Navigation risk and route optimization in the northern waters of Zhoushan

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Abstract. With the implementation of the national strategy of marine development and economic integration of the Yangtze River Delta, Zhoushan will become an "international logistics island" and "free trade island", and the port and shipping logistics industry will become the leader of Zhoushan's economic development [1]. However, with the further development of port and shipping logistics industry, many islands will face the development, construction and utilization in the future, and the navigation situation of Zhoushan Island will face new challenges. In order to meet the needs of the development of Zhoushan port logistics and the improvement of navigable condition of Zhoushan Island waterway, this paper analyzes the risk factors affecting the navigable safety of the northern waters of Zhoushan, and based on the comprehensive consideration of the influence of the representative ship size, ship field conditions, wind and current as well as water depth on ship operation, reasonably and scientifically optimizes the navigable conditions of the northern waters of Zhoushan Island. Layout design.

1. Introduction

Zhoushan Islands new area is located at the T-shaped intersection of the "golden coastline" in the east of China and the "golden waterway" of the Yangtze River. It is famous at home and abroad for its 1390 islands. It has unique deep-water port resources and remarkable location advantages in connecting the river to the sea. It is the sea gateway and river sea intermodal hub of the Yangtze River Delta and areas along the Yangtze River [2]. However, with the development of the port and shipping industry, the high-density ship traffic flow in Zhoushan island area, the large impact of the climate on ship navigation and the complex navigation environment are urgent issues. In order to meet the needs of the development of Zhoushan port logistics and the improvement of navigable condition of Zhoushan Island, according to the existing navigable conditions of Zhoushan port, on the premise of ship handling characteristics, navigable water flow and meteorological conditions, and the development trend of logistics industry chain, it is of great practical significance to carry out reasonable and more scientific optimal layout design of navigable channels in the northern Zhoushan island area.
2. Risk analysis of navigation environment in the northern waters of Zhoushan

2.1. Accident analysis
At 4:00 a.m. on April 6, 2018, Zhangjiagang bulk carrier "dapujiang" ship tilted during anchoring in the northern waters of Zhoushan. At that time, the gust in the water area reached level 9, and the ship was in danger of capsizing at any time, which eventually led to the sinking of the bulk carrier, 13 people falling into the water and one death.

2.2. Cause analysis
With the rapid development of Ningbo Zhoushan port shipping economy, the number of import and export ships continues to increase. According to the latest data of Ningbo Zhoushan port, in the first half of 2019, the cargo throughput of major ports has reached 673.01 million tons, up 7.3% year on year; the foreign trade cargo throughput has reached 213.52 million tons, up 2.5% year on year; the container throughput has reached 126.99 million international standard containers, the same as 5.1% growth. In the first half of this year, the top ten ports in terms of cargo throughput are Ningbo Zhoushan port, Shanghai port, Tangshan port, Guangzhou port, Qingdao port, Suzhou Port, Tianjin port, Rizhao Port, Yantai port and Dalian port. Among them, Ningbo Zhoushan port [3] has become the only port with a cargo throughput of 557.96 million tons in half a year, as shown in Table 1.

At the same time, with the improvement of Zhoushan port's functional division, the operation of bulk cargo, crude oil, liquid chemical industry, container and other terminals, there are more and more types of ships entering and leaving Zhoushan water area, and the tonnage is increasing, which causes the problems of complex ship types in the navigable waterway, the increase of the number of ships, the difference of scale and speed, and the uneven maneuverability, etc., which leads to the stability of Zhoushan port and large-scale wharf. The difficulty and strength of berthing and anchoring are increasing, and the hidden danger of water accidents is also increasing [4]-[5].

| Sort | Port               | January to August | Year-on-year increase |
|------|--------------------|-------------------|-----------------------|
| 1    | Ningbo Zhoushan Port | 75253            | 7.0%                  |
| 2    | Shanghai port      | 47971             | -0.5%                 |
| 3    | Tangshan port      | 42148             | 4.1%                  |
| 4    | Guangzhou port     | 40284             | 10.3%                 |
| 5    | Qingdao port       | 38005             | 8.3%                  |
| 6    | Suzhou port        | 35002             | -0.6%                 |
| 7    | Tianjin port       | 32510             | 5.4%                  |
| 8    | Rizhao Port        | 30758             | 4.5%                  |
| 9    | Yantai port        | 25640             | 11.0%                 |
| 10   | Dalian Port        | 23786             | 3.0%                  |

Unit: 10000 tons

3. Research status and development analysis at home and abroad
In the study of channel problems at home and abroad, some experts only focus on the current situation, maintenance, scour and siltation of the channel unilaterally. For example, Wang Changjie, a famous channel expert at home, mainly focuses on the scour and siltation of the channel. He believes that when the channel is started, the channel will scour, the channel will settle and the channel will be silted up. Some experts only focus on the channel unilaterally. Navigation scale: at present, the safety and reliability of ship navigation in China's Waterway area is mainly based on the relevant requirements of inland navigation standards.
Although the definition of channel scale in inland navigation standard is put forward on the basis of full argumentation, it has certain scientificity[6]. However, there are still some limitations in the definition of channel scale in inland navigation standards. For example, the definition of the navigable width of the channel in the inland navigation standard is only limited to the ship type scale to express the navigable width of the channel. In fact, the navigable width of the channel is not only related to the ship type scale such as the captain and the ship width, but also related to the flow direction angle and the drift of the ship in the wind flow. If the channel is navigable in the bridge area, the width of the channel in the bridge area is not closely related to the range of ship suction effect of the pier. Separable[7]. Especially in Zhoushan navigation area, the dynamic factors such as wind and current change acutely every year, and there are many curved channels and cross channels, and the maneuverability and seakeeping of the representative ships are not the same. It is not scientific to plan Zhoushan channel only according to the requirements of inland navigation standards.

In recent years, the experts represented by Professor Liu Mingjun of Wuhan University of science and technology put forward the method of real ship test to study the navigation conditions in the bridge area, but there are obvious deficiencies in the real ship test: first, the cost of real ship test is expensive; second, the real ship test requires a certain number of measurements to achieve a more accurate accuracy, and the real ship test is not complete Find out the navigation flow condition of the whole channel. Salaliaov and others in the former Soviet Union have studied the navigation environment in the bridge area by using mathematical statistics theory, but the application of the results depends on statistical data, so it is inconvenient to promote the application.

4. Channel optimization

For the optimal layout of the channel, the sediment, water flow, scale of representative ships and the climatic conditions (such as wind, current and fog) of the channel waters should be considered comprehensively. According to various factors, it is of great significance to set up the navigation channel reasonably, avoid the ship jumping out randomly and reduce the time and distance that the ship will encounter, so as to improve the navigation efficiency of the channel and reduce the occurrence of collision accidents[8]-[9].

4.1. Necessity of channel optimization

4.1.1. Guarantee navigation safety. The main function of the channel is for navigation. Ships can navigate safely in the channel and reduce the frequency of traffic accidents, which is one of the main objectives of channel design and layout. In order to provide some reference for the construction of new wharf and waterway, the reasonable planning and layout of the waterway in the northern waters of Zhoushan are carried out.

4.1.2. Few reasonably planned channels on the market. Based on a large number of scientific research and demonstration conducted by relevant scientific research institutions, China's Yangtze River Estuary Channel has set up south branch channel, south channel channel channel and north channel channel channel channel[10], stipulating that the south channel can only run ships with a gross tonnage of less than 500 tons, while the South Channel Channel can only run shallow draft ships, while the north channel channel is arranged to specially run deep draft ships, so that all channels of the Yangtze River estuary are unobstructed and safe, which fully guarantees the navigation. The logistics of seaports and cities along the Yangtze River is smooth. Especially for Zhoushan waterway network, considering the climatic conditions, water flow conditions and maneuvering characteristics of representative ships in the navigable environment waters in the north of Zhoushan, it is rare to plan and layout the existing or to be constructed waterway in Zhoushan.
4.2. Technical key to optimal layout of waterway

4.2.1. Establish the representative ship types and wind wave elements of main navigation channels in the waters of northern Zhoushan Island. The so-called representative ship type refers to the ship type scale of a representative ship with high navigation frequency in a certain channel all the year round, including the length, width and draft of the ship. The representative ship type represents the general characteristics of the ship sailing in a certain channel. Annual climate conditions mainly refer to wind and wave. The wind and wave affect the maneuverability of the ship. The ship not only deflects in the wind and waves, but also drifts. Therefore, in the navigation area with large wind and waves, the conditions of the ship field increase, and the required navigation width is also large. The water depth of the channel affects the draft and the affluence depth of the ship, which is directly related to whether the ship can pass through. The transverse flow of the channel is easy to drift the ship, and the navigation scale of the ship is relatively large.

4.2.2. Establish the field conditions for the safe navigation of representative ships in the main channels of the waters in the northern island area of Zhoushan. Fujii, a famous Japanese scholar, believes that the field of ship is a complex concept. To determine the field conditions of ship, we must consider the ship flow in the channel, the flow conditions of the channel and the representative ship type scale. In order to navigate safely in the channel, ships must have a certain space in the field. If the space is less than this field, ships will have traffic accidents. Different representative ships need different field conditions. For example, because the container ship is relatively large, its maneuverability is good, and its ship orientation is poor, so the field it needs in the transverse direction is larger than other thin ships. Therefore, in view of the actual situation in the northern waters of Zhoushan, how to set the boundary conditions and initial conditions is also a key problem.

4.2.3. Study the drift caused by the wind and current of each channel in the waters of northern Zhoushan Island. The drift caused by wind and current is affected by the length, width, draft, velocity, flow direction angle, wind speed and wind direction angle of the ship. If the water depth is too shallow, the ship will produce shallow water effect in the channel, or even the ship will run aground. According to the representative ship types and flow meteorological conditions of each particular channel in the north of Zhoushan, the amount of drift and the required water depth of the ship in the particular channel are studied. Wind-induced drift, flow-induced drift and water depth are the key factors to be considered in the channel layout.

4.2.4. Study the optimal channel layout scheme. Based on the comprehensive consideration of the influence of representative ship size, ship field conditions, wind and current, and water depth of each channel on ship maneuvering, this paper determines which channels are container ship channels, which channels are fishing boat channels and which channels are deep draft channels in the northern Zhoushan island area, and then studies the optimal channel network layout scheme of the whole northern Zhoushan island area [11].

5. Conclusion
In recent years, with the vigorous development of shipping industry, the number of ships sailing through Zhoushan waters has also increased. But on the premise of not upgrading the channel level, the problem that the capacity of the complex environmental channel in the northern waters of Zhoushan can not meet the needs of port development will become increasingly obvious. Therefore, through a large number of reading literature and investigation and analysis, this paper understands the navigation status and hydrometeorological elements of each channel water area in the northern island area of Zhoushan. Through mathematical analysis, it puts forward the representative ship type scale of each main channel water area in the northern island area of Zhoushan. On the basis of representative ship types, using ship domain model and combined with ship's maneuvering characteristics, this paper
puts forward the optimal layout design scheme of waterway and buoy in the northern island area of Zhoushan, which is of great significance for reference.

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