Site Selection and Resource Allocation of Oil Spill Emergency Base for Offshore Oil Facilities

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Abstract. Based on the analysis of the historical data about oil spill accidents in the Bohai Sea, this paper discretizes oil spilled source into a limited number of spill points. According to the probability of oil spill risk, the demand for salvage forces at each oil spill point is evaluated. Aiming at the specific location of the rescue base around the Bohai Sea, a cost-benefit analysis is conducted to determine the total cost of disasters for each rescue base. Based on the relationship between the oil spill point and the rescue site, a multi-objective optimization location model for the oil spill rescue base in the Bohai Sea region is established. And the genetic algorithm is used to solve the optimization problem, and determine the emergency rescue base optimization program and emergency resources allocation ratio.

1. Introduction

The problem of the marine environment is gaining widespread social attention. Bohai Sea is the earliest oil and gas development area in China. The fixed production platform has accounted for more than 90% of the total number of similar platforms in China. The risk of oil spill pollution in this area is increasing due to the increasingly frequent of offshore oil and gas operations, storage and transportation. The establishment of a reasonable and reasonable allocation of resources and emergency, prompt and effective offshore oil spill emergency service network around the Bohai sea is an important measure to cope with the increasingly serious oil spill risk in this area.

In 2008, *Ukkusuri* and *Yushimito* set up a model for site selection of pre-disaster emergency resource points in the hope of maximizing the likelihood that emergency demand points will be covered by at least one emergency resource point[1]. In 2010, *Wang Jing* used the method of spatial clustering to solve the problem of site selection of emergency supplies in the integrated area[1]. The dual effect of high emergency rescue efficiency and low reserve cost of emergency materials is achieved through the study of the example. Based on the analysis of the historical data of the oil spill in the Bohai Sea, this paper divides the oil spill in the Bohai Sea into a limited number of oil spill points, selects and corrects the oil spill model suitable for the Bohai Sea, and predicts the oil spill drift trajectory. The specific location of the emergency base can be established around the Bohai Sea for cost-effectiveness analysis, genetic algorithms can be used to optimize the site selection of the emergency base, and the decision-making suggestions can be provided for the planning and construction of the emergency base.

2. Location Optimization of Oil Spill Emergency Base in Bohai Sea

At present, three oil spill emergency rescue bases in Suizhong, Tanggu and Longkou have been built in the Bohai Sea. The oil spill recovery capability at sea is 926 m^3/h and its disposable oil spill removal capacity reaches 1460m^3, forming a marine oil spill response network covering Liaodong Bay,

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Bozhong area and Boxi area in the Bohai Sea. However, once the offshore oil spills to the east of Bohai, this three existing bases have disadvantages including long distance and long response time. In addition, taking into account the increased risk of oil spills in the Bohai Sea region, weather, sea condition and other conditions on the emergency relief work adversely affected. The current three bases are unable to achieve the full coverage of effective emergency relief for oil spills in the Bohai Sea. Based on the distribution of cities around the Bohai Sea, 11 alternative rescue bases are listed on the basis of the existing three bases. From the actual oil spill response, after the oil spill accident, the oil film will not stand still at the sea where the oil spill occurs, and the oil film itself will expand due to its own expansion. The oil film will change due to external forces such as wind and ocean currents, and the external force The influencing factors are more instructive and, therefore, need to be properly compensated for when the rescue site has arrived at each accident point.

Taking into account the seasonal, regional and random characteristics of offshore oil spills, it is very hard to realize the accurate compensation of the arrival time of the rescue points. Only the annual average characteristics of the influencing factors such as the wind direction and the tide in the Bohai Sea region are considered. Based on the comprehensive analysis, we get the time matrix between each rescue point and the accident point by simulating and simulating the oil spill risk points as shown in Table 1.

Table 1 Time matrix of the rescue point reaching the oil spill location

	BZ25-1	BZ34-2/4	CFD11	JZ9-3	LD	PL19-3	QHD32-6	Yingbei
Tianjin	7.544	9.377	4.688	20.102	13.773	11.027	6.53	4.356
Suizhong	11.808	12.029	10.598	5.603	3.182	10.292	8.222	12.675
Longkou	5.867	4.061	8.967	18.52	12.217	4.239	9.255	9.02
Qinghuangdao	8.844	9.611	7.076	9.851	4.616	8.497	4.756	9.079
Yingkou	17.241	17.158	17.858	4.107	7.476	14.865	15.906	20.344
Jingtang	5.178	6.329	2.616	14.356	8.576	6.495	1.002	4.641
Jingzhou	15.059	15.307	14.392	2.019	5.627	13.434	12.143	16.486
Huanghua	5.022	7.575	4.753	21.572	14.922	9.909	7.177	2.746
Laizhou	5.834	4.256	8.932	20.299	13.812	5.543	9.77	8.459
Weifang	5.558	4.821	8.47	22.503	15.347	7.379	9.97	7.156
Dongying	3.045	4.606	4.809	19.14	12.124	6.35	6.582	3.963
Caofeidian	4.628	6.382	1.353	17.317	10.701	7.55	3.153	2.575
Huludao	14.607	14.972	13.831	4.219	5.882	13.676	11.675	15.977
Dalian	5.52	4.764	12.325	15.334	10.567	5.581	11.734	13.269

Note: The speed of the table is calculated by 11 knots

Genetic algorithm is used to optimize the location of oil spill emergency rescue base in Bohai sea[1][1].Compared the 50, 100, 150 and 200 generations of the algorithm. The results of optimization are shown in Table 2.

Table 2 Optimization of site selection results by genetic algorithm

generations	Qinhuangdao	Yingkou	Jingtang	Jinzhou	Huanghua	Laizhou	Weifang	Dongying	Caofeidian	Huludao	Dalian	GCAF
50	0	1	1	1	0	0	0	1	0	0	1	25.995
100	0	1	0	1	0	0	0	2	0	0	1	24.998
150	0	2	0	0	0	0	0	2	0	0	1	21.011
200	0	2	0	0	0	0	0	2	0	0	1	21.011

Table 2 shows that the calculation results under the assumption that rescue forces are equal, "1" in the table shows that the emergency rescue base was established there, "2" can be interpreted as doubling the emergency rescue force at the base. It can be seen from the above calculation results that the genetic algorithm shows good convergence in the 150th generation. Therefore, using genetic algorithm to solve the problem of location in multi-objective optimization has a great advantage.

The calculation results show that in order to make up for the shortage of existing oil spill emergency rescue forces in the Bohai Sea, oil spill rescue bases should be considered to established in three port cities of Yingkou, Dongying and Dalian.

3. Optimum allocation of emergency resources for oil spill base in Bohai Sea

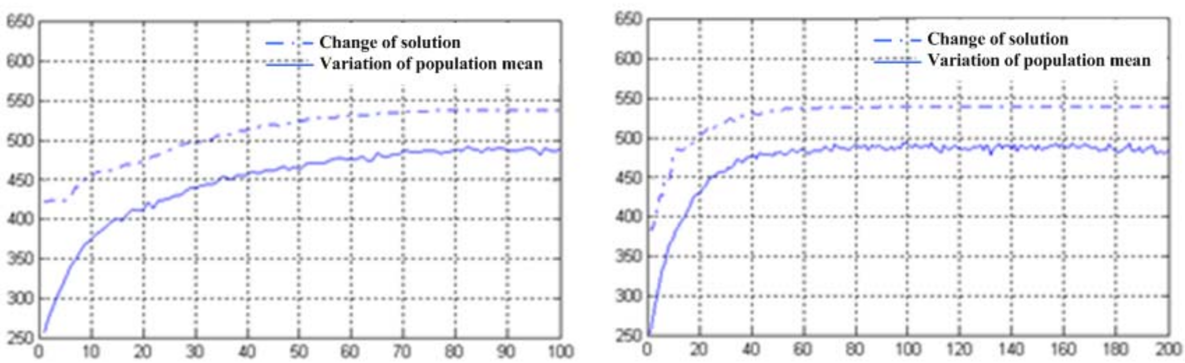
Based on the target assignment problem of genetic algorithm, the result is calculated according to the site selection, and establishing the allocation of resources to six bases in Tanggu, Longkou, Suizhong, Yingkou, Dongying and Dalian as the optimization target. Meanwhile, according to the probability and distribution of oil spill in the Bohai Sea, the virtual n-batches of oil spill accidents are set as the targets of emergency relief. The level of threat to batches of oil spills prior to the allocation of emergency rescue forces to emergency rescue targets has been assessed and the assessment of the j-th batch of oil spills is w_j. In addition, assuming that the i-th emergency rescue base for the j-th batch of oil spill assessment of the effective rescue level is p_{ij}, then the emergency rescue base for each batch of oil spill emergency relief benefits are $c_{ij} = w_j \cdot p_{ij}$, c_{ij} indicates the extent of the benefit of oil spill relief for a batch of oil spills. Now, to achieve the target allocation under the premise of meeting the basic principle of target allocation so as to achieve the best overall rescue benefit. That is to seek max $\sum_{j=1}^{n} c_{ij}$. Based on the construction of the objective function, the problem is translated into the question of how to evaluate the matrix W and P.

Based on the data in Table 1, taking into account the impact of external forces on oil spills, this paper analyzes the assessment of the effective rescue levels of each rescue point relative to the oil spill batches, and we can calculate the effective rescue degree matrix P of six bases relative to each oil spill batch.

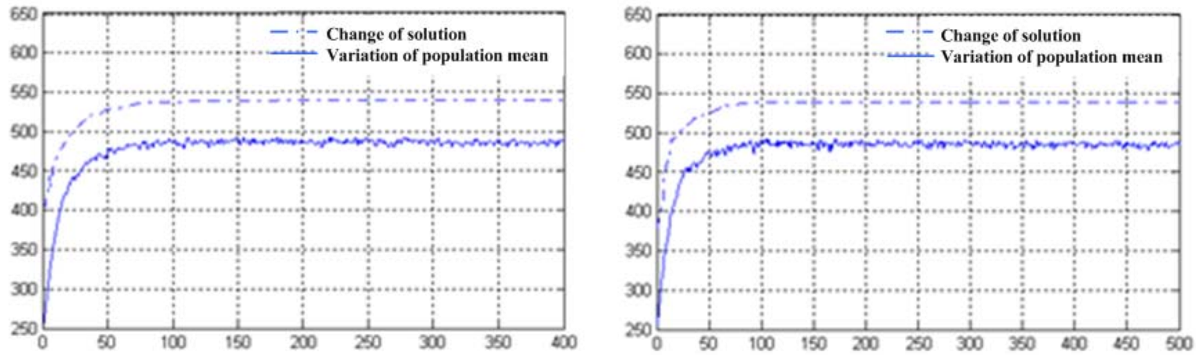
Based on genetic algorithm, we can optimize the best salvage team of all the oil spill batches. The calculation results are shown in Table 3. The solving process of the corresponding genetic algorithm is shown in Figure 1.

Table 3 Distribution of Rescue Corps by Oil Spill Batch

Oil spill batch	1	2	3	4	5	6	7	8	9	10	11	12
Rescue team	3	4	1	4	2	3	1	1	5	3	1	4
Oil spill batch	13	14	15	16	17	18	19	20	21	22	23	24
Rescue team	2	3	6	1	5	6	1	4	2	3	1	3
Oil spill batch	25	26	27	28	29	30	31	32	33	34	35	36
Rescue team	5	6	1	4	2	3	1	5	6	1	1	6
Oil spill batch	37	38	39	40	41	42	43	44				
Rescue team	1	6	6	1	2	6	1	3				



(a)Genetic 100 generation (solution: 537.381) (b)Genetic 200 generation (solution: 538.619)



(c)Genetic 400 generation (solution: 539.024) (d)Genetic 500 generation (solution: 539.044)

Fig.1 Genetic algorithm solution and population change in resource optimization configuration

According to the data in Table 3, we can calculate the cumulative benefits for each site by $c_{ij} = w_j \cdot p_{ij}$. The results are shown in Table 4.

Table 4 Cumulative assistance and benefits for each base

	Tianjin	Suizhong	Longkou	Yingkou	Dongying	Dalian
Rescue times	16	5	7	4	5	7
Total benefit	116.745	77.356	91.56	54.312	116.435	82.317
Resource allocation	21.07%	15.11%	16.8%	10.31%	20.94%	15.77%

In order to obtain the maximum benefit of offshore oil spill rescue service, the oil spill rescue resources in the Bohai Sea region can be deployed according to the resource allocation plan in table 4 to improve the resource utilization rate.

4. Conclusion

The configuration plan for oil spill rescue resources in Bohai Sea region should be: 21% of the relief resources should be allocated to each of Tianjin and Dongying; about 15% of the rescue resources should be allocated to each of Suizhong, Longkou and Dalian; and Yingkou should allocate about 10% of rescue resources. Application research also shows that the optimal resource allocation method based on genetic algorithm can effectively solve the key problems such as the frequency of resource utilization and resource allocation. Through the study of this article, it is of great realistic significance to establish an emergency service network for oil spill on the Bohai Sea with reasonable spatial distribution of emergency resources, optimization of resource allocation, and fast and effective allocation of resources to enhance emergency response capacity for sudden sea oil spills in Bohai Sea.

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