Study on site selection of ship refuge in Zhanjiang sea area

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Study on Site Selection of Ship Refuge in Zhanjiang Sea Area

By

FU YU

The People’s Republic of China

A dissertation submitted to the World Maritime University in partial
Fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

In

MARITIME AFFAIRS

(SHIPPING MANAGEMENT)

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DECLARATION

I certify that all the materials in this dissertation that are not my own work have been identified, and that no materials are included for which a degree has previously been conferred on me.

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Abstract

Title of Dissertation: Study on site selection of ship refuge in Zhanjiang sea area

Degree: MSc

With the enlargement and professionalization of ships, there’s an increasing amount of dangerous cargo vessels and oil tankers shuttling the port area which brings great risk to the marine environment. Once there is an accident, it will do severe harm to the marine environment. Reasonable ship refuges are needed to prevent and reduce the accident. We put forward a site selection evaluation model to choose the proper refuge. First, we analyzed the conditions and factors in site selection of ship refuge, developed corresponding evaluation indexes, and formulated an evaluation model from the aspects of the extent of Marine pollution and the amount of leakage, storm prevention conditions, seafloor sediments and the manageable sea area of the ship, etc. According to the type and scale of ships, we select the best place for ship refuge through the evaluation of areas including all the seaports, harbors, natural harbors, anchor berths, temporary stranded sites or inshore areas of Zhanjiang sea area with the use of the model proposed in the thesis. Results show that, we choose anchorage ground 19#( Location: 21°04’05”N, 110°33’20”E, the radius is 500 meters, the water depth is 16.6-23.2 meters, the bottom sediment is sand and mud), the second pilot anchorage and anchorage ground 11#( Location: 21°06’06”N, 110°26’36”E, the radius is 400 meters, the water depth is 10.2-28 meters, the bottom sediment is sand and mud) in the Zhanjiang bay, berth No.1 and berth No.2 in Zhanjiang steel main pier of east island port and Pier 208#:212# in Xiashan port as refuges for general cargo ships; outside the Zhanjiang bay, we choose the northern area of the outer section of Zhanjiang Harbor Long Teng channel which is about 2 sea miles from the center line of the longteng channel and 300 thousand ton class lightering anchorage of Long Teng channel as refuges for overloaded supertankers and large bulk carriers.

Key words: ship refuge; quantitative risk assessment; site selection; Zhanjiang sea area
TABLE OF CONTENTS

DECLARATION............................................................................................................................ I
ACKNOWLEDGMENTS.................................................................................................................. II
Abstract........................................................................................................................................ III
TABLE OF CONTENTS.................................................................................................................... IV
LIST OF TABLES............................................................................................................................. VI
LIST OF FIGURES.......................................................................................................................... VII

CHAPTER 1 INTRODUCTION........................................................................................................... 1

CHAPTER 2 THE STUDY ON THE PLACE OF REFUGE................................................................. 3
2.1 THE CONCEPTION OF THE SHIP IN DISTRESS AND THE PLACE OF REFUGE............ 3
2.1.1 The conception of the ship in distress.............................................................................. 3
2.1.1.1 The provisions on the ship in distress in The Dictionary of Maritime Law.......................... 3
2.1.1.2 Relevant provisions of the guidelines on places of refuge for ships in need of assistance of IMO.......................................................................................................................... 3
2.1.1.3 Relevant provisions of the guide to the decision of main ship refuge of Canadian security ministry of water, land and atmosphere................................................................. 4
2.1.2 The conception of the place of refuge.............................................................................. 4
2.1.2.1 The provisions on the place of refuge in the dictionary of maritime law4
2.1.2.2 The provisions in the guidelines on places of refuge for ships in need of assistance of IMO.......................................................................................................................... 4
2.1.2.3 The provisions on the organization of The Guide to the Decision of the Place of Refuge in Alaska.......................................................................................................................... 4
2.2 BACKGROUND OF THE PLACE OF REFUGE..................................................................... 5
2.3 ASYLUM CASES OF ACCIDENT SHIP................................................................................. 6
2.4 THE PRESENT RESEARCH AND IMPLEMENTATION OF SHIP REFUGE BOTH AT
HOME AND ABROAD................................................................................................................... 7
2.4.1 International general situation......................................................................................... 7
2.4.1.1 Status of International Legislation.................................................................................. 7
2.4.1.2 National initiatives........................................................................................................... 7
2.4.2 Domestic general situation............................................................................................... 8

CHAPTER 3 LOCATION REQUIREMENTS AND MODELS OF SHIP REFUGE................................................................. 9
3.1 LOCATION REQUIREMENTS OF SHIP REFUGE................................................................... 9
3.1.1 Introduction to the selection system of ship refuge at home and abroad..... 9
LIST OF TABLES

Table 3.1  Evaluation index system table  13
Table 3.2  Reference tables for evaluation grade and score of refuge site  14
Table 3.3  Reference tables for evaluation indicators of the refuge site  15
Table 3.4  The weight values of evaluation factors  18
Table 4.1  VTS monitoring data statistical table of Zhanjiang port  23
Table 4.2  Towboats in Zhanjiang port  30
Table 5.1  The evaluation indexes of 11# anchorage ground  34
Table 5.2  The evaluation score of each place  35
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>The tree figure of the location factors</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Site selection process</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Site selection process</td>
<td>18</td>
</tr>
<tr>
<td>4.1</td>
<td>The main and branch channel of Zhanjiang port</td>
<td>21</td>
</tr>
<tr>
<td>4.2</td>
<td>Development trend of Zhanjiang port cargo throughput in 2000--2016</td>
<td>23</td>
</tr>
<tr>
<td>4.3</td>
<td>The proportion of different types of ships</td>
<td>26</td>
</tr>
<tr>
<td>4.4</td>
<td>Zhanjiang Ocean function zoning map</td>
<td>27</td>
</tr>
<tr>
<td>5.1</td>
<td>11# Anchorage oil spill simulation test results</td>
<td>34</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION

The establishment of ship refuge is a symbol of the progress of social civilization and the scientific and humane development of a country's port management. With the development of global ship enlargement, the abilities to cope with oil spilling of various countries are faced with new challenges. Countries should act aggressively to build marine refuges for ships that can deal with ship accidents including widespread oil spilling and chemical pollution to approach the challenge. The IMO regulation, guidelines on places of refuge for ships in need of assistance, has transferred the power of establishing refuges to coastal states. Those states should consider its own interests, respond to IMO's call actively and put the establishment of ship refuges on the agenda. (IMO 2004a)

With the increase in traffic demand, there is an increasing trend of maritime traffic volume around the world every year. The increase in the volume of vessel traffic leads to an increase in the number of ships entering the port. The enlargement, high-speed orientation and professionalization of ships result in the increasing of the ship concentration and the corresponding sailing risk. The busier the port is, the greater the probability of accidents may happen. Different types of ships and different types of accidents lead to different risks, for instance, the risk caused by oil tankers and chemical tankers are far greater than that of ordinary cargo ships. If ships in coastal waters are in distress, and enter the port may cause greater danger to the marine environment and port facilities, then we must give the ships in distress a qualified and safe refuge for the risk of worsening while not leading greater harm to the nearby port. In this case, we should select the proper refuges through the study on the selection and evaluation models of the corresponding refuges. The key to the
selection of refuge places is quantitative risk assessment of ship's impact on port environment.

The planning and design of coastal accidents ship refuges in Zhanjiang is a response to IMO’s call which can protect the port's environment, security and economy from being threatening. It also improves the control level of Zhanjiang port and prevents the risk of accidents, reduces secondary accidents, and maintain the “ship safety and ocean cleanness” of Zhanjiang. At present, with the launching of Baogang Zhanjiang steel base and the petrochemical carrier of Zhongke Refining and Petrochemical Corporation, 300-thousand-ton crude oil ship, 200-thousand-ton refined oil tanker and 300-thousand-ton bulk cargo ship will sail in and out of Zhanjiang port in large quantities. Once those large ships are in distress and accidents such as oil spilling or stranding are deteriorated, it will seriously threaten the security of Zhanjiang sea area without proper refuges. As a result, there has to be some reasonable refuges in Zhanjiang sea area for protecting the ships in distress.(Zhanjiang Authority 2016)

The second chapter of this thesis introduce the concept of ship in distress and place of refuge, case of ship refuge and research status at home and abroad; The third chapter analyzes the main factors of refuge selection and based on this, establishes the site selection model; chapter four introduces the traffic and natural environment of Zhanjiang port and nearby waters; chapter five apply the site selection model proposed in chapter four to the water area around Zhanjiang port for gaining the corresponding refuges; chapter six is conclusion and discussion.
CHAPTER 2
THE STUDY ON THE PLACE OF REFUGE

2.1 The conception of the ship in distress and the place of refuge

2.1.1 The conception of the ship in distress

2.1.1.1 The provisions on the ship in distress in The Dictionary of Maritime Law
The ship in distress is a ship that is shipwrecked. A shipwreck is a catastrophic accident occurring at sea that causes damage to human’s life or property, such as a collision, reefing, stranding, fire, explosion, overturning, sinking, blowout or damage to important parts that happens to ships or maritime facilities. (Si yuzhuo. 1998)

2.1.1.2 Relevant provisions of the guidelines on places of refuge for ships in need of assistance of IMO
IMO adopted the provisions of the guidelines on places of refuge for ships in need of assistance at the 23rd mission on March 5, 2004: ships in need of assistance are ships in danger of losing or causing a threat to the environment or the navigation, not including the condition in which people aboard the ship require assistance. (IMO 2004a)

In fact, the conception of “ships in need of assistance” adopted by the IMO guide has made a more further expansion in the ships coverage than the conception of ships in distress, because not all ships shipwrecked need assistance and to get into the emergency refuge and the reasons and the reason why ships need assistance is not all
due to shipwreck. The conception of “ships in need of assistance” is more accurate and more rich than the conception of “ship in distress”. (IMO 2004a)

2.1.1.3 Relevant provisions of the guide to the decision of main ship refuge of Canadian security ministry of water, land and atmosphere

The expression of the ship in distress in The Guide to the Decision of Main Ship Refuge published by Canadian security ministry of water, land and atmosphere is exactly same with that in The Guide to the Place of Refuge of Ships in Need, without any difference.

In the different stages of the information and documents, there are many names for ships that occurred shipwreck, such as ship in distress, ship in need of assistance, disabled vessel, etc. But according to experts understand, they are only different ways of expression, so the actual meanings are not different (Canada authority 2001).

2.1.2 The conception of the place of refuge

2.1.2.1 The provisions on the place of refuge in the dictionary of maritime law

The conception of “refuge port” was used earliest. The definition of the refuge port in The Dictionary of Maritime Law is that a refuge port is a port that ships would travel to for their safety when ships encounter accidents in transit. (Si yuzhuo. 1998)

2.1.2.2 The provisions in the guidelines on places of refuge for ships in need of assistance of IMO

The place of refuge is a place where a ship in need of assistance may take measures to stabilize its situation, reduce the risk of navigation, protect human life and environmental safety. (IMO 2004a)

2.1.2.3 The provisions on the organization of The Guide to the Decision of the Place of Refuge in Alaska

The place of refuge in The Guide to the Decision of the Place of Refuge passed by Alaska sub-committee to handle and organize the problem of the place of refuge in
October, 2004 is a place that ships in need can get into occasionally, in which ships can take measures to secure ships at the site, to protect human lives, to reduce the risk of navigation and to ensure vulnerable natural resources and other resources in the area such as fishing, tourism and so on. The place of refuge includes the harbor, the harbor, the natural bay, the temporary stranded place or the coastal area. In Alaska, the designated refuge is not confirmed in advance. (Alaska 2004)

The place of refuge should be a general understanding, and as long as the place can provide some help for the ship to reduce the risk and loss can be, it can be named as the place of refuge. In different stages and different information and documents, there are many names for the emergency refuge, such as place of refuge, place of safety, place of refuge, refuge of water, etc... But the place of refuge is the most popular reference.

2.2 Background of the place of refuge

In recent years, large-scale crude oil spill accidents in some countries have been emerging due to ship failures and others, and the severity of these accidents has increased due to improper measures taken by coastal countries to ships. For example, the "CASTOR" tanker incident in 2000 caused great attention of the public and media, which also led to the issue of "the place of refuge" becoming an important issue of the Legal Committee at the IMO meeting of secretary-general in October 2001. IMO expressed great concern and the 23rd IMO Congress had adopted two resolutions and guidelines on the place of refuge: The Resolution on the Guide to the Place of Refuge for Ships in Need of assistance (Resolution A.949 (23)) and The Resolution on Maritime Assistance Services (Resolution A.950 (23)), which have provided guidance on the establishment of ship refuge for coastal countries. (IMO 2015)

The introduction of The Guide provides a way to solve the problem for the coastal countries to deal with such incidents, and the International Maritime Organization has transferred the right to establish asylum to all coastal countries. (IMO 2004a)
2.3 Asylum cases of accident ship

In recent years, a series of shipwrecks have occurred, such as the Erika, the Castor, the Prestige are closely linked to the refugee problem, which has aroused widespread concern in the international community and has made the relevant aspects aware of the urgency and importance of solving the ship refuge problem.

Case 1: The sinking of "Ship Erika"

At the end of 1999, the Erika loaded with 30,000 tons of oil cargo ran into danger, but the French authorities refused to provide the place of refuge for the ship, and soon the ship broke into two parts, sank in the deep sea.

Case 2: The lightering of "Ship Castor"

In December 2000, the "CASTOR" of the Athens Shipping Company appeared deck cracks in the Mediterranean on its way to Nigeria, which had been removed to Morocco, Gibraltar, Spain, France, Italy, Turkey, Malta, Algeria and Greece and other countries for help, but was rejected, and finally as the "abandoned kid" of maritime sector, it lightered on the high seas. Fortunately, the crude oil was eventually lightered not causing sea pollution.

Case 3: The port unloading of Ship" Eastern Power"

On December 8, 2000, the super tanker "Eastern Power" loaded with 250,000 tons of Iraqi crude oil suffered severe storms and slightly oil leaking, and the Canadian authorities refused to enter the waters under their jurisdiction, so the ship was forced to go to other ports for cargo unloading.

Case 4: The sinking of Ship "Prestige"

On November 13, 2002, the Bahamian single-hull tanker "Prestige" was leaking on the coast of the province of Galicia, Spain (carrying 77,000 tons of fuel oil on board). The Spanish government refused to provide the place of refuge for the ship or rescuer, and asked the tanker to leave its coast of 60 nautical miles away. Six days
later, the ship sank causing huge losses because it was not provided with the place of refuge.(IMO 2005)

2.4 The present research and implementation of ship refuge both at home and abroad

2.4.1 International general situation

2.4.1.1 Status of International Legislation
At present, there is no special international maritime legislation which stipulate the problem of place of refuge specially, but there is a series of conventions and legislation that relate to the problem of place of refuge, such as: Protocol Relating To Intervention On The High Seas In Cases Of Marine Pollution By Substances Other Than Oil,1973,The International Convention For The Safety Of Life At Sea,1974,and its amendments especially the provisions of Chapter V, International Convention On Maritime Search And Rescue, 1979 and its amendments and International Convention On Salvage, 1989 and so on.(IMO 2004b)

2.4.1.2 National initiatives
Some of the relevant international and regional collaborative organizations in the world have also provided a number of recommendations for the establishment of ship refuges, such as the International Port Association, the European Harbor Organization and the International Maritime Insurance Union and so on. They have discussed the selection of refuges, the costs involved and the risks involved Evaluation and other issues in detail.(Van Hooydonk, E. 2003)

Many countries in the world have already embarked on the construction of refuges and maritime aid service systems. Now, the United Kingdom, the United States and Australia have already had a relatively complete supporting institutions and facilities.(Browne, B 2003)
2.4.2 Domestic general situation

China has not established any related system of coastal refuge, institutions and technical facilities, there are many related legislation of maritime distress ship refuge, such as The People's Republic of China Maritime Traffic Safety Law in 1983, Maritime Law of the People's Republic of China in 1992 and Marine Environmental Protection Law in 1999 and so on. (Wang, S.Y. 2005)

According to the Provisions on maritime relief in the chapter 7 of Maritime Traffic Safety law, the ship should report the request to the competent authorities in the most prompt way (China authority 1983). The competent authority shall immediately organize the rescue after receiving the distress report. Foreign dispatch ships or aircraft into the territorial sea or territorial waters of the People's Republic of China to rescue the ship in distress must be approved by the competent authority. Chapter 9 of Maritime Law provides special provisions for maritime relief, and Article 192 provides that "the salvor shall be entitled to the rights and remedies provided for in this Chapter for relief operations provided by the competent authorities of the State (China authority 1992)." In Chapter 8 of Marine Environmental Protection Law, "Prevention and control of ships and related activities on the marine environment pollution damage "provides that shipshipwreck accidents, resulting in or may cause significant damage to the marine environment, the national maritime administrative authorities have the right to force Take measures to avoid or reduce pollution damage. (China authority 1999)
CHAPTER 3
LOCATION REQUIREMENTS AND MODELS OF SHIP REFUGE

3.1 Location requirements of ship refuge

3.1.1 Introduction to the selection system of ship refuge at home and abroad

After the "CASTOR" incident in 2000, IMO passed The Resolution on the Guide to the Place of Refuge for Ships in Need of assistance (Resolution A.949 (23)) and The Resolution on Maritime Assistance Services (Resolution A.950 (23)) at the 23rd IMO convention, which ask all member states establish a ship refuge to ensure that ships in need can get the necessary assistance and maintenance in the place of refuge, and to reduce pollution to the environment.(IMO 2004a)

Many coastal countries around the world have begun to construct the place of refuge, and there are two systems in the international community for the establishment of ship refuge.(Sturgeon. A 2002) First, some countries (such as Britain) believe that each region has the potential to be the place of refuge, and that there is no places of refuge suitable for all ships in need, so when they need to aid the ship applying to the place of refuge, they should make a concrete analysis according to the specific situation. Because every assistance operation involves uncertain factors. Therefore the British thinks every port, anchorage or water may become the ship refuge, and that all the details of the refuge area need a statistics, so when ships need assistance, they just according to the data determine the proper place of refuge. Second, some countries (such as Denmark, Spain, etc.) have specified a number of ports, harbors and anchorage areas as a refuge for ships in accordance with the actual situation of
their coastal areas. According to the natural conditions of the harbor, bay and anchorage, it is necessary to decide whether to meet the requirements of ships in need. These two systems both have advantages and disadvantages. (CMI 2004)

The former, according to the concrete analysis of each rescue operation details, has stronger pertinence. But it needs higher instantaneity of information collection, information authenticity and the high-speed of decision in every rescue. The advantage of the latter is to prejudge the ports, the gulf and the anchorage, and choose the suitable place for the ship, which takes less time to make decisions in real time, and the amount of information required to make decisions is relatively small, but the pertinence is obviously not as good as the former.

As a member of IMO, China is also a major maritime power, but it is still relatively backward in the establishment of the ship refuge, and it will not be able to timely assess and provide help upon the request for asylum. According to domestic experts and scholars, the establishment of the ship refuge must be guided by the national unity, and the ship refuge should be established with necessary facilities, emergency response procedures and emergency contingency plans according to the objective conditions. (Zhang, H 2006)

In our country, in fact, there have been some similar places of refuge and disposal methods, for example, 10 refuge anchorages in the northern coast, east coast and south China coastal regions opened early are actually ship refuges from the wind. The ship refuges are provide for ships in need of refuges from the wind, which belong to the ships without pollution risk, but the really qualified ship refuge means a place that ships in need can get into temporarily, in which ships can can take action to keep its stable status, reduce the navigation risk, protect the life safety of life, protect the environment from pollution and protect the other area (culture zones, tourist area, etc.). The selection of ship refuge can be ports, anchorages, natural bays or inshore waters.
3.1.2 Requirements of ship refuge establishing

There is no uniform requirement and standard for the establishment of the ship refuge. According to the recommendations of some international organizations, the ship refuge is generally located in the anchorage, the deep-water area of the harbour or the harbour, the floating pier, etc., in order to ensure the safety of the life on the ship in distress, and make necessary repairs or uninstall services to reduce the navigation risk and environmental pollution so that it can resume normal navigation.(IMO 2005)

The factors to be considered in determining the location of the refuge include:

(1) The possible threat of the use of ship refuge to the public security (e.g. the distance to the neighborhood);
(2) Whether there is a designated environmental protection area near or on the way to the ship refuge;
(3) Sensitive environment and rare species in or near the refuge area;
(4) Whether there are any fishing or shellfish farms in or near the cargo lightering area or the channel to the refuge;
(5) Economic/industrial facilities (e.g. distance to nearby industrial areas);
(6) Places for tourism and entertainment;
(7) Available (providing) rescue equipments (e.g. salvage vessels or aircraft, transfer equipment, dangerous goods receiving equipment and some necessary maintenance equipment);
(8) Natural conditions within the refuge area including:

1) Prevailing winds in the area (to consider whether the refuge area can withstand strong winds and waves);

2) Tides;
3) Meteorological and sea conditions (local meteorological statistics and the number of days that people can't operate and get close to the refuge);

4) Water depth and bottom quality of local waters (Maximum and minimum depth, maximum allowable draught, bottom quality, etc. to consider the possibility of grounding a faulty ship without sinking in the refuge and the channels to the refuge);

5) Seasonal effects;

6) Navigation characteristics (whether the operation of salvage or cargo lightering can be carried out safely in a refuge without refuge; in the absence of propulsion, whether there is enough room for the ship to operate and limit the measurement of the ship, such as the length, width and draught of the ship, the risk of obstruction of channels, navigation, or ship operation due to ship grounding);

7) The operating environment of the surrounding waters, especially in the harbor.

9) All possible consequences and scenarios, such as the risk of safety of human life, fire, leakage of toxic substances, explosions, etc.

10) Whether there is an effect on national defense security. (Chen xingrong. 2012)

3.2 The Location model of the ship refuge

Among the relevant factors in the site selection of refuges, there are national security factors, which are crucial. Once a location has an impact on national security, the site cannot be used as a ship refuge. Therefore, the primary election is according to the distance from the national defense security equipment (warships, research institute and headquarters, etc.). When the distance from the defense security facility is less than the set distance, the site is considered to have an impact on national defense security and cannot be used as a ship refuge. For the remaining major evaluation factors, we should give the corresponding evaluation index, determine the weight of each factor, and establish the location evaluation model of the ship refuge. (Yang tianxue 2011)
In this paper, the location selection evaluation factor of the ship refuge is divided into four categories and nine items. Four categories: plane layout factors, natural factors, rescue equipment acquisition degree, sensitive resource environment impact; nine evaluation factors: wind, wave, flow, water depth, location cyclotron range, geology of waters, the time for rescue vessels (emergency equipment depot) to arrive at the site, the scope of sensitive resources pollution due to oil spill, the distance from sensitive resources. The nine factors constitute the evaluation indexes selected by the location model of the ship refuge, and the specific factors can be seen in the evaluation index system of the tree figure 3.1 and table 3.1.(Liu wei 2009)

Table 3.1 Evaluation index system table

<table>
<thead>
<tr>
<th>site selection evaluation</th>
<th>4 types of factors</th>
<th>9 Specific indexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation grade scores</td>
<td>plane layout factors</td>
<td>scope of the return of water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water depth</td>
</tr>
<tr>
<td></td>
<td>Natural conditions factors</td>
<td>wind</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wave</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flow</td>
</tr>
</tbody>
</table>
3.2.1 Evaluation factors for the ship refuge location

A quantitative method was used to evaluate the location of ship refuges in Zhanjiang sea area. According to refuge of uniform evaluation indexes, the alternative sites is divided into five grades: "entirely appropriate", "moderately appropriate", "generally appropriate", "inappropriate", "totally inappropriate", and its corresponding quantitative score intervals are (85 100], (70 85], (55 70], (35 55]和[0 35].(IMO 2011)

Table 3.2 Reference tables for evaluation grade and score of refuge site

<table>
<thead>
<tr>
<th>Grade of refuge</th>
<th>Completely suitable for</th>
<th>Medium suitable for</th>
<th>Generally suitable for</th>
<th>inadequacy</th>
<th>Totally out of place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score interval</td>
<td>(85 100]</td>
<td>(70 85]</td>
<td>(55 70]</td>
<td>(35 55]</td>
<td>[0 35]</td>
</tr>
</tbody>
</table>

(Source: edited by author)

For the specific nine evaluation factors, we can obtain the corresponding rating scores by referring to the index parameters in table 3.3.

Table 3.3 Reference tables for evaluation indicators of the refuge site
<table>
<thead>
<tr>
<th>evaluation factors</th>
<th>evaluation grade</th>
<th>completely suitable for</th>
<th>medium suitable for</th>
<th>generally suitable for</th>
<th>inadequacy</th>
<th>totally out of place</th>
</tr>
</thead>
<tbody>
<tr>
<td>the ratio of cycle water diameter / the length of design ship</td>
<td>≥4.0</td>
<td>3.0~4.0</td>
<td>2.0~3.0</td>
<td>1.0~2.0</td>
<td>≤1.0</td>
<td></td>
</tr>
<tr>
<td>The ratio of water depth / full draft of ship</td>
<td>1.6~2.5</td>
<td>1.3~1.5</td>
<td>1.0~1.2</td>
<td>0.7~0.9</td>
<td>≤0.7</td>
<td></td>
</tr>
<tr>
<td>wind-prevention grade</td>
<td>≥12</td>
<td>10~12</td>
<td>8~9</td>
<td>6~7</td>
<td>≤5</td>
<td></td>
</tr>
<tr>
<td>wave</td>
<td>≤0.5</td>
<td>0.5~1.0</td>
<td>1.0~1.5</td>
<td>1.5~2.0</td>
<td>≥2</td>
<td></td>
</tr>
<tr>
<td>flow</td>
<td>≤0.25</td>
<td>0.25~0.75</td>
<td>0.75~1.25</td>
<td>1.25~2</td>
<td>≥2</td>
<td></td>
</tr>
<tr>
<td>bottom sediment</td>
<td>Mud and sand</td>
<td>Mud and sand</td>
<td>Sand and gravel</td>
<td>Hard clay, hard sand</td>
<td>Shells, rocky bottoms, rocks</td>
<td></td>
</tr>
<tr>
<td>The time of rescue facilities to the premises</td>
<td>≤3h</td>
<td>4-6h</td>
<td>7-12h</td>
<td>13-18h</td>
<td>19-24h</td>
<td></td>
</tr>
<tr>
<td>Area of sensitive resource pollution</td>
<td>≤9</td>
<td>9-24</td>
<td>25-63</td>
<td>64-100</td>
<td>&gt;100</td>
<td></td>
</tr>
<tr>
<td>the shortest distance to sensitive resource</td>
<td>&gt;1.5nm</td>
<td>1.0-1.5nm</td>
<td>0.7-1.0nm</td>
<td>0.3-0.6 nm</td>
<td>≤0.3 nm</td>
<td></td>
</tr>
</tbody>
</table>

(Source: International maritime organization. (2004a, March 5). The guidelines on places of refuge for ships in need of assistance. London: author)

1) The ratio of cycle water diameter / the length of design ship

The ship refuge needs to provide sufficient turning water for the ship in distress which is convenient for rescue ships to provide rescue and for the ship in distress to anchor and emergency control. Usually with the help of the tug, the turning water is at least twice the length of the ship. Obviously, the greater the range of the turning waters is, the more favorable for the ship in distress.
(2) The ratio of water depth/ full draft of ship

We need know the maximum and minimum depth, maximum allowable draught in
the refuge and the channels to the refuge. The navigable water depth of the site is 1.2
times of load draught, which can meet the navigation requirements and the water
depth can meet the anchorage requirements of the ships. When the water depth is 1.5
to 2.5 times of load draught, the anchor effect is better.

(3) Grade of protection from wind

Refuge can generally protect ships in distress from wind. If a place can resist the wind at level 12,
it is entirely appropriate for the ship refuge; If a place can resist the wind at level 11-12, it is
appropriate for the ship refuge; If a place can resist the wind at level 8-9, it is generally
appropriate for the ship refuge; Obviously, the stronger the wind resistance level is, the more
appropriate it is as a ship refuge.

(4) Wave height

The ship refuge is usually covered by shore, mountains and buildings, with small waves in the
water. The smaller the wave, the more suitable for a ship refuge

(5) Flow velocity

As a refuge area, the waters are usually well covered and less affected by the flow. It
is generally considered that the flow velocity is entirely appropriate less than 0.25
m/s. The flow rate is moderately appropriate between 0.25 and 0.75 m/s. The flow rate is generally appropriate between 0.75 - 1.25 m/s. When the flow rate is large, for
example the flow velocity of 1.25 to 2m/s is not inappropriate and the flow velocity
greater than 2m/s is totally inappropriate

(6) Bottom sediment

The best bottom sediment of the ship refuge is sand or mud in order to facilitate the landing of
the ship and protect the bottom of the ship after its bottom touching the land.

(7) The time for rescue vessels (emergency equipment depot) to arrive at the site

The shorter the time required for key equipment such as salvage vessels, cleaning vessels and salvage or rescue equipment to sail from the anchorage to the refuge site, the better the site will be as a ship refuge. The average time of the main rescue equipment such as rescue boat, tugboat to rescue place is selected as the evaluation index.

(8) The area of sensitive resources pollution

When oil spill accidents occur in the place, if in the effect of prevailing wind in the sea area, the oil spread causes pollution to the Marine environment, the area of sensitive resources pollution in 12 hours is regarded as the evaluation index. The smaller the area of contaminated sensitive resources is, the more appropriate the site is for a refuge.

(9) The distance from sensitive resources

If oil spill accidents occur in the place, the sum of nearest distances between the boundary of the spill area and each nearby sensitive resource after 12 hours divided by the number of sensitive resources, and the smallest evaluation distance of sensitive resources is used as an evaluation index. If the refuge is further away from the sensitive resources, the more suitable it is. (Liwang.H 2013)

3.2.2 The process of location selection

The location selection process of the ship refuge is shown in Figure 3.2. In the process of selecting a place from the alternative site of Zhanjiang sea area, the primary selection is necessary to judge whether it could influence national defense security. If national defense security is not affected, the site will obtained a score as a ship refuge by the location evaluation model. If national defense security is not affected, the site will obtained a score as a ship refuge by the location evaluation model. (Tian Chai 2017)
3.2.3 Weight of all factors

According to the importance of the location of the site of the refuge, we can set the weight values of the nine factors, wind, wave, flow, water depth, location cyclotron range, geology of waters, the time for rescue vessels (emergency equipment depot) to arrive at the site, the scope of sensitive resources pollution due to oil spill, the distance from sensitive resources. The weight values are shown in table 3.4.

Table 3.4 the weight values of evaluation factors

<table>
<thead>
<tr>
<th>number</th>
<th>Evaluation factors</th>
<th>Weight values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>the ratio of cycle water diameter / the length of design ship</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>The ratio of water depth/ full draft of ship</td>
<td>0.1</td>
</tr>
<tr>
<td>3</td>
<td>wind-prevention grade</td>
<td>0.1</td>
</tr>
</tbody>
</table>
3.2.4 site selection model

The detailed data of a specific place in Zhanjiang sea area is given, according to this data quantify the nine evaluation indexes and calculate the score $Spot_{Score}$ of the place as a refuge based on formula (1).

$$Spot_{Score} = \sum_{j=0}^{9} a_i B_i$$  \hspace{1cm} (1)

In the formula:

$ai$—weight value of the $i^{th}$ evaluation index;

$Bi$—quantized value of the $i^{th}$ evaluation index;

If the place’s score $Spot_{Score} \geq 85$, then the place is suitable as a ship refuge.

(Source: Tian Chai, Jinxian Weng, De-qi Xiong. 2017 Development of a quantitative risk assessment model for ship collisions in fairways.)
CHAPTER 4
TRANSPORTATION AND NATURAL ENVIRONMENT OF ZHANJIANG PORT

With the economy development, Zhanjiang port has developed rapidly especially in 300-thousand-ton crude oil wharf, 300-thousand-ton bulk cargo wharf of Baogang Zhanjiang iron and steel base and a forthcoming 300-thousand-ton crude oil wharf of Zhongke Refining and Petrochemical Corporation. At present, 300-thousand-ton channel of Zhanjiang port is the deepest artificial channel in Asia and ships of 250 – 300 tonnage can sail in and out of Zhanjiang port. The construction and implementation of steel, petrochemical and papermaking fundamentally reduce the transportation cost of hinterland customers and ship owners at home and abroad.

By the end of 2017, there are 126 productive berths and 34 deep water berths in Zhanjiang port; the port throughput of year 2016 is 255 million tons, which has increased 15.8%, the container is 632147 TEU with an increase of 15.8%. The construction and development of Zhanjiang port play an important role in promoting the national economic and social progress of Zhanjiang city and its hinterland (Zhanjiang Authority 2016)

4.1 The channel of Zhanjiang port

4.1.1 Main channel

The main channel of Zhanjiang port is about 71.886 km from the Gangchi channel of Tiaoshun island harbour district through the inner segment of the Longteng channel (the mouth of Zhanjiang Bay) to the Longteng channel, and is divided into two grades:

(1) 300-thousand-ton channel of Zhanjiang port is 54.9 km from open sea to Techeng
Island, the bottom width is 310m, the inner bottom elevation is -21.6m, and the outer section bottom elevation is -21.9m.

(2) 60-thousand-ton tide channel, with a total length of about 16.96km from Gangchi channel of Tiaoshun island harbour district through Moyanlou channel to Maxie channel of the west side of Techeng Island, is an natural channel with 13m depth.

4.1.2 Branch channel

Longcun channel (from the east channel of Doulong village through Longshuiling channel and north channel of Doulong village to south channel of Nansan Island), located outside the mouth of Zhanjiang bay and the north side of Naozhou island, is about 23km, and its maintenance depth is -9.8 m which can navigate 60-thousand-ton ship with the use of tidal navigation.

Figure 4.1 The main and branch channel of Zhanjiang port (source: Zhanjiang vts)
4.2 Anchorage ground

There are eighteen commonly used anchorage grounds which are of above 10,000 tonnages in the Zhanjiang Bay, and the natural water depth are 10.2-18m and the bottom sediment is sand and mud; 8 anchorage grounds for small ships which natural water depth are 2-10m and the bottom sediment is sand and mud. There are three anchorage grounds which are of above 10,000 tonnages outside the Zhanjiang Bay:

(1) The first pilot anchorage(ten thousand dwt ) : In the circular waters, of which the center of the circle is 20°58′03″N, 110°37′18″E and the radius is 740m, the water depth is 12.8m, and the bottom is mud. It can be used by three 50-thousand -ton class ships to anchor.

(2) 100-thousand -ton pilot anchorage, located at about 16.8 km southeast of the entrance of longteng channel, of which the center of the circle is 20°57′00″N, 111°00′00″E and the radius is 1.5 sea miles. Its area is 24.24km², the water depth is about 20m and the bottom sediment is mud. It can navigate thirty-three 100-thousand –ton ships to anchor.

(3) 300-thousand-ton lightering anchorage, located at about 30km southeast of the entrance of longteng channel, of which the center is 20°57′00″N, 111°10′00″E and the radius is three sea miles. Its area is 96.98km², the water depth is about 30-33 m and the bottom sediment is sand and mud. It can used by nine 300-thousand –ton ships to anchor.(Zhanjiang Authority 2016)

4.3 ship transportation of Zhanjiang port

4.3.1 the composition of merchant marine transportation

Zhanjiang port is an integrated port including business, fishery, and military port. With the steady development of the port, the throughput has maintained a certain increase over the years. In 2016, throughput of cargo handling in zhanjiang port
reached 255 million tons, with a year-on-year growth of 15.8%, as shown in the following figure 4.2.

![Figure 4.2 Development trend of Zhanjiang port cargo throughput in 2000--2016](source:Zhanjiang Authority. 2016. Zhanjiang local Yearbook, published by Zhanjiang Authority)

There are several types of vessels that make up the traffic flow in the waters of Zhanjiang port:

(1) Merchant ship

According to the date of the VTS monitoring, we calculate the ships in Zhanjiang port from 2013 to 2016. Statistics are shown in the table 4.1.

Table 4.1 VTS monitoring data statistical table of Zhanjiang port

<table>
<thead>
<tr>
<th>year</th>
<th>The number of the ships entering and leaving port</th>
<th>Throughput capacity(ton)</th>
<th>Average daily number of the ships entering and leaving port</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>19390</td>
<td>118441829</td>
<td>53</td>
</tr>
</tbody>
</table>
According to the statistics of merchant visa, the average traffic flow is about 60 cargo ships a day including 3 large and ultra-large ships which navigate on the 300-thousand-ton channel.

The large ships are concentrated in and out of the port with tide rising. Most of the large-scale wharf and channel are designed on the basis of tide-bound water level, as a result ships’ berthing time is concentrated in high and slack tide period, which lead to the imbalance in the time of the ships' arrival and departure and most of the large and ultra-large ships pass this channel in the slack tide. The number of ships awaiting the tide to anchor in Longteng 100-thousand-ton tide-bound anchorage is more than in large and ultra-large lightering anchorage of Zhanjiang port. The traffic flow around is mainly used to ship accustomed to the small ship routes and large ships entering and leaving Zhanjiang port, thus the traffic density is less.

(2) Ferry inside the port, motorboat, operating ships

There are five ferries crossing the main channel inside the port including Haibin to Techeng island ferry, Haibin to Nansan island ferry, Haibin to Maxie ferry, Pingle to Haidong ferry. Nineteen ships are sailing on the ferries, the ferry lanes in the port are special lines which crossing the main channel of Zhanjiang port. Because of the development of island tourism, there are several motorboats crossing the main channel in the daytime, some of them also sail in the evening. There are about 30 operating ships, mainly including towage, work traffic vessel, pilot boat, mainly sails between the main channel and its vicinity and the port area.

(3) Warship and public vessel
Due to military secrets, it is not counted. But we can find that the number of this kind of ships entering and leaving the port is relatively small at ordinary times, only during the typhoon period some of the ships may enter the port to defend the typhoon.

(4) Fishery vessel

According to the statistics of relevant department, the total number of fishery vessels in Zhanjiang is 685, some of them are accustomed to fish in the port while other often leave port to the near shallow to operate.

Fishery vessels entering and leaving the port through Nansan river channel, Doulong village channel and Longteng channel specifically. During the fishing season, fishing vessels are sailing frequently in and out of the port; small fishing vessels are shuttling in the waters inside the port which influence the traffic flow of the port and pose non-negligible threat to the security of the vessels.

4.3.2 The composition of merchant transportation

Through the analysis on the statistical data of Zhanjiang sea area AIS, we can obtain the composition of shipping transportation of Zhanjiang sea area (figure 4.3). It is obvious that container vessel takes the largest proportion in the graph (36.36%), the second is bulk carrier (20.50%) and oil tanker (18.30%). Passenger and ro-ro ship are the smallest proportion (4.77%).
Figure 4.3 The proportion of different types of ships (source: Zhanjiang VTS)

4.4 sensitive resources

Zhanjiang, surrounded by sea on three sides, has a coastline of 1556km. It has plentiful marine resources and abundant marine economic strength. The port of Zhanjiang coastal waters is the presence of numerous agricultural areas, marine protected areas as well as tourism leisure and entertainment districts. The following content describes the marine function distribution of the main areas near the refuge area of marine vessels, as shown in figure 4.4.
4.4.1 Distribution of breeding area

The main areas of agriculture and fishery are:

(1) Yingluo port - haikang port agriculture and fisheries area: from the 109°51’31" in the east to the 109°34'02"in the west; from the 20°40'40" in the south to the 21°31'41"in the north;

(2) Leizhou bay rural fisheries area: from the 110°39'09" in the east to the 110°07'39"in the west; from the 20°15'15" in the south to the 21°00'59"in the north;

(3) Zhanjiang-Zhuhai offshore agricultural: from the 113°30'50" in the east to the 109°24'40"in the west; from the 20°07'01" in the south to the 22°03'37"in the north;

Main marine protected areas are:
(1) Yingluo port marine conservation areas: from the 109°48'17" in the east to the 109°44'41" in the west; from the 21°29'42" in the south to the 21°36'05" in the north;

(2) Marine conservation area in northeast part of Shatoujiao: from the 109°55'23" in the east to the 109°48'37" in the west; from the 21°20'31" in the south to the 21°28'49" in the north;

(3) Techeng island marine conservation area: from the 110°26'45" in the east to the 110°24'51" in the west; from the 21°08'07" in the south to the 21°09'26" in the north;

(4) South Naozhou island marine conservation area: from the 110°35'06" in the east to the 110°30'43" in the west; from the 20°47'02" in the south to the 20°49'59" in the north;

(5) East Naozhou island marine conservation area: from the 110°40'59" in the east to the 110°37'00" in the west; from the 20°49'00" in the south to the 20°53'59" in the north. (Guangdong government. 2004)

4.4.2 Tourism leisure and entertainment districts

There are three tourism leisure and entertainment districts, respectively are:

(1) Techeng island tourism leisure and entertainment districts: from the 110°26'45" in the east to the 110°24'51" in the west; from the 21°09'26" in the south to the 21°09'59" in the north;

(2) Donghai island tourism leisure and entertainment districts: from the 110°33'35" in the east to the 110°31'24" in the west; from the 20°55'27" in the south to the 21°03'38" in the north;

(3) Nansan island tourism leisure and entertainment districts: from the 110°37'43" in the east to the 110°34'17" in the west; from the 21°05'40" in the south to the 21°12'48" in the north. (Zhanjiang Authority. 2016)
4.5 prohibited military zone

The refuge must not affect national security. Thus, it must stay away from the military zone. Zhanjiang port is an integrated port including business, fishery, and military port. There are military restricted zones around the waters of military port and facilities, which civil ships are not allowed to enter without permission. When the ships are sailing on the channel, special attention should be given to the prohibition of entering and anchor to ensure the safety of navigation.

(1) 21°11'57"N, 110°25'26" E, 21°13'03"N, 110°26'02. 5"E, 21°13'44"N, 110°26'05"E, 21°14'20"N, 110°25'56"E, 21°14'35"N, 110°25'50"E The area east of the five points’ connection

(2) 21°14'27"N, 110°25'03"E, 21°14'38"N, 110°25'18"E, 21°14'53"N, 110°25'01"E, 21°14'38"N, 110°24'48"E the area beyond the 4 points’ connection.

4.6 Rescue facilities

The closer the distance between refuge and rescue facilities, the faster the rescue ships and towboat will rescue the ship in distress. The main rescue facility of Zhanjiang sea area includes the search and rescue base and the duty station, the salvage tug and the ship repair factory.

(1) Search and rescue base and duty stations

Ministry of communications South China Sea Rescue Bureau set up rescue base in Zhanjiang port, with maritime rescue personnel, boats and helicopters in Zhanjiang port on duty, is a national professional relief force and it implements a 24 hours duty system.

According to the relevant provisions of the Ministry of communications, the rescue ship carries out "put forward the checkpoint, increase the sites, standby dynamically,
move at once" management mode, to win time for salvage, rescue efficiency and improve the success rate.

(2) Towboat

Zhanjiang port group and Zhanjiang branch of China Sea oil service and other enterprises possess a number of available emergency equipment including marine salvage tug with fire-fighting capability, and fire-fighting and anti-pollution equipment. Zhanjiang port now possesses more than 10 towboats with over three thousand horsepower; Zhanjiang port group owns 16 among them. Those towboats have high horsepower and advanced equipment, it can help ship berth and maneuver; South sea salvage bureau possesses 2 towboats to guard the Zhanjiang port. Western Oil Company of the South China Sea also owns high horsepower towboats. Those towboats have high horsepower and advanced equipment, it can help with rescuing work. There is a list of towboats in Zhanjiang port (figure 4.6).

Table 4.2 Towboats in Zhanjiang port

<table>
<thead>
<tr>
<th>The name of the ship</th>
<th>horsepower</th>
<th>date of construction</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towboat1</td>
<td>3400</td>
<td>1994.9</td>
<td>All Rotation</td>
</tr>
<tr>
<td>Towboat3</td>
<td>600</td>
<td>2000.1</td>
<td>2 engines, fixed bolt</td>
</tr>
<tr>
<td>Towboat6</td>
<td>2360</td>
<td>1992.12</td>
<td>engines, fixed bolt</td>
</tr>
<tr>
<td>Baogang Towboat4</td>
<td>4000</td>
<td>1991</td>
<td>All Rotation</td>
</tr>
<tr>
<td>Zhangang pilot 3</td>
<td>2800</td>
<td>2013.5</td>
<td>engines, fixed bolt</td>
</tr>
<tr>
<td>Towboat8</td>
<td>3200</td>
<td>1975</td>
<td>All Rotation</td>
</tr>
<tr>
<td>Towboat11</td>
<td>3200</td>
<td>1985</td>
<td>All Rotation</td>
</tr>
<tr>
<td>Towboat12</td>
<td>3200</td>
<td>1986</td>
<td>All Rotation</td>
</tr>
<tr>
<td>Towboat501</td>
<td>5200</td>
<td>2005.12</td>
<td>All Rotation, both for tug and firefighting</td>
</tr>
<tr>
<td>Towboat502</td>
<td>5200</td>
<td>2005.12</td>
<td>All Rotation, both for tug and firefighting</td>
</tr>
<tr>
<td>Towboat503</td>
<td>5200</td>
<td>2009.1</td>
<td>All Rotation, both for tug and firefighting</td>
</tr>
<tr>
<td>Towboat504</td>
<td>5200</td>
<td>2009.1</td>
<td>All Rotation, both for tug and firefighting</td>
</tr>
<tr>
<td>Towboat505</td>
<td>5000</td>
<td>2016.2</td>
<td>All Rotation, both for tug and firefighting</td>
</tr>
<tr>
<td>Towboat15</td>
<td>4000</td>
<td>2011</td>
<td>All Rotation, both for tug and firefighting</td>
</tr>
<tr>
<td>Towboat16</td>
<td>4000</td>
<td>2011</td>
<td>All Rotation</td>
</tr>
<tr>
<td>Towboat601</td>
<td>6000</td>
<td>2013</td>
<td>All Rotation, both for tug and firefighting</td>
</tr>
<tr>
<td>Towboat17</td>
<td>4000</td>
<td>2015</td>
<td>All Rotation</td>
</tr>
<tr>
<td>Towboat18</td>
<td>4000</td>
<td>2015</td>
<td>All Rotation</td>
</tr>
</tbody>
</table>

(source: Zhanjiang MSA)

(3) Ship repair factory

There are two ship repair factories, respectively are 4804 factory and Maxie factory, can provide necessary repair service for small and medium size ships in distress.
Chapter 5
Selection of place of refuge in Zhanjiang sea area

The inside area of Zhanjiang harbor is surrounded by the Nansan island, Techeng Island, Dongtou Mountain Island, East Island and Naozhou Island, which has formed a natural barrier and good cover conditions. The water depth is very deep and the waves are smooth, the coastline is relatively flat and stable, thus it is an ideal refuge for ship in distress. For the study on the ship refuge of Zhanjiang coastal area, according to the present situation of utilization in Zhanjiang city planning and marine function zoning and coastal waters of Zhanjiang port, port anchorage, shoreline natural conditions and characteristics, combined with the shoreline, international usual practice, can make full use of existing resources, such as the Gulf of Zhanjiang port, wharf, anchorage as a refuge for ships in need of assistance place. By using the method introduced in the third chapter, suitable ship refuge sites are selected from the coastal waters, ports, bays, wharfs and anchorages in Zhanjiang port.

In order to demonstrate the effectiveness of the site selection model, this paper uses Zhanjiang 11 # anchorage to calculate and judge whether it is a place for ship refuge. 11 # Anchorage is located in Zhanjiang Bay. The water depth is from 14.3 to 20.3m, and the rotation of the water diameter is 800m. The bottom sediment in 11# anchorage is mud and sand. The place is 3 sea miles from the nearby Baogang Iron and Steel wharf tugboat base, rescue tugs can get there within 2 hours. The distance between the anchorages to the nearest military restricted area is 5n mile, so there is no impact on national security. The anchorage is resistant to 12-grade winds and is
covered by the Donghai Island and Nansan Isles, where the waves and streams are less affected.

In order to obtain the 11 # anchorage’s influence of oil spilling on the sensitive resources of the marine environment, the oil spilling simulation experiment was carried out to obtain the corresponding index parameters. In the experiment, the oil spilling was 47 cubic meters, the duration is 1 hour, the warning duration was 12 hours, and the forecasting step was 60 minutes. With the ordinary wind direction, the experimental results are as follows:

(1) Summer leading wind direction ESE, the maximum diffusion area: 7.5 square kilometers, 12 hours residual oil volume: 14.9%. The first time to shore: 2 hours (total 32 hours); the remaining oil of the first time reaching the shore: 77.9%. Distance from the nearest sensitive resource is 2n mile.

(2) Winter regular wind N; maximum diffusion area: 6.2 square kilometers; first time to shore: 3 hours (total 21 hours); he remaining oil of the first time reaching the shore: 63.6%.

From the oil spilling warning report we can know that in the ESE wind direction and N wind down, the first time to shore are both 2 to 3 hours. 12 hours of diffusion time will not affect the surrounding sensitive resources, such as the recent Zhanjiang mangrove ecological protection zone. But if the diffusion time is more than 32 hours and under the N wind direction, it will spread into the Zhanjiang mangrove ecological protection zone. The oil spill simulation test results of Anchorage 11 # are shown in Figure 5.1 (24 hours marked with black node).
According to the data of anchorage ground 11#, to those 5-thousand-ton ships, Length of ship \( L < 150 \text{m} \), draft \( d < 7.0 \text{m} \), we can obtain the evaluation factors indexes of anchorage ground 11#, shown as table 5.1. (Zhanjiang MSA 2015)

Table 5.1 The evaluation indexes of 11# anchorage ground

<table>
<thead>
<tr>
<th>number</th>
<th>Evaluation factors</th>
<th>index</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>the ratio of cycle water diameter / the length of design ship</td>
<td>800/150=5.8</td>
<td>92</td>
</tr>
<tr>
<td>2</td>
<td>The ratio of water depth/ full draft of ship</td>
<td>14.3/7=2.1</td>
<td>88</td>
</tr>
<tr>
<td>3</td>
<td>wind-prevention grade</td>
<td>13</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>wave</td>
<td>0.4</td>
<td>86</td>
</tr>
<tr>
<td>5</td>
<td>flow</td>
<td>0.5</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>bottom sediment</td>
<td>mud and sand</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>The time of rescue facilities to the premises</td>
<td>2</td>
<td>90</td>
</tr>
</tbody>
</table>
Using the site selection model formula to calculate the score of the refuge:

\[
\text{Spot}_{\text{score}} = 92 \times 0.1 + 88 \times 0.1 + 90 \times 0.1 + 86 \times 0.1 + 80 \times 0.1 + 90 \times 0.2 + 100 \times 0.1 + 90 \times 0.1 = 89.6.
\]

The evaluation score of anchorage ground 11# is 89.6>85, so we can say that this place is suitable for being a refuge for 5-70 thousand tons ships.

For other Zhanjiang sea areas, a similar approach was adopted to exclude part of the pier and anchorage waters by requiring at least 2 nautical miles away from the military restricted zone. Then, through the location model of refuge sites, we can draw the following water areas as refuge places. Table 5.2 lists the scoring points for the refuge.

Table 5.2 the evaluation score of each place

<table>
<thead>
<tr>
<th>Name of place</th>
<th>Type of ship in distress</th>
<th>Evaluation score</th>
</tr>
</thead>
<tbody>
<tr>
<td>anchorage ground 17-19#</td>
<td>A general cargo ship of 70,000 tonnage or above</td>
<td>92</td>
</tr>
<tr>
<td>the second pilot anchorage</td>
<td>ship of 5,000 tonnage or below</td>
<td>89</td>
</tr>
<tr>
<td>anchorage ground 8#-11#</td>
<td>ship of 5,000-70,000 tonnage or below</td>
<td>86</td>
</tr>
<tr>
<td>berth No.1 and berth No.2 in</td>
<td>ship of 70,000-150,000</td>
<td>90</td>
</tr>
</tbody>
</table>
Zhanjiang steel main pier of Donghai island port  | tonnage or below
---|---
Pier 208#-212# in Xiashan port  | ship of 70,000-150,000 tonnage or below  | 87

(Source: edited by author)

5.1 The refuge inside the Zhanjiang port

The areas inside the Zhanjiang port refer to the area from Dahuang River entrance to Jialong Wharf of Tiaoshun Island. We set the following refuges in that area for ships of different tonnage by the use of existing anchorage grounds and wharf:

(1) 17#, 18#,19# anchorage grounds. These anchorage grounds can be used as refuges for ships of over 70 thousand tonnage since their deep water depth, large radius of water area, and their bottom sediment are all mud and sand which has good anchoring force.

(2) The second pilot anchorage: refuge for ships of less than 5 thousand tonnage.

(3) 8#-11# anchorage grounds are used as refuges for ships of 5-70 thousand tonnages.

(4) The existing berth used as refuges: Donghai Island port: berth No.1 and berth No.2 in Zhanjiang steel main pier; Pier 208#-212# in Xiashan port.

5.2 The refuge outside the Zhanjiang port

The area outside the Zhanjiang port refers to the area from the entrance of Dahuang River to Zhanjiang port sea boundary, which includes Wuchuan, east coast of Leizhou, Xuwen, west coast of Leizhou, Suixi, Lianjiang and etc. This area is suitable for providing personnel, goods and oil transfer and ship maintenance for ships in distress because this area is flat and the sediment is mud and sand. It also has
a good mooring force, and it is less affected by ocean currents. The average wind over 6 grade is only 16 days a year.

We choose the northern area of the outer section of Zhanjiang Harbor Longteng channel which is about 2 nm from the center line of the longteng channel and 300 thousand ton class lightering anchorage of Longteng channel as refuges for overloaded ultra-large ships. The first pilot anchorage is taken as a refuge for overloaded ships.
Chapter 6
Conclusion

Because of the advantages in sea transportation, there will be an increasing amount of large vessels in Zhanjiang navigating zone in the future. From a practical point of view, the refuges can be selected through quantitative evaluation model from the corresponding places in Zhanjiang sea area and the refuges can provide shelter for vessels sailing in Zhanjiang effectively. In addition, the evaluation model takes various factors into consideration, such as ship type, size, rescue equipment and Marine environmental pollution factors. Finally it is concluded that:

(1) Inside the Zhanjiang bay: 19# anchorage ground (Location: 21°04'05"N, 110°33'20"E, the radius is 500 meters, the water depth is 16.6-23.2 meters, the bottom sediment is sand and mud), the second pilot anchorage and anchorage ground 11# (Location: 21°06'06"N, 110°26'36"E, the radius is 400 meters, the water depth is 10.2-28 meters, the bottom sediment is sand and mud), No.1 berth and No.2 berth in Zhanjiang steel main pier of east island port and Pier 208#-212# in Xiashan port are chosen as refuges for general cargo ships;

(2) Outside the Zhanjiang bay: the northern area of the outer section of Zhanjiang Harbor Longteng channel which is about 2 nautical miles from the center line of the longteng channel and 300 thousand ton class lightering anchorage of Longteng channel were chosen as refuges for overloaded supertankers and large bulk carriers. These sites will provide shelter for ships sailing in the Zhanjiang sea area and support the maritime security in Zhanjiang.
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