

**WORLD MARITIME UNIVERSITY**

Dalian, China

**STUDY ON THE IMPACT AND  
COUNTERMEASURES OF SHIP OIL  
POLLUTION IN PORT CAOFEIDIAN**

By

**YANG DEJIN**

**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**

**(MARITIME SAFETY AND ENVIRONMENT MANAGEMENT)**

**2016**



## **Declaration**

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): Yang Dejin

(Date): Aug. 5th, 2016

Supervised by: Wu Wanqing

Professor of Dalian Maritime University

Assessor:

Co-assessor:

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## **ABSTRACT**

Title of Dissertation: **Study on the Impact and Countermeasures of Ship Oil Pollution in Port Caofeidian**

Degree: **MSc**

Over the past several years, with the quick development of international and domestic shipping, the amount and the tonnage of the ships become larger and larger. Ports, the starting and ending points of the voyages, become extremely busy, and are faced with great challenge - the increasing pollution from the ships arriving at and departing the ports. Oil pollution from ships is one of the most serious challenges.

Port Caofeidian is a new port in Bohai Sea near Beijing, the capital of China, which was open since the end of 2005. Now it witnesses a fast development beyond people's imagination. It is an important port to export and import energy, raw materials and other products for North China.

Port Caofeidian is in Bohai Sea, which is a half-enclosed bay, and this port is near the capital and the urban agglomeration around Bohai Region. If there were accidents of oil pollution, the consequences will be very serious.

This paper is trying to analyze the current situation of Port Caofeidian, to find the risks of oil spill pollution in Port Caofeidian, to analyze the impacts of oil spill, and to give the emergency response as well as the countermeasures for preventing pollution.

**KEY WORDS:** Oil spill, impact, countermeasure, Port Caofeidian, shipping sector

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## **LIST OF ABBREVIATIONS**

CNKI	China National Knowledge Infrastructure
CCTV	Closed Circuit Television
DWT	Dead Weight Tonnage
IMO	International Maritime Organization
ITOPF	The International Tanker Owners Pollution Federation
MSA	Maritime Safety Administration
VTS	Vessel Traffic System
POPs	Persistent Organic Pollutants
RMB	RENMINBI (Chinese Yuan)
VLCC	Very Large Crude Oil Carrier
VLOC	Very Large Ore Carrier

# **CHAPTER I**

## **INTRODUCTION**

### **1.1 Oil Pollution - A Great Challenge for Ports**

Over the past several years, with the quick development of international and domestic shipping, the number and the tonnage of the ships becomes larger and larger. Ports, the starting and ending points of the voyages, become extremely busy, and are faced with great challenge --- the increasing pollution from the ships arriving at and departing the ports. Oil pollution from ships is one of the most serious challenges. It has been argued that 35% of the pollution of the sea is from ships and the oil is the uppermost pollutant(Jiang., Tang., 2009). The ship oil pollution harms the biotic resources and the human health in both direct and indirect aspects. With the development of social economy and recognition of environmental awareness, people realize that if there is serious oil pollution from ships in ports near big cities or developed regions, there will result in big cost on oil removal, environment recovery, social influence, and so on. So, we should pay more attention to ship oil pollution in ports and take steps to analyze the situation and reduce the pollution and its influences.

### **1.2 The Basic Information of Port Caofeidian**

Port Caofeidian is a new port in Bohai Sea near Beijing, the capital of China, which

was open since the end of 2005. Now it witnesses a fast development beyond people's imagination. It is an important port to export and import energy, raw materials and other products for China. In 2014, the volume of incoming and outgoing freights of Port Caofeidian was 2.9 hundred million tons(Workercn, 2015). Tangshan Port including Port Caofeidian and Port Jingtang ranked 7th in the list of biggest ports of the world in 2015(China Water Transport, 2016). The ships visiting Port Caofeidian are mainly Very Large Ore Carriers and Very Large Crude Oil Carriers. The amount of oil transported as cargo and carried as fuel is enormous. Port Caofeidian is in Bohai Sea, which is a half-enclosed bay, and this port is near the capital and the urban agglomeration around Bohai Region. Very serious consequences would result if there were accidents of oil pollution.

### **1.3 Objectives of This Research**

Beijing-Tianjin-Hebei region is a vital area for China in the economic and social aspects, and Port Caofeidian is an important port to export and import energy, raw materials and other products. To keep the port safe and the Bohai Sea clean has become an urgent task. This research is going to make a detailed analysis into this issue. The primary purpose of this research is to analyze the current situation of Port Caofeidian and to find out the risks and influences of oil pollution from ships in Port Caofeidian. The subsequent objective is, through analyzing the problems and vulnerabilities, to give countermeasures for reducing oil pollution in Port Caofeidian and its influences, and to help to take appropriate emergency reaction to avoid loss and ecological crisis.

### **1.4 Methodology**

The author has widely reviewed the relevant literature, including some related IMO documents, international conventions and regulations, domestic regulations of China, some related materials from the central government, the local government of Caofeidian area and shipping industry agencies, some articles from journals, and some essays from CNKI, a network for storing and sharing research paper and articles from main universities' graduates of China. Some data have been obtained from Caofeidian Maritime Safety Administration and publication, and some opinions were exchanged from the local shipping companies, port authorities, and some related companies.

### **1.5 Structure of This Dissertation**

The dissertation consists of six chapters and two appendices. Chapter I is introduction, which introduces the background, the basic information of Port Caofeidian, the objectives, the methodology and the structure of the essay. Chapter II introduces the basic and current situation of Port Caofeidian, including the Geographic information and range, the natural condition including meteorology and hydrology, navigation condition, and sensitive area and resources influenced. Chapter III is the risks of oil pollution, and the risks of various kinds of oil pollution in Port Caofeidian will also be analyzed. Chapter IV is to analyze the impacts of oil pollution in Port Caofeidian. Chapter V is the countermeasures. And the last chapter, Chapter VI, will be the conclusion of this essay.

## **CHAPTER II**

### **THE CURRENT SITUATION OF PORT CAOFEIDIAN**

Caofeidian was a small island for fishermen sheltering from the strong wind with an acreage less than 4 km<sup>2</sup> before the year of 2002. From the beginning of year of 2003, the port began to be constructed, and people there had already reclaimed about 210 km<sup>2</sup> of land from the sea till the year of 2013(PRCSTEEL, 2013). Now, Port Caofeidian is becoming one of the biggest ports in the world with a cargo throughput of 300,000,000 tons, 80 opening berths, and 14 more berths under construction.

#### **2.1 Geographic Information and Characteristics**

The geographical coordinates of Port Caofeidian are 38°55' N, 118°30' E. Caofeidian is a coastal area in Tangshan City, Hebei Province, North China, and it is in the central area of Bohai Bay. Its distance on the sea to Tianjin New Port is 38 nautical miles, on land to Tangshan City is 55 km, and to Beijing City, the capital of China, is 230 km.

Port Caofeidian is in the Bohai Rim Region, which is a vibrant and important economic area for China. Bohai Rim urban agglomeration is one of the five biggest urban agglomerations in China. It is also an important constituent part of Integration of Beijing-Tianjin-Hebei regions, which was introduced by Li Keqiang, Prime Minister of China, in the year of 2014. Map 2.1 shows the basic geographical

information of Bohai Rim Region.

### 2.1.1 Bohai Rim Region - Large Population and Plenty of Cities

This is a coastal economic zone including Beijing-Tianjin-Hebei region, Liaodong Peninsula, Shandong Peninsula, witnessing the back-land of the north part of China. The land area of Bohai Rim Region takes 13.31% of the land of China, and the population of Bohai Rim Region takes 22.2% of the population of China(Hu., Liu., 2007). There are a lot of big cities in this region and there are about 310,000,000 people living in this region.

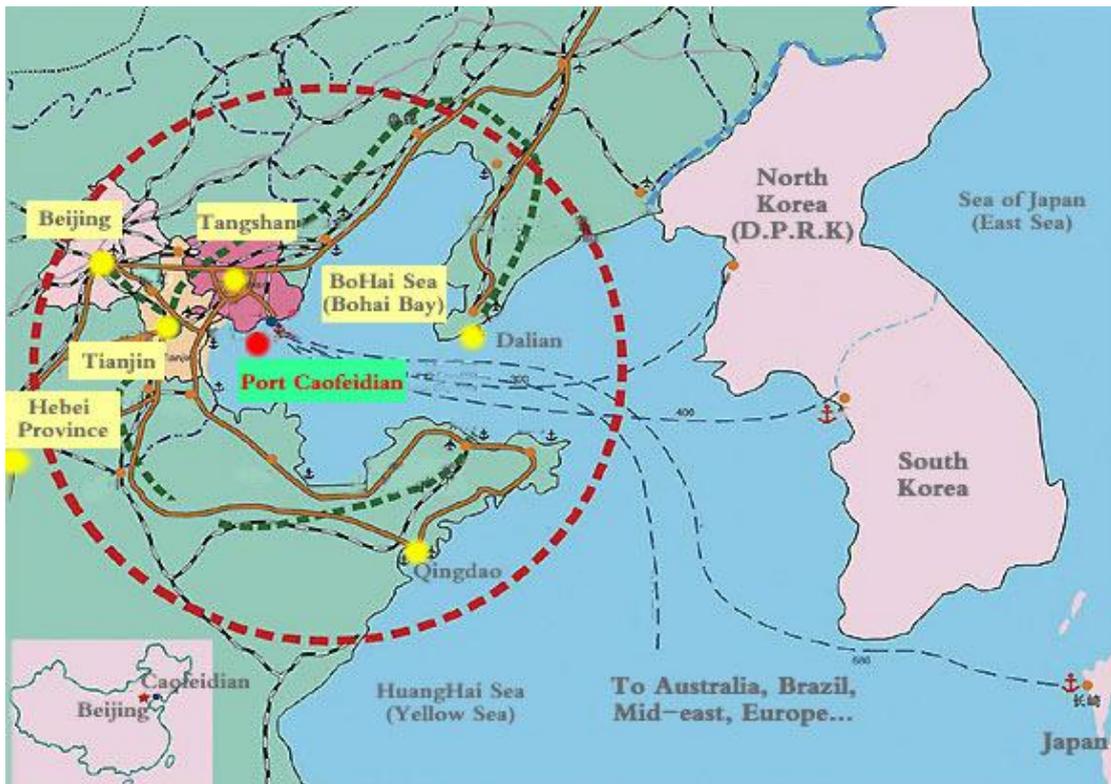


Figure 2.1 The Map of Bohai Rim Region

### 2.1.2 Integration of Beijing-Tianjin-Hebei Regions - Big Demand of Energy and

## **Raw Materials**

Integration of Beijing-Tianjin-Hebei regions was introduced officially by Li Keqiang, Prime Minister of China, in the year of 2014. According to the agreement between Beijing City, Tianjin City and Hebei Province, the ports of Hebei Province including Port Caofeidian have been designed to be international ports for energy, ore and other bulk raw materials.

Hebei Province, including Tangshan City where Port Caofeidian is located, is a province whose pillar industries are iron and steel, equipment manufacturing, and petrochemical industry.

There will be bigger and bigger demand for crude oil, ore, and other raw materials in this region. According to the prediction of some experts, the capacity of petroleum refining in this region will be 100,000,000 tons(China's small- and medium-sized enterprises network - Shanxi Branch, 2016).

### **2.1.3 The Distributions of Berths**

Figure 2.2 shows the distributions of berths in Port Caofeidian. There are three harbor basins and one open area. The crude oil berth, which are 300,000 tons level, the ore berths, which are 400,000 tons level and 250,000 tons level, and LNG berth, which is 150,000 tons level, are all constructed in the open area and are in the front of the whole port. Harbor Basins No.1 and No.2 are mainly for dry bulk cargo, coal, and steel products, and Harbor Basin No.3 is for liquid chemicals, wood, and mechanical products. Table 2.1 also shows the distributions of berths of Port Caofeidian.



**Figure 2.2 The Distributions of Berths of Port Caofeidian**

## **2.2 Cargo and Ship Types**

Port Caofeidian is an important port in North China, near Beijing-Tianjin-Hebei urban agglomeration, which imports energy, ore, and other raw materials and exports steel products, coal and other products. Port Caofeidian is a main part of Port Tangshan, which ranks No.7 in the list of biggest ports of the world in the year of 2015(China Water Transport, 2016). In the year of 2014, the volume of incoming and outgoing freights in Port Caofeidian was 2.9 hundred million tons(Caofeidian Government Website, 2016). Till the year of 2016, 69 berths have been finished and 375 berths (capacity>10 thousand tons) can be built in the shoreline of Port Caofeidian(Caofeidian Government Website, 2016).

Table 2.1 Shows the Cargo types of Port Caofeidian in the year of 2014, and the total amount of cargo is very large, and the amount of crude oil is also enormous, about 12,000,000 tons. And Table 2.2 presents the types of the imported crude oil through Crude Oil Terminal of Port Caofeidian.

**Table 2.1 Cargo Types of Port Caofeidian in the Year of 2014**

Cargo Types	Ore	Steel Products	<u>Crude Oil</u>	Coal	Others	Total
Quantity (Million Tons)	140	32	<u>12</u>	101	5	290

Source: Workercn, 2015

**Table 2.2 Types of Imported Crude Oil**

No.	Item	SAUDI ARABIAN LIGHT CRUDE OIL	SAUDI ARABIAN MEDIUM CRUDE OIL
1	Density (20℃)(g/cm <sup>3</sup> )	0.856	0.8677
2	Solidifying point(℃)	-28	-15
	0℃	18.76	
	8℃	13.55	
3	Dynamic Viscosity (mPa s)		34.91
	10℃		
	12℃	11.68	
	13℃		31.31
	15℃	10.50	
	20℃		24.28
	35℃		
	40℃		
	45℃		
	50℃	4.34	
4	Sulfur content (%)	1.94	2.4

Source: Caofeidian Crude Oil Terminal Manual 2015

Table 2.3 shows the situation of planning and construction of berths in Port Caofeidian. There are big liquid bulk cargo berths including big crude oil berth for 300,000 tons VLCC and there are many big dry bulk cargo berths for VLOC and other kinds of big ships.

**Table 2.3 The Berth Planning of Port Caofeidian**

<u>No.</u>	<u>Area</u>	<u>Shorelines(km)</u>	<u>Quantity of berths</u>
<b>A</b>	<b>Open area</b>	<b>5.9</b>	<b>14</b>
a1	Big dry bulk cargo berths	2.4	6
a2	Liquid bulk cargo berths	1.9	4
a3	Dry bulk cargo berth for steelworks	1.6	4
<b>B</b>	<b>Harbor basin No.1</b>	<b>18.5</b>	<b>65</b>
b1	Coal berths	5.1	20
b2	Dry bulk cargo berths	2.5	10
b3	Steel products berths	2.9	10
b4	Berths for steelworks	1.6	5
b5	General cargo berths	6.4	20
<b>C</b>	<b>Harbor basin No.2</b>	<b>8.6</b>	<b>36</b>
c1	Liquid chemical industry berths	4.3	18
c2	Backup berths	4.3	18
<b>D</b>	<b>Harbor basin No.3</b>	<b>29.1</b>	<b>121</b>

d1	North area	17.6	78
d2	South area	11.5	43

**Source: Caofeidian Government, 2009**

## **2.3 Natural Condition Including Meteorology and Hydrology**

### **2.3.1 Climate Characteristics**

The climate of Caofeidian is monsoon climate of medium latitudes, and Caofeidian is in semi humid areas. It is characteristic of typical continental monsoon. There are four distinctive seasons in Caofeidian. The average temperature of a year is 11.8°C. The average amount of precipitation is 569.4 millimeter. Because of the influence of monsoon, the amount of precipitation changes with the seasons and is uneven. The precipitations are mainly in July and August, and the amount of precipitation in these two months takes half of the total amount of precipitation of a whole year(Caofeidian Government Website, 2016).

When winter comes, it blows mainly northerly wind, and in summer, the prevailing wind is southerly wind. And in spring and autumn, the wind directions are not stable.

### **2.3.2 Wave**

According to the observational data in the years of 1996, 1997 and 1999: the normal wave direction is S, and the frequency is 10.87%; The second normal wave direction is SW, and the frequency is 7.48%. In the period of wave measuring, there is no wave whose average period is > 7.0s. The distribution situation of all wave directions can

be found in Table 2.4.

**Table 2.4 The Wave Height in the Years of 1996, 1997 and 1999 of Caofeidian(m)**

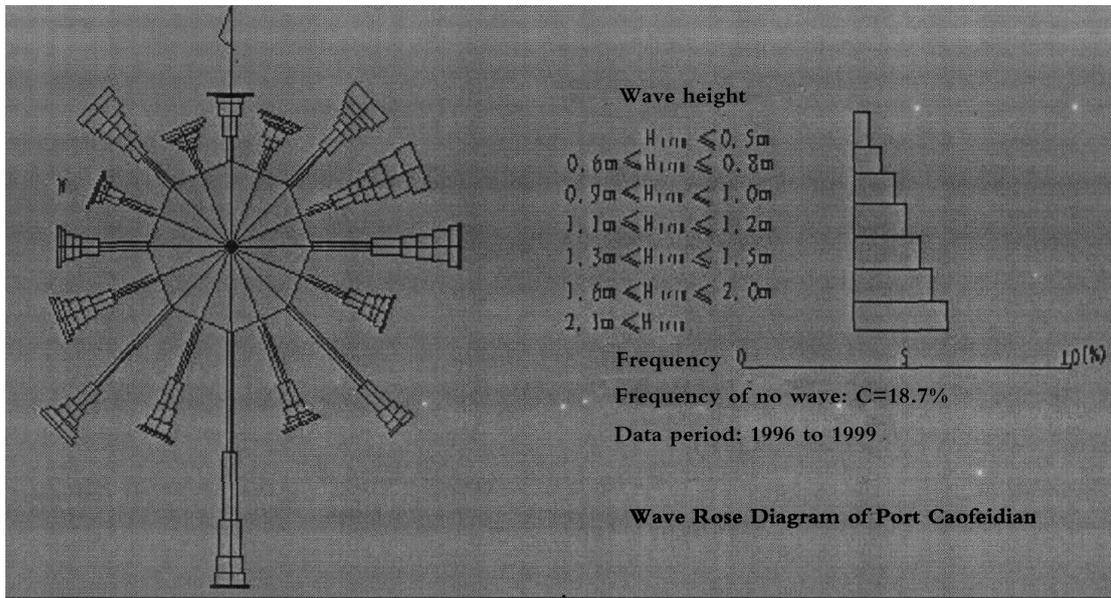
<b>Wave Height/</b>								
<b>Wave</b>	<b>0-0.5</b>	<b>0.6-0.8</b>	<b>0.9-1.0</b>	<b>1.1-1.2</b>	<b>1.3-1.5</b>	<b>1.6-2</b>	<b>&gt;2.1</b>	<b>Total</b>
<b>Direction</b>								
N	1.08	0.81	0.43	0.27	0.11	0	0.05	2.79
NNE	0.76	0.41	0.43	0.14	0.16	0.19	0.08	2.17
NE	2.11	1	0.35	0.38	0.24	0.35	0.62	5.07
ENE	1.27	0.87	0.46	0.43	0.65	0.84	0.79	5.31
E	2.55	1025	0.7	0.65	0.79	0.41	0.14	6.48
ESE	1.95	0.79	0.46	0.24	0.24	0.16	0	3.85
SE	4.5	1.44	0.46	0.38	0.16	0.03	0	6.97
SSE	2.47	0.98	0.52	0.22	0.19	0.11	0	4.47
S	4.99	2.82	1.65	0.62	0.6	0.11	0.08	10.87
SSW	2.28	1.38	0.68	0.54	0.14	0.11	0.03	5.15
SW	4.74	1.41	0.52	0.27	0.14	0.24	0.16	7.48
WSW	1.87	1.11	0.52	0.43	0.3	0.19	0.16	4.58
W	2.25	0.84	0.41	0.33	0.16	0.22	0.03	4.23
WNW	1.71	0.81	0.24	0.24	0.14	0.19	0.03	3.36
NW	1.9	1.14	0.73	0.46	0.35	0.6	0.35	5.53
NNW	0.92	0.24	0.19	0.22	0.14	0.08	0.22	2.01
C	19.68							

Total	57.03	17.3	8.75	5.82	4.51	3.86	2.74	100
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Source: Zhang, 2009

The Wave Rose Diagram of Port Caofeidian have been shown as follows.

**Table 2.5 Wave Rose Diagram of Port Caofeidian**



Source: Zhang, 2009

### 2.3.3 Wind

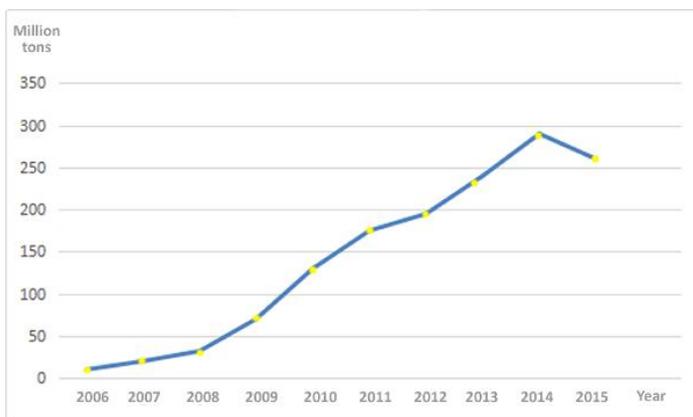
The direction of prevailing wind in Caofeidian area is SSW, and the frequency is 10.0%; the directions of secondary prevailing winds are ENE and SSE, and the frequencies are both 9.0%. The direction of strong wind is ENE, and the maximum wind velocity is 25m/s; the direction of secondary strong wind is NE, and the maximum wind velocity is 21m/s; the average wind velocity of all directions is 5.3m/s. The frequency of wind > Strong breeze is 4.9%.

The directions of winds change with the seasons. Northwest wind takes 47% in winter, and the average wind velocity is 5.1m/s; the prevailing winds in spring and summer are southerly wind and southeasterly wind, and the frequencies are 49% and 64% respectively, and the average wind velocities are 5.1m/s and 6.6m/s respectively; the prevailing wind in autumn is southwesterly wind, the frequency is 34%, and the average wind velocity is 4.9m/s.

### 2.3.4 Visibility

The visibility is effected by fogs, torrential rains and snow. The average foggy days of many years is 29d, and the number of foggy days when the visibility distance is below 1km is 9.0d, and this situation is often found from November to February of the next year. The foggy days in the period from November to February of the next year takes 77% of the year. The longest period of foggy days is 3.0d.

### 2.4 Traffic Flow of Ships



**Figure 2.3 The Cargo Throughput Situation of Port Caofeidian**

**Source: Wang, 2013; Around Bohai Sea News, 2010-2016**

There is a direct connection between the traffic flow of ships and risk of oil spill from ships in port(Yang, 2004, p.11). Figure 2.1 shows the throughput situation of Port Caofeidian in each year. The throughput increased dramatically in the past 10 years since the opening of the port. And there is a significant growth for the traffic flow, and accordingly the noticeable risk of oil pollution from ships is growing quickly.

**CHAPTER III**  
**ANALYSIS OF RISKS OF OIL POLLUTION FROM SHIPS**  
**IN PORT CAOFEIDIAN**

As Port Caofeidian develops, the traffic flow of ships also grows rapidly, and thus people are facing a serious environmental risk of oil pollution from ships.

Oil spill accident of ships refers to environmental pollution accident caused by the ships and their related activities, and the pollutants are oils and oily mixtures. It can be divided into two kinds, oil spill accident from marine casualty and operational oil spill accident. The factors causing accidents can be the operational miss during the loading and discharging of cargoes, the illegal discharging of bilge water, the operational miss during bunkering, collision, stranding, unforeseen event or circumstance caused by bad weather.

The risk identification and risk analysis of oil pollution from ships are the basis for risk and impact evaluation. Through analyzing the oil spill sources in the whole process of ships' activities in Port Caofeidian, we can identify the risk factors and their weight to estimate the probability of oil spill from ships, and we can take steps to attenuate risks, reduce the accidents of oil spill and the economical and environmental losses.

### **3.1 Historical Oil Spill Analysis**

Table 2.1 is Global Oil Tanker Spill Statistics from ITOPF in the years from 1974 to 2009. As is shown in the table, there are 5472 times of operational oil spill, accounting for 57% of the oil spill accidents of oil tankers, and there are 2019 times of average oil spill, accounting for 21% of the total oil spill accidents from oil tankers, and there are 2049 times of other or unknown causes of oil spill accidents from oil tankers. This means that the operational oil spill accidents is in a great measure, while in average oil spill accidents, collision and stranding account for 32% and 33% respectively, and they are the main causes of average oil spill accidents.

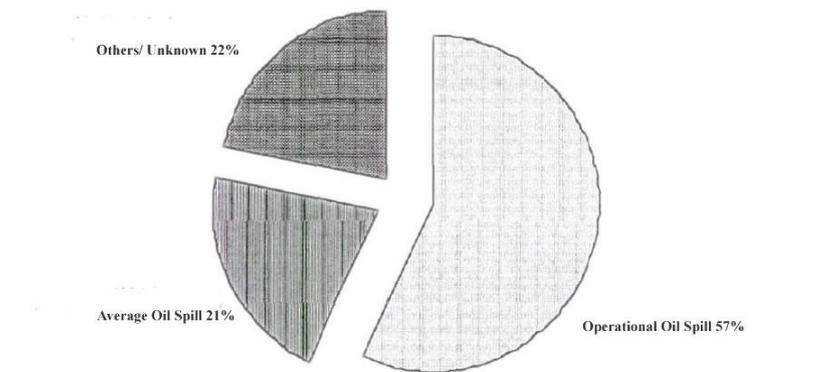
**Table 3.1 Global Oil Tanker Spill Statistics from ITOPF (1974 - 2009)**

Accident type/Cause		<7t	7-700t	>700t	Total
Operational Oil Spill	Loading/Discharging	3155	383	36	3574
	Bunkering	560	32	0	593
	Other Operations	1221	62	5	1305
	Total	4936	477	41	5472
Average Oil Spill	Collision	176	334	129	640
	Stranding	236	265	161	662
	Hull damage	205	57	55	316
	Equipment Failure	206	39	4	249
	Fire/Explosion	87	33	32	152
	Total	910	728	381	2019
Others/Unknown		1983	44	22	2049
<b>Total</b>		<b>7829</b>	<b>1249</b>	<b>444</b>	<b>9540</b>

Source: Gao., 2015

From Table 3.1 and Figure 3.1, we can find that the main types of accidents are oil spilling accidents less than 7t, and most of them belong to operational oil spill accidents whose results are not very serious. However, the percentage of large oil spill accidents is not very high, most of which are average accidents, and once occurred, the result will be very serious. So more attention should be paid to the large

operational accidents and the average oil spill accidents.



**Figure 3.1 Statistics on Types of Global Oil Spill Accidents**

**Source: Gao., 2015**

## **3.2 The Risk Analysis**

### **3.2.1 The Principles and Methods**

We should follow the three principles, scientificness, systematicness, and comprehensiveness to carry out the risk identification. The methods of risk identification can be observational survey, direct questioning, accident recording, marking safety checklist, access of external information, preliminary hazard analysis, hazard and operability analysis, event tree, fault tree, failure mode and consequences analysis.

### **3.2.2 The Range and Content of the Investigation**

#### **3.2.2.1 The Investigation of Risk Source**

The range will be taking the intertidal zone as the center, extending to land for 1 km from the shorelines, extending to the sea area of the object of study.

The content of investigation is the distribution situation of objects causing the risks of oil spill, including the ships, the crew members of the ships, berths, the facilities of the berths, the workers on the land, oil from unidentified sources, and others.

### **3.2.2.2 The Investigation of Sensitive Resources**

Reed et al (1989, pp. 411-449) have noted that the sensitive objects refer to the sensitive resources of oil spill including shorelines, biotic resources, and available resources for human-beings.

The range of investigation about shorelines is extending to 2 m contour in the direction of land not exceeding 100 m, and is extending to 0 m depth contour. The range of shorelines of estuary should be extended to tidal reach. The type, length, and land-forms should be investigated. The space distribution and temporal distribution of representative species, such as common species, dominant species, and rare or endangered species should be investigated.

The range of available resources for human-beings should be extended to the land for 1 km from the shoreline and be extended to the contiguous zone. The location, area, function of resources should be investigated. There are six kinds of resources:

A. Leisure and recreation, including bathing beach, ferry berth, surf zone, diving sites, coast park, landscape, building, and so on;

- B. Protection zones;
- C. Mari-culture areas
- D. Development zones for resources including fishing area, coastal mining area, water intake, power plant;
- E. Archaeological site and historical site;
- F. Projects under construction.

### **3.2.3 Risk Factors**

There are four main risk factors for oil spill from ships: equipment factor, natural environment factor, navigation environment factor, and human factor.

#### **3.2.3.1 Equipment**

A. Ships, ships' type, gross tonnage, technology of equipment, age, and stability will all influence the safety of navigation of ships to a certain degree. The dangerous level and control difficulty are different between different types of ships. There is a positive correlation between the tonnage and the amount of oil spilling for a certain type of ship. The technology reflects the ships' stability and degree of automation. The possibilities will be high if the ship is old with a bad condition(Hong et al, 2010, pp.49-56; Eide et al, 2007, pp.1619-1633).

B. Terminal is an important platform for discharging cargoes, especially for oil terminals. It is important that the oil discharging arms, valves, pumps and other equipment are in good condition and with function of pressurization and explosion-proof. If the equipment is aging or breaking down, accidents will occur if there is not enough effective and timely maintenance and repairing(Liu., 2012; Friis

et al, 2003, pp.1-34).

C. Oil pipeline.

### **3.2.3.2 Natural Environment Factors**

A. Weather. Although there is no relationship between the weather and the oil spill accident, the bad weather can cause the happening of accident or make the accident more serious. The main factors of weather include wind speed and visibility. In 2.3 of Chapter II, the climate characteristics have been introduced, and we should pay more attention to the strong wind in winter and the fogs in autumn and spring. In aerography, wind can be divided into 13 scales, from 0 scale to 12 scale, and wind speed of the 12 scale wind is above 32.6m/s. In the condition of strong wind, the ship's speed will be increased in a short period of time or the ship will stall probably. Fog is the major factor of influencing visibility, and in the condition of poor visibility, the ship may have the risks of going off course, stranding, running on rocks or collision. And the weather of fog and strong wind will influence the normal operation for discharging oil, bunkering, or others to a great degree.

B. Sea conditions. The whole process of port operation is influenced by the wave, depth of the sea, current, and the tide. The severe condition of the sea will directly influence the navigation, discharging, and other operations of the ships. And this also influences the clearing of the oil on the surface of the sea and the recycling of the spilling oil.

### **3.2.3.3 Navigational Environment**

There is a link between the oil spill accident and the navigational environment, such as the conditions of the channels, the traffic flow, the distribution of berths and the capacity of the berth and the port. The denser the traffic flow is, the more crowded the channels are, and the higher the probability of oil spill accident will be.

### 3.2.3.4 Human Factors

Human is the main body for maritime safety, security, and the environmental protection. According to the analysis of accidents, people find the human-factor is the main factor for pollution accident on the sea. The operators including the crew members of the ships and the workers on the land may have problems of sound in body and mind, fatigue, lack of experience, management defects, the identification error, misoperation, mistakes in commanding or commanding against rules. All of the above situation will influence safety seriously.

### 3.3 The Main Sources and Oil Types of Oil Spill in Port Caofeidian

**Table 3.2 The Main Sources and Oil Types of Oil Spill**

Main ship types in Port Caofeidian	Oil Spilling Types		
	Crude Oil	Fuel oil	Sludge and Oily Water
VLCC	√	√	√
VLOC & other bulk-cargo ships		√	√
Small ships including barges, fuel ships, ships collecting sludge and oily water		√	√
Other ships including tug boats, official ships and fishing vessels		√	√

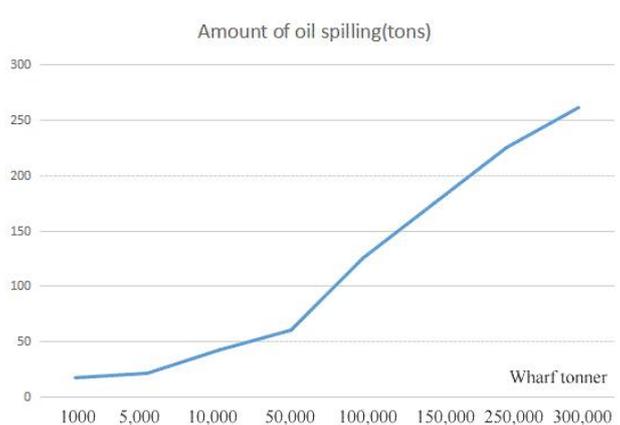
Table 3.2 shows the main sources of oil spill and the oil types of oil spilling. We can

find out that there are four kinds of ships, which are VLCC, VLOC and other bulk cargo ships, small ships, and other ships. And the oil spilling occurs to crude oil, fuel oil and sludge and oily water. According to this table, we should pay more attention to the VLCC oil discharging operation and the VLOC and small ships bunkering, discharging sludge operation, and the berthing and unberthing of the big ships.

### 3.4 Evaluation of Amount of Oil Spilling

#### 3.4.1 The Oil Spilling in Crude Oil Terminal of Port Caofeidian

According to the evaluation method of standard JT/T 451-2009, the Requirement of Emergency Equipment for Oil Spilling of Berths in Port, the time of closing down of pump valves to correct is 5 minutes in berths of less than 10,000 tons capacity, and the time of closing down of pump valves to correct is 3 minutes in berths of greater than 10,000 tons. We can evaluate the amount of oil spilling.



**Figure 3.2 The Amount of Oil Spilling of Different Wharf Tonner**

**Source: Standard JT/T 451-2009**

From Figure 3.2, we can find out that the highest possible amount of oil spilling of 300,000 tons crude oil terminal in Port Caofeidian is 261 m<sup>3</sup>, and the oil type is crude oil. If the density of crude oil is 0.9t/m<sup>3</sup>, the max possible amount of oil spilling is 235t.

The amount of oil spilling of operational accident is not so enormous, and the amount of most of the accidents is below 50t. Because there are not enough oil spilling data for Port Caofeidian, we take the data of Liaoning for consult, and Liaoning is similar to Port Caofeidian. According to the statistics for oil spill accidents in Liaoning from the year of 2002 to the year of 2008, the oil spilling when discharging oil takes 92.3% of the total, and the average amount of oil spilling is 1.1t, and the maximum amount is 8.98t(Gao., 2015, p.48). From the above analysis and the analogy, the possible amount of operational oil spilling is less than 10t.

#### **3.4.2 Amount of VLCC Oil Spilling on the Waterway**

We take an example of a crude oil tanker of 300,000 tons capacity, carrying 250,000 tons of crude oil. There are usually 18 wing tanks in the construction of VLCC in China, however, there are usually 5 middle tanks and 10 wind tanks in the construction of VLCC in other countries, and there are 26,000 tons of oil in each middle tank, and 11,000 tons to 15,000 tons of oil in each wing tank. If there is an accident of collision, the maximum amount of oil spilling of a wing tank is 14,000 tons to 15,000 tons. But the VLCC is usually with double-deck and double-bottom, the oil spilling will be less than the oil carried in the tank. If the percentage of oil spilling is 20%, the amount of oil spilling is about 2,800 tons to 3,000 tons.

#### **3.4.3 Amount of VLOC and Other Bulk-cargo Ships' Oil Spilling**

The maximum amount of fuel oil taken in the fuel oil tanks of the VLOC and other bulk-cargo ships varies with the size of the ships. The maximum amount of fuel oil of VLOC can be 3000 tons, and the fuel oil amount of other bulk-cargo ships can be several hundred tons, and we take 100 here. And now, the fuel oil tanks are usually double-deck, and there are often two to six fuel oil tanks. If the percentage of oil spilling is 20% of the total amount after the collision or other accident on the waterway, the amount of oil spilling will be between 20 tons to 600 tons.

#### **3.4.4 The Amount of Oil Spilling of Small Ships and Other Ships**

Bunkering ships usually take less than 3,000 tons of fuel oil, and the recovery ships of sludge usually take less than 200 tons of oily water and sludge. And now the small tankers are usually double-deck and double-bottom, and there are usually 2 to 6 tanks, and we take the percentage of oil spilling at 20% after collision or other accident on the waterway, the amount will be about 40 tons to 600 tons.

According to the methods of standard JT/T 451-2009, the maximum amount of operational oil spilling during the bunkering is 21 m<sup>3</sup>, if the density of crude oil is 0.9t/m<sup>3</sup>, the max possible amount of oil spilling is 18.9 tons.

#### **3.4.5 A Simple Conclusion for the Evaluation of Amount of Oil Spilling**

We can get a simple conclusion for the evaluation of amount of oil spilling from Table 3.3. We should pay more attention on VLCC operation on the terminal and navigation in the waterway to the port and to the berths. At the same time, because of the big amount of other types of ships, the risk of small oil spill accident is high.

What's more, the conditions of service ships in the port, such as bunkering ships, sludge recovery ships, are often poor, we should also strengthen the administration of these ships.

**Table 3.3 The Evaluation of Amount of Oil Spilling in Port Caofeidian**

Area	Accident Type	Amount of Oil Spilling (tons)	
		Most-possible	Maximum
The Crude Oil Terminal	Operational	10	235
Other Terminals	Operational	10	18.9
Waterway for VLCC	Average		2800-3000
Waterway for VLOC and Other Cargo Ships	Average		20-600
Waterway for Bunkers and Other Small Tankers	Average		40-600

**CHAPTER IV**  
**IMPACTS OF OIL POLLUTION FROM SHIPS IN PORT CAOFEIDIAN**

**4.1 The Sphere of Influence from Oil Pollution**

According to *Regulations of The People's Republic of China on the Prevention of Vessel-Induced Sea Pollution*, we can divide the oil spill accidents into six levels on the basis of the amount of oil spilled, the degree of impact on the environment, or the direct economic loss. For details we can find them in Table 3.1. From this table, we can find two direct impacts of ship oil accident on environment and economy. And the indirect impact is mainly about the social influence.

**Table 4.1 Qualitative Classification of Harmful Consequences of Ship Oil Accidents**

Level	Oil spilling	Or	Environmental Impact	Or	Direct Economic Loss(RMB)
Disastrous	>10000 tons	Or	Disastrous	Or	>1000,000,000
Extraordinarily Serious	1000-9999 tons	Or	Extraordinarily Serious	Or	>200,000,000
Very Serious	500-999 tons	Or	Very serious	Or	100,000,000-200,000,000
Serious	100-499 tons	Or	Serious	Or	50,000,000-100,000,000
Ordinary	50-99 tons	Or	Ordinary	Or	10,000,000-50,000,000
Small	0-49 tons	Or	Little	Or	<10,000,000

**Source:** *Regulations of The People's Republic of China on the Prevention of*

## **4.2 The Environmental Behavior and Toxic Effects of Spilling Oil**

### **4.2.1 Influences on the Living Beings in the Sea Water**

Once the oil comes into the marine environment, it will be influenced by the wind, wave, light, air temperature, water temperature and the activities of the living beings, and the amount of oil, its chemical composition, physical property and chemical property will also change as time goes on.

The fate of the oil in the marine environment can be summarized briefly as follows:

- a. The oil spreads on the surface of the sea rapidly to be an oil slick with uneven thickness.
- b. With the stirring of the seawater, some of the oil can be mixed into the sea water to be emulsified to a brown milk with layers of oil and water with the function of the wave.
- c. After the two processes above, the relative density of oil clot increases. Some will go on floating on the sea, some will move with the adsorption of particulates, and some will be degraded by the microorganism.

The direct influence of the oil slick is blocking the gas exchange between aquatic lives and atmosphere, reflecting the sunshine, and adhering to the biological individuals. The aquatic lives will be poisoned, smothered, or harmed irreversibly. The biotic resources will be influenced seriously and marine ecosystems will go backwards.

#### **4.2.2 The Toxic Effect of Spilling Oil in the Sea and the Surroundings**

Oil is a kind of complex mixture of saturated hydrocarbon, arene, asphaltene, and peucine. The chemical toxicity of oil is mainly from the dissoluble arenes, especially the PAHs(Perez et al, 2010, p.p 254-261). PAHs is a kind of POPs (persistent organic pollutants), and they are easy to be concentrated in the fatty tissue, such as brains.

The toxic functions are as follows(Li et al, 2011, p.p 347):

- a. The phototoxic function.
- b. The neurotoxicity.
- c. Intergenerational influence.

Oil pollution will influence the reproductive system, hematological system, and respiratory system, and influence the growing and breeding of animals. And what is more worrying is that the strong inherent toxicity of PAHs will influence the animals on the intergenerational aspects.

#### **4.2.3 Ecosystem Effects**

The short-term effects from oil pollution are the acute and chronic toxic effect, the decreasing of biomass, the decreasing of microbiologic population, and red tides. The long-term effects are on the phytobiocoenose structure, the species variation and oil enrichment in the plants and benthonic organism. And the long-term risk evaluation about the human health of oil pollution needs to be explored with our continuous efforts.

### **4.3 The Influenced Sensitive Areas and Delicate Resources of Port Caofeidian**

Generally speaking, sensitive areas and delicate resources contain natural protection area, drinking water and industrial water source, aquatic resources and aquaculture resources, habitats for endangered animals, farmland, wet land, salt pan, water fronts of all kinds, places of historic interest and scenic beauty, landscapes, tourist and recreation places, ships and facilities.

#### **4.3.1 Aquatic Resources and Aquaculture Resources**

Bohai Sea, where the Port Caofeidian is located, is a big base for aquatic products. Some famous products are *penaeus orientalis* and yellow croakers. Farmed marine products take more percentages than the wild products. For instance, sea cucumber, shrimp, globe fish, fan shell and son on are popular. Caofeidian is the biggest breeding base of globe fish in China(China Fishery Administration, 2016). The annual output of fishery industry in Caofeidian is about 120000 tons, and the value of output is 2,200,000,000 RMB, that is about 329,000,000 USD(China Fishery Administration, 2016).

#### **4.3.2 Natural Protection Areas**

Oil pollution will greatly influence the ecosystem and the biodiversity in the natural protection areas, and the influences on the valuable resources are difficult to eliminate.

##### **4.3.2.1 Caofeidian Wetland**

Caofeidian wetland is the biggest wetland in north part of China with international significance. There are more than 1,200 kinds of animals and plant lives(Tangshan Government Website, 2014) living there. Caofeidian wetland is an important courier station for the birds migrating from Siberia to Australia. This is a provincial level natural protection area for wetland and birds. Caofeidian wetland is very close to Port Caofeidian.

#### **4.3.2.2 Tianjin National Ancient Coast and Wetland Nature Reserve**

Tianjin National Ancient Coast and Wetland Nature Reserve was established in 1984 and it is an important part of Tianjin National Nature Reserve. There are a lot of rare animals and plant lives living there, and the historical remains of ancient coast are very valuable. This nature reserve is about 40 nautical miles from Port Caofeidian.

#### **4.3.2.3 The Yellow River Delta National Nature Reserve**

The Yellow River Delta National Nature Reserve was established in 1992, and it was listed in the Wetlands of International Importance(People.cn, 2013). This nature reserve is about 100 nautical miles from Port Caofeidian.

#### **4.3.2.4 Liaohe River Estuary National Nature Reserve**

This is a nature reserve established in 1985 in the east shore of Bohai Sea with a lot of rivers. There are many valuable and rare waterfowls living in the beautiful reeds, such as red-crowned cranes, white cranes, and black-headed Gulls. There are 9 kinds of birds under the First Grade State Protection, and there are 282 kinds of birds in total(China State Forestry Administration, 2016). This nature reserve is about 190

nautical miles from Port Caofeidian.

#### **4.3.2.5 Other Nature Reserves**

There are also some other nature reserves near from Port Caofeidian, such as Changli Golden Coast National Nature Reserve in Hebei Province, Chengshantou Coast and Land-forms National Nature Reserve in Liaoning Province, Snake Island and Laotieshan National Nature Reserve in Liaoning Province, Changdao Island National Nature Reserve in Shandong Province and Binzhou Shell Banks and Wetland National Nature Reserve in Shandong Province.

#### **4.3.3 Resources for Tourism and Leisure**

There are a lot of resources for tourism and leisure very near from Port Caofeidian, such as Beidaihe Scenic Spot of Qinhuangdao City, Three Islands Scenic Spot of Tangshan Bay, Golden Coast Scenic Spot of Changli County. Beidaihe is a nice summer resort, and several years ago, it was a summer office for leaders of Central Government of China. Port Caofeidian is about 70 nautical miles from Beidaihe Scenic Spot.

There are also some other places for tourism and leisure around Port Caofeidian, such as Huludao of Liaoning Province, Xingcheng of Liaoning Province, Panjin of Liaoning Province, Dalian of Liaoning Province, Yantai of Shandong Province, Changdao of Shandong Province. There are some beautiful coastal views of temperate regions.

There are also some bathing places with a large number of visitors in summer in

Beidaihe of Hebei Province, Tianjin City, Huludao City of Liaoning Province, Dalian City of Liaoning Province, and Yantai City of Shandong Province.

#### **4.3.4 Shoreline Types and Their Sensitiveness**

Because of the land being reclaimed from the sea, the shorelines of Port Caofeidian are mainly artificial ones. The shorelines in Port Caofeidian including shorelines of the harbor basins and the shorelines in the south part --- the open area--- are mainly artificial constructions and breakwaters.

It has been argued that the length of the shorelines of Caofeidian is 11.403 km in the year of 1989, however, the length is 162 km in the year of 2012. The natural shorelines have been changed to be artificial shorelines(Tian., 2015, p.71).

Only the shorelines of the northwest part, northeast part and the north part --- the Caofeidian Wetland--- are natural shorelines. And there are also a few shorelines being multiple ones, consisting of inter-tidal zone and artificial constructions and breakwaters.

Spilling oil influences the artificial constructions and breakwaters at flood tide, and the spilling oil will be carried on the breakwaters and on the rugged surface of breakwaters or artificial constructions. However, the spilling oil will influence the inter-tidal zone of silts. And because the percentage of sand in shorelines is high, the spilling oil will sink down into the bottom of the shorelines, and stay on the surface for a long time. It is more obvious when there are some weeds on the shorelines.

And the berths in the open area of Port Caofeidian are mainly piled jetty with a long

trestle bridge. When there is some oil spilled into the sea, quite a number of oil will come below the berth. Under the action of artificial constructions and waves, the oil will stay for a long period of time and it is hard to clear up.

#### **4.3.5 Water Intakes**

Caofeidian is also an area for heavy industries. And there are some water intakes around the shorelines of Port Caofeidian. The big and important ones are water intakes for Shougang Jingtang Iron and Steel Company, which is one of the biggest iron and steel companies in China, water intakes for China Resources Power, Tangshan Caofeidian, and water intakes for Aqualyng Sea Water Desalination Company.

These companies often get water from the intakes as cooling water for machines. If the system was invaded by some oil from oil spill of the ships, the heat exchange efficiency will be reduced, and the system of the above-mentioned companies will be shut down if the situation was serious. This is a very serious situation for electric power plant, iron and steel company and petrochemical enterprises, and there will be tremendous loss.

#### **4.3.6 Sea Salt Resources**

Nanpu Salt-work, 20 km from Port Caofeidian, is the biggest Salt-works in Asia, producing about 2,000,000 tons of Industrial salt. Changlu Daqinghe Salt-work, 40 km from Port Caofeidian, is also a good-sized company for producing salt.

There are also some other salt-works around Port Caofeidian, such as Fuzhou Bay

Salt-work in Dalian City of Liaoning Province, Tanggu Salt-work in Tianjin City, and Yangkou Salt-work in Weifang City of Shandong Province.

The oil pollution will influence the normal productive activities of above-mentioned salt-works.

### 4.3.7 Bohai Sea - A Half-Enclosed Sea

Bohai Sea, the gateway of Beijing City, the capital of China, is a half-enclosed sea, surrounded by land in three directions. The acreage of Bohai Sea is 77284 km<sup>2</sup>. It is linked to Huanghai Sea(Yellow Sea) through Bohai Strait, which is only about 59 nautical miles and with 30 islands. The self-purification function of Bohai Sea is very low. Wang notes(2011) that it takes about 30 years for Bohai Sea to finish a total exchange of sea water. Because of the half-enclosed situation, the effects of pollution in Bohai Sea will be more serious than that in open sea(Guo, 2011).

## 4.4 The Impacts Range

**Table 4.2 Resources Sensitiveness Classification of Port Caofeidian**

Classification		Extremely insensitive	Low sensitiveness	Middle sensitiveness	High sensitiveness	Very high sensitiveness
Natural & Ecological	Shoreline	Berths and breakwater	Exposed Rocks,marine foreland, bed rock with waves' washing	Fine sand beach, flat intertidal zone, mudstone, rough Beach	Shallows, mud beach, gravel beach, screened rocky coast	Screened flat intertidal zone, salt marshes, mangrove
	Animal and plant		Common wetland	Wetland of city level	Provincial wetland	National wetland
	Natural Reserve		County level	City level	Provincial	National
	Culture	No importance	Some importances, low positive influence on region	Important influences on local areas, and low influences on nation	Important influences on local areas with some national positive influence	Big influences on nation
Economic & Social	Society & Entertainment		Common bathing place & tourist area	Middle-sized bathing place & tourist area	Big bathing place & tourist area	Beidaihe tourist area
	Waterintakes		Small company	Middle company	Big company	Super-large enterprise or water enterprise
	Salt Pans				Small salt pan	Big salt pan

From Table 4.2, we can find the influenced resources in Port Caofeidian from oil

spill pollution, and their sensibilities and impacts from ship oil pollution.

The maps of the short-term forecast and the long-term forecast for the influencing orbit of spilling oil from ships in Port Caofeidian can be drawn with the help of weather forecast and the monitoring of satellites, CCTV system and the visual inspections by the ships and the people on the land.

## **CHAPTER V**

### **THE COUNTERMEASURES**

Prevention and emergency response are the two keys to solving the problem of oil spill pollution. The oil spill prevention can help to provide a thorough solution to the problem, while the emergency response is the key point to reduce the loss and the influence.

#### **5.1 The Oil Spill Prevention**

##### **5.1.1 The Prevention of Operational Oil Spill Accidents**

According to the discussion of chapter III of this essay, there is a relatively high probability of occurrence of the operational oil spill accidents although the amount of oil spilling is not very large. This kind of accident is related to the management of crew and ship, and the management of the workers of the terminal. In order to reduce the rate of oil spill accident, the ship and the terminal should pay more attention to the management of human-factors. Firstly, in practical work, safety training should be carried out termly and effectively in the group of crew members on the ships and the workers on the land. Secondly, during the process of the oil operation, supervisory persons play important roles in the prevention of the incorrect operations, and they can help to find the accidents timely and take professional steps immediately. Thirdly, the supervision and inspection of the Administration can play a

helping role in preventing the operational oil spill accidents.

### **5.1.2 The Prevention of Average Oil Spill Accidents**

Although the probability of average oil spill accident is low, the amount of oil spilling can be enormous, and the loss and the influences will be very serious.

#### **5.1.2.1 The Maintenance and Management of the Ship**

The company and the shipper should keep the ship in a safety condition, and the company and the ship should follow the existing procedure to maintain the equipment and machines according to the regulations and conventions. During the maintenance of the equipment, the crew should maintain not only the equipment with existing faults, but also the equipment running well. The maintenance period should be strictly followed to increase the reliability of the key equipment and the machines. And the aged ships should pay more attention to the key and main equipment of the ships. The company should supervise and inspect the maintenance work on board to help the ship to keep safety. If some problems were found, the ship should finish the rectification within a prescribed time limit. The safety foundation can only be solid after we finish the setting up and carrying out the procedure of removing the hidden danger from hardware.

#### **5.1.2.2 The Safety Administration of the Traffic Flow**

With the rapid development of Port Caofeidian, the throughput capacity is increasing sharply, and the traffic flow increases continuously. And the ships visiting Port Caofeidian are larger and larger, the biggest ship visited Port Caofeidian is M/V ORE

CHINA with 400,000 DWT on Feb. 23<sup>rd</sup> in the year of 2016(Around Bohai News, 2016). The probability of ships' meeting increases with the increasing number of ships and the largeness of the ships. Because the open area is near to the busy course to Port Tianjin, and there are several harbor basins of Port Caofeidian, the navigable waters are limited, and the functions of navigation facilities will be also limited. The safety administration of the traffic flow can play an important role in helping to keep safe traffic flow. Caofeidian Maritime Safety Administration (M.S.A) has constructed a large and modern VTS to serve the ships. In the area of VTS, the service can interact with the traffic flow, and respond to the change of the traffic situation. Through the VTS center, the VTS officer can monitor the traffic flow, finding out the vessels off the course, the directions of the ship, speed, and the meeting situation of the ships. The VLCC and VLOC and other high-risk ships can be labeled and monitored especially. The optimized service from the Caofeidian VTS center can not only increase the efficiency of the port, but also prevent the potential accidents to protect the environment.

## **5.2 The Emergency Response**

The most positive and effective way to treat oil spill pollution is to reduce the damage to the marine environment and to cut the loss down to the minimum. The emergency response can help to do this. There should be perfect emergency plans, enough emergency equipment, qualified emergency groups of people, excellent emergency system, and professional commanders.

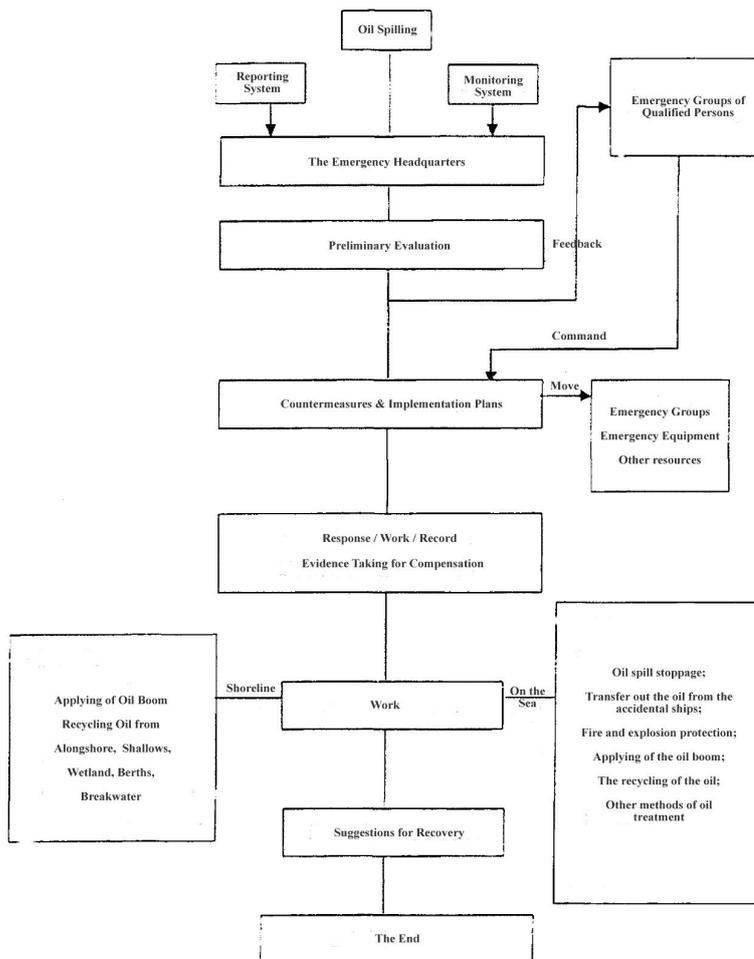
### **5.2.1 The Oil Spill Emergency System**

Oil spill emergency is a systemic and complicated program, therefore we should set

up a perfect system to handle it. The system should include the following aspects:

- a. A sound command organization.
- b. Detailed environmental resource map with important zones.
- c. Effective oil spill monitoring system with scientific analysis and decision system.
- d. Enough emergency equipment with the correct distribution.
- e. Effective training for the groups of emergency persons.
- f. Effective and expedite command and communication system.

**Table 5.1 The Emergency Procedure Design for Small Oil Spill Accidents**





On the one hand, appropriate bases for emergency response should be built in the areas close to the berths, on the other hand, the bases in different berths or ports should support to each other and to form a emergency response net with a command center. Figure 5.1 shows the site selection design, the oil spill response bases should be developed with the quick steps of construction of ports at the same time. Thus, the bad results of oil spill in Bohai Sea--- an important sea for China with large amount of population --- can be effectively reduced.

### 5.3 The Resources Protection Order Design

Table 5.2 is the protection order design for different resources in the area of Caofeidian and the Around Bohai Sea Area. The Administration and the port authority should pay more attention to the resources in the top part of the table though all resources are important.

**Table 5.2 The Design of Resources Protection Order for Port Caofeidian**

Types of Resources	Order
National Nature Reserve	1
Waterintakes	2
habitat of endangered species	3
Fishery resources	4
Salt pan	5
Intertidal zone	6
Important Wetland	7
Places of historic interest and scenic beauty and tourist areas	8
Farmland	9
Shorelines	10
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## **CHAPTER VI**

### **SUMMARY AND CONCLUSIONS**

In order to prevent the oil spill accident and reduce the loss and influences of oil spill accidents, the risk and impact evaluation and effective emergency response are the appropriate and important ways.

Because there are many kinds of factors influencing the risk and impact analysis and evaluation, the research for risk and impact evaluation is very complex, and the research work should be comprehensive and painstaking. This paper is for Port Caofeidian, collecting the information of natural environment, situations of society and economy, the situations of cargo and ships, analyzing the position of Port Caofeidian, and pointing out the importance of oil spill prevention and emergency response. Through the analysis of the data of other areas and Port Caofeidian, the risks and impacts of oil spill accidents have been evaluated, the amount of oil spilling, the resources influenced and the range influenced have been defined. In order to reduce the risk and the impacts of oil spill pollution, some countermeasures should be taken, such as the management of ships and the terminals, the human-factor management, the administration of traffic flow, the effective TVS center, the excellent emergency response system, the complete emergency plan, and the management of emergency equipment and persons.

This paper has evaluated the rough probability the several kinds of oil spill accidents,

the amount of oil spilling of different kinds of ships and the different kinds of accidents. Some accident prevention methods have been introduced and the emergency response procedure has been designed. What is more, the data of possible influenced resources have been completely collected and analyzed and the order of protection has been designed.

Oil spill accident prevention and the emergency response are the two main aspects for oil pollution. Only if we take measures on both of these two aspects, can we reduce the accidents, their impacts and loss from ship oil spill accidents.

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