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WORLD MARITIME UNIVERSITY

Dalian, China

**ANALYSIS AND RESEARCH OF THE SYSTEM
FOR THE PREVENTION AND CONTROL OF
VESSEL-INDUCED POLLUTION IN
SHANGHAI PORT**

By

WANG LONGXUE

The People's Republic of China

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

**MASTER OF SCIENCE
(MARITIME SAFETY AND ENVIRONMENTAL MANAGEMENT)**

2017

DECLARATION

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

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

(Signature): Wang Longxue

(Date): June 29, 2017

Supervised by:

Cheng Dong

Professor of Dalian Maritime University

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First of all, grateful acknowledgement is made to my supervisor, Professor Cheng Dong, for his instructive advice and useful suggestions on my thesis. I very much admire his profound knowledge and rigorous scholarship which I will model for future study and work.

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Fourthly, I must give my thanks to World Maritime University (WMU) and Dalian Maritime University (DMU), the Maritime Safety and Environmental Management (MSEM) jointly held by them give me the platform to systematically learn the professional knowledge which has laid a solid foundation for my future work.

The last but not least, I also owe a special debt of gratitude to all professors had taught me in the MSEM 2016 program. I learned a lot from them this year. Their profound knowledge broadened my horizons and their professional and critical attitude benefit me forever

ABSTRACT

Title of research paper: **Analysis and Research of the System for the Prevention and Control of Vessel-induced Pollution in Shanghai Port**

Degree: **MSc**

This research paper is a study on the system for the prevention and control of vessel-induced pollution in Shanghai port. In recent years, Shanghai port has been committed to the prevention and control of vessel-induced pollution and the basic anti-pollution system has been established. However, in the present anti-pollution system, there are still many outstanding issues that restrict the comprehensive prevention and control of vessel-induced pollution, resulting in the severe pollution situation caused by ships in Shanghai port waters.

The comprehensive prevention and control of vessel-induced pollution is a systematic project, which should not only achieve the objective of comprehensive control of all the potential pollution caused by ships, but also emphasize the whole process of prevention of the pollution incident. This paper carries out integrated research on the prevention measures on potential ship-source pollution and countermeasures of emergency response, investigation and compensation mechanism after the pollution incidents.

The outstanding issues existing in present anti-pollution system seriously restrict the comprehensive prevention of ship-source pollution and overall protection of the marine environment. Hence in order to improve the present anti-pollution system in Shanghai port, the prominent problems are deeply analyzed and the corresponding practical recommendations are finally put forward on the basis of drawing on the experience and good practices in combating the vessel-induced pollution at home and abroad.

KEY WORDS: Pollution; System; Prevention and Control; Vessel-induced; Ship-source; Shanghai port.

TABLE OF CONTENTS

DECLARATION	i
ACKNOWLEDGEMENTS	ii
ABSTRACT	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vi
LIST OF FIGURES	vii
LIST OF ABBREVIATION	viii
Chapter1: Introduction	1
1.1 Background	1
1.2 The objectives of the research.....	2
1.3 Methodology	3
1.4 The innovation of the research.....	3
Chapter2: The basic conditions of Shanghai port	4
2.1 Port waters and infrastructure	4
2.2 Cargo handling capacity of shanghai port.....	6
2.3 The particularity of the water environment.....	6
2.3.1 <i>Drinking water source protection area</i>	6
2.3.2 <i>Marine natural reserves</i>	7
2.3.3 <i>Fishery</i>	7
2.3.4 <i>Coastal tourism districts</i>	7
2.4 Statistics of vessel-induced pollution incidents in Shanghai port.....	7
2.5 Status quo of marine environmental conditions in Shanghai port.....	9
2.6 Air quality conditions in Shanghai port	11
Chapter3: Vessel-induced pollutions to the port waters	12
3.1 Pollution by oil	13
3.2 Pollution by HNS	13
3.3 Pollution by garbage from ships.....	14
3.4 Pollution by sewage from ships	15
3.5 Pollution by exhaust gas from ships.....	15
3.6 Pollution by ballast water from ships.....	16
Chapter4: The present system for prevention and control vessel-induced pollution in Shanghai port	17
4.1 Legal sub-system.....	17
4.1.1 <i>International Conventions</i>	18
4.1.2 <i>Domestic laws and regulations</i>	23
4.2 Governing bodies and law enforcements.....	28
4.3 Reception Facilities.....	31
4.4 Emergency response to pollution incidents	31
4.5 Investigation mechanism for pollution accident.....	32
Chapter5: Issues existing in the present anti-pollution system	33
5.1 The defects of present legislation system.....	34
5.1.1 <i>Insufficient implementation of the international conventions</i> ..	34
5.1.2 <i>Imperfect laws and regulations</i>	35

5.1.3 <i>Imperfect legal provisions on the compensation mechanism</i>	35
5.2 Seriously lack of reception facilities.....	36
5.3 The imperfect monitoring system	37
5.4 The issues existing in maritime law enforcement	38
5.4.1 <i>Poor consciousness of marine environmental protection</i>	39
5.4.2 <i>Too many regulatory authorities</i>	39
5.4.3 <i>Poor Comprehensive quality of the law enforcement officer</i>	39
5.4.4 <i>Backward Enforcement Devices</i>	40
5.5 The neglect of the ballast water pollution.....	41
5.6 Issues in the prevention of air pollution.....	42
Chapter6: Recommendations for the establishment and improvement of the system for the prevention and control of vessel-induced pollution	43
6.1 Assessment of the environmental conditions.....	44
6.2 Perfection of the legal system.....	45
6.3 Improvement of the ship-source pollution monitoring system.....	46
6.4 Provision of adequate reception facilities.....	48
6.5 Establishment of a sound compensation mechanism for ship-induced pollution damage.....	49
6.6 Promotion of the technological level for control of ship-source pollution.....	49
Chapter 7 Summary and Conclusion	51
REFERENCE	53
APPENDIX	57

LIST OF TABLES

Tab.1	Statics of the main air pollutants from ships in 2010	11
Tab.2	Relevant international conventions for prevention of vessel-induced pollution	22
Tab.3.	Domestic Laws and Regulations for prevention of vessel-induced pollution	27
Tab.4	List Pollution Accident Classification	33
Tab.5	The relevant regulations on reception facilities in the Annexes of MARPOL convention	37
Tab.6	The provision of reception facilities under domestic laws or regulations	37
Tab.7	Archival filing of units of entities engaged in the reception of various vessels' wastes in Shanghai port	37

LIST OF FIGURES

Fig.1	Shanghai port waters	5
Fig.2	The quantity of above-scale terminals in Shanghai port	5
Fig.3	The quantity of terminals with tonnage capacities of over 10,000 tonnes in Shanghai port	6
Fig.4	Statistics of vessel- induced pollution incidents in Shanghai port from 1999 to 2011	8
Fig.5	Statistics of oil spill from ships in Shanghai port from 1999 to 2013	9
Fig.6	Schematic diagram Marine ecological environment monitoring stations in Shanghai in 2015	10
Fig.7	The proportion of four grades of sea water quality in Shanghai	10
Fig.8	The proportion of four grades of sea water quality in Shanghai	11
Fig.9	Governing bodies and law enforcements in Shanghai port	29
Fig.10	The emergency response mechanism in Shanghai port	32
Fig.11	The frame diagram of the system for the prevention and control of vessel-induced pollution	44
Fig.12	The planning construction of ship-source pollution monitoring system in the key water areas in Guangdong	48

Abbreviations

BWMS convention	International convention for the control and management of ship's ballast water and sediment, 2004
CCTV	Closed-circuit television
CLC	Civil Liability Convention
DMU	Dalian Maritime University
DPM	Diesel particulate matter
GB:	Guo Biao (National standard of PRC)
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Pollution
HNS	Hazardous and Noxious Substances
IMO	International Maritime Organization
ISO	International Organization for Standardization
MEPPRC	Ministry of Environment Protection of PRC
MOT	Ministry of Transport
MSA	Maritime Safety Administration
MSAPRC	Maritime Safety Administration of PRC
NLS	Noxious liquid substance
NOx	Nitrogen Oxides
NPC	National People's Congress
OILPOL1954	The International Convention for the Prevention of Pollution of the Sea by Oil, 1954
OPRC, 1990	International convention on oil pollution preparedness, response and co-operation, 1990

OPRC-HNS Protocol	Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000
PM10	Particulate Matter 10
PM2.5	Particulate Matter 2.5
PRC	People's Republic of China
PSC	Port State control
SCNPC	Standing Committee of the National People's Congress
SEPB	Shanghai Environmental Protection Bureau
SEQB	Shanghai Marine Environmental Quality Bulletin
SHMSA	Shanghai Maritime Administration
SMG	Shanghai Municipal Government
SMMAB	Shanghai Municipal Marine Affairs Bureau
SOx	Sulphur oxides
TEU	Twenty-foot Equivalent Units
UN	The United Nations
UNCLOS	United Nations Convention on the Law of the Sea
VOCs	Volatile organic compounds

CHAPTER 1: Introduction

1.1 Background of research

Shipping plays an irreplaceable role in the development of the world economy and it is generally accepted that more than 90 per cent of global trade is carried by sea (IMO, 2012). However, while shipping brings benefits to human, it inevitably results in the issues of marine environmental pollution. Under the definition of UNCLOS, pollution of the marine environment refers to the introduction by man of substances or energy into the marine environment, which results in harm to living resources and marine life, hazards to human health, hindrance to marine activities, impairment of quality for use of sea water and reduction of amenities (UN, 1982). The operating ships produce a large number of pollutants involving oil, oily waters, sewage, garbage, noxious liquid substances (NLS), ballast water with harmful organisms and pathogens, as well as the exhaust gas and the operational discharge or accidental release of these wastes from ships into waters will unavoidably generate marine environmental pollution issues.

With the development of Shanghai economy and the accelerating pace of the construction of Shanghai International Shipping Center¹ forward, coupled with the unique geographical position, in recent years, Shanghai port has experienced rapid development and become one of the largest and busiest international ports in the world. In 2016, it totally handled 707 million tones cargoes and 37.13million TEUs, making it rank first in the world in terms of container throughput for the 7th consecutive year². However, the economic advance of Shanghai port has to pay a price. Presently, due to the frequent pollution incidents caused by ships and the random discharge of the pollutants from ships, Shanghai port is undergoing the ever deteriorating marine environmental quality of the port waters and facing the increasingly serious vessel-induced pollution issues. The negligent, deliberate, or

¹ The construction of Shanghai International Shipping Center started in 1996 and is planned to be completed by 2020. With the deepening of the construction of Shanghai International Shipping Center, the development of Shanghai Port has greatly promoted.

² In 2010, Shanghai completed container throughput of 29.05 million TEUs, exceeding Singapore (with container throughput of 27.68 million) for the first time, ranking the world's largest port.

accidental release of oil and other harmful substances from ships have become a serious source of pollution to the port waters. With the purpose to secure sustainable development of Shanghai port, the vessel-induced pollution must be comprehensively prevented. And in recent years, Shanghai port has been committed to a comprehensive prevention and control of the pollution caused by ships to the port waters and the basic anti-pollution system has been established. However, from the monitoring results of the increasingly worsening marine environment, the status on the implementation of the anti-pollution system is not ideal in general, still remains many issues. Hence, it is necessary to carry out study on the assessment of the present anti-pollution system to explore the outstanding problems, providing the practical suggestions for improving and perfecting it.

Additionally, as a law enforcement officer engaging in the work of anti-pollution, through my own work practice for many years, it is recognized that the marine environment should be considered as a whole and in order to effectively protect it, the comprehensive system for the prevention and control of vessel-induced pollution shall be established in the port.

1.2 The objectives of the research

There are four main purposes for this paper. Firstly, based on the analysis of actual conditions in Shanghai port, the severe situation of vessel-induced pollution in Shanghai port and the urgency of measures to be taken are recognized. Secondly, through the deep analysis of the present anti-pollution system, the outstanding issues existing in the present anti-pollution system are identified. Thirdly, with the purpose to comprehensive prevention of vessel-induced pollution and overall protection of the marine environment, the practical suggestions are provided to improve the present anti-pollution system which is imperfect. Fourthly, through the systematic learning of the Maritime Safety and Environmental Management (MSEM) this year, I have acquired the comprehensive knowledge on the prevention of vessel-induced pollution

and I realize that the most importance of learning knowledge is to apply it in practice. I try to use this knowledge I have learned this year to conduct the research on the actual environmental management in Shanghai port.

1.3 Methodology

The methods used in the present study include literature research, comparative analysis, systems analysis and other research methods. Firstly, regarding literature analysis method, a documentary analysis is conducted on the research papers and the relevant international conventions and domestic laws and regulations. Based on the full absorption of the research results, it can sort out the relevant theoretical knowledge on the comprehensive prevention of ship-source pollution in Shanghai port waters. And also, following a complete and thorough review of the literature on prevention and control of ship-source pollution, the issues can be found and the targeted measures can be provided. Secondly, as for systems analysis, an integrated analysis is performed on the potential pollution caused by ships and through the comprehensive structure analysis of the present anti-pollution system in Shanghai port, the study aims to find the outstanding problems needed to be solved. Thirdly, concerning comparative analysis, by comparing and absorbing the good experience and practice at home and abroad, the recommendations for the improvement of the present anti-pollution system in Shanghai port are provided.

1.4 The innovation of the research

System is a holistic concept and a system is a regularly interactive or interdependent group of items forming a unified whole³. From the angle of system theory, the marine environment is a systematic and holistic concept⁴, including sea water, sediment, marine organisms and the atmosphere above the sea and each part is polluted can be

³ The wikipedia web site gives further information on courses: <https://en.wikipedia.org/wiki/System>

⁴ According to the constituent elements, the ocean is consisted of sea water, sediment, marine organisms and the atmosphere above the sea. And also for the need for holistic protection of the marine environment and convenience of research, the atmosphere above the ocean environment is regarded as an integral part of the marine environment in this paper.

regarded as harm to whole marine environment. The protection of the marine environment is also to protect the marine environment as a whole, rather than only one or some of aspects. In addition, the pollution caused by ships to the marine environment and the corresponding prevention and control measures taken therefrom should also be considered as a whole. However, to date, the researches on the vessel-induced pollution generally focus on one or several aspects such as oil, oily waters, garbage or sewage, etc. Few overall studies have been carried out. The innovation of this paper is that the holistic research on the measures for the prevention of vessel-induced pollution is carried out following the overall study of all the main potential pollution caused by ships, aiming to explore the countermeasures to establish and perfect the anti-pollution system to achieve the goal of holistic protection of marine environment in Shanghai port.

CHAPTER 2: The basic conditions of Shanghai port

2.1 Port waters and infrastructure

Shanghai port is located in the east of China's mainland coastline, where the Yangtze river meets the east China sea, latitude 31 degrees 14 and longitude 121 degrees 29. The water area of Shanghai port is 3613 square kilometers, including the Huangpu river, Shanghai section of Yangtze River and Shanghai sea area, as shown in Fig.1. There are four major waterways in Shanghai port: Yangtze Estuary Channel, Hangzhou bay Deepwater Channel, Huangpu river channel and Yangshan port channel (Fig.1). The coastline of the Shanghai port is 280 kilometers and at present, there are totally eight port districts⁵. With the three phases of Yangshan port (phase I , phase II, phase III) putting into use putting into operation in recent years , Shanghai port has experienced rapid expansion. The construction of port infrastructure has been continuously improved and the function of port area and the

⁵ The eight port districts in Shanghai port are consisted of the three ports in the upper, middle and lower reaches of Huangpu River, Baoshan port, Waigaoqiao port district, Hangzhouwan port district, Yangshan Deepwater Port and Chongming port.

structure of berths have been optimized. As shown in Fig.2 and Fig.3, after the majority of terminals above a designated scale experiencing exponential growth from 2007 to 2008, the ship berthing capacities of the Shanghai port are greatly improved. There are nearly 1300 major terminals above a designated scale now, 190 of which have tonnage capacities of over 10,000 tons by the end of 2015. Among these terminals, according to the statistics of Shanghai Maritime Safety Administration (SHMSA), there are 50 terminals engaged in the handling of hazardous and noxious cargoes.

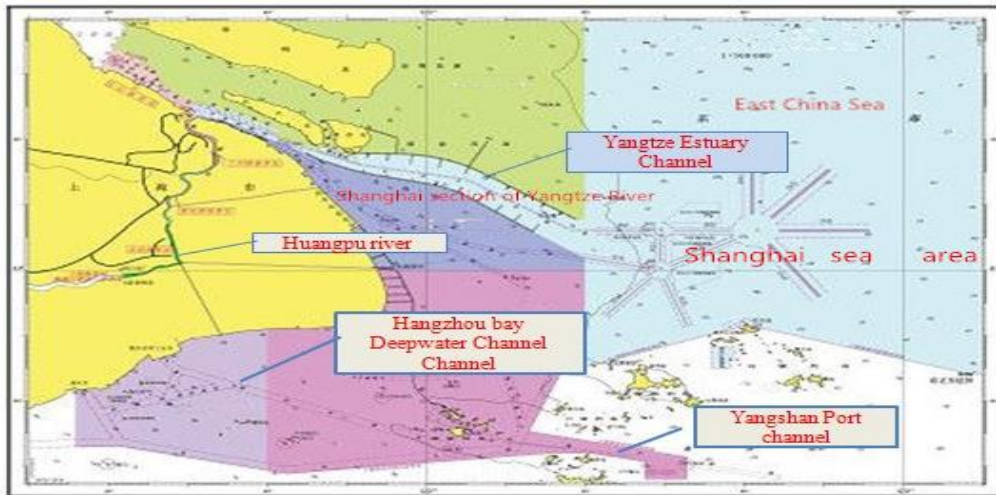


Fig.1 Water areas under the jurisdiction of Shanghai Port

Source: <http://www.shmsa.gov.cn/>

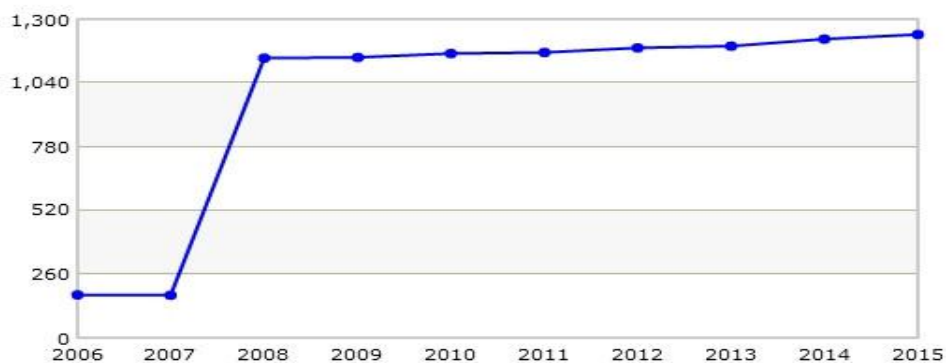


Fig.2 Statistics of terminals above a designated scale in Shanghai port from 2006 to 2015

Source: <http://www.shippingdata.cn/index.html>

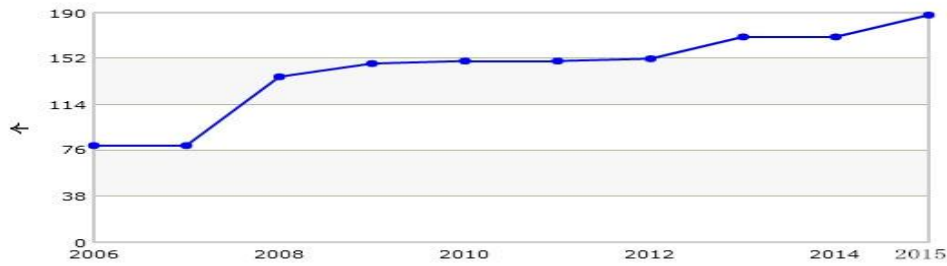


Fig.3 Statistics of terminals with tonnage capacities of over 10,000 tonnes in Shanghai port from 2006 to 2015

Source: <http://www.shippingdata.cn/index.html>

2.2 Cargo handling capacity of Shanghai port

With the rapid development of Shanghai economy and the accelerating pace of the construction of Shanghai International Shipping Center forward, the cargo handling capacity of shanghai port is increasing year by year. According to the statistics of Ministry of Transport of PRC (MOT), in 2016, it totally handled 707 million tonnes cargoes and 37.13million TEUs, making it rank first in the world in terms of container throughput for the 7th consecutive year. These achievements can not be made without the countless operating ships from home and abroad in the port waters. According to statistics of SHMSA, Shanghai port received more than 560 thousands ships in 2016, including 91.25 thousand of large and medium type and 20.8 thousand foreign ships, an average of nearly 250 ships of large and medium type operating in the port per day (SHMSA, 2016). So many ships operating in the port waters produce a large number of wastes every day, which generate high pollution risk to the marine environment. If these wastes or effluents containing harmful substances are discharged from ships into port waters, the marine environment in Shanghai port will be serious polluted.

2.3 The particularity of the water environment

2.3.1 Drinking water source protection area

Shanghai port waters are the important drinking water sources for the citizens and there are four main drinking water source protection areas, including the drinking

water sources of the upper reach of Huangpu River, Qingcaosha, Chenhang, Chongming Dongfengxisha, and other drinking water sources (SMG, 2009). These drinking water sources bear the task of supplying water for production and daily life for 26 million people in Shanghai Municipality. If the port waters are contaminated, the safety of drinking water for residents will be seriously affected.

2.3.2 Marine natural reserves

In order to protect the marine biodiversity and prevent deterioration of marine ecological environment, four main marine natural reserves are established in the Shanghai port waters. There are two national reserves including Chongming Dongtan wetland reserve and Jiuduansha shoal wetland reserve and two provincial nature reserves including Jinshan three-islands reserve, comprising of Da Jinshan island, Xiao Jinshan island and Fushan island, and Chinese sturgeon reserve in Yangtze Estuary.

2.3.3 Fishery

Shanghai port waters are the important habitat for fishes and the sea area is the largest estuarine fishing ground in China and there are more than 250 types of fish species, such as whitebait, hilsa herring, coilia ectenes and eriocheir sinensis, etc.

2.3.4 Coastal tourism districts

There are many coastal tourism districts in Shanghai port. The main ones include Pudong-Nanhui coastal tourist area, Fengxian Bay tourist resort, Jinshan seaside tourist area, Wusongkou Paotai Bay Wetland Park.

2.4 Statistics of vessel-induced pollution incidents in Shanghai port

Shanghai port, one of the busiest ports in the world, has thousands of ships operating

in the harbor every day and the potential risk of ship-source pollution accidents is very high. Due to a large number of oil or other harmful substances spill into waters in a short time, the accidental pollution is more harmful to the water environment. And the historical statistics of ship-source pollution incidents in Shanghai port can contribute to understanding the degree of marine environmental damage caused by vessels. From 1999 to 2013, as outlined in Fig.4 and Fig.5, a total of 231 oil or chemical pollution accidents happened, resulting in the leakage of 5391.5 tonnes of oil and chemicals into the port waters, which cause serious harm to the marine environment (Chen, 2015). On August 5, 2003, the Changyang vessel fuel oil spill accident resulted in the leakage of 85 tonnes of fuel oil into the drinking water source protection area in Huangpu river and caused large-area pollution, which seriously affected the safety of drinking water for the public. Moreover, in recent years, with the tendency of large-scale ship, the oil spill in single accident has also increased. In 2013, the oil pollution accident of British container ship named *CMA CGM Florida* resulted in 613.2 tonnes of fuel oil leaking into the Yangtze Estuary, bringing about disaster to the local marine environment.

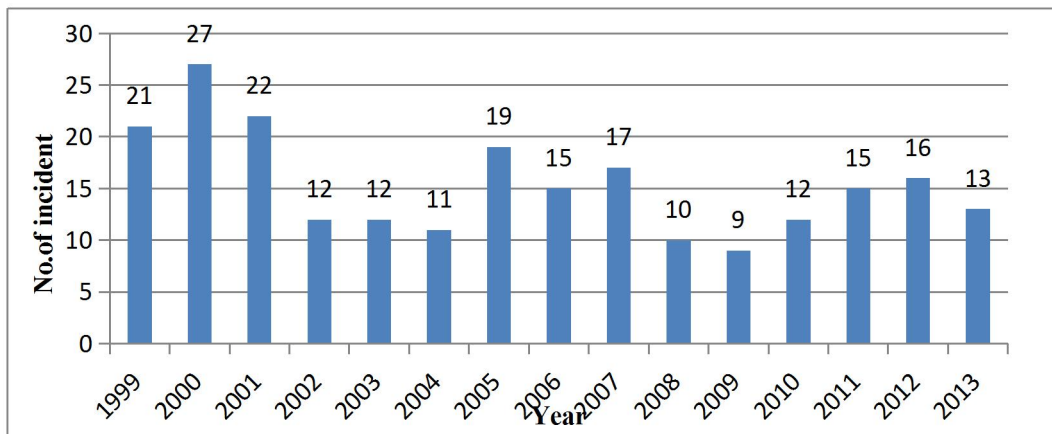


Fig.4 Statistics of vessel- induced pollution incidents in Shanghai port from 1999 to 2013

Source: Chen, W. (2015). Study on Risk Assessment of Oil Spill Oil Pollution Accident in Shanghai Port

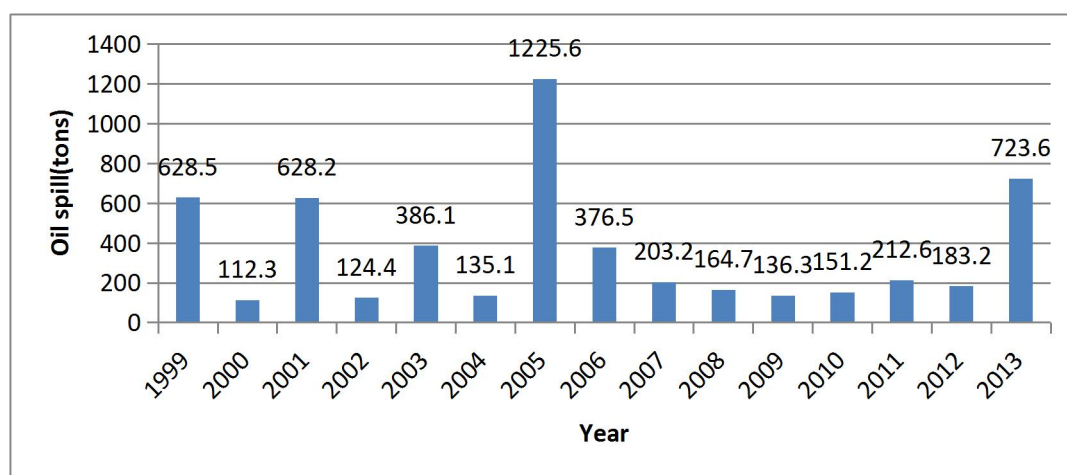


Fig.5 Statistics of oil spill from ships in Shanghai port from 1999 to 2013

Source: Chen, W. (2015). Study on Risk Assessment of Oil Spill Oil Pollution Accident in Shanghai Port

2.5 Status quo of marine environmental conditions in Shanghai port

Currently, the poor quality of marine environment, seriously damaged marine ecology and high potential risks of vessel-induced pollution are the three serious issues facing Shanghai port. Vessel-induced pollution not only damages or causes harm to marine lives and corals, etc., and their habitats, but also affects and harms the local residents (Du, 2017). In order to study and assess the overall situation and the variation tendency of the marine environment, Shanghai Municipal Marine Affairs Bureau (SMMAB) set up 307 environmental supervision stations (Fig.6), in water areas in Shanghai in 2015, monitoring more than 17,200 square kilometers of sea areas. Based on the monitoring data, the marine environmental pollution situation is intensive in Shanghai port (Lun, Tian, He, 2017). In May, 2016, *Shanghai Marine Environmental Quality Bulletin, 2015* (SEQB,2015) was published by SMMAB and it indicates that the sea areas of grade I, grade II, grade III, grade IV which are defined in *Sea Water Quality Standards of PRC (GB 3097-1997)*⁶ accounts for 2.8%, 6.8%, 5.5% and 7.6%, respectively, and the areas of the sea water inferior to Grade IV which means sea water quality is worse than Grade IV accounts for 77.3% (SMMAB, 2016), as shown in Fig.7. And according to SEQB, the areas of sea waters inferior to

⁶ *Sea Water Quality Standard of PRC (GB 3097-1997)* was issued in 1997 and according to the different use of sea areas and protection objectives, it divided the quality of sea water into four categories

Grade IV mainly distribute in the north and south branch of the Yangtze River Estuary and the whole sea area of Northern Hangzhou Bay, where the density of operating vessel is very high, and the areas of sea water of grade I are mainly located in the areas off the Yangtze Estuary where the operating ships are fewer.

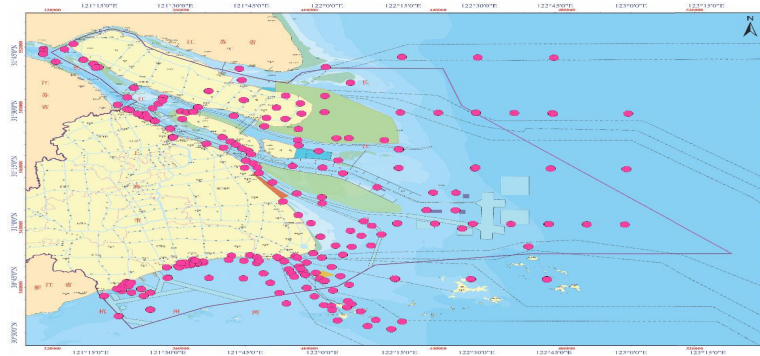


Fig.6 Schematic diagram Marine ecological environment monitoring stations in Shanghai in 2015
Source: SMMAB. (2015). Shanghai environmental quality bulletin

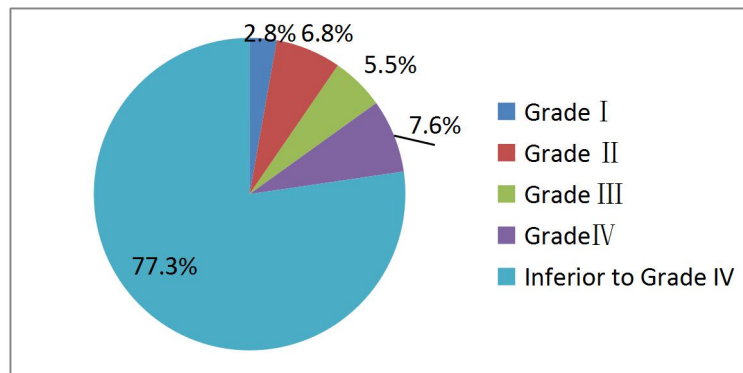


Fig.7 The proportion of four grades of sea water quality in Shanghai
Source: SMMAB. (2015). Shanghai environmental quality bulletin

China Coastal Waters Environment Quality Bulletin, 2015, published by Ministry of Environment Protection of PRC (MEPPRC) in August, 2016, even gave a worse result. The Bulletin indicates that the quality of Shanghai coastal waters is extremely poor. There is no grade of sea waters and the grade II, grade III, inferior to grade IV⁷ accounts for about 20%, 10% and 70%, respectively (Fig.8) (MEPPRC, 2016).

⁷ The four grades are also determined under the sea water quality standards of PRC (GB 3097-1997).

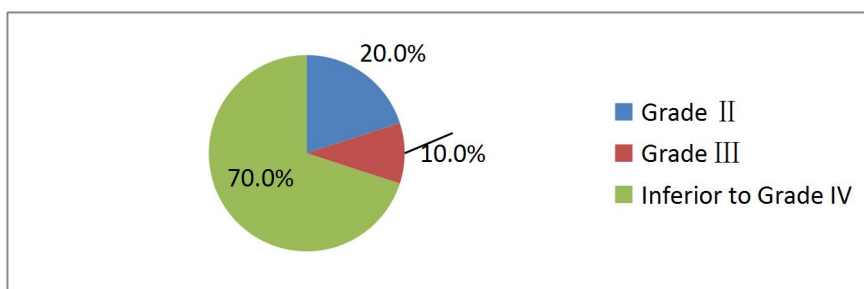


Fig.8 The proportion of four grades of sea water quality in Shanghai

Source: MEPPRC. (2016). Environmental quality bulletin of coastal waters in China, 2015.

2.6 Air quality conditions in Shanghai port

In addition to the worse quality of water, Shanghai is also experiencing serious air pollution and research indicates that emissions from the operating ships in the port have become one of the main sources of air pollution. According to the study carried out by Shanghai Environmental Protection Bureau (SEPB), the total amount of various air pollutants discharged from the operating ships in Shanghai port in 2010 are shown in Tab.1. The three main air pollutants from ships are SO_x, NO_x and PM_x (including PM₁₀ and PM_{2.5}) and comparing to the total inventory of the three basic air pollutants (SO_x, NO_x and PM_x) in Shanghai, the emissions from the operating vessels in Shanghai port accounts for 12.4%、 11.6% and 5.6%, respectively. With respect to the green house gas emissions from ships, which will make the earth warmer, the mentioned above research show that, in 2010, the emissions of CO₂, N₂O and CH₄ are 2,885,500 tons, 100 tons and 40 tons, respectively. Hence, Ship emissions have become one of the important sources of air pollution in Shanghai and it is urgent to take effective measures to control them.

Tab.1 Statics of the main air pollutants from ships in 2010

Air pollutants from the ships	Emissions(tons)
PM ₁₀	4,600
PM _{2.5}	3,700
SO _x	57,300
NO _x	35,400
CO	4,900
HC	2,100

Greenhouse gas from ships	
CO ₂	2,885,500
N ₂ O	100
CH ₄	40

Source:(Fu, Shen, Zhang, (2012). The Research on Emission Inventory in Shanghai Port

CAPTER3: Vessel-induced pollutions to the port waters

In view of the special nature of marine waters in Shanghai port, coupled with the severe situation of marine environmental pollution, it is urgent to conduct a study on the measures for the prevention of ship-source pollution. In order to all-dimensionally prevent the vessel-induced pollution, achieving the overall protection of the marine environment, a comprehensive understanding of the ways of pollution caused by ships is necessary. The vessel-induced pollution to a port refers to the pollution to the water environment and atmospheric environment caused by ships during navigation, berthing, loading and unloading of goods and dismantling (Wu, 2010). And according to MARPOL convention, the deliberate, negligent or accidental release of oil and other harmful substances from ships constitutes a serious source of pollution to marine environment (IMO, 2011). As for the reasons caused contamination, the ship-source pollution is generally divided into three types: operational pollution, accidental pollution and the pollution caused by dumping of wastes and other matters. Firstly, the operational pollution is mainly caused by intention or negligence of the ship crew. For instance, some seafarers deliberately discharge the contaminated washings containing harmful substances into ocean or some marine engineer release the untreated oily water into ocean on purpose. Secondly, the accidental pollution refers to the pollution induced by accidents or the failure of equipment or hull, such as the marine environmental pollution caused by the leakage of oil or other harmful substance resulting from collision, grounding, stranding, etc. Thirdly, that the wastes and other matters which are generated by production or life of land are transported by ships and dumped into sea will also cause marine environmental pollution. On the basis of the categories of pollutants, the ship-source pollution can be divided into six types, shown as follows:

-
- Oil
 - Hazardous and Noxious Substances (HNS)⁸
 - Sewage
 - Garbage
 - Exhaust gas
 - Ballast water

They will be further analyzed made in this paper.

3.1 Pollution by Oil

Oil refers to the petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products (IMO, 2011). The oil pollution from ships consists of accidental leakage caused by collision, groundings, fire and exploding, etc., and operational discharges, mainly including dirty ballast water, cleaning water, residues (sludge) and bilge water. And based on the estimation of Joint Group of experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) study, the total amount of the oil discharge from ships is estimated to be 457,000 tonnes per year, with accidental and operational discharges accounting for 45% and 36 % respectively, and of the operational discharges, fuel oil sludge from vessels is the major routine operational pollution (186,000 tonnes per year), making up 68% of ship operational discharges (IMO, 2012). For Shanghai port, due to the lack of relevant statistics, it is impossible to make accurate statistics on the discharge of oil originating from the operating ships, but from the oil pollution accidents such as Changyang and *CMA CGM Florida*, and the results from daily monitoring, the ship-source oil pollution in the port indeed cause damage to the marine environment.

3.2 Pollution by HNS

The pollution caused by HNS may come from many aspects and for Shanghai port,

⁸ Hazards and Noxious Substances refer to the following substance other than oil: oil derivatives; liquid substances which are noxious or dangerous; liquefied gases; liquids with flashpoints not exceeding 60°C; packaged dangerous, harmful and hazardous materials; and solid bulk material with associated chemical hazards.

the greatest threat of HNS is noxious liquid substances (NLS). NLS in bulk other than oil, posing a threat of harm to the marine environment are divided into three categories, Categories X, Y and Z (IMO, 2013). There are many kinds of noxious liquid substances (NLS) carried by ships in bulk and the main characters of NLS are of strong corrosion, toxicity, flammability, self-reactivity, thermal sensitivity, etc. If NLS leak into the port water in the process of cargo handling or transit, it will directly result in the deterioration of the environment, biological death, destruction of the environment ecosystem, which will seriously pollute the port waters. According to the statistics of SHMSA the annual throughput of the NLS cargos has reached about 40 million tonnes in Shanghai port. In addition, there are about 10,950 bulk chemical tankers transiting through Shanghai port waters per year. Hence, NLS is also the potential source of pollution for Shanghai port waters.

3.3 Pollution by garbage from ships

MARPOL convention gives the definition of garbage, which means all kinds of victual, domestic and operational waste during the normal operation of the ship and liable to be disposed of continuously or periodically (IMO, 2011, p.245). And the garbage governed by MARPOL convention or Chinese laws includes plastics, food wastes, domestic wastes (e.g., paper products, rags, glass, metal, bottles, crockery, etc.), cooking oil, incinerator ashes, operational wastes, cargo residues, animal carcasses and fishing gear. The discharge of garbage from ships will bring about pollution to the ports waters and many studies have described their lethal and sub-lethal effects on populations of turtles, seabirds, and mammals (Laist, 1997). The floating garbage will worsen the sanitary conditions of the port and cause diseases. And the organic matter in the wastes consumes the dissolved oxygen in water, which weakens the self purification ability of the seawater. In the event a large amount of garbage from ships sinking at the bottom of the port waters will change and destroy the habitat of marine organisms. With respect to the plastic wastes, it will take about 450 years to completely decompose, which can cause long-term damage to the marine

environment.

Another meaning of pollution by garbage from ships will be discussed in this paper is the dumping of refuses which is generated by the production or life on land and transported by ships for dumping. And in 2016, Shanghai port experienced a serious garbage pollution incident which was caused by the intentional illegal dumping of wastes to the port waters. And 10,994.4 tons of household wastes from land were transported by ships and dumped to the Yangtze Estuary, which led to serious pollution to one of the main drinking water source-Dongfeng xisha reservoir and the water intakes had to be closed, affecting the safety of drinking water for millions of people. This incident reminds us, in the process of preventing the ship-generated garbage pollution, we should not only prevent and control the garbage produced by ships themselves, but also the control of illegal intentional dumping of the wastes carried by ships.

3.4 Pollution by sewage from ships

Sewage means drainage and other wastes from any form of toilets and urinals, drainage from medical premises, drainage from places containing living animals and other waste waters when mixed with the drainages defined above (IMO, 2011). The waste waters from the operating vessels in the port waters are considered to be one of the significant sources of the marine environment pollution. The discharge of untreated sewage may not only create a health hazard but also result in oxygen depletion, and for the ports with tourist industries, the floating raw sewages can be obvious visual pollution. Moreover, large amount of untreated wastewater discharged into sea will cause serious eutrophication problem which is an outstanding issue facing Shanghai port now.

3.5 Pollution by exhaust gas from ships

According to MARPOL convention, air pollutants from ships mainly include ozone-depleting substance, SO_x, NO_x, PM and VOCs. On a global scale, the emissions of basic pollutants (SO_x, NO_x and PM) and GHGs (mainly CO₂) from global shipping increased from 585 to 1096 million tons from 1990 to 2007 (IMO, 2009). And the vessel operations at port play a particular role in port-related air emissions (Tichavska, Tovar, Gritsenko, Johansson and Jalkanen, 2017) and due to the urbanized character of many ports, the spatial impact of ship exhaust pollutants is highlighted (Tzannatos,2010). The pollution of air may bring diseases, death or allergies to the local residents and it may also cause harm to other living organisms in the port waters. For Shanghai port , in view of the analysis above, the exhaust pollutants from the operating ships in the port has become the main sources of the air pollution. Therefore, in the process of improving present anti-pollution system in Shanghai port, more attention shall be paid to the control of air pollution.

3.6 Pollution by ballast water from ships

The alleged ballast water pollution not only refers to the harm brought by the pathogens in ballast water, but also issues of alien biological invasion. The uncontrolled discharge of ballast water and sediments from ships has led to the transfer of harmful aquatic organisms and pathogens, causing injury or damage to the environment, human health, property and resources (IMO,2004) .The translocation of marine species around the world via ships' ballast water is a serious threat to fisheries, ecosystems and even human health (Oemcke & Leeuwen, 2003). The biological invasion caused great pressure to the port ecological environment in the past century and ships' ballast water is considered to be one of the primary sources of the spread of alien species. Because the ships' ballast water carries a large number of biological organisms from different bio-geographical areas, the uncontrolled discharge will pose a serious threat to the ecological environment of the waters where the ballast water is discharged. For Shanghai port, it is also facing the high risk of ship ballast water pollution. The study carried out by Zhou Shuhui, who is a researcher working at

Entry-Exit Inspection and Quarantine Bureau, on the red tide alga containing in ship's ballast water of exotic vessels from 2007 to 2011 and the result indicates that 62 kinds of red tide algae generate risk to marine ecosystem of Shanghai port.

CHAPTER 4: The present system for prevention and control vessel-induced pollution in Shanghai port

Based on the analysis in Chapter-2, the pollution caused by ships is diverse and complex, the pollutants from ships involving the oil (including oily waters), sewage, garbage, HNS and exhaust gas, etc. Coupled with the mobility of the ships, comprehensive prevention of ship-source pollution to the marine environment is still a challenging task in the world. In recent years, Shanghai port has been working on the comprehensive control of ship-source pollution and has made great achievement. Presently, the basic anti-pollution system has been established and it plays an irreplaceable role in preventing the ship-source pollution. However, with the development of economy and society, some new issues appear and it is urgent to improve and further modernize the present anti-pollution system. In order to explore the issues, it is necessary to make a thorough and comprehensive analysis of the existing anti-pollution system. With the purpose to review the present anti-pollution system, this paper will carry out the analysis from the following five dimensions: legal sub-system, governing bodies and law enforcements, reception facilities, emergency response, investigation mechanism

4.1 Legal sub-system

Legal system is the basic foundation for combating the ship-source pollution and it defines the basic obligations of environmental protection and the legal consequences of violating acts. As a sovereign state, China has established a relatively perfect legal system, including international conventions, domestic laws and regulations, to prevent and control the pollution from ships. As an important part of China, Shanghai has also formulated local practicable regulations or rules for controlling the ship-source pollution. All these international conventions, domestic laws and regulations and local

regulations are the basis for the establishment and perfection of the present anti-pollution system in Shanghai port. Therefore, in order to explore the existing issues in the legal system, it is necessary to comprehensively analyze these regulations and the concrete discussion will be carried out from the following three levels: international conventions, domestic laws and regulations and local regulations.

4.1.1 International Conventions

The development of international conventions to prevent the ship-source pollution is the main work of IMO and by now, IMO has adopted 21 conventions or protocols on or closely related to environmental protection (Du, 2017), accounting for 42% of all the international conventions or protocols adopted by IMO. Tab.2 shows the main international conventions on prevention, compensation and emergence response of ship-source pollution. Under the provision of IMO Instruments Implementation Code (III Code), each Party has the responsibility to take all other steps to give IMO conventions full and complete effect so as to ensure protection of the marine environment (IMO, 2013). As shown in Tab.2, China has ratified most of the international conventions on the prevention of ship-source pollution and these international conventions are the main legal instruments for the regulation of the foreign ships, and some of them even apply to domestic sailing ships. The main relevant international convention for the control of ship-source pollution will be discussed in the following.

UNCLOS

As the parent law status⁹, the UNCLOS provides guidelines for the IMO and States to take measures to combat the pollution of the marine environment from ships. Under the provisions of UNCLOS, each State has the obligation to protect and preserve the marine environment (UN, 1982). Part XII of it establishes the basic principles for the

⁹ UNCLOS was signed in 1982 and entered into force in 1994 and it is by far the highest level of fundamental law for the adjustment of the marine relationship. It is praised as “constitution for the oceans”.

marine environmental protection and article 219 grants the port State the right to take administrative measures to avoid the pollution from foreign ships and article 226 provides that the port State have the right to investigate the foreign vessels.

MARPOL Convention

MARPOL convention is the most significant comprehensive international convention on the prevention and control of ship pollutions, including accident and operational discharges. With the purpose to prevent the potential pollutions from ships and protecting the marine environment, MARPOL convention establishes general rules on the control of pollution caused by oil, noxious substance in bulk, harmful substances carried by sea in packaged form, sewage, garbage, as well as air pollution. It is comprised of the following six Annexes:

- Annex I : Regulations for the prevention of pollution by oil
- Annex II : Regulations for the control of pollution by noxious liquid substance in bulk
- Annex III: Regulation for the prevention of pollution by harmful substances carried by sea in packaged form
- Annex IV: Regulation for the prevention of pollution by sewage from ships
- Annex V : Regulation for the prevention of pollution by garbage from ships
- Annex VI: Regulation for the prevention of air pollution from ships (IMO,2011)

In the anti-pollution system, MARPOL convention is the most effective legal instrument for the supervision of foreign ships for the port States and the standards and measures stipulate in it are also an important line of defense against the pollution of marine environment. The implementation of MARPOL convention heavily depends on practice of Port State Control (PSC) and it provides that the ships shall be subject to inspection by the authorized officers for the purpose of verifying whether the ship has discharged any harmful substances in violation of the provisions of the regulations when they are in the ports or offshore terminals under the jurisdiction of a Party (IMO, 2011). In addition, all the six Annexes of the convention provide specific measures of control by port States. In the practice of Shanghai port, PSC has indeed greatly contributed to enhanced prevention of marine pollution and it plays an important role

in protecting the marine environment of port waters.

Under the requirements of MARPOL convention, discharge of pollutants from ships into port reception facilities is also an important way to prevent these pollutants going into marine environment and five of the six Annexes stipulate that the port State to provide adequate reception facilities to meet the needs of the operating ships in the port waters. Hence, in the process of establishing a sound system for the prevention and control of vessel-induced pollution, the assurance of sufficient reception facilities shall be one of the main contents of the system.

On July 1st, 1983, China adopted Annex I of MARPOL convention and it entered into force on October 2^{ed}, 1983 and subsequently adopted the series of amendments. And from 1983 to 2006, China has adopted the remaining Annexes from Annex II to Annex VI, and by now, all the six Annexes have taken effect on China. Upon its accession to the MARPOL convention, China has not put forward any reservations on the contents of convention and Annexes, therefore, China shall fully perform the obligations in accordance with the provisions of the MARPOL convention. In Shanghai port, SHMSA is the administration for the implementation of MARPOL convention and , SHMSA can take all measures and steps to ensure the implementation MARPOL convention.

OPRC, 1990

Another dimension of the pollution prevention of the ships refers to the emergency and disposal measures aiming to reduce the damage of pollution accidents as much as possible when the pollution incidents especially serious pollution accidents happen (Wu, 2010, p.7). It is very important to take precautionary measures to avoid accidental pollution of oil in the first instance and in the event of an oil pollution incident, prompt and effective actions are essential to minimize the damage caused by the incidents (IMO,1990) . Based on the lessons learned from the fatal oil pollution accidents, OPRC, 1990 emphasizes the prevention and control measures to reduce

accident damage to the marine environment caused by ship oil pollution incidents. Under the provisions of OPRC, 1990, each Party shall establish a national system for responding promptly and effectively to oil pollution incidents (IMO, 1990) and all the applicable ships and terminals shall develop oil pollution emergency plans. China adopted OPRC,1990 on March,30,1998 and it entered into force for China on June 30,1998. As a party to the convention, China shall fulfill the responsibility under OPRC,1990. And as the administration for the performance of the convention, SHMSA can require the terminals and applicable ships to establish the corresponding oil pollution emergency plans and carry out the supervision on them

OPRC-HNS2000

OPRC-HNS 2000 requires the Parties to establish systems for preparedness and response in combating incidents or threats of marine pollution involving HNS. Under the provisions of OPRC-HNS 2000 the involving ships and ports shall establish pollution incident emergency plan. China is a party to OPRC-HNS 2000 and adopted it on February, 2010. Under the provisions of relevant domestic laws, MSAPRC is designated national authority. As part of MSAPRC, in Shanghai port, SHMSA shall fulfill the responsibilities under OPRC-HNS 2000 to supervise the establishment of pollution incident emergency plan for the involving ships and ports.

1992 CLC PROT

As a perfect system for the prevention and control of ship pollution, there must be a corresponding pollution damage compensation system and CLC is the basis for the establishment of such mechanism. The CLC was adopted by IMO in 1969 and subsequently amended in 1976 and 1992 respectively. The objective of CLC is to ensure the victims of the ship pollution accident get adequate damages and requires the ships carrying more than 2,000 tons of oil shall maintain insurance involving oil pollution damage. This Convention places the liability for such damage on the owner of the ship from which the polluting oil escaped or was discharged. China approved the CLC 1969 and 1976 CLC PROT in 1980 and 1986 respectively, but both of them

are denounced subsequently. And on May, 2001, China approved 1992 CLC PROT. Therefore, for Shanghai port the 1992 CLC PROT is the basis for the establishment of the compensation mechanism for oil pollution damage.

BWM convention

BWMS convention provides support for the port State to eliminate the damages caused by the uncontrolled discharge of ballast water and sediment from ships which will cause the transfer of harmful aquatic organisms and pathogens (IMO, 2004). Under the provisions of BWMS convention, the port State can require the ships which discharge ballast water and sediment in the port waters must meet the standards set by BWMS convention. By the implementation of PSC inspection and analysis of the samples, the port State can judge whether the discharge meets the standards and determine whether the ship is permitted to discharge. Presently China is not a party to BWMS convention, but the marine environment of China, especially for the port waters, is facing the issues of ballast water pollution. Therefore, for Shanghai port, in the practice of perfection anti-pollution system, reference should be made to the BWMS convention and measures should be taken to eliminate the pollution of ballast water and sediment from ships.

Tab.2 Relevant international conventions for prevention of the vessel-induced pollution

No.	Convention	Date of entry into force	Date adopted by China
Parent law			
1	UNCLOS,1982	16-11-1994	05-15-1996
Anti-pollution international conventions or Annexes			
2	MARPOL 73/78 (Annex I)	02-10-1983	02-10-1983
3	MARPOL 73/78(Annex II)	02-10-1983	06-04-1987
4	MARPOL 73/78(AnnexIII)	01-07-1992	13-12-1994
5	MARPOL73/78(AnnexIV)	27-09-2003	02-02-2007
6	MARPOL73/78(Annex V VI)	31-12-1988	21-02-1989
7	1997 MARPOL PROT(addition of ANNEX VI)	19-05-2005	23-08-2006
8	2004 BWM CONVENTION	08-09-2017	Not approved
9	2001 AFS CONVENTION	17-09-2008	07-06-2011
10	1972 LC(London convention)	30-06-1975	14-12-1985

11	1996 LC PROT	24-03-2006	29-10-2006
International conventions for emergence response			
12	1990 OPRC	13-5-1995	30-06-1998
13	OPRC-HNS 2000	14-06-2007	19-02-2010
International conventions for compensation			
14	1973 INTERVENTION PROT	30-03-1983	24-05-1990
15	1969 CLC	19-06-1975	29-04-1980 Denunciation
16	1976 CLC PROT	08-04-1981	28-12-1986 Denunciation
17	1992 CLC PROT	05-30-1996	05-01-2001
18	2001 Bunkers	21-11-2008	09-03-2009
19	1992 FUND PROT	05-30-1996	Only apply to Hongkong
20	2000 FUND PROT	27-06-2001	Only apply to Hongkong
21	2003 FUND PROT	03-03-2005	Not approved

Source: Dalian Maritime University (Ed).(2015).International Maritime Convention Overview

4.1.2 Domestic laws and regulations

As shown in Tab.2, the domestic laws and regulations for prevention of vessel-induced pollution in Shanghai port consist of national laws, administrative regulations, provisions or standards issued by relevant Ministries and local regulations or rules. Prior to the analysis of the various laws and regulations, the relationship between them should be clear. In accordance with Legislation Law of PRC (2015 amendment), the hierarchy of legal validity, from the high to low, is the constitution, laws, administrative regulations, ministries' rules and local regulations. SCNPC of PRC is responsible for the development of the relevant laws for the prevention of ship-source pollution and State Council of PRC take charge of the enactment of relevant administrative regulations. Taking into consideration of the actual situation, the local governments can formulate the regulations or rules shall not contravene any provision of the Constitution, national law and administrative regulations.

Environment protection law of PRC

As the basic law of environmental protection law, environment protection law of PRC is the first comprehensive law relating to the protection of the marine environment in China. *Environmental Protection Law of PRC* (for trial implementation) was enacted in 1979 and subsequently revised in 1989 and 2014. It provides the obligation and

responsibility of various levels people's governments of PRC to protect the marine environment. It also provides that the discharge of pollutants and the dumping of wastes into the sea waters must be conducted in compliance with legal provisions so as to prevent and reduce the pollution damage to the marine environment.

Marine Environment Protection Law of PRC

With the purpose to prevent the damage of pollution and protect the marine environment, *Marine Environment Protection Law of PRC* was issued in 1983 and amended in 1999, 2013 and 2016. It is composed of ten chapters and 97 articles. Serving as the basic and comprehensive law for protection of the marine environment, Marine Environment Protection Law of PRC develops clear and systematic provisions for the prevention and control of pollution damage to the marine environment caused by ships and their correlative operations, including the provisions on prevention, emergency response , investigation and compensation for damages. In order to implement the *Marine Environment Protection Law of PRC*, the interrelated regulations such as *Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment* and *Regulations of the PRC on the Dumping of Wastes at Sea* are issued by State Council, *Effluent Standard for Pollutants from Ships* was established by Ministry of Environmental Protection of PRC, and *the Administrative Provisions of PRC on the Prevention and Control of Marine Environmental Pollution by Vessels and Their Operations* was issued by MOT.

Although *Marine Environment Protection Law* is a domestic law, it also applies to the foreign ships operating in the waters under Chinese jurisdiction. In order to avoid the conflict with the relevant international conventions approved by China, it provides that the international convention applies when the conflict occurs, except the terms reserved by China.

Atmospheric Pollution Prevention and Control Law of PRC

As a law to deal with air pollution, *Atmospheric Pollution Prevention and Control*

Law of PRC was adopted by SCNPC in 1987. With respect to the issues of air pollution caused by ships, it provides that the pollutant emissions from vessels must satisfy the emission standards in principle. Under the provisions of the law, the technologies such as new energy and shore power are encouraged to use for the solution of air pollution caused by ships. It also requires that the MOT can designate the Emission Control Areas (ECAs) and require that the ships in the ECAs shall comply with the standards of emissions. For the violations, the law also formulates the corresponding punishment measures.

Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment

This regulation entered into force on March 1, 2009 and has undergone three amendments. The newest revision is 2016 version which consists of 9 chapters and 76 articles. It applies to the prevention of pollution caused by ship and its related operations to the sea areas of China. And in accordance with *Marine Environment Protection Law of PRC*, it further defines the provisions of prevention and control of ship-source pollutions from the following six aspects:

- Discharge and reception of pollutants from vessels
- Prevention and control of the pollution Caused by vessel and its related operations
- Emergency response to the pollution accident caused by vessels
- Investigation and treatment of pollution accident by ship
- Compensation for marine environmental damage caused by ships pollution
- Legal liability

These provisions in the Regulation are more practicable and comprehensive, giving the basic framework for construction of anti-pollution system and it also stipulates that MSA is specifically responsible for the supervision and administration of the prevention and control of the vessel-induced pollution to the marine environment.

Effluent Standard for Pollution from Ships

In order to carry out the Marine Environment Protection Law of PRC and to prevent

the ship-source pollutions, *Effluent Standard for Pollutant from Ships* was established by Ministry of Environmental Protection of PRC in 1983. This Standard not only applies to the Chinese ships but also applies to the foreign ships in Chinese waters. However, the Standard is not comprehensive and only provide standards for the discharge of some pollutants from ships, including: the maximum allowable discharge concentration of ship's oily wastewater, the maximum allowable discharge concentration of domestic sewage (involving three indicators: biochemical oxygen demand, suspended solids and coliforms) and the requirements on the discharge of garbage. The Appendix indicates effluent standard for pollution from ships in detail.

Regulations of the PRC on the Dumping of Wastes at Sea

In order to strictly control the dumping of wastes at sea, the *Regulations of the PRC on the Dumping of Wastes at Sea* was issued and entered into force on March 6, 1985. According to its provisions, the dumping of wastes and other substance from ships to sea, except the discharge of wastes from normal operation of the ship, shall be approved by State Oceanic Administration of PRC or its subordinate bodies. In addition to being fined, the violators will be ordered to remedy the pollution damage within a definite time, pay clean-up expenses and compensate for the losses.

Regulation on the Safety Management of Hazardous Chemicals

The formulation of this Regulation provides the specific requirements for the safety management of hazardous chemicals carried by ships from three aspects: ship, terminal and crew. Under the provisions of it, the ships carrying dangerous chemicals shall be inspected by the assigning authorities and obtained the *Certificate of Fitness for the Carriage of Dangerous Chemicals*, the terminals shall be equipped with adequate equipment and facilities for emergency response and the seafarer who engage in transportation of hazardous chemicals shall be qualified by the maritime administrative institution and obtain certificates of competency.

Local Regulation and Rules

Considering the actual situation, a series of local regulations and rules are formulated in accordance with the relevant laws and administrative regulations, with the purpose to better protect the marine environment of Shanghai port. These local regulations and rules play an important role in combating the ship-source pollution in Shanghai port. Firstly, *Regulations of Shanghai Municipality on Environmental Protection* went into force on May 1, 1995 and was subsequently revised in 1997, 2005, 2011 and 2016. It provides that the vessels shall comply with the requirements of the ships' discharge when navigating, operating and berthing in the waters of Shanghai port. Secondly, in order to protect the air from pollution and improve the air quality of the Shanghai Municipality, *Regulations of Shanghai Municipality on the Prevention and Control of Atmospheric Pollution* was adopted by Shanghai municipal people's congress and entered into force on October, 1, 2014. It requires that emissions of the air pollutants from ships shall not exceed the discharge standards stipulated by the State and Shang Municipality. Thirdly, with the view to comprehensive prevention of pollutions caused by the vessels operating in Shanghai port waters, *Measures for the Prevention and Control of the Vessel-Induced Pollution of Shanghai Ports* took effect on June 1, 2015, and repealed the previous *Measures for the Administration of the prevention of Vessel-Induced Pollution of Shanghai Ports* adopted in 1996.

Tab.3. Domestic Laws and Regulations for prevention of vessel-induced pollution

Laws			
NO.	Name	Effective date	Issuing authority
1	Environment protection law of PRC	26-12-1989	SCNPC
2	Marine Environment Protection Law of PRC	23-08-1982	SCNPC
3	Water Pollution Prevention and Control Law of PRC ¹⁰	01-11-1984	SCNPC
4	Atmospheric Pollution Prevention and Control Law of PRC	06-01-1988	SCNPC
Administrative Regulations			
5	Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment	03-01-2010	State Council
6	Regulations on the Safety Management of Hazardous Chemicals	15-03-2002	State Council

¹⁰ Under the provisions of this law, it applies to the prevention of pollution of rivers and can provide basis for the protection of Huang River.

7	Regulations of the People's Republic of China on the Dumping of Wastes at Sea	06-03-1985	State Council
Provisions or Standards issued by relevant Ministries			
8	Provisions of PRC on the Administration of Emergency Preparedness for and Emergency Response to Vessel-Induced Pollution to the Marine Environment	01-06-2011	MOT
9	Administrative Provisions of PRC on the Prevention and Control of Marine Environmental Pollution by Vessels and Their Operations	01-02-2011	MOT
10	Effluent Standard for Pollution from Ships	09-04-1983	Ministry of Environmental Protection
11	Provisions on the Safety Management of Hazardous Goods at Ports	01-02-2013	MOT
12	Provisions of the PRC on the Investigation and Settlement of Vessel-source Marine Pollution Accidents	01-02-2012	MOT
Local Regulations of Shanghai			
13	Regulations of Shanghai Municipality on Environmental Protection	01-09-1996	SMG
14	Regulations of Shanghai Municipality on the Prevention and Control of Atmospheric Pollution	01-10-2014	SMG
15	Measures for the Prevention and Control of the Vessel-Induced Pollution of Shanghai Ports	01-06-2015	SMG

Source: Compiled by the author, 2017

4.2 Governing bodies and law enforcements

The implementation of the responsibilities and obligations of marine environmental protection under international conventions, domestic laws and regulations shall be guaranteed by certain mechanism and system (Sun, 2006), which is consisted of governing bodies and law enforcements, and without the enforcement mechanism the law will become a dead letter no matter how good it is. Fig.9 demonstrates the relevant governing bodies and law enforcements in Shanghai port and in accordance with *Marine Environment Protection Law of the PRC (2016 Revision)*, maritime administration is in charge of the regulation over the waters pollution induced by the non-military vessels within the port waters, fishery administration is responsible for the control over the waters pollution resulting from non-military vessels within the fishing port waters and armed forces is responsible for the supervision over the

marine pollution induced by military vessels (SCNPC, 2016). At present, Shanghai port has formed a supervision and management system for the prevention of ship-source pollution, which is leading by the SHMSA and assisted by the Shanghai Municipal Government and its subordinate organs and other competent authorities. As part of the anti-pollution system, in Shanghai port, the governing bodies and law enforcements shall be competent in the implementation of the anti-pollution system. Based on the professional division of labor and cooperation among them, the supervision, monitoring, control and prevention of the ship-source pollution are conducted, achieving the purpose of protection of the marine environment in the port waters. In the following section, the governing bodies and law enforcements in Shanghai port will be analyzed in detail.

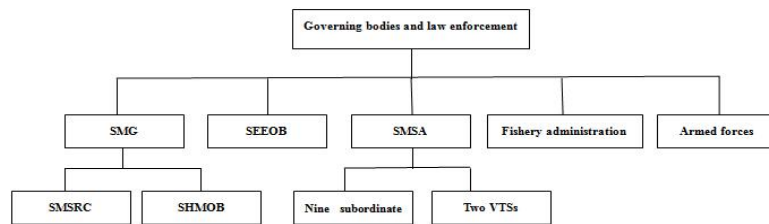


Fig.9 Governing bodies and law enforcements in Shanghai port
 Source: Compiled by the author, 2017

Shanghai municipal government (SMG) and its subordinate bodies

In present anti-pollution system, SMG is responsible for the formulation of contingency plans for the accidental pollution caused by vessels. Shanghai Maritime Search and Rescue Centre (SMSRC), the subordinate body of SMG, is an emergency command platform for pollution accidents induced by ships and responsible for the organization, command, coordination and supervision of the work for control of pollution accidents caused by ships in Shanghai port waters. Shanghai Municipal Ocean Bureau (SHMOB) which is under the leadership of Shanghai municipal government bears the responsibilities for the supervision and control over the marine environment in Shanghai, including survey, surveillance, supervision, assessment and scientific research, as well as the prevention of dumping of wastes from ships in

Shanghai port.

Shanghai Entry-Exit Inspection and Quarantine Bureau (SEEQB)

Shanghai Entry-Exit Inspection and Quarantine Bureau is responsible for the epidemic prevention of the international navigation ships. In accordance with the State-specified sanitary standard, Shanghai Entry-Exit Inspection and Quarantine Bureau is in charge of the supervision of sanitary conditions of the ships docking at Shanghai port. Its responsibility is to supervise and inspect whether the ship's treatments of the garbage, wastes, sewage and ballast water meet sanitary standard provided in Chinese laws and in order to achieve regulatory objectives, as the law enforcement agency, it may, in the light of the laws, impose fines on the vessels that fail to meet the sanitary standard.

SHMSA

SHMSA is the leading governing body in the management and supervision mechanism. SHMSA is fully responsible for the specific supervision and control over marine environment pollution caused by vessels within the Shanghai port waters, which is concretely performed by nine subordinate bodies¹¹ and two VTSS¹² at present. Its main responsibilities are listed as follows.

- Be responsible for the investigation and treatment of the pollution accidents.
- Be responsible for the implementation of the international maritime convention
- Implement PSC inspection and FSC inspection and
- Carry out pollution prevention inspection of ships
- Monitor the ship-source pollution in port waters
- Formulate and implement port oil pollution emergency plans
- Be responsible for supervision and prevention of pollutions of dangerous cargo and other goods from ships
- Be responsible for the acceptance of oil Pollution Damage from Ships

¹¹ The nine subordinate includes: Minghang MSA, Huangpu MSA, Yangpu MSA, Wusong MSA, Pudong MSA, Wai Gaoqiao MSA, Chongming MSA, Jinshan MSA and Yangshan port MSA

¹² The two VTSS includes: Wusong VTS and Yangshan VTS.

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- Organize investigation, verification and evaluation of claims for oil pollution damage from ships

The relevant stations or the entities

These relevant stations or the entities include terminals, docks, loading and unloading stations, ships' pollutants receiving companies, etc. Although these entities are not the governing bodies, serving as the entities engaged in building or repair of vessels, loading or unloading cargoes, etc., they are responsible for the provision and maintenance of the pollution monitoring facilities and adequate pollutant receiving facilities for the operating ships. They are indispensable to the prevention and control of ship-induced pollution in Shanghai port.

4.3 Reception Facilities

MOT published the standard for *Requirements of Receiving and Disposing of Units/Enterprises Operating Ship's Pollutants Disposal and Tank Cleaning Operation* (JT/T-673) in 2006 and it provides standards for discharge and reception of vessel pollutants including the provision of enterprises, ships and personnel engaged in the reception of vessel pollutants, and requirements for the receiving operation and the disposal of the ship's pollutants. In the reference to the standard and relevant laws and regulations, as the administration in charge of pollution prevention of ships, SHMSA has established the integrity management mechanism and built up the system of archival filing of the enterprises/units engaged in the reception of vessel pollutants. The credit rating is divided into three grades: (i.e., Grades A, B and C) and according to the different credit rating, the management measures will be different.

4.4 Emergency Response to Pollution Incident

The system for emergency response to pollution incidents caused by ships in Shanghai port is mainly composed of emergency response mechanism and the

administration regime of agreement for ship pollution response. As shown in Fig.10, the emergency response mechanism includes three levels. Firstly, Shanghai municipal people's government is responsible to prepare the municipal emergency response plan for preventing and controlling the pollution. Secondly, the owner, operator or manager of a vessel of Chinese nationality take charge to develop the emergency response plan for their ships, and report it to the MSA of port of ship's registry for approval. Thirdly, the owner of terminals shall prepare an emergency response plan for the prevention of pollution accident caused by the ships operating in their terminals and report emergency response plan to SHMSA for recordation.

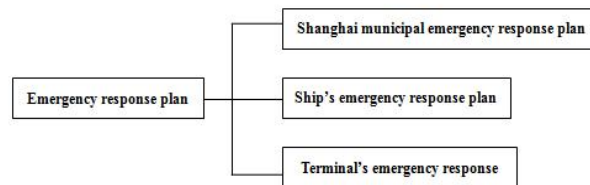


Fig.10 The emergency response mechanism in Shanghai port

Source: Compiled by the author, 2017

With respect to the administration regime of agreement for ship pollution response¹³, the vessel-induced pollution clean-up entities are classified into four grades, from the highest to the lowest, based on different service regions and pollution clean-up capabilities. Under the provision, the owner, manager or actual operator of a ship, including the oil tanker, bulk chemical carrier and other types of ships of 10,000 gross tonnage and above shall, prior to ship's operation or entering into or leaving Shanghai port, conclude this agreement with a qualified ship pollution response organization.

4.5 Investigation Mechanism for Pollution Accident

¹³ The regime for Agreement for Ship Pollution Response has been established since 2011 and the owner, manager or actual operator of a ship shall, prior to ship's operation or entering into or leaving from a port, conclude the agreement with a qualified ship pollution response organization.

Investigation into pollution accidents by ship is a good way to explore the causal factor and learn lessons to improve the system for the prevention of accidental pollution from ships (Schröder, 2017) and the compensation mechanism can ensure the adequate compensation for the victims of the pollution accidents. Hence, as a relatively perfect anti-pollution system, it shall not only have the function of controlling all the potential pollution caused by the ships, but also include the mechanism for investigation and compensation on the pollution accidents. In accordance with the *Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment*, the responsibilities of the administrations for the investigation and treatment of vessel-induced pollution accidents which occur in Shanghai port water are determined according to the grades of accidents. For extraordinarily serious vessel-source pollution accidents, the State Council shall organize the investigation and settlement thereof. For serious vessel-source pollution accidents, MSAPRC shall organize the investigation and settlement thereof. For relatively large and common vessel-source pollution accidents, SHMSA shall be responsible for the investigation and settlement thereof. And in 2011, the *Provisions of the PRC on the Investigation and Settlement of Vessel-source Marine Pollution Accidents* was published by MOT and it further defines SHMSA is specifically responsible for the investigation and treatment of pollution accident caused by ship in Shanghai port.

Tab.4 List Pollution Accident Classification

Pollution Accident Classification	Oil Spill (ton)	Direct Economic Loss (million Yuan)
Extraordinarily serious vessel-source pollution accidents	above 1,000	Above 200
Serious vessel-source pollution accidents	from 500 to 1,000	From 100 to 200
Relatively large vessel-source pollution accidents	from 100 to 500	From 50 to 100
Common vessel-source pollution accidents	below 100	Below 50

Source: State Council of PRC.(2017). Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment (2016 Revision)

CHAPTER 5: Issues existing in the present anti-pollution system

Based on the current quality of waters and air in Shanghai port, it can be concluded that the status of marine pollution is very serious. Through the analysis of the *Marine Environmental Quality Bulletin of Shanghai* from year to year, it can be found that the water quality has experienced a downward trend since 2005 and the proportion of areas of the sea water inferior to Grade IV increased from 60% in 2005 to 77.3% in 2015. Researches indicates that vessel-induced pollutions are one main source of marine environmental pollution in Shanghai port and the worsening quality of marine environment illustrates that the present anti-pollution system is still imperfect, and there are still many problems need further study to resolve. This chapter will analyze these issues existing in the present anti-pollution system, providing support for the continuing improvement of the system for combating the ship-generated pollutions in Shanghai port.

5.1 The defects of present legislation system

5.1.1 Insufficient implementation of the international conventions

The first issue is that the fulfillment of the international conventions is inadequate. The general way in which China implements the international conventions is that the international conventions are applicable to the international navigation ships first, including the foreign ships and the ships entitled to fly Chinese flag, and then to the domestic navigation ships. This model of fulfillment actually limits the scope for the application of the international conventions. Take MARPOL convention as an example, five of the six annexes (i.e., Annexes I , II , III, VI& V) , provide that they shall apply to all ships, and only Annex IV provides for the application of an international navigating ship. China has adopted all the six Annexes to the MARPOL convention now, therefore, except Annex IV, all the other five Annexes shall apply to all ships in China, including international navigation ships and domestic navigation ships. However, at present, MARPOL convention only applies to ships engaged in the international voyages, the domestic navigation, especially the inland water ships do

not follow MAPOL convention, which only apply to the comparatively loose domestic laws.

5.1.2 Imperfect laws and regulations

Another noticeable problem that should be considered is that the current legal system can not meet the needs for comprehensive control of ship pollution and comprehensive protection of the marine environment. Some laws or regulations only stipulate in principle, lacking of specific and operational standards. For instance, both *Marine Environment Protection Law of PRC* and *Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment* require that each terminal shall provide sufficient reception facilities to satisfy the needs of ships, but they do not provide the standards for the types, quantity and configuration location of the reception facilities, which directly result in the serious shortage of the reception facilities in Shanghai port. The *Effluent Standards for Pollutants from Ships* developed in 1983 only provides for the effluent standards of oily water, sewage and garbage, and with respect to other wastes from ships, such as HNS, exhaust gas and ballast water, etc., the Standards do not apply. To make matters worse, the severity of detriment of the ballast water from ships has not yet been realized in China and, in domestic laws and regulations, there is still no legal provision to solve the problem of biological invasion caused by ship ballast water.

5.1.3 Imperfect legal provisions on the compensation mechanism

The imperfect legal provisions on the compensation mechanism for oil pollution damage shall also be taken into consideration. Although the oil pollution compensation mechanism has been established in Shanghai port, the mechanism does not cover all the ships. The provision of *Measures of the PRC for the Implementation of Civil Liability Insurance for Vessel-induced Oil Pollution Damage*, published by the MOT of PRC in 2010, only applies to vessels carrying oil substances and vessels

carrying non-oil substances with a gross tonnage of above 1,000 gross tonnages which are navigating within the sea areas of the PRC (MOT, 2010). The seagoing vessels carrying non-oil substances with a gross tonnage of below 1,000 gross tons, as well as the inland ships are not covered and in the event of serious pollution accident caused by these ships, the victims may not get enough compensation to make up for the damage.

5.2 Seriously lack of reception facilities

The preparation of sufficient reception facilities in the port contributes significantly to the reduction of the discharge of the wastes from vessels. Five of the six Annexes of MARPOL convention clearly define that adequate reception facilities shall be provided in the port (Tab.5). Hence, the adequate provision of the reception facilities is an important guarantee for the effective implementation of the MARPOL convention. As a party to MARPOL convention, China has also enacted various domestic laws or regulations and required the port shall provide adequate reception facilities (Tab.6). But for Shanghai port, the reception facilities are seriously inadequate. In accordance with the statistics of SHMSA, Shanghai port received 560 thousand ships in 2016 (SHMSA, 2016) and so many ships operating in port waters produced a large number of wastes that need to be received. However, according to the archival filing of units of SHMSA, there are a total of only 66 entities engaged in the reception of various vessels' wastes in Shanghai port, as shown in Tab.7, which can hardly meet the need of the operating vessels in the port. Additionally, few terminals are equipped with the relevant reception facilities for the control of pollution of ship exhaust and the ballast water (including the related sediments), such as the receiving facilities for the ozone-depleting substances being removed from ships and the exhaust gas cleaning residues from the exhaust gas system, the facilities for receiving the substandard ballast water and its sediments, etc. To make the matter worse, due to the absence of specific standards for the preparation of the reception facilities in the port, no one knows how many reception facilities shall be provided in

Shanghai port to meet the need of the operating ships.

Tab.5 The relevant regulations on reception facilities in the Annexes of MARPOL convention

Annex	Regulation of relevant Annexes
Annex I	Regulation 28
Annex II	Regulation 18
Annex IV	Regulation 12
Annex V	Regulation 7
Annex VI	Regulation17

Source: Compiled by the author, 2017

Tab.6The provision of reception facilities under domestic laws or regulations(

Law or Regulation	Article
Marine Environment Protection Law of PRC	Article 69
Water Pollution Prevention and Control Law of PRC	Article 54
Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment	Article12 Article 15
Provisions on the Administration of Port Operations	Article 7, Article 9 and Article 10

Source: Compiled by the author, 2017

Tab.7 Archival filing of units of entities engaged in the reception of various vessels' wastes in Shanghai port

Port Reception Facility Providers	No. of Companies (providers)
Oil residue and oily water receiving entity	37
Sludge receiving entity	4
Treatment of the chemical tank washings receiving entity	2
Treatment of oil residue, sludge and oily water receiving entity	2
Garbage receiving entity	13
Sewage receiving entity	5
Ship' s toxic liquid substance washing water receiving entity	3

Source: SHMSA.(2017). Archival filing of units of entities engaged in the reception of various vessels' wastes in Shanghai port

5.3 The imperfect monitoring system

The monitoring of vessel-induced pollution shall be composed of the monitoring of the quality of the marine environment (including the air) and the monitoring of potential ship-source pollution. Through the previous analysis, it can be concluded

that, in Shanghai port, the duty of the monitoring and supervision of the vessel-induced pollution is performed by the SHMSA, while the responsibility of the monitoring of the quality of the marine environment is fulfilled by SEPB. At present, the two authorities do not establish the cooperation mechanism between them and the monitoring data do not share, which result in the short knowledge of the specific data on the extent of contamination and damage caused by ships to the marine environment in Shanghai port. Additionally, the technical means for monitoring of ship-source pollution is very backward. Currently, the monitoring of ship-source pollution is mainly dependent on the cruise of guard boat of MSA, VTS, the video surveillance of CCTV system and the reports from the sailing ships in Shanghai port waters, which do not form a complete monitoring system. Since 2013, the cruising helicopter has been used to monitor the illegal discharge of the wastes and the oil spill from ships, however, due to the lack of dedicated airborne monitoring equipment, the effectiveness is very limited. As a result of the imperfect monitoring system, when the ship-induced pollution accidents happens, the on-site information is hardly obtained in time to start the appropriate emergency measures for the control of the pollution. And when the illegal discharges or violations occur, it is difficult to collect sufficient evidence to support the proceedings or penalties, which will result in the impunity of these violations.

5.4 The issues existing in maritime law enforcement

Both the relevant international conventions and domestic laws or regulations explicitly stipulate the prevention and control of the ship-source pollution and the implementation of all these provisions depends on the law enforcement of the related governing bodies and the voluntary compliance by the ships operating in Shanghai port waters. However, from the perspective of the overall effect of the present anti-pollution system in Shanghai port waters, there are still many issues to be solved in the enforcement of these maritime domestic laws and international conventions.

5.4.1 Poor consciousness of marine environmental protection

The essence of environmental problems lies in the lack of environmental awareness of mankind, originating from ignorance of human being (Sun, 2006). At present, the largest number of vessels operating in Shanghai port are inland vessels and coastal navigation vessels. These ships are the major source of operational pollution from ships. Due to the low educational level, the seafarers working on these vessels have poor consciousness of marine environmental protection and pay very little attention to the control of pollution caused by their vessels to the port waters. Coupled with the lack of legal consciousness, they randomly discharge the wastes into the port waters, which will lead to the serious marine environmental pollution problems. In the event of their violations detected by the competent authorities, they generally think they are fined because of their bad luck without realizing that their violations have polluted the marine environment.

5.4.2 Too many regulatory authorities

On the basis of the previous analysis in Chapter-4, the administrative departments for the prevention and control of ship-induced pollution in Shanghai port waters involves SHMSA, fishery administration, military, SMG and its subordinate bodies, inspection and quarantine department. And due to indistinct provisions under the domestic laws and regulations, the responsibilities of these regulatory authorities are decentralized which makes the marine environment cannot be protected as a whole. What is worse, some of the responsibilities and obligations between the competent authorities overlap, resulting in the absence or offside of regulation. Moreover, there is no cooperation mechanism between the various competent authorities and the work on the prevention and control of the ship-source pollution can not be carried out from the whole, which will affect the enforcement of the anti-pollution laws and regulations to some extent.

5.4.3 Poor comprehensive quality of the law enforcement officer

As the law enforcement officers, their comprehensive quality plays an important role in the work of preventing and controlling the ship-source pollution. However, due to the particularity and complexity of law enforcement work on the combating ship-source pollution, the officers not only possess the professional knowledge of shipping, but also acquire the basic English skill when the work involves the foreign ships. Hence, the work on the combating ship-source pollution requires a high level of comprehensive quality on the law enforcement officers. But, presently, the prominent problem is that the quality of the law enforcement officer obviously can not meet the need of anti-pollution work. Furthermore, because of the lack of systematic training mechanism, the issue is difficult to solve in a short time. Hence, the poor comprehensive quality of law enforcement personnel will become a chronic problem that restricts the marine environmental protection in Shanghai port.

Another issue shall be considered is that the weak awareness of environmental protection of the law enforcement officers. Many officers, even the leaders, have not realized the importance of the marine environmental protection work and the serious situation of marine environmental pollution issues facing Shanghai port waters. In the process of enforcement, they do not pay sufficient attention to the work of combating the ship-source pollution work. For instance, as a law-enforcement officer in SHMSA, from my own work practice, we pay too much attention to the target performance measure assigned by our superior authority and ignore the effectiveness of environmental protection through law enforcement.

5.4.4 Backward Enforcement Devices

The backward equipment for the investigation and collection of the evidence of the illegal discharge of pollutants from ship is another obstacle for the effective performance of the anti-pollution work in the present system. Due to the lack of necessary equipment for the monitoring and testing, such as the oil content analysis

instruments and equipments for the control oil pollution, the apparatus for testing the content of various substance in sewage, the equipment for analysis of the content of SO_x, NO_x and particulate matter in the emissions from ships, etc., it is difficult to collect evidence for illegal discharge of pollutants on the voyage and the restrictions and penalties are rarely imposed on the related ships or crew, which leads to the reduction of the costs of their illegal activities and, to some extent, encouraging the continuous occurrence of their illegal activities.

5.5 The neglect of the ballast water pollution

The discharge of the ballast water from the operating ships, especially the international navigation ships, may bring about disaster the marine environment. Since the early 1980s, the international community began to recognize that ballast water is a primary source for the introduction of harmful species and pathogens (David, Perkovic, 2004) and uncontrolled discharge of ballast water and related sediments from ships has led to the transfer of harmful aquatic organisms and pathogens, causing damage to the environment (IMO, 2004). In order to prevent the environmental risks induced by the discharge of ballast water from the ships, IMO adopted the specific BWM convention in 2004. At present, the anti-pollution system in Shanghai port does not include the prevention of the pollution of ballast water. By the analysis of system of laws and regulations, China is not a party to the BWM convention and there are no specific domestic laws or regulations with a view to prevent the introduction of harmful aquatic organisms through the discharge of ballast water from ships and some relevant provisions are scattered in various laws and regulations, which are mainly to avoid the spread of pathogens from the epidemic area to our territory. For instance, as the basic law to protect the marine environment, *Marine Environment Protection Law of PRC* only requires that any ship shall not discharge ballast water to the sea in violation of the provisions of it, without the specific management and treatment standards for the discharge of ballast water and related sediment to avoid the alien biological contamination. And *Frontier Health and*

Quarantine Law of PRC only provides the discharge of ballast water from ships shall meet the hygienic standard. *Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment* only stipulates in principle that the discharge of ballast water from ships shall be in accordance with the laws and regulations. As a result of the lack of specific provisions in the laws and regulations, the relevant prevention and control work can not be carried out in the practice to address the severe situation of ballast water pollution in Shanghai port.

5.6 Issues in the prevention of air pollution

Based on the analysis above, the pollutants from ships are the main source of the air pollution in Shanghai but the present anti-pollution system on the prevention of the air pollution from ships are not comprehensive and the measures for combating is very limited. At present, the measures Shanghai port has taken only focus on the control of the pollution caused by emissions of SO_x from ships and the means used is to control the sulphur content of diesel oil used on the operating ships¹⁴. With respect to the pollution caused by NO_x, PM, VOC and greenhouse gas including CO₂, N₂O and CH₄ are ignored. For instance, VOCs from ships are an important source of air pollution from tankers. Under the provision of MARPOL convention, the terminals and applicable tankers shall be provided with vapour emission collection system and the terminals shall take measures to regulate the emissions of VOCs from tankers (MARPOL, 2011). However, the present system does not pay enough attention to the control of the pollution of VOCs from ships. According to the statistics, only one terminal¹⁵ is provided with the vapor recovery equipment at present and other terminals do not take any prevention measures.

The supporting solutions to the air pollution from vessels also have many problems.

¹⁴ Since April 1st, 2016, Shanghai port has began to implement Domestic Emission Control Area in port waters and require the sulphur content of any fuel oil used on board vessels berthing at Shanghai Port shall not exceed 0.5% m/m.

¹⁵ On May 27th, 2016, the first vapor recovery equipment in China put into use in Shanghai Petrochemical.

For example, promoting the application of LNG fuelled ship is an effective way to solve the air pollution from ships, but at present, there are many problems such as imperfect technical standards, gaps in supervision laws, lack of fuel filling sites, incomplete facilities and, etc., which have seriously affected the popularization of LNG power ships in the Shanghai port.

CHAPTER 6: Recommendations for the establishment and improvement of the system for the prevention and control of vessel-induced pollution

The ultimate objective of the prevention and control of the ship-source pollution is to eliminate the operational pollution and minimize the accidental pollution, achieving overall protection of marine environment, which means that, firstly, the ship-source pollution can be reduced as far as possible through the implementation of the preventive measures, and secondly, in the event of pollution incidents, the damage to the marine environment can be minimized through the performance of response measures. Hence, the comprehensive prevention and control of vessel-induced pollution is a systematic project, which emphasize all-dimension and the whole process. Based on the overall study on the literatures of control of ship-source pollutions, including the domestic laws and regulations, international conventions and relevant research papers, the comprehensive anti-pollution system should be established from three aspects which include prevention and control measures, emergence response to pollution accidents and compensation for pollution accidents. Hence, for Shanghai port, in order to comprehensively combat the ship-source pollution, a sound anti-pollution system which is comprised of the three interrelated and dependent subsystems should be established. The three subsystems are shown as follow:

- (1) Prevention subsystem: it consists of perfect legal system, well defined governing bodies and law enforcements, adequate reception and treatment facilities, monitoring system, to implement the functions of prevention, regulation, monitoring, assessment and investigation of ship-source pollution.
- (2) Emergency response subsystem: in the event of pollution incidents, the positive

and effective emergency response is taken to control the spread of pollution and minimize the pollution damage and for Shanghai port, as shown in Fig.11, this subsystem is consisted of municipal emergency response plan, ship's emergency response plan and terminal's emergency response plan

(3) Pollution damage compensation subsystem: to ensure that the victims are adequately compensated for dealing with the environmental damage caused by vessel-induced pollution incidents.

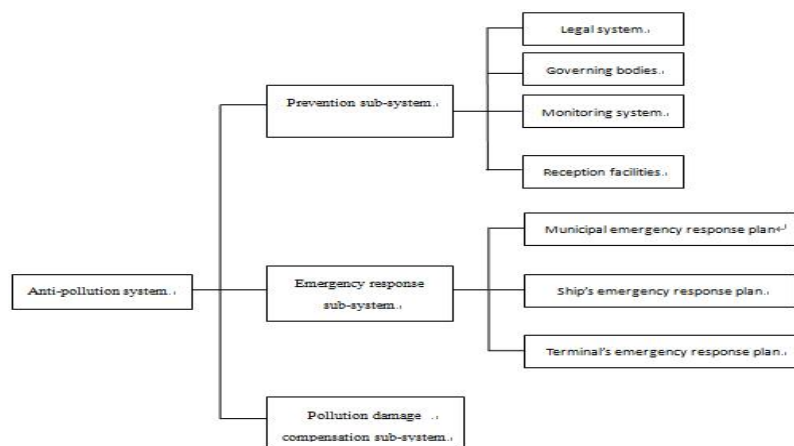


Fig.11 The frame diagram of the system for the prevention and control of vessel-induced pollution

Source: Compiled by the author, 2017

In view of the issues existing in the present anti-pollution system in Shanghai port, the comprehensive control of the vessel-induced pollutions and all-sided protection of the marine environment fail to be effectively implemented, resulting in the serious environmental pollution situation now. In the near future, it is necessary to improve the present anti-pollution system to achieve the purpose of integrated preservation of the marine environment in the port waters. On the basis of drawing advanced experience from home and abroad, the practical suggestions and recommendations for the improvement of the present anti-pollution system in Shanghai port will be provided in detail in the following sections.

6.1 Assessment of the environmental conditions

Comprehensive and effective assessment of the environmental conditions in Shanghai port can provide a basis for the improvement of the present anti-pollution system. However, to date no assessment on the environmental conditions in Shanghai port waters has been carried out and when the research is conducted on the prevention of the ship-source pollution, only little data can be obtained from the literatures. Hence, it is necessary to carry out the comprehensive assessment of the general situation of the pollution to the port waters caused by operating ships in Shanghai port. In order to grasp the overall situation of vessel-induced pollution to the port waters, the evaluation can be conducted on the following four aspects: the total quantity of pollutants from ships, the extent of the impacts of pollutants from ships on the port waters, port water environmental carrying capacity of ships' pollutants and the performing effects of the present anti-pollution system. The results of assessment can provide recommendations for the development of policies for promoting the improvement of the present anti-pollution system.

6.2 Perfection of the legal system

The increasing willingness to comprehensively protect the environment is leading to stricter and systemic construction of law framework (Iannelli et al., 2012). In order to synthetically combat the ship-source pollution to the marine environment, the utmost importance is the establishment of specific laws defining and organizing the environmental protection regime (Zhu & Zhuo, 2017). A sound and perfect anti-pollution legal subsystem is the basis of the system for the prevention and control of vessel-induced pollution and the potential defects existing in anti-pollution legal subsystem is not conducive to protect and preserve the whole marine environment, which may even result in disaster to the marine environment. With respect to the issues in the legal system, the national legislature of China shall accelerate the pace of revision and improvement of existing legal system, which is considered to be the fundamental measures to solve the existing problems in anti-pollution system, such as the outdated effluent standards, the lack of quantitative criteria for the reception

facilities, the imperfect compensation regime, the ignorance of the prevention of the pollutants (eg. ballast water, VOC, etc.). In this process, the legislative body of China can draw the advanced experience from IMO. Up to now, IMO has established a relative perfect legal system to control the ship-source pollution including pollution prevention, emergency response to pollution accident and compensation for pollution accident¹⁶. While ratifying these international conventions, China can introduce mature ship-source pollution control measures into the domestic law system to expand the scope of application of the convention. For instance, regarding the unsound compensation mechanism for ship oil pollution, China can refer to the relatively perfect mechanism of compensation for oil pollution damage under *CLC convention* and *1992 Fund convention* and perfect the existing mechanism from the national level, which can be improved from three aspects including the civil liability insurance for ship oil pollution damage, the fund for compensation the ship oil pollution and the legal system for ship-induced pollution compensation.

Moreover, with respect to the development of maritime legislation, both IMO and western developed countries are widely applying Formal Safety Assessment (FSA)¹⁸ methods to promote the study of Maritime Legislation and many new amendments and new proposals of the international maritime conventions are the result of the applications of FSA. To some extent, if we can integrate the FSA methods into the formulation of domestic maritime laws and regulations, it will lead to a qualitative leap in our maritime legislation. Therefore, with the view to meet the comprehensive anti-pollution situation needs, the national legislature of China can take advantage of the tool of FSA to assess the inadequacies in current anti-pollution legal system and the results of FSA can provide scientific suggestions for the revision and perfection of anti-pollution laws and regulations.

6.3 Improvement of the ship-source pollution monitoring system

The monitoring and supervision system is an essential part of the system for the

¹⁶ See Tab.2

¹⁸FSA is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property. FSA can be used as a tool to help in the evaluation of new regulations for maritime safety and protection of the marine environment or in making a comparison between existing and possibly improved regulations.

prevention and control of vessel-induced pollution in Shanghai port. The data of the marine environmental monitoring can reflect the quality of the waters and the degree of water polluted, as well as the trend of changes of the water quality. Realizing the importance of the monitoring and supervision system, MARPOL convention provide that the Parties shall use all appropriate and practicable measures of detection and environmental monitoring (IMO,2011) and the domestic law of China requires MSA shall perform the obligation to establish the mechanism for the monitoring and supervision of the ship-source pollution. According to the relevant research results, the perfect marine environmental monitoring system that can be consisted of CCTV remote sensing, VTS remote sensing, ship radar detecting, aviation remote sensing, satellite remote sensing and information processing center (Gao, 2004). In recent years, Guangdong Maritime Safety Administration (GMSA) has also made a further successful exploration. In 2015, GMSA published the 13th five-year construction planning for the ship-source pollution monitoring system in the key water areas, aiming to establish a monitoring system by means of the advanced monitoring technology including: VTS, AIS, CCTV, cruising helicopter, satellite remote sensing, aviation remote sensing, ship radar detecting, fixed point and mobile APP (Fig.12) . The program is an effective and efficient system for the monitoring of the ship-source pollution and it will greatly improve the coping capability of the pollution incident. Therefore, it is a good guide for Shanghai port to establish a perfect monitoring system in Shanghai port in the near future. Moreover, in order to solve the problem that the monitoring data can not be shared in the present anti-pollution system in Shanghai port, the cooperative mechanism between SHMSA and SEPB shall be established in the future.

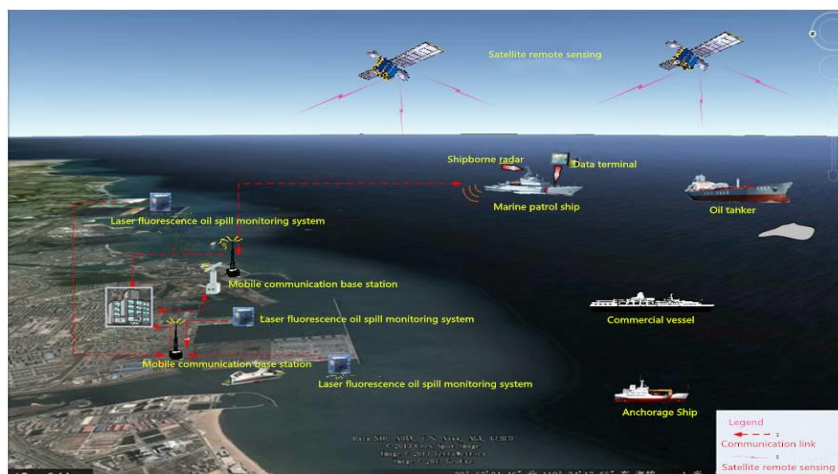


Fig.12 The planning construction of ship-source pollution monitoring system in the key water areas in Guangdong. Source: GMSA. (2015). The 13th five-year Construction planning of the ship-source pollution monitoring.

6.4 Provision of adequate reception facilities

Under the provisions of MARPOL convention, the terminals shall provide adequate reception facilities to meet the needs of the ships (IMO, 2011) and the domestic laws and local regulations also have the same requirements. Hence, in the process of the improvement of the present anti-pollution system, the issues of the serious lack of reception facilities must be solved. Firstly, at the national level, the State legislatures shall improve the relevant legal requirements and produce the quantitative criteria for the preparation of reception facilities of the terminals as soon as possible, guiding the provision of the reception facilities. Secondly, Shanghai port shall conduct a comprehensive evaluation of the gap between the total amount of the pollutants generated by ships in the port and receiving capacity of the reception facilities, accurately assess the general situation of the reception facilities in Shanghai ports and preparing basis for the adequate provisions. Thirdly, in the process of the improvement of the reception facilities, Shanghai port can draw the advanced experience from other organizations and States. IMO adopted *Guidelines for Ensuring the Adequacy of Port Waste Reception Facilities* in 2000 (MEPC.83 (44)) to assist the Parties to ensure the proper provision of adequate facilities and arrange for effective receipt of ships' wastes (IMO, 2000). *European Union* (EU) adopted *Directive 2000/59/EC* on port reception facilities in 2000 and establish a perfect management

mechanism for the reception and treatment of pollutants arising from ships (EU, 2000). All the experience can provide Shanghai port with good references for the construction of reception facilities. Fourthly, Shanghai port shall promote the construction of the reception facilities in coordination. The construction of receiving facilities shall be coupled with the building of the vessel-generated pollutant treatment facilities and the planning of facilities construction in Shanghai, establishing an effective management mechanism for discharge - reception - treatment – regulation.

6.5 Establishment of a sound compensation mechanism for vessel-induced pollution damage

Due to the particularity of waters in Shanghai port, if a serious pollution accident occurs, the damage to the marine environment and local society will be huge. In view of the inadequacies of the compensation mechanism under present anti-pollution system, it is necessary to improve the system. Given the existing compensation mechanism does not cover ships of all tonnages, it is possible to consider the enlargement of applicable scope of vessels in the future, ensuring that the victims can get enough damages. And in issues of the lack of compensation regime for the pollution incidents by hazardous and noxious substances, the corresponding compensation mechanism can be established on the basis of reference to the existing compensation regime for oil pollution damage. In order to ensure the practicability of the compensation system, the scientific damage assessment procedures and evaluation methods shall be set up and in the process of perfecting the present ship-source pollution compensation mechanism, the latest achievements of marine economics and marine ecology shall be widely absorbed to scientifically establish the evaluation model of quantitative assessment of marine ecological damage, reasonably determining the scope of compensation.

6.6 Promotion of the technological level for control of ship-source pollution

The eventual aim of complete elimination of operational pollution and minimization of the accidental pollution from ships can not separate from the advanced supporting technology of prevention and treatment. On the contrary, the backward anti-pollution technologies will seriously restrict the level of the prevention and control of the ship-induced pollutions in Shanghai port. Hence, in the process of improving the present anti-pollution system, the advanced technologies shall be absorbed to serve the comprehensive prevention of the ship-induced pollutions, improving the technology level for anti-pollution in Shanghai port.

The technology for the prevention of air pollution caused by ships is the most challenging issue at present and the application of alternative energy is seen as the fundamental solution. The technologies such as retrofitting ships' engines for LNG and shore power are viewed as useful strategies (Tseng, Pilcher, 2015). Researches indicate that the popularization and application of LNG fuelled ships will bring apparent environmental benefits are apparent, the emissions of LNG-operated engines contain about 20% less CO₂, 80–90% less NO_x and almost zero PM and SO_x (Kumar et al., 2011b, Burel, Taccanti, & Zuliani, 2013). In the future, Shanghai port shall improve the construction of supporting facilities to popularize the usage of the LNG-fueled ships in the port waters. Regarding the technology of cold ironing, or shore power is another way to solve the air pollution caused by ships in port waters and it has been suggested and implemented in many global advanced ports. In 2015, SMG established the *Pilot Program for Shore Power Supply of International Navigation Ship in Shanghai Port* and at the same time, the construction of shore power facilities was started in Yangshan terminal and Wusong International Cruise Terminal. In July, 2016, Phase I project of the shore power supply of Wusong International Cruise Terminal was put into use, which can replace 36.6 million kwh of electricity consumption a year, annually reducing the emissions of CO₂, SO_x and NO_x by 36 thousand tons, 750 tons and 65 tons respectively, according to estimates. In times to come, Shanghai port should popularize the application of shore power technology and encourage the berthing ships to use the shore power and reduce air

pollutions. In addition to the application of alternative energy, the technologies of ship exhaust gas after-treatment have also been proved to have a broad application prospects to solve the air pollution in the future. With respect to air pollution by VOC from tankers, US State and Europe have promoted the use of oil-gas recovery technology during the oil-tanker handling process, but the relevant researches and application have just started in Shanghai and in the future, Shanghai port shall conduct in-depth study on this technology and promote the use of it in liquified cargo terminals.

Due to the mobility of ships, it is difficult collect evidence of the illegal discharge of the wastes from ships. But with the development of automation technology of ship, automatic monitoring of the goods, automatic records of the piping system, and even dynamic monitoring of sensitive areas have become possible. In the future, Shanghai port can improve the research and application of these technologies and promote the technological level for the prevention of ship source pollution.

CHAPTER 7: Summary and Conclusion

Based on the above analysis in this paper, the effectiveness of the prevention of ship-source pollution in Shanghai port is not ideal, which leads to the increasingly serious marine environmental pollution situation and seriously restricts the sustainable development of Shanghai port. And with the further development of Shanghai port and the accelerating pace of the construction of Shanghai international shipping center forward, the threat of pollution from ships in Shanghai port will continue to increase. This research indicates that the reason for this situation is that the imperfect anti-pollution system can not comprehensively prevent and control the ship-source pollution, failing to achieve a holistic protection of the marine environment in Shanghai port. On the basis of integrated research on the anti-pollution system in Shanghai port, the outstanding issues are identified and the corresponding recommendations for the improvement are provided finally.

Additionally, in order to comprehensively and effectively prevent and control the pollution caused by ships, both the relevant organizations, especially IMO and States have made many beneficial explorations and accumulated numerous successful experience. Shanghai port can draw integrate them into the system for the comprehensive prevention of ship-induced pollution, making them serve for the improvement of the present anti-pollution system, paving the way for sustainable development of Shanghai port.

The last but not least, it should also be recognized that , a perfect system for the comprehensive prevention and control ship-induced pollution is relative. Due to the diversity and complexity of the ship-source pollution, the pollutants from ships involving the oil, oily waters, sewage, garbage, NLS and exhaust gas, ect., coupled with the mobility of ships and development of Shanghai port, in the future, there will be new problems challenging the ant-pollution system. Hence, the construction of the system for comprehensive prevention and control of ship-source pollution needs constant exploration and improvement.

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Appendix Effluent standard for pollutants from ship

1. The maximum allowable effluent concentration of oil content of the oily water from ships, including ballast water and washings from tanks and oily bilge water shall meet the standards in Tab.1

Discharge area	Effluent concentration(mg/L)
Inland rivers	Not more than 15
Sea areas within 12 nautical miles from the nearest land	Not more than 15
Sea areas more than 12 nautical miles from the nearest land	Not more than 100

Tab.1 The maximum allowable effluent concentration of oil content of the oily water from ships

2. The maximum allowable effluent concentration of sewage from ships shall meet the standards in Tab.2

Discharge area Item	Inland rivers	Coastal areas	
		Within 4 nautical miles from the nearest land	Between 4 and 12 nautical miles from the nearest land
Biochemical oxygen demand	No more than 50	No more than 50	
Suspended solids	No more than 150	No more than 150	No visible suspended solid
Coliform group	No more than 150/100ml	No more than 150/100ml	No more than 1000/100ml

Tab.2 The maximum allowable effluent concentration of sewage from ships

3. The discharge of garbage from ships shall meet the requirements in Tab.3

Types of garbage	Inland rivers	Coastal areas
Plastics	No discharge into waters	No discharge into waters
Flotage	No discharge into waters	No discharge into waters within 4 nautical miles from the nearest land
Food wastes and other garbage	No discharge into waters	The discharge may be permitted when they have been passed through a comminuter within 12 nautical miles from the nearest land. After comminuting, the wastes with diameter less than 25 mm may be permitted to discharge in areas more than 3 nautical miles from the nearest land

Tab.3 The requirements of discharge of garbage from ships