The Volgoneft-248 Oil Spill in the Marmara Sea

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Abstract

On December 29th, 1999, oil tanker Volgoneft-248, carrying over 4,000 tons of heavy fuel oil, broke into two pieces off the southern coast of Istanbul in the Marmara Sea. While the bow section sank at 30 meters of water, the stern was driven aground near the Menekşe Shores of Istanbul. Approximately 1,300 tons of oil were initially spilt to the sea, affecting more than five kilometers of shoreline. Buildings, roads, fishing ports and coastal structures located in the area were heavily affected from the oil pollution. Clean-up operations at the shore continued for more than four months. Field surveys were carried out right after the accident and at later stages of the clean-up operations to document the initial and later stages of the environmental damage on the coast and fishing ports in the area. Significant progress was observed from the initially catastrophically oil contamination at the coast. However, the remaining oil in the sunken bow section continued to leak and mixed to the seawater until the summer of 2000. The location of the accident and the motion of the oil slick were found to be compatible with the forecast scenarios based on 1998 computer simulations. Numerical models were found to be powerful tools in forecasting and hindcasting oil spills in the Marmara Sea.

1. Introduction

Oil tankers are prone to accidents in narrow water passages, in rough seas and while navigating along coastlines with busy sea traffic. Tankers from oil exporting countries surrounding the Black Sea have only one exit to the Mediterranean Sea: via the Bosphorus Strait, the Sea of Marmara and the Dardanelle Strait. The Bosphorus and the Dardanelle's are typical narrow water channels and navigation route through the Sea of Marmara is very close to the northern coastline during exit from the Bosphorus and entrance to the Dardanelle's straits. This route therefore increases the risk of collisions and running aground (Tan and Otay, 1999; Or and Kahraman, 2000). Two major tanker accidents resulting in oil spills had occurred in the past within the region before the last accident involving the Russian vessel Volgoneft 248. The Independenta accident in 1979 where 95,000 tons of crude oil was spilt and burnt occurred at the exit of the Bosphorus to the Sea of Marmara (Etkin, 1997). The Nassia accident in 1994 where 13,500 tons of crude oil were spilt, occurred at the northern exit of the Bosphorus to the Black Sea (Oğuzülgen, 1995).

In the early hours of the December 29th, 1999, there was a severe storm with southwesterly winds of force 7-8 in Istanbul. The Russian tanker Volgoneft-248, (about 4,000 DWT), carrying 4,365 tons of heavy fuel oil loaded from Bulgaria, had crossed the Bosphorus Strait on the December 27th, 1999 and had anchored off Ambarlı oil terminal and was waiting for her turn to unload her cargo. The severe storm forced the anchor to break free and the ship broke into two approximately one kilometer off the coast. The bow section of the ship sank immediately and the stern was driven aground at 100 meters off the shore (Figure 1). The entire cargo of 1,290 tons in the two oil tanks located at the breaking point was spilt (ITOPF, 2000). When the bow section sank to a depth of about 30 meters and there were still four more tanks full with 2073 tons of oil.

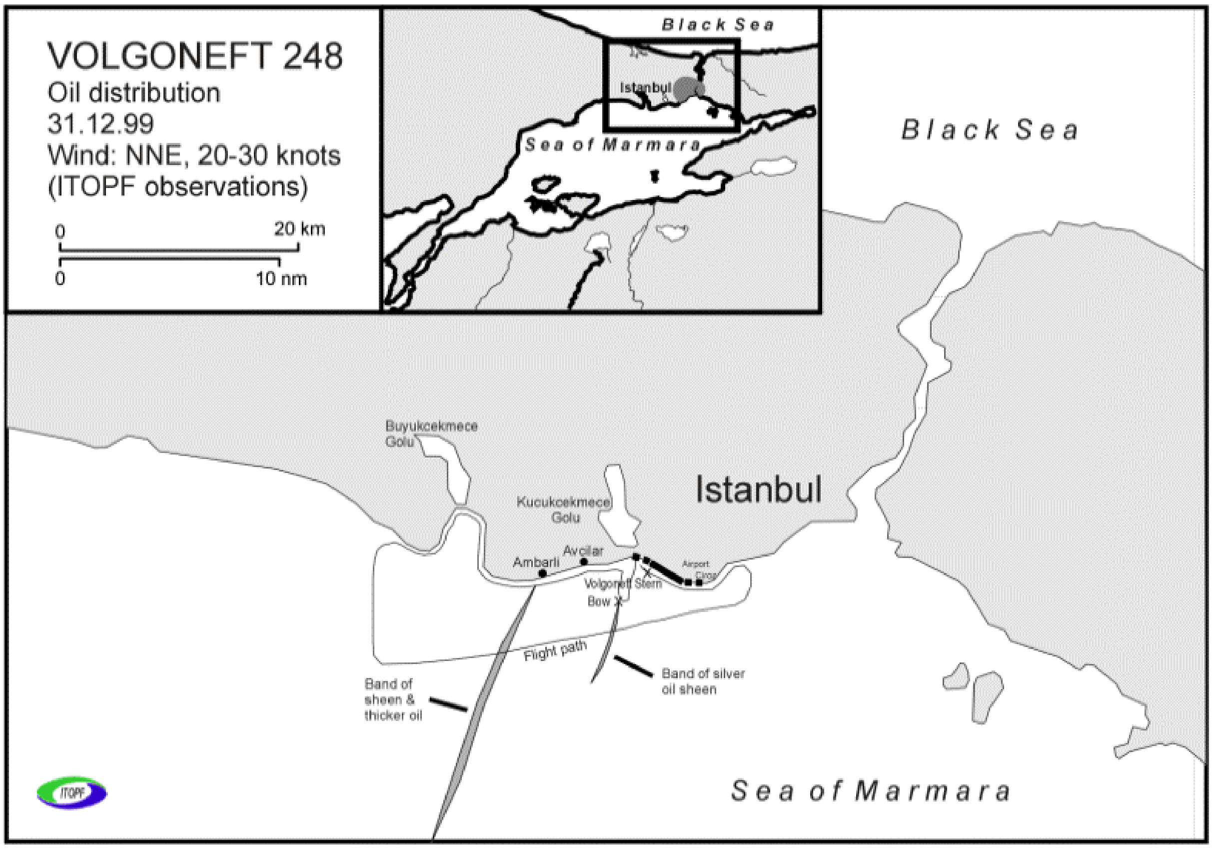

Figure 1. Spill Area (ITOPF, 2000)

The spilt oil was carried ashore by the strong winds and waves and within several hours of the accident. In the morning, at first sight, the scene of the accident exhibited an oil cover of about five kilometers of beaches, rocks and concrete platforms. The oil was 2-10 meters wide and five centimeters thick. Oil slicks on the sea surface could be observed.

2. General Effects of Oil Contamination in the Coastal Waters

The environmental pollution due to an oil spill can be regarded in four areas: at the sea surface, within the water column, at the sea floor, and swashed to the coast. Depending on the environmental conditions, most affected living creatures are the fish, marine mammals, planktons, and also sea birds. If the oil reaches the coast, aquaculture, beaches, coastal parks and marinas are the most sensitive facilities. To better understand the oil contamination, oil transport processes, starting from the spill instant, need to be examined.
As soon as the oil contacts the water surface, it instantly forms thin layers and spreads to large areas. With the effect of wind, wave and surface currents, the oil slick starts to move.

The main factor controlling the direction of transport of the oil slick is the surface current. Wind and wave intensity and direction have minor contribution to the overall migration of the oil slick. As oil disperses at the sea surface, it undergoes complex processes at rates depending on the physical and chemical conditions. These are evaporation, flocculation, emulsification, dissolution, oxidation, sedimentation and biodegradation (Figure 2).

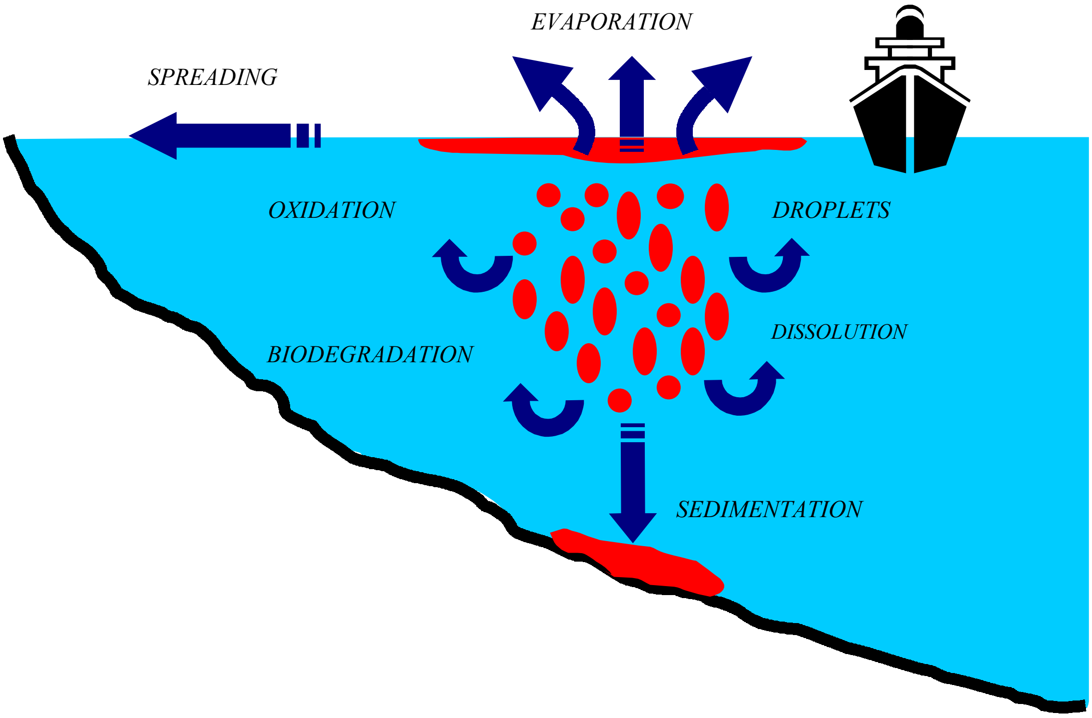

Figure 2. Physical Processes Related to Behavior of Oil in Water (Copty et al., 2000)

Under the physical, chemical and biological processes, part of the oil leaves the system, part of it gets mixed into the water column and another part sinks to the bottom (Copty et al. 2000). As the oil is transported to shallower waters where wave energy dissipation is increased, the oil droplets are attached to sediments particles suspended in the water column and sink to the bottom of the sea. The re-entrainment of the oil attached to the seafloor back to the water column and therefore the continued contamination due to the bottom oil lasts much longer than the surface oil. As long as oil is present at the seafloor, it continues to contaminate the seawater through water and sediment motion.

On the other hand, when the oil slick reaches the coast by forces of currents and other factors, a massive coastal pollution threatens the coastal environment. Houses, recreational facilities, roads, beaches, coastal protection structures, ports, marinas, and fish farms are affected by the pollution. Shellfish are killed and habitats of local fish are destroyed. Fish and other marine creatures are forced to change their habitat due to oil contamination. Most of the migrating fish are not affected directly, however, planktons and small organisms are more sensitive to oil pollution. A break-up in the food chain may force the adult fish to migrate to other areas.

Fish farms are the most sensitive eco-systems to accidental oil spills. Large amounts of fish and other marine species can be trapped in contaminated and lost. However, fishing activities in on open sea can suffer large losses only in large-scale oil spill accidents where the escape routes of local marine life are also contaminated.

Quantification of losses in an oil spill is only possible if certain physical parameters are measured or computed. Most important parameters are the properties of the spilled oil, the amount of spill, bathymetry of the sea, geometry of the coast, effective wind, wave and currents during and after the spill. Most reliable way is the direct measurement of the above parameters using scientifically accurate methods. However, the past experience has shown that even in oil spill accidents in the coastal waters of developed countries, the direct measurement of the movement and fate of the oil and the environmental conditions was not possible due to lack of time and money. Today, with the technological and scientific developments, it is possible to forecast and hindcast the transport and fate of oil in the seawater at a much lower cost using computer simulations.

3. Field Observations

Following the Volgoneft-248 tanker accident in the early hours of December 29th, 1999, the accident site was visited, and visual data were collected at the coastline affected from the oil spill (Figure 3).

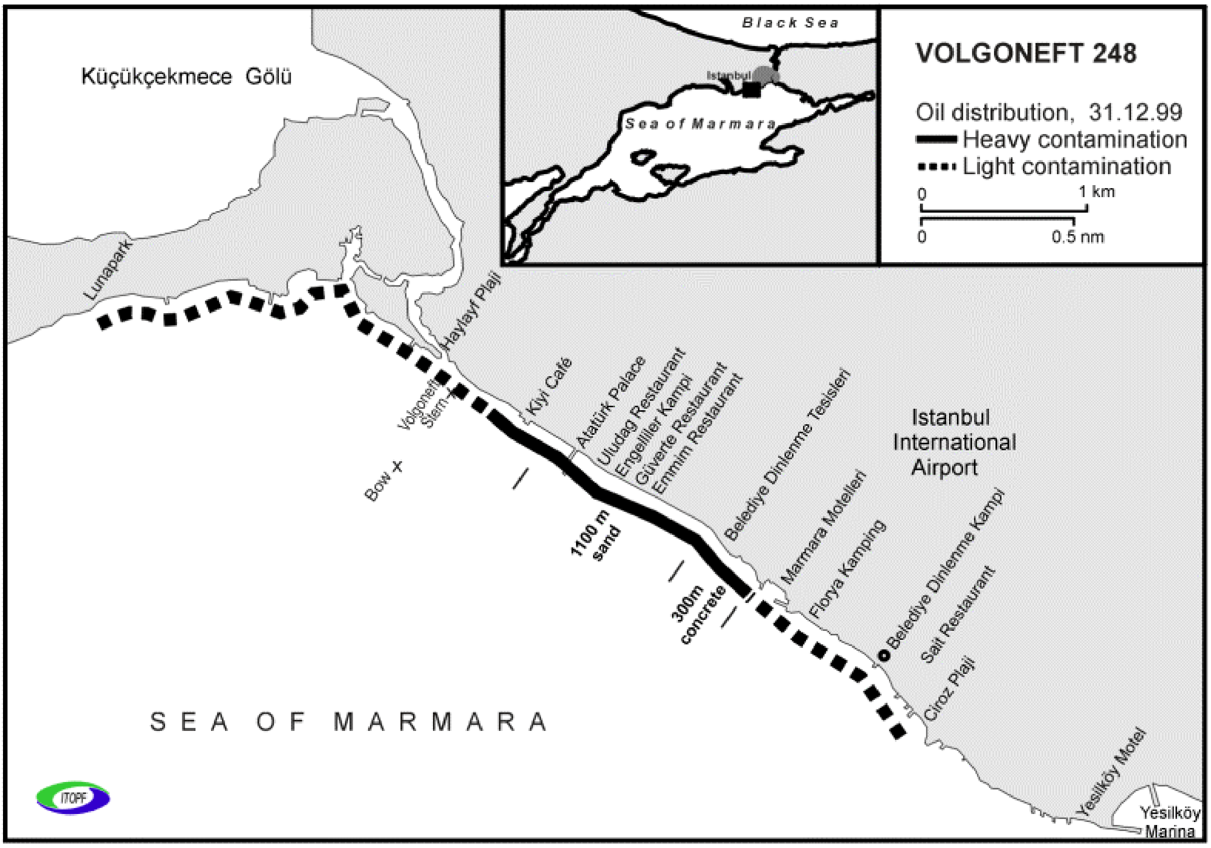

Figure 3. Oil-Affected Coastline (ITOPF, 2000)

Field observations on the accident day showed that the oil contamination has affected the shorelines in the immediate vicinity of the grounded stern section off the Menekşe Coast (Figure 4) and the eastern shorelines (Figure 5).

Figure 4. Grounded stern section off the Menekşe Coast (December 29th, 1999)

Figure 5. Oil contamination East of Menekşe Coast (December 29th, 1999)

Approximately three months later after the accident, a larger field program has been initiated to document the contamination in the area within the scope of legal investigations related to the accident and the following oil pollution (Yenigün et al., 2000a-g; Otay, 2000). In April and May, 2000, the southern coast of Istanbul is surveyed between Yenikapı and Silivri. Site visits are concentrated on a five kilometer-long coastal strip located West of Çiroz Beach and East of Menekşe Coast where heavy contamination was found earlier.

The sites visited during and after the clean-up operations are summarized in Table 1. During the field trips, contamination levels at the coastline and the coastal waters are examined, visual photographs are taken, and residents are interviewed.

Table 1. Field Trips for Expert Witness Reports

Site Location	**Visit Date**	**Court**	**Report No**
Atatürk Pavilion, Florya	2 May 2000	Bakırköy 9. Asliye	2000/74
Çiroz, Florya, Menekşe Coasts	7 April 2000	Bakırköy 2. Sulh	2000/74
Kumkapı Fishing Port	5 May 2000	Bakırköy 2. Sulh	2000/127
Avcılar Fishing Port	5 May 2000	K.Çekmece 3. Asliye	2000/125
K.Çekmece Fishing Port	4 April 2000	K.Çekmece 3. Asliye	2000/89
Silivri Fishing Port	4 April 2000	Silivri Sulh	2000/27
Selimpaşa Fishing Port	5 May 2000	Silivri Sulh	2000/37

Comparison of field observations at the day of accident (Figures 6a and 7a), and approximately three months later (Figures 6b and 7b) have shown that most of the oil contamination at the surface of beach sediments has been recovered during the clean-up operations along the coastline. However, evidence has been found for pollution in limited quantities on the Florya Beach and on the rock groin at Çiroz Park.

Some of the observed contamination in April, 2000 had signs of fresh oily marks, suggesting that oil might be still leaking from the sunken bow of the tanker. A boat trip off the Menekşe Coast on April 7th, 2000 showed oil slick concentrating on the water surface approximately one kilometer offshore. At the exact location of the sunken ship bow indicated with surface markers, oil has been observed to be rising from 30 m water depth up to the surface (Yenigün et al., 2000d). After reporting the evidence to the court, the sunken half of the tanker was recovered and the oil leakage has been stopped further polluting the sea.

Another important finding was that the specific gravity of the heavy fuel oil carried by the tanker was approximately 0.9914 g/cm^3 which very close to the specific gravity of seawater. Therefore, the unrecovered portion of the initial spill is likely to sink either by attaching to suspended sediment particles in the water column or transported with the net vertically downward mass flux of water in turbulent flow conditions. The sunken oil at the seabed causes long-term residual contamination as described in Section 2 and continues to be a continuous threat to the environment.

Figure 6a. Florya Municipality Recreation Facilities (29 December 2000)

Figure 6b. Florya Municipality Recreation Facilities (7 April 2000)

Figure 7a. Florya Atatürk Pavillion (29 December 2000)

Figure 7b. Florya Atatürk Pavillion (7 April 2000)

4. Computer Simulations

For an oil spill accident in Tuzla Shipyards, in the Sea of Marmara in February, 1997, Kazezyılmaz et al. (1998) modeled the water circulations and consequently, the dynamic distribution of oil concentrations in the Marmara Sea. In addition to local accident conditions, they reported that "*several oil spill scenarios are simulated for different locations and wind conditions at the Sea of Marmara*" including accident scenarios off Silivri, Tekirdağ, Şarköy, Karabiga, Gemlik and at the southern entrance of the Bosphorus. Their model findings showed that "*the most critical point in terms of pollution is the entrance of the Bosphorus to the Sea of Marmara*" (Figures 8 and 9).

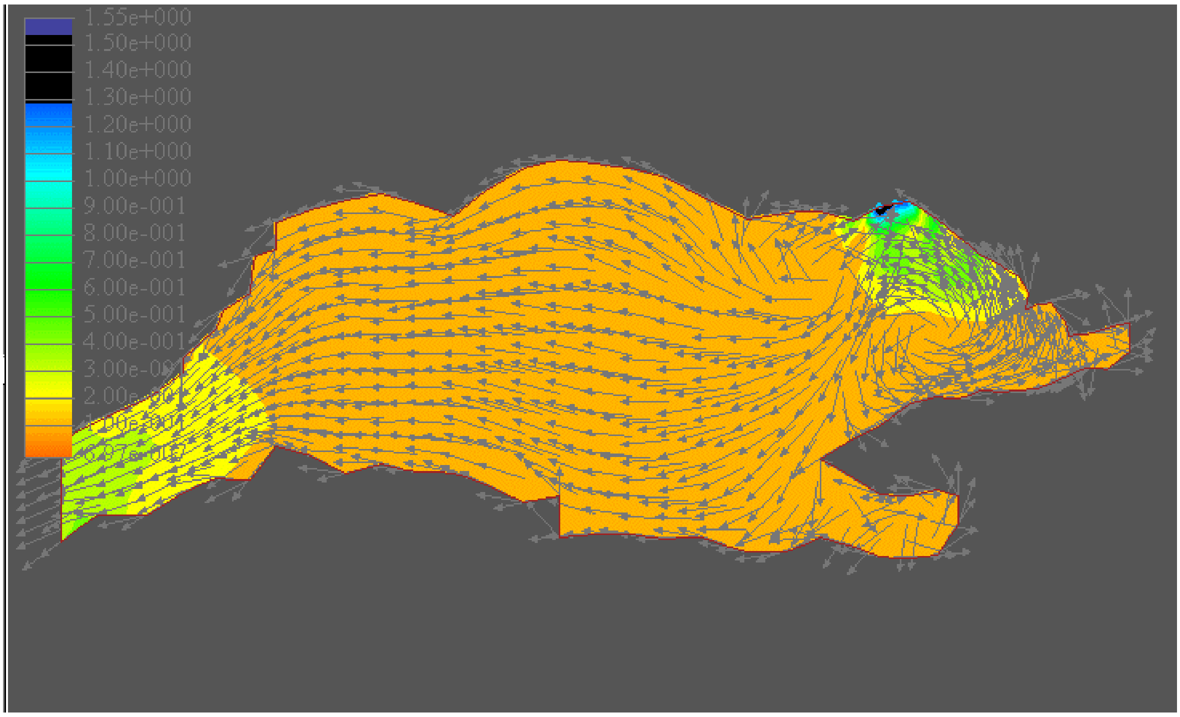

Figure 8. Forecasted Water Circulation in the Marmara Sea for a Hypothetical Oil Spill South of Bosphorus (Kazezyılmaz et al., 1998)

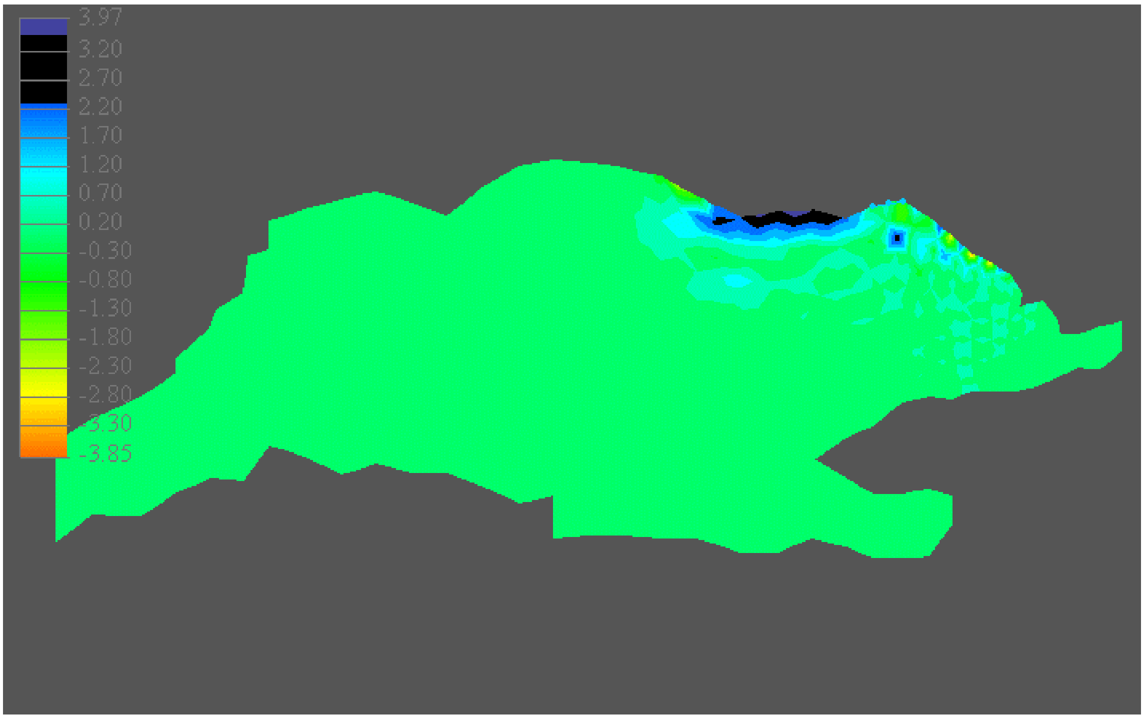

Figure 9. Forecasted Oil Concentrations in the Marmara Sea for a Hypothetical Oil Spill South of Bosphorus (Kazezyılmaz et al., 1998)

Two years later, the Volgoneft-248 accident happened at a close location, which was reported by Kazezyılmaz et al. (1998) as the most critical point in the Marmara Sea. The forecast conditions were modeled with southerly wind conditions, which are typical for the northern Marmara Region. The model results showed that the oil slick moved westward along the South Coast of Istanbul, affecting the coastlines in Yesilköy, Florya and Küçük Çekmece. The field observations at the accident day and three to four months later showed that the computer simulations from 1998 have forecasted the motion of the oil slick and the contaminated coastlines reasonably well.

5. Conclusion

A 4,000 DWT Russian tanker, Volgoneft-248 lost its control off the South coast of Istanbul in stormy weather on December 29th, 1999. Strong surface water currents and waves forced the tanker to break to two pieces. The bow section sank approximately one kilometer off the Menekşe Coast in 30 m water depth. The stern of the ship was pushed ashore and grounded off the Menekşe Coast.

The amount of heavy fuel oil spilled from the Volgoneft-248 tanker to the Marmara Sea is estimated to be 1,290 tons. Approximately 1,000 tons of the remaining oil was discharged ashore, leaving another 2,000 tons in four tanks located in the sunken bow section.

Field observations on the accident day evidenced that the spilled oil contaminated the shorelines between the grounded ship stern off the Menekşe Coast and the rock groin at Çiroz Park five kilometers to the East of the accident. Beaches, fishing ports, restaurants, recreation facilities, the Atatürk Pavilion, piers, groins and seawalls located in this area are directly affected.

Later field surveys associated with legal damage investigations were carried out to survey the state of pollution and the result of clean-up operations three to four months after the accident. It was found that the shorelines have been cleaned to a large extent except some minor leftover, and some fresh marks indicating a continuing contamination. The source for this recent pollution was found to be the oil leakage from the remaining oil in the sunken bow section of the tanker, which was later, recovered in Summer, 2000.

The location of the accident and the motion of the oil slick were found to be compatible with the forecast scenarios based on computer simulations carried out in 1998. Numerical models were found to be powerful tools in forecasting and hindcasting oil spills.

Acknowledgments

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