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Research Article

Marine pollution simulation and comparative intervention procedures based on case scenario

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Abstract

Experience and evolving technology have made it possible to combat marine pollution in more effective ways. Apart from a lack of appropriate reaction resources in prior oil spill catastrophes, presently Turkiye has a more potent ability. The objective of this research is to establish the efficiency of the response to marine pollution which might emerge in the Istanbul Strait with the presently available functionalities, as well as to offer suggestions over what operational and technical upgrades could be made to ramp up this effectiveness. PISCES II (Potential Incident Simulation Control and Evaluation System) oil pollution modelling and decision support system was utilized to fulfil the study's purpose. In the conclusion of the study, correlative statistics prove how to use assets in the intervention action to combat oil pollution in the Istanbul Strait, how surface vessels are employed during these operational processes, as well as the significance of the initial reaction speed.

Keywords: Marine Pollution, Oil Spill, Intervention to Oil Spill, Istanbul Strait, PISCES Simulation.

Introduction

Straits, narrow waters and canals among the waterways used in maritime transport create advantages in terms of shortening the distances, but they also preserve the risks for navigation safety and environmental pollution when traffic density, morphological and oceanographic factors are taken into account. Among the Turkish Straits, Istanbul, with its sharp turning points and narrow structure, as shown in Figure 1, poses a morphological threat to the ships passing through oceanographically, with strong and opposite surface and subsurface currents. In addition to its oceanographic and morphological features, Istanbul Strait also poses great risks in terms of heavy ship traffic. When the cargo analysis of the ships passing through the Strait was made, it was determined that a total of 8248 tankers carrying petroleum, chemicals, liquefied natural gas and liquefied petroleum gas passed through in 2021 (UAB, 2022). These navigational difficulties and heavy maritime traffic in Istanbul Strait have brought serious accidents and environmental disasters in the past. For instance, as a result of the Independenta accident in 1979 and the Nassia accident in 1994, a total of 72 crew members lost their lives and 115,000 tons of dangerous goods were spilt into the Istanbul Strait (Korçak, 2015). While many seafarers lost their lives because of these accidents, a great environmental disaster was experienced due to the oil spilling into the sea and burning. In addition to these social and environmental losses, the closure of the Strait to maritime traffic for days has also brought about economic losses.

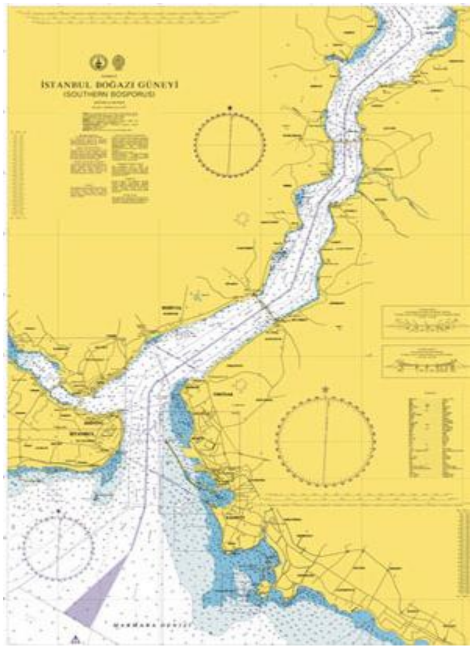


Fig. 1. Istanbul Strait (ONHO, 2020)

After the Exxon Valdez tanker accident, which resulted in the spilling of 37,000 tons of crude oil into the sea in the Gulf of Alaska in 1989, it became clear that a single state's intervention would not be sufficient for such large-scale marine pollution, which threatens not only the relevant coastal state but also other littoral states, and that cooperation and coordination are necessary. In parallel with this, The International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), brings the responsibility of states to create an effective organization to be prepared for oil pollution at sea and to develop their capabilities, to share these opportunities with other states within the scope of mutual support and to establish regional cooperation organizations was signed in 1990 (Güven et al., 2006).

Parallel to the OPRC 1990, which is the most comprehensive and effective international agreement in the fight against marine pollution, Turkiye enacted Law No. 5312 pertaining to principles of emergency response and compensation for damages in pollution of the marine environment by oil and other harmful substances in 2005. In parallel with these responsibilities, Turkiye has both strengthened its organizational structure and increased its response efficiency with the improvement in its technical infrastructure to fight against marine pollution that may occur both in the Istanbul Strait and within its area of responsibility. This study aims to reveal how the oil pollution that will occur as a result of a possible accident in the Istanbul Strait can be intervened with the existing equipment in the inventory, and then how the improvements to be made in this equipment will provide advantages in the intervention.

When the studies on how the oil spill that will occur after a ship accident spreads and the principles of intervention to it are examined,

Korçak (2015) numerically revealed the environmental pollution risks that will occur due to oil pollution and loss of life and property to be caused by a possible marine accident in the Istanbul Strait. Koroglu and Kabdasli (2011) created an oil pollution scenario in the Haydarpaşa port area of the Istanbul Strait, revealed the spread pattern of this pollution through the OILMAP program, and emphasized the effectiveness of the use of dispersant and the importance of the first intervention to be made within 1 hour. Güven et al. (2004) searched that; after the maritime accident in 2002, the oil spilt from the ship Gotia into the Istanbul Strait waters polluted where, which sea creatures were damaged and to what extent, and on which coasts, and how much pollution was experienced. In the thesis of Doğrul (2010), the propagation of oil pollution occurring in the Rumeli Kavağı region of the Istanbul Strait was modelled using the computational fluid mechanics method. Başar (2003) used the Princeton Ocean Model (POM) to produce the Istanbul Strait surface current model, and via the General NOAA Oil Modeling Environment (GNOME) model, determined the oil spread and risky areas depending on time. Can (2007) on the other hand, carried out an oil spill simulation in the Istanbul Strait through Fluent and GNOME programs. Bozkurtoğlu (2017) presented oil spill modelling in the Istanbul Strait through the Particle Tracking Oil Spill Model (PTOSM) and recommendations for intervention with barriers have been suggested in the study. Ozsoy (2014) evaluated 12 narrowband images obtained by the RADARSAT-1 satellite for marine pollution at the North exit of the Istanbul Strait in the summer and autumn months of 2010 and 2012 and demonstrated the effectiveness of the use of satellites for the detection of oil pollution. Marta-Almeida et al. (2013) simulated the Krimsk accident on the Texas coast, the Prestige accident in the Galicia region, and the Campos accident on the Brazilian coast using GNOME software and demonstrated the effectiveness of GNOME by comparing it with the actual oil spills that occurred. Ventikos et al. (2004) developed a decision-making process by making an operational synthesis in the use of oil spill intervention tools and evaluated with examples which tool should be used effectively and with priority. Perkovic et al. (2008) compared the satellite images obtained for marine pollution during the Lebanon crisis with the PISCES-II simulation outputs and demonstrated the efficiency and accuracy of PISCES-II. A similar study was conducted by Nicolae et al. (2016) for the Black Sea, and in this study, an oil pollution scenario was produced on the Romanian coast and how the fuel would spread on the sea surface in the light of meteorological and oceanographic data, the technical equipment allocation and decision process for the intervention were simulated through PISCES-II. In Perkovic et al. (2010), a study was conducted on the detection of ship creating marine pollution. In this context, detecting marine pollution with satellite images, detection of suspicious vessels for oil pollution through the Automatic Identification System (AIS) integrated into the PISCES-II decision support system, detecting the source ship causing oil pollution by using the backtracking future of the PISCES-II system method have been applied. Another study which is carried out by Usluer et al. (2022), in the chosen sample region on the Strait of Canakkale, one of the Turkish Straits, described how to simulate and forecast a tanker accident of the scale of the Nassia or Independenta by utilizing PISCES-II.

Material and methods

For the purpose of the study, the scenario of a ship accident in the Istanbul Strait and subsequently a large amount of fuel pollution on the sea has been created. This scenario was processed into the Potential Incident Simulation, Control and Evaluation System (PISCES-II) simulation program, subsequently, it was revealed how the spilt oil spread over time, and then, again utilizing PISCES, it is simulated how long and effectively it can be controlled by using available oil pollution intervention tools. Then, it has been determined how this time and effectiveness can change if the technical conditions of the said intervention tools are improved. Within the framework of the results obtained; proposals have been made to increase the effectiveness of the response to oil pollution.

PISCES (Potential Incident Simulation Control and Evaluation System)

As a result of the literature research, it has been determined that the studies on the oil spill at sea are carried out with programs such as OSCAR, OILMAP, StatMap, GRACAT, GNOME, ADAM, but these programs do not simulate how to intervene in the spilt oil, and which types of vehicles can be used with what tactics. In the same way, it has been revealed that it is not possible to decide to employ these programs at which angle the barrier is laid, the oil can be controlled, with which formation ships should tow the barrier, and which type of skimmer should be deployed in which locations. The mathematical model of the PISCES II application, which is focused on oil pollution response, considers human-induced response activities, coastal structure, surface currents, weather and sea conditions, and environmentally sensitive marine areas. The coastline is presented in the program as a series of closed polygons automatically derived from vector-based nautical charts. Surface currents are derived from time-dependent velocity changes of a set of reference vectors. The velocity of the runoff at a given point is produced by linear interpolation of the reference vector value. The spreading of oil is based on the Langrangian model, in which the particles that make up the oil mass are subjected to horizontal motion as a result of the effects of current, wind and diffusion (Delgado et al., 2006; Aydın and Solmaz, 2019).

Initial setup of the simulation

In the study, within the scope of the scenario to be created in the Istanbul Strait, the reference current vectors for the surface current map, which will be the basis for the oil dispersion in the PISCES decision support system, are interpolated by the system. These interpolated values have been consolidated by correlation with the Turkish Straits Oceanographic Atlas ONHO (2009) prepared by the Turkish Naval Forces Command, Department of Navigational Hydrography and Oceanography (ONHO), Can (2007), Özyalvaç (2009), Koroglu and Kabdasli (2011), Doğrul (2010), Bozkurtoğlu (2017), Başar (2003) and statistical data of the current buoys placed in the Istanbul Strait by the Coastal Safety General Directorate and consequently Istanbul Strait surface current maps were created according to the seasons.

For meteorological data such as seasonal averages of air temperature, wind conditions, and sea water temperature, which are input to the scenarios created, were requested from the General Directorate of Meteorology, a subordinate of the Ministry of Agriculture and Forestry, and the obtained values were inserted into the PISCES simulation program.

For deciding on the starting location of the fuel pollution in the scenarios; the maritime accidents and sensitivity analyses that have been made for the Istanbul Strait before were examined. In order to test the maximum capacity of the technical possibilities, an accident in Haydarpaşa in the spring season, which has the most difficult environmental conditions, was decided to form the basis for the scenario.

Intervention capabilities of the Coastal Safety General Directorate and civilian companies were revealed, and scenarios were built on this inventory information in the PISCES simulation program. Especially the heights of the barriers play a leading role in controlling the oil in places with high-speed currents such as the Istanbul Strait. For this purpose, the technical features of the barriers available in the inventory were examined and their surface height has been accepted as 0.6 m. while underwater (draft) lengths as 1 m. For the cases where these conditions are modified, the height above the water of the barriers has been inserted into the simulation as 1 m and the length of the underwater (draft) as 2 m. As a result of the field studies in the Coastal Safety General Directorate and civilian companies, it has been determined that making ready for the 1.000m length, single point inflated via external compressor barriers takes at least 3 hours and this time can be reduced to 1 hour for self-inflatable barriers of the same length (Versatech, 2022). For the skimmer, when the current conditions are simulated, the ones with a maximum capacity of 50m3/h are used, while the ones with 200 m3/h capacity are used in the improved conditions.

Although the types of crude oil carried by the tankers passing through the Strait vary widely, neither too light nor too heavy fuel type was preferred to measure the effectiveness of the intervention, and AMAULIGAK (light crude oil) was chosen in the Group III category as the basic fuel type for pollution in all scenarios and density: 0.89 g/cm3, surface tension: 21.1 dyn/cm, viscosity: 15.7 cSt have been set to the simulation as oil values. In the scenarios where the accidents were created, it was assumed that 1.000 tons of oil were spilt at the time of the first accident, followed by a leak, a total of approximately 2.800 tons at the end of 4 hours, and approximately 3.200 tons at the end of 5 hours. To serve the purpose of the study, after obtaining all the above-mentioned simulation infrastructure data, initially, it has been revealed how the fuel will spread over the sea over time. Subsequently, these pollutions were intervened with the assets in the inventory, and then their technical features were used with improved versions, the results were compared and tactics that would provide optimum intervention conditions were revealed consequently. The simulation inputs and the basis for the scenario are summarized in Table 1.

Table 1. PISCES-II Simulation setup conditions

Position	Oil Type	Wind	Current	Oil spill amount	Air temp.	Water temp.	Wave height	Water density
41°01.5’N 028°59.9’E	AMULIGAK, Group III Viscosity:15.7 cSt Density: 0.89 g/cm^3 Surface tension: 21.1 dyn/cm	N-NE 7 kts.	S-SW-SE 3-4 kts	Initial point source spill: 1.000 m^3 Leak source spill: 500 m^3/h	17.5 °C	13°C	0.1 mt.	1010 kg/m^3

Discussion

The scenario in Istanbul Strait, spring season, Haydarpasa location

In this scenario, it is assumed that there was a ship accident in the south of the Strait, off Maiden's tower-Haydarpasa, 1.000 tons of oil spilt into the sea at the time of the accident, and a total of 3.150 tons of fuel was spilt in the next 5 hours after the ship ran aground on the east of the Haydarpasa breakwater.

Spreading oil at sea without intervention

The fact that the average surface current speed, which is 0.5-2 kts in the northern and middle parts of the Strait, reaches 2.5-3 kts in the southern parts, especially around Haydarpasa, makes it even more important to plan the measures to be taken against oil pollution in this region. In this context, while alternatives can be produced to control the oil spreading to the sea surface using barriers by turning the curved morphological structure into an advantage in the northern and middle parts, this is not possible in the southern part with the disadvantage created by the current speed. The accuracy of this prediction has been tried to be revealed in the context of response scenarios to be produced with the support of PISCES-II. For this purpose, within the initial conditions specified in Table 1, how the oil on the sea surface will spread after 4 hours without intervention, is given in Figure 2 to Figure 5, how much of the sea area the oil pollutes, what thickness it reaches after 5 hours, etc. statistical information is presented in Table 2 and Figure 6.

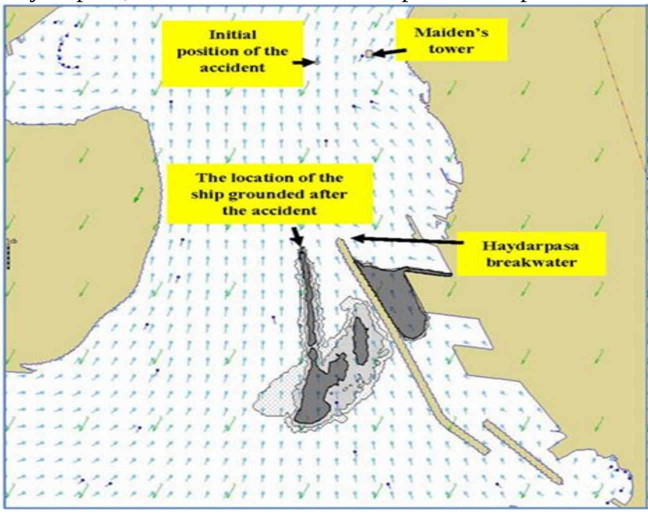


Fig.2. Spreading of oil after 30 minutes- (No intervention)

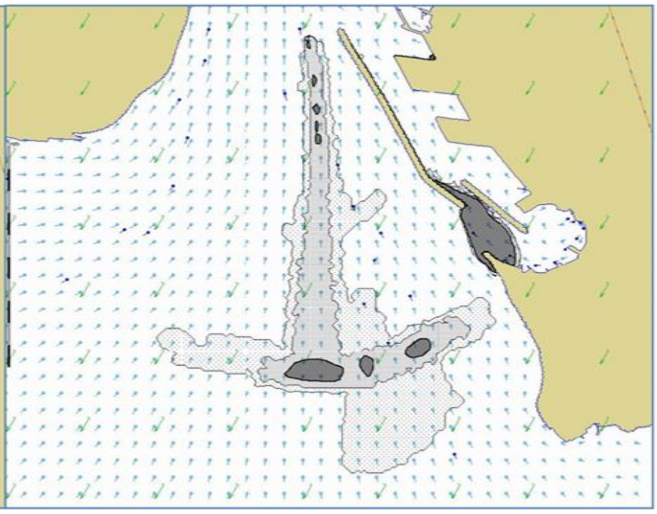


Fig. 3. Spreading of oil after 60 minutes - (No intervention)

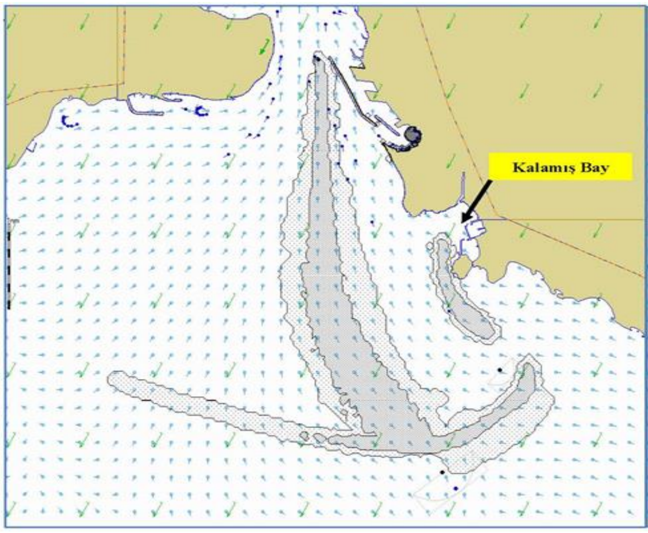


Fig. 4. Spreading of oil after 180 minutes - (No intervention)

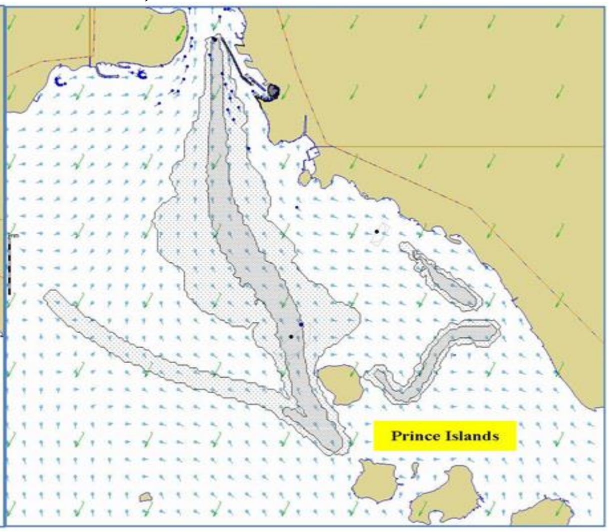


Fig. 5. Spreading of oil after 300 minutes - (No intervention)

Figure 5 shows how the oil on the sea surface will spread after 5 hours. It is determined that 3.153 tons of oil spilt into the sea at the end of 5 hours. If no action is taken, first oil fills up in Haydarpasa bay and from the entrance of the breakwater and where the ship is grounded, oil spreads to the Prince Islands in the south-southeast direction and pollutes a sea area of approximately 44 km².

Table 2. Statistics of spilled oil on the South of Istanbul Strait for the spring season (No intervention).

Time	Amount spilt, t	Amount floating, t	Amount dispersed, t	Amount stranded, t	Amount floating mixture, t	Max thickness, mm	Slick area, km²	Viscosity, cSt
00:30	1202	1202	0,1	0,5	1265	49,9	0,6	12,7
01:00	1444	1442	0,4	1,4	1600	40,7	2,6	14,3
02:00	1909	1904	2,3	2,2	2308	52,3	8,6	17,6
03:00	2349	2340	6,2	2,2	3065	32	19	21,1
04:00	2763	2750	11,3	2,3	3868	25,3	30,6	25,1
05:00	3153	3134	16,6	2,3	4713	22	43,8	29,6

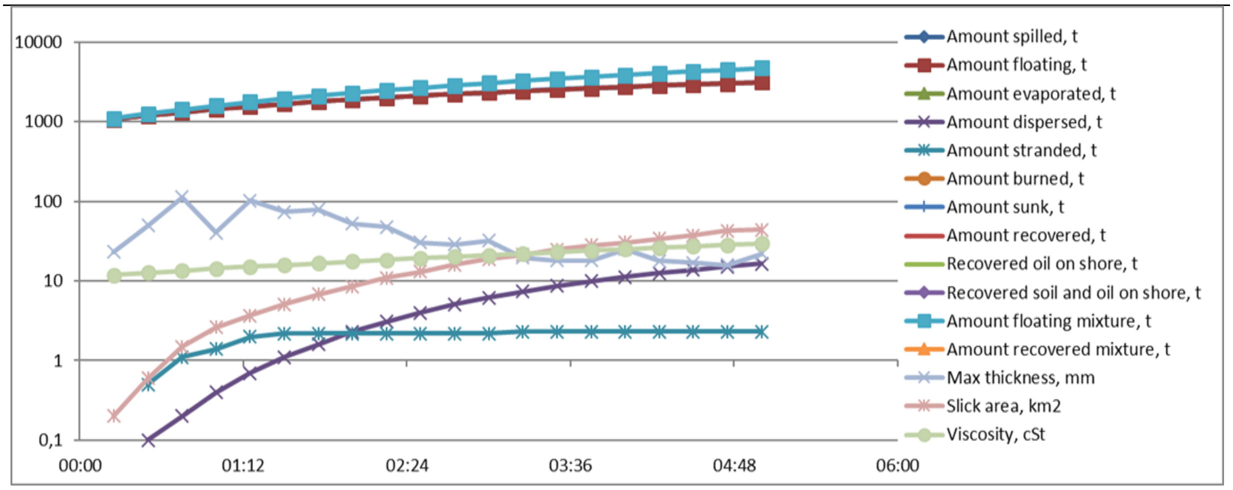


Fig. 6. Graphical statistics of spilled oil on the South of Istanbul Strait for the spring season (No intervention).

Intervention to spilled oil with present capabilities.

It has been evaluated that the oil spill specified before cannot be intervened with the tactics as confining the oil to specified bays/coves determined in the Istanbul Strait and that barriers towed by means of vessels should be used. In this context, it is envisaged that 5 vessels will tow the offshore barriers with a total height of 1.6 m in 2 separate “U” and “V” type formations and collect the fuel they control in this way with 3 skimmers with a capacity of 50 m3/h. Considering the time it takes, to prepare the vehicles to respond to the oil pollution in the southern region of the Strait, to transfer them from their deployment areas to the scene of the incident, make ready for single-point inflatable open sea barriers and skimmers for use, it is foreseen that the intervention can start at least 5 hours after the notification. However, as a first response, it was planned to lay a barrier around the shipwreck and the southern end of the Haydarpaşa breakwater and to deploy skimmers which was foreseen that the time for these vehicles to be ready for intervention would be 3 hours. As a result, the response plan containing these tactics with the available means is shown in Figure 7 to Figure 10, and behaviours of oil and response statistics after 6 hours are presented in Table 3 and Figure 11. When the 3.518 tons of spilled oil that occur after 6 hours in the southern part is intervened with the available means, as shown in Figure 7 to Figure 10, it is determined that,

- Some of the oil filled Haydarpasa bay,
- * The oil leaking from Haydarpasa bay is directed to Moda-Kalamış Bay,
- Although the towing speed is 1.5 kts, the barriers which has been laid around the grounded ship and towed by Search and Rescue Vessel (SRV) and Oil Recovery Vessel (ORV) miss the oil from the top and bottom and 573 tons of fuel can be recovered from the sea surface,
- A total of 2.921 tons of oil spread on the sea surface pollutes 62.6 km² of sea area,
- The uncontrollable oil reaches the Prince Islands, 6,5 nm away from the incident position.

Intervention with modified assets.

With the improvement of the technical capabilities of the barriers and collectors used in the response to oil pollution in the scenario created in the Southern parts of the Strait, the results obtained in the intervention under the same pollution and environmental conditions are compared in this section. In this context, offshore barriers had a draft of 2 m and a freeboard height of 1 m. In this way, their total height has been increased to 3 m and self-inflatable models have been used instead of those that can be inflated by external compressors from a single point. In this way, the inflation time of the 1.000 m barrier, which takes 3 hours with an external compressor, has been reduced to 1 hour thanks to its self-inflating feature. The skimmer was used as a large disc type with a capacity of 200 m³/h. Response tools with the aforementioned improved conditions are still produced by many manufacturers in the world, and their examples are shown in Figure 12 and Figure 13

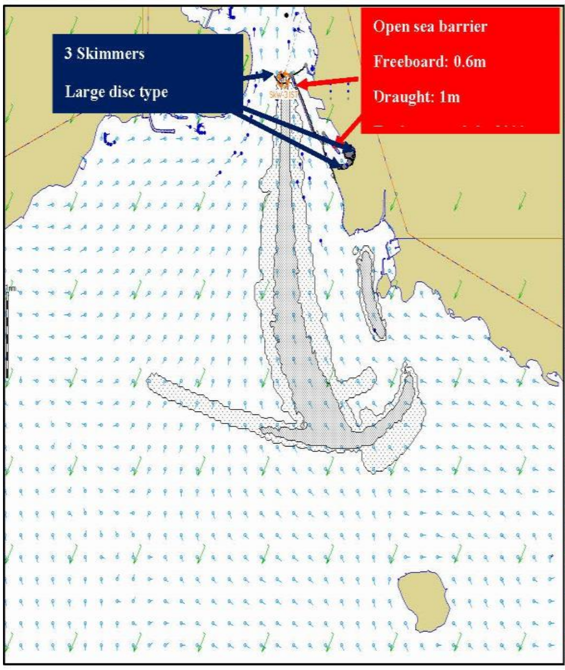


Fig. 7. Spreading of oil after 180 minutes when the intervention was conducted with present capabilities

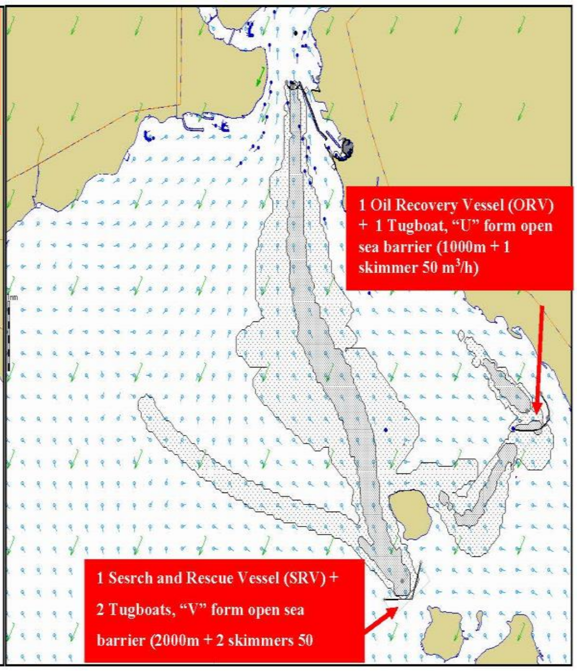


Fig. 8. Spreading of oil after 300 minutes when the intervention was conducted with present capabilities.

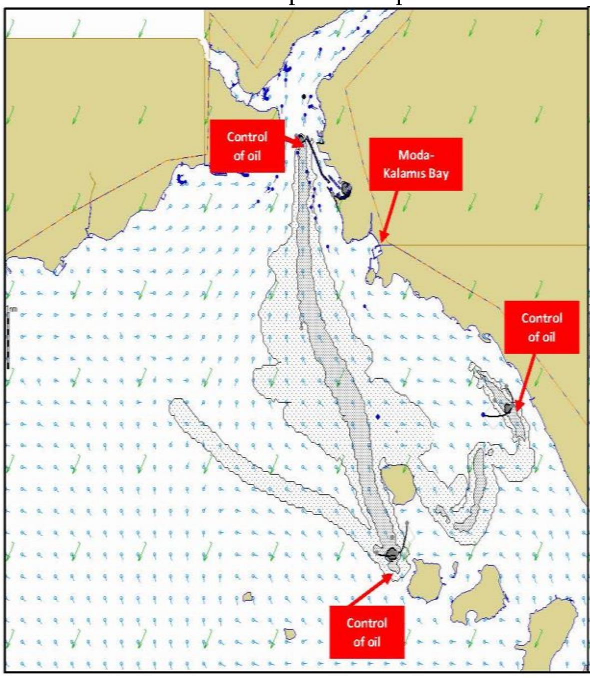


Fig. 9. Spreading of oil after 330 minutes when the intervention was conducted with present capabilities

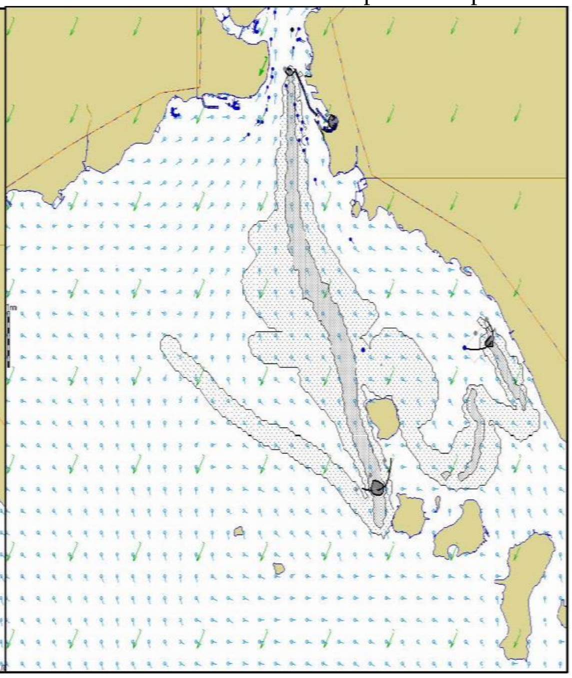


Fig. 10. Spreading of oil after 360 minutes when the intervention was conducted with present capabilities.

Table 3. Statistics of oil behaviour and intervention action on the south of Istanbul Strait for spring season (Response with present capabilities).

Time	Amount spilt, t	Amount floating, t	Amount dispersed, t	Amount stranded, t	Amount recovered, t	Amount floating mix. t	Amount recover mix., t	Max thickness, mm	Slick area, km²	Viscsity , cSt
00:30	1202	1202	0,1	0,5	0	1265	0	56,8	0,6	12,7
01:00	1444	1442	0,4	1,4	0	1600	0	56,6	2,6	14,3
02:00	1909	1904	2,3	2,2	0	2308	0	72,1	9,1	17,6
03:00	2349	2335	6,1	2,3	4,9	3060	5,7	20,2	19,5	21,2
04:00	2763	2583	11	2,3	167	3684	171	18,4	32,6	26
05:00	3153	2797	16,3	2,3	338	4313	351	27,6	47,9	31,6
06:00	3518	2921	21,5	2,3	573	4829	650	32	62,6	37,6

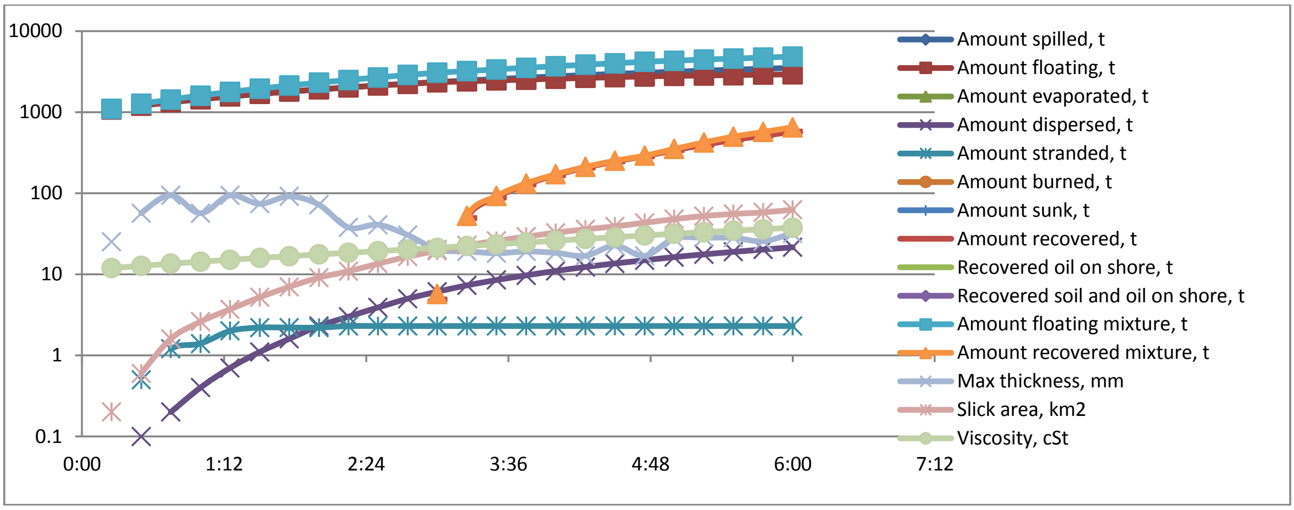


Fig. 11. Graphical statistics of oil behaviour and intervention action on the south of Istanbul Strait for spring season (Response with present capabilities).

Fig. 12. Self Inflaitable barrier (Versatech, 2022).

Fig. 13. Self Inflaitable barrier (Markleen, 2022).

When the intervention specified in previous section is performed with modified barriers (total height: 3 m and self-inflating) and skimmers (capacity: 200 m³/h) under the same conditions, the results are shown in Figure 14 to Figure 17. In this context, it is foreseen that it takes 2 hours to lay the barriers around the Haydarpaşa breakwater and the shipwreck and make the skimmers ready to use. In this way, a total of 2.000 m. barrier and 3 skimmers were used. Intervention ships SRV and ORV were again in the "V" and “U” type towing formation; in total 3.000 m. modified barrier and 3 large disc type skimmers with a capacity of 200 m³/h were used in it.

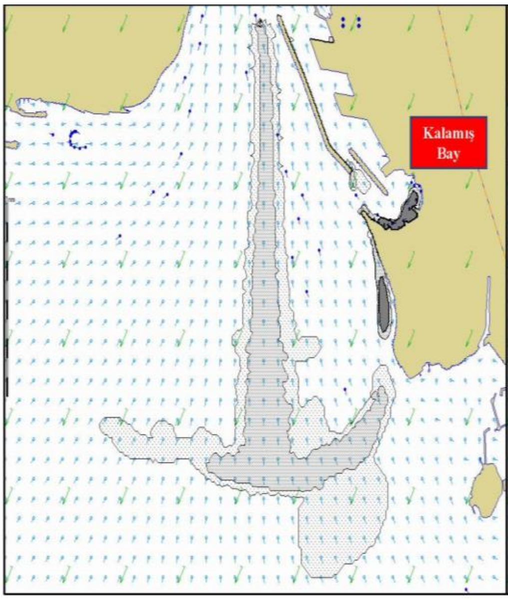


Fig. 14. Spreading of oil after 90 minutes when the intervention was conducted with modified capabilities.

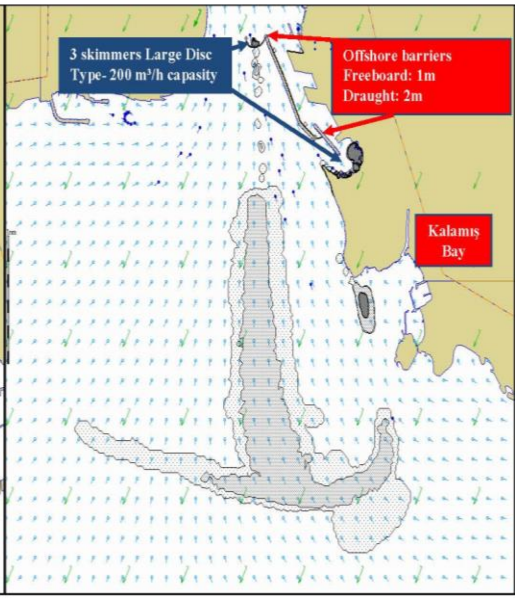
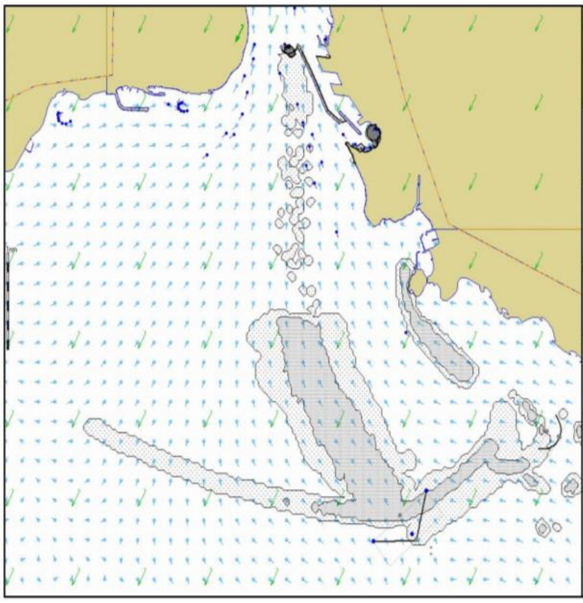


Fig. 15. Spreading of oil after 120 minutes when the intervention was conducted with modified capabilities.



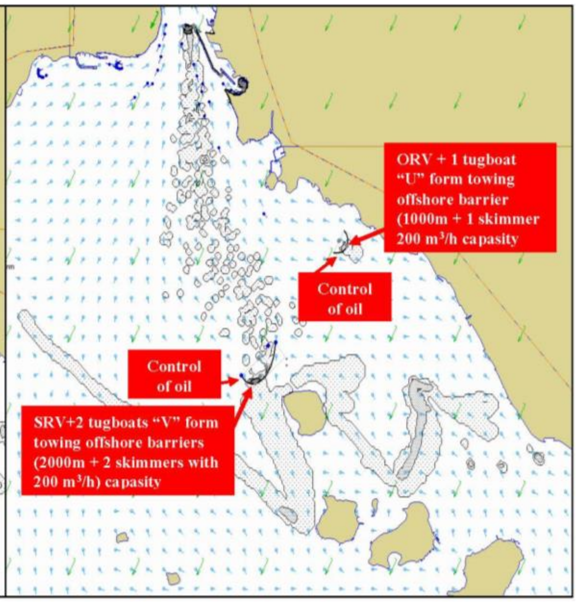


Fig. 16. Spreading of oil after 180 minutes when the intervention was conducted with modified capabilities

Fig. 17. Spreading of oil after 360 minutes when the intervention was conducted with modified capabilities.

Table 4. Statistics of oil behaviours and intervention activities in the south of Istanbul Strait for spring season

Time	Amount spilled, t	Amount floating, t	Amount dispersed, t	Amount stranded, t	Amount recovered, t	Amount floating mix, t	Amount recovere mix, t	Max thickness, mm	Slick area, km²	Viscosit cSt
00:30	1202	1202	0,1	0,5	0	1265	0	48,4	0,6	12,7
01:00	1444	1442	0,4	1,4	0	1600	0	35,3	2,6	14,3
02:00	1909	1869	2,2	2,2	35,5	2268	39,7	61,1	8,7	17,6
03:00	2349	2058	5,6	2,3	282	2715	328	30,2	15,4	21,5
04:00	2763	2124	9,4	2,3	628	2998	784	82,1	19,8	25,4
05:00	3153	2019	11,9	2,3	1120	2992	1502	56,5	25,6	28,6
06:00	3518	1998	14,2	2,3	1503	3108	2062	95,2	29,4	32,2

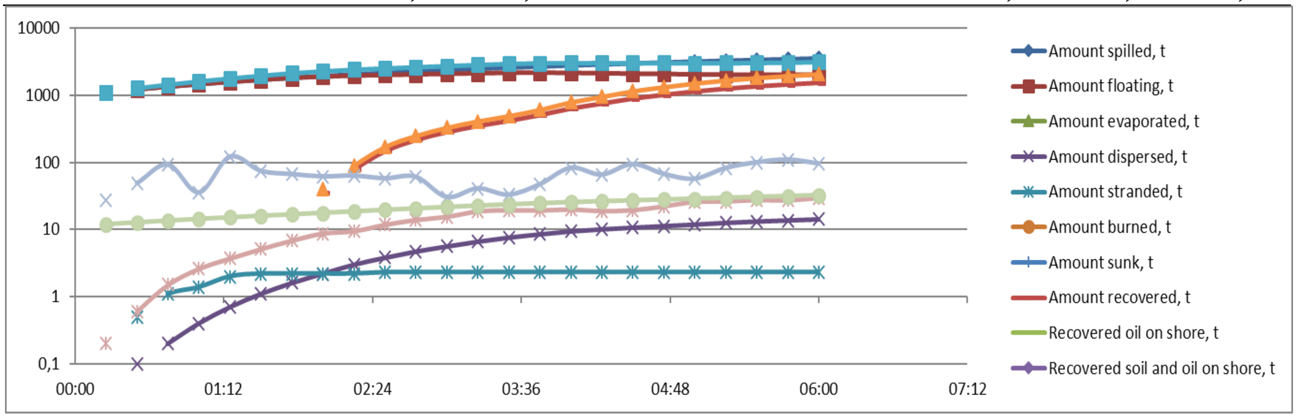


Fig. 18. Graphical statistics of oil behaviour and intervention action on the south of Istanbul Strait for spring season (Response with modified capabilities).

The time for these towing formations and the start of the intervention is foreseen as 3 hours, considering the transfer times of the vehicles from their deployment locations and the inflation times of the self-inflatable barriers. 6-hour oil response statistics obtained as a result of the intervention plan containing modified assets are presented in Table 4 and Figure 18.

As seen in Figure 14 to Figure 17, when the 3.518 tons of oil spilled in the southern part at the end of 6 hours, it was not possible to intervene in the first 2 hours.

- Some of the oil filled the Haydarpaşa bay.
- The oil comes from Haydarpaşa bay was directed to Moda-Kalamış Bay.
- The modified barrier laid around the wrecked ship had better control on the spilled oil and a reduction in the amount of oil emitted to the south.
- Barriers towed by SRV and ORV assets had better preserve the oil spread on the sea surface and 1.503 tons of fuel was recovered.
- It has been also determined that a total of 1.998 tons of floating oil pollutes only 29.4 km² of sea area at the end of 6 hours.

In this section, based on a scenario in which a maritime accident occurred in the southern part of the Istanbul

Strait and the oil spill that occurred after it, the results obtained as a conclusion of the intervention with existing capabilities within the inventory and the use of assets in modified conditions are presented in Figure 19, Figure 20 and Table 5 comparatively.

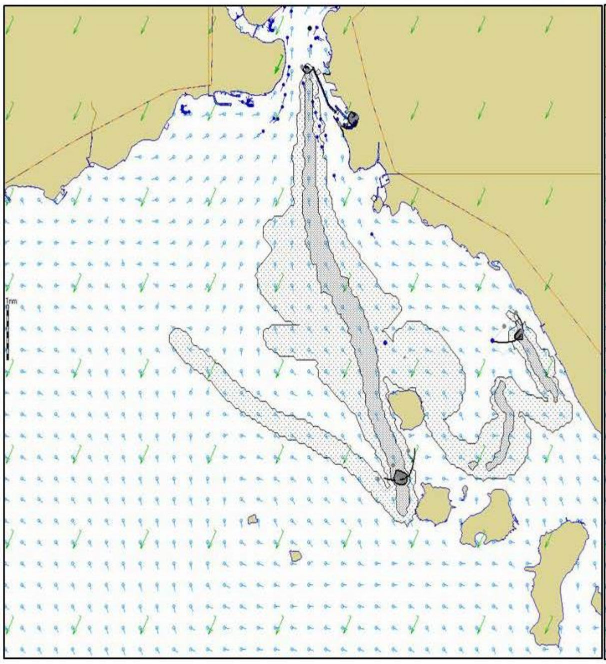


Fig. 19: Intervention with the exiting capabilities at the end of 360 minutes

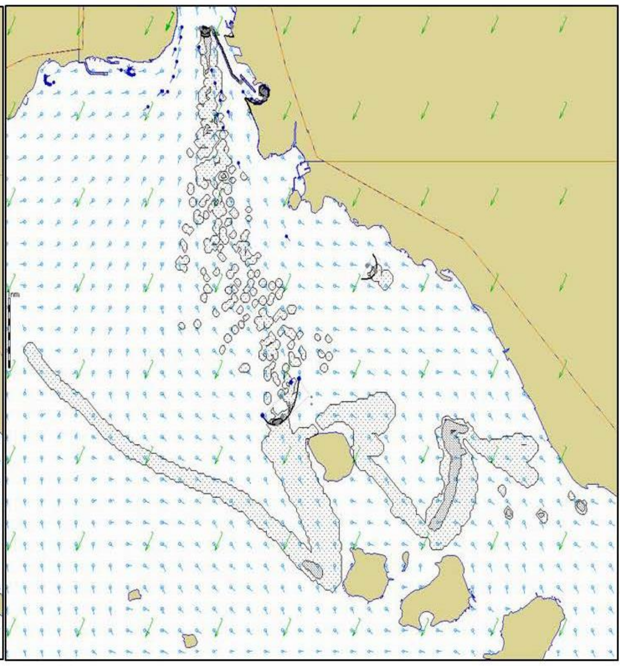


Fig. 20: Intervention with the modified assets at the end of 360 minutes

Table 5: Comparison of statistics on intervention to oil pollution in the southern region of the Istanbul Strait with existing and modified assets at the end of 6 hours.

Interven	Amount spilled, t	Amount floating, t	Amount disperse t	Amount stranded, t	Amount recovered, t	Amount floating mixture, t	Max thickness, mm	Slick area, km²	Viscosity, cSt
Existing	3518	2921	21,5	2,3	573	4829	32	62,6	37,6
Modified	3518	1998	14,2	2.3	1503	3108	95,2	29,4	32,2

In the southern parts, where the average surface current is 3-4 kts., the southward current has spread the oil to the open sea in a short time, which has not only made it possible to provide control with barriers but has also made the use of surface vessels obligatory. As it is seen in Table 5, a total of 573 tons of oil could be recovered with the existing barriers and 50 m³/h capacity skimmers with a height of 1.5 m. towed against the current with a speed of 1.5 kts, this figure reached 1.503 tons with modified assets. Another remarkable point here was the polluted sea area. While the intervention with existing capabilities caused the pollution of a sea area of 62.6 km², the polluted sea area was limited to 29.4 km² thanks to the modified barriers (3 m. height) and skimmers (at least 150 m³/h).

Conclusion

In this study, the measures taken against pollution for the waterway, which plays an important role in world maritime transport and is equally dangerous, such as the Istanbul Strait, were discussed, their efficiencies were tested, and more effective measures were investigated. In this context, a pollution scenario was created in the south of the Istanbul Strait on the PISCES II oil spill simulation and decision support system. When the results are examined;

Barrier heights become more important in controlling oil in regions where the current is above 1 kt. In the case of the Istanbul Strait, it has been determined that the existing barriers with a height of around 1.5 m. cannot control the oil and, in parallel, cannot be recovered using skimmers, whose capacity is already limited (50 m³/h). Besides this, simulation has proven that modified barriers, which has got 3m. total height, could recover much more oil with the assistance of modified skimmers which have got better capacity (at least 150 m³/h).

The fact that the high speed of the current in the Istanbul Strait makes it necessary to intervene in spilt oil at the sea surface as quickly as possible. The oil, whose composition changes as a result of its interaction with the air depending on the increasing time, becomes more difficult to recover from the sea surface, increases the toxicity of the sea area where it spreads and makes the intervention impossible by dispersion to the sea column and thus paralyzing the marine life, making the initiation time of the intervention vital. Since most of the existing barriers in the inventory can be inflated by external compressors from a single point, it takes at least 2-2.5

hours for them to be ready for intervention, taking a 1.000 m. barrier as an example, even though the time for its transfer to the scene is ignored. This period is considered to be excessive in waters with high current velocity and narrow coastal areas such as the Istanbul Strait. It is of great importance that the barriers, which are the first and necessary condition of mechanical response to oil pollution at sea, are ready as much as possible independently of human intervention, in terms of shortening the duration of the intervention. In this context, it is considered that the self-inflatable nature of the barriers, which are intended to be used for the Istanbul Strait, will provide a great benefit as it will reduce the time to be ready for intervention.

Declaration of competing interest

The author declares that there is not any competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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