Oil Spill Scenarios in the aftermath of Ship Accidents at the Anchorage Area for the Marmara Sea Entrance of the Istanbul Strait

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Abstract: The Istanbul Strait, which is a part of Turkish Strait System (TSS), is narrow and navigationally risky waterway for ships. This risk increases daily due to oil transportation from Central Asian and Russia. Crude oil tanker traffic is getting denser as the need for the transportation of Asian and Caucasian petroleum increases. In the present work, the risky region of the tanker waiting for in the queue for the Marmara sea entrance of the Istanbul Strait is run for simulations studies. It is assumed that 500 tonnes of medium crude oil may be spilled in the aftermath of a tanker accident. The oil spill is then determined with respect to time and space by considering 2 different dominant wind directions and scale. The simulation code GNOME™ version 1.3.3 is utilized to generate the oil spill scenarios. As a result of these runs, risky areas were identified and necessary actions to minimize the effect of spill were discussed in the Marmara Sea entrance of the Istanbul Strait. Florya and Ahırkapı coast were identified as the high risk areas. In order to minimize the effect on these areas, stocking booms and skimmers at other risky areas were found to be helpful for speedy action.
Keyword: Oil Spill, Istanbul Strait, Simulation, Marmara Sea, GNOME, Tanker Accident, Marine Pollution

1. INTRODUCTION

North western Turkey is divided the Istanbul Strait by a complex waterway that connects the Black Sea to the Sea of Marmara and the Aegean Sea. The channel passing between the Black Sea and the Sea of Marmara is named the Istanbul Strait. Istanbul is positioned at the south end of the Istanbul Strait. The very narrow and winding shape of the strait is more a kin to that of the river. It is an established fact that the Turkish Straits are one of the most hazardous, crowded, difficult and potentially dangerous, waterways in the world for

marines. All the dangers and obstacles characteristic of narrow waterways are present and acute in this critical sea lane. The Sinuous geometry of the strait (Figure 1) and the narrowness of some sections make this waterway an extremely difficult passage for oil tankers. These negative effect is also couplet with hydrographical and meteorology of the area.

Particularly for the Black Sea, the Straits are the only water exchange passage with other water mass. However, due to various environmental problems, 52 marine species in the Straits are severely threatened. One of the most serious problems is oil spill, related to ship traffic, because the Istanbul Strait is one of the world's busiest waterways: 50,000 ships passed in 2000, 5 % of which were supertankers more than 200 m in length with a potential carrying capacity of 100 million tons of crude oil. Accidents of shipping in the straits are examined under four categories: collision, grounding, fire and stranding. Each of them has a direct effect on the marine ecosystem. Collision is the dominant type of accidents. It is caused by poor visibility and strong current, which result in navigation failure. One of the largest collisions occurred in 1979 between a Greek cargo ship Evriyali (10,000 dwt) and a Romanian tanker Independenta (165,000 dwt) which carried 94,000 tons of Libyan crude oil. In 1994, the marine environment was seriously affected by the Nassia tanker accident which resulted in the discharge of 20,000 tons of oil into the Black Sea, Istanbul Strait and Marmara Sea. The most recent disaster was caused by a Russian river ship, Volganeft 248 that split in two in bad weather close to Istanbul in December 1999. Some 2,000 tons of oil were spilt into the sea [1].

The Strait of Istanbul is not very convenient for maritime traffic due to the morphological characteristics mentioned above. However, the greatest dangers to navigation are posed by surface and subsurface current, eddies and counter currents. Oceanographic and meteorological conditions that make navigation more difficult in the Strait of Istanbul are currents-counter currents, cross-currents at the bends rain and fog.

Southern entrance of strait is chosen as simulation area. While ships are waiting for entrance, they either anchoring or drifting. Therefore, there is congestion at this location. This increases the risk at accident at this region. It is well known that if there is an accident at this region, there would be oil pollution in the strait.

Transit traffic consists of the goods imported and exported by the Black Sea countries and also at an alarmingly increasing rate, of the oil Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG). In the past decade the system consisting of the Istanbul and Canakkale Straits with the inner Sea of Marmara in between became a major oil hub of the world energy transportation system [2].

1.1 Current and Environmental Parameters

The Strait of Istanbul is approximately 16.74 nautical miles long, with an average width of 0.81 nautical miles. It is only 0.378 nautical miles wide at its narrowest. The Straits of Istanbul takes several sharp turns. The ships are bound alter course at least 12 times at these bends. At the narrowest point, Kandilli (700 m), a 45 degree course alteration is required. The current can reach 7-8 knots at this point. At Yenikoy, the necessary course alteration is 80 degrees. At the above mentioned turns (Kandilli and Yenikoy) where significant course alterations have to be made, the rear and forward sights are totally blocked prior to and during the course alteration.

Current the Marmara Sea entrance of Istanbul Strait is generally accepted that the flow from Black Sea to Marmara sea Figure 2 [3]. Also, It is know that flow field in the Istanbul Strait has a 2 layer structure [4].

Figure 1. The Istanbul strait.

The ships approaching from the opposite direction cannot be seen round these bends. There is also very heavy ferry traffic in the Strait of Istanbul, which crosses between European and Asiatic sides of the city. There are two suspension-bridges spanning the Istanbul Strait which connects Europe and Asia. Istanbul - Bosphorus suspension bridges 3 miles within the Strait connects Europe and Asia. It is 1074 m long between the legs and has a vertical clearance of 64 m over a width of 400 m decreasing to 58 m at each end.

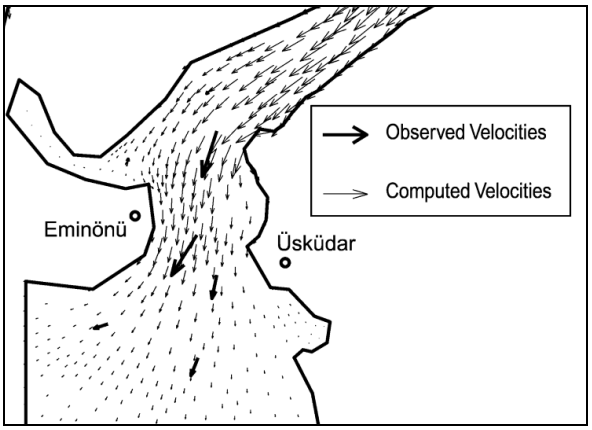

Figure 2. The current in the Istanbul strait entrance. Source [3]

2. METHOD AND SCENARIOS

GNOME™ developed by NOAA was used to simulate spatial and temporal distribution of oil [5]. This software uses wind, tide, and current values to calculate the movement of oil at sea surface [6]. The simulation code GNOME™ version 1.3.3 is utilized to generate the oil spill scenarios. Başar *et all*, simulated risky areas for oil spillage after tanker accidents at Istanbul Strait [7].

Simulations were run for tankers waiting at the northern entrance of the strait. It is assumed that 500 tonnes of medium crude oil may be spilled in the aftermath of a tanker accident. The oil spill is then determined with respect to time and space by considering 2 different wind directions (South and North West) and speed (4 knots and 14 knots) Table 1. The tide is negligible at the strait therefore it is not taken into account [8].

Scenarios was run for coordinate longitude 40° 59' 34" N – latitude 28° 57' 09" E at the Black Sea entrance of the Istanbul Strait (Figure 3). It means that two or three tankers collide at this coordinate after that oil spill starts from tankers. All simulations were running for 30 minutes.

Table 1. Scenarios

Scenarios	Wind Direction	Wind Speed (knot)
Scenario 1	W	14
Scenario 2	W	4
Scenario 3	S	14
Scenario 4	S	4

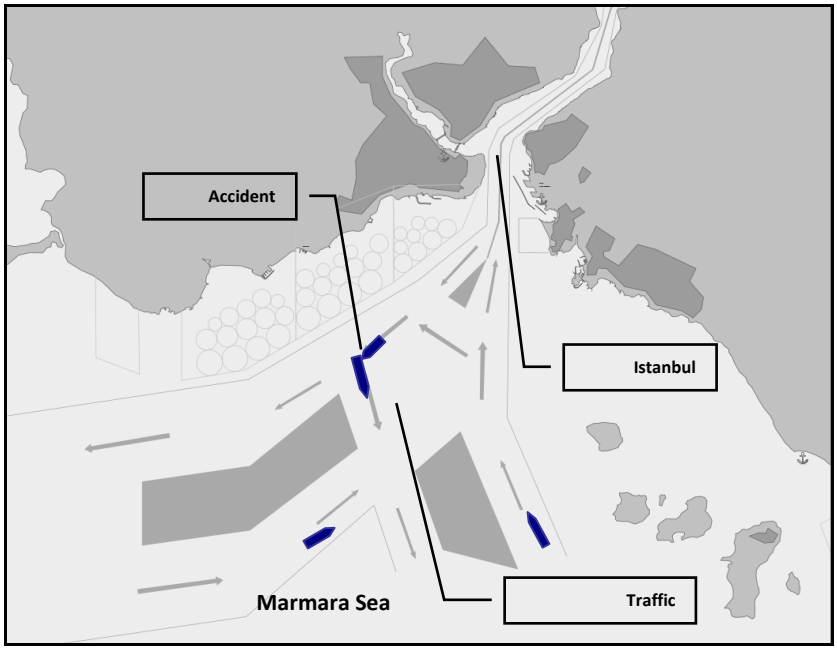

Figure 3. Tankers collision scenarios

In order to input straits data to GNOME, map with Mercator projection was digitized at 1290 latitude and longitude points. Currents data for simulation was input as 50 x 85 matrix with the special format. Current values were *u* and *v* (m/s) at x and y directions respectively [9]. The simulation code GNOME^{TM} version 1.3.3 is utilized to generate the oil spill scenarios.

3. RESULTS

The first simulation was run by using 14 knots wind speed and W wind direction at the Marmara entrance of Istanbul strait. As a result of the first simulation, which runs for 30 minutes, the oil spill affected offshore of Marmara sea if necessary action is not taken, oil spill reaches into the Marmara sea (Figure 4). Then wind speed was reduced to 4 knots and the simulation run again. As seen from figure 5, the spill was under the effect of current and gone into the Marmara sea.

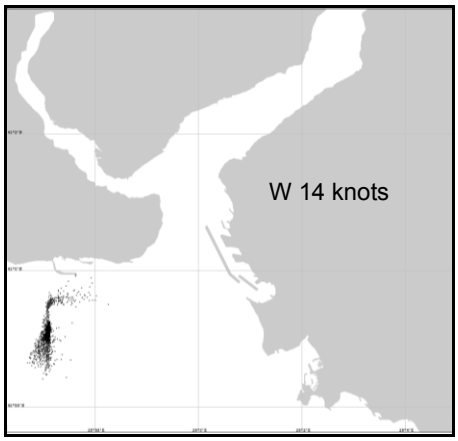

Figure 4. Distribution of crude oil at 1st. scenario

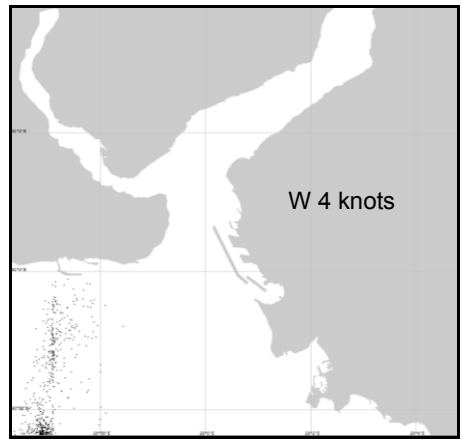

Figure 5. Distribution of crude oil at 2nd. scenario

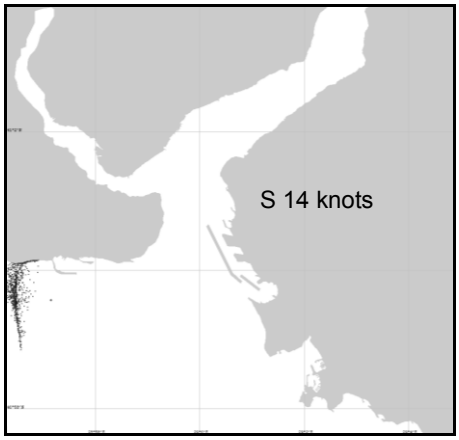

Figure 6. Distribution of crude oil at 3rd. scenario

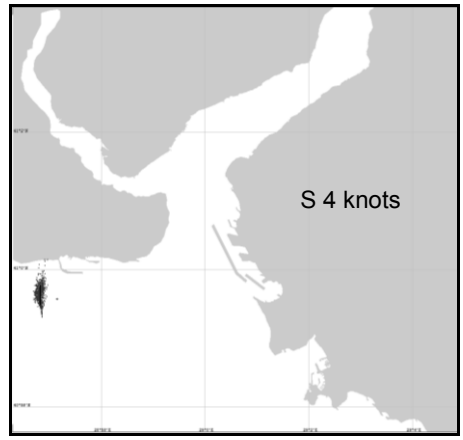

Figure 7. Distribution of crude oil at 4th. scenario

Third scenario was to run with a south wind direction. In this scenario, oil spill effected the north side of the entrance of strait and the oil spill reached Ahırkapı coast line (Figure 6). Also, Florya beached by the oil and it was a fast spill due to wind affect. Forth scenario was to run south wind direction and 4 knots speed. The spill was under the effect of current and gone to the Ahırkapı coast line (Figure 7). Florya beach beached by the oil and it was a slowly spill than scenarios 3 due to slowly wind affect.

All simulations result showed that simulations with south and west strong wind were important to oil spill behavior. The spill affected from Ahırkapı to Florya coast line. These areas were identified as the risky line (Figure 8).

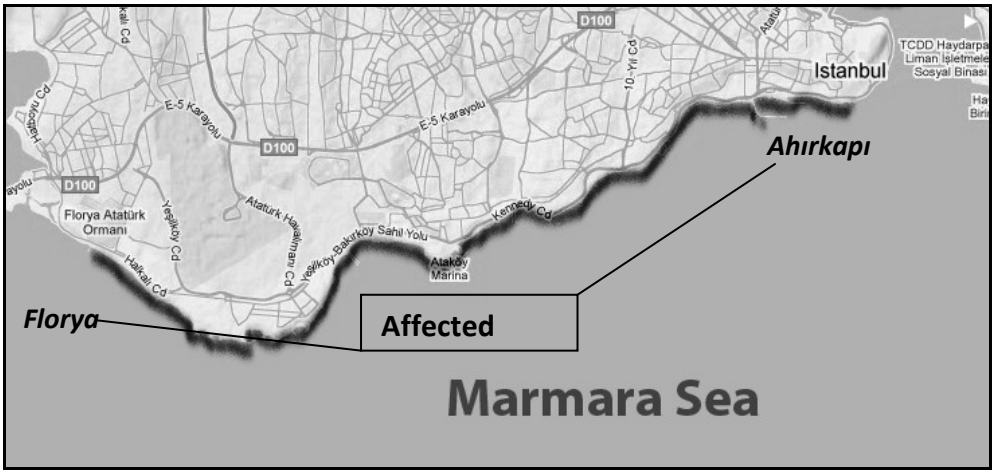

Figure 8. Affected Areas

4. CONCLUSIONS

The ever growing demand for energy in the modern world continues to increase the risks of major oil spills during the lengthy travel of this natural resource along global sea routes. The Istanbul Strait is under ever increasing tanker traffic.

In this study, the movement of the oil spill issuing from a tanker accident has been simulated in the entrance of Istanbul Strait, south boundary. It is show that under the strong wind, oil reaches the Florya coast. It is obvious that this will cause oil pollution in the beach, and cleaning will be troublesome. It is important that necessary action should be taken, if necessary action is not taken, the oil spill reaches to Florya coast in 120 minutes. First action has to be fast and effective with the barrier at accident area, so that it can stop oil spill to reach to Florya coast. In order to act fast and efficiently, stocking booms and skimmers at risky areas is advisable and would reduce the damage and cleaning cost.

Tanker accident risk increases daily due to oil transportation from Central Asian and Russia. Crude oil tanker traffic is getting denser as the need for the transportation of Asian and Caucasian petroleum increases.

We suggest that pipeline system, like Tbilisi-Baku-Ceyhan (TBC) pipeline or planed new pipeline for crude oil transportation, should be used instead at carrying by ships.

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