Environmental Effect of Oil Spill from Aftermath Accident around the Planned Oil Rigs at the Black Sea

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Abstract

As oil rig started in open seas in parallel with energy need in our day, the risks towards sea ecosystem and the environment increase. The negative examples experienced in recent years show that a possible accident during oil rig and shipment give irrevocable damages to environment and organism lives. In this study, the risks of oil rigs being planned to be made in Black Sea on coastal area or sea environment are determined through 5 different scenarios. In addition to possible effects on endemic and economic species, the procedures that should be conducted to reduce these effects have been discussed. Being one of the most special water basins of the world, the Black Sea is a unique ecosystem which involves endangered species in addition to endemic and economic species according to IUCN. It is only possible to foreseen irrevocable damages against such an important ecosystem through accident scenarios being developed under different conditions. Therefore, to assess possible scenarios for a certain area during the studies of oil exploration and oil rig will minimize the damage to sensitive coastal ecosystem.

Key-Words: Oil spill, oil rigs, accident scenarios, economic fish species, Black Sea

1 Introduction

The Black Sea is land-locked basin and a unique sea with a physical and chemical structure [1-4]. It has an oxygenated surface layer overlaying a sulfide containing (anoxic) deep layer [5]. The Black Sea presently faces strong ecological disequilibria owing to eutrophication and pollution arising from many contaminants injected principally from rivers discharging into the basin, atmospheric deposition, direct discharges from point and non-point coastal sources and occasional accidents at sea [6]. Major contaminants include oil residues, pesticides, hydrocarbons, nutrients and heavy metals. The Black Sea has suffered from extensive pollution during the last 30 years due to unmanaged fishing, unrestricted shipping, mineral exploitation, dumping of toxic wastes, discharge of domestic wastes from coastal cities and the load of pollutants from rivers discharging into the northwestern region of the sea [1,3,7-8].

The coastal waters of the Black Sea are principally fed with the input from the rivers especially in the northeastern shelf and with the lateral as well as the vertical nutrient transport mechanisms [9]. The upper layer waters of the Black Sea are characterized by a predominantly cyclonic, strongly time-dependent and spatially-structured basin wide circulation [10]. As a result, the major part of the Black Sea has become critically eutrophic and hypoxic [11]. In the northeastern Black Sea, hyper eutrophication is one of the main causes of plankton blooms and there is occasional local hypoxia [12]. Despite all these negative factors, in ecologic terms, Black Sea marine area has marine living resources of the sea trade conjunction which heavily benefits from high economic and ecological value. Even more, fishing in Black Sea is one of the most important means of livelihood for both Turkey and neighboring countries [13]. The annual fishery production of Turkey is about 514,755 tons (2011); 432,442 tons (2012) and more than 80% of the total fishing in Turkey is produced in the Black Sea region [14]. Fishery plays such an important role in the region’s economy and the biological community has been so heavily impacted over the past decades [10]. It hosts very productive fish types having economic value such as *Mullus barbatus, Sprattus sprattus, Engraulis encrasicolus, Trachurus mediterraneus, Trachurus trachurus, Dicentrarchus labrax, Pomatomus saltatrix, Merlangius merlangus, Sarda sarda, Sardina pilchardus, Mullus surmuletus, Alosa fallax nilotica* and *Belone belone* [15].

Black Sea has biological, physiographical and hydrological characteristics which combine to form a marginal ecosystem [12]. The Black Sea has been used by six state countries for export and import, as well as transportation and living resources constituted underground origins and significance in the recent years. Particularly in the oil exploration, activities come to the forefront in this sea. Areas of oil exploration in the Black Sea, north-south transition areas that have intense ship traffic and oil rigs increase the risk of accidents. The rigs, which will be distributed at the same time following an accident caused by an environmental point of fact poses significant risks and challenges. This situation poses a considerable threat on the Black Sea ecosystem which is one of the most important migration routes of Mediterranean and Black Sea fish species.

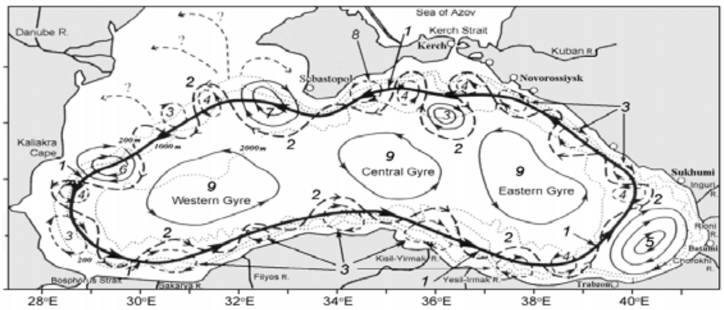
Accidental spills of the contaminants pose a very high level of risk for the marine ecosystem and coastline, and economic fish species are very sensitive to continued high fluxes of contamination as the Black Sea is essentially a closed basin [6]. Among the most damaging spills, those resulting from collisions and groundings of oil tankers whilst in transit as well as accidental spills at oil terminals bring damage to coastal pipelines [16]. The annual amount of oil released into the Black Sea is ~110000 tons [17]. Table 1 summarizes the estimates of oil contamination emanating from the countries surrounding the Black Sea. A rising threat of sea borne accidents emerges as oil tanker traffic increases from accelerated exploitation of the oil fields of Azerbaijan, Kazakhstan, the Russian Federation, and Turkmenistan [6].

During the next decade, industry projections indicate that about 2 billion tons of oil will be extracted and processed in the countries presented in Table 1. Transporting this cargo by ship across the Black Sea to Mediterranean ports and beyond will require more than 32000 additional oil tanker trips. The danger of oil spills will inevitably raise, particularly during extreme weather events [6].

Table.1 Oil Input to the Black Sea (ton yr^{-1}) [6].

Sources of Pollution	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine	Total
Domestic	5469.00		3144.10		7.30	21215.90	30016.30
Industrial	2.72	78.00	4052.50	52.78	752.86	10441.00	15379.86
Land-based				4200.00		5169.20	9369.20
Rivers	1000.00			165.00		1473.00	2638.70
Total	6651.72	78.00	7196.60	4418.48	760.16	38299.10	57404.06

As shown Fig. 1 is a generalized composite image of surface circulation in the Black Sea, based on historical measurements, satellite imagery and numerical models [6,18-23].



1:mean position of the cyclonic Rim Current jet current; 2:Rim Current meanders; 3 anticyclonic coastal eddies (ACEs); 4: cyclonic eddies (CEs); 5: Batumi anticyclonic eddy; 6: Kalikara anticyclonic eddy; 7 Sebastopal anticyclonic eddy: 8; Crimea anticyclonic eddy; and 9: quasi-stationary cyclonic gyres.

Fig.1 Schematic image of the Black Sea circulation during summer based observations [6,19]

In this study, possible accident scenarios of oil drills and platform to be conducted within the previously detected oil reserve area in Black Sea where is an intense ship traffic. It was aimed to determine pressure and ecologic impacts that may arise from the results of these scenarios in Black Sea marine ecosystem. In addition, possible threats to fish migration roads were tried to be detected in this special ecosystem which hosts endemic fish species having ecologic and economic importance.

2 Materials and Methods

2.1 Study Area

Being prioritized and intensely used for the commerce by countries having coastline to Black Sea such Turkey, Georgia, Russia, Ukraine, Romania and Bulgaria, Black Sea has a strategic importance as it can be opened to oceans through Mediterranean and to Aegean Sea through Turkish Straits System. Particularly, harbors' in Novorossiysk, Russia; Odesa, Ukraine; Constanta, Romania and also Varna, Bulgaria; Batum, Georgia and İstanbul, Samsun and Trabzon, Turkey are the most intense harbors for marine trade and ship traffic [24]. Oil drill lands being constructed or to be constructed within the oil areas detected in the roads where intense ship traffic is seen will create a new pressure on ship traffic. The study coordinations were detected by matching both ship traffic roads (Fig. 2) and oil areas (Fig 4) as special area to study on scenarios. At the same time, these areas host species which emigrate from Mediterranean to Marmara and then to Black Sea; or within Black Sea for spawning as well. (*Migration and spawning of fishes in the Turkish straits system)* Of these species, the most important ones are as follows; *Engraulis encrasicolus ponticus*, *Trachurus trachurus*, *Sprattus sprattus phalericus*, *Belone belone*, *Alosa fallax*, *Pomatomus saltatrix*, *Scomber japonicus*, *Sarda sadra* [12,25].

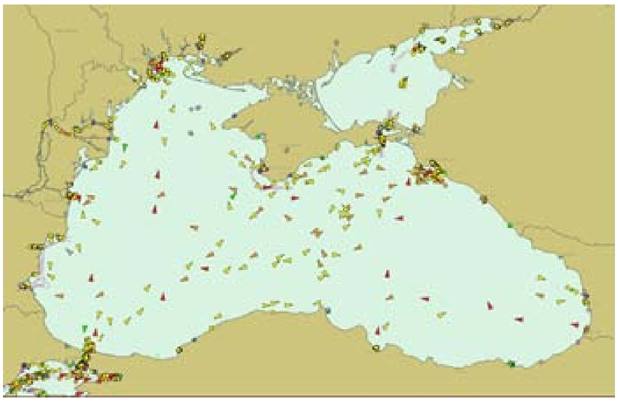


Fig. 2 Ship traffic roads [24]

There are pre-determined areas of oil exploration in the Black Sea. TPAO oil exploration in these areas and work continue today, in partnership with international companies presented in Fig. 3. In this study to be conducted in these areas, the resulting impact of vessel traffic accidents rigs after spill oil spill in the fields have been identified.

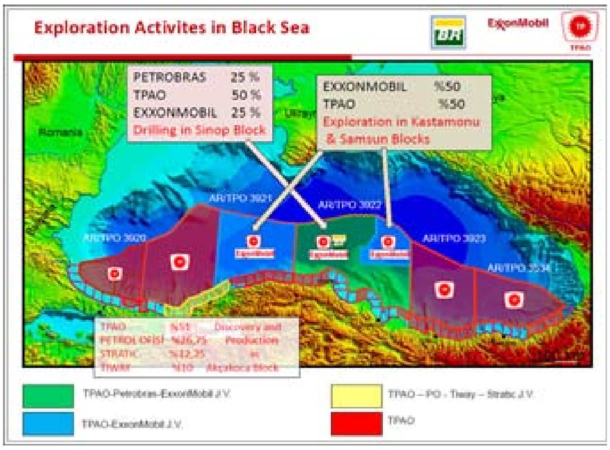


Fig.3 Schematic of the Black Sea exploration activities areas [26]

2.2 Method and Scenario

GNOME™ developed by NOAA was used to simulate spatial and temporal distribution of oil [27]. This software uses wind, tide, and current values to calculate the movement of oil at sea surface [28-29]. The simulation code GNOME™ version 1.3.3 is utilized to generate the oil spill scenarios. In order to input straits data into GNOME, map with Mercator projection was digitized at 1000 latitude and longitude points. Currents data for simulation were input as 100 x 70 matrices with the special format. Current values were *u* and *v* (m/s) at x and y directions, respectively. Oil spill distribution for some seas was determined through this simulation. It can be observed that the simulation is especially used in areas being close to Black Sea such as Marmara Sea and İstanbul Strait [30].

Başar et al., (2006), simulated risky areas for oil spillage following the tanker accidents at Istanbul Strait [31]. As it is well known, the major factor for distribution of oil is the sea surface current [32]. Krivosheya et al., (2000), modeled current of the Black Sea surface water in Fig. 1 [19]. Simulations were run for oil rig areas of Black Sea. It is assumed that 10000 tonnes of medium crude oil may be spilled in the aftermath of an accident. The oil spill is then determined with respect to time and space in consideration of wind directions (NW) and speed (5 knots) as presented in Table 2. In determination of wind direction and force, general wind direction and force observed in south regions of Black Sea were considered as basis. Wind direction and force may differ by hourly-changing climate conditions. In this study stable direction and force were considered for all scenarios.

Scenarios were run for 5 coordinates at the Black Sea (Figure 4). It means that a tanker collided at that coordinate (at oil rigs) after beginning of the oil spillage from rig. It is thought that oil spill may occur at the end of an accident in rigs that can be found in these coordinates and also tankers which come to these platforms to get oil and ships which navigate to the region may result in the accident. Starting points of these scenarios were detected as distribution starting point. All simulations were running for 10 days.

Table 2. Coordinates of Scenarios

Rig Areas Scenarios	Lat	Long	Wind Direction	Wind Speed (knot)
Scenario 1	41°34'37" N	40°40'19" E	NW	5
Scenario 2	41°45'49" N	38°30'47" E	NW	5
Scenario 3	43°11'07" N	35°44'38" E	NW	5
Scenario 4	42°56'29" N	31°58'36" E	NW	5
Scenario 5	41°47'33" N	30°29'24" E	NW	5

3 Results

In the analysis on the results of the possible scenarios, the effects that may emerge in Black Sea ecosystem can be clearly observed. Although the completion period for scenarios were determined as 10 days; effects in coastal area were determined on 4th day in 1st and 2nd scenarios; at the end of 6th day in 5th scenario and the oil reached the coast easily. Oil distribution and connection areas with the coast in these scenarios created in southeastern and western parts of the Black Sea (1st, 2nd and 5th Scenarios) are presented in Figure 5,6 and 9. However, in the scenarios conducted with Central Black Sea locations (3rd and 4th Scenarios), it was found that the oil does not contact with the cost even at the end of 10th day and the oil spill mostly expands under the effect of current (Fig 7 and 8).

The first simulation was run at 5 knots wind speed and northwest wind direction at the east of Black Sea. As a result of the first simulation, which ran for 4 days, the oil spill affected south east beach considering the necessary action was not taken, oil spill were not under the control as presented in Fig. 5. The second scenario was to run same condition and second rig area in Fig 6. Oil beached after 6 days on the south of Black Sea coast. Third scenario was to run 3rd rig area. In this scenario, oil spill affected the center of the Black Sea in 10 days (Fig. 7). Forth scenario was to run the same environmental condition. As seen from Figure 8, the spill was moved to Black Sea offshore. Fifth scenario was to run 5^{th} rig area at the west of Black Sea. In this region, it was observed that the oil contact with the coast on 6th day. Oil spill affected Turkish coast as presented in Fig 9. Depending on the characteristics of the area determined for the scenario, the distribution mostly affects a much wider area with the effect of current and wind effect. For that reason, 5th scenario was detected to be the one which affects the coastal area most.

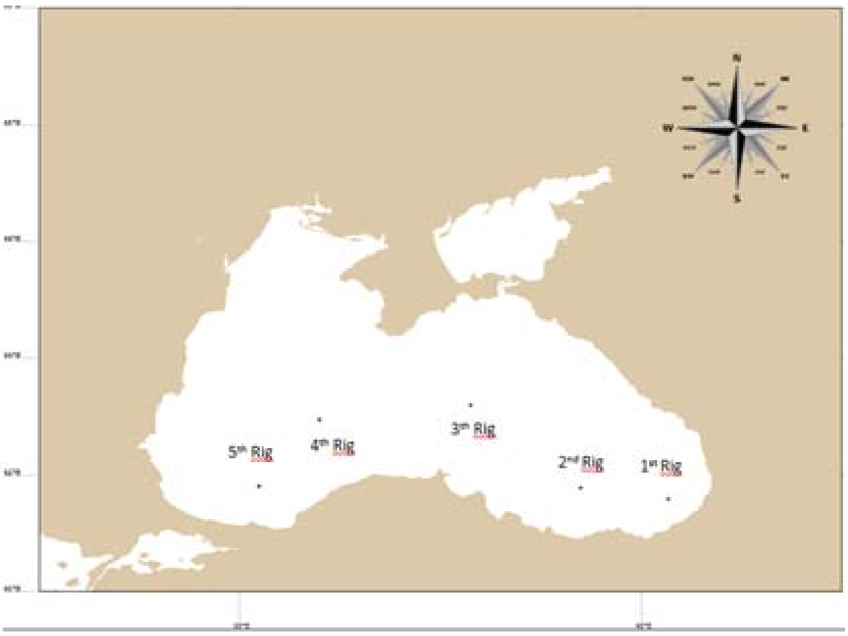


Fig. 4 Points of accident scenarios area

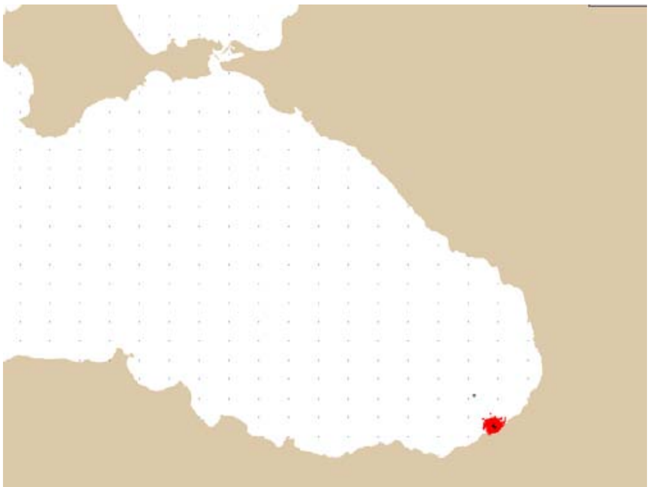


Fig.5 Distribution of crude oil at 1st. Scenario

Fig.6 Distribution of crude oil at 2nd. Scenario

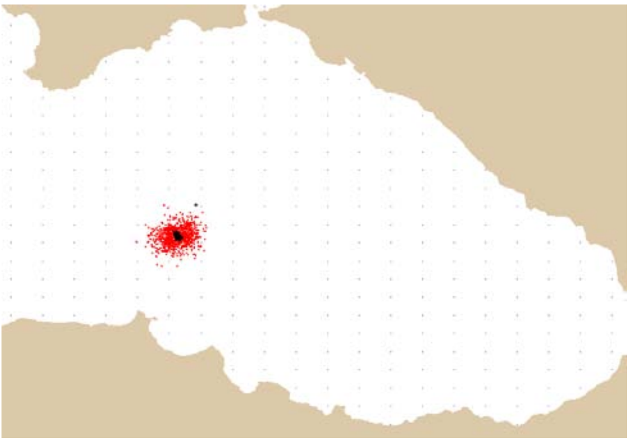


Fig.7 Distribution of crude oil at 3rd. Scenario

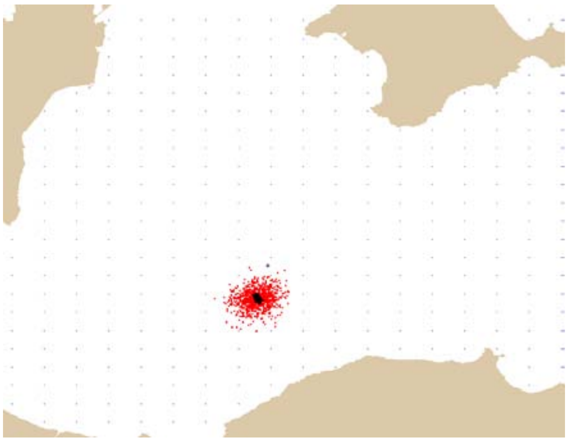


Fig.8 Distribution of crude oil at 4th. Scenario

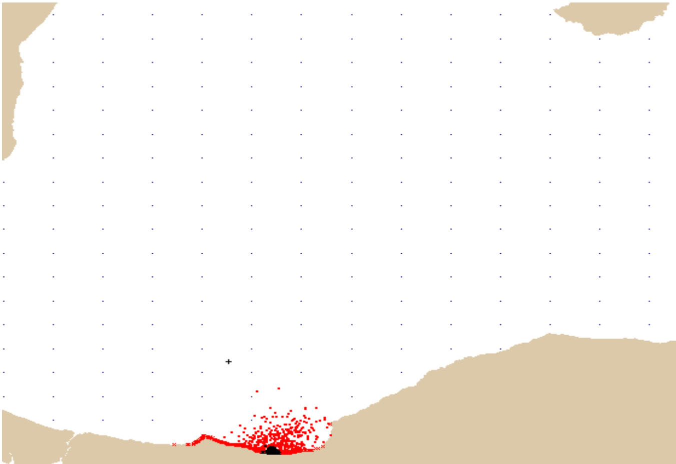


Fig. 9 Distribution of crude oil at 5th. Scenario

4 Discussion

In recent years, many studies have been conducted through the results of the accidents or by the support of scenarios in order to prevent accidents related to, oil exploration, drill in seas and transportation [30-31,33]. The priority, in these studies, is to determine the effects on sea ecosystem reveal threats against biodiversity, reduce short and long-term damages. The ever growing demand for energy in the modern world continues to increase the risks of major oil spills during the lengthy travel of this natural resource along global sea routes. Despite all these studies, oil spills/accidents is the inevitable result of oil rig, storage and shipment. Black Sea is under ever increasing ship traffic and oil rig.

In oil spills, as soon as the oil contacts with the water, it tends to swim without being mixed with the water and to spread on the surface due to the physical specifications such as surface tension, viscosity, density etc. Owing to this characteristic, it affects costs and poses a vital threat for the organisms using the sea surface. Direct fatal toxic effect of oil products on sea organisms results from the impact on accumulation and physiologic activities in tissues and cells. Such contaminators affect eggs, larva and young members of living sources more. Sustainable generations of living sources and their chance to maintain their generations are under threat [34]. Physiological effects of contaminators can be ranged as follows; causing delay and prevention for cell division in planktonic organisms; dietary changes in crustaceans, abnormal spawning and change in spawning periods in fish; formation of cancer tumors. The highest effect is observed in living communities living in high tide-low tide line of the sea. Especially, photosynthetic plants which play a significant role in sea ecosystem and provide oxygen for the water are contaminated with the oil film spreading on the surface and they die [35]. 1st and 2nd scenarios which affect the coastal area most started to threat the coastal area on 4th day; 5th scenario started to affect on 6th day through direct distribution. These areas are located within the Eastern Black Sea Region of Turkey being the most important fishery area of Turkey. Approximately 65% of the production obtained through fishery in Black Sea is obtained from the Eastern Black Sea Region. It is also an important coastal structure where the mostly fished, economic fish species such as in terms of fishery anchovy (*Engraulis encrasicolus*), saurel (*Trachurus trachurus*), haddock (*Merlangius merlangus*), mullus (*Mullus barbatus*), acorn (*Sarda sarda*) and bluefish (*Pomatomus saltatrix*) [25]. In addition, there are macro and meiobentic organisms for Arthropoda, Mollusca, Annelida and Nematoda groups which take place on soft ground. Among these forms, the dominant one; *Rapana venosa* is an economic species. Other endemic species are *Tricolia pullus* and *Rissoa splendida* [36]. The effect of the oil which reaches coastal areas is not limited with aquatic organisms; it can also reach birds and terrestrial-origin organisms which use the environment for feeding. It can also interact with human beginning from the very first step of the food chain.

Especially, acorn (*Sarda sarda*) and bluefish (*Pomatomus saltatrix*), which arrive Black Sea for feeding and spawning through maturing their gonads in spring months are the mostly preferred fish species by public [37]. The oil which takes place on migration roads of these fish species and is observed to spread in 3rd and 4th scenarios has a very clear effect on the species. In addition, dolphins which take place in Black Sea region as a sea mammal species and are registered to be under threat by IUCN (International Union for Conservation of Nature**)** face the similar effect [38-39]. The most recent example for the fact that other economic fish species and birds which feed in the same area can be the accident in Mexico Gulf. In the oil platform accident which took place in Mexico Gulf in 2010; 780000 m^3 crude oil were spilt on the gulf and this pollution which covers the whole gulf reached until the coasts of the United States of America. In addition to its effect on sensitive coastal areas, it affected many endangered species as well. It caused the death of economic fish species and irrevocable contamination for environment [40-41]. The scenarios showed that the similar effects may be observed in Eastern Black Sea being one of the most special areas for fishery as well.

5 Conclusion

The increase in the use of fossil fuels bears great risks that can adversely affect the coastal ecosystems. In this study, the petrol platforms which are planned to be made in Black Sea are known to be located in the regions where ship traffic is intense. The crash of oil-loaded ships to the platform, spills that may arise during oil transfer and platform derived possible risks are the first threats to come to mind. Following these possible accident scenarios, it is clear that there will be an oil distribution/spreading to the sea ecosystem intensely. It is foreseen that this situation will worsen the Black Sea ecosystem which is already affected by the current contamination. To be prepared for the possible accidents, to place required emergency plans and equipments in right places are very important to reduce the possible effects to ecosystem. These precautions will be an effective way to prevent and/or limit distribution thanks to rapid intervention. To store sufficient oil spill intervention equipment in risky coastal areas will be useful to minimize the possible contamination.

When the oil contact with coastal regions, cleanup process gets longer and the costs increase. The effect on ecosystem is relatively less in the scenario of disintegration process in open sea and diffusibility of oil. For that reason, open sea intervention should be conducted more effectively in order to prevent platform derived distribution from reaching to coastal areas. In these areas, different scenarios can be run and risk assessment can be made based on the effect on next stages and recreation areas. The possible scenarios will ensure to conduct legal and administrative regulations required to conduct the follow-up and practice of the national sanctions.

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