Deepwater Horizon Accident Investigation Report. UK.
- Burger, J. (1994).Before and After an Oil Spill: The Arthur Kill. USA: Rutgers
- Butler, R., & Fennell, D. (1994). The effects of North Sea oil development on the development of tourism: the case of the Shetland Isles. Tourism Management, 15(5), 347-357.
- Campbell, D., Cox , D., Crum, J., Foster, K., Chrístie, P. and Brewster, D. (1993). Initial effects of the grounding of the tanker Braer on health in Shetland. BMJ 307: 1251–1255.
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). (2018). Retrieved 02/12/ 2017 from http://wwz.cedre.fr/en
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). Exxon Valdez. (2014). Retrieved 15/11/2017 from http://wwz.cedre.fr/en/Resources/Spills/Spills/Exxon-Valdez

- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). Erika. (2012). Retrieved 20/11/2017 from http://wwz.cedre.fr/en/Resources/Spills/Spills/Erika
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). ABT Summer. (2010). Retrieved 01/12/ 2017 from https://wwz.cedre.fr/en/Resources/Spills/Spills/ABT-Summer.
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). Braer. (2004). Retrieved 03/03/2018 from http://wwz.cedre.fr/en/Resources/Spills/Spills/Braer
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). Nakhodka. (2000). Retrieved 03/03/2018 from http://wwz.cedre.fr/en/Resources/Spills/Spills/Nakhodka
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). Luno. (2014). Retrieved 03/03/2018 from http://wwz.cedre.fr/en/Resources/Spills/Spills/Luno
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). Torrey Canyon (2014). Retrieved 03/03/2018 from http://wwz.cedre.fr/en/Resources/Spills/Spills/Torrey-Canyon
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). Castillo De Bellver (2010). Retrieved 04/03/2018 from http://wwz.cedre.fr/en/Resources/Spills/Spills/Castillo-de-Bellver
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). ABT Summer (2010). Retrieved 04/03/2018 from http://wwz.cedre.fr/en/Resources/Spills/Spills/ABT-Summer
- Chang, S. E., Stone, J., Demes, K., and Piscitelli, M. (2014). Consequences of oil spills: a review and framework for informing planning. Ecology and Society 19(2): 26.
- Cheong, S. M. (2011). A social assessment of the Hebei-Spirit oil spill. GeoJournal 76:539-549.
- Choi, H. M., & Cloud, R. M. (1992). Natural sorbents in oil spill cleanup. Environmental Science & Technology, 26(4), 772-776.

- Conan, G., Dunnet, G. M. and Crisp, D. J. 1982. The long-term effects of the Amoco Cadiz oil spill. Philosophical Transactions of the Royal Society B: Biological Sciences 297 (1087):323-333.
- Conroy, J. W. H., Kruuk, H. and Hall, AJ. (1997). The effects of the Braer oil spill on otters and seals in Shetland. In: The Impact of an Oil Spill in Turbulent Waters: The Braer. Proceeding of a Symposium held at the Royal Society of Edinburgh, 7-8 Sept 1995. Davies, J.M., and G. Topping, eds. The Stationery Office, pp. 106-120
- Coombs, W. T. (2007). Crisis management and communication. Institute for Public Relations. USA.
- Covic, I., Simunac, A., Veza, J., Sliskovic, M. & Jelic-Mrcelic, G. (2013). Methods of Pollution Removal after Tanker Erika Accident. Transactions on Maritime Science, 2 (01) (2013), pp. 41-48, Croatia.
- Damage Assessment, Remediation, and Restoration Program (DARRP). Retrieved on 07/04/2018 from https://www.darrp.noaa.gov/
- Devanney, J. (2006). The Tankship Tromedy. The Impending Disasters in Tankers. The CTX Press. Tavernier. Florida.
- EPA (1999) Understanding oil spills and oil spill response. Emergency response. EPA report 540- K-99-007.
- Erikson, D. E. (1995). Surveys of murre colony attendance in the northern Gulf of Alaska following the Exxon Valdez oil spill. Pages 780-819 in P. G. Wells, J. N. Butler, and J. S. Hughes, editors. Exxon Valdez oil spill: fate and effects in Alaskan waters. ASTM Special Technical Publication 1219. American Society for Testing and Materials, Philadelphia, Pennsylvania, USA.
- European Commission (EC) (2001). Two years after the Erika disaster, the European Union is at the forefront of maritime safety. Retrieved 03/01/2018 from http://europa.eu/rapid/press-release_MEMO-01-387_en.htm
- European Commission (EC) (2002). We could have avoided the PRESTIGE oil spill. Retrieved 03/01/2018 from http://europa.eu/rapid/press-release_IP-02-1721_en.htm
- EVOSTC, Exxon Valdez Oil Spill Trustee Council (2009). Legacy of an Oil Spill. 20 Years After the Exxon Valdez. Status Report. Northern Printing, Anchorage, Alaska.

- Faulkner, B. (2001). Towards a framework for tourism disaster management. Tourism management, 22(2), 135-147.
- Faure, M. and Hui, W. (2003). The International Regimes for the Compensation of Oil-Pollution Damage: Are they Effective? Review of European Community and International Environmental Law (RECIEL). 12: 3, 242–253 pp.
- Fay, J.A. (1969). The Spread of Oil Slicks on a Calm Sea. Oil on the Sea. Ocean Technology. Springer. Boston.
- Fearn-Banks, K. (2006). Crisis communications: A casebook approach. Routledge. New York. USA
- Fingas, M. F. (2012). The Basics of Oil Spill Cleanup. Taylor and Francis. New York. USA.
- Ganten, R.H. (1985). The Tanio spill: A case history illustrating the work of the International Oil Pollution Compensation Fund. API Publication. American Petroleum Institute, Washington DC, USA
- Gelin, A., Gravez, V. and Graham, J. E. (2003). Assessment of Jessica oil spill impacts on intertidal invertebrate communities. Mar Pollut Bull 46:1377–1384.
- Graham, L., Hale, C., Maung-Douglass, E., Sempier, S., Swann, L. and Wilson, M. (2016). Oil spill science: The Deepwater Horizon oil spill's impact on people's health. Increases in stress and anxiety. MASGP-16-030.
- Grigalunas, T.A. & Anderson, C.R. & Brown, M.G. & Congar, R. & Meade, F.N. & Sorensen, P.E. (1986). Estimating the Cost of Oil Spills: Lessons from the Amoco Cadiz Incident. Marine Resource Economics 2(3): 239–262.
- Hawkins, S. J., Evans, A. J., Moore, J., Whittington, M., Pack, K., Firth, L. B., Adams, L. C., Moore, P. J., Algar, P. M., Mieszkowska, N., and Southward, E. C. (2017). From the Torrey Canyon to today: A 50 year retrospective of recovery from the oil spill and interaction with climate-driven fluctuations on Cornish rocky shores. International Oil Spill Conference. California. USA.
- Heubeck, M. (1997). The direct effect of the Braer oil spill on seabird populations, and an assessment of the role of the Wildlife Response Centre. In: Davies,J.M.,Topping,G. (Eds.),The Impact of an Oil Spill in Turbulent Waters: The Braer. Proceeding of a

Symposium held at the Royal Society of Edinburgh,7–8 September 1995. The Stationery Office,pp. 73– 90.

- Hiles, A. (2011). The Definitive Handbook of Business Continuity Management (3rd Ed.). John Wiley & Sons, Ltd. Hong Kong. China.
- Hiles, A. (2014). Business continuity Management. Global Best Practices (4th Ed.). Rothstein Publishing. USA
- Horn, S.A. & Neal, P. (1981). The Atlantic Empress Sinking – A Large Spill Without Environmental Disaster. Mobil Oil Corporation. New York.
- Idris, J., Eyu, G. D., Mansor, A. M., Ahmad, Z. & Chukwuekezie, C. S. (2014). A preliminary study of biodegradable waste as sorbent material for oil-spill cleanup. The Scientific World Journal, 638-687.
- International Maritime Organization. (1998). MARPOL - 25 years. Retrieved 03/01/2018 from http://www.imo.org/en/KnowledgeCentre/ReferencesAndArchives/FocusOnIMO(Archives)/Documents/Focus%20on%20IMO%20-%20MARPOL%20%2025%20years%20(October%201998).pdf#search=marpol%2025%20years%20after
- International Maritime Organization. (2018). 1973 International Convention for the Prevention of Pollution from Ships. Retrieved 03/01/2018 from http://www.imo.org/en/OurWork/Environment/PollutionPrevention/OilPollution/Pages/Background.aspx
- International Maritime Organization. (2018). International Convention for the Prevention of Pollution from Ships (MARPOL). Adoption: 1973 (Convention), 1978 (1978 Protocol), 1997 (Protocol - Annex VI); Entry into force: 2 October 1983 (Annexes I and II). Retrieved 03/01/2018 from http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-(marpol).aspx
- International Organization for Standardization (ISO). (2012). Business continuity management systems. Retrieved on 14/04/2018 from https://www.iso.org/obp/ui/#iso:std:iso:22313:ed-1:v1:en

- International Organization for Standardization (ISO). (2018). Risk Management ISO 31000. Retrieved on 14/04/2018 from https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100426.pdf .
- Jaques, T. (2010). Embedding issue management as a strategic element of crisis prevention. Disaster Prevention and Management, 19(4):469-482.
- Jernelov, A. (2010). The threats from oil spills: now, then, and in the future. Ambio 39:353–366.
- Jernelov, A., and Linde´n, O. (1981). The effects of oil pollution on mangroves and fisheries in Ecuador–Colombia.
- Jernelov, A., Linde´n, O. and Rosenblum, I. (1976). The St. Peter Oil Spill—an ecological and socio-economic study of effects. Colombia–Ecuador.
- Jernelov, A., Rosenberg, R. and Hagstro¨m, A. (1975). Ecological aspects of oil pollution. Principles for advice on treatment and methods for quantitative follow-up studies. IVL Publ. B 235.
- Joye, S. (1988). Joye Research Group. Odyssey. Retrieved 04/03/2018 from http://www.joyeresearchgroup.uga.edu/public-outreach/marine-oil-spills/other-spills/odyssey
- Joye, S. (2016). Joye Research Group. Atlantic Empress and Aegean Captain. Retrieved 01/12/2017 from http://www.joyeresearchgroup.uga.edu/public-outreach/marine-oil-spills/other-spills/atlantic-empress-and-aegean-captain.
- Joye, S. (2018). Joye Research Group. Various Oil Spills and Blowouts. Retrieved on 05/12/2017 from http://www.joyeresearchgroup.uga.edu/public-outreach/marine-oil-spills/oil-spills
- Judson, R. S., Martin, M. T., Reif, D. M., Houck, K. A., Knudsen, T. B., Rotroff, D. M., Xia, M., Sakamuru, S., Huang, R., Shinn, P., Austin, C. P., Kavlock, R. J., and Dix. D. J. (2010). Analysis of eight oil spill dispersants using rapid, in vitro tests for endocrine and other biological activity. Environmental Science and Technology 44:5979-5985.
- Kash, T.,J & Darling, J.R. (1998), Crisis management: prevention, diagnosis and intervention, Leadership & Organization Development Journal, Vol. 19 Iss 4 pp. 179–186.

- Ketkar, K. W. (1995). Protection of Marine Resources . The US Oil Pollution Act of 1990 and the Future of the Maritime Industry. Marine Policy. 19:5, 391–400 pp.
- King, R. O. (2010). Deepwater Horizon Oil Spill Disaster: Risk, Recovery, and Insurance Implications. Congressional Research Service 7-5700, Washington D.C., USA.
- Kingston, F. P. (2002). Long-term Environmental Impact of Oil Spills. Spill Science and Technology Bulletin 7: 53–61.
- Knapp, S. and Franses, P. H. (2009). Does ratification matter and do major conventions improve safety and decrease pollution in shipping? Marine Policy. 33:5, 826–846 pp.
- Knowland Group. (2010). The Gulf Coast oil spill and the hospitality industry. McLean. Virginia. USA.
- Kujawinski, E. B., Kido Soule, M.C., Valentine, D. L., Boysen, A. K., Longnecker, K. and Redmond, M. C. (2011). Fate of dispersants associated with the Deepwater Horizon oil spill. Environmental Science and Technology 45:1298-1306.
- Lance, B. K., Irons, D. B., Kendall, S. J., and Mcdonald, L. L. (2001). An evaluation of marine bird population trends following the Exxon Valdez oil spill, Prince William Sound, Alaska. Marine Pollution Bulletin 42:298-309.
- Leacock, E. (2005). Environmental Disasters, The Exxon Valdez Oil Spill. USA: Facts on File, Inc.
- Lerbinger, O. (1997). The crisis manager: Facing risk and responsibility. Lawrence Erlbaum Associates, Inc. New Jersey. USA.
- Levy, J. and Gopalakrishnan, C. (2010). Promoting ecological sustainability and community resilience in the US Gulf Coast after the 2010 deep ocean Horizon Oil spill. J Nat Resource Pol Res 2, 297–315.
- Loureiro, M. L., Ribas, A., López, E. and Ojea, E. (2005). Estimated costs and admissible claims linked to the Prestige oil spill. Ecological Economics 59:48-63.
- Luoma, E. (2009). Oil Spills and Safety Legislation. Publication from the Center for Maritime Studies. University of Turku. Finland.
- Lyons, R., Temple, J., Evans, D., Fone, D. and Palmer, R. (1999). Acute health effects of the Sea Empress oil spill. J. Epidemiol. Commun. Hlth 53: 306–310.

- Matkin, C. O., Saulitis, E. L., Ellis, G. M., Olesiuk, P. and Rice, S. D. (2008). Ongoing population-level impacts on killer whales Orcinus orca following the ‘Exxon Valdez’ oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series 356:269-281.
- McCormick, J. (2015). Five Years and Counting. Gulf Wildlife in the Aftermath of the Deepwater Horizon Disaster. National Wildlife Federation. USA.
- McDowell Group. (1990). An assessment of the impact of the Exxon Valdez oil spill on the Alaska tourism industry. McDowell Group. Juneau. Alaska. USA.
- Mitroff, I., Harrington, K., & Gai, E. (1996).Thinking about the unthinkable. Across the Board, 33(8), pp.44-48
- Moller, T.H. (1997). The Nakhodka Oil Spill Response – The Technical Adviser’s Perspective. The International Tanker Owners Pollution Federation Limited. Japan
- Moore, L. Y., Footitt, A. J., Reynolds, L. M., Postle, M. G., Flyod, P. J., Fenn, T. and Virani, S. (1998). Sea Empress cost-benefit project - final report research and development. Environment Agengy. Bristol, UK.
- Morita, A., Kusaka, Y., Deguchi, Y., Moriuchi, A., Nakanaga, Y., Iki, M., Miyazaki, S. and Kawahara, K. (1999). Acute health problems among the people engaged in the cleanup of the Nakhodka oil spill. Environ. Res. 81: 185–194.
- National Academies of Science (NRC). (2003). Oil in the Sea III: Inputs, Fates, and Effects. National Research Council, p.11.
- National Fish and Wildlife Foundation (NFWF). (2017). Deepwater Horizon Oceanic Fish Restoration Project. Retrieved on 09/04/2018 from http://www.nfwf.org/pll/Pages/home.aspx
- National Oceanic and Atmospheric Administration (NOAA). (2015). Births Down and Deaths Up in Gulf Dolphins Affected by Deepwater Horizon Oil Spill. Retrieved 09/04/2018 from https://response.restoration.noaa.gov/about/media/births-down-and-deaths-gulf-dolphins-affected-deepwater-horizon-oil-spill.html
- National Oceanic and Atmospheric Administration (NOAA). (2017). Deepwater Horizon Oil Spill: Long-term Effects on Marine Mammals, Sea Turtles. Retrieved 31/03/2018 from https://oceanservice.noaa.gov/news/apr17/dwh-protected-species.html

- National Oceanic and Atmospheric Administration (NOAA). (2018). How do Spills happen? Retrieved 18/03/2018 from https://response.restoration.noaa.gov/training-and_education/education-students-and-teachers/how-do-spills-happen.html.
- National Oceanic and Atmospheric Administration (NOAA). (2018). Retrieved 05/12/2017 from http://www.noaa.gov/
- National Oceanic and Atmospheric Administration Fisheries (NOAA). (2016). Cetacean Unusual Mortality Event in Northern Gulf of Mexico (2010-2014). Retrieved on 01/04/2018 from: http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm
- National Oceanic and Atmospheric Administration Fisheries (NOAA). (2018). Lingering Oil from Exxon Valdez Spill. Retrieved on 10/04/2018 from https://www.fisheries.noaa.gov/feature-story/lingering-oil-exxon-valdez-spill
- National Oceanic and Atmospheric Administration Fisheries (NOAA). (2016). Cetacean Unusual Mortality Event in Northern Gulf of Mexico Investigation Results. Retrieved on 09/04/2018 from http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico_results.html
- National Oceanic and Atmospheric Administration Fisheries (NOAA). (2018). Oil Spill Assessment and Restoration. Retrieved 07/04/2018 from https://response.restoration.noaa.gov/environmental-restoration/oil-spill-assessment-and-restoration.html
- National Research Council. (1985). Steering Committee for the Petroleum in the Marine Environment Update, Board on Ocean Science and Police, Ocean Sciences Board, Commission on Physical Sciences, Mathematics, and Resources. Oil in the Sea: Inputs, Fates, and Effects. National Academy Press. Washington. DC
- Onwurah, I. N., Ogugua, V. N., Onyike, N. B., Ochonogor, A. E., & Otitoju, O.F. (2007). Crude oil spills in the environment, effects and some innovative clean-up biotechnologies. International Journal of Environmental Research, 1(4), 307-320.
- OSIR. (2009). European Union Toughens Up Maritime Safety Rules. Oil Spill Intelligence Report. 32:18, 3–4 pp.

- Othumpangat, S., & Castranova, V. (2014). Oil spills. In Encyclopedia of Toxicology (p. 678-681). Elsevier. Washington.
- Oxford Economics. (2010). Potential impact of the Gulf oil spill on tourism. Oxford Economics. London. UK.
- Paine, R. T., Ruesink, J. L., Sun, A., Soulanille, E. L., Wonham, M. J., Harley, C. D. G., Brumbaugh, D. R., and Secord, D. L. (1996). Trouble on oiled waters: lessons from the Exxon Valdez oil spill. Annual Review of Ecology and Systematics 27:197-235.
- Palinkas, A. L. (2012) A Conceptual Framework for Understanding the Mental Health Impacts of Oil Spills: Lessons from the Exxon Valdez Oil Spill. Research Gate Publications. USA
- Palinkas, L. A., Downs, M. A., Petterson, J. S. and Russell, J. (1993). Social, cultural, and psychological impacts of the Exxon Valdez oil spill. Human Organization 52:1-13.
- Pallardy, R. (2017). Deepwater Horizon oil spill of 2010. ENVIRONMENTAL DISASTER, GULF OF MEXICO Encyclopaedia Britannica, Inc. UK.
- Paraskevas, A. (2006). Crisis management or crisis response system? A complexity science approach to organizational crises. Emerald Insight. Vol. 44 Iss 7 pp. 892 - 907
- Paris MoU. (2007). Port State Control on Course for safer shipping. Retrieved 05/01/2018 from https://www.parismou.org/sites/default/files/Annual%20report%202007.pdf .
- Paris MoU. (2018). A short history of the Paris MoU on PSC. Retrieved 05/01/2018 from https://www.parismou.org/about-us/history
- Pauchant, T. C., & Mitroff, I. I. (1992). Transforming the crisis-prone organization: Preventing individual, organizational, and environmental tragedies. Jossey-Bass. San Francisco. USA.
- Pauly, J,J. & Hutchison, L,L. (2005). Moral Fables of Public Relations Practice: The Tylenol and Exxon Valdez Cases. Journal of Mass Media Ethics. 20(4): pp.231-249.
- Pegau, W. S. (2014). 25 years after the Exxon Valdez, where are the herring? Science, 343, 1416.
- Peterson, C. H., Rice, S. D., Short, J. W., Esler, D., Bodkin, J. L., Ballachey, B. E., and Irons, D. B. (2003). Long-term ecosystem response to the Exxon Valdez oil spill. Science 302

(5653):2082-2086. Journal of Hazardous Materials. 86:1–3, 121–133 pp. Elsevier. Canada.

- Picou, J. S., Formichella, C., Marshall, B. K. and Arata, C. (2009). Community impacts of the Exxon Valdez oil spill: A synthesis and elaboration of social science research. Synthesis: Three decades of research on socioeconomic effects related to offshore petroleum development in coastal Alaska pp.279-310.
- Picou, J. S., Marshall, B. K. and Gill, D. A. (2004). Disaster, litigation, and the corrosive community. Social Forces 82:1493-1522.
- Punzón, A., Trujillo, V., Castro, J., Perez, N., Bellido, J. M., Abad, E., Villamor, B., Abaunza, P. and Velasco, F. (2009). Closed area management taken after the 'Prestige' oil spill: effects on industrial fisheries. Marine Biodiversity Records 2(2009):e75.
- Ramseur, J. L. (2010). Oil spills in U.S. coastal waters: background, governance and issue for congress. Congressional Research Service 7-5700, Washington D.C., USA.
- Rodin, M., Downs, M. A., Petterson, J. S. and Russell, J. (1992). Community impacts resulting from the Exxon Valdez oil spill. Organization and Environment 6(3):219-234.
- Rung, A. L., Oral, E., Fontham, E., Harrington, D. J., Trapido, E. J., & Peters, E. S. (2015). Mental health impact of the Deepwater Horizon oil spill among wives of clean-up workers. Epidemiology, 26(4), e44-e46.
- Russell, J. C., Downs, M. A., Strick, B. R. and Galginaitis, M. S. (2001). Exxon Valdez oil spill, cleanup, and litigation: A collection of social-impacts information and analysis. Final Report, 1.
- Sabucedo, J. M., Arce, C., Ferraces, M. J., Merino, H. and Durán, M. (2009). Psychological impact of the Prestige catastrophe. International Journal of Clinical Health and Psychology 9:105-116.
- Sage, B. (2004). Identification of "High Risk Vessels" in coastal waters. Marine Policy. 29:4, 349–355 pp. Elsevier. Ireland.
- Scanlon, J. (2001). Increasingly intolerable boundaries: future control of environmental
- Simpson, A. C. (1968). The Torrey Canyon Disaster and fisheries. Fisheries Laboratory. Essex. UK

- Spill Prevention, Control and Countermeasure. (2014). Environmental Protection Agency. Retrieved on 20/03/2018 from http://www.epa.gov
- Steiner, R. (2014). Lessons from Exxon Valdez, 25 years later. USA. Retrieved on 13/03/2018 from http://www.greenpeace.org/usa/lessons-from-exxon-valdez-25-years-later/
- Stopford, M. (2008). Maritime Economics, 3rd edition, 300 pp. Routledge, New York.
- Teal, J.M. and Howarth, R.W. (1984). Oil Spill Studies: A Review of Ecological Effects. Springer-Verlag. Environmental Management 8: 27.
- Tejedor, A. & Spinosa, L. (2004). Oil Spill Prevention and Response: The U.S. Institutional System in the Coast of California. Friends of Thoreau. Madrid
- The International Tanker Owners Pollution Federation Limited (ITOPF). (2018). Retrieved on 01/12/2017 from http://www.itopf.com/
- The International Tanker Owners Pollution Federation Limited. (1978) AMOCO CADIZ, France, 1978. Retrieved on 01/12/2017 from http://www.itopf.com/in-action/case-studies/case-study/amoco-cadiz-france-1978/.
- The International Tanker Owners Pollution Federation Limited. (1993). Braer, UK, 1993. Retrieved on 18/03/2018 from http://www.itopf.com/in-action/case-studies/case-study/braer-uk-1993/ .
- The International Tanker Owners Pollution Federation Limited. (2014). TORREY CANYON, United Kingdom, 1967. Retrieved on 20/11/2017 from http://www.itopf.com/in-action/case-studies/case-study/torrey-canyon-united-kingdom-1967/
- The International Tanker Owners Pollution Federation Limited. (2014). ATLANTIC EMPRESS, West Indies, 1979. Retrieved on 01/11/2017 from http://www.itopf.com/in-action/case-studies/case-study/atlantic-empress-west-indies-1979/.
- The International Tanker Owners Pollution Federation Limited. (2014).ABT SUMMER, off Angola, 1991. Retrieved on 01/11/2017 from http://www.itopf.com/in-action/case-studies/case-study/abt-summer-off-angola-1991/ .

- The International Tanker Owners Pollution Federation Limited. (2016) Oil Tanker Spill Statistics 2017 Revised. Retrieved on 25/11/2017 from http://www.itopf.com/knowledge-resources/data-statistics/statistics/
- Thebeau, L. C., Tunnell, J. W., Dokkenm Jr. Q. R., and Kindinger, M. E. (1981). Effects of the Ixtoc I spill on the intertidal and subtidal infaunal populations along lower Texas coast barrier island beaches. Pp. 467-475 in Proceedings of the 1981 Oil Spill Conference. American Petroleum Institute. Publ. No. 4334.
- U.S. Department of Commerce. (1983). Assessing the social costs of oil spills: the Amoco Cadiz case study. U.S. Department of Commerce. Washington. USA.
- U.S. Fish and Wildlife Service (2011). Deepwater Horizon response consolidated fish and wildlife collection report. Retrieved on 31/03/2018 from https://www.fws.gov/southeast/articles/deepwater-horizon-oil-spill-killed-as-many-as-102000-birds-across-93-species/
- United States Environmental Protection Agency. (2017). EPA's Role in Emergency Response. Retrieved on 05/01/2018 from https://www.epa.gov/emergency-response/epas-role-emergency-response
- United States Environmental Protection Agency. (2017). National Response Team. Retrieved 05/01/2018 from https://www.epa.gov/emergency-response/national-response-team
- United States Environmental Protection Agency. (2017). National Response Team (NRT) Member Roles and Responsibilities. Retrieved on 05/01/2018 from https://www.epa.gov/emergency-response/national-response-team-nrt-member-roles-and-responsibilities
- Venn-Watson, S. et al. (2015). Adrenal gland and lung lesions in Gulf of Mexico common bottlenose dolphins (Tursiops truncatus) found dead following the Deepwater Horizon oil spill. PLoS One,10(5), e0126538.
- Wadsworth, T. (1999). Country Profiles: A Summary of Oil Spill Response Arrangements and Resources Worldwide, Paper presented at The International Oil Spill Conference 1999, Seattle, USA.

- Walther III, H. R. (2014). Clean Up Techniques Used for Coastal Oil Spills: An Analysis of Spills Occurring in Santa Barbara, California, Prince William Sound, Alaska, the Sea Of Japan, and the Gulf Coast. Master's Projects and Capstones. 104. USA.
- Watters, J. & Watters, J. (2014). Disaster Recovery, Crisis Response, and Business Continuity. A Management Desk Reference. Apress. USA.
- Webler, T. and Lord, F. (2010). Planning for the human dimensions of oil spills and spill response. Environmental Management 45:723-738.
- White, C.I. & Baker, M.J. (1998). The Sea Empress Oil Spill in Context. The International Tanker Owners Pollution Federation Limited. Wales.
- White, I.C. & Molloy, F.C. (2003). Factors affecting the cost of oil spills. The International Tanker Owners Pollution Federation Limited. UK.
- White, I.C. & Nichols, J.A. (1983). The Cost of Oil Spills. The International Tanker Owners Pollution Federation Limited. UK
- Wiens, J.A., 1995. Recovery of seabirds following the Exxon Valdez oil spill: an overview. In: Wells,P.G.,Butler,N.,Hughes,S. (Eds.), Exxon Valdez oil spill: fate and effects in Alaskan waters. American Society for Testing and Materials, Philadelphia, PA, pp. 854–893.
- Wilson, C. V. (1973). The Impact of the Torrey Canyon disaster on technology and national and international efforts to deal with supertanker generated oil pollution: an impetus for change? ProQuest LLC. USA.
- World Wildlife Fund. (WWF). (2009). Lessons Not Learned: 20 Years After the Exxon Valdez Disaster. Little Has Changed in How We Respond to Oil Spills in the Arctic. Exxon Valdez Trustees Council. US.