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RESEARCH ARTICLE

Oil spill modeling of the M/T STI Pimlico and M/V Celestyal Crystal accident on Çanakkale Strait

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ABSTRACT

Turkish Sea Area is the most important waterway because of its geographical position. According to 2022 statistics of strait passage, 9904 tanker vessels passed through the Strait of Çanakkale. This statistical value shows that the Strait of Çanakkale is at risk due to the tanker vessels' passage. On June 27, 2015, the Celestyal Crystal cruise ship and the STI Pimlico tanker ship collided in the Çanakkale Traffic Separation Scheme, approximately 0.7 nautical miles from the Gelibolu Lighthouse. STI Pimlico suffered an explosion in one of the port wing cargo tanks and listed 15° to port. There were no injuries in the incident, but it was reported that naphtha leaked from the ship into the sea. Directorate General of Coastal Safety teams responded to oil spillage immediately, the leak was taken under control before it spread too much. In this study, the pollution and spread that will occur in case the response of coastal safety teams is delayed has been estimated. The oil spill was determined according to time and place, taking into account the northerly wind direction and strength. Leak simulation was performed with the GNOME™ simulation program. Characteristic of cargo on STI Pimlico was taken from the ADIOS2 program. Results of the simulation showed that the spill reached the coast. 7 kilometers of the coast was polluted by an oil spill.

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Introduction

Approximately more than 10 billion tons of liquid bulk cargo, container and solid cargo are transported annually worldwide by maritime transportation. (Walker et al., 2019). The rapid growth in global trade in recent years has led to an increase in the number, size and voyages of ships in the world fleet. (Branch, 2007). Maritime accidents generally occur in waterways such as canals where there are geographical

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difficulties and traffic density. (Chen et al., 2018; Luo & Shin, 2019).

The Turkish Straits System consists of the Sea of Marmara, Istanbul Strait (Bosporus) and Çanakkale Strait (Dardanelles). Turkish Straits System is one of the very complex and narrow waterways connecting the Black Sea to the Mediterranean. It is a known fact that the Turkish Straits are one of the most difficult and dangerous waterways for ships in the world with their traffic density. The Turkish Straits, which extend from the Black Sea to the Mediterranean, are 164 nautical miles (nm) long and have unique physical, geographical and oceanographic features in the world and the complex navigation conditions prevailing in the region. (Basar, 2010).

According to statistics 8653 tanker ships passed through the İstanbul Strait in 2022 and 9904 tanker ships passed through the Çanakkale Strait in the same year (Ministry of Transport and Infrastructure of the Republic of Türkiye, 2022). In the light of these data, it is concluded that the Turkish Straits are dangerous. A ship must use the straits to pass from the Black Sea to the Istanbul Strait, then continue through the Sea of Marmara and complete its passage to the Aegean Sea via the Çanakkale Strait. Ships passing the Çanakkale Strait make an average of 10 major route changes, and the largest route changes are made in the Nara Return point and Kilitbahir region (Tatlisuluoglu, 2008).

There was a total of 162 maritime accidents in the Çanakkale Strait between 2007 and 2018 (Bayazit et al., 2020). The Celestyal Crystal cruise ship and the STI Pimlico production ship collided at the Çanakkale traffic separation system, approximately 0.7 nautical miles from the Gallipoli Lighthouse, at around 01:26 (UTC+3) on June 27, 2015 (MSIU, Marine Safety Investigation Unit, 2016). Celestyal Crystal suffered extensive damage to her bow above the waterline. Two people were slightly injured. The ship was made ready for voyage with temporary repairs. STI Pimlico suffered damage to port side of her main deck, electrical systems and piping. STI Pimlico's hull plating was punctured above and below the waterline. One tank of the tanker STI Pimlico was punctured and listed 15° on its port side. No one was injured, but it was reported that naphtha leaked into the sea. (MSIU, 2016). General Directorate of Coastal Safety teams intervened quickly and stopped the leak before it spread too much.

Various studies have been carried out with GNOME oil spill simulation. The oil spill that occurred in Point Wells in 2003 was simulated and examined with the GNOME program (Duran et al., 2018). The oil spill incident that occurred in Kota Tinggi, Malaysia is modelled. According to the simulation results, it was determined that a very large coastline was affected (Balogun et al., 2021). Additionally, the impact of possible oil spill events was modeled with the GNOME program. The movement of a 10000-barrel oil spill that may occur on the North-West Coast of India was modeled and found that the spill possibly took 10 hours to reach the Gujarat coast and 15 hours to reach Maharashtra coast (Remyalekshmi & Hegde, 2013). According to the oil spill simulation results conducted on the Bohai Sea, it was determined where it would be beneficial to deploy oil spill response teams (Yu et al., 2016). The pollution caused by the Nassia and Independenta tanker accidents in the Çanakkale Strait was determined using the Oil Spill Simulator program (Usluer et al., 2022). In another study, 4 different scenarios were simulated in 4 areas determined in the Çanakkale Strait and it was determined that greater pollution than expected could occur (Usluer et al., 2020).

In this study, assuming that the delay in intervention to the oil spill and the distribution of 2200 metric tons of cargo of the ST Pimlico (one wing tank totally leaked into the sea) as it leaks the sea, according to the current weather and sea conditions, was determined with the Gnome Oil Spill Simulator. Thus, it is aimed to show how important it is to intervene early in oil spills and how great the consequences of delay will be.

Material and Methods

In the study, GNOME and ADIOS2 simulation programs were used to predict the oil spill. GNOME, developed by the National Oceanic and Atmospheric Administration (NOAA), was used to simulate the temporal and spatial distribution of oil (NOAA, 2001). This software uses wind, tide, and current values to calculate the movement of oil at the sea surface (Beegle-Krause, 1999).

ADIOS2 is an oil spill response program that helps oil pollution response teams and coordinating personnel make decisions about response methods. It integrates a memory of thousands of oils to predict how long the spilled oil product will remain in the sea and to help develop clean-up methods (Al-Mebayedh, 2014). The ADIOS2 oil memory was created in collaboration with many countries and compiled from many sources.

In this study, a scenario was created regarding the leak that occurred as a result of the collision between the M/V Celestyal Crystal and the M/T STI Pimlico in 2015. Information about the accident was taken from the accident report published by MSIU, affiliated with Transport Malta. The amount of leakage was not given in this report, so since STI Pimlico was damaged

by the port side, the worst-case scenario was that one of the port tanks leaked into the sea. It means that approximately 2200 metric tons of cargo were leaked into the sea.

Results and Discussion

The Maltese-registered Celestyal Crystal (Figure 1) is a passenger/cruise vessel built in 1980 at Wartsila Ab, Turku, as an Ice Class 1A Ro-Ro1 ferry. She was converted to a cruise ship in 1992. The vessel has a gross tonnage (GT) of 25,611 and is classed by DNV GL (MSIU, 2016). Her length overall is 158.88 m and breadth extreme is 25.2 m.

Figure 1. M/V Celestyal Crystal

STI Pimlico is a chemical/products carrier, double hull, owned by Scorpio Ship Management SAM and managed by Scorpio Commercial Management of Monaco. The vessel was built by Hyundai Mipo Dockyard Co. Ltd., Korea in 2014 and is registered in Marshall Islands and classed by DNV GL (MSIU, 2016). Her DWT is 38,734, length overall is 184 m and her width is 27.4 m.

Weather conditions at the time of the accident was given in Table 1.

Table 1. Weather conditions at the time of the accident

Weather Condition	Status
Wind speed	Beaufort 2
Wind direction	Northeast
Barometric pressure	1012 MB
Sea	Smooth
Visibility	Clear
Current Drift	1,2 kts

According to Accident Report of MSIU, after 12 hours of collision wind speed was 4 Beaufort and the direction was Northeast, after 24 h of collision wind speed was 4 Beaufort and the direction was North, after 36 h of collision wind speed was 3/4 Beaufort and the direction was Northeast (MSIU, 2016).

M/T STI Pimlico was carrying 30,000 tons of naphtha (density (15°C): 0.64 g/cm^3; viscosity (15°C): 0.39 cSt; product type: solvent; flashpoint: > 38°). According to the scenario, it is assumed that 2200 tons of this leaked into the sea during the conflict.

These data were entered into the GNOME simulation program and simulations were run according to 3 hourly currents + hourly wind. Oil spilling situation after the occurrence was given in Table 2.

3 hours after the occurrence 121 mt naphtha leaked. The natural dispersion rate was %0.6, the beached rate was %5.4 and the floating rate was %94.

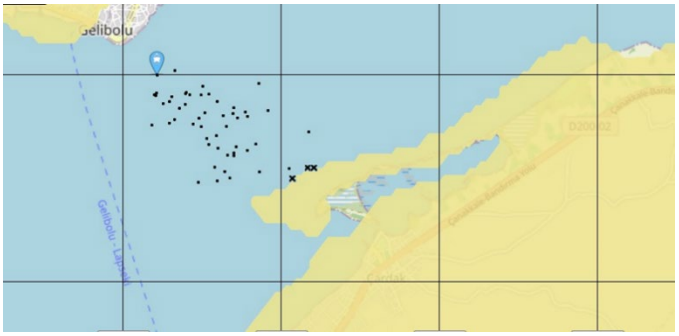

Figure 2. 3 hours after the occurrence

6 hours after the occurrence 244 mt naphtha leaked. The natural dispersion rate was %2.3, the beached rate was %56.4 and the floating rate was %41.3.

12 hours after the occurrence 488 mt naphtha leaked. The natural dispersion rate was %3.6, the sedimentation rate was %0.2, the beached rate was %82.3 and the floating rate was %13.9.

24 hours after the occurrence 977 mt naphtha leaked. The natural dispersion rate was %4.4, the sedimentation rate was %0.2, the beached rate was %82.6 and the floating rate was %12.8.

60 hours after the occurrence 2200 mt naphtha leaked. The natural dispersion rate was %6.0, the sedimentation rate was %0.3, the beached rate was %93.5 and the floating rate was %0.1.

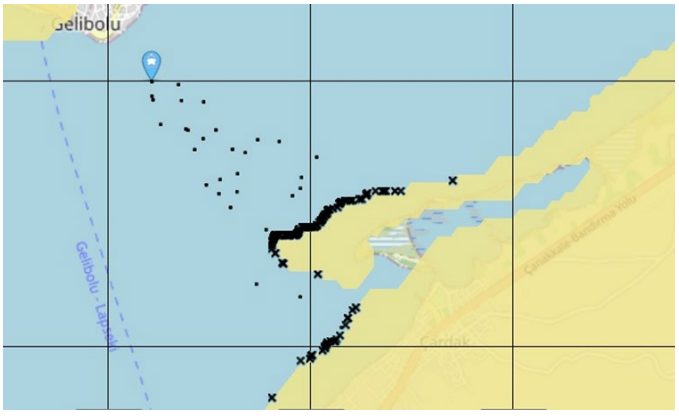

Figure 3. 6 hours after the occurrence

Table 2. Oil spilling situation after the occurrence

Time (hours later)	Amount released (mt)	Natural dispersion (%)	Sedimentation (%)	Beached (%)	Floating (%)
1	39.6	0	0	0	100
6	244	2.3	0	56.4	41.3
12	488	3.6	0.2	82.3	13.9
18	733	4.1	0.2	86.6	9
24	977	4.4	0.2	82.6	10
36	1465	6.6	0.4	85.9	7.1
42	1709	6.2	0.4	88.3	5.2
48	1954	6	0.3	90.3	3.4
60	2200	6	0.3	93.5	0.1

Note: Oil spilling duration was 60 hours. %93.5 of leaked cargo was beached and %6.1 of leakage was natural dispersion.

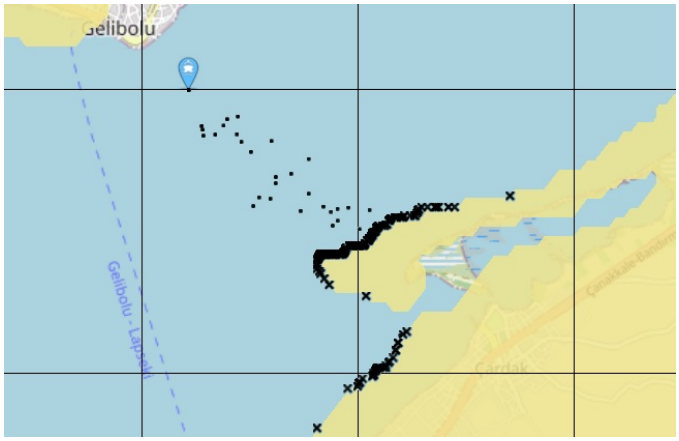

Figure 4. 12 hours after the occurrence

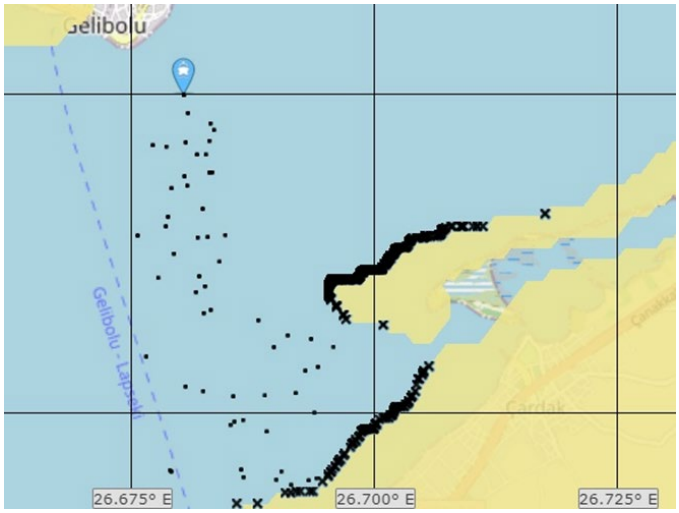

Figure 5. 24 hours after the occurrence

The biggest reason why the naphtha leaked from the ship as a result of the accident spread to such a great distance is that the Strait of Çanakkale has strong winds and currents. In the Independenta tanker accident that occurred in the Strait of Istanbul in 1979, approximately 30,000 tons of crude oil spilled into the sea. By entering the same parameters, the possibility of the Independenta accident occurring off the coast of Gallipoli was also tested in the simulation, and it was observed that the spillage polluted the coastline and sea surface for 22 km.

Figure 6. 60 hours after the occurrence

Conclusion

Sedimentation did not occur 6 hours after the incident, but approximately 66 metric tons of cargo collapsed to the seabed 9 hours later. This is a very dangerous situation for marine creatures. Naphtha contains heavy metal so all marine creatures on the seabed have been affected. The settled oil would have different negative effects on the benthic and pelagic marine life, and the case of cleaning these pollutants would be more time-consuming and expensive.

Oil spill reaches the coast at a high rate and pollution. Approximately 7 km of the coast was polluted by the oil spill. On this coast was a residential area and lots of people lived there. This pollution has been affected to human life.

Quick intervention after the accident occurred prevented the pollution from spreading over a large area. But to prevent such accidents from occurring, tankers and other ships must pass through the Çanakkale Strait in order and without encountering each other.

Compliance With Ethical Standards

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Funding

Not applicable.

Data Availability

The data that support the findings of this study are available from the author upon reasonable request.

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