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Selection of the best suitable place as a marine pollution response center: suggestions for Iskenderun Bay

Muge BUBER*, Ali Cemal TOZ

Marine Transportation Engineering, Maritime Faculty, Dokuz Eylul University, 35160, İzmir, Turkey.
*Corresponding author: ali.toz@deu.edu.tr

Abstract: The aim of this study is to determine the best suitable place for a center that can response any ship-based oil spilage that may occur in Iskenderun Bay. In this context, the risky regions for ship-based incidents in the gulf are detected in the light of the regional conditions using the incident data obtained from Main Search and Rescue Coordination Centre (MSRCC). Suggestions concerning geographical borders of the response center for oil spills, response duration and equipment infrastructure have been made in order to minimize the risks in the region.

Keywords: MSRCC, Marine Pollution, Response Center, Oil Spill.

Introduction

Oil transportation by sea in the Mediterranean, which stands for 70-80% of all European oil imports, feeds the energy sector in Europe. These rates are expected to increase over time as the dependence of the European oil supply on the Gulf countries increases. Dangerous cargoes carried by ocean going tanker-type vessels are making the coasts even more fragile to pollution by oil (Ezra et.al, 2000). The environmental sensitivity of the Mediterranean Sea to maritime oil transport can be evaluated in case of a large oil spill in the Mediterranean will cause catastrophic effects due to its unique nearness to the sea and limited water exchange (Turley, 1999).

Time is of critical importance in marine pollution response. Weathering processes begins as soon as the oil is released. It is also difficult to control the spilled oil as time passes. For this reason, the deployment of pollution response equipment and the reaction time of response are very important in terms of the efficiency of the operation. In other words, the success of the operation is closely related to the instantaneous and realistic predictions to be taken (Aamo et al., 1997; Aguilera et al., 2016; Walker et al., 1994; Tuler et al., 2006).

In this research, oil spill response center location has been proposed considering possible pollution scenarios for Iskenderun Bay, which has intensive ship traffic depending on the increasing transportation potential in recent years. Today, the oil and natural gas flowing from Bay of Iskenderun to the Mediterranean, the oil and natural gas transported by the Suez are the first places in the world's natural gas and oil production and capacity, the maritime trade traffic from Suez, The Eastern Mediterranean is continuing to create the biggest problem from the problems of the world (Ratner, 2011). For the last 10 years Bay of Iskenderun has an intensive oil transport, while tanker transport oil leaking into the sea causes the Iskenderun Bay to become polluted (Ozcan et al., 2005). Oil the vessels that transport vessels discharge the bilge and ballast water 40-50 miles from the shore and that pollution is coming to the shore (Abousamra et al., 2005).

In this context, initially MapInfo software 8.0 version was used to locate ship accidents on the map, and then Center of Gravity method was used to find the most risky place. The COG Method, known as one of the site location tool, is cost effective method. Ding and Zeng (2015) used COG method to allocate of professional oil recovery ships in China. Esnaf and Kucukdeniz (2009) conducted the center of gravity method to solve multi-facility location problem. Krajewski et al. (2007) present the Center of Gravity method as a refined version of the load-distance method. The aim of this study is to determine the best suitable place for a center that can response any ship-based oil spill that may occur in Iskenderun Bay

As soon as oil is released into the environment, it undergoes significant property changes. For example, oil begins to spread as soon as it is spilled but it does not spread uniformly (Lehr et al., 2002). If response is not conducted in optimum period, spilled oil will spread and threaten wider areas. This will lead to the formation of a response gap (Robertson, 2007). Contingency planning is an extremely important tool to come up with such challenges. Contingency planning can help to minimize potential harm to human health and the environment by ensuring a timely and coordinated response (Chen et al., 2012).

Various mathematical models have been formulated in the past to overcome strategic and the tactical decision-making problems. Verma et al. (2013) proposed optimization program to find best location of oil-spill response facilities for the south coast of Newfoundland, Psaraftis et al. (1986) formulated and then Srinivasa and Wilhelm (1997) and Iakavu et al. (1996) used a mixed integer programming problem to decide on the location of the appropriate levels and types of clean up equipment to respond to oil spills. Gucma et al. 2012 used cost optimization model to al locate optimum locations of oil spill response in Baltic Region, Belardo et al. (1984) conducted a partial covering approach to site response resources for major maritime oil spills. Salman and Yucel (2014) proposed a tabu search heuristic to find Emergency facility location for Istanbul. Krohling and Campanharo (2011) used Fuzzy TOPSIS method for selection of best combat responses to oil spill.

Materials and Methods

In this research, an application was conducted for the determination of the oil spill response location Bay of Iskenderun. In this context, risky areas were identified with Center of Gravity (COG) Method taking into consideration the ship accidents that occurred in the region and the most appropriate response center required for this region was located.

Center of Gravity Method (COG): It can be used to find the optimal location coordinates for a facility which is time effective. Like the main function of a load-distance method, it minimizes the distance that loads travel but also gives the x and y coordinates for the location. The formulas used in the center of gravity calculations are as follows (Onnela, 2015):

$$x = \frac{\sum_{i=1}^{n} x_i w_i}{\sum_{i=1}^{n} w_i} \qquad y = \frac{\sum_{i=1}^{n} y_i w_i}{\sum_{i=1}^{n} w_i} \qquad (1)$$

Where x=actual latitude coordinate for the optimal location, y=actual longitude coordinate for the optimal location, x_i=x coordinate of the load point, y_i=y coordinate of the load point and w_i=load of each location.

The spherical shape of the Earth affects the distance functions. The situation is the same with the traditional center of gravity method: it is suitable on a plane but does not take into account the curvature of the Earth. The main difference between the normal and the spherical center of gravity method is that in the spherical method, latitudes and longitudes are not simple coordinates but directions from the center of the sphere. The spherical shape of the Earth is possible to take into account by using three dimensional Cartesian coordinates. In order to do that, the degree values of coordinates should be expressed in radians. Then Cartesian coordinates (x, y, z) can be named for each coordinate point by the following formula (Onnela, 2015):

$$x = \cos(lat) * \cos(lon) \qquad (2)$$

$$y = \cos(lat) * \sin(lon) \qquad (3)$$

$$z = \sin(\text{lat}) \qquad (4)$$

Where, lat = latitude point in radians and lon= longitude point in radians. Three dimensional coordinates can be extra polated with an arctangent function in order to get a point on the surface of the Earth. That point should then be converted from radians to degrees.

Study Site: In order to realize the purpose of the work, ship accidents are taking place in the Gulf of Iskenderun between the years 2003-2016. Bay of Iskenderun is shown as study site Figure 1 (http://www.gulf-marine.com/press /news/2014).

As it is understood from the figure, there are port facilities in Iskenderun Bay where various products, mostly fuel oil, are handled. These facilities are located in a region that can be highly fragile in the case of pollution. The maritime traffic of the region is also affected by the increased trade capacity of the region. Increasing maritime traffic is increasing this risk. Density of Mediterranean shipping traffic is shown in Figure 2 (Marine Traffic, 2017).

There is an increase in maritime traffic density, which may pose risks to the community as a result of vessel collisions, fires and other accidents. Such incidents may result in spills and discharges that might spread, affecting

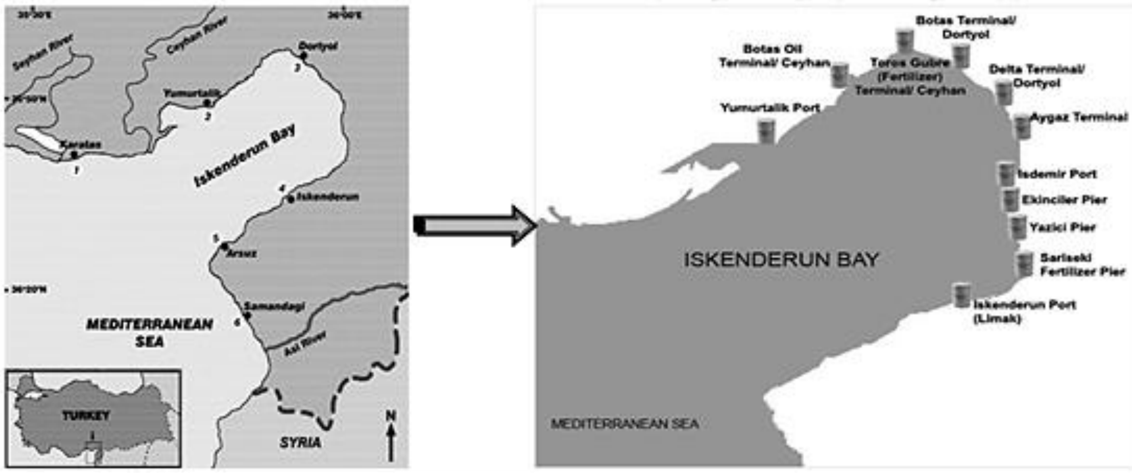

Figure 1. Location of bay of Iskenderun.

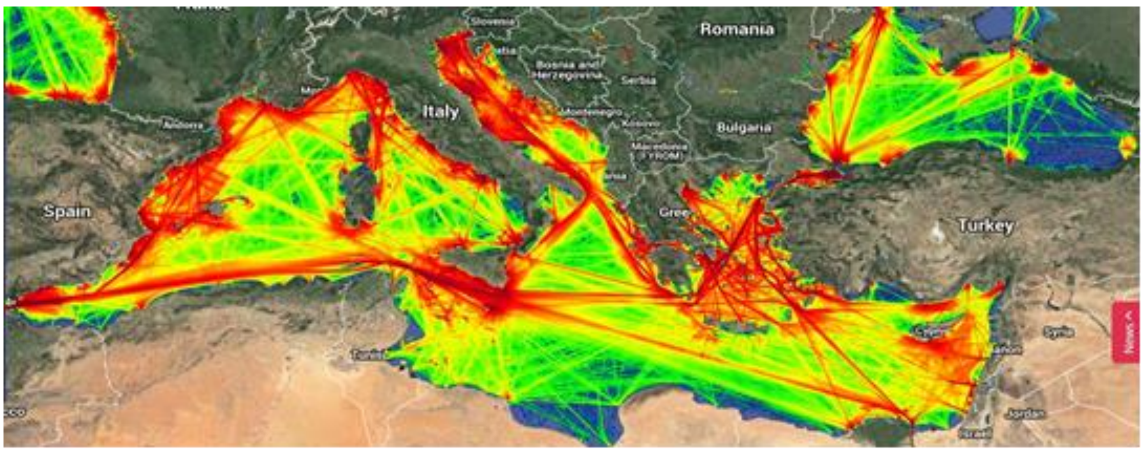

Figure 2. Mediterranean Shipping Traffic Density Map (2017). Note: The color coding represents traffic density in each area. The numbers refer to quantity of distinct vessels on a daily basis and count their positions per square km. The colors stand for: blue—less than 30; green—30 to 70; yellow—71 to 140; red—more than 140.

		2015	
Harbor Master		Handling Tonnage	%
1	BOTAŞ	78.093.461	18,77
2	İZMİT	64.628.031	15,53
3	ALİAĞA	48.794.379	11,73
4	AMBARLI	36.177.123	8,70
5	İSKENDERUN	36.134.784	8,69
6	MERSİN	31.996.360	7,69
7	TEKİRDAĞ	14.979.216	3,60
8	GEMLİK	12.747.057	3,06
9	KARADENİZ EREĞLİ	10.426.460	2,51
10	SAMSUN	9.776.562	2,35
TOTAL		343.753.433	82,63
OTHER PORTS		72.283.262	17,37
HANDLING		416.036.695	100,00

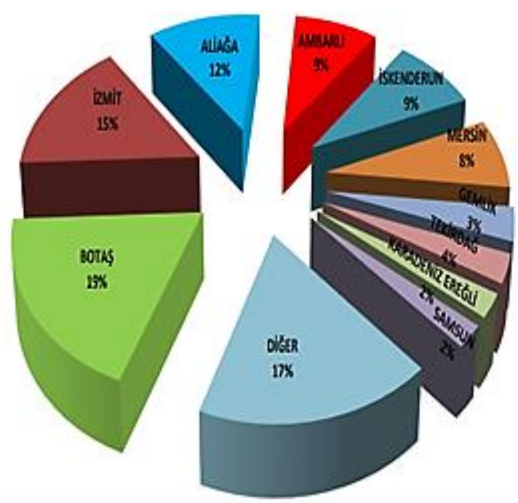

Figure 3. Cargo Handling Statistics of Turkish Ports (2015).

marine life and disturbing recreational activities in Iskenderun. In Figure 3, cargo handling statistics of Turkish ports are shown (http://www.ubak.gov.tr/).

It is understood that as of 2015, most of the cargo in Turkey is handled at the botas terminal located in Bay of Iskenderun. The fact that the total handling cargo is oil

Table 1. Details of accidents.

No	Location	Type Of Ship	Tonnage (Grt)	Accident
1	Limak Port	Bulk Carrier	4441	Collision
2	Yazici Port	Ro-Ro	33163	Collision
3	Limak Port	Bulk Carrier	44010	Grounding
4	Bay Of Iskenderun	Dredger	127	Collision
5	Bay Of Iskenderun	Bulk Carrier	3658	Medical
6	Isdemir	Bulk Carrier	1501	Collision
7	Isdemir	Bulk Carrier	3125	Collision
8	Isdemir	Bulk Carrier	3186	Fire
9	Ister Dockyard	Bulk Carrier	7669	Fire
10	Port Of Iskenderun	Bulk Carrier	13380	Fire
11	Yazici Port	Bulk Carrier	2491	Collision
12	Yazici Port	Bulk Carrier	3909	Collision
13	Isdemir	Bulk Carrier	10022	Medical
14	Port Of Iskenderun	Bulk Carrier	50296	Medical
15	Port Of Iskenderun	Tanker	50	Collision
16	Yazici Port	Bulk Carrier	1231	Collision
17	Port Of Iskenderun	Bulk Carrier	3086	Medical
18	Port Of Iskenderun	Bulk Carrier	3221	Medical

Figure 4. Geographical locations of ship accidents (2001-2016).

Figure 5. Location of COG of ship accidents.

and derivative products also increases the risk of pollution in the region.

Results and Discussion

In order to identify risky areas in the region, a list of the accidents that took place firstly was made. The data related to these accidents were obtained from the MRCC (Mission Rescue and Coordination Center) data base and transferred to the Microsoft excel form and adapted to the file format of the Map Info 8.0 software. The details of accidents are shown in Table 1.

As can be seen in the Table 1, there are 18 marine accidents occurred in the region between 2003 and 2016. It is seen that most of these accidents are near the terminal and the type of vessels involved in the accidents are usually bulk carriers. Figure 4 shows the locations of the accidents on the map with the MapInfo program.

As seen in the figure, the accidents often took place in areas close to the eastern shores of Bay of Iskenderun. In this area, there are facilities that provide services especially to vessels other than tankers. The location of COG in the light of this information is calculated as shown in Figure 5.

As seen in the figure, the location of COG of the accidents appears to be in position very close to the YazıcıPier. The exact coordinates of COG are 36°39´.6N 36°10´.8E. Therefore, the response center needs to be established near this point. The distribution of the accidents according to the accident types is also shown in Figure 6.

As it is shown in the figure, it is seen that a large part of the accidents that have occurred in the region are

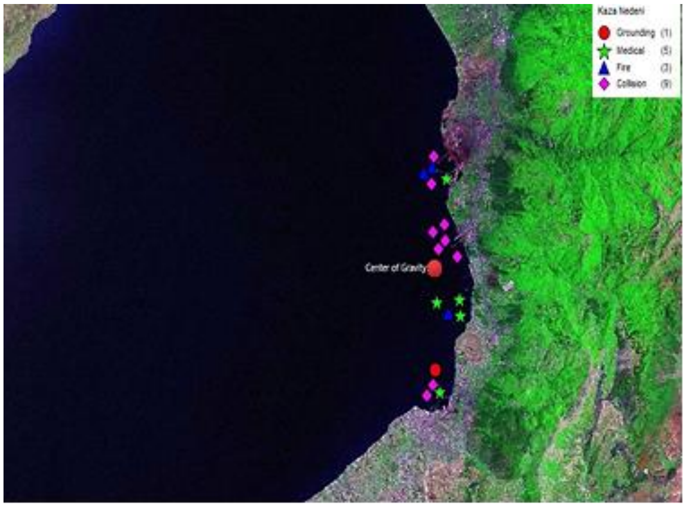

Figure 6. Distribution of the accidents according to the accident types.

Figure 7. The position of the COG relative to the closer terminal.

collisions. The distribution of accidents with fire and medical content comes after these accidents. The position of the COG relative to the closer terminals in the region is shown in Figure 7.

The center of gravity is located at the point between the POAS terminal and Gubretas terminal as seen in the figure. It is therefore recommended that the emergency response center has to be established between those terminals. The optimum location of emergency response center is shown in Figure 8.

As can be seen, the position of the center of gravity is very close to the shore. Although this situation is favorable in terms of the duration of the reaction, it can be troublesome in terms of the spread of marine pollution. The closest region to this point is considered as the most suitable region in terms of the emergency response center.

Figure 8. The optimum location of emergency response center.

Conclusion

In emergency situations the timing of the reaction is extremely important. Reducing the destructive effect of accidents depends on the time of response. The response operations at sea require many challenges to be overcome. Weather conditions, duration of deployment, and time of arrival at scene are the most important variables. In particular, accidents that are likely to cause environmental damage are extremely dangerous for settlements and ecosystem.

In this study, it is proposed to establish emergency response center for Iskenderun Bay, which is located in the eastern Mediterranean region and has great potential in terms of sea transportation. In this context, the accidents in the region were examined and the center of gravity of the accidents was found.

In this study, it was determined that the accidents were concentrated in one area and accordingly, the emergency response center had to be close to this risky location. In addition, only time variable was taken into account. Cost and other operational variables are excluded. This study can be repeated using different methods in subsequent studies.

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