Scientific Journals
Maritime University of Szczecin

Zeszyty Naukowe
Akademia Morska w Szczecinie

2013, 36(108) z. 1 pp. 110–115
ISSN 1733-8670

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M/t "Baltic Carrier" accident. The reconstruction of oil spill with PISCES II simulator application

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Key words: oil spill, accident, PISCES II simulator, safety, mathematical models

Abstract
This paper presents reconstruction of the oil spill that occurred as result of an m/t "Baltic Carrier" accident. This reconstruction was carried out with use PISCES II simulator. The result of several simulations could be the step to usability and validation of PISCESS II simulator and as a guideline for setting up this kind of simulations.

Introduction

Problems related to oil spills are still actual [1] especially on sea areas of high sensitivity like Baltic Sea qualified by IMO to PSSA (Particularly Sensitive Sea Areas) [2]. However, the safety on the Baltic Sea is relatively high comparing to other regions [3]. All possible efforts have to be taken to increase its level.

Such aims were set up to the Baltic Master I and II project where Maritime University of Szczecin took part as partner conducting several studies in field of oil spill at sea.

The research area with highest importance is using mathematical models and simulators for prediction of accidental situations, response planning and training. The paper presents the biggest oil spill on the Baltic Sea reconstructed with used of PISCES II simulator for validation purposes.

M/t "Baltic Carrier" accident

In the morning of the 29th of March 2001 at 0015 (L.T.), the vessel "Tern" and the oil tanker "Baltic Carrier" (Table 1) collided on the Baltic Sea in the position 54°43'N and 012°35'E, east of the Danish Falster Island. "Tern" was the bulk carrier carrying sugar from Cuba to Latvia. "Tern" ran into the tanker "Baltic Carrier", which was carrying 30,000 tons of heavy fuel oil of 380 type from Estonia to Sweden [4]. Parameters of collided ships are presented in table 1.

Table 1. Particular of the vessels [4]

Name of ship	BALTIC CARRIER	TERN
Registration No.	V7CC4	P3Q02
Home Port	Majuro	Limassol
Flag	Marshall Island	Cyprus
IMO No.	9208124	7327603
Type of ship	Chemical / Oil Tanker	Bulk Carrier
Construction year	2000	1973
Tonnage	22500 BT	20362 BT
Length / breadth / draft (in meters)	182.2/27.3/10.9	185.5/26.0/11.1
Engine Power	12 871 kW	8496 kW
Crew	19	22
Owner	Interorient Nav, Hamburg	Ranger Marine SA, Piraeus
Classification Society	Det Norske Veritas	American Bureau of Shipping

After collision heavy fuel oil from tank No. 6 began to release. Sea conditions at that time didn't allow the controlling of leakage and oil slick started to drift towards Danish islands.

Despite the implementation of the contingency plan for a couple hours after the accident, the operation at sea was limited only to observe the leakage from the air. Sea operations were difficult to organize due to waves of two meters height. About 0530 p.m. the oil slick reached the coast of Bogø, Møn and Falster islands.

Fig. 1. 'Baltic Carrier' after the collision [4]

On March 30th the Danish Environmental Protection Agency prepared the Task Force mission to collect the oil settled on beaches. About 50 km of beach was polluted by oil. There was no time left because the highly polluted coastline which consisted mainly on very sensitive wet, shingle and gravel beaches. Also disturbing was the fact that much of the oil had settled on the shore overgrown with reeds.

Due to the inconvenient weather conditions oil recovering was not performed at the sea. About 16 km of the coast was polluted by oil. The area of pollution was divided into 8 zones to make the oil clearance operation more efficient. There were 220 civilians who helped with oil cleaning and 15 vessels involved.

Fig. 2. Localization of the sites of oil recovering [4]

In total from 2700 tons released, 2135 tons of oil was recovered on the coast.

PISCES II Simulator

The Potential Incident Simulation, Control and Evaluation System (PISCES II) is a response simulator that helps with preparing and conducting command centre exercises and area drills in oil spill response. Simulator PISCES II is one of the most effective tools to control and predict the propagation of oil spills.

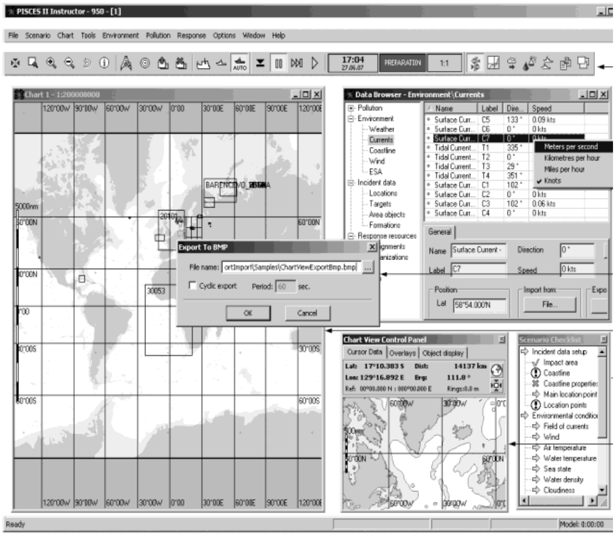

Fig. 3. PISCES II graphical interface layout

The PISCES II (Fig. 3) spill model simulates processes in an oil spill on the water surface: transport by currents and wind, spreading, evaporation, dispersion, emulsification, viscosity variation, burning, and interaction with booms, skimmers, and the coastline (stranding or beaching). The following factors are taken into consideration in the math model [5, 6]:

- environmental parameters: coastline, field of currents, weather, wave height and water density;
- physical properties of spilled oil: specific gravity, surface tension, viscosity, distillation curve and emulsification characteristics;
- properties of spill sources;
- human response actions: booming, on-water recovery, application of chemical dispersants.

Reconstruction of oil spills by PISCES II with use of "Baltic Carrier" case

To check if reconstruction in PISCES II simulator is possible, the case of "Baltic Carrier" has been chosen. Two scenarios were performed on the basis of the real data. Both of them were simulated to evaluate if the oil slick movement is similar to the real scenario.

Scenario 1

In the first scenario the information obtained from the "Baltic Carrier" report provided by Denmark Authorities was applied. In this report there were only general hydrometeorological data, given for the moment of collision. There was no detailed information about its temporal changes.

The simulation was performed on the following data:

Date of accident:

29th of March 2001, 0015 LT.

Accident position:

$\varphi = 54°43.33'N, \lambda = 012°35.12'E$.

Spill:

– type of oil: IFO 300 (similar particulars to 380 UK Texaco);
– amount of spill: 2700 tons.

Hydrometeorological conditions:

– wind: direction S-SE, speed 15–18 m/s;
– height of waves: 2.5 m;
– water temperature: 2°C;
– air temperature: 3°C;
– current: direction 315°, speed 5 knots;
– coastland type: sands.

The above conditions were not changed during the simulation as the accident report contained any information about it.

In the first scenario any response resources were used. Oil slick movement in this case was much different than in real case. The probability of reaching the coastline near the real positions was 0 and continuing simulation was abandoned after five hours and 20 minutes (Fig. 4).

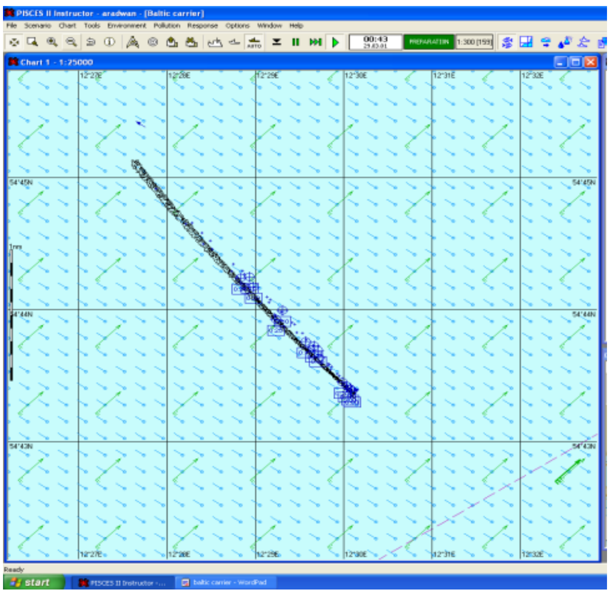

Fig. 4. Movement of the oil slick half an hour after collision

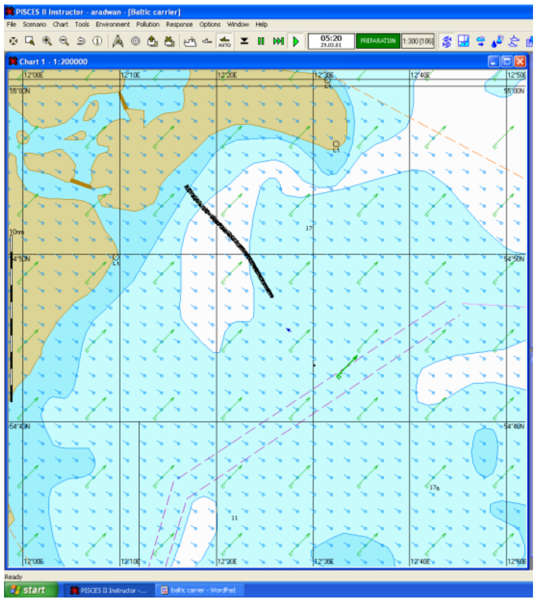

Fig. 5. Position of the oil slick five hours after simulated spill in Scenario 1

Scenario 2

In the second scenario the input data were the same as in the first scenario. Only difference was that now current data are changed during simulation.

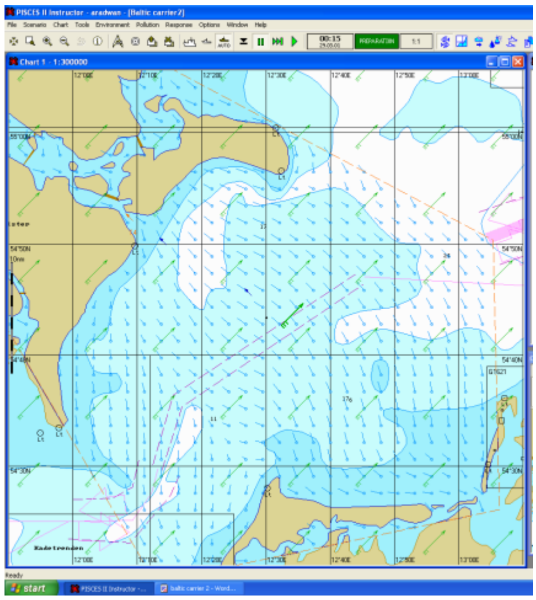

Fig. 6. The beginning of the simulation in Scenario 2

During the simulation the most important data to change were tidal current speed and direction. One hour fifteen minutes after starting the scenario, to increase probability of reaching the coast, current parameters were changed to: direction 295°, speed 2 knots, which is presented in the figure 6. A parameter change has been made in order to fit the simulated trajectory to the real trajectory of the slick.

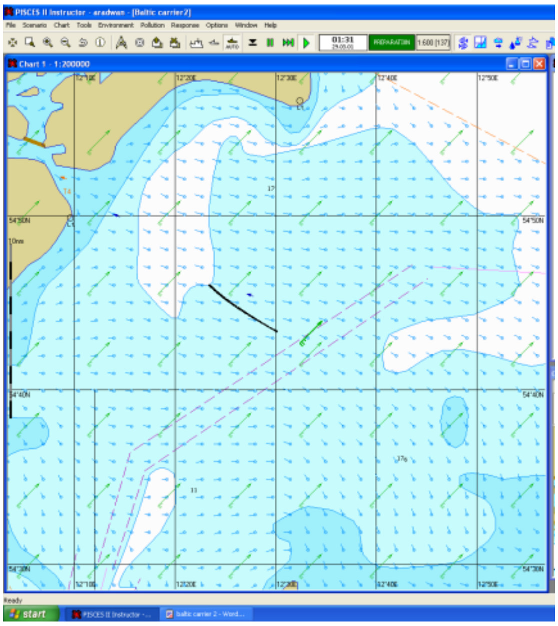

Fig. 7. Movement of the oil slick during changing current parameters

The current speed was reduced to two knots and direction was stated as 290°. The wind speed through the all simulation was not changed. At 0543 a.m. the following data of oil slick were obtained (Fig. 8):

– area of pollution: 3,622,866 m^2;
– maximum thickness: 5.1 mm;
– floating amount: 2645 t;
– stranded amount: 0.0 t.

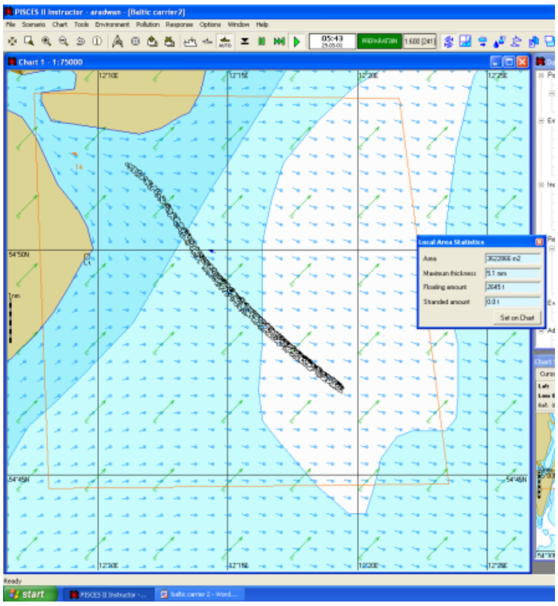

Fig. 8. Movement of the oil slick during changing current parameters 2

In the figure 8 it is precisely presented that the oil will reach the coast on Møn Island. It happened at 0618 a.m. and program showed the information "Oil impact the land" in the information window (Fig. 9). Oil slick parameters at those moments were as follows:

– area of pollution: 3625,501 m^2;
– maximum thickness: 5.7 mm;
– floating amount: 2627 t;
– stranded amount: 8.6 t.

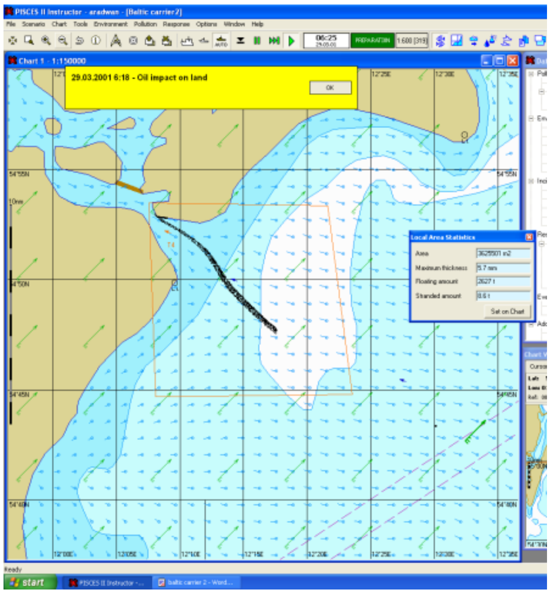

Fig. 9. Oil slick while impact the coast

In the figure 10 it is presented two booms, used in simulation, in "U" shape which were placed at 0700 AM between Bogø and Møn Islands in positions:

– boom formation 2: φ = 54°54.377'N, λ = 012°05.794'E;
– boom formation 3: φ = 54°54.251'N, λ = 012°06.194'E.

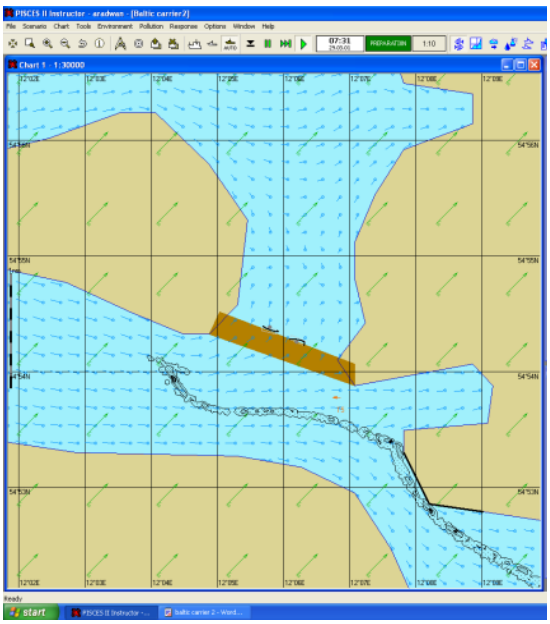

Fig. 10. Booms formation positions

The direction of the tidal current was changed to 270° at about 0800 am. The oil impacted the Bogø Island. The slick was still moving north-east and three more boom formations were set in positions:

– boom formation 4: φ = 54°56.694'N, λ = 011°58.804'E;
– boom formation 5: φ = 54°56.557'N, λ = 011°59.066'E;
– boom formation 6: φ = 54°55.889'N, λ = 011°59.881'E.

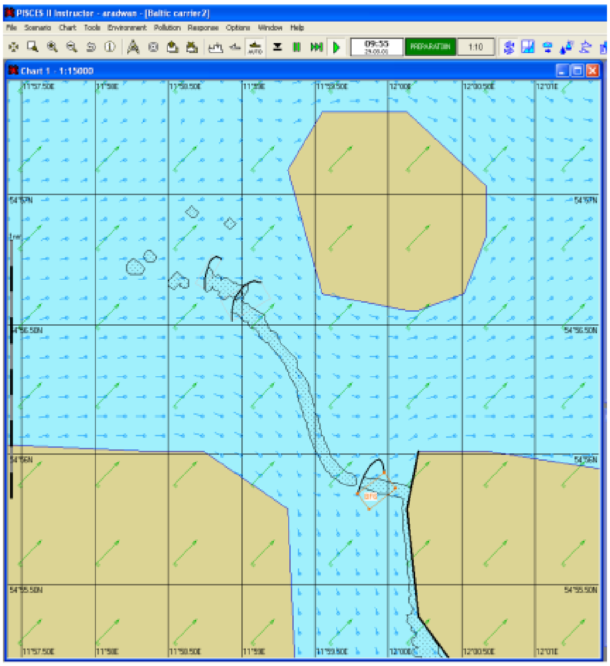

Fig. 11. Oil spill reaches the coast of Bogø Island and goes through the booms

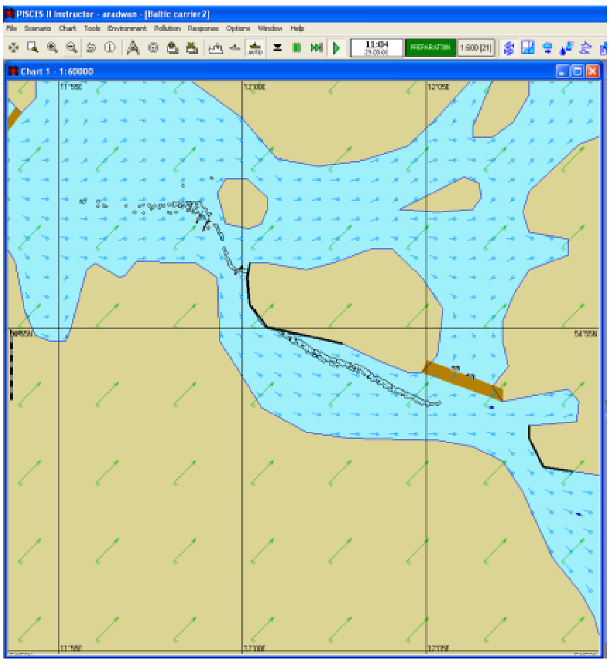

Fig. 12. Booms formation in positions 1

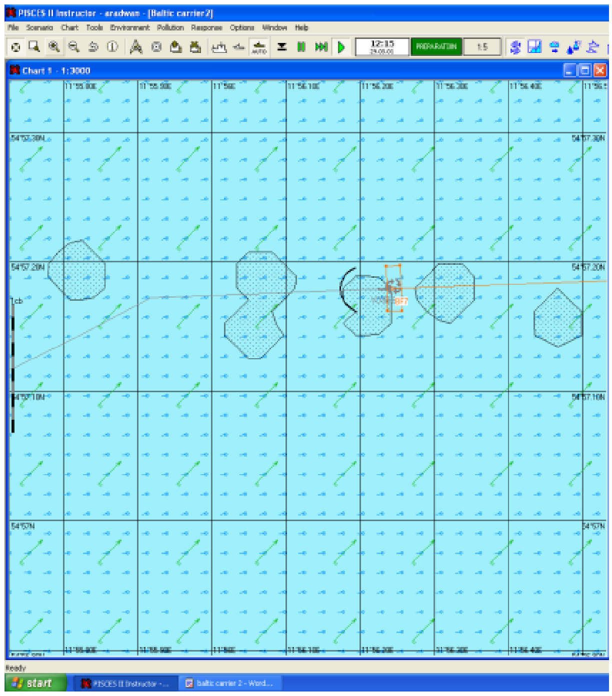

Fig. 13. Booms formation in positions 2

The oil could not be stopped integrally by those three booms, as it is shown in figure 12, so for the thickest and the smallest groups of oil there was located one more boom formation at 1148 a.m. in position φ = 54°57.172'N, λ = 011°55.916'E (Fig. 13).

The boom formation No. 7 was also "U" shape 20 meters length device as the previous booms. But in the opposite it was moving in direction of 88° with speed of 5 knots. Such data were adopted because of tidal current speed and direction. The last boom collected final groups of oil. Only small part of the slick was moving on but it evaporated very quickly not impacting other coasts. After one hour of using boom formation No. 7, which was at 1250 p.m. the simulation was finished.

Conclusions

The aim of this study was to prove that the oil spill reconstruction with use PISCES II simulator is possible. Several limitations, however, have been observed during realization of experiments. The crucial for oil behavior at sea are meteorological conditions which rarely are known. Especially the currents are affecting oil spills. The currents are nor recorded and in many cases only information from accident reports could be used for its determination in past.

The PISCES II simulator showed good correlation with real data especially in case of amount of oil which polluted the beach.

The main advantage of using such tools is possibility to test several scenario of response action with application of scenarios.

As a result of conducted simulations the guidelines could be developed for performing this type of research on the simulator PISCES II. These guidelines relate mainly to the quality and quantity of information to be provided in order to efficiently and accurately simulate. This includes detailed data on every possible change of direction and strength of the wind and current at a given area, type and physical and chemical properties of spilled substance and hydrometeorological conditions.

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