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WORLD MARITIME UNIVERSITY

Dalian, China

**China's Implementation of the Ballast Water
Convention, Analysis of Treatment Technology and
Main Points of PSC Inspection.**

By

W1904443

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

In

MSEM

2020

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): W1904443

(Date): SEP 28, 2020

Supervised by:

Liu Qiang

Professor of Dalian Maritime University

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ABSTRACT

Title of Dissertation: **China's Implementation of the Ballast Water Convention, Analysis of Treatment Technology and Main Points of PSC Inspection.**

With the rapid development of the global fleet and the tendency of bigger size ships, the invasion of alien species caused by ships ballast water has a great negative impact on human health and the ecological environment.

For this reason, IMO promulgated the BWMC in 2017, with the purpose of effectively controlling and eliminating the environmental pollution caused by the discharge of ballast water. Since the Convention came into force, China has made a lot of efforts in compliance.

In this paper an overview of BWMC is given which focusing on the D1 and D2 standards of ballast water. As for the D1 ballast water exchange standard in which three methods for ballast water exchange are proposed. As for the D2 ballast water performance standard in which introduces the specific discharge requirements, compares the IMO and USCG standards, classifies and introduces the BWMS ballast water treatment process and points out the possible future development trends of the BWMS. In the end, the author starts from the status of China's implementation of BWMC, analyzes the current problems and challenges in implementation process, and puts forward suggestions and proposals from three perspective, the PSC inspection perspective, the pollution prevention perspective and law and competent authority perspective.

KEY WORDS: BW, BWMC, BW Treatment Process, China's Implementation, PSC Inspection.

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LIST OF ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
BW	Ballast water
BWE	Ballast water exchange
BWM Convention	International Convention for The Control and Management of the ships' ballast water and sediments, 2004
BWMS	Ballast water management system
BWRB	Ballast water record book
CCS	China Classification Society
CWA	The Clean Water Act of 1977
DDS	Decision Support System
GEF	Global Environmental Facility
HAOP	Harmful Aquatic Organisms and Pathogens
IAS	Invasive Alien Species
IMO	International Maritime Organization
IOPP	International Oil Pollution Prevention Certificate
MEPC	Marine Environmental Protection Committee
MSA	Maritime Safety Administration
PBBS	Port Biological Baseline Surveys
PSC	Port State Control
PSCO	Port State Control Officer
UNDP	United Nations Development Programme
USCG	United State Coast Guard
MARPOL	The International Convention for the Prevention of Pollution from Ships

Chapter 1 Introduction

1.1 Definition

Ballast Water (BW) means water with its suspended matter taken on board a ship to control trim, list, draught, stability or stresses of the ship(BWM Convention 2004). Prior to the 1880s, ships used solid ballast materials such as rocks and sand, which had to be upload by man into the cargo hold tanks, and similarly discharged when cargo was to be loaded on board. If not properly secured, solid ballast was prone to shifting in heavy seas causing instability(Transport Canada 2010).

With the introduction of steel-hulled vessels and pumping technology, water became the choice of ballast. Water can be easily pumped in and out of ballast tanks, which requires little manpower, and causes little stability problems as long as tanks are kept full.

BW is used in vessel's tanks to control their stability, balance and trim. It is loaded directly from the sea to the ballast tanks and increase the control on the ship. There are mainly three function for using ballast waters(EPAV, 2017):

- To control the stability while loading or unloading the cargo of the vessel, depending on the weight distribution.
- To have an extra stability in adverse or foul weather conditions.
- To avoid the stress on the hull.

1.2 Main Advantage of Ballast Water

The advantages of the usage of BW are as follows, (GLOBALLAST PARTNERSHIP, 2018).

- Reduction of stress on the hull, the provision of transverse stability, mostly during navigation.
- Improvement of the propulsion of vessel.
- Increase of maneuverability during navigation.
- Compensation for weight changes due to differences on cargo levels and due to fuel consumption mostly during navigation (as the change while berthed is insignificant for the stability).

We can say that nowadays it is essential for vessels to use BW for their safety and there is no other method or technology that can substitute completely the performance of ballast water(David & Gollasch, 2014).

1.3 Main Disadvantage and Secondary Effect of Ballast Water.

Although BW plays a very important role in the safe navigation and loading and unloading operations of ships, ballast water has a certain secondary impact on the environment and species in the water (WERSCHKUN, 2018). As shown in the figure below, the ship sucks in BW with organisms at the source port and discharges the ballast water with organisms at the destination port. If certain marine organisms or viral bacteria in the discharged BW multiply in the ecological environment of the destination port where the species does not exist before, it may cause some trouble of invasion alien species(IAS).

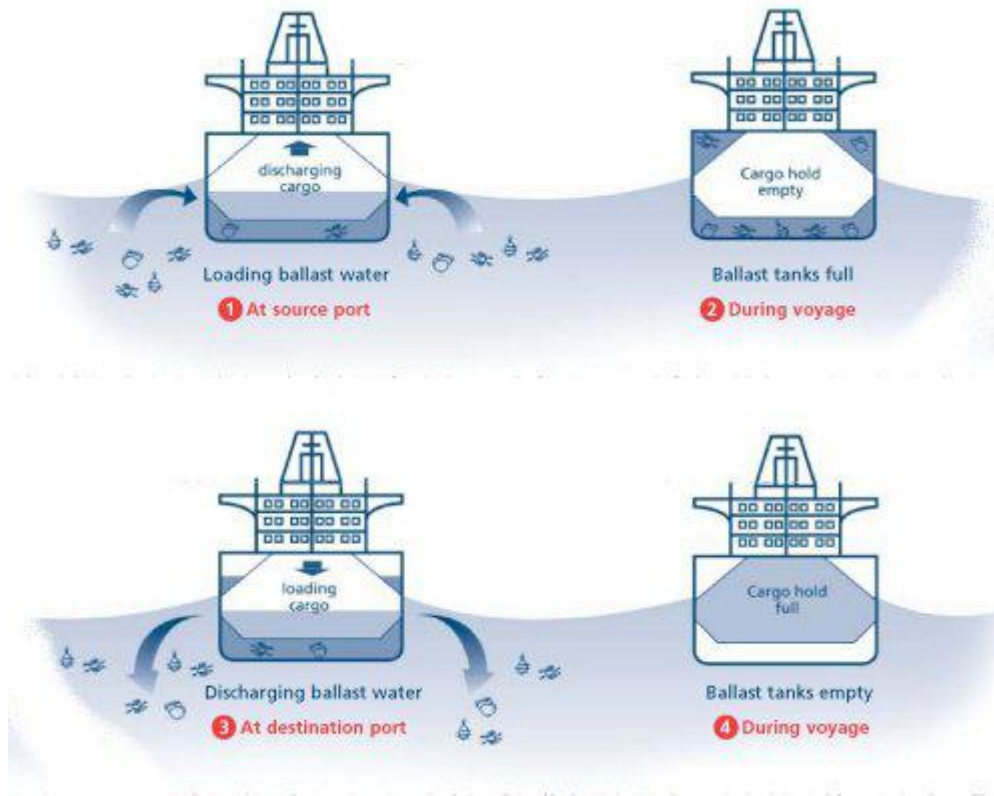


Figure 1- Ballasting and De-ballasting process

Source: <https://jrramos84.weebly.com/notes/what-is-ballast-and-de-ballasting#>

The picture below is provided by IMO. The figures in it illustrate the seriousness of the IAS caused by ship's ballast water. There are 2.4 billion people live within 100KM of the coast and 80% of the world trade is carried by ships, 10 billion tons of ballast water transferred per year which would fill 4 million Olympics sized pools, there are 7000 species transferred in BW every hour of everyday and there is an invasion every nine weeks. These BW numbers are shocking. What's more, it is worth mentioning that the problems caused by ship's BW will become more and more serious with the increase of international trade, the increase in the size of newly built ships. Obviously, the IAS will continue to increase and will affect those waters that are not affected by alien species.

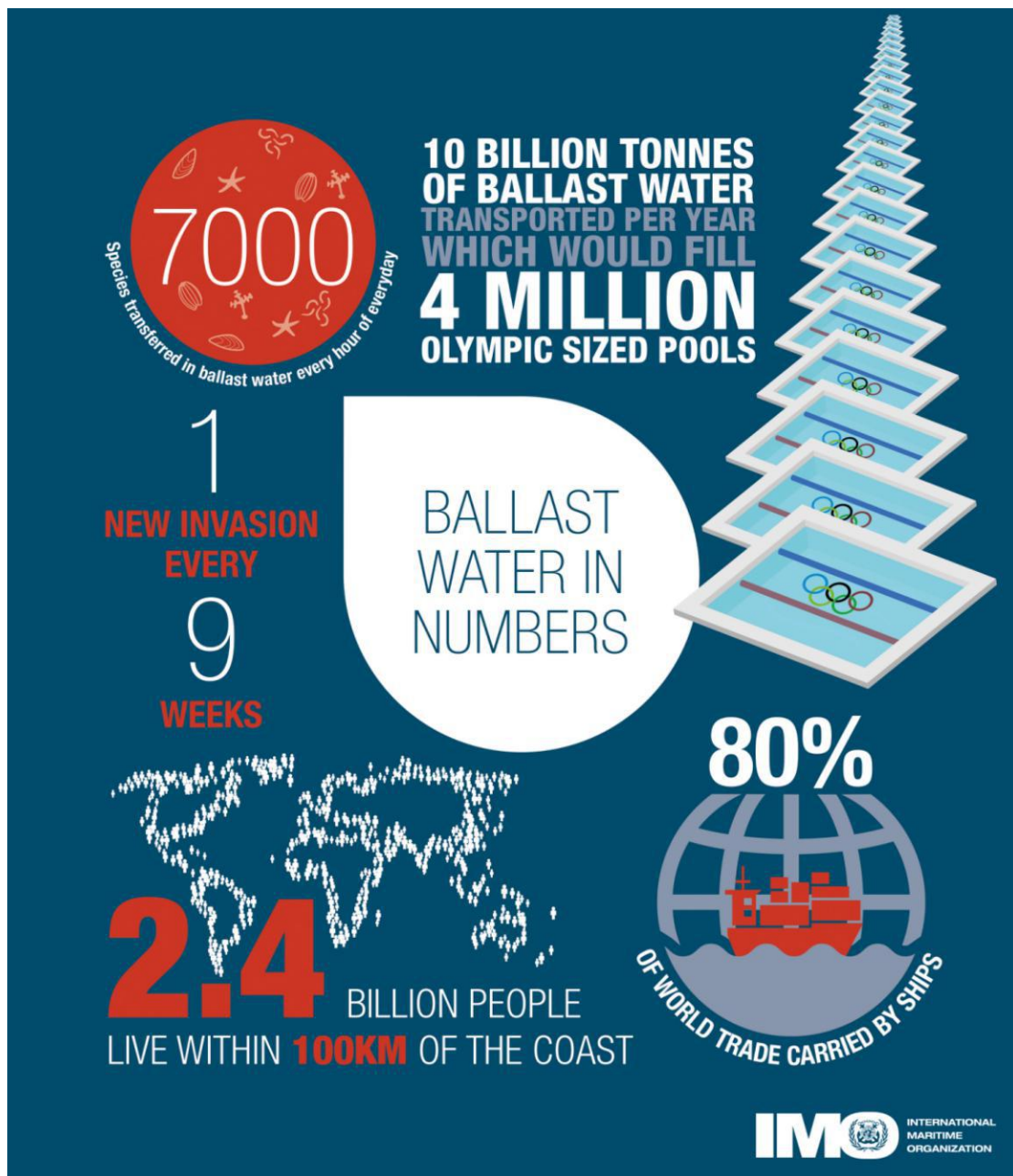


Figure 2- The impact of BW worldwide.

Source: <http://www.imo.org/en/MediaCentre/HotTopics/BWM/Pages/default.aspx>.

The IAS caused by BW will cause the following problems.

1.3.1 Ecological Problem.

The seawater that was loaded into the ship's BW tank was brought up when the ship was on the route or in port. Therefore, when ship is loaded with BW, various kinds of organisms were introduced into the BW tanks and transported to other place with the discharging of the ballast water, in which it may contain bacterias, microbes, eggs, small invertebrates, cysts and larvae of many different species(China Academic Journal, 40-45).

It is estimated that ships around the once these species are discharged in any other environment, if they can survive, they can reproduce and increase populations in areas that have never existed. If the reproduction and survival of species are achieved, they will become IAS and compete with all native species, which in many cases will be a disaster for the new environment(Maria, 2009).

World's ocean-going ships carry about 10 billion tons of ballast water each year, with an average of 3,000 to 4,000 species transmitted daily by ships. It has been confirmed that the IAS transmitted by ship ballast water are about 500(Bai, M. D & Zhang, Z. T, 2010, PP. 1-3). The first confirmed invasive species was in the North Sea in 1903, when the Asian phytoplankton algae *odontella* spread. Formally, in the 1970s, scientists first considered studying ecological issues. It was not until the 1980s that Canada and Australia experienced the problem of IAS caused by ships' ballast water. Since then, this concern was taken by the both two countries to the the Marine Environment Protection Committee (MEPC)(Hadar dex, 2020).

1.3.2 Economic Problems.

There are many economic impacts due to IAS carried by ballast water. In addition to the economic losses of the food industry (decreased production of fisheries and aquaculture), there are also economic losses related to hulls (fouling), buoys or any other port structure. In addition, it indirectly affects leisure areas and tourism. The money used to prevent or control IAS and the cost of ballast water treatment systems(BWTS) on board need to be considered.

In the mid-1980s, European zebra mussel invaded the Great Lakes of North America with ballast water, multiplied, blocked the intake pipes of cities and factories, and promoted the abnormal growth of seaweeds, which seriously threatened local species and caused US \$ 3-5 billion economic loss.(BRAUTIGAM, 2001, PP. 33-67).

1.3.3 Health Problems.

Humans are clearly connected to the sea. Changes in species may have a significant impact on the species that humans are eating which will causing health problems.

In addition, we need to consider that humans are usually accustomed to bacteria located in this area where they live. Due the fact that the ballast water were loaded faraway and may contain many bacteria that humans are not used to which can cause digestive system problems.

If the ballast water drawn by the ship comes from the epidemic area, there is a risk of carrying the virus or bacteria in the epidemic area in the ballast water. If

the untreated ballast water is discharged at this time, it will put an agent risk of epidemic which threaten the health of human beings, and due to the small size of pathogenic microorganisms, it is easy to invade and spread through various channels. However, the current quarantine and detection measures are difficult to find and block in time(Tang, Y., & Su, S, 2015, pp.130-137).

1.4 Growth of the Problem Worldwide.

In fact, the number of merchant ships in the world has never stopped growing, which means more ships will sail from one place to another in the world. In the figure below, we can observe the growth of the world fleet in the past 6 years from 2014 to 2019, both the number of ships and average size of the ships have a certain increase. Therefore, the problem of IAS caused by ballast water will become more severe.

World fleet data	2014	2015	2016	2017	2018	2019
Thousand DWT	1,675,562	1,732,520	1,791,609	1,848,224	1,910,012	1,962,582
Number of ships	47,797	48,240	49,445	50,146	50,732	51,684
Average size of ship DWT	35,056	35,915	36,234	36,857	37,649	37,973
Controlled world fleet by top 15 countries (Top 15 as per 2019*)	78.02%	78.56%	79.02%	78.92%	79.61%	80.51%

Table 1- Worldwide merchant fleet(over 1000GT) growth (2014-2019).

Source:<http://infomaritime.eu/index.php/2020/05/07/top-15-shipowning-countries/>

1.5. Ballast Water Management Convention

1.5.1 Promulgation of the Convention

According to the statistics of IMO, the IAS is increasing to an alarm level. It not only affects the marine ecological environment but also the health of people (mainly from food intake). What's more, this problem is far from reaching its peak and will develop in the future and become more and more serious.

The introduction of harmful aquatic organisms and pathogens to new environments had been identified as one of the four greatest threats to the world's oceans (the other three being land-sourced marine pollution, over exploitation of living marine resources and destruction of habitat) (IMO web). In order to reduce the impact of ballast water, IMO has promoted the introduction of regulations on ballast water discharge. The conference held at the IMO headquarters in London on February 13, 2004 adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (the Ballast Water Management Convention), which aim is to establish standards and procedures regarding the control and management of ballast water from ships(IMO, 2017).

According to the Ballast Water Convention, ships on international voyages are required to manage ship's ballast water and segmentation in accordance with the standards stipulated in the Convention, and develop a ballast water management plan(BWMP). Further, it requires ships to hold a ship's ballast water management certificate(BWMC)(or a certificate of compliance where the flag state has not ratified the convention)and requires that ballast water operations be recorded in

the ballast water record book(BWRB). In general, most ships need to install ballast water treatment system board due to the ballast water discharge standards required by the Convention.

The ballast water convention was entry into force on 8 September 2017, having a total of 81 States signing it and representing 81.83% of worldwide merchant shipping tonnage, according to the last update.(IMO, 2020).

1.5.2 Structure and Guidelines of the Convention.

The Convention is divided into text, annex and guidelines. A total of 22 articles, all of which are general provisions, the annex is divided into five section: section A is general provisions , section B is management and control requirements for ships, section C is special requirements in certain areas, section D is standards for ballast water management and section E is survey and certification requirements for ballast water management. The text and annex are mandatory requirements. The convention contains 16 guidelines, in which G8(Guidelines for approval of ballast water management systems) and G9(Procedure for approval of ballast water management systems that make use of active substances) is mandatory requirements and the rest 14 guidelines are non-mandatory requirements.

1.6 Regulations

1.6.1 Application

As stipulated in Article 3 of the Convention, this Convention shall apply to: (a) ships entitled to fly the flag of a Party; and (b) ships not entitled to fly the flag but which operate under the authority of a Party. And because of the no more favourable treatment, the BWM convention could apply to any ships which engage in international shipping(BWM Convention 2004).

1.6.2 Ballast Water Exchange Standard.

It is the most important parts in the BWM Convention. There are two standards for ballast water management, D1 ballast water exchange standard and D2 ballast water performance standard to meet the requirements of the BWM convention.

In order to comply with the D-1 standard, ballast water exchange must be carried out in the high seas, which should be far from the coastal area (about 200 nautical miles from the coast), with a minimum depth of 200 meters (FEDERALE, 2018). The idea of the regulation is that the living species or aquatic organism used to live in the deep water may have little possibility to live in the water in the port. According to standards, the ballast water exchange could be the following three ways.

Sequential Flow Method – This method is currently the most widely used method on ships. It is to empty the ballast tanks one by one in sequence, and then suck in seawater to 95% of the tank capacity of the ballast tanks. Its advantage is that it takes less time and can use the existing pump system and pipelines on the

ship to operate. It is not affected by other operations on the deck and does not require additional installation pipelines. Its disadvantage is that it may be restricted by sailing time and stability

Flow-through Method - The principle of this method is to pour water from the bottom of the ballast tank into the ballast tank through a water pump, thereby forming an overflow. In this way, to achieve a 95% replacement rate, three times the volume of exchanging water is required. This method's advantage is that it is easier to ensure the stability of the ship and strength, especially in the case of bad weather. The disadvantage is that the time required to replace the water is long and it is necessary to pay attention to the protection of the deck structure, the structure of the ballast tank and the cargo on the ship, especially when the ambient temperature is low.

Dilution Method - This method is the least commonly used method. The opposite of the overflow method is that it replaces the ballast water by sucking ballast water from the top of the ballast tank, similarly to achieve a 95% replacement rate that three times of the water exchange volume also needs to be achieved. In addition to the advantages of the overflow method, the advantages of this method can strengthen the control of the sediment and avoid direct contact between the crew and the viruses or germs that may exist in the seawater, thereby ensuring the health and safety of the crew. The disadvantage is that it will affect the structure of the ballast water tank. If the sea water pump fails during the ballast water replacement by using this method, it may bring risks to the stability of the hull of the ship.

However, as one of the ballast water management method, there are still some restrictions for the ballast water exchange. Ships sailing in the waters that are

allowed to exchange are not long enough to allow the ship to complete the cycle of discharging ballast water and sucking in ballast water, especially ships with short routes or ships that call at ports multiple times in one route. In addition, ship ballast water exchange operations in some sea areas with poor sea conditions will bring risks to the hull structure and ship stability.

From 8th September 2017, compliance with IMO-D1 standard will be mandatory for ships unless the ship install and operate the Ballast Water Treatment systems(BWTS) on board or use an alternative method for compliance with BWM convention requirements.

1.6.3 Ballast Water Performance Standard.

Article D-2 specifies the standards for ballast water treatment which stipulates that when discharging the ballast water, the maximum size of the organism is allowed is as the table shows.

Type/ Size of Organism	Maximum number	volume
Planktons (number)		
Size = ≥ 50 microns	10	1 tonne
Size = 10 to 50 microns	10	1 mL
Microbes (colony forming units, cfu)		
V. Cholerae	1	100 mL
E. Coli	250	100 mL
E. Cocci	100	100 mL

Table 2- The D2 ballast water performance standard.

Source: Song, Y. S. (2019). BWM convention. Unpublished lecture handout.

As shown in the figure above, ships conducting ballast water management must discharge fewer than 10 viable organisms per cubic metre that are greater than or equal to 50 micrometers in minimum dimension and fewer than 10 viable organisms per millilitre that are less than 50 micrometers in minimum dimension and greater than or equal to 10 micrometers in minimum dimension; and discharge of the indicator microbes must not exceed the specified concentrations.

The indicator microbes, as a human health standard, include, but are not limited to: 1. Toxicogenic vibrio cholerae (O1 and O139) with less than 1 colony-forming unit (cfu) per 100 millilitres or less than 1 cfu per 1 gram (wet weight) zooplankton samples. 2. Escherichia coli – less than 250 cfu per 100 millilitres. 3. Intestinal enterococci – less than 100 cfu per 100 millilitres. This method is considered to be the most efficient method of ballast water management.

In order to meet such discharge standards, the BWMS approved by the competent authority needs to be installed on ships.

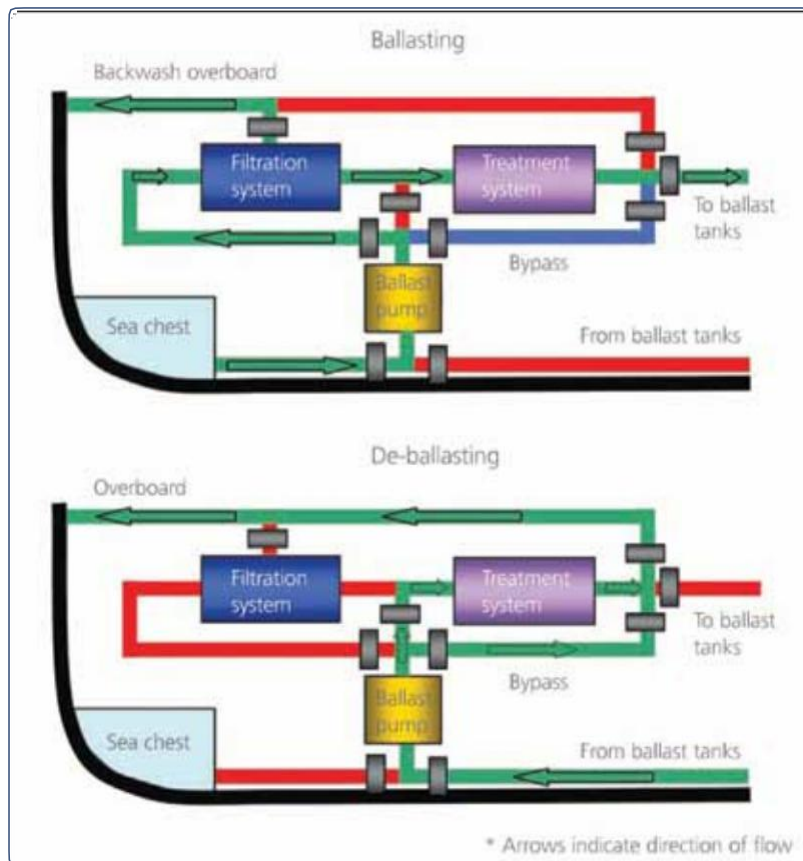


Figure 3-Typical ballast water treatment process

Source: <https://www.lr.org/en/ballast-water-management/>

As shown in the figure above, there are multiple pipelines, mechanisms and systems used for BWTS, and the BWTS is generally classified by its treatment process and technology, From the process of treating ballast water, it is divided into solid-liquid separation, chemical disinfection and physical disinfection(CORRINA,. et al 2018). Of course, each process includes many specific treatment techniques, commonly they choose to use more than one type of the treatment technologies as incorporated technologies for better treatment effect(MITSUBISHI HEAVY INDUSTRIES, 2018). IMO has published an extensive list of the approved BWTS including 61 basic approvals for systems including active substances, 45 final approvals for systems including active substances, and 83 type approval certifications for BWT systems(Eduardo,

2018). The following table gives a list of the BWT processes and a brief description for each of them.

Process	Method	Benefit	Considerations	Comments
Solid-liquid separation				
Filtration	Generally using discs or fixed screens with automatic backwashing	Effective for larger particles and organisms	Maintaining flow with minimum pressure drop requires backwashing. Low membrane permeability means surface filtration of smaller micro-organisms is not practical	Mesh sizes are proportional to size of organism filtered (e.g. larger organisms such as plankton require mesh between 10 and 50µm)
Hydrocyclone	High velocity centrifugal rotation of water to separate particles	Alternative to filtration and can be more effective	Effective only for larger particles	Effectiveness depends on density of particle and surrounding water, particle size, speed of rotation and time
Coagulation	Optional pre-treatment prior to separation to aggregate particles to increase their size	Increasing size of particles increases efficiency of filtration or hydrocyclone separation	May require additional tank space to store water which has been treated due to long residence time for process to be effective	Ballasted flocculation uses ancillary powder (e.g., magnetite or sand), to help generate flocs which settle more quickly
Chemical disinfection (oxidising biocides)				
Chlorination	Classed as an oxidising biocide that, when diluted in water, destroys cell walls of micro-organisms	Well established and used in municipal and industrial water disinfection applications	Virtually ineffective against cysts unless concentration of at least 2mg/l used. May lead to by-products (e.g. chlorinated hydrocarbons/ trihalomethanes)	Efficiency of these processes varies according to conditions of the water such as PH, temperature and type of organism
Electrochlorination	Creates oxidising solution by employing direct current into water which creates electrolytic reaction	As chlorination	As chlorination. Brine, needed to produce the chlorine, can be stored onboard the vessel as feedstock for the system	Upstream pre-treatment of the water is desirable to reduce the 'demand' on the chlorination process
Ozonation	Ozone gas (1-2mg/l) is bubbled into the water which decomposes and reacts with other chemicals to kill micro-organisms	Especially effective at killing micro-organisms	Not as effective at killing larger organisms. Produces bromate as a by-product. Ozonate generators are required in order to treat large volumes of ballast water. These may be expensive and require sufficient installation space	Systems in which chemicals are added normally need to be neutralised prior to discharge to avoid environmental damage in the ballast water area of discharge. Most ozone and chlorine systems are neutralised but some are not. Chlorine dioxide has a half life in the region of 6-12 hours, according to suppliers, but at the concentrations at which it is typically employed it can be safely discharged after a maximum of 24 hours
Chlorine dioxide	As chlorination	Effective on all micro-organisms as well as bacteria and other pathogens. It is also effective in high turbidity waters as it does not combine with organics	Reagents used can be chemically hazardous	
Peracetic acid and hydrogen peroxide	As chlorination	Infinitely soluble in water. Produces few harmful by-products and relatively stable	Reagent is typically dosed at high levels, requires suitable storage facilities and can be relatively expensive	
Chemical disinfection (non-oxidising biocides)				
Menadione/ Vitamin K	Menadione is toxic to invertebrates	Natural product often used in catfish farming but produced synthetically for commercial use. Safe to handle	Treated water will typically require neutralising before discharge	
Physical disinfection				
Ultraviolet (UV) irradiation	Amalgam lamps surrounded by quartz sleeves produce UV light, which denatures the DNA of the micro-organism and therefore prevents it from reproducing	Well established, used extensively in municipal and industrial water treatment applications. Effective against wide range of micro-organisms	Relies on good UV transmission through the water and hence needs clear water and unfouled quartz sleeves to be effective	Can be enhanced by combining with other reagents such as ozone, hydrogen peroxide or titanium dioxide
Deoxygenation	Reduces pressure of oxygen in space above the water with inert gas injection or by means of a vacuum to asphyxiate the micro-organisms	Removal of oxygen may result in a decrease in corrosion propensity. If an inert gas generator is already installed on the ship then deoxygenation plant would take up little additional space	Typically, the time required for organisms to be asphyxiated is between 1 and 4 days	Process has been developed specifically for ballast water treatment whereby the de-aerated water is stored in sealed ballast tanks
Cavitation	Induced by ultrasonic energy or gas injection. Disrupts the cell wall of organisms	Useful as pre-treatment to aid in overall treatment process	Must be used in conjunction with additional treatment process downstream in order to kill all micro-organisms	
Heat	Heat treatment of ballast water	Ballast water can be used to provide engine cooling while being disinfected through heat treatment	Requires a length of time for process of heating to be effective	

Table 3-Ballast water treatment process.

www.lr.org/bwm

1.7 Ballast Water and Sediments Management Plan (BWMP)

The BWMP explains the needed actions to implement the BWM convention requirements in detail, and elaborates the resources, responsibilities and timings of such actions in terms of procedures. BWMP needs to be documented for each ship and approved by the administration and submitted for the surveys of the flag state or competent classification societies. The document will be used as the main reference in the surveys of the ballast water management system. The BWMP document should include:

International rules and regulations for different port state controls all over the world, location of ports providing shore discharge facility of sediments and ballast water, duties of the personnel on board for carrying out ballast operation, operational procedure along with the method to be used for ballasting, the locations at different coastal water for ballast exchange should be mentioned in the plan and sampling point and treatment method should be given in the ballast water management plan(DNV, 2020).

1.8 Ballast Water Record Book(BWRB).

Recorded all information of ballast water replacement operation for at least two

years. All information about the operation of the ballast is recorded in the log, as shown in :

- Date and time of start and complete ballasting/de-ballasting.

- Tanks ballasting and volume per tank in m³.

- Location in Latitude/Longitude or port/facility.

- Least depth of water during the operation

Least distance from nearest land, if outside port

- Total quantity of ballast water exchanged or method of treatment used

- Signature of the Master being responsible for the exchange operation.

- Remarks as any problem that could have happened during ballasting or de-ballasting (Anish, 2019).

1.9 The Timeline of Enforcement.

According to the regulations of the Convention, existing ships and newly built ships have significantly different requirements for ballast water management. For the newly built ships after the date of the Convention's entry into force, it is required to meet the standards and to have an approved BWMS on board when delivery of the vessel.

The figure below shows the timeline of the implementation of the BWM

convention.

New vessels	Existing vessels where:	For other existing vessels	Existing vessels not required to have an IOPP certificate
Keel laid on or after 8 th September 2017:	Completed IOPP renewal survey between 8 th September 2014 and 7 th September 2017:	Install BWM system at whichever occurs first of the following:	Tankers of less than 150GT and ships other than oil tankers of less than 400GT
Install BWM system upon delivery	Install BWM system at the first IOPP renewal survey on or after 8 th September 2017	First IOPP renewal survey on or after 8 th September 2019; OR Second IOPP renewal survey on or after 8 th September 2017*	Install BWM system not later than 8 th September 2024

Table-4 The timeline for implementation of the BWM convention

Source:<https://www.westpandi.com/publications/notice-to-members/2017-2018/notice-to-members-no-10-20172018>.

As we can see the existing ships must comply with the renewal of the first International Oil Pollution Prevention Certificate (IOPP Certificate), which is valid until September 8, 2019 (two years after the effective date of the Convention). For existing ships undergoing IOPP renewal surveys from September 8, 2014 to September 7, 2017, the ship must use BWMS or the next IOPP renewal survey after the effective date of the Convention.

Finally, ships built before September 8, 2017 that do not require any IOPP renewal (ships smaller than 400 GT or tankers smaller than 150 GT) must meet Standard D-2 by September 8, 2024. Vessels applying the convention will have an approved BWMS that meets the D-2 standard by September 8, 2024.

Chapter 2 China's Compliance Status, Comparison and Experience Learned from Other Countries and Project.

2.1 Current Status of China's Compliance

From January 22 of 2019, the BWM Convention officially come into force in China. The compliance status of China is as follows.

2.1.1 Accession to the convention

In October 2018, China ratified Ballast Water Management (BWM) Convention which came into force in September of 2017. The BWM Convention aims to prevent the spread of harmful and invasive aquatic species from one region to another by establishing standards and introducing global regulations to control ships' ballast water and sediments.

2.1.2 Domestic regulation

Before the Ballast Water Convention entered into force in China, there were mainly two laws which related to ship's ballast water regulations. One is the "Marine Environmental Protection Law of the People's Republic of China" in

which there are relevant regulations on the discharge of ballast water. This law is China's first national law to protect the marine environment and resources and promote the development of marine industry. Since its implementation, it has played a vital role in protecting China's marine environment, preventing marine pollution damage, and guarantee human health, but it has only mentioned ballast water in general. Another is the "Regulations on the Prevention and Control of Marine Environmental Pollution by Ships." Article 15 of Chapter 3 of the main text stipulates that the discharge of ballast water by ships shall meet relevant requirements. After acceding to the BWM Convention, considering that domestic legislation often took a long time, The Notice of the Maritime Safety Administration of the Ministry of Transport of the People's Republic of China on the Announcement of the "Measures for Supervision and Administration of Ship Ballast Water and Sediment (Trial), was issued by the Maritime Safety Administration of the Ministry of Transport in order to prevent harmful aquatic organisms and pathogens introduced by ship ballast water and sediments from causing pollution and damage to the ecological environment and human health.

2.1.3 Ballast Water Treatment System Research and Development.

18 companies in domestic China have obtained the type approvals for ballast water management systems that are in accordance with Guidelines (G8) (resolutions MEPC.125(53) and MEPC.174(58)). It accounts for more than 21% of the world's approved ballast water management system. Two Chinese companies have obtained the type approval certificate of the USCG ballast water

management system.

2.1.4 The Rapid Detection of Ballast Water

The BWM Convention requires contracting States to sample and inspect the ballast water of ships arriving at the port to verify compliance with the discharge standards. At present, China MSA and Dalian Maritime University are developing hand-held ballast water rapid testing equipment with independent intellectual property rights. Currently, Chinese PSC officers don't have the ability to carry out rapid testing of ballast water, and the testing capabilities of the laboratory need to be further improved.

2.1.5 Mutual exemption agreements with other countries

On May 28, 2019, the China MSA and the South Korean Maritime Department signed a mutual exemption agreement on ballast water, exempting the international vessels navigating between China and South Korea that meet the conditions, and the validity period is June 1, 2019 to September 7, 2024(Xinde Maritime News, 2019). The Ministry of Transport uses the existing bilateral and multilateral mechanisms to actively discuss cooperation with neighboring countries on the mutual exemption of ballast water management. Currently, it is accelerating the mutual exemption cooperation with Japan and Association of

Southeast Asian Nations(ASEAN).

2.1.6 Ship inspection and certification

China MSA has agreed to the China Classification Society(CCS), based on the application to the shipowners whose ship engage on international shipping to carry out the renewal inspection of the "International Oil Pollution Prevention Certificate" before the effective date of the Convention. So that the ship can meet the D- 2 standards. CCS has formulated and organized the implementation plan for the inspection and certification of Chinese ships engage on international voyages.

2.2 Opportunities From the Implementation of the Ballast Water Convention for China.

Since Ballast Water Convention entered into force in China, China has made a lot of efforts in the implementation process. While carrying out relevant implementation work, it has also brought many opportunities for ballast water management(Fan, 2013).

First, taking the implementation of the Convention as an opportunity to protect the marine ecological environment from ecological damage and red tides caused

by the invasion of alien organisms which threatening Chinese marine ecological security and causing losses to the marine aquatic economy. The discharge of ballast water loaded by ocean-going vessels during navigation and loading and unloading operations is one of the reasons for the IAS in China. After acceding to the BWM Convention, the competent authority of China can require that the ballast water discharged by the ships to the waters under the jurisdiction of China to meet the requirement of discharge standards, effectively reducing or eliminating the risk of introducing foreign aquatic organisms and pathogens from the ship's ballast water, which is benefit to protect Chinese marine ecological environment and strengthen Chinese jurisdiction over sea areas.

Second, using the implementation of the BWMC as a starting point to safeguard the interests of China's industry. The Convention clearly stipulates that no favorable treatment is given to ships of non-parties. After the Convention enters into force, China flagged ocean-going ships must accept the supervision and inspection of the contracting states. Major shipping countries such as Japan, Germany, Denmark, and Singapore, and Panama the world's largest flag of convenience, have all joined the convention. If China has not acceded to the Convention, it will not be able to carry out supervision and inspection of foreign ships in Chinese waters in accordance with the Convention, which has objectively caused unequal treatment between Chinese shipping companies and the shipping companies of other contracting states.

Third, using convention negotiation as a platform to help China to participate in global maritime governance. China has been elected as the IMO category A

council for 14 consecutive times. In recent years, China has actively participated in global maritime governance and exerted effective influence on the formulation and revision of relevant conventions and technical standards. During the formulation and revision of the BWMC, the revision of the BWMC Type Approval Guidelines, the implementation roadmap of the Ballast Water Convention, and the revision of the implementation timetable of the Ballast Water Convention and other key issues have fully expressed China's idea and safeguards Chinese interests. The current revision of the G8 Guidelines and the revision of the implementation timetable of the Ballast Water Performance Standard (D-2 Standard) are basically in line with Chinese expectations. Joining the Convention is conducive to China's deep participation in global maritime governance and its due contribution to the establishment of a more open, fair and justice international maritime order.

Forth, guiding the development of the industry, building a system of "production, study, research and use". The Ministry of Transport attaches great importance to the establishment of the "production, study, research and use" chain in the tracking study of the convention's performance. Management system manufacturers put forward requirements, and scientific research units, including universities, scientific research institutions and CCS, carry out relevant research. In participating in the international negotiations of the BWMC, we paid attention to the introduction of social resources, absorbed some industry units to participate in the revision of the BWMC, and provided data and theoretical support for the revision of the BWMC and related guidelines. Relevant units of the Ministry of Transport take the lead, make full use of industry-wide resources, prepare plans and proposals to participate in

international negotiations, strive for benefits for China externally, and promote healthy development of the industry internally.

Fifth, relying on subject research to continuously consolidate the foundation. The Ministry of Transport has successively launched a number of subject research work in 2016, including the joint development of BWMC specifications and standards with the Shanghai Ship Technology Research Institute under the Ministry of Industry and Information Technology, entrusted Harbin Engineering University to carry out the project. We have also carry out research on port state supervision and inspection of the BWMC, and supported Dalian Maritime University to develop hand-held ballast water rapid testing equipment with completely independent intellectual property rights. At the same time, it also actively applied for special projects from the Ministry of Science and Technology and the Asian Development Special Fund, which is effective for China Performance to provide support and hardware guarantees.

Sixth, improving the legal framework system. "Marine Environmental Protection Law of the People's Republic of China", "Frontier Health and Quarantine Law of the People's Republic of China", "Management Regulations on the Prevention and Control of Marine Environmental Pollution from Ships" and other domestic laws and regulations all of which have established regulations on ballast water discharge and quarantine. The principle stipulates that it is in conformity with the overall requirements of the BWMC and has laid a good foundation for the domestic transformation and implementation of the Convention. On this basis, the Ministry of Transport will continue to promote

the establishment of a compliance legal system to formulate domestic implementation procedures and enrich the legal system.

2.3 Compliance Challenge for China.

Even if China has adopted a series of implementation measures after joining the Ballast Water Convention to achieve certain results, we still need to see that there are still many shortcomings and there is a long way to go to fully implement the Convention.

2.3.1 From the Perspective of Legal System

Firstly, Lack of independent legislation on ship's ballast water, the research on the control of IAS from ballast water in China started relatively late. At present, only a few legal documents, such as Marine Environmental Protection Law of the People's Republic of China and Regulations on the Prevention and Control of Marine Environmental Pollution by Ships. However, there are only one or two of the rules that mention ballast water management regulations and too general.(Hu, C. B. 2015, pp, 44-46).

Secondly, there is a lack of industry standards for ship ballast water-related industries. For example, the standardization of ship ballast water treatment systems has not yet been formed, resulting in high maintenance costs and low

efficiency of ship ballast water treatment systems due to uncommon parts(Kong, Q, et, al 2018, pp, 81-86). Chinese domestic ballast water treatment system manufacturers occupies a certain proportion in number, and they have certain advantages in cost. With the implementation of the Convention, ships will intensively install new ballast water equipment, and domestic ballast water treatment system manufacturers will become large beneficiaries. However, judging from the current situation, most of the technical standards for domestic equipment are based on the old guidelines

What's more, the requirements of the United States for ballast water are stricter than the requirements of the IMO and the BWMC(Standards implemented in China). Under such circumstances, even if shipowners spend a lot of money to install ballast water treatment system on board, it may still fail to meet the standards of some countries. It will reduce the enthusiasm of shipowners and makes them have a wait-and-see attitude. On the other hand, due to the time of the D2 standard required by the ballast water convention is approaching, a large number of ships piled up in the shipyard waiting to install the ballast water treatment system, which brought huge capacity pressure to the shipyard (Chen, X. S. 2017, pp, 14-17.).

Thirdly, Ballast water management is a very complex task, involving ballast water risk monitoring and prediction and early warning, ballast water management system inspection and ballast water detection, ballast water exchange and disposal technology. The government departments involved in ballast water management in China include the Ministry of Environmental

Protection, the Ministry of Industry and Information Technology, the General Administration of Quality Supervision, Inspection and Quarantine, the Bureau of Oceanography and the Ministry of Transport. Each department has their own responsibilities on ballast water management. However, in the process of implementing the Convention, there is a lack of close cooperation and a complete supervision system which has not been established to control the harmful aquatic organisms and pathogens carried by ballast water from the source. It is impossible to further improve the inter-ministerial cooperation mechanism, promote the establishment of information and data sharing platforms for various departments, optimize the allocation of resources, and form a supervisory force.

2.3.2 Challenges for PSC Inspection.

The implementation of the BWMC is still in the period of accumulation of experience and there are some challenges. Firstly, the knowledge challenges of PSCOS. As we know that the BWMS has various different treatment technology. The PSCOS must have sufficient inspection experience to determine whether the ship is actually manage the ballast water through BWMS and no missing or falsification in the BWRB. Secondly, there are still many uncertainties for the PSCO sampling ballast water, and it will also encounter many difficulties, such as there is a controversy for the testing result. (Zhu, et al 2019, pp, 11-16), Thirdly, The ballast water quick testing equipment has not been equipped with PSCO which makes it impossible for PSCO to obtain the results of ballast water

testing at the first time during inspection, and because it will take longer time to send ballast water samples to the onshore laboratory for testing. What's more, the principle of the BWMC shall not hinder the normal operation of the ship. If the result from the laboratory shows that it does not meet the standards but the ship has already departure, it will cause trouble for the penalize. Finally, The lack of ballast water receiving facilities or insufficient ballast water receiving capacity in the port will bring some limitation to PSCO to carry out the inspection. (Cheng, 2018).

2.3.3 Disguised Increase of Shipping Freight, to A Certain Extent Affects the Development of the Shipping Industry.

The cost of shipping companies and ship owners has increased. This cost comes from the cost of the ships ballast water treatment system itself which includes the design of new ships and the increase in the cost of the ballast water treatment system and the cost of rebuilding existing ships. It also includes the cost of operation and maintenance of the water treatment system which include the cost of the labor cost and the cost of running the ballast water system. In order to ensure that the income remains unchanged, the shipowner can only add the increased cost to the freight, resulting in an increase in freight that is not conducive to the long-term development of the shipping industry.

2.3.4 Port Biological Baseline Surveys (PBBS) Has not yet Done .

PBBS has many advantages. The aim of PBBS is to provide inventories of marine lives in and around ports by ships carrying ballast water. The underlying reason for these surveys is to determine the presence, abundance and distribution of non-indigenous species (NIS) which may have been introduced by shipping either in ballast water or attached to hulls, as well as by other vectors. They can also provide a baseline of biological data base on which future changes in the structure and function of marine communities can be measured(IMO, 2014). For countries newly join to BWCM, performing PBBS at selected ports can reveal the current status of NIS in coastal waters, inform decisions making on the need for BWM and thus bringing benefits for adopting the BWMC. Carrying out local biological surveys in ports is an important basic method for implementing ballast water testing and supervision. To implement the Convention effectively, it is necessary to conduct PBBS as soon as possible to establish aquatic organisms invasion database. By using big data platforms to share data, integrate technical resources and develop a forecast and early warning system for NIS to achieve the preventable and controllable measures for ballast water management.

2.3.5 Lack of Deep International Cooperation.

China has established BWM information databases and established emergency

response mechanisms for ballast water management with neighboring countries such as South Korea, Japan, Indonesia and the Philippines. Nowadays the reality is only one country, no matter how strong this country's economic and technological strength is, it is impossible really solve global or regional problems, only by mutual cooperation which can effectively protect and solve environmental problems. Prevent and control of marine environmental damage caused by ships ballast water must cooperate through various countries as its harm has transcended national borders. It has become a common problem that all countries can't avoid. So in order to protect the common interests of mankind, in the environmental field limiting national sovereignty has become the consensus of the international community. Countries must start from the basis of the overall interest of the marine environment that is closely related to prevention and control of marine environmental damage caused by ship's ballast water(Li, Z. W., & Du, X. 2012, PP, 40-45).

2.3.6 Research and Development of Ballast Water Treatment and Testing Equipment is Relatively Backward.

The related research and development of ship ballast water treatment technology in China started late, and the level of research and development is relatively insufficient. The accumulated research investment is less than 10 million yuan, and the research direction and research content overlap rate is high, the research level is uneven and the research scope is mostly limited to the development of ballast water treatment equipment(Mo, L. S. 2017). Research on prediction and

early warning of invasion of foreign organisms carried by ballast water, investigation of local biological information in major ports in China and emergency treatment of ballast water ports are still blank. On the one hand, these problems have caused China to be in a passive position for a long time due to the lack of relevant data in international negotiations. On the other hand, it has also brought great challenges to China's subsequent effective implementation of the convention.

What's more, the fast testing equipment or quick testing kit for ballast water on the ship is still in the research and experimental stages, and there is still some distance from the large-scale practical application. At present, some technical conditions of the BWMS type approval test are still incomplete, such as: insufficient consideration of the salinity, temperature, turbidity of the test water; the influence of inconsistent microorganisms used in the standard test; ballast water treatment technology on the coating of ballast tanks; the electrolytic seawater method has certain requirements on the salinity of the seawater, etc. If ships is sailing in the fresh water area, the normal operation of the BWMS may be affected due to insufficient water salinity. The ultraviolet irradiation method depends on the ultraviolet light in the water and the penetrating power is affected by the turbidity of sea water, so it is difficult for this kind of ballast water treatment system to work in such seawater condition, For example, Zhoushan and other sea areas with relatively large cement sand content witch is difficult for this type of ballast water treatment system to operate normally.

Ballast water port reception and treatment facilities are also needed in accordance with the requirements of the Convention. There are still cases where larger ports

can't provide enough ballast water receiving and treatment facilities for ships.

2.4 Comparison of IMO Standard and USCG Standard.

The IMO ballast water standard applies to ships arriving at any port or near-shore terminal of a signatory to the BWMC. Ships entering a signatory must strictly abide by the management regulations of the BWMC. China implements IMO standards, In addition, the USCG has formulated more stringent ship ballast water discharge standards, which are applicable to all ships with ballast tanks and operating in US waters. Exceptions include crude oil tankers, U.S. military ships, ships operating in the same port area (due to the nature of short voyages), and ships passing harmlessly, the following table lists the IMO and USCG ballast water discharge standards.

ORGANISM SIZE INDICATOR MICROBES	IMO D-2 Regulation BW Performance Standard	USCG Regulation BW Discharge Standard (2012 built)(phrase I)	USCG Regulation BW Discharge Standard (2016 built)(phrase II)
$\geq 50 \mu m$	<10 cells/m ³	<10 cells/m ³	<0.01 cells/m ³
$10 \mu m \leq \text{Size} < 50 \mu m$	<10 cells/m ³	<10 cells/m ³	<0.01 cells/m ³
Toxicogenic Vibrio cholera(O1 and O139)	<1cfu/100m or <1cvu zooplankton samples	<1cfu/100m	<1cfu/100m
Escherichia coli	<250cfu/100mL	<250cfu/100mL	<126cfu/100mL
Intestinal enterococci	<100cfu/100mL	<100cfu/100mL	<33cfu/100mL

Table 5-IMO ballast water discharge standard and USCG discharge standard overview.

Source: <https://www.mdpi.com/journal/jmse>

It can be seen from the table that the USCG Phase I discharge standard is consistent with the IMO D-2 replacement standard, and the USCG Phase II discharge standard is approximately 100 times the IMO D-2 discharge standard. In addition, the "death" standards for organisms in ballast water discharged under the USCG Type Approval model are stricter than the IMO standards for "inactive" organisms discharged from ballast water. Currently, USCG-Type Approval is authorized by the American Bureau of Shipping (ABS), DNV GL Group, Korea Register of Shipping (KR), and Lloyd's Register of Shipping (LR).

In order to deal with the differences between the two standards, without affecting international shipping vessels. The following methods can be adopted by most shipowners for the normal operation of their ships.

① Loading and discharging ballast water from the U.S. public water area, or not discharging ballast water within 12 nautical mile offshore, or using ballast water receiving facility.

② Using USCG type-approved BWMS.

③ Using those that have passed IMO type certification, and then approved by USCG as an alternative ballast water treatment device (AMS);

④ Apply for extension, this method is applicable to the installed USCG Type-approved ballast water treatment system, but ships that are about to or have expired. Such ships are also valid as long as they submit an extension letter issued by the USCG(Wang, 2019, pp, 41-46).

2.5 Introduce the Practices of Other Countries and Project on Managing Ships' Ballast Water.

In addition, China needs to learn the implementation practices from other countries to improve compliance level.

2.5.1 Australia

Due to its unique geographical location, Australia's domestic and international trade mainly depends on the shipping , and about 95% of its goods are transported by sea. Every year, about 10,000 ships come from 600 seaports around the world and can discharge about 150 million tons of ballast water in Australian ports(Dai, 2004, pp, 20-21).

The marine ecosystem along the coast of Australia is unique. There are many rare species and precious barrier reefs. The famous Great Barrier Reef is located on the east coast of Australia. Australia first implemented guidelines on BWM in 1990. In 1994, Australia adopted a coordinated national approach ballast water management.

This guide includes a research on technology management and a decision support system (DSS) for targeting high risk vessels. Ships that are to discharge ballast water in Australian ports must provide a copy of the data through the DSS system

before the ship calls to the port. This system then performs the evaluation report of each pressure on the ballast water tanks based on the information provided by the captain. If the evaluation report gives a low risk of introducing IAS, the ship will not be required to implement special management measures. However, if the evaluation report gives the high risk of introducing IAS, ships are required to discharge ballast water by methods or management measures approved by the Australian Quarantine and Inspection Service(David & Gollasch,2015). These methods include, exchange of ballast water at sea through sequential exchange, flow-through or dilution; non-discharge of high risk ballast tanks; tank-to-tank transfer; or comparable treatment options as developed(Tamelander,J., et.al.2010, p. 29).

2.5.2 America.

As the first country in the world to pay attention to the issue of IAS, the United States has formulated regulations related to the prevention of water pollution and the replacement of ships' ballast water, 1972 US Congress amends Federal Water Pollution, Control Act from 1948 called the Clean Water Act (CWA) and 1990 US Congress through Non-Indigenous Aquatic Nuisance Prevention and Control Act (NIANPCA) all of which grant authority to USCG for establishing and implementing BWM regulations; USCG mandates BW exchange in Great Lakes and voluntary trial(Campara, L., et, al. 2019. pp, 2-3).

2.5.3 The GloBallast Partnerships Project 2007-2017

The project name is called The GloBallast Partnerships Project 2007-2017. The aim of this project is to establish a partnership to assist developing countries to reduce the transfer of harmful aquatic organisms in ballast water, which is referred to as the GloBallast Partnership (GBP), which was launched at the end of 2007 with the aim of making progress in the original project. It focuses on the national policies, legal and institutional reforms of targeted developing countries, and focuses on integrated management. The project was originally planned as a five-year plan, from October 2007 to October 2012. Later the project executive committee had agreed to extend the project until June 2017.

The Project is being implemented by United Nations Development Programme (UNDP) and executed by IMO, under the GEF International Waters portfolio. It is funded by the Global Environmental Facility (GEF) Grant, with co-financing by IMO, GBP Participating Countries and Private Sector. The project benefits 15 Lead Partner Countries, over 70 Partnering Countries with framework to be replicated throughout the regions. It also makes partnership with Shipping and port industries, national administrations, international environmental non-governmental organizations and other parties for the project develops.

This project achieved a total of more than 100 countries participated, of which more than 65% of the compliance countries, published 30 technical publications,

conducted six international research and discussion forums, and formulated more than 40 countries or regions Strategy, more than 4,000 people have studied online.

What is more, the project also achieves as below,

- 1, Establish global coordination arrangements and Form Regional Task Force (RTFs) to support development and adoption of a regional approach to ballast water management

- 2, Develop and implement communication, education, awareness raising and outreach programmes.

- 3, Develop knowledge management and GloBallast electronic information exchange systems including country profile database and information clearing-house mechanisms

- 4, Develop introductory and more specialized training packages to train Lead Agency, port and shipping personnel in ballast water management measures as contained in IMO Convention and associated guidelines.

- 5, Develop model legislation and compliance monitoring and enforcement models and related training modules to build capacity among the LPCs to address the issue

- 6, Undertake rapid review of the baseline situation and an economic assessment in all LPCs to assist the development of a National Ballast Water Management Strategy (NBWMS)

- 7, Review legislation relevant to ballast water in each country and advise/assist improvements

- 8, Develop regional capacity to undertake Port Baseline Surveys (PBS) of native biota and introduced marine species through regional PBS training programmes.

- 9, Establish Global Industry Alliance for Marine Biosecurity (GIA) and GIA Fund to support activities aimed at technology development and technology

diffusion among the industry(GloBallast Partnerships Project ,2007).

Chapter 3 Proposal for Better Implement BWM Convention in China.

In response to the above-mentioned problems and challenges in China's compliance process and better carry out compliance work. The relevant proposals are as follows.

3.1 From the Perspective of PSC Inspection

Firstly, I will make some introduction of the PSC inspection and two guidelines about PSC. The BWMC came into force on 8 September 2017. In Paris MoU alone, the PSC issued more than 70 deficiencies regarding BWM in the last four months of 2017; worldwide more than 160 deficiencies were identified up to March 2018(DNV-GL 2018).

China's accession to the Ballast Water Convention has great practical significance. On the one hand, it means that Chinese international ocean-going vessels must meet the requirements of the BWM convention. On the other hand, it means that it can be implemented on foreign ships calling at Chinese ports of Port State Control (PSC) inspections for ballast water. The PSC inspection originated from the Liberian oil tanker AMOCO CADIZ ran aground off the coast of BRITTANY in France on March 17, 1978, causing a serious oil spill of 230,000 tons. After the oil spill, the French Maritime Ministry and the 13 countries of Northwest and Northern Europe reached an agreement on the inspection of foreign ships entering their area. In January 1982, IMO signed the "Paris Port State Control Memorandum of Understanding" (referred to as "Paris

Memo" ParisMOU, which is the first regional port state control organization established in the world), and is scheduled to come into effect on July 1, 1982. The main purposes of PSC inspections include, improving seawater safety and pollution prevention; improving living conditions on board; eliminating low-standard ships and avoiding distorted competition between ports.

3.1.1 Guidelines for PSC.

The first chapter of this guideline mainly introduces the requirements of PSC to comply with the requirements of BWM convention. One thing to note is that regulation 1.3.4, With respect to ships of non-parties to the BWM Convention, which should apply the same requirements to ensure that no more favourable treatment is given to such ships. No more favorable treatment means that if a ship of the flag State have entered the country which joined the BWMC, even if the ship's flag state has not joined the BWMC, the relevant requirements of the Ballast Water Convention shall also apply to this ship.

The main content of the second chapter is the specific implementation of the PSC, which is divided into four stages. The first stage is the initial inspection, also known as the document inspection, the second stage is more detailed inspection, the third stage is the sampling, and the fourth stage is the Comparative analysis of D2 standard.(GUIDELINES FOR PORT STATE CONTROL UNDER THE BWM CONVENTION 2014).

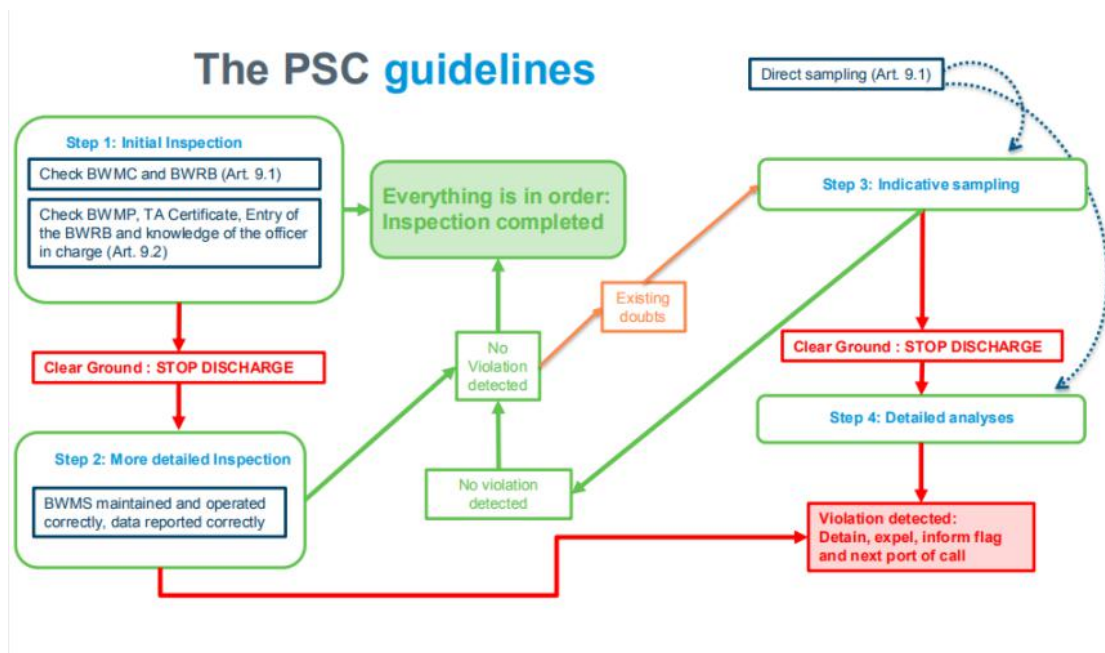


Figure 4- The PSC guidelines for the procedures of inspection.

Source: https://mtu.gov.ua/files/nahaievska/2018_07_03_BWM/5%20-%20CME%20Port%20State%20methods%20and%20exercises.pdf

The above figure shows the specific operation process according to the PSC guidelines, below I will give a specific introduction according to each inspection stage.

The first stage is mainly to check the IBWMC and BWRB on the ship, and to check whether the personnel on board are familiar with the operation procedures and operations of the ship's ballast water management equipment. If there are clear grounds, including for example, IBWMC is missing, not valid, or has expired, absence of a BWMP approved by the flag State, absence of a BWRB or a BWRB that does not meet the requirements of the BWM Convention or entries in the BWRB do not reflect the actual ballast water situation on board (A total of 12 items are not listed), the more detailed inspection will be carried out.

For more detailed inspections, PSCO will conduct inspections on the compliance of BWMP on board, such as whether the crew following specific operational or safety restrictions associated with ballast tank or whether the crew managing ballast water sediments in accordance with the BWMP. If the BWMS was installed on board, the BWMS will also make some more detailed inspection, for example, whether the BWMS and associated equipment in good working condition, whether the crew following safety procedures associated with operation of the BWMS, whether the BWMS being operated according to the operational instructions. What's more, unsanctioned change made to the structure, equipment, fittings, arrangements or material associated with the BWMP are also to be checked.

The third stage is sampling, it needs to high light that the indicative analysis should not unduly delay the movement, operation and departure of the ship. The quantity of the sampling water to be taken and location in the ship chosen should be in accordance with the Guidelines for ballast water sampling and associated guidance developed by the Organization. Finally, the PSCO could make control actions, warn, detain or exclude the ship or grant such a ship permission to leave to discharge ballast water elsewhere or seek repairs.

3.1.2 Guidelines for ballast water sampling.

The objectives of these Guidelines are to provide Parties, including PSCOS, with practical and technical guidance on ballast water sampling and analysis for the

purpose of determining whether the ship is in compliance with the Ballast Water Management Convention. (GUIDELINES FOR BALLAST WATER SAMPLING 2008)

In-tank sampling is used to sample for compliance with the D-1 (ballast water exchange standard). It takes sample via sounding or air pipes and manholes by using pumps, sampling bottles or other water containers. Samples may also be taken from the discharge line(Honeywell, 2017).

Prior to test for compliance with D-2 standard (ballast water treatment standard), an indicative analysis should make the first step to determine whether the ship's ballast water is compliance or non-compliance with the standard. Sampling from the discharge line, as near as practical during the ballast water discharge process is a better way to make accurate sampling analysis result for check the compliance with the D-2 standard.

However, this guidelines also has certain problems due to the complexity and uncertainty of sampling, for example, it can't use a solo parameter to prove non-compliance with the D-1 standard, the method should be rigorously validated and widely distributed through the Organization. As it states in these guidelines, since the sampling-related technology is still in the process of development, the most suitable method and the best and most suitable sampling method are still under research, and there is currently no specific sampling or analysis protocol for the administration to use. The above all add difficulty and uncertainty for PSCO to carry out on board sampling work.

3.1.3 Implement the Three-Level PSC Inspection System Base on the Ship's Ballast Water Management Credit Rating System.

Combined with the inspection mechanism of the PSC inspection guidelines of the BWMC, an inter-departmental joint inspection system based on credit ratings should be established. In this PSC system, the IMO guideline regarding PSC and ballast water sampling are generally observed. On the first level of management, the MSA is responsible for all the supervision and checks. On the second level of management, based on the credit of each ships call on the port, random checks of blacklisted ships are conducted jointly with China's Quarantine department. On the third level of management, the system convenes MSA, Customs department, quarantine department and border guard department to board ships and take ballast water samplings.

As for the three-level PSC inspection system, the first level of management is also the same as document inspection. Documentation such as ballast water management plan and ballast water records book of ships are checked. If there are concerns regarding the recorded content, e.g., the master or the crew are not familiar with ballast water management procedures, more detailed PSC inspections are carried out. Ballast water is sampled to test water quality as required. Ships that do not meet the Convention's obligation are listed on the blacklist. Additionally, ships' discharged ballast water could not meet the management standard and are penalised. The second level of management is triggered when a vessel is added in the blacklist of PSC. In the second level of inspection, the frequency of compulsory on board inspections for blacklisted

ships is increased. If necessary, each time a blacklisted ship enters a port, it undergoes a mandatory PSC inspections. If a ship's discharge ballast water in a port does not meet the water discharge standards, the ship will be penalised. Maritime law enforcement officers is also asked to conduct visual inspections of blacklisted ships during routine patrols to check whether they are illegally discharging ballast water in Chinese territorial waters, if any, is recorded and reported to the PSCOS, whom will board the ships for inspections when the ship call the ports. The third level of management is triggered when a vessel came from areas known to contain outbreak, infestations, or populations of IAS. The MSA would invite Customs department, quarantine department and border guard department to form a joint inspection team to board ships that have passed through epidemic areas during their present voyages to sample and test ballast water. If the testing indicates ballast water is not compliant with the water quality standards, such as ballast water containing infectious pathogens, the ship will be penalised by the MSA in accordance with Chinese maritime Pollution Penalty Regulations. The treatment method of ballast water on board needs to be discussed and decided by the joint inspection team(Liu, et al 2019, pp, 1-8).

3.2 From the Perspective of Pollution Prevention.

3.2.1. Upgrade the Maritime Anti-pollution System, Strengthen the Monitoring and On-site Inspection of Ship's Ballast Water Discharge.

The anti-pollution declaration system has achieved full coverage of the national

maritime system in China. Its functional business scope includes all ship anti-pollution related operations, such as the declaration of ship garbage recycling, the declaration of ship's ballast water discharge, the declaration of taking bunker operations, etc. Ballast water discharge declaration is one of its functions. At present, it can only be used as a way to declare and the declared ballast water operation can only be carried out after the approval by MSA. It seems that this system can't provide better services for ship ballast water-related operations. Therefore, it is necessary to upgrade the system, just like the ship's PSC inspection system has the black list and form a credit rating system for ship's ballast water discharge. The credit rating mechanism comes from the system's calculation of ship data, such as ship type, ship age, route, whether it is punished due to ship's ballast water discharge, etc. A blacklist is also formed to facilitate the selection of ships for inspections.

Of course, after the upgrade of the system, it also facilitates on-site inspections of officers of MSA. It is mandatory to conduct on-site inspections on blacklisted ships and increase the frequency of inspections. For ships with good reputation and good condition the frequency can be appropriately reduced. If on-site inspections found that ships did not operate in accordance with their declared ballast water operations, on-site evidence will be collected and penalize will be conducted.

3.2.2 Possibility of Exempting the Ballast Water Management for Ships Navigating in Fixed Route.

According to Regulation A.4 of the Convention, parties to the Convention can exempt ships from complying with D-1 and D-2 standards as scheduled in Regulation B-3 and additional measures derived from ballast water management as stated in Regulation C-1, but all the remaining obligations of the Conventions will still need to be observed. Exemptions are only granted for ships operated only between specified ports or locations, and an acceptable low risk must be obtained based on the assessment in accordance with the Convention guidelines G7 (Guidelines for Risk Assessment under Regulation A-4). Based on the actual situation in China, ships on fixed routes between China and neighboring countries also account for a certain proportion. For example, ships on fixed routes between China and Japan, China and Russia. Carry out relevant assessments between their fixed ports, if the risk level between the two ports is low, then an exemption can be obtained, making it more convenient for ships on fixed routes sailing between the two ports to carry out ship ballast water related operations. It also should take notice that the maximum length of an exemption is five years and reviews should be conducted during this period. Once the risk situation becomes unacceptable, the exemption shall be revoked(David & Gollasch, 2010).

3.2.3 Explore the Possibility of Establishing Alternative Ballast Water Exchange Zone(ABWEZ).

Currently China has reached an exemption agreement with South Korea, and ships flying the China flag or South Korean flag that sail between the two countries will be exempted from the ballast water regulations. ABWEZ is an opportunity provided by the Convention Regulation B-4 paragraph 2 that Port

State may consult with adjacent or other States as appropriate to designate areas for BWE, for example at least 200 nautical miles from the nearest land and in water at least 200m depth can not be found. By clearly designating an appropriate ABWEZ can the risk of intrusion by IAS be further reduced. Moreover, ballast water exchange on average removes approximately 90% of coastal organisms(Ruiz&Reid, 2007). Therefore, the Chinese government and MSA should increase consultations with neighboring flag states to explore the possibility of establishing a ABWEZ. Countries such as North Korea, Japan, Russia, Vietnam, etc, due to their geographical proximity and the risk of IAS caused by ballast water is probably low, which should base on the assessment accordance with the convention G7. The general location of ABWEZ is selected with a relatively deep sea depth, a distance from the nearest land, and a certain ocean current and wind current location. Because under such marine ecological environment, the ballast water loaded by ships contains less harmful organisms, and has a strong ability to dilute the ballast water discharged by ships(Samue, 2019).

3.2.4 Actively Participate in International Cooperation projects for Ballast Water Management.

A basic principle of international environmental law is international cooperation. International cooperation means that in the field of international environmental protection, member states have carried out in-depth cooperation to unanimously adopt environmental resource protection measures to realize the vision of protecting the shared environment(Giulietta, 2019, pp, 245-253).

The 1992 "Rio Declaration on Environment and Development" not only re-emphasized the importance of international cooperation, but also further proposed "the goal of establishing a new and fair global partnership." The principles of international cooperation are also clearly stipulated in the international conventions on marine environmental protection. Part 12 of the "Convention" specifically stipulates the principle of international cooperation: "When countries draft and formulate methods and procedures that comply with the international rules, standards and recommendations of this Convention for the protection and preservation of the marine environment, they shall be on a global basis or on a regional basis, cooperate directly or through competent international organizations, while taking into account the characteristics of the region. Here, the Convention also emphasizes the characteristics of the region and highlights the importance of regional cooperation.

Therefore, proceeding from this principle, the development of global cooperation is particularly important to prevent the pollution of the marine environment caused by ships ballast water. IMO has launched international cooperation projects such as "GLOBALLAST" which has been mentioned above. China as a major shipping country, has also participated in it and achieved certain good result. However, it is clear that it is still not enough, China must strengthen cooperation with other countries and regions, establish closer international, regional cooperation projects and earnestly care about ships ballast water.

3.2.5 Start PBBS Work As Soon As Possible.

The importance of PBBS has been mentioned before, I won't repeat it here so it seems necessary to carry out PBBS as soon as possible. On the one hand, it is to conduct biological surveys on the terminal waters and coastal waters and establish marine biological data of China. Once IAS occurs, it can be found in time, which could be the technical basis for China to establish a ballast water emergency management mechanism. On the other hand, the development of PBBS is also the basis for risk assessment of IAS accidents caused by ballast water, ballast water exemption and the basis for the formulation of ABWEZ . However, considering the length of China's coastline and the complexity of the water environment, the full implementation of PBBS will inevitably bring about a huge workload and require huge capital and manpower investment. It is obviously unrealistic to fully develop it in the short term. It is suggested that the relevant competent authorities can formulate plans to develop PBBS, considering some key water areas and sensitive water areas as pilots of PBBS, and then gradually extending it to coastal waters across the country. In addition, the characteristics of PBBS make it non-permanent and periodic re-inspection is necessary.

3.2.6 Better Performance Effect Brought by Technological Progress and Technological Innovation.

With the advancement of science and technology and the development of technological innovation, more technological innovation applications are applied to ships to achieve smarter ships with lower costs and more environmentally friendly functions. For example, the application of advanced technology to ballast water treatment technology or the application of PSC officers' fast inspection equipment when inspection on board ships. I will introduce two innovative applications both from the BAWAT project of ballast water treatment which may be the trend for the ballast water management. I also hope that relevant Chinese enterprises can use this as a reference to accelerate the process of technological innovation and better serve the performance of ballast water management.

The first one is BWMS which use waste heat for ballast water treatment. IMO pays more attention to energy conservation, emission reduction and environmental protection, how to build a more efficient, energy-saving and low-cost ship ballast water treatment system has become an important development trend. Before introducing this ballast water treatment system, I must first explain the ship's waste heat accounts for a considerable portion of the energy produced by the main engine. The vast majority (47%) of the capacity generated by the ship is converted into the power to drive the propeller, and the exhaust gas energy of the scavenging tank accounts for 18%(Mirko, et al, 2015, pp, 4273-4299).

It is a system that uses the thermal energy generated by ship's waste heat to heat up the ship's ballast water and has reached the treatment standard. It has the following advantages over the conventional system First, it is simple and easy to install, and it can be modified using the existing system on the ship. Second, it

reduces the work load of the crew when the ship is in port, because the ship's ballast water treatment has been processed during the ship's navigation, the crew can focus more on the loading and unloading operations. Third, it is a green technology, it does not use filters, ultraviolet rays, or chemicals. It only uses ship waste heat to treat the ballast water, which will not cause pollution to ships and the environment. What's more, it also provides a more flexible treatment circulation, circulation treatment within a ballast water tank, from sea chest to a ballast water tank, from one ballast water tank to another ballast water tank, from a ballast water tank to overboard(Bawat, 2020).

The BAWAT BWMS get 2.4 million EUR support from the European Union Research and Innovation Programme (Horizon 2020), which has laid a good foundation for this system to obtain USCG certification.

The second is called MOBILE BWMS. This is a small synthetic ballast water treatment system. When the ship's ballast water treatment system fails, the use of terminal receiving facilities for ballast water also means high costs. This kind of movable ballast water treatment system comes into use and its cost is relatively low.

Its advantage is that it occupies small space and can be placed on the deck of the ship. It is generally the same size of a standard container, but the handling rate is not low, which can fully meet the discharge requirement of the ship. It only need to connect to the ballast water pump on the ship to carry out the operation of ballast water treatment. It is based on the innovative pasteurization technology which offers an additional ballast water treatment options for ships. The figure

below is a MOBILE BWMS. It can be seen that all parts of the BWMS system are integrated in a standard container, so it has the characteristics of portability and small space occupied.

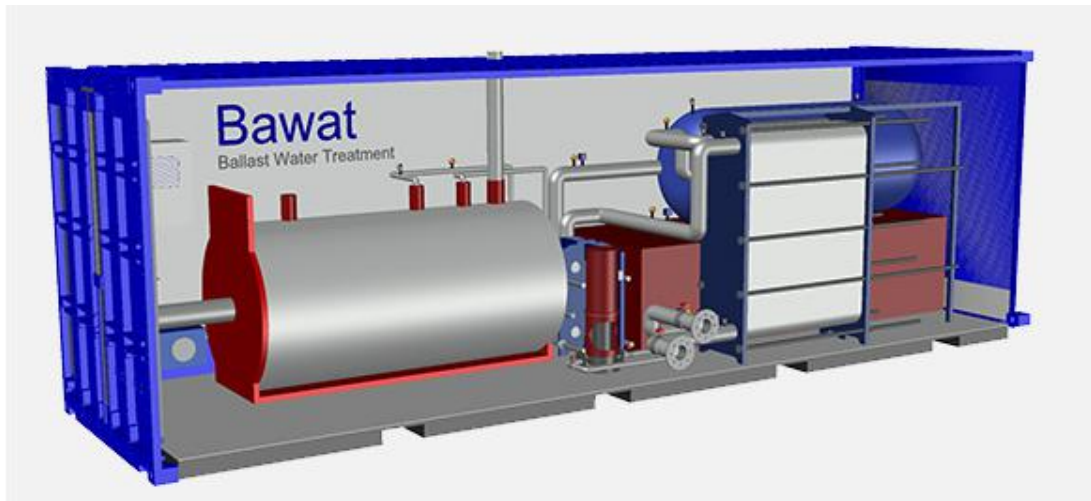


Figure 5-The Bawat MOBILE BWMS.

Source: <https://www.bawat.com/port-bwms/port-bwms/>

Therefore, from the application of the two innovative ballast water systems above, we can also speculate on the future ideas of ballast water management, which is more energy-saving, environmentally friendly, low-cost, and in line with international conventions for ballast water discharge standards and requirements, this also makes ships ballast water management more convenient and efficient.

3.3 From the Perspective of the Law and the Competent Authority.

3.3.1. Strengthen Legislation.

In order to more effectively fulfill the relevant requirements of the BWMC to ensure that ships entering Chinese jurisdictional waters and ports carry out relevant ballast water operations strictly in accordance with the requirements of the BWMC, by which to effectively protect Chinese marine environment, public health and safety. Special laws and regulations regarding ships ballast water must be formulated. Although China's marine environment protection legislation has issued the "Marine Environmental Protection Law" and the "Anti-pollution Regulations", the management regulations related to ballast water are less involved. There are only 1-2 regulations, and most of the regulations are pointing to the requirements of the BWMC, there is no provision for the relevant details, causing problems in the specific implementation and enforcement of the provisions.

The establishment of a sound and complete legal system should include the detailed requirements of the convention, so as to fully cover the convention and should include China's specific practices, procedures and required documents, etc. It should also include supervision, inspection, and punishment measures. Specifically, according to the relevant provisions of the BWMC and Guidelines, China's BWM legal system should include the following aspects: 1. Clarify the responsibilities of relevant departments responsible for ballast water supervision and management. 2. Determine the relevant penalties stipulated by the relevant conventions and regulations concerning illegal ballast water. 3. Develop ballast

water management system certification procedures. 4. Develop emergency management plans, including ballast water transfer measures under special circumstances such as ships from epidemic areas or abnormal seawater. 5. Develop procedures for receiving ballast water on shore. 6. Establish a compensation mechanism for IAS problems caused by ballast water. 7. Develop ABWEZ plans and procedures with neighboring countries. 8. Develop and determine PSC on board inspection, inspection procedures and sampling standards(Mo, 2017).

3.3.2. Increase investment from the government level.

The government must increase capital investment, first of all to increase the investment of scientific research funds. At current stage, there is still a gap in the accuracy of ballast water discharge sampling and testing equipment because of the immature technology. Therefore, increasing capital investment in scientific research and technology to develop stable and high-accuracy testing equipment as soon as possible will facilitate better implementation of the BWMC. The second is to increase the input of law enforcement equipment of maritime law enforcement personnel (including PSCO), and the quick inspection equipment for ballast water inspection should be fully covered as soon as possible. Finally, the implementation of the PBBS plan also requires a large amount of capital investment, especially China's long coastline and vast coastal waters.

3.3.3 Establish a Set of Emergency Management Mechanisms to Deal With Emergencies of IAS, Speed Up the Construction of Ship's Ballast Water Receiving Equipment at Port and Shipyards.

The four types of environmental emergencies are classified in the "National Emergency Plan for Environmental Incidents". The fourth type is "large-scale outbreaks of red tides, enteromorpha and other marine disasters, invasions of alien species that damage biodiversity, and other biosecurity events". However, marine emergencies are difficult to deal with and have high technical requirements. It is difficult to quickly mobilize emergency personnel and property, and it is difficult to obtain them in a short time to achieve effective control of hazards(Liu, 2015. pp, 10-11). This makes it particularly important to speed up the construction and perfection of ballast water emergency management system and emergency team building.

Under certain special circumstances, it may be necessary to perform unconventional operations on the ship's ballast water and sediments or take corresponding additional measures. These special circumstances include the risk of transfer of alien organisms, the leakage of ballast water (such as the rupture of ballast tanks) caused by accidents and the need to discharge the ballast water to eliminate existing dangers, etc. Therefore, the competent authority should formulate necessary emergency work plans to deal with the above special circumstances, establish an emergency management team and pay attention to the team's usual emergency drills so that it can be adequately dealt with in real

emergency situations.

The content of the emergency plan should include the organization and implementation of the ship's ballast water emergency response, risk assessment under special circumstances, the level of emergency response, the measures that should be taken at different levels, information notification, and post-emergency assessment, etc. For example, from areas where epidemics or biological abnormalities in the sea area, or areas where ballast water operations are not recommended, the competent authority should notify the ships arriving at the port to avoid ballast water operations as soon as possible, reduce the possibility of aquatic organisms transferring, and thereby reduce the risk of IAS. For another example, a grounded ship can be get refloat by other means (unloading, passing by tide), try not to discharge ballast water.

What's more, although the establishment of ballast water reception facilities is not a mandatory requirement of the BWMC, it is considered that the port state government should try to provide necessary supplementary measures for ships that can't meet the requirements of BWM due to special reasons. Especially when the ship is repairing or cleaning the ballast tank, the sediment in the tank must be properly disposed. Therefore, consideration should be given to establish appropriate ballast water reception facilities in ports where conditions permit, especially the reception and disposal of sediments. At present, Article 15 of the Anti-pollution Regulations has relevant requirements on the receiving and treating of ship's ballast water. On the basis of the perfect domestic laws and regulations on ballast water, ports and shipyards need to have certain ballast water receiving capabilities. Therefore, the maritime competent authority must

fulfill the duties assigned by laws and regulations, strictly examine and approve the qualifications of the ballast water receiving facilities of ports and shipyards, supervise the operation of receiving equipment, and urge relevant parties to accelerate the construction of receiving facilities.

Chapter 4. Conclusion

With the development of the shipping industry and the impact of economic globalization, more and more countries, regions and organizations, including IMO, pay more attention to environmental protection. The IAS problem caused by the discharge of ballast water from ships is also becoming more and more serious. It has an impact on people's health, loss of national economy and destruction of the ecological environment. Although the IAS problem caused by ballast water has long been noticed and formulated by some countries, there has never been a unified ballast water treatment standard. The IMO promulgated the ship's ballast water management convention in 2004, which made relevant regulations on ships ballast water management and formulated relevant guidelines to guide ballast water related operations.

Chinese accession to the Ballast Water Convention in 2017 and China has taken a substantive step and actively implemented corresponding measures in accordance with the requirements of the BWMC after its entry into force. The performance of the implementation has achieved certain results and promoted the progress of Chinese ballast water management under this opportunity, which has brought good news to Chinese marine environmental protection and human health. However, it should still be noted that there are some problems and challenges in China's implementation process, such as the unclear formulation of laws and regulations related to ballast water management, the problems and challenges encountered in PSC inspections, the lack of carrying out in-depth international cooperation and the lack of carrying out PBBS in time, etc. These issues have brought challenges for China to implement of the BWMC.

The proposals are based on three aspects, legislation, PSC inspection, pollution prevention and law and competent authority which put forward corresponding suggestions and countermeasures for problems in China's implementation of the BWMC. It is hoped that China's ballast water management can achieve better results at a higher level. In addition, it needs to be emphasized that the problem of ballast water management is definitely not only a problem for China. It involves stakeholders including flag states, coastal states, competent authorities, PSCO, shipowners, ships, crews to make efforts. Flag states and coastal states are responsible for formulating relevant domestic laws and regulations to restrict ship ballast water management. The competent authority is responsible for the certification and inspection of ship ballast water. PSC inspection is responsible for the inspection of ship ballast water management on board. Shipowners, ships and crews are responsible for the specific implementation of the Ballast Water Convention and relevant laws and regulations on ships. It can be said that the good implementation of a convention can't lack any link or the efforts of all stakeholders which could really make the ballast water management work implemented. Thus, to reduce IAS problems caused by ballast water and protect the health of people and the safety of the marine environment.

REFERENCES

- Anish, (2019). What is Ballast Water Management Plan? Retrieved on Mar. 14, 2020 from the World Wide Web: <https://www.marineinsight.com/maritime-law/what-is-ballast-water-management-plan..>
- Bai, M. D., & Zhang, Z. T. (2010). New technology of prevention and control of invasive marine species and pathogene[M]. China Ocean Press,2010, 1-3.
- Bawat, (2020). Bringing New Port based solutions to the bwts market. Retrieved on jul.02.2020 from the world wide web:<https://www.ballastwatercontainers.com/>
- BRAUTIGAM L A. (2001) Control of aquatic nuisance species introductions via ballast water in the United States: Is the exemption of ballast water discharges from Clean Water Act Regulation a valid exercise of authority by the environmental protection agency. *Ocean & Coastal Law Journal*, 6(1) ,33-76.
- Chen, X. S. (2017). Opportunities and Challenges for China to Join the Ballast Water Convention. *China Academic Journal*. 1284, 14-17.
- Campara, L., Vlado, F., Lovro, M., & Nermin, H. (2019). Overview and Comparison of the IMO and the US Maritime Administration Ballast Water Management Regulations. *Journal of Marine Science and Engineering*. 383: 2-3.
- Chen, F. G., Zhang, J. W., Chen, K. L & Huang, H. P(2015). Research on marine ecological damage assessment method based on ecological restoration. *Ocean Journal*. 1, 10-11.
- Cheng, H. T & Jia, Z. M. (2018). Analysis of vessel ballast water sampling

method. China Academic Journal. 1284, 42-46.

Control of the Environmental Damage Caused by Ship's Ballast Water. China Academic Journal. 618X, 40-45.

CORRINA, J., CHRISTINE. R., & JUDITH. P., (2018). MARINE BIOINVASIONS FACT SHEET: BALLAST WATER TREATMENT OPTIONS. Retrieved on May. 24, 2020 from the World Wide Web: <https://massbay.mit.edu/resources/pdf/ballast-treat.pdf>.

Dai, X. J (2004). Learn from The Experience of Australia to improve anti-pollution mechanism. China Academic Journal, 1395, 20-21.

David, M & Gollasch, S.(2010). Ballast Water Risk Assessment for Intra North Sea Shipping, Final Report, Retrieved on Aug.07.2020 from the world wideweb:https://www.researchgate.net/publication/236154730_Ballast_water_risk_assessment_for_intra_North_Sea_shipping.

DNV (2020). Ballast Water Management Plan. Retrieved on Aug.07.2020 from the [worldwide web:](http://www.anave.es/images/documentos_socios/lastre/dnv_modelo_plan_gestion_agua_lastre.pdf) http://www.anave.es/images/documentos_socios/lastre/dnv_modelo_plan_gestion_agua_lastre.pdf

DNV-GL (2018). BALLAST WATER MANAGEMENT AND PORT STATE CONTROL-CHECKLIST FOR PREPARATION OF PSC INSPECTIONS. Retrieved on jul.02.2020 from the world wide web: www.dnvgl.com/maritime.

Eduardo, S. A. (2018). Comparative study of approved IMO technologies for treatment of ballast waters. Unpublished master's thesis, Political University of Catalonia, Barcelona, Spain.

ENVIRONMENT PROTECTION AUTHORITY VICTORIA (2017). Ballast water - regulation 8. Retrieved on Jun. 14, 2020 from the World Wide

Web:<https://www.epa.vic.gov.au/yourenvironment/water/ballast-water>.

FEDERALE OVERHEIDSDIENST MOBILITEIT EN VERVOER, (2018). Ballast Water Management Convention Guidance for implementation: Retrieved on Jun. 14, 2020 from the World Wide Web:https://mobilit.belgium.be/sites/default/files/resources/files/bmmc_presentation_general.pdf.

Fan, D. S.(2013). China's entering "BWM convention" Strategy Research. Unpublished master's thesis, Dalian Maritime University, Dalian, China.

Giulietta, R., Damir, Z., Maia, M. K., Darinka, J., Stephan, G. & Matej, D.(2019), The implementation of the ballast water management convention in the Adriatic Sea through States' cooperation: Thee contribution of environmental law and institutions. Marine Pollution Bulletin Journal. 147, 255-253.

GLOBALLAST PARTNERSHIP (2018). The GloBallast Story: Reflections from a Global Family Partnerships to catalyze transformational innovations in marine biosafety. Retrieved on Jun. 15, 2020 from the World Wide Web: http://www.imo.org/en/MediaCentre/HotTopics/BWM/Documents/Monograph_25_The_GloBallast_Story_LR_-_rev_1.pdf.

GUIDELINES FOR BALLAST WATER SAMPLING.(2008).

GUIDELINES FOR PORT STATE CONTROL UNDER THE BWM CONVENTION.(2014).

GUIDELINES FOR RISK ASSESSMENT UNDER REGULATION A-4 OF THE BWM CONVENTION (G7). Retrieved on Sep.11.2020 from the world wideweb:<http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Marine-Environment-Protection-Committee-%28MEPC%29/Documents/MEPC.289%2871%29.pdf>.

Hazardex (2020), Are you ready for ballast water management regulation. Retrieved on Sep.11.2020 from the worldwide web: <http://www.hazardexonthenet.net/article/180210/Are-you-ready-for-Ballast-Water-Management-regulations-.aspx>

Honeywell, (2017). BALLAST WATER SAMPLING SOLUTIONS. Retrieved on jul.02.2020 from the world wide web: <https://www.honeywellprocess.com/library/marketing/brochures/Ballast-Water-Sampler-A4-07-25-17-lowres.pdf>.

Hu, C. B. (2015). Analysis on the status and development of ship ballast water legislation in China. China Academic Journal. 1395, 44-46.

IMO, (2017). International Convention for the Control and Management of Ships' Ballast Water and Sediments. Retrieved on Jun. 14, 2020 from the World Wide Web: [http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-theControl-and-Management-of-Ships'-Ballast-Water-and-Sediments-\(BWM\).aspx](http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-theControl-and-Management-of-Ships'-Ballast-Water-and-Sediments-(BWM).aspx).

International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004.

IMO, (2020). Status of IMO Treaties. Retrieved on Jun. 14, 2020 from the World Wide Web: <http://www.imo.org/en/About/Conventions/StatusOfConventions/Documents/StatusOfTreaties.pdf>.

IMO (2014). GUIDANCE ON PORTBIOLOGICAL BASELINESURVEYS (PBBS). London: Author.

Jaimie, T, A., & Dirk, P. (2018). Non-Native Species and the Great Lakes: Killer Shrimp. Retrieved on Mar. 14, 2020 from the World Wide

Web: <http://www.ncinlm.in.go/pc/artiles/C190628/paf/10874746.pdf>.

KAZUMI, J. (2018) Ballast Water Treatment Technologies and Their Application for Vessels Entering the Great Lakes via the St. Lawrence Seaway. May. 4, 2020 from the World Wide Web: http://onlinepubs.trb.org/onlinepubs/sr/sr291_kazumi.pdf.

Kong, Q., Liu, J. F., Kong, L., & Xu, F. Q. (2018). Analysis on Difficulties Faced by Full Implementation of Ballast Water Convention. China Academic Journal. 161, 81-86.

Lian g, Y, B., & Wang, B. (2001). Alien marine species and their impacts in China. Biodiversity Science. 0094(2001)04, 458-465.

Li, Z. W., & Du, X. (2012). International Cooperation and Coordination on Prevention and

Liu, T. k., Wang, Y. C & Su, P. H.(2019). Implementing the ballast water management convention: Taiwan's experience and challenges in the early stage. Maritime Policy Journal. 1-8.

MITSUBISHI HEAVY INDUSTRIES. (2018). Coagulation and Magnetic Separation Technology “Hitachi Ballast Water Purification. Retrieved on May. 24, 2020 from the World Wide Web: <https://www.mhi.com/news/story/080407.html>.

Mirko. G., Vladimir. M&Gojmir. R(2015). Calculation of Efficiencies of a Ship Power Plant Operating with Waste Heat Recovery through Combined Heat and Power Production. Journal of energies. 3390, 4273-4299.

Mo, L. S. (2017). The Challenge of China 's Convention on Ballast Water and Its Legal Countermeasures. Unpublished master’s thesis, Dalian Maritime University, Dalian, China.

Pureballast , (2020). Pureballast 3.1. Retrieved on May. 24, 2020 from the World Wide Web: <https://www.alfalaval.com/products/process-solutions/ballast-water-treatment-system/pureballast-3-1/>

Ruiz,G.M & Reid,D.F.(2007) Current State of Understanding about the Effectiveness of Ballast Water Exchange (BWE) in Reducing Aquatic Nonindigenous Species (ANS) Introductions to the Great Lakes Basin and Chesapeake Bay. Retrieved on jul.02.2020 from the world wide web: www.vliz.be/imisdocs/publications/128990.pdf.

Samue,S.,Asami,C.,Selcan.Z&Shota,K.(2019).Ballast Water Management:Protectinq Marine Environments in Small Island Developing States in the Pacific.Unpublished master’s thesis,University of California, Los Angeles. America.

Tamelander, J., Riddering, L., Haag, F & Matheickal. J. (2010). Guidelines for Development of a National Ballast Water Management Strategy. (P, 29). London: Author.

Tang. F. B., Xu. Z. & Yang. X. Z. (2017). Brief analysis on the outfit type of ship ballast water treatment unit and PSC inspection. China Academic Journal. 2278, 43-44.

Tang, Y., & Su, S. (2015). Study on ballast water management for prevention and control of invasive species introductions. JOURNAL OF SHANGHAI OCEAN UNIVERSITY. 5566(2015)01, 130-137.

The GloBallast Partnerships Project 2007-2017. (2007). GloBallast Partnerships’s list. Retrieved on May. 4, 2020 from the World Wide Web: <https://archive.iwlearn.net/globallast.imo.org/the-globallast-partnerships-project-2007-2016/index.html>

The International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004, IMO, (2004).

The International Maritime Organization web gives further information on course.

<http://www.imo.org/en/OurWork/Environment/BallastWaterManagement/Pages/BWMConventionandGuidelines.aspx>.

Transport Canada. (2010). Ballast Water Defined.. Retrieved on Jun. 14, 2020 from the World Wide Web: <https://tc.canada.ca/en/marine-transportation/marine-safety/ballast-water-defined>.

Wang, N., Liu, M. H., Zhang, B., Shi, W. T & Lu, Y. Y (2019). Review on Interpretation and Implementation of International Convention for the Control and Management of Ships Ballast Water and Sediments. TIANJIN SCIENCE & TECHNOLOGY JOURNAL, 46, 41-46.

Wei, Y. F & Wang, J. Z. (2016). Research on Conversion and Selection of Ship Ballast Water Treatment System. China academic journal. 31-1420, 5-10.

WERSCHKUN, (2018). Emerging risks from ballast water treatment: The run-up to the International Ballast Water Management Convention. Retrieved on Jun. 15, 2020 from the World Wide Web: <http://dx.doi.org/10.1016/j.chemosphere.2014.03.135>

Xinde Maritime News, (2019). Notice from the Maritime Safety Administration (MSA) of the Ministry of Transport Regarding the Exemption from Conducting Ballast Water Exchange by Ships Plying Between China and Korea. Retrieved on Mar. 14, 2020 from the World Wide Web: <https://www.xindemarinenews.com/en/market/2019/0617/12943.html>.

Xu. Yang & Xu. L. S. (2015). Ship Ballast Water Treatment System. China Academic Journal. 664, 43-45.

Zhu, D. T., Zhao, Y. X & Liu, X. P. (2019). Analysis of the main points and difficulties in the supervision of "Ballast Water Convention". *Journal of Maritime Management*. 1284, 11-16.

BIBLIOGRAPHY

David, M & Gollasch, S (2015), Global Maritime Transport and Ballast Water Management. Dordrecht: Springer Press.

David, M & Gollasch, S.(2014), Global Maritime Transport and Ballast Water Management Issues and Solutions. Netherlands: Springer Press.

Maria, H. R.(2009). The International Law on Ballast Water - Preventing Biopollution. Martinus Nijhoff Press.