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The optimization of emergency response for oil spill in Wusongkou waters

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THE OPTIMIZATION OF EMERGENCY RESPONSE FOR OIL SPILL IN WUSONGKOU WATERS

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DECLARATION

I certify that all the materials in this research paper 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.

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

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ABSTRACT

Title of Dissertation: **The Optimization of Emergency Response for Oil Spill in Wusongkou waters**

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The economy of China has become increasingly dependent on oil in the past few years, however the frequency and scale of oil spill accidents in Shanghai waters has also increased significantly. According to statistics, marine oil spill accidents account for the largest proportion of the four major oil spills. If a marine oil spill accident occurs, the drift and spread of oil pollution will not only affect the wetlands, ecological protection areas and tourist areas along the waterway, but also endanger the safety of water abstraction in the water sources within the distribution area. Therefore, it is of great significance to carry out emergency disposal of oil spill accidents.

At present, the research on oil spills in Wusongkou waters are still relatively rare, and it is difficult to quickly and intuitively formulate marine oil spill emergency response (Shou, 2015, pp.6-8). The purpose of this paper is to systematically analyze the development of oil spill emergency response in Wusongkou waters, and to establish a set of oil spill emergency response system which is suitable for the waters. The realization of this system is not only beneficial to the management and control of oil spill risks in Wusongkou waters, but also has positive guiding significance for reducing potential future oil spill accidents, such as ecological losses and socio-economic losses.

KEY WORDS: Wusongkou waters, oil spill, marine emergency response, emergency countermeasures

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MSA	Maritime Safety Administration

CHAPTER 1

INTRODUCTION

1.1 Background Information

With the rapid development of the maritime transportation industry and oil industry chain, offshore oil transportation has become unprecedentedly prosperous. However, although offshore oil transportation has brought in huge economic benefits, it has also greatly increased the risk of marine oil spill accidents. These potential spills will seriously threaten the balance of the marine ecosystem.

Major sources of marine oil spill pollution include marine shipping accidents (collisions, hits, runs, sinks, sinks, etc.), as well as the discharge of oily wastewater from coastal areas, breakage of oil irrigated areas at terminals, damage of offshore drilling platforms or damage of submarine pipes (Pan, Wang &amp, 2011, pp.176-186). Oil pollution of marine vessels can be summarized into two forms, i.e. sudden input pollution and chronic long-term input pollution. Sudden input pollution refers to the accidents caused by ships or tankers hitting rocks. In addition, sudden input pollution also includes accidents such as blowouts and explosions occurred during the exploration, development, production, or underwater oil pipeline transportation of oil fields. Sudden input pollution causes large amounts of oil to

flow into the ocean, leading to huge economic losses and serious damage to the marine ecological environment. Chronic long-term input pollution refers to the leakage of ships in ports during the installation of fuel oil and cargo handling activities, as well as intentional or negligent discharge of oily wastewater, natural seafloor seepage, erosive seepage of oil-bearing sedimentary rocks, industrial civil wastewater discharge, settlement of oily waste gas, etc. Chronic long-term input pollution generally produces less oil, but the durability cannot be underestimated. At present, with the increase of sudden input pollution incidents, the hazards of chronic long-term input pollution are increasingly exposed. In addition, petroleum hydrocarbons have become the major pollutants in the whole oceans (especially shallow sea areas). Studies have shown that once marine oil spill pollution contaminates water areas or the food chains, the aromatic hydrocarbons which they contain are persistent, cumulative, migratory and highly toxic (Li & Fan, 2004). Such pollution will inevitably endanger the body, causing symptoms of carcinogenicity, degeneration and teratogenicity, and is a serious threat to human health. Meanwhile, since the proportion of waste oil wastewater is greater than that of seawater, and after the leak, the oil droplets will stick to the sea suspended particles and sink to the bottom of the sea, these toxic substances often pollute the sediments and organisms on the seabed through the seafloor, causing a large number of biological deaths and damaging the biodiversity of the ocean.

1.2 Objectives of research

Among the coastal cities in China, Shanghai is located at the intersection of the "T" shape between the coastal areas of China and the Yangtze River Economic Belt. As the largest bulk cargo terminal and oil terminal of Shanghai Port, Wusongkou waters is located in the upper reaches of the Shanghai section of the Yangtze River, and it is a must for all ships entering and leaving the Yangtze River and coastal ports.

Meanwhile, Wusongkou waters is an important source of fishery resources in China where many important ecological protection areas and waterways locate.

In addition, the waterway in Wusongkou waters is also an important channel for energy sources such as crude oil and fuel. Due to the high density of vessels, it is one of the areas where large number of accidents occurred. For example, the incident of submerged oil spills from a tanker named “Tongyin 6” severely aggravated the marine ecological environment, causing massive deaths of marine fish, birds, seaweeds and marine mammals. The oil spills also drifted under the influence of winds, waves, and streams, contaminating near-shore and fishing areas. In particular, it caused direct damage to Qingcaosha, Chenhang, Xisha and other important drinking water sources within Wusongkou waters, seriously threatened human health and production. It is believed that with the ever-increasing throughput of Shanghai Port, ships will become denser and more similar accidents will occur. This will undoubtedly pose potential and serious threats to the ecologically sensitive areas such as drinking water sources and tourist areas distributed in Wusongkou waters and nearby areas. In order to promote the construction of ecological civilization, it is particularly important and urgent to effectively monitor and control the marine ecological environment risks caused by marine oil spill pollution. In particular， a set of oil spill emergency response systems suitable for the waters need to be established according to the oil spill situations in Wusongkou waters,

1.3 Methodology

The oil spill emergency response refers to the prompt and effective measures taken against sudden oil spill accidents according to the emergency plan formulated in advance, so as to reduce the risk of oil spill pollution to the environment. The oil spill emergency response is conducted under the guidance of the oil spill contingency

plan, and the rationality and effectiveness of the oil spill emergency response plan need to be tested by the practice of oil spill emergency response, thus providing experience for continuous improvement. Different levels of emergency plans form different levels of emergency response systems. Due to different tasks, the high-level emergency response systems focus on overall organizational coordination, rational allocation of resources, and control of response actions. The low-level emergency response systems focus on the control and removal of pollution damage at the site.

The emergency response system generally consists of four parts: the emergency organization structure, emergency response procedures, emergency operations, and emergency resources. The emergency organization structure includes a command coordination mechanism and a decision consultation center composed of expert consultants and risk analysis and assessment departments (Prince R C, Garrett R M, Bare R E, et al.,2003, pp.145-156). Emergency response procedures include specific action guidelines, information transfer and contact methods. Emergency operations include reporting and alerting, surveillance and monitoring, pollution control, and regional collaboration and support. Emergency resources include professional cleaning and assistance teams, emergency equipment reserve, technical training, emergency guarantee funds, logistics support capabilities, and volunteer organizations. Emergency plan covers emergency preparation beforehand, the whole process of emergency recovery in incidents, events and afterwards, emergency resources, the organization and management of operations and the coordination of command conduct overall procedural specifications.

1.4 Structure of dissertation

This thesis is mainly divided into five chapters. Chapter One provides background information, research objectives and methodologies to be used in subsequent parts.

Chapter Two puts forward the overview of Wusongkou waters, including its natural environment characteristics and the distribution of ecologically sensitive areas. Chapter Three introduces the general situation of oil spill response in Shanghai, and mainly analyzes the oil spill emergency response in Wusongkou waters (Wang, He &amp, 2009, pp.57-60). Chapter Four establishes an accident emergency scenario simulation of an oil spill accident, adjusts the accident emergency measures, and further improves the preparation of oil spill emergency plans. Chapter Five makes final summary and conclusion.

CHAPTER 2

OVERVIEW OF WUSONGKOU WATERS

2.1 Natural environment characteristics

Wusongkou waters is the confluence of the Huangpu River and the Yangtze River. It is more than 30 kilometers away from the Yangtze River estuary in the east, facing Chongming Island in the north. Shanghai, where Wusongkou waters is located in, is the birthplace of China's industry and the leader of economic development. Its water environment is directly related to the sustainable development of Shanghai's social economy. Meanwhile, as the resources of high quality channels, fisheries and tidal flats, Wusongkou waters is rich in resources and has a high degree of development and utilization.

(1) Channels

Except the Yangtze River estuary, Wusongkou waters has the most dense water flow in Shanghai. It is an important strategic waterway for ships entering the sea from the Huangpu River. The main waterway includes Baoshan Channel, Waigaoqiao Channel, Nancao Channel, and Yangtze Estuary Channel.

(2) Fisheries

The largest estuary fishery of China is located in Wusongkou waters. There are more than 250 kinds of fish species, including about 50 kinds of fish, such as the Reeves shad, Coilia nasus, Chinese Mitten Crab, etc. The spawning, feeding, and migration

sites of these fishes also locate in Wusongkou waters.

(3) Tidal flats

The resource of tidal flats in Wusongkou waters is mainly distributed in the Chongming tidal flat, Hengsha tidal flat and Jiuduansha tidal flat. There are some important ecologically sensitive areas, including the Wetland Migratory Bird Sanctuary, Wetland Ecological Nature Reserve, and Chinese Sturgeon Nature Reserve. Among them, the Nature Reserve in Chongming tidal flat is an important fish feeding site and also a very important habitat for endangered species such as Chinese sturgeons. Therefore these tidal flats play a key role in maintaining the ecological environment of the Yangtze River (Lv &amp, 2006, pp.379-384).

2.2 Distribution of ecologically sensitive areas

2.2.1 Marine nature reserve

There are 561 different types of protected areas at different levels near Wusongkou waters. The total area of all protected areas is 32,880,100 square kilometers, of which are 59 national-level nature reserves with an area of 289,890,000 square kilometers and 202 provincial-level nature reserves with an area of 6,435,000 square kilometers. In addition, in Shanghai, Wetland Nature Reserve in Chongming tidal flat is a national nature reserve, while nature Reserve in Yangtze River Estuary is a provincial nature reserve, both of which are in Wusongkou waters.

Wetland Migratory Bird Sanctuary in Shanghai Chongming tidal flat is listed in the International Wetland Directory Ecological Reserves and is the largest wetland migratory bird sanctuary in Asia. Chongming tidal flat starts from Yanjiagang in the south and ends at Bagua Port in the north. It is bounded by a dyke built in 1968 and bounded by the 3000m water level in the east of Wusongkou. It is located at 121°50′

-122°05′ east longitude and 31°25′-31°389′ north latitude, covering an area of 326 square kilometers. It belongs to the typical estuarine wetland of the Yangtze River Estuary. Here, the area of the nature reserve is 231.55 square kilometers, including the tidal flats and the waters. Within the embankment, there are mainly fish and crabs, and the constructed wetland area is approximately 85 square kilometers. It is also an important habitat for migratory water birds. There are 321 species of birds recorded in Chongming tidal flat, including 4 species of class I national protected animals and 43 species of Grade II national protected animals. Chongming tidal flat has now been accepted as an important international wetland. The Chinese sturgeon nature reserve in Yangtze River Estuary starts from Bagua Port, and from the south, it has an area of about 69,600 hectares. The protected area was included in the list of important international wetlands in 2008. It is one of the largest estuarine wetlands in the world and is the saltwater estuarine wetland with the most abundant fish biodiversity and the highest fishery potential in China (Mcgurk, M. D., & Brown, E. D., 1996, pp.2343-2354). Since it is the only juvenile of Chinese sturgeon, it is very important for the protection and reproduction of Chinese sturgeon.

2.2.2 Drinking Water Source and Industrial Water Intake

There are several drinking water sources and industrial water intakes in Wusongkou waters. The main freshwater resources in Shanghai are mainly derived from Taihu Lake and the Yangtze River in the upper reaches of the Huangpu River. From the quantitative perspective, Shanghai is not short of water. However, the upper reaches of the Huangpu River have limited water availability. In the middle and lower reaches of the Huangpu River, the sewage is traced back to the tide and the water quality deteriorates. The over-exploitation of groundwater can easily cause ground subsidence and seawater intrusion. On the whole, Shanghai is a water-short city. In

order to solve the water shortage problem, Shanghai has built several reservoirs along the Yangtze River, such as the Baoshan Reservoir, the Chenhang Reservoir and the Qingcaosha Reservoir. At the arrival of a new round of development of the Shanghai economy, the demand for freshwater resources will increase accordingly. Shanghai municipal government also proposed establishing a water source protection zone in the Pearl Lake and the north branch of the Yangtze River estuary in the western part of Chongming Island (Chen, 2002). Therefore, it is of utmost importance to actively quote the Yangtze River water during the wet period to ease the water shortage in Shanghai.

(1) Baoshan Reservoir

Baoshan Reservoir is located in Shidongkou, with an area of 1.6 square kilometers and a storage capacity of 10.87 million cubic meters. It is used for production.

(2) Chenhang Reservoir

Chenhang Reservoir is closely connected with Baoshan Reservoir. The first-phase project area is 1.37 square kilometers and the water storage capacity is 8.3 million cubic meters. It is the top water supply source in Baoshan District and Pudong New Area. The third phase of the project is currently under planning to increase raw water supply capacity by 1.3 million cubic meters per day.

(3) Qingcaosha Water Conservation Area

Qingcaosha Water Conservation Area is located in the northwest part of Changxing Island and is located at the center of the Yangtze River. It is not subject to territorial discharge and belongs to the jurisdiction of Shanghai Chongming County. It has a large amount of high-quality freshwater, and the water quality belongs to Class I to Class II. The city's excellent water resources and strategic reserve of urban water supply have a total area of approximately 70 square kilometers, with an average annual runoff of 489.6 billion cubic meters, which is 49 times that of the Huangpu River.

Figure 2.1: Drinking water source and industrial water intake

Sources: Compiled by the author

CHAPTER 3

OIL SPILL EMERGENCY RESPONSE SYSTEM IN WUSONGKOU WATERS

3.1 Structure of oil spill response organization in Shanghai waters

At present, there are only two professional oil spill emergency supervision agencies in the maritime system in China. One is the Oil Spill Emergency Technology Center in Yantai, and the second is The Ship Pollution Monitoring Station in the Three Gorges reservoir area. In addition, Shanghai's emergency management of public emergency incidents is under the responsibility of the Shanghai Emergency Management Committee, which mainly examines and supervises the six links, i.e. Measurement, reporting, defense, resistance, rescue, and assistance. The departments of Shanghai Emergency Response Center include public security, public health, safety supervision, civil defense, maritime affairs, construction and transportation, and environmental protection, as well as district and county governments and regional administrative agencies. They are responsible for the early handling of public emergency response linkage within the scope of their respective duties (Zhang, Wang &amp, 2002, pp.804-810). In accordance with the "Interim Measures for the Emergency Handling of Emergency Responses to Public Emergency Incidents in Shanghai" and other relevant regulations, The Shanghai Emergency Response Center took necessary measures to determine the level of incidents in public emergencies, as

well as on-site dynamic information reporting and other preparatory work through organizing, directing, scheduling, and coordinating resources and forces in all aspects.

In addition, Shanghai Maritime Oil Spill Emergency Command Coordination Agency headed by Shanghai MSA, jointly with the Shanghai Ocean Administration, Fisheries Bureau, Environmental Protection Agency, constitute a Shanghai oil spill emergency response organization to monitor Shanghai Waters. It has actively revised and improved the oil spill emergency plan. Through the verification and registration of the current configuration of emergency boats, equipment and personnel, a unified deployment of science has been implemented. Meanwhile, Shanghai MSA has established an expert pool of ship pollution emergency response and developed the Yangtze River estuary oil spill diffusion simulation software to improve the technological content of oil spill emergency response. Shanghai MSA also plans to include the declaration of an oil spill emergency plan in Shanghai as an overall plan for preventing disasters. At present, Shanghai has established an oil spill emergency rescue equipment warehouse in the Yangtze River estuary, and the disposable oil spill control capacity in Shanghai waters has reached 1,000 tons. In 2016, the Shanghai Maritime Search and Rescue Center coordinated a total of 220 maritime search and rescue operations, deployed 250 maritime patrol boats, coordinated 69 professional rescue vessels, coordinated 376 cruises of the society and 67 aircraft, and successfully rescued 1126 people, and the rescue success rate reached 96.57%. In addition, Shanghai is expected to take the lead in setting up a chemical water professional rescue team in the country, equipped with special chemical analysis, disposal, and salvage equipment. The high-level professional and technical personnel will also be introduced to intensify the ship pollution pre-control system in Qingcaosha Reservoir and other important water sources and sensitive water areas.

Through the linkage with various ports on the upper reaches of the Yangtze River, information exchange can be achieved. In addition, dangerous goods ships passing through Shanghai will also be required to report to Shanghai MSA and be escorted by maritime patrol ships.

3.2 Resources for Oil Spill Response in Shanghai

Oil spill emergency response resources include emergency response human resources and emergency response material resources. These oil spill emergency equipment are distributed in ports and coastal areas. Human resources include professional cleaning and assistance teams, technical personnel, experts, legal personnel, and volunteers. Material resources include equipment and materials required for containment and removal of oil spills (such as fire extinguishing equipment, booms, sewers, skimmers, oil dispersants, etc.), medical equipment and supplies (such as ship aircraft, antivirus equipment and medicines, etc.), as well as necessary living materials (such as food, drinking water, clothing, etc.), emergency equipment reserves, emergency technical communication training, and emergency guarantee funds. Maritime pollution emergency resources of China provided to the oil spill emergency response agencies and salvage systems in the North Sea area, others are mainly from ports, terminals, offshore oil companies, and professional cleaning companies (Wang, Wu, 1993, pp.25-27).

Therefore, the oil spill emergency response organization firstly combines pollution indicators such as oil type, oil spill volume, drift trajectory, diffusion area, speed, and impact time. Secondly, it comprehensively considers the sensitivity of the social environment, economic environment, and ecological environment in the region where the accident occurred. Thirdly, the response organization should fully consider the integration of resources, the emergency response time, the deployment of

equipment libraries, and the factors such as the fastest arrival time of pollutants, the most likely polluted area, and pollution intensity. Fourthly, the response organization should determine the number and scope of dispatching emergency response teams and emergency resources, and related logistics support plans (Lin &amp, pp.185-190). Adopting appropriate methods for cleaning up pollution equipped with appropriate emergency rescue vessels and cleaning equipment, and establish an emergency linkage mechanism.

3.3 The procedure of oil spill response in Shanghai waters

The establishment of emergency response procedures can be followed by macro control of emergency operations after an oil spill accident, and corresponding emergency measures can be followed in time to effectively control oil spill contamination. According to the accident process, the specific procedures for establishing an emergency response are as follows:

(1) Alarm and report as soon as possible after receiving an oil spill at sea.

(2) Designate on-site command, quickly launch support systems such as monitoring and intelligent information, and respond, support, and guide emergency response actions against oil spills in various areas.

(3) Assess the level of emergency response work, combine the opinions of the emergency technical consulting expert group, and conduct a comprehensive assessment based on the oil spill information provided by the on-site command and the results of remote sensing interpretation.

(4) Prepare emergency action plans and notify them. According to the level of emergency work, the oil spill emergency command department combines information received, risk zoning and simulated oil spill track information, expert consultation, and on-site command recommendations, formulate emergency action plans, make schedules for clearance operations, estimate costs, and promptly notify

the China MSA, participating organizations, and corresponding search and rescue centers or sub-centers.

(5) Organize and coordinate cleanup teams and resource equipment, mobilize oil spill emergency prevention teams and emergency control ships, equipment, etc., as well as necessary logistic support for oil spill containment and removal. It also organizes and coordinates maritime, port, salvage, shipping companies, environmental protection, marine, fisheries, fisheries, military, public security, firefighting, post and telecommunications, meteorology, agriculture, forestry, tourism, insurance, etc., and invests in emergency activities according to the responsibilities defined by the headquarters.

(6) Application support and regional cooperation. When an oil pollution accident that may affect other waters or shorelines occurs, it need to make mutual announcements. When a major oil spill accident occurs or the emergency team and equipment in the jurisdiction cannot meet the oil spill response requirements, the superior or the China Marine Oil Spill Emergency Command Coordination will coordinate the support of other sea areas，even including the support from neighboring countries. If an oil spill occurs, a secondary disaster (similar to a fire) is triggered. When fire and rescue are required, the fire department is immediately contacted to request rescue. If an oil spill accident occurs, it triggers a secondary disaster (like a person-injured person). When medical assistance is needed, contact the local medical department.

(7) Remedial work. Study and determine the mode of transport and treatment of the recovered oil and the later-stage polluted waste.

3.4 Oil spill response in Wusongkou Waters

According to the procedure of oil spill response in Shanghai waters, the specific contents of the oil spill response can be summarized in the following four aspects.

3.4.1 Alarms and Reports

Early detection, early reporting, and early warning of emergencies include the prerequisites for timely emergency preparedness, effective handling of emergencies, and reduction of casualties and property losses (Liu, 2010). According to the “Water Pollution Prevention Law”, the entity responsible for water pollution incidents shall report to the local government within one hour after the occurrence of the incident. After the ship has caused a pollution accident, it shall immediately report it to the nearest maritime institutions. While receiving the report, the maritime institution shall immediately report the situation to the environmental protection department of the government at the same level, and then timely start investigation and processing work (Li, Huang &amp, 1999, pp.12-14). When enterprises and public institutions encounter water pollution accidents, they must immediately take effective measures to stop or reduce pollution. And within 48 hours after the accident, it is required to report to the local environmental protection department including the time, place and the type of accident, the type and quantity of pollutants discharged, economic loss, personnel damage and emergency measures. After the accident is identified, the enterprises and institutions shall make a written report to the local environmental protection department, including the cause of the accident, the process, the hazard, the measures taken, the result of the treatment, and the potential hazards of the accident or indirect harm, social impact, etc. In addition, after the crisis occurs, government departments must follow the emergency response law to carry out government emergency powers, including the establishment of a command platform, the establishment of oil spill emergency monitoring and command system, so as to reflect the social participation in the response mechanism, clear the responsibilities and division of labor of the rescue forces, etc.

3.4.2 On-site investigation and monitoring

After an oil spill incident occurs, the emergency personnel must go to the site to conduct investigations immediately to obtain relevant information on pollution incidents (Xue, Zeng, 2011, pp.1743-1750). According to the site conditions, the necessary water security and traffic control measures shall be implemented to strictly limit the increase of new sources of pollution and risk investigations for existing key pollution sources need to be carried out. The site survey includes the surveys on waters and shorelines near the sampling site. After the overview survey of the incident, it is necessary to promptly report to the headquarters of the oil spill emergency jurisdiction to determine the scale of the accident, and make a prompt supervision plan to determine the monitoring content (Lin, Jin, 2009). The overview of the oil spill incident to be investigated includes:

(1) Time, location and reason of the oil spill;

(2) Ship name, nationality, gross tonnage, type of ship involved in the accident;

(3) Conditions of pollution sources and contaminated resources around the oil spill site;

(4) Damage to the ship (floating, sinking);

(5) Oil spilled varieties and their physical and chemical characteristics;

(6) Oil spill type (instantaneous, continuous discharge);

(7) Total oil storage and spillage of ships;

(8) Function of oil spill area;

(9) Hydro-meteorological conditions (at the time, in the next few days) and drifting;

(10) Information of perpetrators, eyewitnesses or persons related to the accident.

During the process of oil spill emergency response, the key monitoring contents involved include the determination of physical and chemical characteristics of oil

spills, monitoring of oil spills, monitoring of water pollution, monitoring of spilled oil contamination and confirmation of oil spill sources. The determination of oil spilled varieties and their characteristics (physical characteristics and chemical characteristics) can be compared based on the establishment of an oil film spectrum database by means of remote sensing, or sample measurement within the available range, with the help of "oil fingerprint", "fluorescence spectrometer", etc. Through the identification of marine oil spill samples for analysis and identification, Shanghai MSA should determine the source of spilled oil. When sampling oil spills from the sea, different types of oil spills such as cargo oil, fuel oil, and bilge oil should be determined based on the appearance characteristics of oil spills on the sea surface. And Shanghai MSA should set sampling points in different types of oil spills. Meanwhile, it is also necessary to focus on monitoring the proportion, viscosity, ignition point, wax content, and volatility of oil spills, so as to assess the possibility of oil fires and explosions. During the oil spill clearing period and after the cleanup operation, determine the sampling and distribution scheme for the oil content in the water according to the accident pollution scope, and perform sampling monitoring.

3.4.3 Evaluating emergency response work levels

According to the on-site command, provide oil spill information extracted by means of remote sensing or oil fingerprint interpretation. Combine the results of risk zoning in ecologically sensitive areas, and assess the level of emergency response work for the type of oil spilt in the accident, the amount of oil spilt, and the ecological sensitivity of the affected sea areas. The emergency response work can be mainly divided into 4 levels. The values from low to high correspond to four levels: particularly significant (level I-red emergency response), major (level II-orange emergency response), and large (level III-yellow emergency response), and general

(level IV-blue emergency response). And corresponding oil spill emergency work level corresponds to the leadership organization department and corresponding response measures. It should be noted that when a persistent oil spill is close to the demarcation point in the gulf, the estuary, and the coastal waters, the assessment response work level should be increased by one level. Among them, corresponding emergency response measures also need to be coordinated according to the specific conditions of shoreline type, oil type, resource equipment, etc. The level of oil spill is based on the provisions of the Chinese marine oil spill emergency plan (Wang, 2011). It is divided into three types: small spill (10 tons or less), medium-sized spill (10-100 tons), and large spill (100 tons or more).

Table 3.1: Emergency work levels of oil spills corresponding to Organization Department and measures

Emergency work levels	Level I	Level II	Level III	Level IV
Emergency organization department	China's Offshore Oil Spill Emergency Command and Local Government	Local Government Oil Spill Emergency Command	Marine Oil Spill Emergency Command	China MSA
Emergency response measures	Require regional or national participation in firefighting, fully dispatch boats and firefighting equipment	Require processing, dispatch several search ships	Require sprayed oil dispersant (depending on the size of the oil spill area)	May not require treatment or take simple physical removal

Sources: Compiled by the author

3.4.4 Formulation of Emergency Action Plan

According to the assessed emergency work level, the oil spill response headquarters of relevant departments combine the results of field investigations, risk zoning and oil spill trajectory simulations, as well as the knowledge and experience of contingency planning and emergency response experts, to formulate a plan for assisting decision-making on oil spill response at sea, including the priority protection order of ecologically sensitive resources, specific polluted sea and shoreline cleaning solutions, post-processing of post-contaminated wastes and confirmation of emergency response.

3.4.4.1 Priority of Ecologically Sensitive Resources

In the event of a marine oil spill accident, the primary objective is to protect important ecologically sensitive areas, to control the spread of oil spills, followed is removing pollution. In the oil spill emergency response process, emergency decision-makers can pass through the sensitive resource distribution and risk levels around the accident area in the map of the Shanghai Sea oil spill ecological environment risk. Combining with the predicted oil spill dynamic trajectory, it is possible to predict factors such as the fastest arrival time of pollutants, the most likely polluted area range and pollution intensity, and analyze sensitive areas and resource types that may be subject to pollution hazards (Wang. 2007, pp.31-33). In addition, according to sensitivity of sensitive area, shortest distance between oil spill source and sensitive area and hydro meteorological elements, it should quickly make emergency decisions, focus on early protection of important ecologically sensitive areas, and effectively protect potentially sensitive environmental sensitive resources,

so as to achieve emergency plans.

3.4.4.2 Cleaning Scheme

After the occurrence of marine oil pollution incidents, the oil spill will quickly drift outward from the site of the incident under the influence of sea surface winds, currents, tides, waves, etc., and form a large-area scattered offshore oil film and oil belt. After reaching the shore, its handling is much more difficult than on the sea. Therefore, after the occurrence of pollution, the oil spill on the sea must first be disposed of in an emergency manner in order to effectively control the pollution to a minimum. According to the geographical location of oil spills, the removal of oil spills is generally divided into two forms: offshore and shoreline., commonly used methods such as oil spill control, oil spill recovery, oil spill clearance, application of dispersant and combustion at sea. On the shoreline, due to the difficulty of removal, the best way is to dig a pit at the bottom of the shoreline and pour the oil into the pit for recycling. The oil spill emergency cleaning operations can be summarized into three steps: the cutting off of oil spill sources, the containment and the removal of spilled oil. Then select the appropriate removal technology considering the type of oil and protected resources in a comprehensive manner (Guo, Zhang, 2009). Finally, determine the effective emergency cleanup work plan.

(1) Cut off the oil spill source

The primary task of on-site emergency treatment is to cut off the oil spill source so as to avoid the upgrade of the accident scale. The measures that can be taken are usually plugging and unloading. After the incident, the accident ship needs to start the "Oil Contingency Plan on Board" to carry out plugging and oil transfer of the oil tank (or tubing). These job requirements include: firstly, close all the valves of the tank piping as much as possible and plug the tank vents to prevent oil spills. Take as much

information as possible about the amount of oil on board, the positions of the oil tanks (fuel tanks and cargo tanks) and vents. Initially judge the damage of the ship (or tubing), organize plugging and transfer residual oil. Secondly, when necessary, the salvage personnel conduct underwater exploration. Take every possible method and try your best to block the broken mouth, dispose of residual oil to other cargo tanks or oil tankers, barges and oil capsules that can receive oil. In addition, during the refusal, pay attention to strict compliance with safety and anti-pollution procedures, constantly adjust the amount of oil in each tank, and maintain a steady increase in the hull. Meanwhile, mobile pumping equipment must be provided to prevent the use of cargo pumps on the ship (Liang, 2007, pp.62-63). Finally, in order to ensure the safety and reliability of the two vessels, adequate fenders should be installed on the ship's side. And ready to move the ball type fenders, in the barge, send someone to adjust and strengthen the cable at any time, closely monitor the pipeline and tank status.

(2) The containment and control of oil spill

After the oil spill is cut off, the diffusion range of the spilled oil must be containment，and it must prevent further spillage and drift of the spill and concentrate the spill to make it more recyclable. Or, the oil slick can be guided to water areas where the water conditions are relatively calm and less sensitive to environmental resource-sensitive areas, so as to protect sensitive areas of environmental resources from being polluted. Controlling oil spills at sea, in general, one or more booms need to be built around the accident ship to control it. If there is leakage of gasoline or other inflammable oil products, fire protection booms should be added, fire-fighting vessels should be called on standby, and fire and explosion prevention measures should be taken. However, due to the combined effects of weather and sea conditions, in some cases, despite efforts are made to remove surface oil spills, it is still not possible to avoid the oil spill reaching the shoreline. In this case, comprehensive

consideration should be given to the priority protection order, the geographical environment and structure of the shoreline, as soon as possible, adopt different containment measures for shoreline protection. Different oil containment methods can achieve different treatment effects. The interception containment is designed to intercept oil spills at sea using multiple booms; isolated containment can be used to protect water intakes, sea inlets and sensitive resources; guided containment refers to the use of oil booms to direct oil spills to areas of relatively low sensitivity, and is suitable for situations where the tidal currents on the coast are relatively large; adsorption containment refers to the use of oil-absorbing oil-bars to absorb the oil spilled from the shoreline or spilled over the water surface to protect other shorelines. The number of booms to be considered should take into account such factors as the length of the sensitive shoreline to be protected, the size of the oil spilled vessel, and the number of recycling systems. When assessing the function of the boom, consideration should be given to factors such as the operating water area, the type of controlled oil, and the object of protection. Among them, the length of the sensitive shoreline should be forecasted using the drift prediction model for accident-prone areas, and it is the length of the sensitive shoreline most likely to be affected by oil spills. The specific parameters for the boom need to be set according to the specific sea conditions. For small area oil spill contaminated areas, use oil mops or suction wicks to control oil spills.

Table 3.2 Main requirements data of oil fence

Environment	Maximum Effective Wave Height (m)	Freeboard Height (cm)	Draft (cm)
Near shore or calm sea	0.3	10-25	15-30
Harbor	0.9	25-46	30-61
Sea	1.8	>46	>61

Sources: Compiled by the author

(3) The removal of oil spill

After effective containment of oil spills on the sea, oil spills must be promptly removed to prevent emulsification or sedimentation and damage to the ecological environment in the surrounding area. Common spill clearance methods include physical removal and chemical methods. When handling oil spills, it is necessary to optimize the configuration and disposal scheme according to the specific conditions of the oil pollution. Meanwhile, we must pay attention to protecting the marine environment and minimize the pollution to the surrounding environment during the oil spill treatment process. After a large-scale oil spill occurs, the oil spill must first be physically controlled and removed. Physical removal uses mechanical devices such as skimmers, oil-absorbing materials, and oil spill recovery vessels for recovery, and the recovered oil is stored in oil storage facilities. The advantage of physical removal is that it will not bring additional damage to the marine environment. However, this optimal treatment method has obvious limitations. Especially in the severe sea conditions, the containment measures are easy to fail, and mechanical recovery equipment are also difficult to operate. In order to ensure the effectiveness of containment and recovery, it is not only necessary to be familiar with and understand the applicability of different installations for different types of oil spills and different sea conditions, but also to strive for the completion of containment and centralized recovery operations before large-scale oil spills spread. In general, it takes time to mobilize oil spill containment and recovery tools. Even though the performance of the recycling equipment is good and the action plan is well established, because the spread of oil spills over time and the breakage of the oil film increases the difficulty of recovery at sea, only about 10% of the slick can be recovered. Therefore, during the containment and recovery process, equipment needs to be selected based on factors such as weather conditions, oil spillage range, type of

oil, etc., and appropriate operation modes should be selected for the type of equipment selected.

Chemical methods, is incineration, spraying of oil dispersants and biodegradation. For light oils such as gasoline, kerosene, and diesel oil, due to their characteristics of low density, low viscosity, and rapid diffusion, the formed oil film is very thin, and it is often difficult to recover using physical methods. At this time, consider burning these difficult-to-treat oil spills or using some chemicals. Chemicals can change the presence of oil spills in the marine environment, thereby reducing their degree of contamination in seawater. When the water content in the seawater is small and the oil film thickness is more than 2 mm, on-site incineration can be considered. However, the on-site incineration is expensive and the conditions are harsh. When fired, special fireproof booms are used. Meanwhile, after burning, measures must be taken to deal with unburnt residues and oil beads that sink into the water. In emergency situations where mechanical recovery or fire hazards are not allowed, the preferred method of eliminating oil spills from the sea is to spray oil spill dispersants. Part of the molecular structure of the oil dispersant is hydrophilic, and part of it is lipophilic. After being mixed with oil and water under the action of the waves, the oil can be easily dispersed into small oil droplets to enter the water body, and the oil floating on the sea surface can be quickly eliminated. In addition, oil spill dispersants can accelerate microbial degradation and photo oxidative decomposition of oil spills in water, ultimately shortening the time the oil spills completely out of the ocean. However, because the oil spill dispersant is a chemical agent, especially when the personnel do not spray properly, or when the dispersant is abused when it is not suitable for use, not only does the effect not increase the marine pollution. Even if it is a non-toxic oil spill dispersant, spraying into the sea will increase the foreign matter in the marine environment, so the use of oil spill dispersants is still

controversial.

When deciding on the suitability of dispersants, sensitive resources around the contaminated waters should be considered. In general, seabirds, coastal communities, wetlands, mangroves, and seaport wharfs are greatly affected by oil spills on the sea surface. Dispersants can be used to disperse oil spills from the sea surface into water bodies. However, fish, plankton, benthos, seagrasses, coral reefs, and water intakes are highly affected by oil spills in water bodies, so it is not easy to use dispersants. When spraying oil spill dispersant, it should be used in proportion according to the *Guidelines for the Use of Spill Dispersants* promulgated by China. Since the most suitable conditions for oil spill dispersants are high seawater temperature, large sea-surface winds, and emulsified oil spills, it is necessary to make decisions as soon as possible and implement them as soon as possible. In addition, in the use of the process must continue to assess the effect, when the dispersant is no longer effective should be decisively stopped using.

Therefore, it is usually necessary to use physical treatment methods in conjunction with chemical treatment methods, such as on-site combustion and the use of chemical agents, to minimize the damage to the environment from oil spills. For partially non-recoverable oil spills and oil spills that have changed their forms of existence by chemical agents, we can purify them through biodegradation in the marine environment and eventually eliminate them completely from the marine environment.

The biological treatment method is to catalytically degrade environmental pollutants and reduce or remove oil pollution by using microorganisms as their metabolic nutrient. This is a controlled or spontaneous process. Accelerated degradation by

biotechnology is a long-term process that can be considered when other measures cannot be used. Generally, the method of adding nutrients or increasing the amount of microorganisms in the oil spill area can be used to accelerate the degradation, but the effect often takes several months or years to appear.

In general, sea removal can take measures such as natural degradation, weathering, mechanical recycling, use of dispersants, and on-site incineration. Among them, mechanical recovery uses pumping units to pump oil from the boom and heavily contaminated seawater to rescue boats, minimizing pollution losses. For oil spills where the incident is on the shore or where the drift is diffusing to the shoreline, it is also necessary to carry out oil spills on the shore to protect important sensitive areas and shorelines. Clearance on the shore can take high-pressure flushing, bottom migration, use of dispersants, mechanical recycling and other measures. The specific measures are determined by the type of shoreline and the state of spilled oil. Pay attention not to use hot water to avoid killing the microbial population (Office of the environmental emergency command and guidance group of the Ministry of environmental protection, 2011). However, it is very difficult to avoid re-inflicting damage to shoreline ecology in the process of clearing the shoreline. Therefore, some coastlines with high sensitivity or very difficult to access will be the best choice for natural recovery, but the shoreline that adopts natural restoration should be carried out. Regular monitoring. If it occurs in areas where there are rocks and weeds, it is first adsorbed by oil-absorbing felt, and then stones are removed and weeds are cut off. If the oil occurs on a large area of sandy beach, it is cleaned with water, the washed oil enters the water confined by the boom, and is recovered with an oil mop, suction rope or suction felt. For hard-textured shores, the dirt is removed manually or mechanically and then buried. For wetland shorelines, such as sedimentary belts, mangroves, and other shorelines that are very sensitive to oil spills, there is some

carelessness (Chen, Quan &amp, 2010, pp.69-72). The environmental damage caused by the cleanup operation itself is likely to exceed that of the oil spill itself. Therefore, the measures must be carefully compared. And discussion. Under normal circumstances, no action is the best treatment. If it is decided that cleanup is required, low-pressure seawater flushing is an optional method. However, a suitable site should be selected to dig drains to allow oil to flow into the collection tank.

For non-persistent oils, such as gasoline, light diesel oil, aviation kerosene, etc., in the absence of oil and water emulsions, due to its strong volatility and natural dissipative nature, and easy to degrade, generally do not use recovery methods, let it Volatilize. Since the proportion of non-persistent oils is small, once they are leaked in the river water, they can be treated with oil-absorbing cotton, absorbent felt, etc. When it is possible to spread to nearby sensitive areas, use oil booms to intercept and guide them. When there is a tendency to spread outwards and the shoreline, or priority protection area is not immediately threatened, it can suspend operations and closely monitor its movement. In the event of a possible fire, the same dispersant can be used to emulsify and disperse. For persistent oils, such as crude oil, fuel oil, heavy oil, etc., due to high viscosity, it is difficult to degrade, causing pollutants to be difficult to clean, and the bioaccumulation toxicity is great. Therefore, as far as conditions permit, snorkeling vessels, skimmers, oil trawls, booms, oil-supplying towlines, oil-absorbing materials, and artificially harvested fish should be used as quickly as possible, recovering or removing water spills, preventing it from drifting to the coast and polluting the shoreline and priority areas for protection. After the recovery, the remaining surface oil film can be emulsified and dispersed with an oil dispersant. If it is difficult to use the recovery vessel and dispersant, hot water or steam flushing can be used.

According to different environmental conditions, such as wind, waves, currents, temperature, weather, distribution of sensitive areas, and oil spill characteristics such as viscosity, volatility, solubility, oil film thickness, weathering, etc. different. According to the size of the oil block, the drift state, and the odor in the air, the polluted shoreline can be divided into three different types of pollution areas: Type I pollution areas are light pollution, Type II pollution areas are medium pollution, and Type III pollution areas are heavy pollution.

Table 3.3: Selection principle of protection measures for sensitive area and shoreline

Sensitive area type	Possible measures	Measures to avoid
Marine Nature Reserve	Insulate or control the perimeter (where the tidal current is high), or spray dispersants far away	On-site incineration, close use of dispersant, high pressure flushing
Fishery culture area (within 1km)	Insulation, recycling, biodegradation, on-site incineration, use of dispersant bathing beaches and tourist areas, seaport piers to isolate control or guides, close water inlet gates, close the rest, tourism areas, use dispersants, shoreline cleaning, sediment Migration	On-site burning
Industrial water intakes and sea inlets	Isolated control or orientation control, biodegradation	On-site incineration, close use of dispersants
Shoreline type	Possible measures	Measures to avoid
Large area of sandy beach	After the oil spill is washed into the high tide area, low-pressure water flushing, guiding and control, skimmer or suction felt recycling	Reduce the volume of sand to be transported (only the surface of the sand is contaminated) to reduce the amount of oil
Hard-structured coast (rocky beach, rocky cliff)	Manual or mechanical eradication, ambient temperature low pressure water or high pressure water wash, skimmer or suction felt recovery, burial	Reduce the handling of sediments. Do not spray in the areas where there is a flourishing area of low-tide creatures. Do not cut down oil-contaminated algae. Tidal action will float the oil and consider installing oil-absorbing booms
Wetland shoreline (sedimentary zone, mangrove, etc.)	No action or low pressure seawater flushing	On-site burning
Tidal flats	Use a shallow draft vessel to manually arrange the oil-absorbing material for removal	On-site burning
Marshland	Vacuum pump, oil-absorbing material or low pressure water wash	Preventing oil spills from moving into sensitive areas with low gradients

Sources: Compiled by the author

Table 3.4: Classification of pollution level of the polluted coastal areas

Contaminated Area	Pollution Type	Block Status	Oil block Area	Oil Distribution
I	Light pollution	Scattered oil on the surface	10cm2	A small amount of scattered oil can be seen on the bank walls and beaches
II	Medium Pollution	Nearshore floating oil	Less than 5 m2	Obvious scattered large oil stains can be seen on the bank walls and shore beaches
III	Heavy pollution	The black oil on the offshore oil surface	More than 5 m2 (max. 15-20m2, oil film thickness 5-10cm)	The bank walls and shore beaches accumulate with black oil, and the coast emits a pungent oily smell. Half a month after the incident, floating oil film was still visible on the surface of the sea

Sources: Compiled by the author

3.4.4.3 Remediation of Waste

Leaked oil, whether in the sea or on the shore, often produces more than several times or even several dozen times its own oily waste. In order not to put extra burden on the environment due to emergency response, the aftermath of the emergency should not be taken lightly. For the recovered oil and other oily pollutants, proper measures must be taken to rationally use and dispose of them, study and determine the mode of transport and treatment of the recovered oil and oiled waste, and reduce the possibility of secondary pollution. The following points are mainly taken into consideration when planning the oil spill recovery strategy:

(1) Determine the location of major oil spill recovery and disposal. When selecting an oil spill recovery site, not only the characteristics of the flow velocity distribution (selected to be slower in the flow velocity) but also the area without sensitive resources around should be considered. In addition, it is necessary to consider whether the oil spill emergency equipment can be easily accessed, whether the pollutants recovered from the oil spill emergency are easy to be disposed of later, whether the oil spill emergency equipment can be rapidly deployed, and whether the emergency action can effectively control, recover and dispose of the oil spill.

(2) Assess site conditions and travel paths.

(3) Determine the appropriate recovery and storage system based on the type of oil spill, the access route, and the constraints imposed by the boom.

(4) According to the emergency plan, store and transfer recovered oil spills and oil.

For the reuse of recovered oil, when the recovered oil is still in a flowing state with less impurities, and the quality meets certain requirements, it can be processed by the

oil recovery device of a refinery or a waste oil recovery plant. However, in most cases, due to weathering, the recovered oil is sticky. When the oil spilled on the shoreline retreats, it contains a lot of impurities such as sediment. In addition, the emergency treatment consumes a large amount of disposable materials such as oil-absorbing felt, and eventually it also becomes an oil-containing waste that must be properly disposed of. For oily wastes that cannot be reused, measures such as separation of oily sewage, direct landfill, incineration, and enhanced biodegradation can be adopted according to specific conditions. However, no matter what kind of treatment method is adopted, the disposal of oily wastes is often expensive and time-consuming. Therefore, from the source, it is necessary to reduce the generation of oily wastes that need to be treated as much as possible, and take the most effective emergency treatment measures that generate the least waste at the same time.

3.4.4.4 The end of Emergency Response

The end of the emergency response is based on the emergency response situation. The oil spill emergency commanding department announces the end of the emergency action, including ending the onsite control and cleaning operations, and organizing the emergency summary. The emergency response personnel at the scene of general oil spill accidents declared the end of the emergency action when they judged that there was no oil spill, no odor, no hull or other facilities had oil spill residues. In case of a major oil spill accident, a qualified environmental protection assessment professional and technical unit must inspect the water quality of the contaminated waters and meet the requirements before the end of the emergency response.

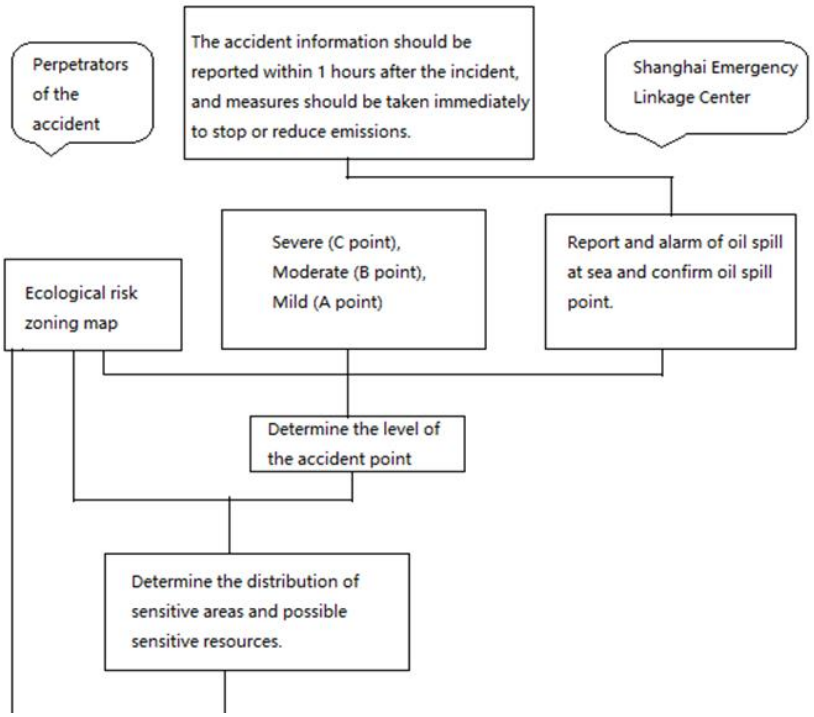
CHAPTER 4

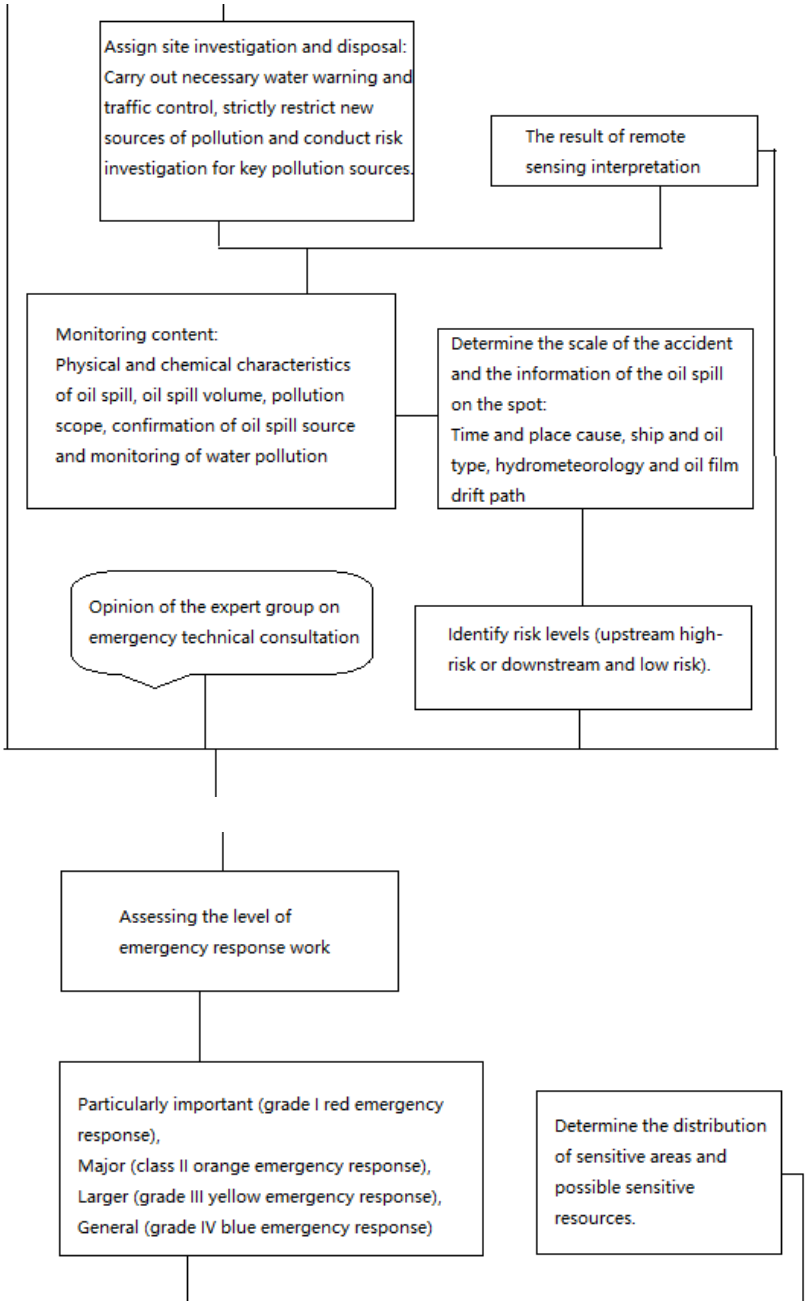
CASE ANALYSIS OF OIL SPILL EMERGENCY RESPONSE

In the case of an oil spill accident of a tanker “Tongyin 6” in Wusongkou waters on May 18, 2012, an accident emergency response scenario simulation was set up, and based on the emergency response system process, improved adjustments on the incident emergency measures are made to further improve the formulation of the oil spill emergency response plan.

4.1 Development Process of Oil Spill Response Plan

Development process of oil spill response plan is as follows in Figure 4.1.




Assign site investigation and disposal: Carry out necessary water warning and traffic control, strictly restrict new sources of pollution and conduct risk investigation for key pollution sources.
The result of remote sensing interpretation
Monitoring content:
Physical and chemical characteristics of oil spill, oil spill volume, pollution scope, confirmation of oil spill source and monitoring of water pollution
Determine the scale of the accident and the information of the oil spill on the spot:
Time and place cause, ship and oil type, hydrometeorology and oil film drift path
Opinion of the expert group on emergency technical consultation
Identify risk levels (upstream high-risk or downstream and low risk).
Assessing the level of emergency response work
Particularly important (grade I red emergency response),
Major (class II orange emergency response),
Larger (grade III yellow emergency response),
General (grade IV blue emergency response)
Determine the distribution of sensitive areas and possible sensitive resources.

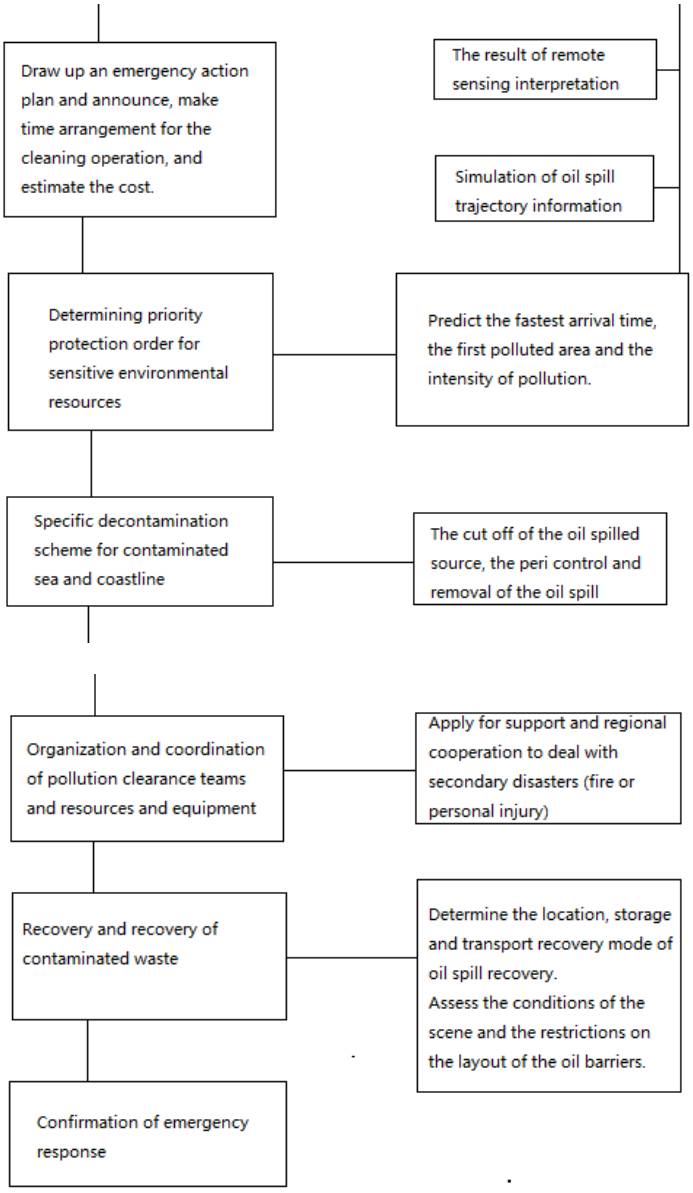


Figure 4.1 Development process of oil spill response plan

Sources: Compiled by the author

4.2 Review of Emergency Response to Incident Cases

Around 20 o'clock on May 18, 2012, a tanker “Tongyin” with 1000 tons of fuel oil sank in the waters of Wusongkou waters due to heavy winds. On the 20th, there were still scattered and small pieces of oil in Wusongkou waters, and no large area of oil was found in the entire waters of the Yangtze River estuary. According to reports, on the morning of May 21, there were patches of oil floating on the surface of the lake in the forest park of the Paotaiwan Wetland Forest Park. There were also dead fishes floating on the side of the trestle bridge. Spotted black oil could be seen everywhere along the river's wooden path and moisture-proof stones. In addition, in wet grass areas, there were five or six large areas of oil pollution; the air was still filled with smell of oil. Based on the weather conditions at that time, the oil belt drifted to Qingcaosha Reservoir at a flow rate of about 3.5 knots. After 3 hours, the oil-polluted belt could reach the reservoir water intake, directly threatening the drinking water safety of more than 13 million people in Shanghai. And then, Shanghai MSA immediately launched an anti-pollution emergency plan and the oil pollution belt was effectively controlled within approximately 3 nautical miles from the Qingcaosha Reservoir. At 7 o'clock on the same day, in conjunction with the meteorological and hydrological conditions on the site, and referring to the result of the oil spill diffusion of the Shanghai Research Institute of Science and Technology, the Shanghai MSA organized an expert group to inspect the anchorages, Wusong Deepwater Channel, Hengsha channel, and the southern shore of Changxing Island. Meanwhile, the Shanghai MSA conducted the monitoring of the waters in its jurisdiction. According to the feedback information of the maritime sector and the monitoring results of the expert group, there were residual sporadic and small pieces of oil pollution in the waters of the Former Taiwan Waters, the shoreline of Majiagang, and the frontier

waters of Jiangnan Changxing Shipyard, but no large areas of oil were found in other areas. As a result, the on-site command of the marine cleanup work timely dispatched cleansing forces to clean up the oil on site.

However, on May 23 of the same year, the Shanghai Environmental Monitoring Team conducted a site survey on the three sites around the site where the accident occurred (Majiagang Port in Changxing Island, Shanghai Paotaiwan Wetland Park and Yangtze River estuary channel ship dredging base). The investigation revealed that oil was found near the coastal wetland. Among them, the situation in the wetland park was more serious, and most of the residual oil was adsorbed on the three-edge grass and stones. The contents of the survey included water temperature, air pressure, wind speed, direction, spectrum acquisition, and sampling of weathered oil. In addition, the data of the wind field on the day of the accident was also collected. The site of the accident was southeast wind on May 18 and the maximum wind speed was 5.9m/s.

Table 4.1 Meteorological data of investigation

Site	Longitude(°E)	Latitude(°N)	Time (hh:mm)	Wind speed(m/s)	Wind direction (°)	Temperature (°C)	Pressure (hpa)
Majia Port	121.683647	31.38005	08:53	2	120	22.2	1091.0
Riverside Wetlands	121.50616	31.40039	12:00	3.1	90	25	1008.6
Dredging channel	31.35470	121.61348	—	—	—	—	—

Sources: Compiled by the author

4.3 Optimization of Emergency Response to Accident Cases

4.3.1 Incident Report and Response Mechanism

After the accident, the operator of the accident ship should immediately raise the alert (within 1 hour). The accident ship should report the accident danger to Shanghai MSA, including information such as the time and place of the accident, the type of oil spilled, the type and quantity of oil pollution, the economic loss, the victimization of the accident, and the emergency measures that can be taken. Meanwhile, as far as conditions permit, the accident ship must adopt a series of preliminary emergency measures such as oil renewal, using quilt plugging, or cable lining, in accordance with the requirements of the Ship Oil Pollution Emergency Plan.

After receiving an alarm, the Shanghai Maritime Department and the Shanghai Maritime Traffic Safety Command Center should jointly establish a command platform with the Shanghai Municipal Oceanic Administration and the Shanghai Municipal Research Institute of Science and Technology to urgently launch and implement emergency plans for ship pollution in Shanghai. The command platform should immediately establish an oil spill emergency monitoring command system to clarify the responsibilities and division of labor of the rescue forces. Based on the general situation of the oil spill described by the parties, the command platform organized a number of members of the Shanghai Sea Oil Spill Response System (200 persons) and five boom containment vessels, five sewage cleaning vessels, and one command vessel to the accident location.

4.3.2 On-site investigation and monitoring

At this time, the command platform should assign on-site command and patrol boats to the scene, evacuation of irrelevant ships, and implementation of oil pollution on the scene, quickly launch support systems such as surveillance and intelligence information, and respond to support as well as guide emergency responses to oil spills on site. It is worth noting the monitoring of the physicochemical characteristics of spilled oil (the proportion of oil spilled, viscosity, flash point, wax content, and volatility, assess the possibility of fire and explosion of oil spills), oil spills, monitoring of pollution areas, and confirmation of oil spill sources. The following oil spill information can be obtained through field surveys:

(1) Time when oil spill occurred: Around 20:00 on May 18, 2012

(2) Venue: Wusongkou No. 6 Anchorage

(3) Oil spill causes: stormy water and sunk

(4) Ship name of accident ship: "Tongyin"

(5) Nationality: China

(6) Total tons: 1,000 tons

(7) Type of ship: Tanker

(8) State and distribution of oil blocks: Scattered and small pieces of oil were floating on the surface of the water. There was a bit of black oil on the boardwalks and damp-proof stones along the river. In the wet grass area, there were also five or six large oil-polluted areas. It was also filled with oil smell.

(9) Possibly contaminated resources: Qingcaosha water source area, Wusong anchorage, deep water channel, Hengsha channel, frontier waters of Changxing Island.

(10) Influencing scope: Majiagang Port on the south bank of Changxing Island, Shanghai South shore Paotaiwan Wetland Park and Yangtze River estuary channel

ship dredging base.

(11) Damage to the ship: Sinking.

(12) Oil spill type: Fuel oil.

(13) Oil spill type: Instantaneous.

(14) Overflow volume: 0.6018 tons.

(15) Film thickness: 20μm.

(16) Function of oil spilled sea area: Harbor Area.

(17) Hydrological and meteorological conditions: Wind direction (120°), wind speed (5.9 m/s), flow rate (3.5 knots).

(18) Information of perpetrators, witnesses or persons related to the accident (Waiting for investigation).

4.3.3 Evaluation of Emergency Response Work Levels

Combining the opinions of the Expert Group on Emergency Technical Consultation, It can be seen that this small-scale persistent oil spill had a direct impact on the sub-sensitivity area in Wusongkou waters based on the comprehensive assessment of the nature of the oil, the amount of oil spilled, and the ecological types of the affected sea areas.. The level of emergency work should adopt the level III mode, and the Maritime Administration of the command area of the oil spill emergency jurisdiction shall be the competent department, according to the oil spill area, dispersant spraying and other corresponding pollution removal measures.

4.3.4 Formulation and implementation of a decontamination action plan

According to the risk of oil spills, the level of emergency work, the distribution of emergency equipment and personnel, the received oil spill accident site reports, monitoring system reports on oil spill spread and pollution damage, and oil spill

model predictions on oil spill proliferation should be given. Information on the zoning system of the oil-ejecting ecologically sensitive areas, and the formulation of an emergency decontamination action plan, expert consultation and on-site command recommendations, the oil spills emergency command department should make time arrangements. These arrangements are for clearance operations, estimates costs, and comprehensively evaluates the manpower, equipment, and equipment for emergency response in the region. Then the existing oil spill emergency resources should be assessed whether they meet emergency response needs, and whether they need support from other regions.

Meanwhile, the headquarters should organize and coordinate the decontamination teams and resources and equipment, mobilize the oil spill emergency prevention team, and emergency control ships and equipment, as well as necessary logistical support for oil spill containment and removal, and then promptly notify the China MSA and other search and rescue centers.

For the oil spill accidents that occurred in the port or the main channel, during the cleaning operation, it is also necessary to assess the plan for the possible damage caused by the oil spill to the port and the ship. When cleaning in the port, it may delay the berthing and berthing of vessels leaving the port, which may cause damage to both the port and the ship. When the main channel is cleaned, there may be a ship that is forced to change lanes or stop, causing great losses to the ship. The port may also cause losses due to the planned allocation of berths. Therefore, it is necessary to comprehensively consider factors such as society, economy, public, environment, ecology, etc., based on relevant standards and claims guidance for oil spill damage analysis, so as to give a comprehensive analysis of oil spill damage and quantitative analysis, as well as the assessment of oil spill claims.

Immediately after receiving the incident alarm, the emergency command center shall issue instructions and immediately dispatch emergency and cleanup ships to the oil spill boat, then quickly invest in clean-up and rescue, lay down the first fence, surround the accident boat. At last clean up the surface of the river by spraying skimmers and oil dispersants in time.

According to the information displayed in the map of the risk of oil spilled eco-environmental hazards in Shanghai, we can quickly infer that the priority protection order for all types of sensitive resources surrounding the oil spill risk source is: reserved areas, utilization and conservation areas of agricultural and fishery resources, and marine nature reserves cause pollution, port shipping areas, drinking water source areas, seaside scenic tourism areas, and industrial and urban areas. And they just correspond to the third-class ecologically sensitive areas: Jiuduansha Wetland Nature Reserve, Wusongkou Anchorage Area, Chongming Sandao Port Area, Changxing Island Port Area, Waigaoqiao Port Area, Qingcaosha Reservoir, Shanghai Binjiang Forest Park, and the dumping area, etc.

Comprehensive diagnosis of the accident that has the highest level of risk in the port and shipping areas, and it is necessary to mobilize various branches of the Shanghai MSA to cooperate with others and carry out surveillance and monitoring of the waters in the area under its jurisdiction. Fortunately, the accident did not affect high-sensitivity areas (Qingcaosha water source). However, under the influence of winds and waves, oil pollution may cause pollution in the Jiuduansha Wetland Nature Reserve and Shanghai Binjiang Forest Park in the higher-risk areas. For the sake of safety, in order to prevent the spread of oil pollution to the upper reaches of the water source protection area under the influence of the tide, it is recommended

that a boom-laying vessel be dispatched to the site for protection. In addition, the Wusongkou waters, which directly affects the accident, should be the primary emergency protection area. Combining the types of affected sensitive areas, oil spill types, oil spill characteristics, and environmental conditions, we can choose mechanical recovery (isolation control or guided control) and biodegradation to clean up the pollution.

To clean and transport sediments on contaminated shoreline, it is necessary to infer that the pollution from the accident to the shoreline is moderately class II pollution, based on the status and distribution of the monitored oil block and the odor in the air. Corresponding to the Jiuduansha and Canton Taiwan Wetlands where there are sandy and gravel mixed beaches, we should wait until all oil spills have been flushed into the high tide area before flushing with low pressure water. We can float the oil from the sediment to the surface and recover it with an oil skimmer or oil-absorbing material. Here, we need to pay attention to minimize the volume of sand to be transported, and only need to carry the sand on the surface to reduce the amount of oil disposal. The exposed rocky platform can enter the high tide area to remove stagnant heavy oil and oil gravel. In addition, dispatching the dual-purpose trailers to cooperate with the outside of the accident continue to spray water mist to disperse scattered oil.

4.3.5 Treatment of Aftermath Work

When performing oil spill recovery, the degree of oil spill recovery needs to be determined jointly based on the weather and sea conditions at the site of the incident, the spilled oil range, the type of oil, the hardware capabilities of the recycling equipment, and the size of the oil storage. Every factor is important. Due to the high

viscosity of heavy oil, it is easy to adhere to suspended solids such as garbage since the floating oil on the sea constantly changes with the fluctuation of wind direction, wind force, and tide. In addition, drifting oils are scattered and sometimes aggregated, constantly drifting back and forth repeatedly polluting the coast, increasing the difficulty of cleaning. Because this cleaning work must be repeated, the amount of cleaning work is also greatly increased. In view of the above situation, and subject to the conditions of the emergency facilities, the means of transport of recovered oil and later-stage polluting waste, as well as the treatment methods, must be adapted to local conditions.

(1) For oil blocks with large area near the shore, physical adsorption method is used to remove the oil absorption felt, granular oil absorbent, dried banana leaf, rice straw and other materials. According to the practice, the efficiency of rice straw removal is better. Spread the straw directly on the surface of the seawater oil film, absorb the oil, and then use tools such as hooks, shovels, boring, and palladium to salvage and put them in the woven bag. In addition, because rice straw is cheap and easy to obtain, it is non-toxic to aquatic organisms and can receive immediate results in the cleaning work.

(2) For the oil stains attached to shore beaches and buildings along the coast, the chemical oil-removing agent method shall be used to remove the oil stains adhered to the embankment wall, and the oil-spraying oil-removing agent on the reef beach stones and on the coastal road. Then, it is washed by hand and rinsed with water to increase the dispersibility of the oil and turn the oil into fine droplets for settlement in water.

(3) Eradication of sand and small stones mixed with oils will be transported to designated places for centralized disposal.

(4) Oil-based waste that needs to be disposed of by burning can be sent to the incinerator of a waste treatment power plant for incineration. This will not only

eliminate oil pollution, but also achieve the purpose of waste recycling. However, this method must be approved by the technical personnel of the waste power plant in advance. Another option is to use the geographical advantages of uninhabited islands around Shanghai. This needs to consider the use of "oily garbage" to ship to a deserted island away from the human smoke and set it aside for incineration in batches. The uninhabited desert island has a wide open terrain and good diffusion conditions. The impact of this practice on the ambient air will have a relatively small impact on the health of the population. However, this method must be approved by the relevant department, under the guidance of the technical personnel can be burned in the designated place.

Finally, after the accident has been identified, the responsible party shall make a written report of the incident to the local maritime department and attach the relevant certification documents.

4.4 Summary

Based on the marine oil spill emergency response system, the corresponding emergency response measures can be formulated into the following seven aspects:

(1) The marine oil spill emergency response team received reports and alarms of oil spill incidents on the sea, and confirmed the incident oil spill point.

(2) According to the geographical location of the spilled point, oil spillage, etc., combined with the ecological risk zoning map of the accident block, roughly determine the grade of the accident point, assign site surveys, determine the scale of the accident, the cause of the spill, and the type of oil, observe the trajectory of oil film drift, and initially determine the pollution block, the level of risk and the distribution of sensitive resources that may be affected.

(3) Combine the opinions of the emergency technical consulting expert group and

conduct a comprehensive assessment of emergency response work level based on the oil spill information provided by the site command (level I-red emergency response, level II-orange emergency response, level III-yellow emergency response, level IV-blue Emergency response four levels).

(4) According to the level of emergency work and ecological risk zoning map, fully consider the integration of resources, the emergency response time and the distribution of equipment pools, and the distribution of sensitive priority protection targets. The factors such as the fastest arrival time of pollutants, the range of the most likely polluted areas, and the intensity of pollution are forecasted, and the distribution map of the emergency protection targets within the region is given. Focus on important ecologically sensitive areas as soon as possible, and select appropriate cleaning programs in combination with oil spill types and on-site environmental characteristics, including the cutting off, containment and removal of oil spill sources (physical removal and chemical methods), and formulating emergency actions. Plan and notify.

(5) Organize and dispatch oil-removal vessels, various types of oil booms, all types of oil skimmers, oil skimmers, and other decontamination teams and resources and equipment, and rush to the scene as soon as possible to give priority to the rescue of important sensitive areas. Finally give suggestions for optimization. The proposal of oil emergency configuration is deployed to establish on-site emergency measures.

(6) Apply for support or regional cooperation, implement necessary water alert and traffic control, strictly limit the increase of new sources of pollution, and conduct risk investigations on existing key pollution sources.

(7) After-sales disposal of waste, study and determine the mode of transport and disposal of the recovered oil and the later-stage polluting waste.

CHAPTER 5

CONCLUSION

Chapter 5 summarizes the research on oil spill emergency response in Wusongkou waters, and makes assumptions and suggestions for further research.

5.1 Natural environment characteristics and statistical investigation of oil spill accidents

Through the statistical analysis of data of oil spill accidents in Wusongkou waters (including spill points, spilled oil, area, etc.), combined with the ecological characteristics of the sea area, the sources of oil spill risk obtained in Shanghai are mainly distributed in fairway (Wai Gaoqiao Channel, Baoshan Channel), anchorage (Dangerous Goods Anchorage in Nancao, Temporary Vessel Anchorage in Nancao, Horizontal Anchorage in Anchorage, Emergency Anchorage for Large Circular Sand Ships, Anchorage in Wusongkou, Anchorage in Baoshan, and Anchorage in Baoshan), and important port areas (the Yangtze River estuary south bank area, Chongming Island port area, Changxing Island south bank port area, Hengsha Island port area, Hengsha Island south bank port area). Among them, the main risk of oil spill accidents in ships and docks is caused by collision, stranding and equipment failure. According to the causes of ship accidents, the accidents in Shanghai can be divided into 78.75% of operational accidents, 12.5% of marine accidents, and 8.75% of intentional emissions. In the law of occurrence of accidents, ship accidents in

Shanghai Port and nearby waters are more frequent in May, August, September, November, and December. The most serious accidents occurred in March-April and August-September, and the periods of events were more frequent during the period of rising tides (Zhao, 2006). In addition, in the past 10 years, about 12 large-scale oil spill accidents occurred in Shanghai Port, and the accumulated leakage amounted to approximately 1632.19 tons, mainly distributed in the Yangtze River Estuary, the lower reaches of the Huangpu River, Wusongkou, Waigaoqiao, Jiuduansha and Chongming waters. Based on the calculation of the basic values of the probability of oil spill accidents in Shanghai seas, the basic value of the ship accident probability at the Yangtze River Estuary is p=4.911×10 -6.

Taking into account the probability of occurrence of operational oil spills, marine oil spills, and intentional emissions in ships, the probability of a ship oil spill in Shanghai waters can be found to be 1.6390. There would be an oil spill incident every 0.61 years. Therefore, it is necessary to carry out key investigations and protections for key ecologically sensitive areas such as Jiuduansha Nature Reserve, Chinese sturgeon Nature Reserve, Qingcaosha Drinking Water Reserve, and Chenhang Reservoir.

5.2 Formulation of emergency response measures

The command and coordination agency for oil spill emergency areas in Shanghai are headed by Shanghai MSA, jointly with the Shanghai Ocean Administration, Fisheries Bureau, Environmental Protection Agency, etc., form the Shanghai Oil Spill Response Organization. Shanghai MSA should combining the results of the oil spill ecological risk zoning in Shanghai waters, from the four aspects of emergency organization results, emergency response procedures, emergency operations and

emergency resources, establish and formulate a corresponding oil spill response system. It is suggested to optimize the surrounding emergency configuration of oil spills, timely determine the impact scope of oil spills, high-risk areas, and the order of protecting sensitive resources, and reduce the emergency response time of sudden oil spill accidents. Among them, the key monitoring contents involved in the oil spill emergency process include the determination of physical and chemical characteristics of oil spills, monitoring of oil spills, monitoring of water pollution, monitoring of spilled oil contamination, as well as the confirmation of oil spill sources. The level of emergency response work is mainly divided into 4 levels. The values from low to high correspond to four levels, respectively, are particularly significant (level I-red emergency response), major (level II-orange emergency response), larger (level III-yellow emergency response), general (level IV-blue emergency response). And these also corresponds emergency response measures.

Meanwhile, it is necessary to make overall arrangements based on the specific conditions of shoreline types, oil types, and resources and equipment. Shanghai MSA should formulate a plan for assisting decision-making on oil spill emergency response, including the priority protection order of eco-environmentally sensitive resources, specific pollution-removing plans for contaminated seas and shorelines, post-processing of post-contaminated wastes, as well as the completion of emergency response. The cleaning program includes three steps: cutting off the oil spill source, controlling the spilled oil, and removing the oil spill. Comprehensive consideration should be given to the type of oil and the situation of protected resources, and appropriate removal techniques should be selected. Shanghai MSA should combining pollution indicators such as oil type, oil spill volume, drift trajectory, diffusion area and speed, impact time, etc., and comprehensively consider the sensitivity of the social environment, economic environment, and ecological environment in the region

where the accident occurred. Shanghai MSA should take full account of the integration of resources, emergency response time, and the deployment of equipment libraries. The factors such as the fastest arrival time of pollutants, the most likely polluted area, and pollution intensity. Shanghai MSA should determine the number and scope of dispatching emergency response teams and emergency resources, and related logistics support plans. Shanghai MSA should take appropriate cleaning methods, equipped with appropriate emergency rescue vessels and cleaning equipment, so as to establish an emergency linkage mechanism.

Finally, through the analysis of accident cases, the content of the oil spill response system was studied. Shanghai MSA should analyze the management operations for emergency response to oil spills under normal and special conditions, provide an intuitive, comprehensive and systematic scientific reference for decision-makers of oil spill response accidents to decisively deal with uncertainties and achieve rapid, orderly and effective emergency rescue operations and reduce accident losses. In order to finally realize the demonstration application in the Shanghai sea area, it is necessary to further expand the number of accident case analysis and simulation points in the study area. Shanghai MSA should set more common or rare (consistent with climate and hydrological conditions in the study area) multi-variable scenarios to conduct more detailed and qualitative quantitative and qualitative analysis of different oil species and oil spills. And Shanghai MSA should collect more on-site measured data and verification data needed to improve the scientificness and accuracy of research methods, and further improve the database of emergency decision-making system. Shanghai MSA should accelerate the establishment of a chemical water professional rescue team, equipped with special chemical analysis, disposal and salvage equipment, and introduce high-level professional and technical personnel to strengthen the ship pollution pre-control system of Qingcaosha

Reservoir and other important water sources and sensitive water areas. By linking up with the ports of the upper reaches of the Yangtze River, information can be exchanged, and the speed and quality of emergency response can be improved. An information-based, intuitive aided decision-making system can be established.

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