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Chinese vessel pollution prevention in the era of the green economy

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Marine Pollution Prevention in China in the Era of the Green Economy

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DECLARATION

I certify that all the material in this research paper that is not my own work has 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.

ZHENG Zhilin

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ABSTRACTS

Title of Research paper:**Marine Pollution Prevention in China in the Era of the Green Economy**

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With the rapid development of the world economy, the World Shipping volume becomes larger and larger and to the numbers of the ships which is also increase dramatically increased. In the same time human using lots of the marine resources, they cause pollution to the ocean. Nowadays marine pollution has become one of the ten environmental issues which have a threat to human survival. What's more, the pollution from ships occupies a large proportion of the pollution of the marine environment.

We must strictly control the pollution from ships, not only for protecting and improving the marine environment, for the health of contemporary human beings, but also in order to create a good living environment for future generations and to make the sustainable development of human society.

China has grown to become a large import and export country since its accession to WTO in 2001. In the process of establishing a green economic powerhouse, the shipping industry must be concerned about the development of the green economy in

order to achieve the safe navigation and green shipping.

The author will comprehensive analysis of many experts and scholars and will use some statistical theory, risk management theory, system management theory and mathematical models, from doing some in-depth analysis and research to build the framework of marine pollution prevention and control in this dissertation.

The main goal of this dissertation is to make a complete diagnosis of green shipping economy and use statistical and comparative method to analyze the possible solutions which deal with the marine pollution prevention and control. In this dissertation the author will take Ningbo-Zhoushan port as typical company example to study the suitable settlement and strategy this kind of companies should take. To achieve this purpose, this dissertation will discuss the possible pollutants in shipping industry at first. Secondly, analyze the possible solutions for pollution damage to the marine environment by vessels. Then, talk about the feasibility of these settlements by way of illustration and mathematical model. At the end of this dissertation, it will give the author's recommended method of realizing the green shipping.

Key words: Chinese shipping, green economy, prevention of pollution from ships, oil pollution, collision, grounding, environmental friendly,risk probability calculation , grey forcast model

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WTO	World Trade Organization
MARPOL	The International Convention for the Prevention of Pollution From Ships
HSR	Harmonized Common Structural Rules
IOC	Intergovernmental Oceanographic Commission
DDT	Dichlorodiphenyltrichloroethane
COSCO	ChinaOceanShipping(Group)Company
HNS	Hazardous and Noxious Substances
NO.	number
IMO	International Maritime Organization

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Chapter 1 Introduction

1.1 Research Background

With the rapid development of the world economy, the World Shipping volume becomes larger and larger and to the numbers of the ships which is also increase dramatically increased. In the same time human using lots of the marine resources, which cause pollution to the ocean. Nowadays marine pollution has become one of the ten environmental issues which have a threat to human survival. What's more, the pollution from ships occupies a large proportion of the pollution of the marine environment.

Despite the sea water has a certain self-purification capacity, it's limited. However during the operation time of the ship, it can generate many kinds of the so called "waste". If we just pull all these "waste" into the ocean without any proper treatment, and make the pollution out of the self-purification limits, then it will destroy the sea environment and in this way the marine pollution forms. As a consequence, it will affect the ecological balance and hydrometeorological, and finally hazards to human health.

We must strictly control the pollution from ships, not only for protecting and improving the marine environment, for the health of contemporary human beings, but also in order to create a good living environment for future generations and to make the sustainable development of human society. Governments have taken measures to control and prevent pollution of the ocean. Mankind has been aware of the irreparable loss of the marine environment, countries started the legislative and the development of international conventions, gradually establish treaty systems and legal rules to

control the pollution due to shipping, and continue to revise and improve. "Safer Shipping, Cleaner Ocean" is the desired and pursued goal by the entire maritime community, which is also the needs for the ecological balance and sustainable human development. However for a long time, shipping companies and crew usually pay more attention to the safety issue than the environment protection, so that lead to a variety of shipping pollution, which finally make a great harm to our ocean. International and domestic maritime accidents statistics and analysis show that more than 80% of maritime accidents are caused by human factors. The crew are the most critical factor to protect the water personal and property safety and to prevent of pollution from shipping. So how to strengthen the management of the crew and how to prevent and control human factors to reduce maritime accidents, marine pollution incidents have become the important contents which are concerned about and researched by all the maritime countries and relevant international organizations in the same time with developing the environmentally friendly ships.

David William Pearce, Anil Marandya, Edward B. Barbier,1989 , first proposed the term "green economy"in Blueprint for a Green economy. In the green economy mode, the numbers of technology such as environmental protection technology, technique of cleaner production has been processed into productivity and benefit the environment or the economic behavior of non-confrontation with the environment, which leads to sustainable economic growth. The essence of green economy is based on ecological and economic coordinated development as the core of the sustainable development, and is the economic development method characterized in maintaining human living environment, protecting resources energy reasonably, improving human body health, which is regarded as a balanced economy.

Development of the green economy is a fundamental negation of the centuries since t he industrial revolution of the traditional economic development model, and is the ine

vitable trend of development of the world economy in the 21st century. It is time to t ake this opportunity to change the situation on the serious unsustainable black econom y in reforming the existing resource consumption and black economy environmental p ollution, establishing and improving the economic development of the ecological syst em, promoting scientific and technological ecology, productivity ecology, national eco nomic system ecology, and enable socialist China to become a green economic power in the 21st century.

China has grown to become a large import and export country since its accession to WTO in 2001. In the process of establishing a green economic powerhouse, the shipping industry must be concerned about the development of the green economy in order to achieve the safe navigation and green shipping.

Therefore, this research has its practical significance.

1.2 Research Purpose

The main goal of this dissertation is to make a complete diagnosis of green shipping economy and use statistical and comparative method to analyze the possible solutions which deal with the marine pollution prevention and control. In this dissertation the author will take Ningbo port as typical company example to study the suitable settlement and strategy this kind of companies should take. To achieve this purpose, this dissertation will discuss the possible pollutants in shipping industry at first. Secondly, analyze the possible solutions for pollution damage to the marine environment by vessels. Then, talk about the feasibility of these settlements by way of illustration and mathematical model. At the end of this dissertation, it will give the author's recommended method of realizing the green shipping.

1.3 Research Methodology

This dissertation will use grey forcast model and risk analysis probability calculation some statistical theory, risk management theory, system management theory and mathematical models, from doing some in-depth analysis and research to build the framework of marine pollution prevention and control.

1.4 Recent research of green shipping and pollution prevention of ships

Many experts and scientists in the world have done many research on this problem, they try to find a more suitable way to solve this more and more serious issue.

At first, introduction to the definition of green economy. Green economy was first suggested by Professor David W. Pearce ,who was an Emeritus Professor at the Department of Economics in the University College London (UCL). He specialised in, and was a pioneer of, Environmental Economics and published his 'Blueprint for a Green Economy' series in 1989.

Second, research on basic theory of pollution prevention of ships is abundant and many experts dig into theory research. In Yu Guifeng, Wang Binbin, Yu Hailiang, The Calculation of Ocean Environment Capacity Damage for Oil Pollution from Ship the method to calculate the capacity of the marine environment have been introduced into this issue. In Grudzinski, J.M(2000):The design and operation of ship's oil separators complying with requirements of the MARPOL Convention 73/78. He talked about the technical demands which “concerning the construction of oil separators and ship equipment concerning the prevention of sea pollution by oil is discussed”. In Marshall A D Salvage Association (1990).Salvage and pollution, it concerned about “A paper which considers the issue of marine pollution and its prevention form the salvor’s

point of view. In view of a decline in the salvage industry, and the requirement for salvors to minimise oil pollution in attempting to save a ship, it is stressed that design efforts must be made to minimise the escape of oil following an incident".

Third, possible solutions for pollution damage to the marine environment by vessels. In the aspects of policy, in IMO acts to clear the air(1997).The author emphasized "New measures that will reduce air pollution from ships have been adopted by the International Maritime Organization. This article outlines the new rules which take the form of a new Annex VI to the International Convention for the Prevention of Pollution from Ships(1973), as modified by the Protocol of 1978 (MARPOL 73/78). The rules, when they come into force, will set limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibit deliberate emissions of ozone depleting substances." In the aspects of technology, Cui Jianwei wrote The Study on the Technology of Bilge Oil-water Separating in Ships (2009), "As some kind of equipments designed according to the rules, MEPEC.107(49) have difficulty in dealing with the emulsified oil, the bilge water which has already been disposed by these kinds of equipments is still harmful to the environment. In order to solve the difficulty in separating the emulsified oil from the wastewater, this thesis do a deep research on the membrane separation technology，then design a new kind of oil-water separator which is capable of separating the emulsified oil from the bilge water. Now we can prevent the environment from being polluted by the emulsified oil." These are all the solutions of solving ship pollution problem, which can do some help in realizing the target of green shipping.

1.5 Existing problems

Although the IMO, government, shipping companies and port enterprises have made great efforts in order to achieve green shipping, but the problem still exists.

- IMO's policies are not yet perfect, there still need taking time to publish part of maritime rules .

  The International Maritime Organization (IMO) in 2004 published the two conditions needed of “The International Convention for the Control and Management of Ships’ Ballast Water and Sediments, 2004， BWC”,one of them has to meet, this indicates that the validity of the agreement also coming. This two conditions are the number of members of BWC should more than 30,while the merchant ship share of the members should occupy more than 35%. The first has been met, if the second conditions have been met, the BWC will take effect within 12 months. Li Jinai wrote in Convention on ballast water management will come into effect(2011).

  In addition to BWC, there are a lot of policies will come into effect, for example, the new ship energy efficiency design index(EEDI) is expected to come into force in 2013, the Hong Kong international convention for the safe and environmentally sound ship recycling of ships is expected to come into force during 2013 to 2014, the Harmonized Common Structural Rules (HSR) is expected to come into force in 2014, NOX emission of diesel engine Tier ⅢIemission standard is expected to come into force in 2016.

- Some research papers on marine pollution prevention are too academic, which still stay in the theory stage , that the uncertainty and variability actual situation of makes the theoretical research difficult to be applied into the actual situation.

  Wang Hongxin said in his Strengthen the implementation of force is the key to ensure the safety of the ship(2011). He just said that the shipping companies should strengthen the implementation of force, the crew should focus on safety and cleaning. Many author like him always stay at the theoretical level and just shouting slogans, this almost can do nothing help to the actual operation. Research papers like these cannot effectively help to realize green shipping.

1.6 Structure

In this paper, there are five sections:

In Chapter 1, I will introduce the background, research purpose , the methodology, recent research of green shipping and pollution prevention of ships and existing problems.

In Chapter 2, I will talk about the possible pollutants in nowadays shipping industry, from four aspects: Pollution of Ship's Antifouling Paint, Marine pollution from Excess carbon emissions, Marine pollution from Dumping and illegal sewage, Marine pollution from collision and grounding accident.

In Charpter 3, there will study the risk probability calculation of HNS(Hazardous and Noxious Substance) pollution accident in Ningbo-Zhoushan port and use grey forcast model to estimate the number of next year pollution accident

In Chapter 4, there will give some possible solutions for pollution damage to the marine environment by vessels in Ningbo-Zhoushan port, from technology solutions, policy solutions, operation solutions and Management solutions.

In Chapter 5, I will given the summary of this research paper, the conclusion and suggestions to prevent marine pollution.

Chapter 2 Possible pollutants in nowadays shipping industry

With the rapid development of Chinese national economy and the shipping industry, the transportation volume of hazardous cargo which causes the pollution continues to grow. Loading and unloading, lightering, oil supply and other associated operating activities of shipping have become increasingly frequent, and vessels and associated operating activities due to the risk of contamination of the marine environment are also growing. Especially, the damage caused by oil spills from ships to the natural environment, aquaculture and tourism resources is irreparable. China is one of the largest maritime countries, but also a huge oil importer. Since 1993, China collected from oil exporter to oil-importing country, the quantity of oil imports continues to grow and annual oil transportation volume by shipping is nearly 300 million tons. Experts predict that the period from 2000 to 2010, Chinese oil demand growth between 4.3% to 4.4% and offshore oil transport will show a continued growth trend. Increase of the amount of petroleum marine transport increases the risk of ship oil spill. According to statistics, from 1973 to 2009, Chinese coastal oil spills from ships are 2821 times, which means one accident occurred in 4 or 5 days. In recent years, Chinese oil spills from ships entering a high-incidence season and posed a serious threat to the marine environment.

Except the pollution caused by oil spills from ships, construction of green shipping industry, has many "enemies". Intergovernmental Oceanographic Commission (IOC) defines the ship marine pollution is: “Human, directly or indirectly, brings some substances or energy into the marine environment (including estuaries), so that produce harm living resources and endanger human health, hindering various marine activities including fishing activities, and damaging the use of sea water quality and comfort ". According to the MARPOL 73/78 Convention, marine pollution can be

divided into six categories: ① caused by oil pollution; ② caused by bulk of non-oil noxious liquid substances; ③ caused by toxic substances by sea in packaged form; ④ caused by sewage; ⑤ caused by garbage from ships; ⑥ air pollution caused by ship emissions. In the following article, author will expound in these four fields: Pollution of Ship's Antifouling Paint, Marine pollution from Excess carbon emissions, Marine pollution from Dumping and illegal sewage, Marine pollution from collision and grounding accident.

2.1 Pollution of Marine Antifouling Coating

For preventing the adhesion of marine organisms from adhering to the bottom, the most commonly method is painting the bottom of ship. Antifouling paint is a special paint coating on the bottom of the boat, and they can prevent the adhesion of marine organisms in the bottom which will increase the hull resistance and lead to increase the consumption of fuel and mechanical wear. But bottom paint used now, more or less, contains harmful compounds, and these toxic substances will pollute the water and harm fish and other marine life.

Highly toxic pesticide DDT has long been banned in China, but scientists in Yangjiang area found residues of DDT in the detection and the "culprit" is antifouling paint at the bottom of a fishing boat. In Guangzhou Institute of Geochemistry, Zeng Yongping researcher and his team found that in one gulf in southwest, DDT residual concentration is higher. DDT levels in the surface sediments of the Gulf of 0.7 to 4800 ng per gram dry weight (removal of two unusually high values ranging from 0.7 to 94 ng per gram dry weight). Due to the low cost of antifouling paint which contains DDT, in the 1950s, it has become the main choice for fleet maintenance. It is reported that China annually uses 5,000 tons of DDT-containing

antifouling paint and 1/5 in the coastal areas of Guangdong. Although, since 2002, China began to limit the use of DDT for any purpose, over the years, the output amount of DDT antifouling paint production is in downward trend but not been completely eradicated.

View of organic tin coating at the bottom of boats and fishing nets, which causing fish and snails' reproductive abnormalities, the Marine Environment Protection Committee of United Nations International Maritime Organization (IMO) recently adopted the Protocol to promote a total ban on the ship coatings which contains organotin compound and to develop substitutes, and this is a mandatory international agreement. It was from the mid-1960s that Organ tin compounds were used in bottom paint because it has a cumulative and chronic toxicity which can kill attached shellfish in the bottom of boats. In 1968, Europe and the United States reported that chronic toxicity caused the snails' reproductive dysfunction, and since 1990, Japan has also confirmed the same disaster. In November 1990, the Maritime Organization of the United Nations advice that the small vessels would like to fill the organ tins the bottom paint, and meanwhile Japan advocated the complete prohibition. In recent years, environmental protection has become increasingly strengthen. The Netherlands, Switzerland and some other countries are in favor of Japan's advocating of complete prohibition, and then this resolution became international total ban on ship use organic tin compounds. Since then, ships are totally banned on use of organic tin compound coatings.

However, in recent years, Chinese Shenzhen Shekou Port and its adjacent waters has been found organotin contamination. The concentration of tributyltin in seawater was over nearly eight times the U.S. residue standard and nearly 80 times higher than Canada residue standards. In fact, Shenzhen organotin pollution of waters was more than Shekou, and Yantian International Container Terminals waters near suffer.

Yantian port sea area of high density and large-tonnage ships docked lead to a higher chance of organotin release into the sea. This sea area located in the top of the Mirs Bay, which has weak dilution effect of the exchange of water, which also leads to the level of accumulation in the Yantian Port organic tin and other pollutants is worse than Shekou. It is reported that Shenzhen specialty one manhole Ho is also the victims of seawater organic pollution, and it has basically disappeared in Shenzhen.

The “culprit" of these pollution is the paint on the bottom of ships, offshore platforms, this kind of coating can prevent the defacement for the ships and offshore platforms from marine fouling organisms, to extend the service life of marine construction and ships, and to reduce fuel consumption, but by far the organic tin in the paint is one of the most toxic chemical in a large number of human factors released chemicals into the seawater, and it is extremely difficult to degrade. At present, China has not yet introduced the relevant restrictions and residual standard about this.

What's more, International Convention on the Control ofHarmful Anti-fouling Systems on Ships,2001 from the International Maritime Organization (IMO) also stipulates the prohibition of applying antifouling paint containing organic tin on the ships and other facilities in the worldwide from January 1, 2008.TheChinese government has approved the accession to the Convention, this Convention started to effect on China on June 7, 2011, and began to gradually restrict or prohibit the domestic ship antifouling paints containing organic tin.

2.2 Marine pollution from Excess carbon emissions

With the improvement of the globalization process, the global vessels CO2 emissions

has risen to the level of alert, which is two times of the aviation industry. If no measures are taken to control, in the following 15-20 years, the ship's carbon dioxide emissions will be increased by 75%, posing a serious threat on the global climate.

In the past years, the environmentalists have accused the airline industry should be responsible for global warming. They do not realize, in the past 20 years, the shipping industry's carbon dioxide emissions have risen sharply. However, with regard to the carbon dioxide emissions of the ship has not attracted the attention of the people, "Kyoto Protocol" does not make provision for this ship's carbon dioxide emissions standards. Neither does the EU.

According to the report of the second of greenhouse gases, which is released by the International Maritime Organization in 2009, the global maritime fleet emissions of carbon dioxide in 2007 alone amounted to 1.04 billion tons, accounting for 3.3% of global carbon dioxide emissions in the year total. International maritime emissions reached 870 million tons, accounting for 2.7% of the total global emissions, which is almost equivalent to twice the annual carbon dioxide emissions in the United Kingdom, more than the sum of all African countries annual emissions. And increase speed as much as the airline industry.

Donald Gregory , the person in charge of shipping industry and environmental work in BP Amoco (BP), has said, It is estimated that over 70,000 vessels annually consumes about 200 million tons of fuel, and will consume 350 million tons of fuel till 2020. The ship's carbon dioxide emissions now account for 4% of the total global emissions, with the increase in the volume of global trade, the emissions will be increased by 75% in the next 15-20 years. It is predicted that, with the growth of the shipping trade, if no measures are taken, the global maritime ship emissions of greenhouse gases in 2020 will be more than the terrestrial greenhouse gas emissions,

150% -250% increase in 2050 than in 2007; if taking effective control measures to improve the energy efficiency of the ship, it is possible to achieve the emissions to be reduced by 25% -75%.

Furthermore, with the acceleration of the globalization process, the volume of the ship will be growing faster and faster speed, resulting in the next 20 years the ship's carbon dioxide emissions will rise sharply, according to the International Maritime Organization.

Gregory pointed out that vessel should be responsible for global climate change. At the same time, the International Maritime Organization (IMO) needs to develop strategies of limiting the steamship carbon dioxide emissions.

2.3 Marine pollution from Dumping and illegal sewage

The illegal sewage refers to the process of the operation of the ship, the crew of human error or human intentional emissions regulations. For example: deliberately dumping washing sewage which contains harmful substances into the sea; intentionally dumping the untreated sewage containing waste oil cabin into the sea; others due to the negligent fuel transfer operations, full cabin with oil cabinet, spilling the fuel over into the sea.

The ship illegal sewage has a close relationship with human factors. It is the operation of the crew on the ship, directly or indirectly, lead a number of substances or energy into the marine environment (including estuaries) so that the negative effects do harm to the living resources and endanger human health, obstruct kinds of marine activities, including fishing activities, destruct the using quality and comfort of seawater. There are several direct aspects listed below that lead to incidents of illegal sewage:

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(1) Slack and lazy thinking

Because of the difficult conditions, poor working environment, long time working period at sea, plus mostly repetitive operation and management of daily work on board, some crew are becoming to think numbly, and work negatively in low mood. A variety of situations indicate that some of the crew show no ideological importance in their own work, not enough serious in the course of their work, and lack of sense of responsibility. Even they do not put emphasis on the antifouling exercise, within the loosen discipline, slow movements, resilience, eventually leading to the pollution accidents.

The accident caused by handling the cargo oil and reception of pollution from Ships, the installation of fuel, are mostly caused by the vast majority of one or both lack a sense of responsibility, or the tour inspection is not serious, or long interval; duty neglect on lookout; not obeying to rules and operations, and other factors result. For example, on February 5, 1995, in Qinhuangdao, a company was in the process of loading and unloading of a tanker, the person on duty subjectively made a judgment of loading and unloading operations which might require 6.7 hours according to the cargo volume and oil loading rate, and didn't check the cargo holding oil level timely after changing the oil loading rate, resulting in the accident of splitting over the cargo oil into cabin. Nearly 3 tons of oil was dumped into the sea, causing a large area of the pollution in the sea.

(2) Weak environmental awareness

First of all, the pollution prevention education is not enough, and secondly, the crew lack the environmental awareness. Shipping companies and crew have long been

widespread heavy security instead of environmental consciousness. The weak performance of the environmental awareness shows in the ignorance in national environmental regulations. Some of the crew, for the sake of their own convenience, discharge the cabin sewage and washing water into the sea. They only deal with the competent authority inspection while the pollution prevention equipment installed on board are neglect able; They are not familiar with the laws and regulations. In addition, many of the crew are not familiar with the basic content of the waste management of the ship, or even do not know. They regard the ocean as a natural dump, all kinds of garbage can be dumped optionally. Despite the sea water has a certain self-purification capacity, it's limited. Many ship gradually implement classification of the source of the garbage collection, but with little success. The crew often take the principle of not pouring inside harbor, only pouring outside harbor, not dumping during the day, only dumping at night, in order to save money the easy way, thus escaping the check of the maritime sector. They do not realize that they are the junk nuisance maker, who is also the garbage victims of pollution, and so forth, the vicious cycle continues.

(3) Operational errors

Operational errors are caused by the technology to a large extent. The main problem is that at their professional level is not high, the crew are unskilled when using the anti-pollution devices equipped on board and operating the systems, and they are not familiar with the emergency procedures neither. In particular, these kinds of problem often happen prominently on those crew who work in some private company's small tonnage ships. For example, although the crew who work on the oil tanker, have passed the training of safety knowledge and safe operation, certificated of special training, however, individual crew attempt to do the training for the sake of the certification itself. They don’t learn carefully in class and grasp the smattering of

knowledge, even not understand. They rely on cheating in examinations to pass through the tests. They will be only helpless at those critical moments.

(4)badly maintained

Most the pollution due to the damage of ship machinery equipment occur in small local companies, old ships or Ship of Flag of Convenience. These ship companies generally have chaotic management and lack of machinery and equipment maintenance.

There are clearly defined provisions for the maintenance of all the decontamination equipment in the engineer department. Some equipment have to be maintained when they are in the running process, while some others need to be maintained within a stipulate period. If those maintenance are not be done in time then will inevitably result in insecurity.

There have been many examples in this regard. The reason is necessary due to the strong idleness of some crew. They do not follow the requirements of timely maintenance and requirement of the ships.

(5) Management loopholes

Loopholes in management is the direct cause of human errors. This is mainly reflected in: seafarers' organizations and lax discipline; board rules and regulations are not sound or sound no management which did not form the perfect management system, such as device management, crew management, regulatory management, environmental education management.

Mismanagement, this phenomenon is reflected in the ships, but the main problem lies in the company, and is due to lax management, not following established rules, unsound safety goal-setting, rules and regulations, safe production responsibility system not being implemented and other causes.

As in ship waste management side, controlling and reducing garbage into the sea, is the primary means of preventing the marine pollution. So the ships should earnestly comply with the relevant waste management requirements.

Ship waste management related to the contents of the signs announcement, ship garbage management planning and garbage from ships handler and <<Garbage from Ships Record Book>> records.

However, the maritime sector management mainly focus on security and pays insufficient attention to the anti-fouling problems. Although Regulations of the People's Republic of China on the Prevention of Vessel–Induced Sea Pollution has clearly definition, and at the same time, make detailed requirements for waste disposal program of garbage collection, the garbage processing and equipment, waste storage, the garbage disposal etc, shipping companies and the majority of the crew did not receive the education and training of the system, pollution prevention work is not truly implemented. It is also a lot of garbage in the ocean where no way to check the reasons.

2.4 Marine pollution from collision and grounding accident

The cause of pollution which leads by the kind of ship accidents that cargo oil or bunker leakage is relatively complex. Sometimes caused by single factor, such as the

case that because of crew’s errors, it leads to ship grounding or collision which directly leads to the ship damage, oil leakage. But the fact is that many accidents are caused by many reasons. The ship of oil spill accidents are the main cause of marine pollution from ships. Ship oil pollution accidents occur basically divided into two categories, namely, operation by human errors or intentional acts of the oil spill accident (hereinafter referred to as the "operational oil spill"); average accident caused the accident of oil spill accident (hereinafter referred to as the "accidental oil spill"). "The operation of oil spill" refers to: the crew does not comply with the relevant provisions, illegal discharge of bilge water, waste oil, waste oil, or error work loading and unloading time, stagger the valve or flange connector off, or rupture caused by pipeline overflow full when oil pollution. "Accidental oil spill" refers to: the ship for a collision, grounding, stranding, fire and explosion accident, resulting in sudden oil or fuel leak caused the oil spill accident. In this paper, the author mainly analysis for ship collision, grounding accidents caused by the oil spill, namely "Accidental oil spill". After analysis of a large amount of data, I think: a. Accidental oil spill are the main cause of marine environment of oil spill pollution caused by ships. b. The major oil spill accident was mainly caused by the average. c. The oil pollution accident is the biggest ship pollution which does damage to the marine environment. The harmless degree of ship oil spill accidents not only depends on the oil spill volume, overflow difference, oil types of sea of different types of weather, sea conditions, differences in condition of the vessel, all affect the degree of harmless of oil spill accidents, and these factors are interrelated, interaction, cannot separate a factor from other factors apart.

The evaluation of the damage degree of oil spills from ships at sea will directly influence the processing of oil spill. Whether the damage degree evaluation of oil spill at sea ship appropriateness or not, will affect the environmental protection strategy, man and equipment’s call quality, organization and coordination, whether the accident

treatment is effectiveness and convenience etc.. In this paper, the evaluation of the extent of the harmless of oil spill from ships at sea, is resulted from the oil spill damage after the result of the analysis, and will focus on the overall damage degree of oil spill brings to the whole sea area. There are complex interactions between various factors, I will talk about it from the following aspects: a. The most significant factor that leads to marine pollution is the oil spill volume. b. The factor from the spilling oil's characteristics. c. Factors of the difference between the types of the sea. d. Factors of influencing the weather condition. e. The influence factors of the oil spill accident condition of ship. Factors of oil spill volume, oil properties, sea, sea state, weather type ship 5 influence. The oil spill is the most basic, the most important evaluation index, oil characteristics including the persistent, toxic, flammable.

With the rapid development of petroleum industry, it has an increasing share of world energy consumption . Oil not only provides a liquid fuel, but also provides a cheap chemical raw materials. The facts are development of petrochemical technology, petrochemical products increased rapidly and the scope of delivery is increasing. At present ,there are about 30,000 kinds of chemicals have registered in the International Maritime Organization (IMO) . Until 1990,marine pollution problem group of scientists (GESAMP) had identified1400 species of them . It estimates that the bulk chemicals has more than 1,100 kinds of species. In the MARPOL annex II Amendments Act 1992, there have been identified 596 of which can be used for bulk chemical carrier for bulk transport at sea, of which more than 200 are often transported by sea transport. So it can be said that, the bulk liquid chemicals transportation is the inevitable trend under the world petrochemical industry's rapid development.

Taken Ningbo Zhoushan port as an example. In recent years, with the rapid economic development, Ningbo Zhoushan port's throughput sits in the second in Chinese

mainland ports these years. In 2007, port cargo throughput reached 3.34 tons, including 86,490,000 tons of hazardous chemicals, which account for about 25.9% of the total port throughput. The following Table 1 is the statistical data of Ningbo Zhoushan's throughput and dangerous chemicals' throughput during 2005~2013.

Tab. 1 The Port Handling Capablity and Dangerous Chemicals Handling Capablity in Ningbo-Zhoushan port

Year	Port Handling Capablity(hundred million tons)	Dangerous Chemicals Handling Capablity (ten thousand tons)	Percent
2005	2.69	7173	27%
2006	3.1	8073	26%
2007	3.34	8649	26%
2008	3.61	9024	28%
2009	3.84	10106	24%
2010	4.12	13424	26%
2011	6.91	21303	45%
2012	4.53	15782	-34%
2013(01-04)	1.15	3458	

Source: Maritime Safety Adiministration of the Ningbo

We can see that dangerous chemicals are the main products of Ningbo Zhoushan port, which have a very large throughput. From the statistics, bulk liquid chemicals port throughput have a rapid growth in recent years , the throughput of liquid chemicals in bulk in Ningbo Zhoushan port are 14,000,000 tons (including transit goods)in 2007. From 2005 to 2011 these eight years, the port throughput to bulk liquid chemicals were growing at an average annual growth rate of 27%.The arrival of the liquid chemicals in bulk liquid chemicals in bulk ship have a synchronous growth, there are 3,800 vessels which carry bulk liquid chemicals in and out. Moreover, there are many kinds of the liquid chemicals which carried by bulk vessel. At present, Ningbo Zhoushan port operations reached over a hundred kinds. Liquid chemicals in bulk ships and liquid chemicals in bulk throughput of Ningbo Zhoushan port's statistics

between 2000-2007 as shown in table 2.

Tab 2 The Situation about Liquid Chemical in Bulk and Handling Capability of Ningbo-Zhoushan port

Year	In and Out	Compare to the same period last year%	Handling Capablity(ten thousand tons)	Compare to the same period last year%
2000	1007	62	145	63
2001	1186	18	180	24
2002	1441	22	227	26
2003	1618	12	294	30
2004	1753	8	364	24
2005	2096	20	490	35
2006	2764	32	59	21
2007	3800	37	1432	141

Source: Maritime Safety Adiministration of the Ningbo

In the downstream products of these chemical products and intermediates are mainly in chemical industry chain, including all kinds of chemical raw materials, fine chemicals, plastics and its products, rubber and its products and pesticide and intermediates. These species which are flammable, explosive, toxic, corrosive and have many other special physical and chemical characteristics of the goods ,such as butadiene, acrylonitrile, xylene, styrene, vinyl chloride, acrylic, acrylic acid, acetone, acetic acid, caustic soda occupy a large share of in the throughput of bulk liquid chemicals. With the increasing of the throughput of bulk liquid chemicals, the increasing number of this kind of vessel, the increasing time in port ,Chinese offshore bulk chemical transport exposed many serious problems. First, the port layout is not reasonable, the design is not standard. Due to historical reasons, some of the old pier is located in the industrial area which is densely populated. These place always have the narrow channel but with crowded vessels, which leads to frequent water traffic accidents. Second, the safety and prevention facilities and equipment are not complete or not do the maintenance as rules. Third, the port pollution emergency ability is

limited. Due to some port facilities are not complete, the emergency is not practical, when the pollution accidents occurred in the waters, it is difficult to make effective response.

For example, in 1988 May, the Netherlandish bulk chemical carrier ANNABROERE, which contains propylene (acrylonitril), sank in North sea ,the coastal of Holland directly leads to the convening of the first session of the international bulk liquid chemicals spilled on water and emergency response meeting. In December 1993, a chemical tanker ballast tank rupture caused by wind at coastal waters of British Denver, resulting in 40 °heeling and finally the ship capsized. the ship carried 2500 tons of toluene,which caused serious marine pollution. On 19 March 1993,at the sea area near Terschelling, Holland, the 8th hold of Shiokaze, which carried 2,000cubic metres ethylhexanol and many other dangerous chemicals，boomed and fired that leads many chemicals spilled into the sea.

In October 31 2000, a Italy cargo ships carried 6000 tons of highly toxic chemicals sank in the coastal northern France, the ship named "Ievoli Sun" cargo ship carrying 3998 tons of styrene, 1000 tons of methylethyl ketone , 1000 tons of alcohol and isopropyl chemicals, in which 200 tons of styrene leaked into the sea due to ship grounding, it become the biggest accident of styrene.

Chapter 3 Case study : leakage accident in Ningbo-Zhoushan port

3.1 The risk probability calculation of HNS(Hazardous and Noxious Substance) pollution accident in Ningbo-Zhoushan port

In the file of IMO, substance HNS defined first appeared in the "1996 international maritime transport of harmful and toxic substances damage the International Convention on liability and compensation for" (HNS Convention),it define IMO existing conventions and rules relating to transportation safety and environmental harmful substances as the meaning of the HNS agreement. OPRC-HNS Protocol: Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 pointed that HNS refers to the matter if be pour into the sea environment may cause harm, biological resources and marine biological damage, cause any material damage or other legitimate use of the ocean caused by interference of pleasant environment on human health, excluding oil. This definition contains very many types of HNS goods, not only contains safety hazards and environmental pollution substances the international shipping community has identified, but also brought the interface for the new HNS goods after technology development. At present, the definition of HNS in the world reference the IMO Convention and rules involved in the nature of toxic, harmful substances list, mainly including the provisions of the following five aspects.

(1) dangerous bulk liquid chemical substances which stipulated in IBC rules,

(2) liquid or provisions substances which stipulated in annex II of MARPOL73/78,

(3) the packaging of dangerous or hazardous substances which stipulated in the IMDG rules,

(4) dangerous chemical hazardous bulk solid substances which stipulated in IMSBC rules,

(5) liquefied gas material which stipulated in IGC rules.

Classification of the five aspects of material can cross each other but different, however, the definition of toxic and harmful substances have a very broad scope, large quantity, almost all of the current can be used for the commercial transport, harm to the marine environment material. At the present, there are a number of toxic and harmful substances of ship transport more than 6000 worldwide, and at the same time, with the development of industrial technology, it will continue to add new varieties.

With the sustained and rapid economic and social development of China, China has become the world's liquid chemical products production and consumption country. Especially after joining the world trade organization, China has become the "world factory", the excess chemical production capacity in the developed countries became transfer to China. The expansion of production capacity of domestic chemical industry to release after 2006, the domestic level reliance on chemical raw materials also have a gradually improve. Ningbo port as Chinese important energy transfer and storage base, the Industrial Development in the near port area has a rapid development in recent years, Zhenhai Refining & Chemical, Formosa Petrochemical, Mitsubishi Chemical, Qingshi chemical zone, Xiepu chemical industry zone and many other chemical production base are putting into operation. The rapid development of chemical industry accelerate the growth of HNS sea cargo throughput. Bulk HNS ship and its throughput of Ningbo Port in recent thirteen years is shown in table 3.

Tab.3 2000-2012 Ningbo-Zhoushan Port HNS Vessel & Cargo Throughput Statistics

Year	HNS Vessel's in and out	Compare to the same period last year%	HNS Handling Capablity (ten thousand tons)	Compared to the same period last year%
2000	1007		168	
2001	1186	18	236	40
2002	1441	22	324	37
2003	1618	12	428	32
2004	1753	8	621	45
2005	2096	20	775	25
2006	2764	32	927	20
2007	3800	37	1924	108
2008	3990	5	2434	27
2009	4581	15	2778	14
2010	4855	6	3111	26
2011	5486	13	3826	23
2012	5705	4	4323	13

Source: Maritime Safety Adiministration of the Ningbo

From the carriage of HNS ship and the number of vessel's in and out, carrying HNS ships entering and departing the second growth of 355%, but the HNS throughput is increased by 1554%, HNS cargo throughput of the average increase is 4.4 times since 2000 ten years, we can see that the size of ship carrying HNS is in a development of bigness trend.

The happen of HNS pollution and port traffic pollution accidents, vessel density, cargo throughput and other factors are positively correlated. The increase of these data, will also improve the possibility of response of the accident probability and contaminant leakage. Investigation and statistics show that more than 100 kinds of HNS goods import and export in Ningbo, Top ten import and export HNS by sea from Ningbo Port in 2010 are shown in table 4.

Tab.4 2010 Top Ten Import & Export HNS by Sea from Ningbo-Zhoushan Port

NO.	Cargo	Handling Capability(ten thousands tons)
1	Edible Oils	285.5
2	p-xylene	264.3
3	chlorethylene	129.6
4	ethanediol	135.2
5	phenylethylene	63.9
6	liquefied petroleum gas	32.4
7	acrylonitrile	31.1
8	liquid caustic	30.4
9	hydrochloric	30.4
10	aminobenzene	30.3

Source: Maritime Safety Adiministration of the Ningbo

These HNS material, in addition to edible oil, the rest are in the downstream products of petrochemical industry chain which has the very strong flammable, explosive, toxic, corrosive environment.

Table 5 is the Top ten HNS cargo TAB of Ningbo three port areas.

Tab.5 Top Ten HNS Cargo of Ningbo-Zhoushan Three Port Areas

NO.	Zhenhai Port Area		Beilun Port Area		Daxie Port Area	
	Cargo	Handling Capability(ten thousands tons)	Cargo	Handling Capability(ten thousands tons)	Cargo	Handling Capability(ten thousands tons)
1	p-xylene	132.2	Edible Oils	270.4	p-xylene	132
2	ethanediol	130.2	chlorethylene	129.6	ethylic acid	23.5
3	phenylethylene	43.9	phenylethylene	16.7	hydrochloric acid	15.4
4	acrylonitrile	26.1	aminobenzene	15.4	aminobenzene	14.9
5	liquid caustic	10.6	hydrochloric acid	14.9	liquid caustic	7.8
6	isooctanol	9.4	dimethylbenzene	7.7	carbinol	3.3
7	acetone	8	propylene	6.3	n-butyl alcohol	2.5
8	butadiene	7.5	butyl acrylate	5.2		
9	Adiponitrile	7.2	acrylonitrile	5		
10	ethylic acid	6.3	n-butyl alcohol	3.8		

Source: Maritime Safety Adiministration of the Ningbo

From the above table, it is not difficult to see that p-xylene, styrene, chlorethylene, acrylonitrile, butadiene, aminobenzene, liquid caustic, such as these inflammable and explosive, toxic, corrosive and other special physical and chemical characteristics of the goods occupy a large share of the Ningbo port throughput of HNS.

With the rapid growth of Chinese HNS water transport volume, transport ship pollution accidents occur in ship carried HNS. From the Ministry of transport and Maritime Bureau statistics about HNS accident statistics (see Table 6), from 1995 to 2010, Chinese coastal HNS occurred in 74 accidents, accidents reached a high point in 2001. According to statistics, nearly 10 years Chinese coast happened more than 50 tons of heavy ship carrying HNS pollution accident about 19 cases, the average leakage rate reached 350 tons per accident. Although accidents since 2002 continued to decline, but as more and larger ships carrying HNS which result in HNS leakage does not fall instead by rise.

Tab.6 1995-2010 HNS Accident Statistics of Chinese Coastal

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NO.	2	4	6	1	2	4	12	8	7	4	4	3	4	2	5	4

Source: Maritime Safety Adiministration of the People's Republic of China

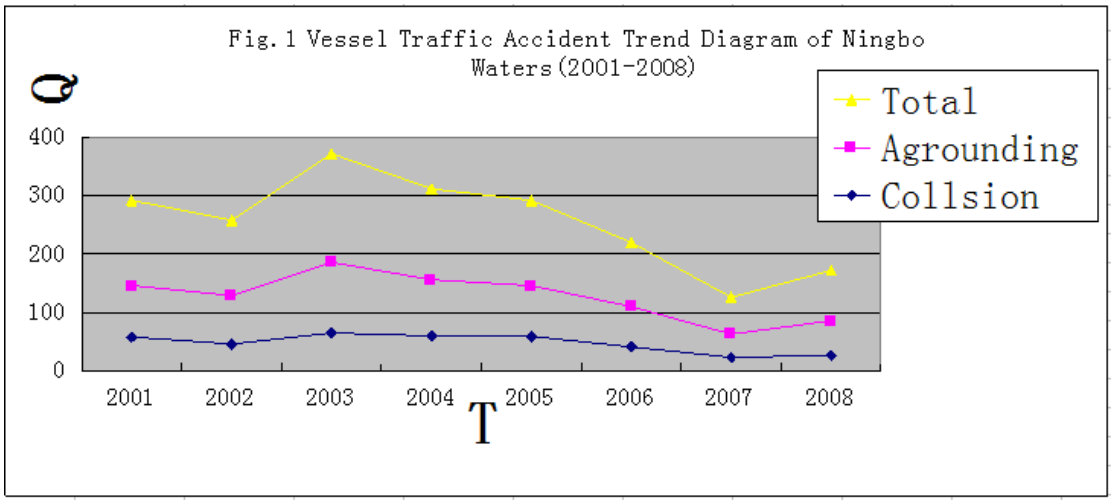
Table 7 contains some example of HNS accidents between 1995-2005.

Tab.7 1995-2005 Accidents Involving HNS Vessels of Chinese Costal

Year	Place	M/V	Categories	Tonnage	Cause
1995	Zhanjiang	Chung Mu	phenylethylene	310	collision
2001	mouth of the Yangtze River	Da Yong	phenylethylene	639	collision
2002	mouth of the Yangtze River	Accord	methacrylic acid	125	
2005	Shanghai	GG Chmemist	methylbenzene	64	collision

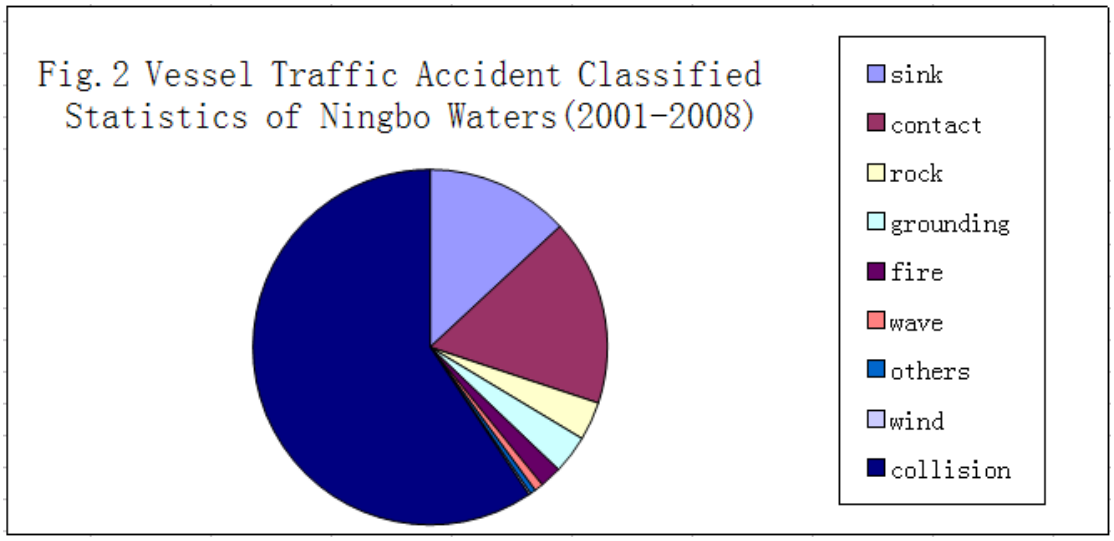
Source: Maritime Safety Adiministration of the People's Republic of China

Figure 1 is the trend of traffic accident in Ningbo-Zhoushan port between 2001-2008



Source: Marine accident report

Figure 2 is the classified of traffic accident in Ningbo-Zhoushan port



Source: Marine accident report

HNS pollution risk, including leakage channels, the number of HNS leakage, leakage of toxic and environmental capacity and other factors, in which the risk which lead to the leakage of pollutants and environmental capacity are two main genera of ship pollution accidents risk. From the statistical data we can see that the collision between vessels, ship structures, ships stranded and many other vessel traffic accidents are a result of ship hull damage and are the most important cause of HNS leakage. Risk assessment of ship pollution accidents caused by HNS is different from the general assessment of environmental impact, in addition to environmental consequences possibly caused by HNS, the probability of ship loading NHS accident is the important content of risk assessment, and the accident probability and the environmental impact are interdependent.

At present, the definition of risk of domestic and international recognized is that the risk of accident (A) is the accident probability (Pr) environmental consequences and accident (AC) product, namely A=Pr x AC. The cover of the accident probability is the probability of accident specific objects, the object in this paper is the ship carrying HNS. Ship accidents is a random event, we cannot conclude that will happen or not

happen, but the probability of occurrence in certain conditions is an objective existence of fixed value, there are rules to follow. Therefore, based on the statistical data of the previous accidents, using probability and statistics method can calculate the probability of the accident probability is obtained, and then use the value to predict the possibility of ship accidents, so that can measure the ship pollution accidents and the magnitude of risk and safety degree level.

According to the analysis of ship accident statistics in Chinese coastal ports, accident quantity and ship in and out the harbor is proportional. Consequently， we can use the previous ship pollution accidents and ships entering and departing the port ships ratio in the port of Ningbo as a parameter estimation of single ship pollution accidents, establish a mathematical model to get probabilistic prediction of Ningbo port future occurrence of pollution accidents by ship.

(1) The theory estimate of ship accident probability

The probability of collision, stranding, damage and other accidents when ship is sailing on the sea, in the anchorage, in the berth is very small, and belongs to the low probability event. Therefore, maritime accident probability obeys the Discrete binomial probability distribution. Supposing that there are k accidents caused by n ships in the specific waters we will research, then ship accident risk probability in this waters is：

$$\Pr(X = k) = c_n^k pr^k q^{n-k} \quad ①$$

In the formula ①, Pr is the probability of every ship accident, it is based on the collision probability value in the certain areas, q=1-Pr is the probability of each ship does not occurred accident. Figures of number of import and export in Ningbo port count by Marine board of Ningbo shows that, since 2001 the number of out port

ship in Ningbo port increased year by year and nearly five years the number of ships in the harbor gradually stabilized while shows the larger trend. During 2007 to 2010 ,the average is 970000, which in 2008 reached 1010000. Taking into account the throughput of the port development and large ships trend in the harbor of Ningbo port development, we can assume that the annual ships is stable at 1000000 and the port of Ningbo in the next S years the ship of Ningbo port for a total volume is n=1000000 × S. The confidence of no serious marine pollution accidents (HNS leakage of more than 50 tons of accident) was 99.4% in Ningbo port, from the formula ① , we can get:

$$\sum_{i-1}^{n} c_n^i pr^i (1-pr)^{n-i} \le 0.994 \text{ ②}$$

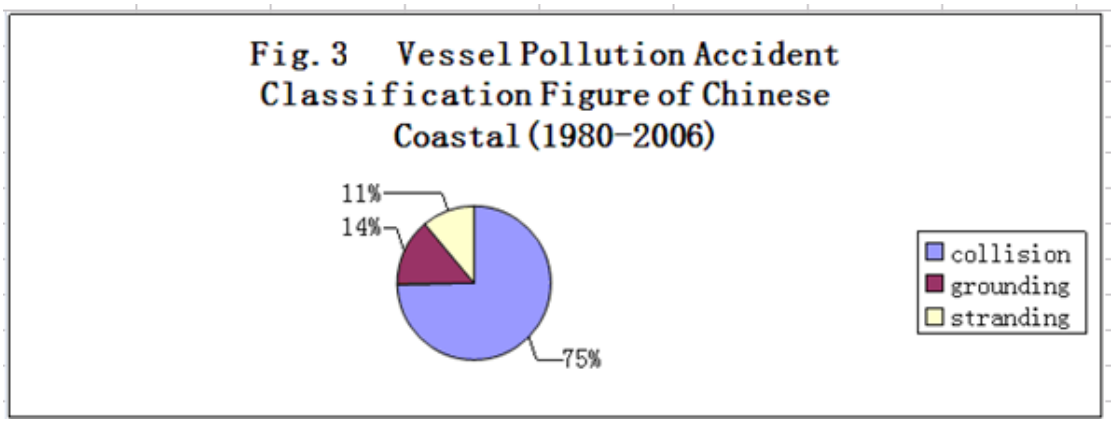
From the formula ②, we can get $p \le 0.663 \times 10^{-5} / S$,the value is the basic value of probability of single ship accident in Ningbo port.

(2) the probability theory estimate of leakage risk of the ships carrying HNS

Through statistical analysis on the HNS ship pollution accidents in the Chinese domestic coastal ports of Ningbo sea area, we can result that HNS pollution accident the main reason has the following several aspects: the ship collision accidents causing HNS pollution, ship grounding accidents causing HNS pollution, hull aground reef damage which lead to HNS pollution.

Supposing that the ship in Ningbo harbor, the ratio of which carry HNS ship is Ri. Due to most of the ship loading HNS are one-way processes, it means that import or export of the ports (such as import) is laden, another process (such as export) as the ballast ships in the harbor, we can set about 50% is ballast, the other 50% is laden. According to the domestic coastal marine pollution accident statistics (see Figure 3) released by Ministry of Transport, from 1980 to 2006, leakage occurred in coastal waters over 50 tons of domestic major accident is 58, according to the ship collision,

the ship ran aground and ship wrecked accident statistics, respectively 75%, 14% and 11%.



Source: Maritime Safety Adiministration of the People's Republic of China

From the statistics in the foregoing， we can calculate the probability of leakage accident in Ningbo port.

1) The probability of ship collision accidents caused by leakage accident

The condition of ship collision accident in the channel, berth is that there must be a non empty HNS ship collide with another vessel, so,

P_1(Two ships are both ballast HNS ships or not HNS ship)= Pr(one is ballast HNS ship or not HNS ship)×Pr(the other one is ballast HNS ship or not HNS ship)

=(1-Ri/2)×(1-Ri/2)

P_2 =Pr(ballast HNS ship）+Pr（not HNS ship）=Ri/2+（1-R）=1-Ri/2

P(at least one is not ballast HNS ship in two of them）=1-P_1=Ri×（1-Ri/4）

According to the hypothesis, the probability of leak channel, berth and berth is

Pr(leakage/collision in the channel)=Pr(leakage/collision in the anchorage)=(75％x pr)×Ri×(1-Ri/4)

P(leakage/collision in the berth)：(75％×pr)×Ri/2

Therefore, the probability due to the collision caused by leakage is

P_0(leakage/collision)=50％×[2×(75％

–
×pr)×Ri×(1-Ri/4)+(3Pr/4)×Ri/2]=3Pr/16×Ri×(5-Ri)

2) the probability of leakage caused by the agrounding accident

the agrounding accident can happen on one single ship, so
P(agrounding in the channel)=Pr(agrounding in the anchorage)=Pr(agrounding in the berth)=15％ Pr
Ballast and laden each account for Ri/2，so：
P(leakage/agrounding)=50％×Ri/2×(15％× Pr+15％×Pr+15％×Pr)=9P/80×Ri

3) the probability of leakage caused by striking on rocks

The occurrence of leakage accident of HNS ship drove on the rocks also can happen on one single ship which is not ballast, the calculation method is as same as the ship ran aground.
Pr(leakage/collision)=50％×Ri/2×(11％x Pr+l1％x Pr+l1％x Pr)=3P/40 x Ri

4) the total probability of HNS ship leakage
HNS ship accident risk probability sum for the collision, grounding and striking probability，that is：

Pr(leakage)=3Pr/16 Ri×(5-Ri)+9Pr/80× Ri+3Pr/40×Ri+Ri=(90-15Ri)×Pr×Ri/80③

HNS ship occupy for about 0.5% of ships in the Ningbo harbor between 2001 and 2010. It expected that with the planned HNS terminals have been completed, Ningbo bulk transfer base, Ningbo Chemical Industrial Park completed and put into production, as well as the chemical enterprise production capacity gradually expanded, Ratio (Ri) of HNS ship which occupies in the total number of ships in Ningbo port

will be increased to 1.1%. The basis value of probability and Ningbo port future single ship accident is 0.663x10-5/s, put this figure into the formula ③, we can estimate that the risk probability of every ship of HNS ship accidents leakage in Ningbo harbor in the next s years is

Pr(leakage)=(90-15Ri)×pr×Ri/80=（90-0.01x15）×0．663×10^{-5}/S×0.01/80=0．744×10^{-8}/S

Therefore, the probability of the ship HNS leakage risk in the whole Ningbo port sea area is

n(the total number of vessel)×Pr(leakage)=1000000×S × 0.744×10^{-8}/S≈1times/13.3a

Through the above analysis, we can think that the occurrence probability of more than 50 tons of HNS leakage accident for about 1 times every 13 years in Ningbo harbor. With the increasing proportion of large ship, port traffic and vessel density will continue improving, at the same time the ratio of carrying HNS ship will increase, the probability of HNS leakage risk will rise. Considering the use of advanced technology, the ship conditions and improve marine traffic management level, the ability to prevent HNS ship accident will also synchronous lifting in the future, we can believe that in the future, the probability of occurrence of HNS major leakage accident can be maintained.

3.2 Grey Forecast Model of leakage accident in Ningbo-Zhoushan port

From Ningbo area accident law and Countermeasure Research Report, I get the data as following,

Tab.8 The Statistics of the Collision ,Grounding and Self-sink Accident

Year	Collision	Grounding	Self-sink	total
2003	64	27	11	102
2004	62	18	9	89
2005	58	15	7	80
2006	42	12	8	62
2007	21	8	9	38
2008	40	9	14	63
2009	46	7	7	60
2010	52	11	9	72
2011	49	9	8	66
2012	41	8	11	60

Source: Accident Law and Countermeasure Research Report in Ningbo area

Then, use grey forcast model to estimate the statistics next year.

Suppose that the collision number is M_0 , the grounding is N_0 ,,the se;f-sink is Q_0

First , I will forcast the number of collision accident in 2013.

The original dara is M_0={64,62,58,42,21,40,46,52,49,41}

After the first accumulate, can get M_1={64,126,184,226,247,287,333,385,434,475}

And then built a marix,

$$B=\begin{bmatrix} -1/2[m_1(2)+m_1(1)] \\ -1/2[m_1(3)+m_1(2)] \\ -1/2[m_1(4)+m_1(3)] \\ -1/2[m_1(5)+m_1(4)] \\ -1/2[m_1(6)+m_1(5)] \\ -1/2[m_1(7)+m_1(6)] \\ -1/2[m_1(8)+m_1(7)] \\ -1/2[m_1(9)+m_1(8)] \\ -1/2[m_1(10)+m_1(9)] \end{bmatrix}=\begin{bmatrix} -95 \\ -155 \\ -205 \\ -236.5 \\ -267 \\ -310 \\ -359 \\ -409.5 \\ -454.5 \end{bmatrix}$$

Yn={62,58,42,21,40,46,52,49,41}^{T}

And then, caculate the $(B^TB)^{-1}$

$$(B^T B)^{-1} = \begin{bmatrix} 8.94394E-06 & 0.002475982 \\ 0.002475982 & 0.796545402 \end{bmatrix}$$

Use the formula $\hat{U} = (B^T B)^{-1} B^T Y$, to caculte the $\hat{a}$ and $\hat{u}$

$$\hat{U} = \begin{bmatrix} \hat{a} \\ \hat{u} \end{bmatrix} = (B^T B)^{-1} B^T Y = \begin{bmatrix} 0.026957047 \\ 53.12927576 \end{bmatrix}$$

Then , add the $\hat{a}$ and $\hat{u}$ in to the equation, because $m^{(0)}(1) = 64$

So the Time responsing equation is

$$\hat{M}^{(1)}(k+1) = \left[M^{(0)}(1) - \frac{\hat{u}}{\hat{a}} \right] e^{-\hat{a}k} + \frac{\hat{u}}{\hat{a}}$$

$$= (64 - 53.12927576 / 0.026957047) \times e^{-0.026957047\,k} + 53.12927576 / 0.026957047$$

$$= (64 - 1970.886364) \times e^{-0.026957047\,k} + 1970.886364$$

Then we can get the statitics as following,

calculated value $\hat{m}^{(0)}(k)$	actual value	residual	fractional error
$\hat{m}^{(0)}(2) = 50.717$	$m^{(0)}(2) = 62$	11.282641	0.1819780
$\hat{m}^{(0)}(3) = 49.368$	$m^{(0)}(3) = 58$	8.6315685	0.1488201
$\hat{m}^{(0)}(4) = 48.055$	$m^{(0)}(4) = 42$	-6.055381	0.1441757
$\hat{m}^{(0)}(5) = 46.777$	$m^{(0)}(5) = 21$	-25.77725	1.2274883
$\hat{m}^{(0)}(6) = 45.533$	$m^{(0)}(6) = 40$	-5.533123	0.1383280
$\hat{m}^{(0)}(7) = 44.322$	$m^{(0)}(7) = 46$	1.6779190	0.0364765
$\hat{m}^{(0)}(8) = 43.143$	$m^{(0)}(8) = 52$	8.8567511	0.1703221
$\hat{m}^{(0)}(9) = 41.995$	$m^{(0)}(9) = 49$	7.0042299	0.1428434
$\hat{m}^{(0)}(10) = 40.878$	$m^{(0)}(10) = 41$	0.1211892	0.0029558

–

And then, put k=9,10 into the equation, we can get $\hat{m}^{(1)}(10) = 514.58$

$\hat{m}^{(1)}(11) = 553.31$

So the estimate data of collision accident in 2013 is

$\hat{m}^{(0)}(11) = 553.31 - 514.58 = 38.73 \approx 39$

Second, I will forcast the number of grouding accident in 2013.

The original dara is N_0={27,18,15,12,8,9,7,11,9,8}

After the first accumulate, can get N_1={17,45,60,72,80,89,96,107,116,124}

And then built a marix,

$$B = \begin{bmatrix} -1/2[n_1(2)+n_1(1)] \\ -1/2[n_1(3)+n_1(2)] \\ -1/2[n_1(4)+n_1(3)] \\ -1/2[n_1(5)+n_1(4)] \\ -1/2[n_1(6)+n_1(5)] \\ -1/2[n_1(7)+n_1(6)] \\ -1/2[n_1(8)+n_1(7)] \\ -1/2[n_1(9)+n_1(8)] \\ -1/2[n_1(10)+n_1(9)] \end{bmatrix} = \begin{bmatrix} -36 \\ -52.5 \\ -66 \\ -76 \\ -84.5 \\ -82.5 \\ -101.5 \\ -111.5 \\ -120 \end{bmatrix}$$

Yn={18,15,12,8,9,7,11,9,8}^{T}

And then, caculate the $(B^TB)^{-1}$

$$(B^TB)^{-1} = \begin{bmatrix} 0.000164243 & 0.013513514 \\ 0.013513514 & 1.222972973 \end{bmatrix}$$

Use the formula $\hat{U} = (B^TB)^{-1}B^TY$, to caculte the $\hat{a}$ and $\hat{u}$

$$\hat{U} = \begin{bmatrix} \hat{a} \\ \hat{u} \end{bmatrix} = (B^TB)^{-1}B^TY = \begin{bmatrix} 0.107980364 \\ 19.66216216 \end{bmatrix}$$

Then , add the $\hat{a}$ and $\hat{u}$ in to the equation, because $m^{(0)}(1) = 27$

So the Time responsing equation is

$$\hat{N}^{(1)}(k+1)=\left[N^{(0)}(1)-\frac{\hat{u}}{\hat{a}}\right]e^{-\hat{a}k}+\frac{\hat{u}}{\hat{a}}$$

$$=(27-19.66216216/0.107980364)\times e^{-0.107980364\,k}+19.66216216/0.107980364$$

$$=(27-182.0901639)\times e^{-0107980364\,k}+182.0901639$$

Then we can get the statitics as following,

calculated value $\hat{m}^{(0)}(k)$	actual value	residual	fractional error
$\hat{n}^{(0)}(2)=15.874$	$n^{(0)}(2)=18$	2.1257807	0.1170989
$\hat{n}^{(0)}(3)=14.249$	$n^{(0)}(3)=15$	0.7505829	0.0500388
$\hat{n}^{(0)}(4)=12.790$	$n^{(0)}(4)=12$	-0.790921	0.0659100
$\hat{n}^{(0)}(5)=11.481$	$n^{(0)}(5)=8$	-3.480709	0.4352136
$\hat{n}^{(0)}(6)=10.306$	$n^{(0)}(6)=9$	-1.306501	0.1451668
$\hat{n}^{(0)}(7)=9.2515$	$n^{(0)}(7)=7$	-2.251581	0.3216545
$\hat{n}^{(0)}(8)=8.3046$	$n^{(0)}(8)=11$	2.6953618	0.2450328
$\hat{n}^{(0)}(9)=7.4546$	$n^{(0)}(9)=9$	1.5453812	0.1717090
$\hat{n}^{(0)}(10)=6.6916$	$n^{(0)}(10)=8$	1.3083970	0.1635496

And then, put k=9,10 into the equation, we can get $\hat{n}^{(1)}(10)=123.40$

$\hat{n}^{(1)}(11)=129.41$

So the estimate data of grounding accident in 2013 is

$\hat{n}^{(0)}(11)=129.41-123.40=6.01\approx 6$

Third. I will forcast the number of self-sink accident in 2013.

The original dara is Q_0={11,9,7,8,9,14,7,9,,8,11}

After the first accumulate, can get Q_1={11,20,27,35,44,58,65,74,82,93}

And then built a marix,

$$B=\begin{bmatrix} -1/2[q_1(2)+q_1(1)] \\ -1/2[q_1(3)+q_1(2)] \\ -1/2[q_1(4)+q_1(3)] \\ -1/2[q_1(5)+q_1(4)] \\ -1/2[q_1(6)+q_1(5)] \\ -1/2[q_1(7)+q_1(6)] \\ -1/2[q_1(8)+q_1(7)] \\ -1/2[q_1(9)+q_1(8)] \\ -1/2[q_1(10)+q_1(9)] \end{bmatrix}=\begin{bmatrix} -15.5 \\ -23.5 \\ -31 \\ -39.5 \\ -51 \\ -61.5 \\ -69.5 \\ -78 \\ -87.5 \end{bmatrix}$$

Yn={9,7,8,9,14,7,9,8,11}^{T}

And then, caculate the $(B^TB)^{-1}$

$$(B^TB)^{-1}=\begin{bmatrix} 0.000197548 & 0.010031059 \\ 0.010031059 & 0.620465994 \end{bmatrix}$$

Use the formula $\hat{U}=(B^TB)^{-1}B^TY$, to caculte the $\hat{a}$ and $\hat{u}$

$$\hat{U}=\begin{bmatrix} \hat{a} \\ \hat{u} \end{bmatrix}=(B^TB)^{-1}B^TY=\begin{bmatrix} 0.107980364 \\ 19.66216216 \end{bmatrix}$$

Then , add the $\hat{a}$ and $\hat{u}$ in to the equation, because $m^{(0)}(1)=11$

So the Time responsing equation is

$$\hat{Q}^{(1)}(k+1)=\left[Q^{(0)}(1)-\frac{\hat{u}}{\hat{a}}\right]e^{-\hat{a}k}+\frac{\hat{u}}{\hat{a}}$$

$$=(11-8.10577609\ /-0.01979872)\times e^{0.01979872\,k}+9.10577609\ /-0.01979872$$

$$=(11+409.4090909)\times e^{0.01979872\,k}-409.4090909$$

Then we can get the statitics as following,

calculated value $\hat{m}^{(0)}(k)$	actual value	residual	fractional error
$\hat{q}^{(0)}(2)=8.4065$	$n^{(0)}(2)=18$	0.5934935	0.0659437
$\hat{q}^{(0)}(3)=8.5746$	$n^{(0)}(3)=15$	-1.574603	0.2249432
$\hat{q}^{(0)}(4)=8.7460$	$n^{(0)}(4)=12$	-0.746060	0.0932576
$\hat{q}^{(0)}(5)=8.9209$	$n^{(0)}(5)=8$	0.0790526	0.0087836
$\hat{q}^{(0)}(6)=9.0993$	$n^{(0)}(6)=9$	4.9006692	0.3500478
$\hat{q}^{(0)}(7)=9.2812$	$n^{(0)}(7)=7$	-2.281281	0.3258972
$\hat{q}^{(0)}(8)=9.4668$	$n^{(0)}(8)=11$	-0.466869	0.0518744
$\hat{q}^{(0)}(9)=9.8492$	$n^{(0)}(9)=9$	-1.656169	0.2070211
$\hat{q}^{(0)}(10)=10.046$	$n^{(0)}(10)=8$	1.1507457	0.1046132

And then, put k=9,10 into the equation, we can get $\hat{q}^{(1)}(10)=93.001$

$\hat{q}^{(1)}(11)=103.04$

So the estimate data of self-sink accident in 2013 is

$\hat{q}^{(0)}(11)=103.04-93.001=10.039\approx 10$

In conclusion, if people wont do anything in Accident prevention and marine pollution prevention, the total accident in Ningbo-Zhoushan port in 2013 is 39+6+10=55. This figure seems going down in 2013, but actually,the present situation we face is still serious.

Chapter 4 Interpretation of Result and Ningbo-Zhoushan Port Marine Pollution Prevention and Control Measures

Along with developing of the transportation shipping industry , Chinese marine environment, especially the pollution of coastal waters is becoming increasingly serious, which directly affects the sustainable development of marine economy. Therefore, the issue of how to make a careful analysis of prevention and control marine environment pollution from ships and how to take effective measures to prevent and reduce the pollution damage to the marine environment has been put on the agenda.

There are various causes of ship pollution , but the prevention means also have become more perfect. In the following article, author will expound in these four field: technology solutions, policy solutions, operation solutions, management solutions.

4.1 Technology solutions

Recently , the scholar of Zhejiang university invented the aerogel ----the "Carbon sponge" from graphene manufacturing, which is currently the world's most light material, and it is expected to play a role in marine cleaning dirt. The"Carbon sponge" weight 0.16 mg per cubic centimeter, even lighter than helium, is about two times that of the same volume of hydrogen by weight. The"Carbon sponge" can be adjusted arbitrarily shape, the flexibility is good, it can be restitution after being compressed by 80%. It has high adsorption capacity, fast to organic solvent, is has been reported on the suction force the strongest materials. This property of the "Carbon sponge" can be used to dealing with marine oil spill, the "Carbon sponge" is scattered in the sea, can make the oil spill quickly suck in, because there are elastic,

breathe in and out of oil recovery, the "Carbon sponge" can also be used again. The following picture is the "Carbon sponge"on the dog's tail grass, the slender grass is not bending at all .

If collision accident happened or other accident which leads to leakage pollution happened,Ningbo-Zhoushan port can use the "Carbon sponge" to absorbing liquid contaminants fastly.

In addition to the use of the "Carbon sponge" to bring the pollution under control, strengthen the leakage of pollutants monitoring ability construction ,so that can find the pollution in the first time. Using the more green power of the device which can reduce the carbon emission is also an efficeint way to realize the marine pollution prevention and realize the green shipping and green port in Ningbo-Zhoushan port.

4.2 Management Solutions

IMO in the ISM rules pionted that, in maritime accidents, about 80% is caused by man-made factors. ISM rules also pointed out that there are about 8096 human factors can be controlled through effective management, namely through to strengthen safety management of the company's internal management and ship control. D.J.Mackenzie thought from the management of ship company perspective to improve shipping

safety and ensure the cleanliness of the marine environment, must ensure that there is a complete management system, namely the shipping company should not be simply pass the ship security responsibility to the captain himself, but should establish a complete management system in the entire firm. Only through the effective management, which can make every link of each department, the company's board and different individuals, together, make the coordination among the various departments, keep the groups with high morale, ensure individual motivation and organizational goals, enhance the cohesion and combat effectiveness and then reduce the occurrence of marine accidents.

Human factors are the most important factors affecting the Ningbo-Zhoushan port Chemical Wharf environmental risk, so for the human factor should be given enough attention.

First, the management layer should be actively involved in risk management.Participate in the management mainly refers to the importance of management of production safety and the number of risk management investment. As an advanced management organization,as a good liquid chemical terminal, managers should attach great importance to the safety work, they should regular requirements of the wharf safety equipment and measures of the implementation of the inspection, the strict requirements of terminal operators operating in accordance with the safety operation procedure is needed.

Second, strengthen the terminal operator training and education is needed. As the terminal operators, they should have skills training and corresponding safety education regularly, so that they can improve their terminal operation personnel professional skills and practical skills and safety awareness.

Strengthen the management of port facilities is also very important to the environmental risk management of Ningbo-Zhoushan port Chemical Wharf. We can strengthen the facilities management from the following aspects: The first, Chemical Wharf has its special dangerous, therefore, chemicals terminal should be equipped with the advanced fire fighting equipment, pollution prevention equipment, anti-static equipment, replace the old equipment existing and some do not meet the requirements of safety equipment. And the second, strengthen equipment maintenance is needed. Daily equipment maintenance plays a very important role in whether equipment can play a normal role at the crucial moment, to prevent accidents and can response quickly once accident occured, and minimize the loss of the accident had a significant impact, so the daily maintenance of equipment should be given sufficient attention.

First, strengthen safety management of the daily work. The management of liquid chemical terminal should be in accordance with the provisions of the safety management system implementate the safety responsibility system. The wharf should develop safety activities often, summarized and evaluated the production safety of the terminal. And at the same time, implemente the employee assistance system, all for the safety in production.Second , strengthen the construction of the emergency system. In order to deal with unexpected accidents, the loss of the accident to a minimum, in addition to strengthen safety management of the daily work, the port should also strengthen the construction of emergency system, including emergency plan compilation and revision of relevant emergency training etc..

Strengthen the management of the ship, especially the old ship management, mainly is to strengthen the inspection for ship age greater efforts. To those which do not conform to the rules or the ship should be eliminated in accordance with the relevant provisions, should resolutely be eliminated at the trading market and should also inform the dangerous of old ship to the owners, let them understand the interests of

short-term and long-term interests, reduce the number of old ship start from the owners .

The loopholes in management is the direct cause of human errors, this is reflected mainly in:

a.The crew organization has lax discipline

b. The ship rules and regulations are not perfect or even sound but no management

c. Did not built a perfect management system, such as equipment management,crew management, regulations, environmental education and management.Improper management although the phenomenon reflected in the boat, but the main problem in the company, is due to lax management, not abidance by the rules, security objectives are not in place, rules and regulations are not perfect, the cause of the safe production responsibility system is not implemented.

Like the waste management of vessel, control and reduce the amount of rubbish that poured into the sea, is the main means for the prevention of marine pollution.Ship should abide by the relevant provisions on waste management. Ship waste management concerns about the announcement, ships garbage management plan, process of ship garbage disposal and "garbage record book" etc.. However，nowadays，the management of maritime sector focus on the safety, not on the prevention of pollution. Although the "marine environmental protection law", "prevention of pollution from ships on the sea area management regulations" made clear of waste discharging. At the same time ，these rules made detailed requirement for waste disposal program of garbage collection, the garbage processing

and its equipment, waste storage, garbage disposal and other aspects and made detailed requirements, but the ship company and the majority of the crew did not accept education and training systems, pollution prevention work are not truly implemented. This is the reason why there are many garbage in the sea but we cannot find the source of them.

There are many ways can reduce the frequency of pollution caused by the loopholes of management. Firstly, exert the managers rises lawfully administrative ability and level, strengthen supervision is an important means. According to Chinese current marine conservation law of the people's Republic of China, a ship of maritime bureau director of pollution affairs. It is the executor and the supervisor of legal and administrative law in preventing the marine pollution. It means that using the administrative means to ensure that the nationality and the antipollution equipment on foreign vessels are in good condition, that can prevent marine environment pollution.

Develop marine oil spill contingency plan and establish a rapid ship spilled oil emergency response mechanism and decontamination force is an efficiency method. In order to cope with possible offshore heavy oil spill accidents, Ministry of Transport has formulated the "China marine oil spill contingency plan" (2000) and the North Sea, the East China Sea, South China Sea and the Strait of Taiwan oil spill contingency plans, basically built ships, wharf, port, sea area, National 5 grades oil emergency response system. The system will be the protection of the marine environment security, emergency response, damage compensation theory and Chinese actual situation closely together, it is the first system engineering which is guiding national waters range against the major marine pollution accidents, scientific, forward-looking, practical and operable. At the same time, the system can also support the establishment of cleaning power of "government leadership, social participation, market operation", can be a decontamination unit to guide the operation

of the market, and make full use of salvage, port, cleaning equipment manufacturers can use the resources and strength, so that let the decontamination capacity in China to a new stage the near future.

It is also a efficient measure that enhanced crew, including ship company personnel's marine environmental consciousness. The authorities in the training and examination of crew, the ship company personnel , in addition to professional knowledge, but also should strengthen the education of marine environmental protection consciousness, strengthen the enforcement of give publicity to preventing marine pollution in "United Nations Convention on the law of the sea", "the people's Republic of China Marine Environmental Protection Law", "the ship pollutant discharge standards" and other public conventions, laws, regulations and standards. Let the crew, the ship company staff are fully aware of the significance of the protection of the marine environment, take the initiative to strengthen ship equipment maintenance work, strengthen the management of the ship pollutants, consciously establish the prevention and control of marine pollution, protection of the marine environment of the legal concept.

In order to strengthen the enforcement of preventing marine pollution, building or improving the port or wharf antifouling receiving equipment is needed. In order to prevent and reduce the pollution of the marine environment of the ship pollutants, country, port authorities, port owners should be expansion by equity trading in more ways, taking "the form of who owns investment" or government subsidies, build or improve port or wharf receive processing equipment, so that can make up the coastal port or wharf in China lack or shortage of antifouling receiving equipment.

In addition to the methods mentioned in the foregoing paragraphs or chapters, strengthen the prevention and control of marine environment pollution from ships supervision, inspection, identification could be another efficient way in preventing

marine pollution.

First, taking sweeping measures in inspection of FSC and PSC.

a.To strengthen pollution prevention certificate and documents on the ship inspection, focus on examination of the direction in which the ship pollutants have gone.

b. To strengthen pollution prevention equipment on ship inspection, which do not meet the requirements of the Convention, laws and regulations, demand the immediate rectification.

c. Enforce the punishment. In violation of regulations or cause marine environment pollution in China in accordance with the relevant laws, rules and regulations shall be punished. Practice has proved that FSC and PSC eliminate the low standard operation of the ship in combat, plays a very important role in the protection of the marine environment, and achieved good results.

Second, With the sea area, including the effective supervision of the port area, adjacent to the territorial sea, exclusive economic zone, outside the area at present, maritime authorities rely mainly on the implementation of supervision by Sea Patrol boats, limited to patrol density, ship tonnage and endurance, wind level factors, simply can not find the ship in waters adjacent area the territorial sea, exclusive economic zone, the violation of laws and regulations such as pollution prevention act.In July 2005, with the "the first Chinese Maritime ship " reputation of the "sea patrol boat service 31", has been to the adjoining area of the South China Sea, the East China Sea and the Yellow Sea waters and exclusive economic zone international routes, offshore construction operation zone, oil and gas platforms and offshore lightering operations in the cruise supervision, it marked the improvement of Chinese

monitoring ability on the waters contiguous zone, exclusive economic zone, the territorial sea, marine environmental protection.

Third, To carry out a wide range of oil spill "oil" identification, find which ship causes the trouble accurately."Oil fingerprinting spectrum," is the name of oil chromatogram image, like human fingerprints, it is unique.Oil spill identification is a kind of oil spill source through a variety of analysis were suspected,which will test a "fingerprint" characteristics and pollution of water environment of oil spill "oil fingerprinting" feature on the ship, to determine the pollution of water environment.It effectively makes up the deficiency of other means of investigation, to ensure the accuracy and scientific of accident, widely used in oil spill pollution accident investigation and handling. It is not only one of the important means of science and technology of ship oil spill source identification, but also for further processing and accident claims, provide strong evidence to support the legitimate.

4.3 Policy Solutions

Along with the development of shipping industry, marine pollution is more and more serious and occupy a considerable proportion in the antifouling system. For the prevention of pollution from ships, China has joined the International Convention for the prevention of pollution from ships related international conventions, these are:International Convention For The Prevention Of Pollution From Ships;Marpol,Oil Pollution Preparedness, Response And Co-Operation, 1990,International Convention On Civil Liability For Oil Pollution Damage,Which made some specific provisions for the prevention of pollution from ships, oil spill emergency treatment and international cooperation, oil spill pollution civil compensation , mainly suitable for ships in Chinese vessels which do international navigation and the vessels which sail in Chinese state.At the same time, China has also promulgated the national laws and

regulations about prevention the marine pollution,there mainly has:Environmental Protection Law,Marine Environmental Protection Law,Air Pollution Prevention Law, Solid Waste Pollution Prevention And Control Law,Environmental Noise Pollution Prevention Law,Prevention Of Pollution From Ships Sea Supervision Management Ordinance ,Water Pollution Prevention Law Implementation Rules, With Respect To The Prevention Of Pollution Of The Environment Management Ordinance,The Ship Pollution Emission Standards,Prevent Garbage From Ships And Coastal Waters Of The Yangtze River Pollution By Solid Waste Management Regulations,Hanging Paddle Boat Noise Limits And Measurement Methods,These mainly applicable Chinese vessels which do non-international sailing,vessels of foreign nationality and vessels without nationality. These international conventions and domestic laws are regulated together and constitute the framework of ship pollution prevention legal system of China, at the same time ,reach a basis for Chinese futher prevention marine pollution.

To prevent and control marine pollution, the regulations policy of governments and organizations is essential.The Ministerial meeting of the Ministry of transport passed The Regulations of the pepole's republic of china governing control and prevention of marine pollution from ships and ship-related operations in 2010 and be effective from February 1, 2011.

4.4 Operation Solutions

Just make relevant policy is not enough, it also need strong supervision and execution.

In marine pollution accidents , although operational emissions not so serious as accidental discharge, the frequency of its occurrence is far higher than the accidental

release, and at the same time, the crew is intentional or unintentional violation emissions.Pollution from operational emissions contact with the human factor is very close, it can not be ignored.

In definition, operational pollution refers to the violation emissions pollution caused by the crew during the operation of the ship.For example,some will deliberately discharged tank washings which containing harmful substances into the ocean, some crew will contain the oil cabin of untreated sewage discharged into the ocean intentionally ,otherwise because of fuel additive, lightering operation negligence to stagger the valve, oil tank full spillover fuel which will discharge oil into the sea.The above shows the relations between ship operational pollution and factors of human is very close. It is the operation of the ship's crew let some matter or energy into the marine environment (including the estuary),directly or indirectly, that product the harmful effects which are the resources of damage of biological, which endanger human health, prevent various marine activities include fishing activities, destroy the seawater using quality and comfort.

At present, in the carriage of goods by sea, species and quantity of dangerous goods and is increasing. According to statistics, in the international maritime trade, dangerous goods account for about half of total. Combustion, explosion, corrosion, toxicity and radiation characteristics of dangerous goods are all having great potential danger for safety of ship, cargo and port facilities. If not be properly managed, these will cause pollution damage to the environment and biological. Especially, with the development of petroleum and chemical industry, shipping of dangerous goods and chemical products increasingly high proportion. And at the same time, most of the chemical products have the characteristics of corrosion, toxicity, so the use of toxic chemicals or carrying toxic, corrosive air leakage or containing such substances in the sewage discharged into the sea, will pollute the sea. It has also become a neglected

source of pollution which caused by the leakage of petroleum products of marine pollution. This situation has caused the attention of international community, especially the attention of shipping industry. The protection of the marine environment has become the topic which takes the common concern of many people. Many countries have taken security measures, including through legislation and international convention to strengthen the management of dangerous goods, try to let the damage of dangerous goods to a minimum. As the ship departments should do a good job in pollution prevention work during transport the dangerous goods, they must understand the international and domestic legal provisions, so that, they can advise the prevent pollution of dangerous goods work during the operation of ships.

Increasing number and tonnage of the vessel, directly affect the amount of various substances from the ship pouring into the sea, these substances are discharged pollutants operation in the operation of the ship, are making harmful effects on marine organisms, for example,

a. The bilge water pollution. In order to ensure the normal operation of the ship power plant, water as cooling medium is needed. Because the system is not perfect enough, some of the cooling water will leak into the engine room bilge, and then mixed with all kinds of pollutant (such as leakage oil) or other contaminated water, and then become the bilge water. The bilge water is once source of pollutant that all kinds of vessels may have.

b. Cargo hold washing water pollution. Especialy, liquid cargo ship (oil, liquid chemicals in bulk cargo ship).In order to achieve the clean degree the goods transport conditions requires , or because of the need to hold repair maintenance, it often need to use water or detergent to wash the hold.The washing water contains oil, chemicals, toxic substances or detergent. Washing water is a major source of pollution in ship

pollution.

c. The life and health water pollution.The ship also need to meet the crew's daily life, passengers' daily life and sanitary water, sometimes also should satisfy the needs of animal.In this case, the influence of ship on the ocean environment of organic waste depends on the amount of the domestic sewage, and may carry a variety of pathogenic microorganisms and parasites.Too much organic waste will damage the balance of oxygen in seawater. Untreated sewage treatment which pouring into the sea will have adverse effects on the marine environment.

d. Garbage pollution. The ship production waste (dunnage, packaging materials, oil, rust, oil cotton yarn), crew, passengers life garbage (food residue, packaging and consumer goods such as the waste), if these are discharged into the sea, will not only affect the marine fishery production and other offshore activities and other marine life, but also affect the growth and development and reproduction of fish and shellfish and then bring the destruction of marine environment.

e.The pollution to the air ship. Power plant exhaust particulate incomplete combustion in the exhaust gas, that the combustion products with harmful chemical composition, volatile hydrocarbon gases discharged the cargo area, loss of the ozone layer and the marine freon refrigerant and 1301, 1211 fire extinguishing agent and so on, these all have different levels of air pollution, in recent years has attracted more attention.

Chapter 5 Conclusion

5.1 Summary of this paper

This paper firstly elaborates the denfinition of green economic.

And then summarizes the status of the marine pollution in this green economic period and elaborates the problems and the risks we face, from four respects, pollution from ship's antifouling paint, pollution from excess carbon emissions, pollution from dumping and illegal sewage and pollution from collision and grounding accident.

Third, the author combined the risk of marine pollution with the Ningbo port HNS pollution model. In this model, it will use some statistical theory, risk management theory, system management theory and mathematical models, from doing some in-depth analysis and research to build the framework of marine pollution prevention and control. And then the author use the grey forcast model to estimate the times of accidents in Ningbo-Zhoushan port in 2013, and then analyse the result.

In the fourth, this paper introduced some possible solutions of these problems and risks in Ningbo-Zhoushan port, such as policy solutions, technology solutions , operation solutions and management solutions.

5.2The conclusion and suggestion of the research

This paper use statistical theory, risk management theory, system management theory and mathematical models, from doing some in-depth analysis of HNS pollution of

Ningbo port and research to build the framework of marine pollution prevention and control to explain the harmfulness of marine pollutants. After the case study of HNS pollution in Ningbo port , we get the conclusions which are shown as follow:

(1) We can get the conclusion from the measure every company takes that establish the green shipping and green economic is the development trend nowadays. But in Chinese there are still no perfect system to prevent marine pollution. Even though I cannot find the newest figure or analysis about marine pollution, the prevent method and the specific data of marine pollution.

(2) The HNS pollution risk analysis in this paper is only a simple example. There are many other pollutants threaten the establishment of green shipping. Through the probability analysis of HNS pollution accident, we can estimate the future number and frequency of HNS pollution accident, so that we can take steps to prevent it or reduce the number of HNS pollution accident or make a plan of control the pollution.

(3) In this paper, we can see that, some companies, such as COSCO, has do some efficient measures to reduce the carbon emission from vessels. But it is not enough. In the long term, as a company, no one can focus on establish the green shipping without worrying about the cost. So people should find more efficient ways to reduce the pollution emission and reduce the frequency of ship accidents.

So I wish that this paper or other connected paper can keep people's eyes on the establishment of green shipping which become a pressing matter of the moment nowadays. The related enterprises and scholars should gradually perfect marine management, especially the hazardous material transportation management. And at the same time, the scientist and the technicians should do their best to improve the

technology used in marine transportation. So that really promoting the Chinese green shipping development.

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