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An Analysis of Maritime Accidents Involving Oil Tankers from a Structural Point of View

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Abstract.

The international tanker owners pollution federation (ITOPF) is an international organization offering technical consultancy and information regarding pollution prevention and spillage prevention effect on the marine environment. ITOPF maintains a data base including oil spillages causes by oil tankers. It includes information regarding accidental spillage except those which result from acts of war. The data base includes information related to spillages starting from 1970.
Our analysis intends to include the type of oil products spilled, the quantity, the cause and place of the incident as well as information related to the ships involved. For historical reasons, spillages are officially classified according to the quantities spilled: quantities lower than 7 t, between 7-700 t and over 700 t. According to the data registered until now, it was determined that out of almost 10.000 incidents, the great majority as in 81% of them are in the first category. Our paper intends to analyse information collected from public sources, such as media publications in the maritime transport field and different specialized publication as well as information given by owners and insurers.

1. Introduction

Public information generally refer to large spillages, usually resulted from collisions and groundings leading to damage of the ship's hull, fires and explosions, while most of the individual reports refer to low operational spillages. We intend to emphasise that statistics include the entire quantity of spillage resulted from an incident and the unfavourable products for the environment, including those which burnt or remained inside the tanks of wrecks. In this paper, we intend to present a brief history of the most important spills of oil. According to a general analysis of the worst oil products spillages the largest ones were produced between 1970 and 2007, out of which 95% occurred in the years 1970, 1980 and 1990, and only 5% took place after 2000. Many of these incidents, despite their large size, caused minor damage on the environment.

Fig. 1 Location of the most important oil products' spillages [ITOPF Oil Tanker Spill Statistics, 2012]

2. Numerical and quantitative statistics of oil spills

The incidence of large oil tankers is relatively low and a detailed analysis statistics is rarely possible, therefore the percentage is used to identify trends. Statistics show that the number of large spills produced by incidents has decreased over the years. The average number of major discharges for the 2000-2009 is about one eighth of the average of the 1970s, so 55% of the major oil spills occurred in the 1970s, with the percentage dropping to 7% for the 2000 period. No large spills were recorded in 2012 but there were recorded 7 average spills. Although the number of average spills is higher than in 2010 and 2011, however, it is well below the average of the last decades.

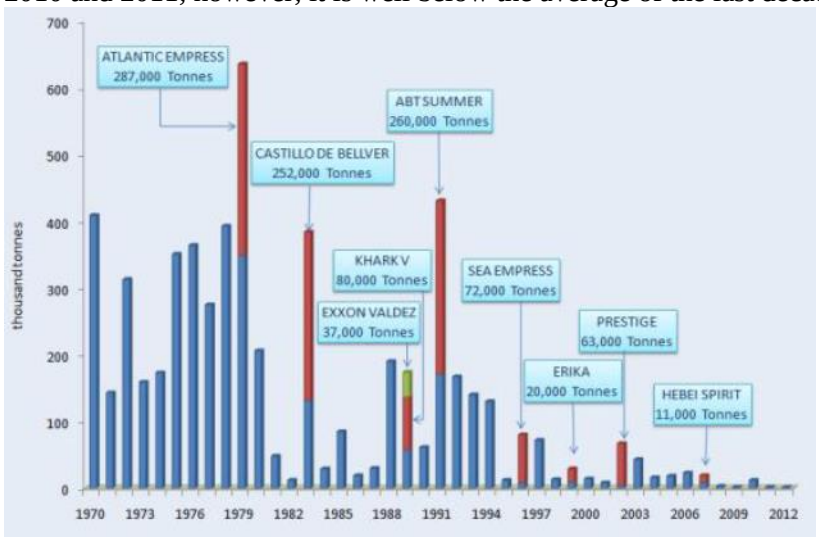

Fig. 2 Major oil product spillages quantities between 1970-2012 [ITOPF Oil Tanker Spill Statistics, 2012]

The two figures show that a small number of major spills covers a large quantity of spilled oil products. Thus, in 1990, there was a number of 360 major spills, which determined a quantity of 1,135,000 tons of spilled products of which only 10 incidents accounted for 73% of the total spillages. In the year 2000, there were 182 major spills, resulting in 212,000 tons out of which only 4 incidents accounted for 54% of total discharges.

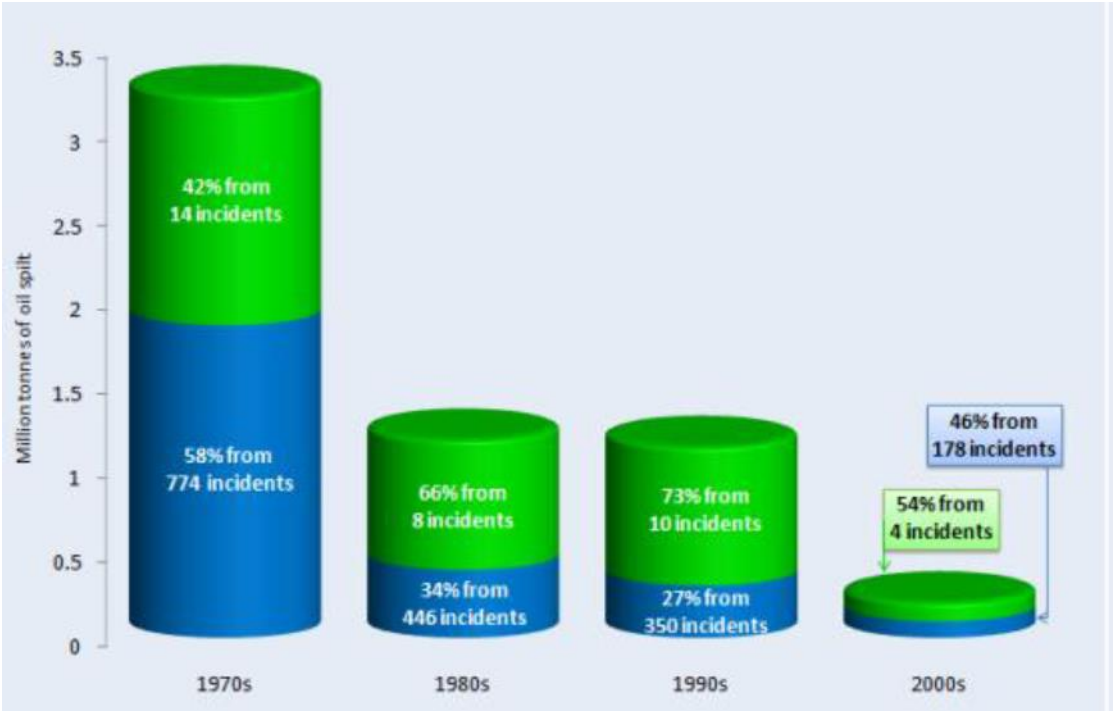

Fig. 3 Major spillages over decades [ITOPF Oil Tanker Spill Statistics, 2012]

3. Major accidents of oil tankers

Torrey Canyon – 1967

On March 18, 1967, due to a nautical error, the Torrey Canyon ran aground on the Pollard's Rock, part of the Seven Stones reef located between the Scilly Islands and the United Kingdom. This was the first major oil spill. A procedure that highlights the way to approach and combat of a spillage near the coast had been promulgated by local authorities a few years before the accident but it seems that it was omitted, and consequently it has been reported that no action plans have been implemented in time against such a catastrophe. The oil tanker in question had been built to be able to deliver cargo anywhere in the world and therefore she had on board only small-scale navigation maps, and the navigation equipment which was still used was the LORAN system instead of Decca Navigator that would have been a more accurate system.

When a risk of colliding with a small fleet of fishing vessels appeared, it produced confusion between the Master and the helmsman, who was actually a cook and had little experience as a helmsman. Thus, the helmsman at the time of the collision did not know for sure whether the ship was on manual or automatic mode. Until this problem has been resolved it was already too late. Repeated attempts to refloat the ship have been done without success, and one member of the Dutch rescue team lost his life. The ship got dismembered after running aground for a few days on the reef and she was finally bombarded by a plane. Attempts to limit the oil spill were ineffective because the barriers used were made of foam and therefore very fragile and inadequate to adverse weather conditions.

About 50 miles (80 km) of coastline belonging to France and 120 miles (190 km) of coastline belonging to the UK were contaminated with oil. It has been estimated that 15,000 aquatic birds and a huge number of marine life were killed, before the oil stain, which covered an area of 270 square miles (700 km2) dispersed. Major damage was also caused by the massive use of the so-called detergent used to disperse the stain. This detergent was the first choice of products used to clean the surfaces in the Engine Room, and did not take into account the toxicity of their components. 42 ships have scattered more than 10,000 tons of dispersants over the oil floating on the surface of the water as well over what was already gathered on the beaches.

In Cornwall (UK), these dispersants were misused; sometimes 45-gallon barrels were emptied from the top of the cliffs to cover hard-to-reach areas. On the beach of Sennen Cove, crude oil and

dispersing agents were buried with bulldozers in the sand, so even after one year there could still be oil under the sand. Compensations have been requested both by the Government of the United Kingdom and by the French Government and these were the greatest damages ever granted. This disaster has led to many changes in international regulations towards the Civil Liability Convention (CLC) of 1969 and the International Convention for the Prevention of Marine Pollution in 1973.

Amoco Cadiz – 1978

Amoco Cadiz oil tanker was off the coast of Brittany, France, on 16 March 1978 following a failure of the steering gear. Within two weeks, the entire quantity of cargo on board, of 223,000 t of crude oil and 4,000 tons of heavy fuel have been spilled into the water due to a heavy storm. Much of the cargo formed a water and oil emulsion that increased the volume of the pollutant by up to 5 times.

By the end of April the pollutant contaminated 320 km of the cost of Brittany province and it was expanded to the Channel Islands. Strong winds and agitated sea prevented any attempt to intervene on the spill. Less than 3,000 t of dispersants were used. Calcium carbonate was used to sink some of the spilled material but with consequences on the environment, as part of the pollutant was transferred to the bottom of the sea. Interventions at sea have not prevented coastal line pollution. A large variety of shore types have been affected, including sandy beaches, rocky shores or those covered with pebbles, rocks, dikes, docks, mud or muddy beach areas. The removal of crude oil on the shore proved to be difficult because it was mixed with marine herbs, algae or garbage.

A successful operation was the use of agricultural units with a vacuum or vacuum trucks, but the vast majority of crude oil was removed manually by over 7,000 people (mostly military). Some of the oil that reached the shore was buried in sediment in small and marshy depths. At the time, the incident caused the greatest loss of marine life until then. Two weeks after the accident, millions of molluscs, sea urchins and other living creatures living on the bottom of the sea were found on the banks. Although some populations of echinoderms and small crustaceans have almost disappeared from certain areas, many species have recovered within a year. Birds that sink in search of food constituted most of the 20,000 dead birds. The oyster cultures in the estuary were seriously affected and it is estimated that 9,000 tonnes have been destroyed due to contamination. In the same way, fish and other crustaceans in the area, as well as tourism were affected.

Cleaning activities in rocky areas such as pressure washes, or the removal of sediments in marshland had serious consequences. While the rocky areas have recovered biologically rapidly in the marshland the process was long. The fact that the pollutant had not been removed from some areas before the tide arrived has resulted in a greater stretch of contamination. Following this incident, many conclusions resulted about how to clean pollutants and their impact, and the ship's failure remains one of the most studied catastrophes in the history of marine spills.

Atlantic Empress and Aegean Captain – 1979

On July 19, 1979, at 19.00, two Very Large Crude Carriers, Atlantic Empress (carrying 276,000 t of crude oil) and Aegean Captain (carrying 200,000 tons of crude oil) collided in the Caribbean, off the Tobago Island. The Atlantic Empress and the bow of the Aegean Captain were in flames. 26 sailors were killed.

The crew of the Aegean Captain managed to keep the on-board fire under control. The ship was towed the following days to Trinidad and then to Curacao, losing small quantities of oil on the road, which were sprayed with dispersants by a tug. In Curacao, cargo was shifted to other ships. The Atlantic Empress, still in flame, was towed off the coast, surrounded by fire-extinguishing ships and an oil stain on the sea surface that was partly in flames. A large-scale operation took place for extinguishing the fire as well as for the treatment of the pollutant with dispersants.

However, despite the efforts made on 23 and 24 July, the ship was rocked by several explosions. On 29 July there was a stronger explosion, which caused the fire to grow in intensity. On August 2, the ship began to list and to lose cargo faster and faster. What remained of the Atlantic Empress continued to burn strongly in the midst of a flamboyant oil smear and disappeared surrounded by smoke. On the morning of August 3, only a spot of oil was visible on the surface of the water. The largest ship ever sunk disappeared after 15 days of agony. The remaining oil disappeared until August 9 and did not reach the shore.

This crash holds the record for the largest oil spill ever recorded, about 280,000 tons. One will never know what percentage of that amount burned and how much it was lost in the sea. The neighbouring islands have not been polluted. There has been no study on the effects of the spill either by the surrounding countries or by the international community. Moreover, at that time, everyone was careful about what happened in another disaster, the explosion of the Ixtoc I platform in the Gulf of Mexico.

Exxon Valdez – 1989

Exxon Valdez failed on the Bligh reef in Prince William Strait, in Alaska, on March 24, 1989. 37,000 tons of oil was discharged and spread over a very large area. Dispersing spraying was fairly small, and there were attempts to burn the oil stain, but at sea the actions taken focused on recovering crude oil and preventing it from expanding.

Fig. 4 Exxon Valdez (http://www.earthlyissues.com/exxon.htm)

Despite the fact that a large number of ships, floating barriers and other equipment were used, less than 10% of the original volume of oil was recovered from the surface of the water. The pollutant therefore affected a diverse range of shores, mainly rocky or rocky shores, for an estimated distance of 1800 km in the Prince William Strait and along the southern coast of Alaska to Kodiak Island. The spill has attracted enormous attention from the media because it was the highest ever in US waters (though modest compared to other international disasters). Moreover, it has drawn attention to the fact that it has happened in a particularly beautiful wild area, with important fishery resources and wild animals such as the sea otter or the bald eagle.

Therefore, the actions taken were among the most expensive in the history of accidents with spills, with over 10,000 workers involved in cleaning operations. Costs amounted to more than $ 2 trillion in just the first year. Coastal cleansing actions included washing with water under pressure or hot water, actions that took place on a scale not seen before or since then until today. This has had a substantial impact on the regeneration of fauna and flora populations and has delayed, in some cases, their restoration. Oil residues have remained blocked in sediments in some areas, and some scientists are still questioning evidence of long-term damage to fish and wildlife populations.

Erika – 1999

The Maltese oil tanker Erika, carrying 31,000 tons of heavy fuel oil, broke into two during a storm in the Bay of Biscay on December 11, 1999, 60 miles off the coast of Brittany, France. Approximately 20,000 tons of fuel was discharged into the sea. The ship's bow sank on December 12, and its stern the next day. The French Naval Department based in Brest has taken command of sea-breaking operations in accordance with the French National Intervention Plan. Intervention ships were sent to the site on December 14, but attempts to recover spilled fuel were thwarted by bad weather and widespread fragmentation of the pollutant stain. Within 15 days, 1,100 t of pollutant was collected. The largest amount was collected during a 24-hour lull, when the sea was relatively calm and low hula. It has been

estimated that less than 3 per cent of the total discharged was recovered during the sea surface collection operation.

Fig. 5 Erika (http://www.wrecksite.eu/wreck.aspx?31185)

Due to the influence of strong currents and winds, the coastline was not polluted as quickly as expected, nor in the areas where it was predicted. The stain advanced first to the southeast, La Rochelle, then headed north, and finally the fuel spill reached the area of the Loara on December 25, 1999.

The coast was polluted over 400 km between Finistere and Charente-Maritime. Due to the long time it floated, a large part of the spilled fuel formed an emulsion with water, which resulted in increased volume and viscosity. Coastal pollution was restricted to that zone. The most contaminated area was located in the Loire Atlantique, the northern area of Vendee and the islands offshore, especially the Belle Ile Island. These areas required many resources to clean the shore first, and then continued with a secondary cleaning that proved to be difficult and long lasting. Some areas were only slightly polluted (eg parts of Finistère and Morbihan) and required only minor cleaning operations.

During the cleaning operation, more than 250,000 tonnes of pollutant were collected and stored temporarily. Temporary storage areas were set up in car parks or plains adjacent to beaches, by building dams or digging pits and lining them with plastic foil. The fuel pumping operation remaining in the sunken sections of the ship began with the improvement of weather conditions in June 2000, and was completed in the next 3 months. 10,000 t of fuel was recovered during the pumping operation and 1,200 t after the on-site cleaning operation. The magnitude of the spill and the length of the coast affected by the spill resulted in a large number of claims for compensation from those affected. In the southern area of the Brittany and Vendee provinces there important fishing areas, mussels and oysters and tourist resources. Salt production areas were also affected by the spill.

Prestige – 2002

In the afternoon of Wednesday, November 13, 2002, the Prestige oil tanker (81,564 tdw), carrying a 77,000 t load of heavy fuel on board, suffered a hull damage in adverse weather conditions north of Spain. The ship listed and floated to the coast. Finally, it was towed by rescue tugs. The ship was denied access to the sheltered coastal areas, both in Spain and Portugal, so it had to be towed off the Atlantic Ocean. Although the rescuers have made considerable efforts to avoid stressing the hull of the ship, it broke in two on the morning of November 19, 170 miles west of Vigo, and the two halves sank several hours later in deep water up to two miles. In total, it was estimated that about 63,000 tons had elapsed from cargo tanks.

Due to the fact that the cargo was of a very persistent nature, the spilled fuel floated for long periods of time, carried by oceanic winds and currents, over long distances. The first polluted shore was in the Galician area, where the predominantly rocky coastal area was severely contaminated. In the

following weeks, fuel stains continued to float and pollute shores from the northern coast of Spain, continuing with the Atlantic coast of France and reaching Brittany. A slight pollution was also recorded on the French and English Channel. Although pollutant spots have reached the Portuguese waters, there has been no pollution of their shores. With the recovery operation commenced off the coast of Spain, 50,000 tons of water-fuel mixture was recovered. However, even though a 20 km floating barrier was stretched, it could not prevent contamination of the shoreline. A total of approximately 1,900 km of coastline was affected by the spills produced. The Spanish shores were manually cleaned by a team of 5,000 soldiers, local staff and volunteers.
The process was slow, especially in rocky areas where access was difficult. Another problem has been shown to be the contamination of the areas already cleaned by the still floating spots. In total, about 141,000 tons of waste were collected in Spain and 18,300 tons in France. Fishing ban areas have been established in Galicia shortly after the accident, prohibiting fishing on about 90% of the coastline. The ban was withdrawn in late October 2003. The impact on French fishing areas was lower. Both countries have suffered a major impact on tourism in 2003. The Spanish authorities have decided to remove all the fuel remaining in the wreckage. The works began in May 2004 and ended in September 2004, and cost around 100 million euros.

4. Conclusions

The causes and circumstances of oil spills are varied, but they can have a significant effect on the amount discharged. The analysis below studies the incidence of spills of different dimensions in terms of vessel operation and manoeuvres as well as the cause of the discharges. The main causes are considered to be collisions, groundings, malfunctions, ship's hull, shipboard equipment failures, fires and explosions, adverse weather conditions or human factor.
When it comes to operating the ship, one of the most important causes for minor or average spills are charging / discharging operations taking place in ports or petroleum terminals, so for minor discharges we have 40%, and for average ones 29%. Much of the spills are due to other operations like ballasting / deballasting, tanks' cleaning or operations but there are also some unknown causes, so 17% minor detours are due to others operations, and 36% have unknown causes. In the case of medium spills, 11% have other causes, and 58% have unknown causes.

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