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RISK FACTORS OF THE OIL PRODUCTS SPILLAGE IN THE LITHUANIAN ECONOMICAL ZONE

Abstract

This paper presents the risk factors connected with oil spillage in the Baltic Sea. Models for the oil drift products give an opportunity to forecast effects of an accident. The accident that happened at Būtingė terminal station caused about 3 tons of oil to be spilt into the sea. After additional data, relating to the kind of oil, amount, co-ordinates, hydro-meteorological conditions, were installed into the Seatrack Web (SMHI Sweden), the results of the model oil drift were close to the real situation.

Oil and oil products are one of the most dangerous and widely spread marine contaminants. Risk factors connected with oil spillage are:

- Import - export of oil products
- Economic activities in Lithuanian oil companies
- The number of ships visiting the harbour of Klaipėda
- Extreme hydro-meteorological factors:
  - Low visibility
  - Gale - force winds
  - Low water level
  - High wave

The area of the Lithuanian economical zone in the Baltic Sea is about 8 thousand km^2. 92 kilometres of the seacoast belongs to Lithuania. Two oil companies perform economic activities there (Fig. 1):

- Joint Lithuanian and the U.S. company "Klaipėdos Nafta"
- Būtingė oil terminal station

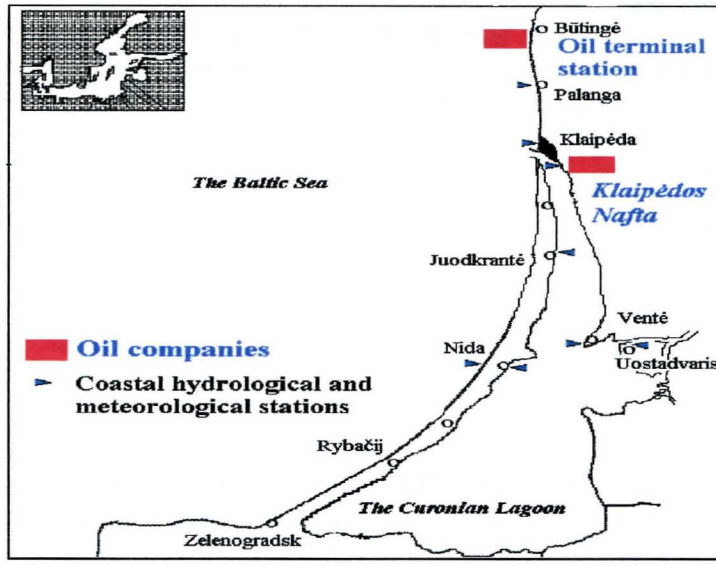
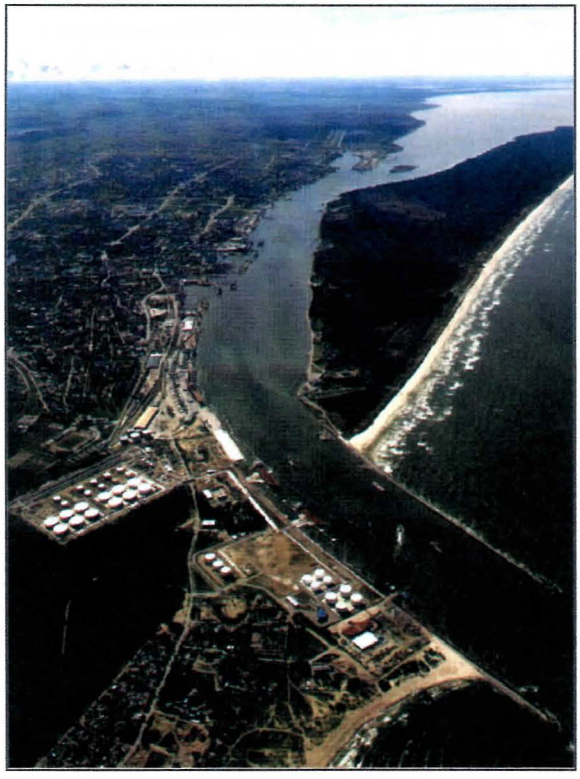


Fig. 1. Oil companies and near shore hydro-meteorological stations in the considered area



The Būtingė terminal station began work in 1999. The buoy of this terminal is in the Baltic Sea about 7 kilometres from the coast. In 2000, the average amount of oil exported through Būtingė terminal reached 4 million tons.

The company "Klaipėdos Nafta" is near the Klaipėda Strait. Reservoirs of the oil terminal station can contain 500 thousand tons of various oil products. It can transfer 7 million tons of all kinds of oil products per year (http://www.oil.lt).

Klaipėda seaport is situated in a narrow strait of 400-800 meters, which connects the Curonian Lagoon with the Baltic Sea (Fig. 2). About 7 thousand ships visit it per year (Table 1). It is highly probable that there will be emergency situations occurring in the port gate.

Fig. 2. Klaipėda Sea port and oil company "Klaipėdos Nafta" is situated in the Klaipėda Strait (photo by V. Karaciejus)

Table 1. Number of ships visiting the port of Klaipėda (according to the data presented by the Council of the Port Captains)

Year	1995	1996	1997	1998	1999	2000
Number of ships	6 931	7 170	7 661	8 155	6 917	7 253

Based on CMR data and on [1, 2, 5], extreme hydro-meteorological factors consist of:

- 48 days with limited visibility per year. During spring and early winter, there is often fog.
- Wind stronger than 15 m/s can be expected, on average, 67 days per year. Table 2 shows that dangerous winds are more often in the cold period of the year.
- Dangerous, stronger than 20 m/s winds, are present on average, 15 days per year.

Table 2. Average days number with fogs in the port of Klaipėda (after V. Jackūnienė [5])

Month	01	02	03	04	05	06	07	08	09	10	11	12	During the year
Number of days	3.4	4.5	6.6	6.5	5.8	3.8	2.0	1.6	2.3	3.5	3.4	4.4	47.9
Average duration of fog (h)	23.4	30	42.6	44.8	34.1	19.2	9.1	5.6	9	19.5	20.2	26	283.5

Table 3. Percentage of years with winds stronger than 15 m/s (period of 1961-1990, after A. Gentvilienė [1])

Month	01	02	03	04	05	06	07	08	09	10	11	12
Occurrence	100	83	92	92	50	67	83	92	92	100	100	100

Table 4. The biggest wind speed (m/s) observed in the meteorological post of Klaipėda in 1946-1999

Month	01	02	03	04	05	06	07	08	09	10	11	12
Max. wind speed (m/s)	34	30	28	26	24	25	34	28	30	40	36	40
Direction	WSW, W	NW	NW, N	WNW	NW	W	SW	W	W	SW	WNW	W

- When there is a strong wind of western direction waves of 3-6 m height appear in the near shore zone.

The highest wave observed in our coastal zone during 50 years of investigations was 7.6 m (15 November 1956). The gale western wind during the hurricane in December 1999 caused the wave of 6 meters.

- The extreme registered water levels in Klaipėda Strait are 186 cm (1967) above zero of the Baltic System and -91 cm (1984). The amplitude of the long-term variations in the strait is 276 cm.
- The characteristic feature of changes in the water level in the Klaipėda Strait is a very prominent change in the daily water level. The water level in Klaipėda may change suddenly.

For example, the maximum level in the Klaipėda Strait was observed in October 1967 (Fig. 3).

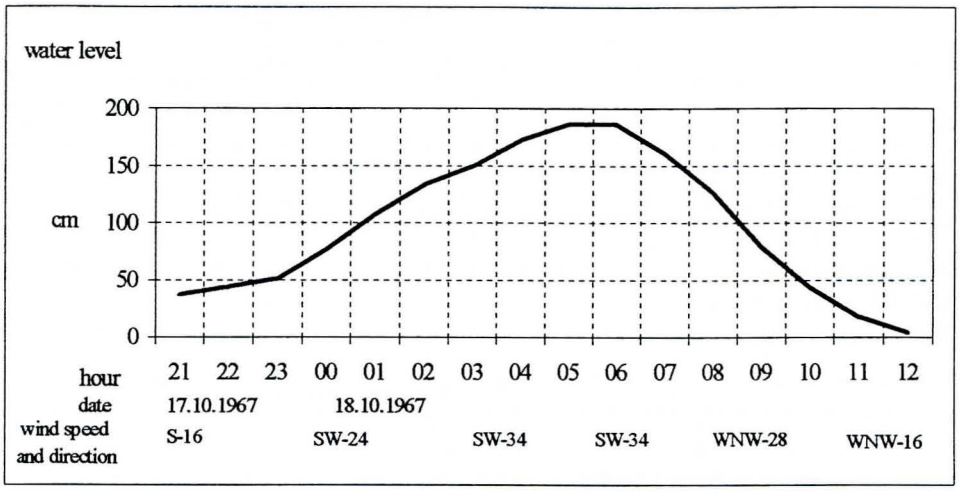


Fig. 3. Variation of the water level in the port of Klaipėda on 17-18 October 1967. Wind direction and speed shown in the lower part of the figure

While at that time the centre of the cyclone was moving from the west towards Klaipėda, the hurricane wind from southwest blew. The wave, which approached the eastern coast of the Baltic Sea, collided in the port of Klaipėda and the northern part of the Curonian Lagoon with the pile up that moved from the southern part of the Curonian Lagoon. Water masses moving at the same time from opposite sides in 7 hours raised the water level in the Klaipėda Strait by approximately one and a half meter. After the direction of the wind changed, the water level in the strait, in 8 hours, was lower by 2 meters. J. Dubra has described this situation well [4].

A similar situation was in December 1999, when at the time of a hurricane the water level in the Klaipėda Strait, in 4 hours, rose by 140 cm.

- Short fluctuations of the water level, caused by wind, water circulation and atmospheric pressure, are observed in the port of Klaipėda. The amplitude of fluctuations of the range actions usually does not exceed 10 cm, but when there are big fluctuations of air pressure, they can reach 50 cm [4]. The harbour oscillation is dangerous due to unexpected sudden formation and often it creates emergency situations for ships in the port [6]. The Tab. 5 (data from the Department of Hydro-Meteorological Forecasts) shows that the probability for dangerous range actions to be formed is most likely when the wind is stronger than 20 m/s and is of South Southwest and Southwest directions.

According to the available data it is determined that northward currents are dominant (about 54%) in the Lithuanian coastal zone. Unfortunately, during storms, when the dynamic processes are most intensive and interesting, there is a lack of measurements. The most interesting situation is in the surf zone, where currents often move bottom sediments.

There is more information on currents from the Klaipėda Strait. Due to river discharge, in the shallow and narrow strait, currents from the lagoon to the sea dominate. During the extreme spring flood (4 May 1958) the speed of 2 m/s was registered [7]. At that time, water level difference between the lagoon (station Juodkrantė) and the Baltic Sea (station Pionersk) was 122 cm.

Table 5. The reliance of the range action on speed and direction of wind in the Klaipėda Strait

Harbour oscillation (range action)	Wind speed and direction				
	SE - S	SSW - SW	WSW - WNW	NW - NNW	N - NNE
Weak 6 - 15 cm	10 - 20	10 - 12	10 - 12	10 - 13	10 - 14
Middle 16 -25 cm		13 - 18	13 - 16	14 - 20	15 - 24
Strong 26 - 40 cm		19 - 34	17 - 23	14 - 20	15 - 24
Dangerous 41 - 60 cm		24 - 34			

Storm winds W, NW, N and NE generate currents from the sea to the lagoon. Sometimes two directions of surface currents can be observed at the harbour entrance. When N or NW wind is blowing, seawater flows into the lagoon close to southern mole and fresh water flows into the sea along the northern mole of the sea gate. When S or SW wind is blowing, the situation is analogous, but with the opposite directions of surface currents. In such hydrodynamic conditions, a ship entering Klaipėda harbour faces rather complicated navigational situation.

When water level difference between the lagoon and the sea is small, a two-layer motion can be seen. In the upper layer of the Klaipėda Strait fresh water flows to the sea, and in the lower layer saline water enters the lagoon. Two-layer currents are dangerous for large ships, as they steer badly.

When storms are observed in the near shore zone of the Baltic Sea - wind, wave and currents create dangerous navigational conditions, dangerous for ships coming into the port of Klaipėda; also difficult conditions appear at the Būtingė terminal.

For example, in November 1981 the British tanker "Globe Assimi" had an accident in the port gate. When the wind of 30 m/s was blowing, the 170 m long ship was thrown on the wave breaker of the northern mole. The tanker split into three parts. About 16.5 thousand tons of fuel oil was spilt to the sea. Rescue work was complicated due to bad hydro-meteorological conditions, so the oil spread quickly and contaminated the coastal area of 90 km [8].

On 6 March 2001 accident happened at Būtingė terminal station (during the loading of m/t "North Pacific") and about 3 tons of oil spilt into the sea. The buoy called SPM is 7 km from the coast (co-ordinates 56° 02' 48" N; 20° 57' 40" E). The main reasons of the accident were bad weather conditions and inobservance of the safety rules. The wind at that time was 17-19 m/s; the height of waves was about 3-3.5 meters. After this incident the decision was made to load tankers when waves up to 2 meters and the speed of wind less than 15 m/s.

The second spillage of oil happened on 08 03 2001 when 300 kg of oil, which had remained in the oil pumping hose, spilt into the Baltic Sea.

At present, my institution is using Swedish (SMHI) Seatrack Web programme. It is a user-friendly program for forecasts and presentation of the spreading of oil, chemicals and substances in water. The system is developed at SMHI to be used, among others, by the Swedish Coast Guard, Swedish Rescue Service Agency, and Swedish Maritime Administration, Lithuanian, Danish, Estonian and Latvian authorities. The document [3] is a manual to the system Seatrack Web.

When login at SMHI Seatrack Web, one has access to current fields from the 3-dimensional HIROMB model. It gives a new 48 hours forecast every morning. The model covers the whole Baltic Sea out to the North Sea with the horizontal resolution of 3 nautical miles and 24 layers in vertical

direction. Current fields are output every third hour. After supplementary data about the kind of the oil, its amount and coordinates, hydro-meteorological conditions were introduced into the Seatrack Web programme, an oil drift model was obtained which was very close to the real situation. It is confirmed by the data received from the captains of the Klaipėda port, the rescue service and also from the rescue vessel "Šakiai", and the coordinates of the oil spots seen from the plane (Fig. 6).
Briefly about both cases:

1) 06 03 2001 at 21:00 3 t of oil were spilt. At first, when the wind was from the west the oil drifted towards Klaipėda in the northwesterly direction. After the direction of the wind changed to the southwest, the oil began to drift towards Latvian coasts, to the north (Fig. 4). This is the Seatrack Web picture that is shown when a calculation is ready, for the last time step. When we want to look at the result more thoroughly, we zoom the picture [3].

   The red cross denotes co-ordinates of the SPM buoy, where the spillage occurred. The red track consists of the calculated oil "particles" in the surface layer. Co-ordinates of these points were recorded and then compared to the real positions observed by the rescue vessel of the SAR service and the safeguard plane.
   The co-ordinates, which were specified by the rescue service, were very close to the co-ordinates pointed out in the Seatrack Web. This situation can be seen in the Fig. 6. I received these data from the port rescue service and I put them next to the coordinates of the data received while working with the Seatrack Web model.

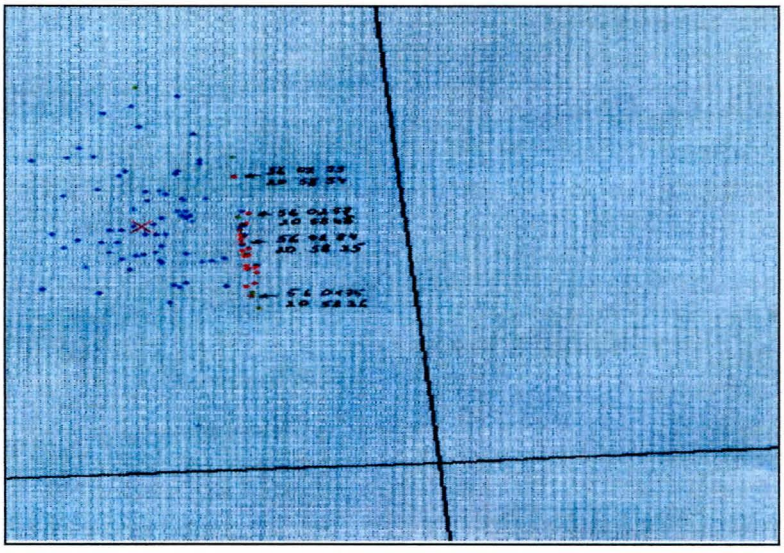


Fig. 4. Seatrack Web model of the oil drift (from 06 03 2001 to 08 03 2001)

2) The second spillage of oil happened on 08 03 2001 at 10 UTC. About 300 kg of oil were spilt. The speed of wind was not big -5 m/s. It is interesting to mention that the wind was from the northwest, and the direction of currents at that time in this part of the Baltic Sea was opposite (water moved to the north) (Fig. 5). After comparison of the concrete data with the calculations of the model we received a similar situation (Fig. 6).

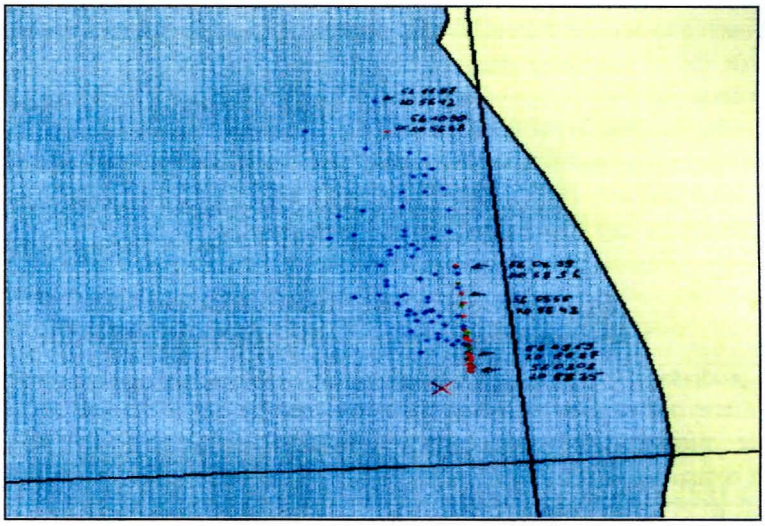


Fig. 5. The model of oil drift the second spillage (08 03 2001)

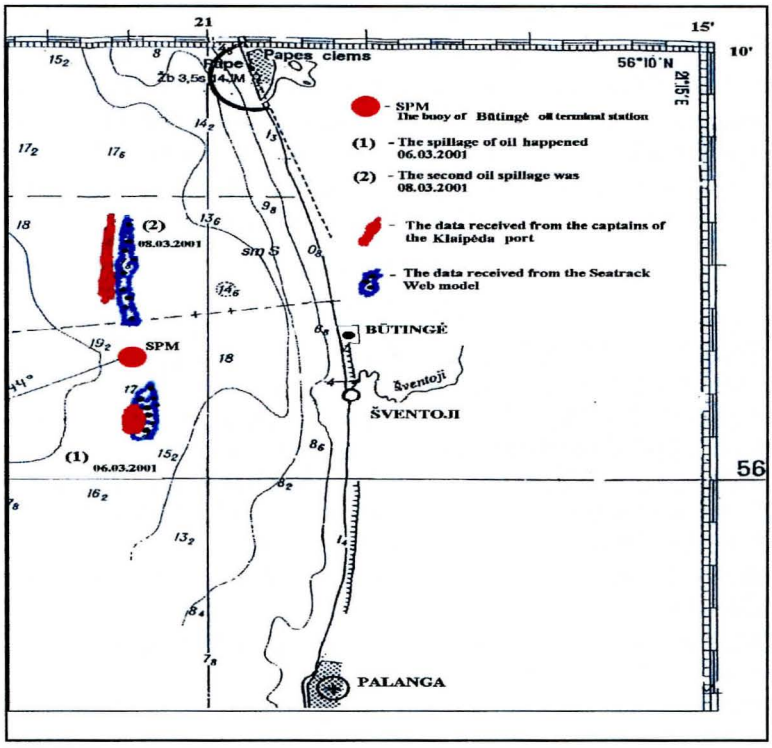


Fig. 6. The co-ordinates of the data received while working with the Seatrack Web model and the data from captains of the port

It was impossible to analyse thoroughly this situation, because at that time the rescue work was being carried out, the oil was being gathered, booms were being placed. It is difficult also because there were two cases and they duplicated one another, i.e. the oil of the second case repeated the drift of the first one after the direction of the wind changed. Therefore both cases might have intersected. Another type of raw oil was installed into the model, which produced inaccuracies also. However, on the whole, the result was very similar, therefore that the Seatrack Web oil drift forecast model, for spills in the Baltic Sea, is very effective and can be used in practice.

Conclusions

Oil and oil products belong to the most dangerous and widely spread marine contaminants. Every spillage of oil is unique. The place of spillage, the amount and the type of the spilt oil, the weather conditions usually are different. Risk factors, connected with oil spillage, are trade of oil products, economic activities of oil companies in the Baltic Sea and hard hydro-meteorological conditions. Strong wind, limited visibility, wind waves, low water level, water currents create dangerous navigational conditions and difficult conditions for any human activity in the Baltic Sea. Investigations of oil spill risk factors can give possibility of a spill prediction. Hydro-meteorological measurement data and forecast are needed to simulate oil spill drift. At present, the Centre of Marine Research is responsible for submitting the forecast of the oil spill drift to the Lithuanian Ministry of Environment after the spillage of oil has happened in the Baltic Sea. CMR is using Swedish (SMHI) Seatrack Web programme. On 6 March 2001 the accident happened at Būtingė terminal. The Seatrack Web oil drift model was close to the real situation. Therefore, oil drift forecast modelling could be very effective. Oil spills have become a large contamination hazard for the Baltic Sea ecosystem. Investigations of risk factors by different methods and models enable us to forecast and warn of possible environmental hazard.

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