

Studies on the oil spillage near shoreline

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Abstract. This paper presents a simulation of an oil spillage near shoreline in real conditions. The purpose of the paper is to determine the evolution of oil spill on sea water surface and in the same time to determine the total costs of depolluting operations organized by the authorities. The simulation is made on the PISCES II Simulator (Potential Incident Simulator Control and Evaluation System) which is designed to handle on real situations such as oil pollutions of the sea. The mathematical model used by the simulator is the dispersion oil-water model, taking account all external conditions such as air/sea water temperature, current/wind speed and direction, sea water density, petroleum physical properties. In the conclusions chapter is presented oil spill details with a financial report for total costs of depolluting operation.

1. Introduction

The authors seek to achieve an estimate financial cost of a depolluting operation, held near the Eforie Nord resort, by simulating the response of authorities to the emergency situation created to limit and recovery the oil spilled on sea water surface.

To achieve simulation is used The Simulator for Emergencies Situations PISCES II from Constanta Maritime University - Department of Engineering Science in the Mechanical field and Environment.

The simulator is designed to be used in the preparation process, training and entrainment of staff management from command and operational centers, which perform practical activities for location, limitation and recovery of petroleum products spilled on the sea water surface. The software is designed to simulate the response in the event of discharges of oil on the water surface, so the mathematical model takes into account the authorities' response to the incident, in addition take into account the main physical-chemical processes which affect oil slick, such as: evaporation, dispersion, emulsification and viscosity variation and environmental factors, shoreline, sea currents, weather, sea state, ice and protected areas [5].

2. Description of the event and the authorities' response

After some technical problems occurred aboard a tanker, while traveling to berth 79, from Constanta Sea Port, next to Eforie Nord resort is accidentally spilled, on the sea water surface, a quantity of 234 tonnes of unrefined oil, Iranian Heavy [6]. Pollution resulting from the discharge of oil product it is immediately revealed by the sailors and according to current regulations, the master report the incident and ask for help to limit and collect the oil product on the sea water surface, while the internal procedure to remedy the defect it is implemented and thus the discharge of oil product it is stopped.



The Romanian Agency for Saving Life at Sea, it is called to intervene for removal of spilled petroleum product, on the sea water surface. The agency decides to use a sea tug, "Hercules", figure 1 respectively two boats "Safir" and "Cristal", figure 2.



Figure 1. Sea tug "Hercules" [1].



Figure 2. Boats "Cristal" and "Safir" [2].

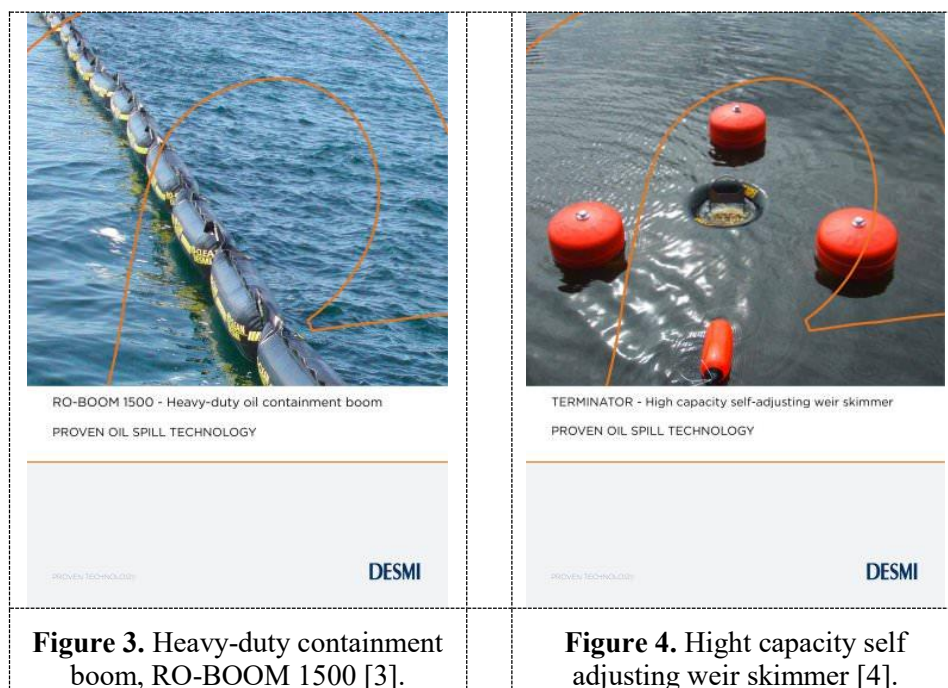
The sea tug "Hercules", figure 1, it is used to transport special intervention equipment which are used to limit and recovery the oil product from sea water surface (booms and skimmers). The sea tug has the following features:

- Length: 68.5 m;
- Width: 16.5 m;
- Speed: 12 Nd;
- Draught: 6.5 m;
- Displacement: 2,388 tons
- Crew: 16 people;

The sea tug "Hercules" transports the following emergency equipment, required to limit and recovery the spilled oil products from sea water surface, as follows:

- heavy-duty containment boom, RO-BOOM 1500, 2000 m, figure 3, which has the following characteristics:

- Producer: Ro-Clean Desmi;
- Model: RO-BOOM 1500;
- Standard section length: 200 m;
- Width: 1.30 m;
- Freeboard: 0.50 m;
- Draught: 0.7 m;
- Launch time/section: 40 min;
- high capacity self adjusting weir skimmer, figure 4, which has the following characteristics:
 - Producer: Ro-Clean Desmi;
 - Model: Terminator;
 - Recovery rate: 130 m³/hour;
 - Weight: 162 kg;
 - Recovery radius: 20 m;



The intervention boats "Cristal" and "Safir", figure 2, are used for launching and handling booms, they have the following characteristics:

- Length: 18.7 m;
- Width: 4.95 m;
- Speed: 18 Nd;
- Draught: 1.5 m;
- Displacement: 46 tons
- Crew: 4 persons;

After 20 minutes from the request one tug and two boats are ready for the mission.

3. Data used for the simulation

To do this simulation it is used The Simulator for Emergencies Situations PISCES II, where we introduced, as input, the following parameters:

- a) hydro-meteorological parameters:
 - Sea water temperature: 15 °C;
 - Air temperature: 12 °C;
 - Sea water density: 1,015 kg/m³;
 - Speed/direction of the current: 0.5 m/s with a 280 °;
 - Speed/direction of the wind: 2 m/s with 270 °.
- b) physical oil product parameters:
 - Density: 876 kg/m³;
 - Surface tension: 0.0264 N/m;
 - Kinematic viscosity: 22.8·10⁻⁶ m²/s;
 - Maximum water content: 70 %;
 - Pour point: - 22 °C;
 - Flashpoint: - 15 °C.

4. The result of the simulation

Two scenarios were simulated, namely:

- in the first scenario, the authorities for various reasons, do not intervene to limit or recovery spilled oil product, so inevitably in this situation the northern beach of the Belona tourist port in Eforie Nord resort will be polluted;

- in the second scenario, specialized forces locate, limit and recovery the entire amount of spilled oil, in this way beach pollution is avoided.

4.1. Specialized forces inaction

The evolution of the oil slick in case of inaction, is shown in figure 5.

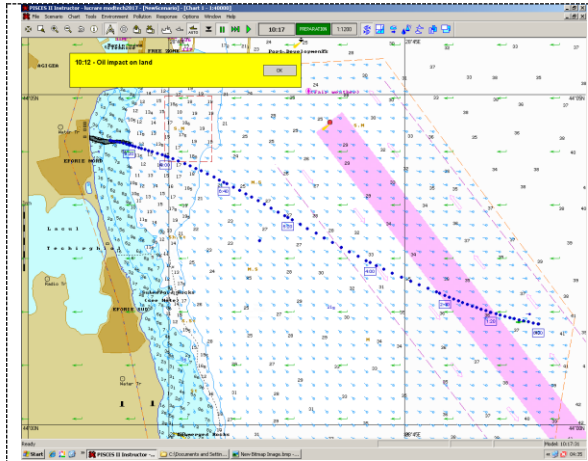


Figure 5. The evolution of oil slick in case of inaction [5].

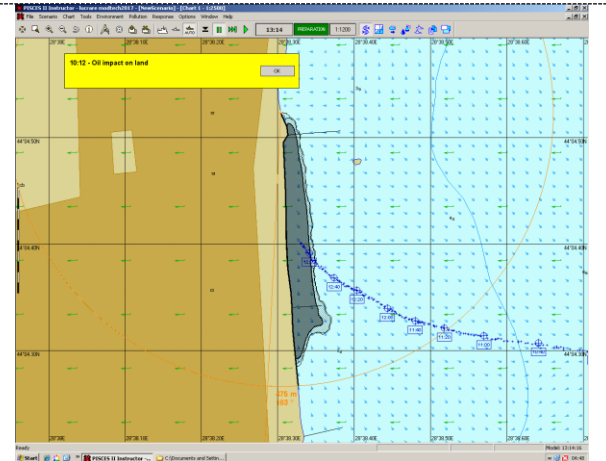


Figure 6. Oil contamination in northern beach of the Belona tourist port in Eforie Nord resort [5].

In this case, as a result of inaction, in ten hours and twelve minutes, oil slick under wind and sea currents actions, it is transported over a distance of 13.8 km, up to the northern beach of the Belona tourist port in Eforie Nord resort.

In thirteen hours and ten minutes, the beach it is polluted over a distance of 475 m, with an amount of 5.1 tonnes of oil product. The volume of mixture (oil/water) is 322 m³, of which 174 m³ it is oil. The maximum thickness of the oil slick is 62 mm, and the surface is 18,711 m², figure 6.

In table 1 it is shown the characteristics of the oil slick during transport, under the action of marine currents and wind to the northern beach of the Belona tourist port in Eforie Nord resort.

Table 1. Characteristic of oil slick in case of inaction.

Time	Amount spilled [m ³]	Amount floating [m ³]	Amount evaporate de [m ³]	Amount stranded [m ³]	Amount floating mixture [m ³]	Max thickness [mm]	Slick area [m ²]
00:30	33.7	33.4	0.3	0	34	5	19.392
01:30	67.9	66.8	1.1	0	69	4.3	50.253
01:30	102	99.6	2.5	0	105	3.5	88.587
02:00	136	132	4.4	0	141	4.9	130.911
02:30	171	164	6.7	0	177	3.8	178.447
03:00	205	196	9.3	0	215	4.7	230.739
03:30	205	194	11.9	0	219	2.8	240.994
04:00	205	191	14	0	224	2.5	250.011
04:30	205	190	15.7	0	228	2.2	253.603
05:00	205	188	17.2	0	233	2.3	258.404
05:30	205	187	18.6	0	238	2.3	254.853
06:00	205	186	19.8	0	244	2.6	243.290
06:30	205	185	20.8	0	249	2.6	232.401

Time	Amount spilled [m ³]	Amount floating [m ³]	Amount evaporate de [m ³]	Amount stranded [m ³]	Amount floating mixture [m ³]	Max thickness [mm]	Slick area [m ²]
07:00	205	184	21.7	0	255	2.6	222.574
07:30	205	183	22.5	0	260	3.4	204.021
08:00	205	182	23.2	0	266	4	179.487
08:30	205	182	23.8	0	272	4.3	159.352
09:00	205	181	24.3	0	279	4.3	148.626
09:30	205	181	24.7	0	285	5.9	141.087
10:00	205	180	25.1	0	291	6	133.329
10:30	205	178	25.5	1.9	294	20.6	117.363
11:00	205	176	25.8	3.7	297	39.9	100.163
11:30	205	175	26.1	3.7	303	46.2	84.526
12:00	205	174	26.3	4.7	308	55	67.814
12:30	205	174	26.5	4.8	314	55.7	47.709
13:00	205	174	26.6	5	320	60.9	24.363
13:10	205	174	26.6	5.1	322	62	18.711

4.2. Specialized forces actions

The evolution of the oil slick, figure 7 and figure 8, in case of the action of specialized forces is stopped after about seven hours and fifty minutes from the announcement of the event, with two heavy-duty containment boom, RO-BOOM 1500, placed in cascade. The recovery of oil product is being made with two high capacity self adjusting weir skimmer.

The oil product recovery operation lasted about three hours and twenty five minutes, in this time the amount recovered mixture is 243 m³ and the amount of recovered oil is 186 m³.

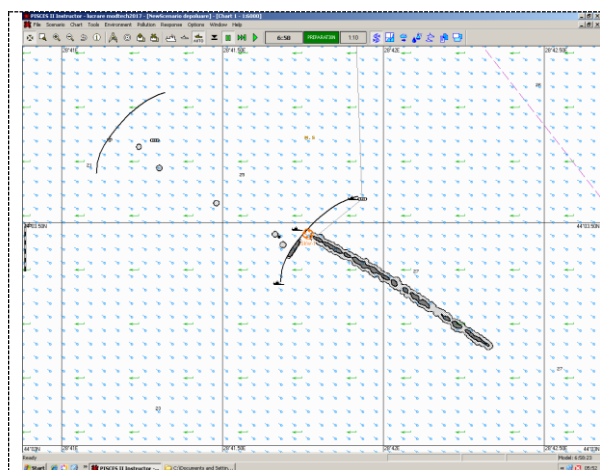


Figure 7. The evolution of oil slick in case of specialized forces action [5].

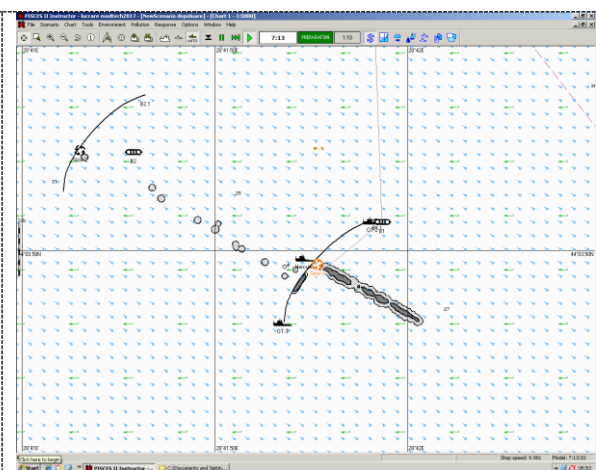


Figure 8. The evolution of oil slick in case of specialized forces action [5].

In table 2 it is shown the characteristics of the oil slick during transport, under the action of marine currents and wind as well as during limitation and not least to its recovery on the water surface.

Table 2. Characteristic of oil slick in case of action.

Time	Amount spilled [m ³]	Amount floating [m ³]	Amount evaporated [m ³]	Amount stranded [m ³]	Amount floating mixture [m ³]	Amount recovered mixture [m ³]	Max thickness [mm]	Slick area [m ²]
00:20	22.3	22.2	0.1	0	22.4	0	4.4	11.490
00:40	45.1	44.6	0.5	0	45.6	0	4.7	28.766
01:00	67.9	66.8	1.1	0	69	0	5	50.204
01:20	90.8	88.7	2	0	92.6	0	3.7	75.464
01:40	114	110	3.1	0	116	0	3.7	102.760
02:00	136	132	4.4	0	141	0	3.9	131.517
02:20	159	153	5.9	0	165	0	3.6	163.111
02:40	182	175	7.5	0	190	0	3.7	193.252
03:00	205	196	9.3	0	215	0	4.1	229.519
03:20	205	194	11	0	218	0	2.8	238.279
03:40	205	193	12.6	0	221	0	2.6	243.413
04:00	205	191	13.9	0	224	0	2.4	246.916
04:20	205	190	15.1	0	227	0	2.3	249.678
04:40	205	173	16.2	16	209	20.9	2.3	228.643
05:00	205	155	17.1	32.9	190	43	11.8	204.362
05:20	205	134	17.8	53.5	165	69.9	9.6	174.403
05:40	205	112	18.4	74.5	140	97.4	10.7	144.094
06:00	205	92	18.9	94.4	116	123	10.8	118.135
06:20	205	71.7	19.3	114	91.4	149	12.1	91.068
06:40	205	52	19.5	134	67.1	175	13.2	66.858
07:00	205	31.5	19.7	154	41.3	202	14	36.837
07:20	205	11	19.8	175	15.1	228	13	13.386
07:40	205	0.5	19.8	185	0.7	243	0.6	2.409
07:50	205	0	19.8	186	0	243	0	0

Finally, the financial implications of the entire operation which was conducted with the help of this simulation is estimated to 20,236.94 €, according to table 3 and table 4.

Table 3. Ships costs.

Operation	Time	Sea tug "Hercules"		Boats "Cristal"/"Safir"		Total [€]
	[min]	Stationing [228 €/oră]	Marching [1,457 €/oră]	Stationing [38 €/oră]	Marching [221 €/oră]	
Training	20	76	-	25.33	-	101.33
Leaving in mission	70	-	1,699.33	-	515.66	2,215
Location of Equipment/Waiting	195	-	4,735.25	-	1,436.5	6,171.75
Oil recovery	185	-	4,492.41	-	1,362.83	5,855.24
Withdrawal equipment	50	-	1,214.16	-	184.16	1,398.32
Return from mission	70	-	1,699.33	-	515.66	2,215
Total	590	76	13,840.48	25.33	4,014.81	17,956.64

Table 4. Emergency equipment costs.

Operațiune	Time	High capacity self adjusting weir skimmer x 2	Heavy-duty containment boom (500 m) x 2	Actuator group for booms	Total
		[min]	[17 €/hour]	[0.28 €/ml/hour]	[12 €/hour]
Training	20	-	-	-	-
Leaving in mission	70	-	-	-	-
Location of Equipment	100	56.66	466.66	20	543.32
Waiting	95	53.83	443.33	-	497.16
Oil recovery	185	104.83	863.33	-	968.16
Withdrawal equipment	50	28.33	233.33	10	271.66
Return from mission	70	-	-	-	-
Total	600	243.65	2,006.65	30	2,280.3

5. Conclusions

Analyzing the price of an oil barrel, which in this moment, 10.03.2017, is approx € 47/barrel and estimating the price of spilled oil, as about € 60,600, we conclude that strict theoretically, the financial implications for locating, limiting and recovery, by simulating the spill of 205 m³ on the sea water surface, is about a third of the price of oil spilled. Estimate ignores that in case of real spill of the same volume of oil, the financial costs of entire operations it is much higher, this is influenced by:

- experience of personnel who operate the special equipment for recovery oil spilled;
- receiving in a timely manner the information about oil spill transport under the influence of wind and marine current;
- practical problems that may arise in real operations and that can delay the operation of recovery (eg operation in rough sea conditions, sudden changes in hydrometeorological conditions, faulty equipment etc.).

6. References

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