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Analysis of challenges and risks for Chinese shipowners in the implementation of BWM Convention

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ANALYSIS OF CHALLENGES AND RISKS FOR CHINESE SHIPOWNERS IN THE IMPLEMENTATION OF BWM CONVENTION

By

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DECLARATION

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

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

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ABSTRACT

Title: ANALYSIS OF CHALLENGES AND RISKS FOR CHINESE SHIPOWNERS IN THE IMPLEMENTATION OF BWM CONVENTION

Degree: Master of Science (M.Sc)

Ballast water is indispensable to ships' stability, integrity and navigation safety. However it is also a major source for aquatic invasive species, for over 90% of the global trade is done by shipping (IMO, 2016), causing biological, social and economic impact on ecosystem worldwide. Due to global nature and other features of shipping, invasion of AIS via ballast water is more extensive and more difficult to prevent. Despite all the treatment technologies currently available, there is no guarantee of 100% kill of these invasive organisms up-to-date.

To address the problem, IMO has adopted The International Convention for the Control and Management of Ships Ballast Water & Sediments (BWM Convention). Yet it took long and arduous effort for the Convention to enter into force and there still many risks and challenges that shipowners are confronted with. China has also made several regulations, though there is room for improvement and Chinese shipowners are eager to learn better solutions to their dilemma stemming from absence of domestic laws and inconsistency of international regulations.

This paper briefly outlines the development of the Convention, analyzes the risks, uncertainties and challenges for shipowners, especially Chinese shipowner against China's unique context. And by providing insights into relevant deficiencies of these measures and the challenges of ballast water management in China, it offers suggestions for shipowners to comply with the BWM Convention and calls for public awareness.

KEY WORDS: BWM Convention, BWMS, Risks, Chinese Shipowner

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AIS	Alien Invasive Species
AMS	Alternate Management System
BWE	Ballast Water Exchange
BWM	Ballast Water Management
BWMS	Ballast Water Management System
CMA	China Metrology Accreditation
CNAS	China National Accreditation Service for Conformity Assessment
GloBallast	Global Ballast Water Management Programme
IMO	International Maritime Organization
MEPC	Maritime Environment Protection Committee
IMCO	Inter-Government Maritime Consultative Organization
GEF	Global Environment Facility
PSCO	Port State Control Officer
NEL	National Engineering Labs
USCG	United States Cost Guard
UNDP	United Nation Development Program

Chapter 1: Introduction

1.1 Ballast Water Management Convention—Context and Significance for China

Invasive species have had ecological, economic and social consequences worldwide (Verner and Harris, 2016). They were held responsible for extinction of 54% of overall species as documented in the Red List database maintained by the International Union for Conservation of Nature (Clavero and Garcia-Berthou, 2005). And shipping is one of the major sources for aquatic invasive species, for more than 90% of the global trade is done by marine transportation (IMO, 2016). And ballast water, which is the indispensable element of safety navigation, is considered to be the most important vector (David et al., 2013). Approximately 10 - 12 billions of tons of ballast water are carried by ships across the oceans every year (Nosrati-Ghods et al., 2016; Qin, 2016), in which thousands of aquatic species are being transferred (Tootsie, 2002; Chen, 2005; Kim, 2016) causing severe damage to marine environment.

The international community has placed great importance to this issue. As early as in 2000, IMO initiated a programme called GloBallast (Global Ballast Water Management Programme). Then in 2004, it adopted the BWM Convention, marking a milestone in combating ballast water source pollution. Not only is it of vital significance for protecting marine ecosystem, the Convention also exerts far-reaching influence on the shipping industry.

China hasn't ratified the Convention yet. Once the Convention enters into force, Chinese shipowners will be the ones that are most affected because there is no more favourable treatment and exemption for non-member states. Therefore it is suggested that shipowners and authorities take joint effort to deal with the challenges in complying with the Convention.

1.2 Aim and Objective of the Research Paper

The aim of this paper in to aid Chinese shipowners in complying with the BWM Convention, for which purpose objective are set out as follows:

a) Identify requirements for shipowners in BWM Convention and other local regulations;

b) Identify challenges and uncertainties for new ships and existing ships; analyze challenges for Chinese shipowners;

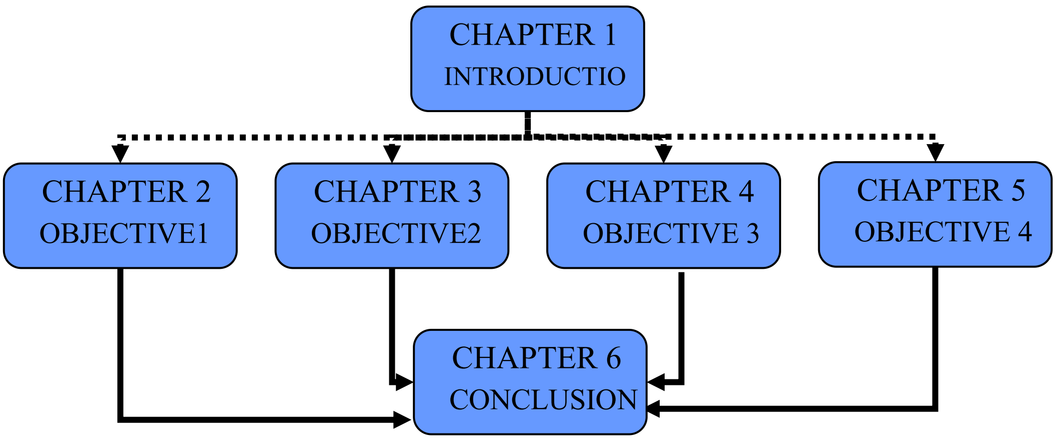
c) Identify risks in complying with the BWM Convention;

d) Discuss possible solutions for Chinese shipowners.

1.3 Structure of the Paper

This paper consists six chapters as illustrated as below:

Fig 1-1 Flowchart of the structure of this paper



Chapter 2 investigates the features and impacts of marine invasive species transferred in ballast water; briefly outlines the development of the Convention and sorts out management requirement for shipowners.

Chapter 3 discusses technologies and legal mechanisms currently available to address AIS in ballast water. By providing insights into relevant deficiencies of these measures it analyzes challenges and uncertainties for shipowners of new ships and existing ships; situation in China and challenges for Chinese shipowners are focused.

Chapter 4 presents risks in complying with standards and procedures.

Chapter 5 provides related suggestions for shipowners as well as authorities to help shipowners hedge safety and administrative risks.

Chapter 6 provides overall summary and conclusions.

Chapter 2 Overview on BWM Convention and Requirement for Shipowners

2.1 Overview on BWM Convention

2.1.1 Ballast Water and Its Impacts to Environment

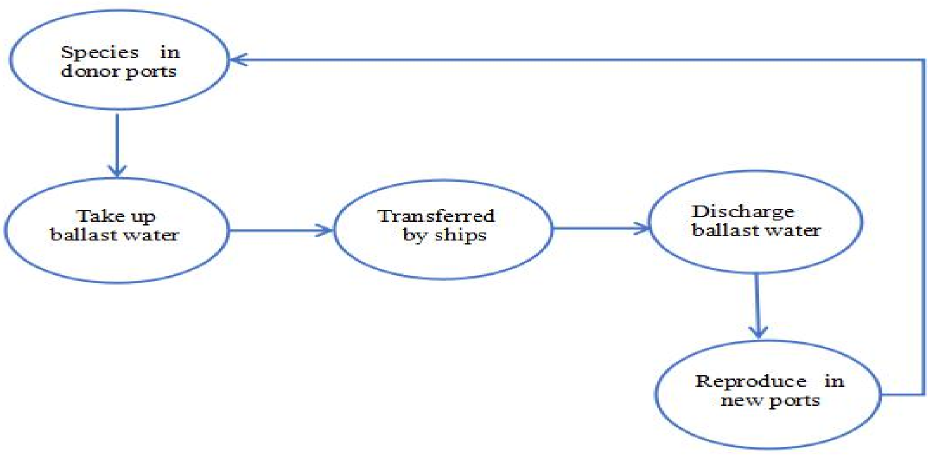
2.1.1.1 Ballast Water

Ballast has long been introduced in shipping industry for the safety of ships. Initially it was in the forms of rocks or packed sand (Fan, 2015). Since 1880, sea water began to prevail and replace solid one as ballast, because it is easily accessible and could avoid any potential safety threats that solid ballast may have caused such as instability due to its shifting in rough weather (GloBallast, 2009). Nowadays, ballast water is not only indispensable for the safe operation of ships but also plays other important roles such as trim optimization and energy efficiency (IMO, 2009).

2.1.1.2 Features of AIS in Ballast Water and Their Impact to Environment

Despite being an important safety and efficiency element, ballast water poses threats to the environment all across the world. Because the AIS in ballast water cause damage to marine ecosystem and its biodiversity, endanger public health and hinder local economic development (Fig 2-1)(Wei, 2016).

Fig 2-1 Flowchart of the transfer of aquatic invasive species in ballast water



Source: Zhu et al. (2010). On Invasion of Marine Alien Species and the Management of Ballast Water in China. *Ecological Layout and Management,* 307-310.

Compared with other invasive species, there are several special features about those brought by ballast water.

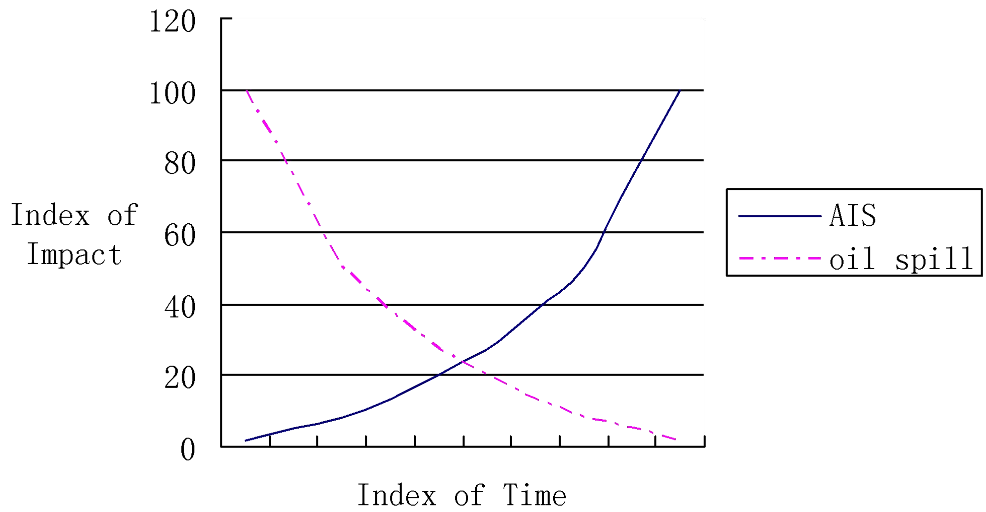
First, the marine invasive species caused by ballast water are more extensive. Some invasive species only occur in certain areas and are limited in scope. But the global nature of shipping leads to the global distribution of marine invasive species transported by ballast water. Statistics show that there are over 100 million plankton in ballast water per cubic meter, and that about 4,000 kinds of marine species are spread across the world into new ecosystem every day (Li and Chen, 2012; Gregg et al.,2009).

Second, invasion of aquatic species transported by ballast water is more imperceptible, is usually overlooked (Li and Chen, 2012). because it is the main function of ballast water as to ensure navigation safety that people tend to focus on rather than the bacteria, pathogens and other microbes in it that cannot be detected by naked eye.

Third, AIS in ballast water strike one place or places repeatedly. Invasive species are discharged continuously into new environment as ships sail around the world all year round. And those transported in ballast water from their original habitats into a new area may be immediately carried away into another part of the world in ballast water of another ship, resulting a “cross-invasion” situation, which amplifies its impact (Ibrahim and El-Naggar, 2012)..

Last but not least, one significant feature that contributes to the destructive effect of AIS is its irreversible nature. The damage caused by AIS in ballast water becomes worse as time goes by. It helps us to understand the nature of this kind of pollution and the urgent need to control it, if we could compare this to the pollution caused by oil spill from ships (Fig 2-2). The contamination from ship source oil spill is usually disruptive and serious, but it will eventually fade away as the oil is cleaned or decomposed. On the contrary, the damage caused by AIS in ballast water may not even be detected easily at first, but it gets worse and lurks for a long period of time (Jiang & Liu, 2011). Unfortunately, there are no measures as effective as cleaning up procedures or emergency plan in dealing with oil spill to control or eradicate the AIS in open water areas.

Fig 2-2 Damage to the environment of AIS *vs* oil spill over time



Source :Zhao et al. (2009). Research on BWM status quo in China and strategies. *China water transport,* 9.

Given the features mentioned above, pollution caused by AIS in ballast water has far-reaching influence and calls for international concerted effort to address.

Fortunately and eventually, the international society will see its effort be paid off on September 8th this year, the day the BWM Convention goes into force.

2.1.2 BWM Convention and Guidelines

2.1.2.1 The Development of BWM Convention

The development of BWM Convention went through an arduous journey. Despite the fact that marine environment pollution caused by ballast water has long been recognized, it dose not qualify for entry into force until very recently with Finland's acceptance on September 8th 2016.

It first started in 1973 when IMCO (Inter-Government Maritime Consultative Organization) identified that bacteria and pathogen contained in ballast water may trigger epidemic across many countries and called for governments to attach more importance to this issue (Wang, et al, 2013).

Although international organizations had made continuous effort to push forward the project, it was not until 1993 that substantial progress was made----the IMO Assembly issued the *Guidelines for Preventing the Introduction of Unwanted Organisms and Pathogens from Ship's Ballast Waters and Sediment Discharges* (A.774(8))-----twenty years after it was first put forward (Shi, 2010). And then in 1997, the *Guidelines for control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens* (Resolution A.868(20)) was adopted; and finally in 2004, *The International Convention for the Control and Management of Ships Ballast Water & Sediments.*

Finland submitted its instrument of acceptance last year, becoming the 52th country to be Party to the Convention, and making the gross tonnage of merchant ships involved reach 35.144% (Xu, 2016). And BWM Convention will eventually enter into force 12 months after that in September 8th 2017.

2.1.2.2 Contents of BWM Convention and Guidelines

BWM Convention consists of 22 Articles covering General Obligations, Reception facilities, Research and monitoring, Survey and certification, Inspection of ships, and Technical assistance, etc; one Annex divided into 5 sections, which provides technical standards and requirements; two Appendices and a series of Guidelines (IMO, 2004) (Requirements for shipowners will be discussed in the next section in details).

The Convention is committed to

> prevent, minimize and ultimately eliminate the risks to the environment, human health, property and resources arising from the transfer of Harmful Aquatic Organisms and Pathogens through the control and management of ships' Ballast Water and Sediments, as well as to avoid unwanted side-effects from that control and to encourage developments in related knowledge and technology.

There are 15 guidelines which are not mandatory but a useful supplement to the Convention and provide guide for proper implementation (Table 2-1).

Table 2-1: Guidelines Concerning BWM Convention

GUIDELINES	**TITLE**
G 1	Guidelines for sediment Reception Facilities (MEPC.152(55))
G 2	Guidelines for Ballast Water Sampling (MEPC.173(58))
G 3	Guidelines for BWE Equivalent Compliance (MEPC.123(53))
G 4	Guidelines for BWM and the development of BWM Plans (MEPC.127(53))
G 5	Guidelines for Ballast Water Reception Facilities (MEPC.153(55))
G 6	Guideline for BWE (MEPC.124(53))
G 7	Guidelines for Risk Assessment under Regulation A-4 of the BWM Convention (MEPC.162(56))
G 8	Guidelines for Approval of BWM systems (MEPC.125(53)). Revised MEPC.174(58)
G 9	Procedure for approval of BWM Systems that make use of Active Substances (MEPC.126(53). Revised MEPC.169(57))
G 10	Guidelines for Approval & Oversight of Prototype BWT Technology Programs (MEPC.140(54))
G 11	Guidelines for BWE Design and Construction Standards (MEPC.149(55))
G 12	Guidelines for Design and Construction to Facilitate Sediments Control on Ships (MEPC.209(63))
G 13	Guidelines for Additional Measures Regarding BWM Including Emergency Situations (MEPC.161(56))
G 14	Guidelines on Designation of Areas for BWE (MEPC.151(55))
G 15	Guidelines for Port State Control under the BWM Convention (MEPC.252(67))

Source: Adopted from IMO website

The BWM Convention and Guidelines constitute a comprehensive system covering various aspects and provide regulations and guidance for stakeholders (shipowners, ports, BWMS manufacturers, shipyard as well as port states and flag states) (Cao, 2015).

2.2 Requirements for Shipowners and Operators

Each international convention lays down certain rights along with obligations on stakeholders. At the end of the day, responsibilities and pressure will be boiled down on the part of shipowners. Although shipping industry is profit-oriented and the BWM Convention is about environment issue, holistic comprehension of all the requirements under the Convention and other regulation is the premise to better comply with them and then to gain marginal profit as much as possible.

2.2.1 Certificates and Documents

2.2.1.1 Ballast Water Management Plan

Once the BWM Convention enters into force, each ship shall have on board and implement a Ballast Water Management Plan approved by the Administration in the form adopted by MEPC.127(53) Resolution. Such a plan shall be specific to each ship and contain detail safety procedures for the disposal of ballast water and sediments, designate the officer in charge of the implementation of the plan and contain reporting requirement. The ship shall submit the plan before filing for an initial survey.

2.2.1.2 Ballast Water Record Book

a Ballast Water record book is required under BWM Convention for each ship and shall be maintained on board for at least two years and thereafter in the Company's control for three years. Each operation and accidental or exceptional discharge of ballast water shall be fully recorded without delay. Also BWR shall be kept readily available for inspection (BWM Convention).

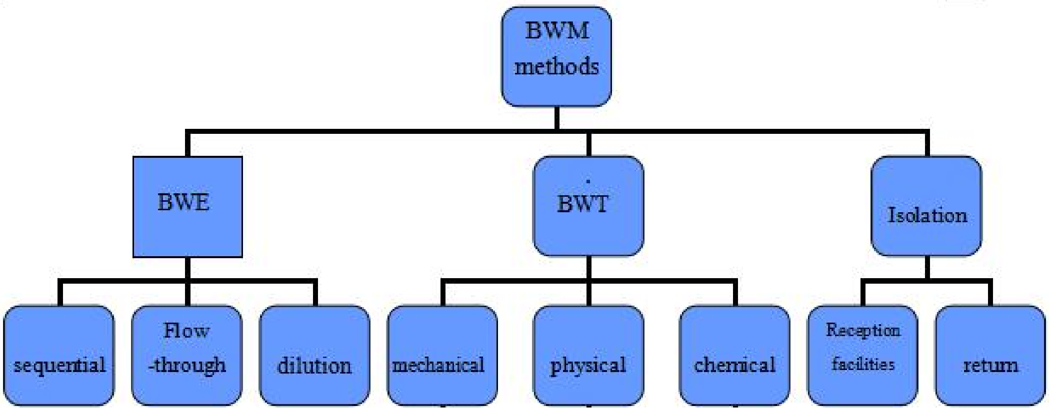
2.2.1.3 International Ballast Water Management Certificate

Ships of 400 gross tonnage and above are subject to a series of surveys including an initial survey, upon the completion of which an International Ballast Water Certificate will be issued. Other ships shall be subject to appropriate measures established by the Administration and a Ballast Water Management Certificate of Compliance shall be issued.

2.2.2 Management Requirements

The BWM Convention is the most important international instrument regarding Ballast Water management and control. Section A of the Annex to the Convention has provided that the discharge of Ballast Water shall only be conducted through Ballast Water Management. Altogether there are 3 ways to conduct Ballast Water Management, i.e. Ballast Water Exchange (BWE), Ballast Water Treatment via Ballast Water Management Systems (BWMS) and Isolation method (Fig 2-3).

Fig 2-3 BWM method currently available



Source： Li Luning. (2016). Chinese Implementation of BWM Convention and suggestions. *China shipping, 37,* 17-21.

BWE operation is subject to weather and sea condition and could have compromised the safety of the ships in extreme cases such as impairing the hull strength and structural integrity or causing change of draft that affects seaworthiness and wave resistance performance of ships, therefore could only be resorted to as a temporary alternative for BWMS for a provisional period of time when the Ballast Water Treatment technology is not proven for market-scale application (Newton, 2012). Eventually for most new ships, their shipowners are confined with the option to install or retrofit BWMS on board as required by the Convention. However, ships on a voyage or voyages or ships that operate exclusively between specified ports or locations could be granted with exemptions based on the Guidelines on risk assessment. Moreover, Section B has provided specific management and control requirement on ballast water and sediment that should give clear clues to shipowners as how to operate or equip the ship in order to comply with the Convention.

2.2.2.1 BWE-D1 Standard

Ballast Water Exchange used to be considered as the most convenient and effective way to prevent the marine invasive species brought by ballast water. The theory behind this is that Coastal organisms couldn't survive in mid-ocean conditions with poor nutrient and high salinity and vise versa. Plus, the organisms density is much lower. So when the exchanged ballast water in the open seas is released at destiny port, the effect of reduced number of organisms in it multiple that of the reduced likelihood of survival will achieve the less chance of invasion.

To ensure the effectiveness of this method, certain standards must be met. As provided in Regulation D-1 of BWM Convention, BWE must be performed with an efficiency of 95% volumetric exchange of ballast water. For ships using pumping through method, three times the volume of each ballast water tank must be pump through, or else the ship shall demonstrate that at least 95% volumetric exchange is met (IMO, 2004).

To meet the standard in regulation D-1, BWE must be conduced in areas in accordance with Regulation B-4 (Table 2-2).

Table 2-2: Regulation B-4 on Ballast Water Exchange (areas)

Scenarios	Requirement
whenever possible	at least 200 nautical miles from the nearest land and in water at least 200 metres in depth
If not possible	as far from the nearest land as possible, and in all cases at least 50 nautical miles from the nearest land and in water at least 200 metres in depth.
If still not possible	in areas designated by the Port State
Others	
If the master reasonably deems that BWE would threaten the safety or stability of the ship or its crews, because of adverse weather, ship design or equipment failure,	BWE should not be required to be conducted in compliance with the above requirements.
Under all circumstances	Neither deviation nor delay of the ship shall be required
	Reasons of any violation of this regulation shall be entered in the Ballast Water record book

Source: BWM Convention. Own adaptation.

2.2.2.2 BWMS--D-2 Standard

BWE is transitional in nature and would buy some time for the BWMS to be developed, which is also the ultimate goal concerning the reduction of harmful AIS in ballast water that IMO is pursuing. After the entry into force of the Convention, the BWMS must comply with performance standards set out in regulation D-2 as shown in Table 2-3.

Table 2-3 Regulation D-2 Ballast Water Performance Standard

Organism category	Regulation
Plankton, >50 μm in minimum dimensions	<10 cells/m3
Plankton, 10-50 μm	<10 cells/ml
Toxicogenic Vibrio cholera (O1 and O139)	<1 colony forming unit (cfu)/100ml or less than 1cfu/g (wet weight)
Escherichia coli	<250 cfu/100ml
Intestinal Enterococci	<100cfu/100ml

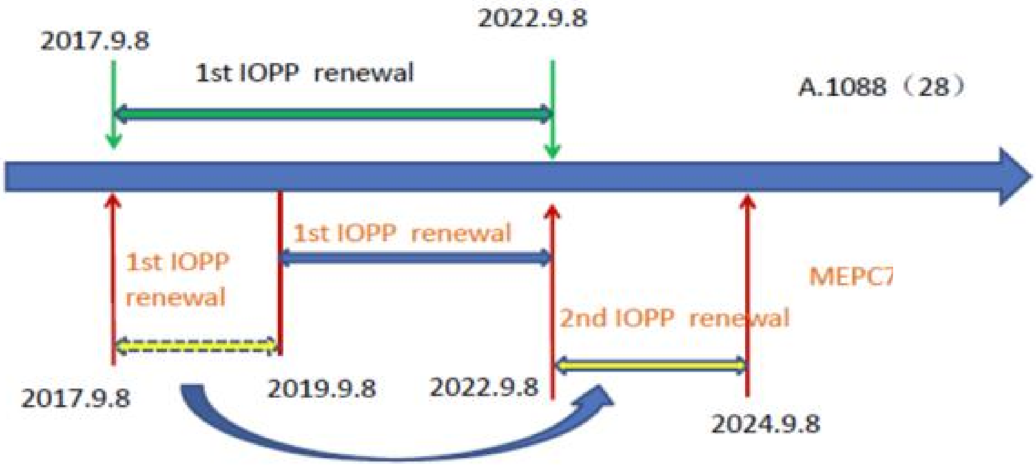
Source: Lloyd's Register Group Limited. (2015). Understanding ballast water management. London. Author.87.Understanding Ballast Water Management(2015)

2.2.2.3 Schedule for Implementation

The schedule for implementing such standard is laid down under regulation B-3. originally there were two versions of timeline for the implementation approved by A.1088 (28) resolution and MEPC 70 meeting (Fig 2-4). Now it is amended and approved in IMO MEPC 71 very recently (July 3th, 2017) (MEPC 71, 2017). The implementation of the BWM Convention for existing ships is postponed for another two years. Specifically speaking: 1) A ship constructed on and after September 8th, 2017 shall conduct Ballast Water Management that at least meets standard in regulation D-2 on the date of delivery of the ship; 2) A ship constructed before September 8th, 2017 shall conduct Ballast Water Management that at least meets standard in regulation D-2 on September 8th , 2019 or the date of the first renewal survey of IOPP thereafter.

MEPC committee also approved the agenda proposed by Japan that ships under 400 GT and not qualified for the renewal survey requirement on IOPP shall be granted to comply with D-2 standard not until 2024, two years later than originally proposed deadline. The amendment to regulation B-3 will be officially approved at MEPC 72 session .

Fig 2-4: Timeline for the implementation



Source: own adaptation.

2.2.2 Other National or Local Regulation

Apart from BWM Convention, there are many other national or local regulations concerning the transfer of AIS via Ballast Water developed by various countries or regions including Australia, Brazil, Canada, China, Egypt, New Zealand, Norway, Northwest Europe, Panama, Russian Federation, Turkey, UK and US etc. Shipowners and operators are bound to these regulations as well if their ships are to trade in these national territory sea areas. Among these regulations, US ones are holding leading position and of great concern to shipowners. It is not only because that US is one of the most powerful trading nations, but also because USCG regulations empower its law enforcement institution to carry out civil fines and penalties and to convict criminal sanctions for deliberate violation (Xu, 2016).

US Ballast Water Regulations consist of USCG regulations, US Environmental Protection Agency (EPA) permits, and individual state acts(Wang et al, 2013). The *"Standards for Living Organisms in Ships' Ballast Water Discharged in US Waters"* also known as *the USCG final rule* was promulgate in 2012 and was already into force. Under this regulation, all ships in US waters within 12 nautical miles from nearest land are required to install an USCG type approved BWMS and to comply with Ballast Water management, Ballast Water reporting and record keeping as well as a number of additional requirements including fouling management, anchor rinse and clean ballast tanks, etc.

Other national regulations are as follow:
Canada requires ships calling ports in Vancouver must conduct BWE outside Canadian waters; Panama forbids any discharge of ballast water in the Panama canal, etc.

Shipowners traveling into these regions must pay special attention to the more stringent requirements of there areas to avoid any detain or delay of their ships.

Chapter 3:Challenges and Uncertainties for Shipowners

3.1 Challenges and Uncertainties in Selection, Installation and Operation of BWMS

For years, the industry has feared that winter is coming. The gross tonnage of world fleet has increased by 50% while shipborne trade only 27.5%, and the figure in 2016 was 2.5% 40% less than the average growth rate between 2010 and 2014 (Liu, 2015). The fear was reinforced by the plummeting number of new ships and the unexpected bankrupt of HANJIN, a former shipping conglomerate. Many even believe the entry into force of the BWM Convention would make it harder for the shipping industry as increasing number of shipowners postpone their contract to build new ships and speed up ship recycling.

However reluctant shipowners may feel, retrofitting BWMS is inevitable and it has become a burning issues for shipowners as the Convention will enter into force soon, let alone some countries like America and Australia has already established even more stringent requirements. But the shipowners will be confronted with huge challenges to select the most appropriate BWMS, because each ship has its unique feature and a tailor-made solution will be required (Cao, 2015). Brief introduction of ballast water treatment technology and sediment control is made before some of the major risks and challenges of retrofitting the system are discussed as follows:

3.1.1 Ballast Water Treatment and Sediment Control

BWT is divided into three major categories (Airahuobhor, 2010): mechanical, physical, and chemical treatments. These methods are not exclusive from each other. (Wu et al., 2011). It is more practical and efficient to combine two or more methods in treatment systems of ballast water. Principles and drawbacks of some typical BWT are illustrated in Table 3-1.

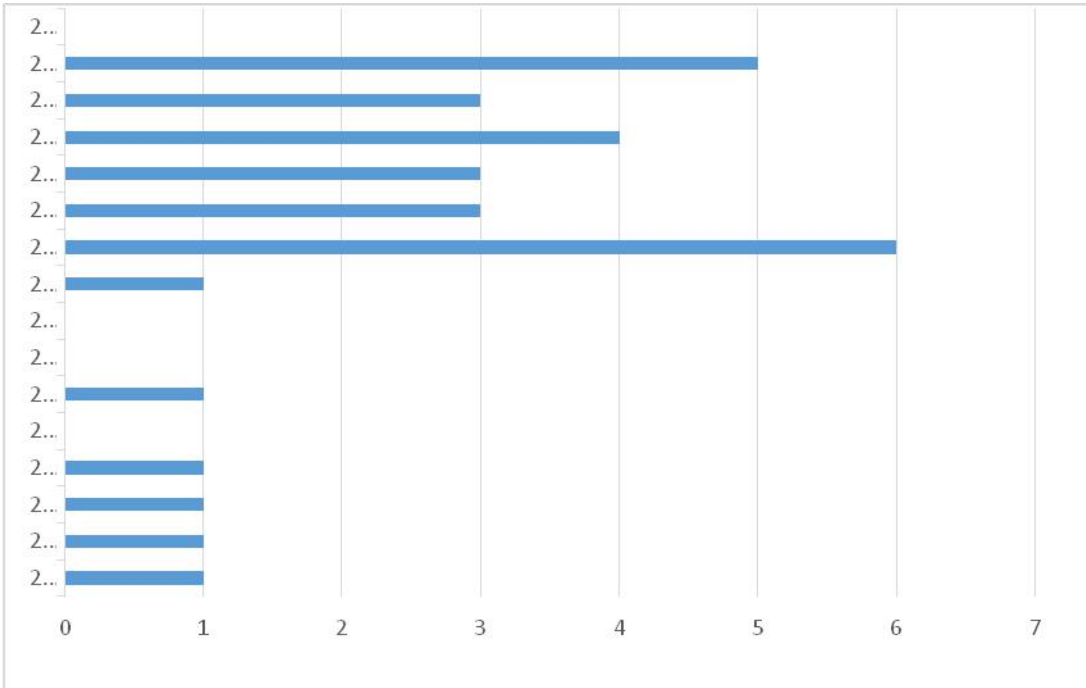
Table 3-1 Main ballast water treatment technology

Treatment	Features/Principles	Drawbacks
Filtration	effective in removing large substances, viruses, bacteria, etc.	time-consuming; New equipment must be installed.
Hydrocyclone	more effective than filtration	not working when it comes to substances of density similar as that of seawater; New equipment must be installed.
Ultraviolet radiation	inactivate microorganisms, intervene the division of cells and prevent them prom reproduction; especially effective for those organisms of short life cycle.	Due to the short wavelength of UV light, it is likely to be blocked or diminished in the transmission process.
Heating	Ballast water is heated to a certain temperature and maintained at that level.	loss of heat due to exchange of sea water; increase possibilities of corrosion.
Ozone	strong oxidant	corrosive to ships' construction; Some marine microorganisms have shown resistance to ozone treatment.
Hydroxyl	oxidation	highly corrosive; One product of the reaction is carbon dioxide.
Deoxygenation	remove oxygen from ballast water	only applies to aerobic respiration organisms
Chlorine dioxide	disrupt the transfer of nutrients through the cell wall	high level of toxicity; Tend to cause secondary pollution

Source: own presentation

However, it is noteworthy that despite various BWTS currently available, there is plenty of proof indicating that not one treatment method, or even a combination of primary and secondary methods, can guarantee 100% elimination of all marine organisms (Gregg et al., 2009; Ibrahim and El-Naggar, 2012). One major implication thereof is the potential for regrowth after treatment, yet little attention has been paid to this issue in the past 15 years or so (Fig 3-1) (Grob and Pollet, 2016). Therefor this is where further scientific research and investigation need to be geared toward. And it is important to keep ship industry as well as policy-makers well informed of this issue so as to not only comply with discharge standard but also contribute towards avoiding new species invasion altogether.

Fig 3-1: Number of publication on regrowth in ballast water between 2001 and 2016



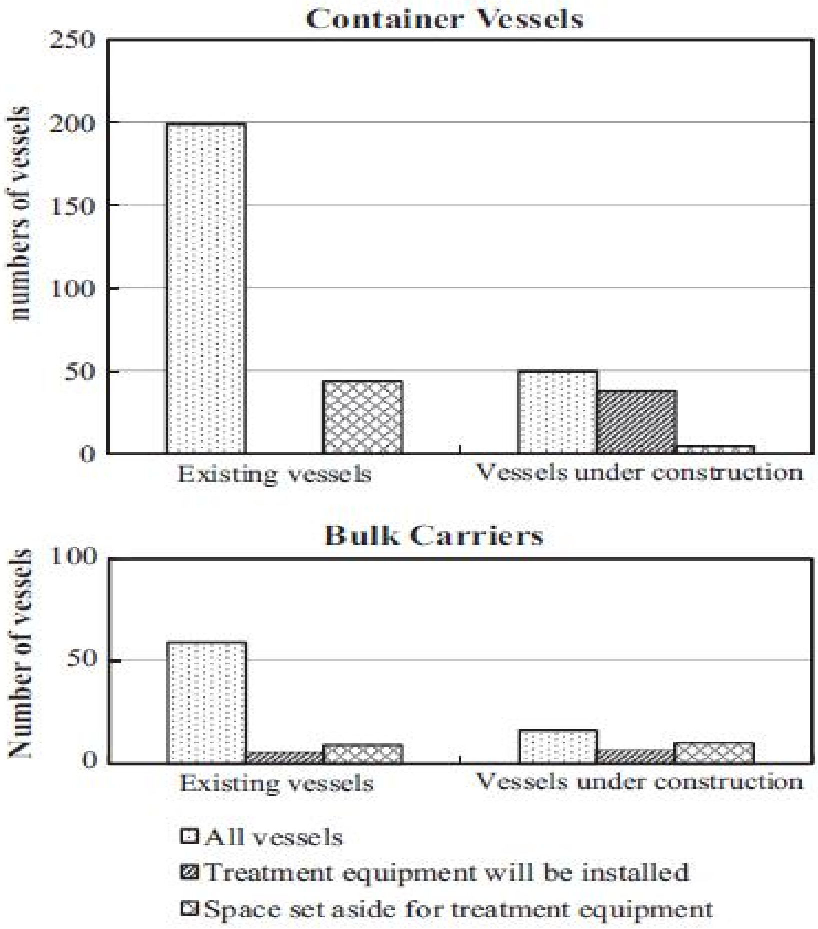
Source: Grob and Pollet, (2016). Regrowth in ship's ballast water tanks: think again! *Marine pollution bulletin,109,* 46-48

3.1.2 Challenges and Uncertainties about BWMS

3.1.2.1 Initial Key Points

Choosing an ideal system is a complex task, especially for existing ships. A recent study conducted by Taiwan academics (Liu, 2015) shows that the percentage for installation of BWMS among new ships is much higher than that among existing ships (Fig 3-2).

Fig 3-2: Vessels reserved space or planned to install ballast water treatment equipment



Source: Ta-Kang Liu,et al. (2015). Management strategies to prevent the introduction of non-indigenous aquatic species in response to the Ballast Water Convention. *Marine policy, 44,* 187-195.

Vessel types, trading routes and the characteristics of different BWMS should all be taken into consideration. As Mr. Leif Eric Caspersen (ERMA First sales manager) said himself "...salinity, turbidity and temperature all affect BWMS performance in one way or another" (ERMA, 2015).

For example, the ballast water dependency varies among different ships. Container ships have much lower ballast water dependency than bulk carriers and oil tankers (Table 3-2), which means container ships have lower requirement on pumping rate of BWMS. However, container ships emphasize prompt and precise schedule, while bulk carriers and tankers have more flexible schedule and their main concern is cost effectiveness. Therefore the pumping rate for container ships shouldn't be too low in terms of the total operation time (Hermann et al, 2015). All these need to be taken into consideration. Unfortunately, there is no BWMS universally applicable regardless of ship types up until now. Therefore particular caution should be in place when selecting BWMS.

Table 3-2: Ballast Water Capacity and Ballast Pump Rate of Different Types of Ships

Dependency level	Vessel type	Total ballast capacity	Pumping rate (m^3 /hr)
High ballast dependency	**Bulk carriers**		
	Handy	180001	1300
	Panamax	35000	1800
	Capesize	65000	3000
	Tankers		
	Aframax	31000	2500
	Suezmax	54000	3125
	VLCC	90000	5000
	ULCC	95000	5800
Low ballast dependency	**Container ships**		
	Feeder	3000	250

	Handy	8000	400
	Sub-panamax	14000	500
	Panamax	17000	500
	Post-panamxx	20000	750
	Other ships		
	Chemical carriers	11000	600
	Ro/Ro	8000	400

Source: adopted from ABS

3.1.2.2 Technical and Operational Challenges

Power and space constraints are another key factor in retrofitting BWMS. Some systems are large power consumers and might cause power shortage during peak load conditions. For instance, UV systems consume 150kW to 300kW for a 2000 m^3 system (Wei, 2016) . Plus, additional load means additional fuel consumption.

Space is a paramount issue for existing ships which did not traditionally plan to install BWMS in the designing stage. BWMS are usually large, with auxiliary equipment----such as ladders, lighting, storage of chemicals used in the treatment----to make it worse (Pereria et al, 2016). In cases where hazardous elements are involved, special attention should be paid to ventilation, fire proof and detection function.

The complexity of BWMS and various operation procedures among different system types are rather demanding for the crew who have never been exposed to such a system before (Banerji, 2012). In addition, some systems using active chemicals might pose hazard to seafarers health and safety, increasing uncertainties during treatment operation.

Right now, as mentioned before, there is no BWMS universally suitable for all types of ships. Comparisons are made among part of different systems and their advantages and disadvantages are listed as below (Table 3-3).

Table 3-3 Comparison among Different BWMS

Pump rate (m^3 /h)	Treatment	Manufacturer	Main parts	Power (/kW)	Space (m^3)	Features
250	Filtration; Photocatalysis	Alfa laval	AOT Filter Flowmeter	40	2.44	Small space occupation; large power consumption; retreatment needed
750				120	4.21	
1500				240	7.49	
2500				400	10.96	
201-400	Cavity; Electrolysis; Ozone	Unitor	Reactor Filter Ozonator	7	4.68	Small space occupation; small power consumption; retreatment not needed
601-1000				12	5.56	
1201-1500				18	7.05	
2001-2500				30	9.6	
301-500	Filtration; Electrolysis; Neutralization	Qingdao SUNRUI	Filter Electrolyte Neutralizer	25	7.66	Small space occupation; large power consumption; retreatment needed
501-1000				50	9.65	
1001-1500				75	11.52	
2001-2500				125	13.87	
400	Magnetic separ ating	Alfa laval	AOT Filter Flowmeter	40	2.44	Small space occupation; large power consumption; retreatment needed
800				120	4.21	
1200				240	7.49	
2400				400	10.96	

Source: own presentation, adapted from manufacturers' website and brochure.

3.1.2.3 Market Consideration

Primarily because of high cost and difficulty of installation, as well as uncertainties of BWMS itself and of regulations among different authorities, most shipping companies are holding a wait-and-see attitude towards installing BWMS on existing ships (Fan, 2015). But extremely high percentage of new ships under construction will be installed with BWMS and many companies have already urged their ships to be equipped with Ballast Water Record Book and Ballast Water and Sediments Management Plan, indicating that shipping companies were aware that the enforcement of BWM Convention is inevitable and are ready to take measures to be compliant with it (Yang, 2014).

Chances are the accumulated demand for installing BWMS on existing ships derived from their flinching attitude will lead to a peak during a five-year-period after 2017 (Xu, 2012). Statistics show that over 70,000 ships will be in want of BWMS from 2017 to 2021, posing great challenge to both the shipyards and manufacturers' capability (Xu, 2016). But liner business is highly competitive and time-sensitive, any undue delay would cause tremendous loss. Therefore when and whether the installation could be carried out in time is crucial to shipowners.

3.1.2.4 Regulatory Aspect

Now the sampling method is not consistent between PSC inspection and BWMS type approval. It is likely that ships equipped with BWMS approved by IMO and treat ballast water in accordance with D-2 standard still be held liable for violating the Convention, just because the PSC inspection shows otherwise due to different sampling method (Warschkun et al, 2014), which will be discussed in detail in next chapter.

Another regulatory issue is the inconsistent requirements. Ships engaged in trade with the US might not be able to just settle for BWMS approved by IMO, because the former establishes higher standard in its national law (Table 3-4). Therefore some propose that it's more prudent to install USCG proved systems (Li, 2016).

Table 3-4 Standard Differences Between BWM Convention D-2 and USCG Final Rule

Organism type	IMO regulation D-2	USCG phase I	USCG phase II
Organism ⩾ 50 μm minimum dimension	＜10 cells/m^3	＜10 cells/m^3	＜0.01 cells/m^3
Organism 10-50 μm	＜10 cells/ml	＜10 cells/ml	＜0.01 cells/ml
Toxicogentic vibrio cholerae	＜1cfu/100 ml or ＜1cfu/g wet weight of zooplankton samples	＜1cfu/100 ml	＜1cfu/100 ml
Escherichia coli	＜250 cfu/100 ml	＜250 cfu/100 ml	＜126 cfu/100 ml
Intestinal enterococci	＜100 cfu/100 ml	＜100 cfu/100 ml	＜33 cfu/100 ml

Source:own presentation

3.2 Challenges and Uncertainties for New Ships and Existing Ships

3. 2.1 Challenges and Uncertainties for New Ships

All the new ships are required to comply with D-2 standards on the date of delivery. Thus the main concern for new ships focus on the BWMS itself (Wei, 2016). The liability of a BWMS is mainly embodied in two aspects: 1) good performance in various adverse situation; 2) continuous working hours with low failure rate.

The bottom line for BWMS from shipowners' perspective is to pass PSC inspection (Fei, 2014). But the shipboard testing during type approval dose not necessarily require that every single processing of the whole Ballast Water treatment to comply with D-2 standard. Chances are, under certain extreme circumstances, the systems might not be working (Samyde, 2011). Though manufacturers would make instructions about reference condition and limits of the equipment, still, it is not unusual for ships to sail through adverse environment that breaches such limits (such as areas of high density of organisms or suspended particles) (Rivas, 2015). The Convention does not provide exemption for this kind of situation that dose not jeopardize the safety of the ship. It will create tremendous burden on shipowners to turn to other remedies to avoid any delay or PSC penalties just because of the breakdown of the BWMS.

3.2.2 Challenges and Uncertainties for Existing Ships

Compared to new ships, existing ships are caught in a more tricky situation. Shipping is an industry that tend to maximize its profit, which is also the major concern for existing ships (Fan, 2013). Without the capacity and speed advantage compared to their modern counterpart, existing ships have to squeeze the cost. But the average cost for retrofitting BWMS is surprisingly high, ranging from 1 million to 10 million per ship (Fan, 2015). Take a cargo ship of 50,000 DWT constructed in 1997 for instance, the cost for simply purchasing the BWMS is very much the same the price for the ship for sale on scrapped vessel market (Fan, 2015). Considering overcapacity in shipping industry, it is only natural that shipowners are not most enthusiasm about such a big move focusing mainly on marine environment protection regime with little economic incentive. But they found themselves in such a dilemma that if they don't retrofit such an expansive equipment, they would be unable to operate their ships at all. Even sending the old ships to scrapping yard could not solve the problem, because that means giving up certain amount of market share which would be increasingly difficult to regain as the ship building price is climbing steadily (Luo, 2013).

For existing ships, it is noteworthy that the expenditure for retrofitting the BWMS is far more than mere procurement cost. As mentioned before, space limit, pipeline layout, power capacity and additional generator and auxiliary machines are all element to take into account when calculating the total cost. Another factor that will increase the cost further is the surplus between the demand and supply of ship repair services. Most ships need to retrofit BWMS when repair interval is due. Since statistics show that at least 30% of existing ships are constructed between 2012-2013 due to the global easy monetary policy from 2008-2012, the docking demand will be skyrocketing (It is estimated that more than 70,000 ships will be required to retrofit BWMS from 2017-2021 as mentioned in last section), making shipowners in a more vulnerable bargaining end.

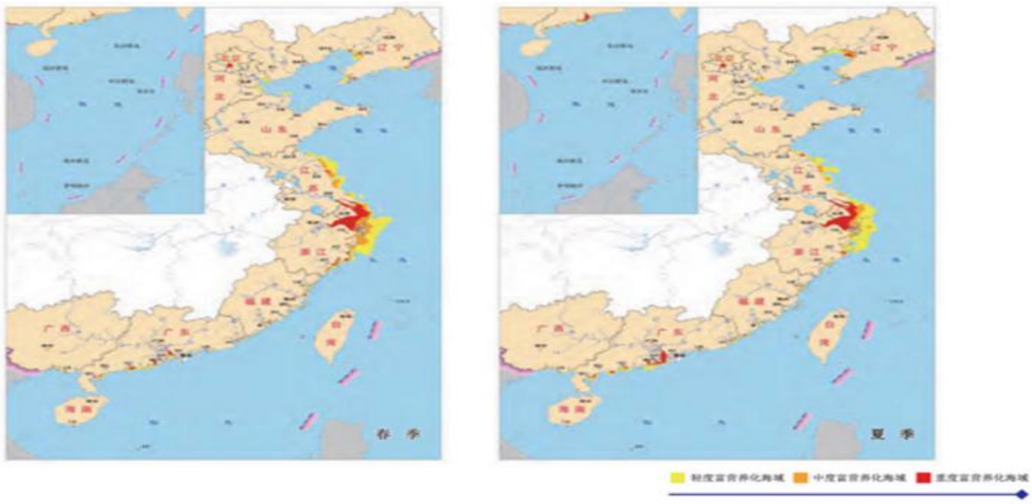
Another dilemma shipowners are in is about the survey and certificate requirement. BWM Convention dose not provide existing ships with any grace period, which means all ships applicable to the Convention shall have BWM certificate once the Convention enters into force. Therefore shipowners shall have the Certificate before the date when the Convention enters into force in order to continue the operation of their existing ships continuously (Zhou, 2013). However, the administrations are only allowed to issue document of compliance instead of the certificate prior to the entry into force of the Convention. The tradition goes back as early as in SOLAS and MARPOL time. When it comes to BWM Convention, even with the document of compliance, shipowners need to get the certificate within 12 month after the Convention enters into force. It’s not practical and feasible to issue about 70,000 certificates worldwide in such a short notice .

3.3 Challenges of Ballast Water Control in China

3.3.1 Status quo

As one of the top ten maritime transport nations in the world, China embraces vast coastline (18000 km in length) and numerous coastal ports (over 230 in total) (NSB, 2016). Shipping, fishery and aquaculture contribute a lot to the national economy. With the expanded fleet and seaborne trade comes the threats to marine environment and local economic development. It is estimated that the direct economic loss caused by invasive species is as high as 57.4 billion yuan (8.57 US dollar), of which AIS is the dominant source (NSB, 2016). That's because the major merchant fleet visiting Chinese port (including oil tanker, bulk carrier) often return their original port with empty cargo hold, therefore are heavily in ballast. The most busiest ports in China including Liaodong Bay in the Bohai Sea, Yangzi estuary in the East China Sea and Pearl river estuary in the South China Sea have been listed by Chinese government as the most polluted areas in China (Fig 3-3). Furthermore, it is confirmed that over 16 types of non-indigenous algae have invaded Chinese marine environment via ballast water. AIS in ballast water has caused serious damage to China's marine ecosystem, which is evident in the statistical year book on the evaluation of Chinese seawater quality (Table 3-5).

Fig 3-3: Eutrophication of China sea areas during 2016 spring and summer time



Source: China marine environment communique 2016. China Oceanic Information Network.

Table 3-5: Evaluation on China's Seawater Quality

	Total area of sea /k·hectares	Average depth/m	Max depth/m	Pollution level/10000 km²			
				null	low	median	high
Sum	472700	/	/	6.55	2.88	1.74	2.53
The Bohai Sea	7700	18	70	0.76	0.56	0.51	0.31
The Huanghai Sea	38000	44	140	1.16	0.67	0.28	0.26
The East China Sea	77000	370	2719	3.41	0.96	0.69	1.59
The South China Sea	350000	1212	5559	1.22	0.69	0.26	0.37

Source: National Bureau of Statistics of China, (2016). China statistical yearbook 2016. China statistics press.

Given the above mentioned situation, China has long been making efforts to put forward ballast water management. Before the BWM Convention was in infantry, China was one of the six countries carrying out the Global Ballast Water Management Programme (GloBallast), a project launched by IMO and United Nation

Development Program (UNDP) and the Global Environment Facility (GEF) to facilitate developing countries with technologies and expertise and to address the global threat to the health of the world's oceans, by further improving the environmental and socio-economic sustainability of shipping and reducing its negative impact on the marine ecosystems .(GloBallast, 2017) .

During that period, China has formed leading group on a national level, held national campaign and seminars on Ballast Water management and control, as well as conduct study and research on legislation feasibility and port biological baseline. After the programme, Transport Ministry of China continued related research and promotion including a 3-year programme called Study on *Strategic Plan and Action to Implement BWM Convention*. To provide shipowners with aid and technical support, Chinese government has gathered experts to explained hot issues of their concern (Liu, 2015). In the meantime, China has actively advanced regional exchange projects on Ballast Water management including bilateral meetings with Korea on issues like BWE areas, risk assessment and ratification to BWM Convention.

3.3.2 Challenges

Despite the efforts made, the drawbacks of ballast water management in present China cause extra burden and difficulties for Chinese shipowners.

3.3.2.1 Absence of Laws and Regulations & Coordination Between Government Institutions

Up to-date, China's regulations on ballast water management and control include: *Frontier Health and Quarantine Law of the People's Republic of China* which specifies that:

> Frontier health and quarantine offices shall, in accordance with state health

> standards, exercise health supervision over the sanitary conditions at frontier ports and the sanitary conditions of conveyances on entry or exit at frontier ports. They shall: supervise and inspect the disposal of garbage, waste matter, sewage,excrement and ballast water (Article 18).

Regulation of the People's Republic of China on the Prevention of Vessel-induced Sea Pollution which specifies that:

> The ballast water kept in all empty oil tankers entering the harbor must be no less than one-fourth of the deadweight capacity of the oil tanker in question. In cases where an oil tanker does not keep sufficient ballast water as stipulated, the harbor superintendency administration shall investigate the whereabouts of its ballast water and handle the matter according to the circumstances therearound (Article 10). Vessels from epidemic-affected ports shall apply to the sanitation and quarantine department for sanitary treatment of the ballast water thereof (Article 25).

These laws and regulations mainly focus on navigation safety, health and quarantine. Aquatic bio-invasion via ballast water is not included (Luo and Yu, 2013). Another problem is that a bunch of authorities including China MSA, State Oceanic Administration, Ministry of Health and Import and Export Quarantine Departments are involved, but it is not specified in any of these laws which authority should be responsible for supervising this kind of ballast water treatment. In addition, the leading group set up in the GloBallast programme did not last nor did it establish long-term coordination mechanism among different departments involved in the group after the program. (Qin, 2016).

3.3.2.2 Insufficient Ocean Database

China enjoys abundant natural marine resources. But researches on these ecosystem is far from enough (Li, 2016). The marine biological baseline data is unclear. Without a clear distinction and definite detection between the indigenous and invasive species, comprehensive monitoring over and thorough study on coastal areas (especially sensitive areas) could not be conducted. On the contrary, the practices of the US is worth learning. It devoted itself into collecting and studying ocean data not only of their own waters but other international and regional areas (Danielle, 2016). With such vigorous research and development activities as backup, the US, though does not rectify to the Convention as well, exerts global influence by laying down its own rules and regulations.

3.3.2.3 Drawback in Laboratory Building and Technology R&D

Falling behind in laboratory building and technology R&D is a bottleneck if China seeks to support and facilitate ships flying its flags in complying with the Convention. Lacking of economic stimulus and mandatory requirements as well as proactive thinking is believed to be accountable (Yang, 2014). Among the 167 laboratory listed as National Engineering Labs (NEL) last year, only 9 of them are specialized in marine and ocean studies. Out of the nine marine labs, only one (NEL for Technology of Testing and Experiment in Offshore Engineering Equipment of *Shanghai College of Fisheries and Life Science*) has obtained international mutual recognition and qualification. It is also the first to be approved by both CMA (China

Metrology Accreditation) and CNAS(China National Accreditation Service for Conformity Assessment) (two sets of approval for laboratory management and technical merit by Certification and Accreditation Administration of the People's Republic of China). Testing organizations that are not internationally qualified are of little use in defending the interests of the fleet to whose flag the organizations belong (Zhang, 2011). Because shortage of advanced technology and specialized agencies would impede the development of procedures that are in favor of shipowners most (quick sampling measures, BWMS technology, risk assessment, etc.)

3.3.2.4 Urgent Demand for Regional Regulation

China has not ratified to the BWM Convention yet. The reasons are mainly threefold: first, as a flag state with a huge registered fleet, it is difficult to reconstruct such a large amount of existing ships; second, without the ballast water and sediment reception facilities and effective and efficient sampling measures, it is hard to live up to its port state obligation; third, under certain condition, excessive untreated ballast water could not be disposed properly (Fei, 2014). In the meantime, ships flying Chinese flag have prepared to fully implement ballast water management to comply with the Convention and other regulations of port states. But as a port state itself, China could not demand no less from ships of other countries due to the lack of domestic laws and regional regulations, leaving the coastal areas susceptible to ballast water pollution. Regional regulation is essential to the protection of a nation's marine environment and to the right to participate in international affairs. Countries with unilateral regulation on ballast water are developed countries which either boast cutting edge technology or attach great importance to marine ecosystem protection.

For years, China has been a big maritime country, but not a strong maritime power

(Li, 2011). It is tied down to answering to others' request, without making a difference for regional interest and international community. Coming up with its own regional rules and regulations, it seems to raise the threshold for domestic BWMS manufacturers. In fact, it is binding for both domestic and foreign players thus urges domestic investment in BWMS R&D and is favorable to domestic manufactures.

Chapter 4: Risks in Complying with Standards and Procedures

Technical barrier imposed by developed economies together with inherent deficiencies of BWM Convention and Guidelines as well as overlaps among different regulations would cause risks for shipowners who are in good faith to enhance ballast water control and comply to these requirements.

4.1 Undue Delay

Article 12 of BWM Convention provides that ships shall not be unduly delayed or detained and is entitled to compensation when this is the case. But unfortunately, neither clear definition nor unified explanation of "undue delay" is specified in the Convention or other IMO instruments.

In the meantime, ships are getting bigger, which is not a new phenomenon. The last decades have witnessed a continuous increase of ship size driven by shipowners in search for economies of scale (Barbara, 2014). Larger ship size entails more volume of ballast water. On the other hand, shipping industry is mainly driven by price competition and is highly time sensitive. Investment is laid considerably in increasing the sailing speed and cargo handling efficiency to reduce voyage time and turn around period in port. The contradiction between the growing amount of ballast water which requires more time to be disposed or treated and the ever shortened time for a single voyage compels ships to slow down in order to finish BWE or BWT process (Li, 2012). In extreme cases when caught in severe weather or on certain route with lower-than-required depth or distance from land, ships may have to deviate from the intended route. Extended voyage time means extra cost which is why undue delay becomes a choke point for shipowners who seek to maximize profits.

4.2 Sampling Standards

Sampling, as well as adequate inspection and monitoring, are equally essential in any environmental pollution control or prevention policy. Sampling analysis results are the ground on which PSCOs would determine whether a ship is in compliance with the BWM Convention in accordance with article 9 “Inspection of Ships”. But right now, sampling procedure is time-consuming. And the sampling methods are not consistent between PSC inspection and BWMS type approval, making it a burning issue for both shipowners and inspectors.

▪ Regulation D-2 of BWM Convention is applicable to ships instead of BWMS. Even though a BWMS passed land-based tests and shipboard tests during type approval, there is still no guarantee that plankton and pathogen would not recover and regrow after the treatment. In such a case, the ship would be deemed as not be in compliance with regulation D-2. Hence, BWT is recommended to be conducted during both ballast water uptake and discharge phases.

▪ Guidelines for Ballast Water Sampling (G2) and Guidelines for Approval of Ballast Water Management Systems (G8) provides practical and technical guidance on ballast water sampling and analysis for inspection and type approval respectively, which are not consistent. So there is a possibility that shipowners installed a type approved BWMS, obtained valid certificate and carried out operation and maintenance properly, still be held liable for violating D-2 standard just because PSC inspection result shows otherwise due to different sampling methods.

To avoid such situation, during the trial period of the sampling analysis method (within 3 years after the entry into force of the Convention), ships will be exempted from penalties. Moreover, the principle of not punishing early mover is confirmed at MEPC 68 that ship owners will not be required to replace the first generation ballast water treatment systems installed onboard until the end of ship's life (MEPC.174(58)). But it's hard to tell whether uneven implementation/installation gives birth to such a compromising principle or does this kind of exemption indulge the chaos and amplify confusion.

4.3 Risk Assessment Based Exemptions

Ballast water risk assessment is a logical process for assigning the likelihood and consequences of specific events, such as the entry, establishment, or spread of harmful aquatic organisms and pathogens (G7,2007). It lays foundation for ship risk management and exemption under regulation 4 of BWM Convention. The accuracy and accountability is the key to the success of ballast water risk control policy (Shi, 2010). And it should be carefully undertaken because any decision to grant an exemption lacking of scientific certainty would allow for the discharge of ballast water that does not meet the D-1 and D-2 standards.

Yet various risk assessment methods currently available all have their own limitations. Three method outlined in G7, i.e.

• Environmental matching risk assessment
• Species' bio-geographical risk assessment
• Species-specific risk assessment

and another frequently used method--Same Risk Area Method (SRAM) will be discussed in details. They all have their pros and cons. For instance, as for transparency, consistency and effectiveness, the same risk ares method outperforms Species-specific method. It is also more efficient and less expansive regarding computing and algorithm cost. But just like Species-specific method, SRAM does not take into account the impact on economy, culture and social development. Nor is there any guidelines directing actions to reduce these impacts. While environmental matching risk assessments have limited value where the differences between a donor bio-geographic region and a recipient port are small

Furthermore, different methods focus on different aspects leading to varying assessment results even for the same environment. For example, as illustrated in Table 4-1, assume two ports with high ecological relevance but different local species. According to same risk ares method, target species in two ports could be transferred freely into each other because of high relevance, thus the port belong to the region with similar risk and exemption can be granted. However, Species-specific risk assessment seems to believe completely the other way that exemption cannot be granted if target species in the two ports are totally different.

Table 4-1: Different Results under Different Ballast Water Risk Assessment Methods

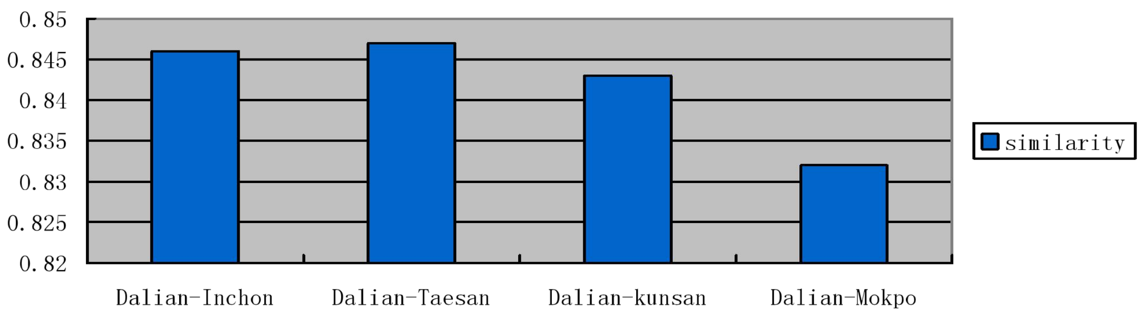
Port condition	High ecological relevance	Low ecological relevance
Same target species	Exemption can be granted	Under G7: Exemption can be granted Under SRAM: Exemption cannot be granted
Different target species	Under G7: Exemption cannot be granted Under SRAM: Exemption can be granted	Exemption can be granted

Source:Xu Miaomiao. (2016). How should shipping industry respond to the entry into force of BWM Convention. *China ship survey, 11,* 50-63.

What is more troubling for shipowner is the division of bio-regions. Previously, the notion of LMEs is recommended (http://lme.edc.uri.edu/). but later at MEPC 68, a proposition was made that domestic voyages no matter how long they may be and how different the environment between the ports of departure and destination are, they should be exempted; while international voyages, on the other hand, should comply with the Convention regardless of the distance. It is not scientifically reasonable to divide bio-regions by national boundary. Because two neighbouring countries might be close and belong to the same bio-region in accordance with LME. A previous study on environment similarity between Dalian port, China and several ports in Korea confirmed this fact (Fig 4-1). Voyages between ports in different countries like this should have been exempted.

Fig 4-1: Total similarity between Dalian port and Korean ports environment

Ports	Dalian-Inchon	Dalian-Taesan	Dalian-Kunsan	Dalian-Mokoo
Similarity	0.8461	0.8464	0.8436	0.8320



Source: Zhang. (2015). study on the environment similarity between Dalian and certain Korean ports. *China ocean study, 6,* 23-36.

4.4 Ballast Water Reception Facilities

Given the risks and challenges in complying with D-1 and D-2 standards (high cost, undue delay, system failure, lack of effective monitoring mechanism etc.) and the complicated inspection procedure, it is believed that for certain types of ships reception facilities would be the solution, which spare expensive installation and maintenance fee with no requirement on space and power capacity. The biggest problem is that ports will be confronted with the new requirements on port-related infrastructure such as standardized connection of pipework so as to ensure ships regardless of their types could enjoy the same service, which is also one of the main purposes of G5. Another risks concerning reception facilities is limited berth capacity. Without universally applicable port infrastructure currently, shipowners' choices would be narrowed down to certain few ports, causing congestion and delay not only for ships themselves but all the other parts along the logistic chain.

Chapter 5: Suggestions for Shipowners and Authorities

5.1 Suggestions for Shipowners

5.1.1 Suggestions for BWE

BWE method should be chosen considering ships' structure, loading and stowage condition, manning, etc and properly adjusted if weather or environment changes drastically during voyage.

5.1.2 Suggestions for BWT

5.1.2.1 Manufacturers with Experiences

Go with manufactures with experiences. There is a wide range of different systems in the BWMS market, each having its own pros and cons. But a mature manufacturer with its dedication to investing in R&D and good market reputation, can not only provide a high quality product tailor-made for the target ship, but also assure after-sale services increasing the system's stability under various conditions (Culin & Mustac, 2015). Furthermore large database acquired from their sold systems and large capacity will also facilitate mature manufactures to deal with the peak time.

5.1.2.2 Technology Innovation

Tackling technical challenges such as power and space limitation depend largely on innovation. Technology innovation in developing BWMS is difficult as presented in heavy investment, complicated experiment and long trial period (Xu, 2012). If shipowners could join in research and development, cost and risks would be largely reduced. Among innovative solutions currently available is "Solid Ballast TEU", a zero ballast water concept, proposed by Daewoo Shipbuilding & Marine Engineering.

This method replaces ballast water with suitably weighting solid containers, creating additional space which was originally used for ballast water tanks. Other innovation include "The BWT 500i" system from Wartsila and Trojan Marinex integrating filtration and UV disinfection techniques into one single unit (Marttinen, 2010); modular installation and deployment of sensors to detect treatment efficiency and control flow rate and power accordingly.

5.1.2.3 Quality Assurance Clause

Considering legal and technical uncertainties in complying with the convention, it is suggested for shipowners to incorporate quality assurance clause when seal the BWMS purchasing contract. By paying deposit or indemnity in exchange of quality assurance from the seller, shipowners can hedge the risks of being detained in PSC inspection (due to BWMS failure not operation mistakes) by getting compensation from suppliers or underwriters (Dang, 2016).

5.1.2.4 Enhance Training

Given the BWMS is complicated and the crew are exposed to potential danger in the cases where toxic chemicals are used, it is necessary to enhance the training on daily operation and personal protection, as well as increase the awareness of the crew (Zhang et al, 2011). Additional investment to safeguard the crew's occupational health and safety will be paid off by a better operational and maintenance performance.

5.1.2.5 Reduction of Retrofitting Time

Planning plays an important role in reducing any unforeseen delays in the retrofitting process. Shipowners and crew should review the existing ballast water system by examining pipeline drawings, equipment information, and operational procedures. Then together with classification society and manufacturers, shipowners can work out a detailed design in regard to the entire layout. 3D laser scanning technology is now being employed by many experienced manufactures, which not only makes the process precise but also less time-consuming(Liu, 2014).

5.1.3 Other Suggestions

5.1.3.1 Collaboration with Regulators

Shipowners should collaborate with competent authorities, on one hand to better understand and implement relevant requirements; on the other hand to help promote the amendments to conventions and regulations because shipowners have best comprehension of the industry and first-hand data (Cao, 2015). For example, given the risks and uncertainties in complying with BWM Convention as discussed in previous chapters, shipowners should actively participate in as well as aid decision making in international organizations like IMO. Because not every international institution embraces the tripartite mechanism like in ILO. Shipowners' participation ensures their interests be better represented and attended to in various instruments (Fei, 2016).

5.1.3.2 Interim Method

The last but not least resort for shipowners is to update the ship's IOPP certificate by getting the renewal survey done prior to the enforcement date of the Convention applicable to their ships (Wei, 2016), so as to extend the transition period to better prepare the implementation until next survey.

5.2 Suggestions for Chinese Authorities

The entry into force of Ballast Water Management Convention and the ever growing ship trade urge China to take the following steps to better safeguard its shipowners' underlying interests: promulgate domestic legislation and regulation on ballast water management and improve prevention and control of pollution caused by ballast water; improve stewardship and coordination mechanism among authorities, or even establish specialized agency on this matter; accelerate scientific research to provide the shipping industry with better technical solution; and more importantly raise public awareness.

Chapter 6: Conclusions

There are many uncertainties and risks in implementing the BWM Convention for shipowners especially Chinese shipowners. It is noteworthy that the teleology of the Convention is more about the protection of marine environment. Therefore no matter how much extra burden shipowners would carry, they are at the front in deploying all kinds of measures to serve this purpose. Because combating pollution caused by AIS in ballast water is a pure environmental protection move, bringing zero even negative profit for shipowners, and up to now there is no treatment technology available that guarantee 100% elimination of AIS. This is where regulation has to be in place to ensure public interests are not sacrificed for short-term economic benefit.

But considering the overwhelming challenges confronted, what shipowner can do is to actively participate in decision making and research and development of technology. One way for shipowners to comply with ballast water requirement is to retrofit BWMS, which is such a complex task, with numerous factors to be taken into account. Only when shipowners work with experienced manufacturers and place more importance to technology innovation and crew training, can better installation be achieved in an easier and less time-consuming way. Collaboration with regulators also help reduce the retrofitting time and help shipowners form a comprehensive and holistic view of the Convention. Chinese authorities need to strengthen domestic legislation and inter-department coordination, raise investment and financial support for scientific research as well as database infrastructure in order to facilitate Chinese shipowners in meeting challenge of ballast water management against Chinese as well as global context.

The enforcement of the Convention is pressing. Shipowners need to keep up with the latest development and better prepare for the implementation. Together with raised public awareness and international joint effort, ballast water problem can be better addressed in China and in the world.

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