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Establishment of Ballast Water and Sediment Reception Facilities in accordance with BWM Convention in Port of HaminaKotka.

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Abstract

The thesis on the Establishment of Ballast Water and Sediment Reception Facilities in accordance with BWM Convention in Port of HaminaKotka was focused on the analysis of the ballast water and sediment reception method and the treatment technology. The theoretical part of the paper explains the Ballast Water Management Convention and its requirements, as well as reviews the ballast water exchange methods, introduction of invasive species and onshore treatment solutions for the port.

The research/development objective of this thesis was to compare and choose suitable treatment methods for establishing the ballast water and sediment reception facilities in a liquid bulk terminal. Available methods have been compared, advantages and disadvantages discussed and a suitable solution has been suggested.

The thesis applies a qualitative research method not only to describe but also to analyze the collected research data. In order to supplement the method, an interview with a Kymen Vesi Oy pumpman-engineer was conducted via e-mail.

The study showed that the ballast water and sediment treatment technologies are not effective when used alone and they do not meet the requirements of the Convention. Theherefore, the proposal for a suitable technology facility suggests to use coagulation/flocculation and filtration followed by UV irradiation stages. The paper also introduces the suitable areas for establishment and shows the advantages of an onshore treatment facility versus an onboard treatment system.

Keywords

ballast water, sediment, ballast water treatment technology, onshore solutions.

CONTENTS

1 INTRODUCTION

This thesis examines ballast water and sediment reception facilities, ballast water and sediment treatment technologies and how they could be established in the Port of HaminaKotka.

The mentioned topic is essential at present due to the Ballast Water Management Convention which entered into force in September 2017. The invasion of species in the Baltic Sea from other seas or oceans is a topic of high importance which should be monitored.

At the author's home university – the Latvian Maritime Academy, was a lecture on environmental pollution prevention for two semesters, where the lecturer spoke mostly about the MARPOL Convention. She also mentioned the BWM Convention, stating that it was going to be a challenge for ports in 2017 once it would enter into force. Taking into account the aforementioned, the author is interested to make a plan for establishing ballast water and sediment reception facilities.

1.1 Research Problem

Vessels sail all around the world, and the content of water in the seas and oceans differs depending on location. Ballast water is used for the vessel's stability. When a vessel is loading ballast water, all the sand, mud, sea/ocean fauna and bacteria are loaded along. It is prohibited to load ballast water, for example, in the Atlantic Ocean and then discharge it in the Baltic Sea, because invasive species would kill and decrease the number of native sea inhabitants and could cause a great problem to the sea environment.

Ballast water tanks need to be cleaned from sediment regularly. It should be possible to do the cleaning in the port where the vessel is supposed to have, for example, a dry dock inspection. This is a problem because not all ports have ballast water reception facilities nor sediment reception facilities. Referring to the homepage of Port of HaminaKotka Ltd. (2017), under waste management instructions, they do not have ballast water reception facilities. These services must be ordered through the vessel's agent from the waste management company.

The research problem is which treatment technologies would be most suitable for establishing ballast water and sediment reception facilities in the Port of HaminaKotka.

1.2 Research Objective and Question

The theoretical part includes a description of the Ballast Water Management Convention, ballast water exchange, types of invasive species that have been introduced to the Baltic Sea, definition of sediment, means to clean it out of ballast water tanks and instruction on how to discharge ballast water and sediment into the reception facilities.

The empirical part of this thesis includes water treatment technologies and suitable solutions for establishment of ballast water and sediment reception facilities in Port of HaminaKotka, i.e. Mussalo harbour, liquid bulk terminal.

Thesis research/development objective is to compare and choose suitable treatment methods for establishing ballast water and sediment reception facilities in the liquid bulk terminal. This could help the port in the process of further development and make it more competitive compared to other Finnish ports.

Questions to be discussed:

1. In which part of the Mussalo harbor could a reception facility be established?
2. Which methods are used for ballast water and sediment treatment?
3. How to dispose of the after-treatment dirt?

1.3 Research Method

The thesis applies an qualitative research method. The purpose of qualitative research is not only to describe but also to analyze the collected research data (University of Wollongong 2001, p. 2). Interviews with Kymen Vesi Oy employees were conducted via e-mail, in order to collect information about their wastewater treatment facilities. This information is used in the empirical part of the thesis for establishing a plan for a ballast water and sediment reception facility, similar to the wastewater treatment plants used at Kymen Vesi Oy.

The qualitative research method is used for the thesis as it will not deal with data and statistics, but with previous researches similar to this topic, which explains the variety of ballast water and sediment reception facilities that can be used, as well as provides an insight as to what would be the easiest accessible place for this reception facility and how to connect it with port operations.

The main sources used for the empirical part are the Ballast Water Management Convention, guidelines introduced by International Maritime Organization, researches published by the Marine Pollution Bulletin, and GloBallast Monograph editions.

1.4 Theoretical Framework

Theoretical issues in this thesis are as follows:

1. What is the Ballast Water Management Convention and its requirements?
2. How does a vessel exchange ballast waters?
3. Which invasive species have been brought into the Baltic Sea with ballast water and sediment?
4. What are the methods introduced for ballast water and sediment reception in the port?

The Ballast Water Management Convention is a convention which states the obligatory rules for ballast water management, required documentation, record-keeping on board and ways to reduce the movement of invasive species to the different regions. The International Maritime Organization’s Maritime Environment Protection Committee (MEPC) has adopted and developed guidelines for the implementation of the Convention (International Maritime Organization 2017).

A vessel can use three methods how to exchange ballast water. The two main methods are the sequential method and the pump-through method (which includes the flow-through and the dilution methods). (STX Offshore & Shipbuilding Co., Ltd 2013, p. 12.)

When loading ballast water into ballast water tanks, there is a chance of loading sediment particles as well. Sediment will collect on the ballast water tank walls and bottom building up layers which can contain bacteria, eggs of invasive species, small fishes and even crabs. These species may adapt to the conditions of the Baltic Sea easily and be stronger than the native inhabitants.

According to the Ballast Water Management Convention, under Article 5 and Guideline No. G5, adequate facilities should be provided, without causing undue delay to the vessel, and safe ballast water and sediment disposal must be arranged without damage to environment and people. These reception facilities should be provided in places such as shipyards or dockyards where ballast water tank repair and/or cleaning can be performed, also in existing ports. (International Maritime Organization 2017, p.4, 31.)

2 BALLAST WATER AND SEDIMENT MANAGEMENT

Invasive species and their harmfulness to the ocean and sea environment have and continue to pose a large problem nowadays. Vessels move invasive species with ballast water and sediment in their ballast tanks from one region to another. (IMO n.d. – a.)

In order to prevent the harmful migration of invasive species and to manage it, the Ballast Water Management Convention was adopted in 2004 and entered into force in 2017. It stipulates standards and procedures for the vessels pertaining to how to monitor and manage the loading and discharging of ballast waters and sediment, as well as exchange and treatment of ballast water. (IMO n.d. – a.)

2.1 Definition of ballast water and sediment

According to the Merriam-Webster Dictionary, the ballast is water which may contain sediment and is placed in ballast water tanks to improve stability and control draft of the vessel, and sediment is ‘’matter that settles to the bottom of a liquid’’. (Merriam-Webster Dictionary n.d. – a, b.)

In the port of discharge, the vessel loads ballast water into ballast water tanks and discharges cargo in the port. This procedure keeps the vessel stable and controls draught (Figure 1). In the process of loading ballast water, invasive species and sediment may enter the tanks. On the voyage to the vessel’s port of destination, sediment settles down at the bottom of the ballast water tank, and invasive species are transported via water and sediment. Having arrived at the loading port, the vessel is loaded with cargo and has to discharge the ballast water in the port area, bringing all the invasive species the vessel has carried during the voyage into a new environment. (IMO n.d. – b.)

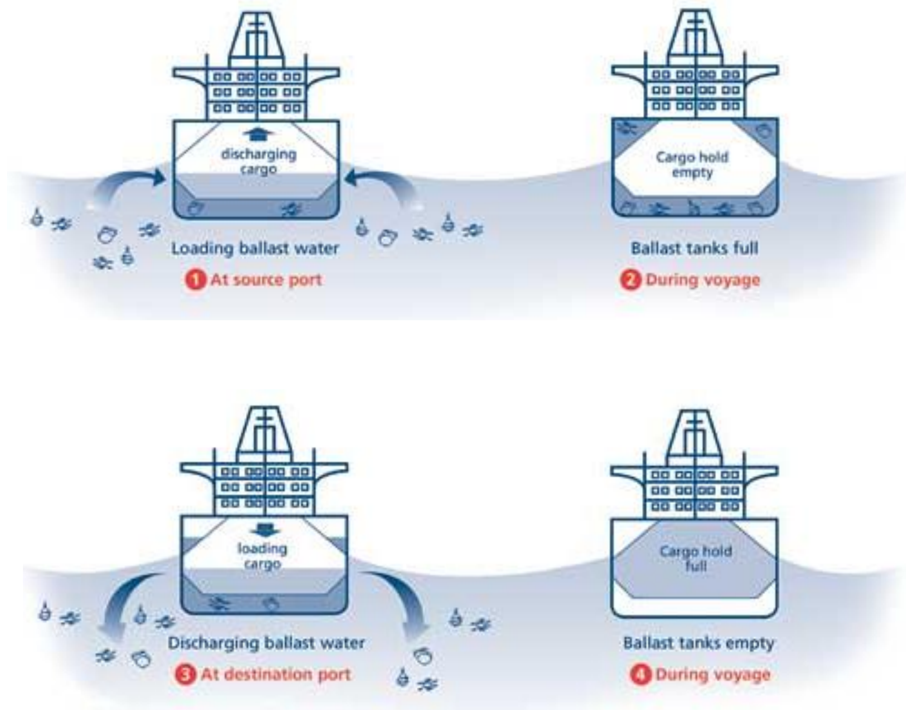

Figure 1. Loading and discharging of the cargo and ballast water (IMO n.d. – b.)

2.2 The Ballast Water Management Convention

The full name of the convention is the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. This convention was adopted to prevent and stop the transfer of invasive species into local environments to protect the marine environment and human health from harm, as well as to introduce rules for managing the discharge of ballast water and sediment. (International Maritime Organization 2017.)

The Convention was adopted on 13 February 2004 and entered into force on 8 September 2017 (IMO n.d. – a).

The convention obliges all vessels which are involved in international trade to manage and control their ballast water and sediments. It also states that each vessel is supposed to have an onboard Ballast Water Management Plan, a Ballast Water Record Book, and an International Ballast Water Management Certificate. (IMO n.d. – a.)

The Ballast Water Management Convention (International Maritime Organization 2017) consists of:

- 22 articles; and
- Annex – with 5 sections and 2 appendices:
  - Section A – General provisions;
  - Section B – Management and control requirements for ships;
  - Section C – Special requirements in certain areas;
  - Section D – Standards for ballast water management;
  - Section E – Survey and certification requirements for ballast water management
  - Appendix I – Form of international ballast water management certificate;
  - Appendix II – Form of ballast water record book.

2.3 Ballast water exchange

Because of its content and all invasive species that might be carried along, ballast water cannot be carried from one region to another without exchange. If the vessel's voyage is short or limited to one region, ballast water is loaded at the vessel's port of discharge and discharged at the port of loading. A fact is, vessels sail all around the world and their loading and discharging ports can be in different regions. (IMO n.d. – b.) For example, a vessel may load in some port of North or South America and then, having sailed across the ocean(s) and seas, will discharge in a port in Finland. The content of water in the American and Finnish ports is different. When ballast water is discharged into the open waters, invasive species are not likely to survive because of the difference in the content of the coastal water loaded in the port and the content of water in the open ocean or sea. (STX Offshore & Shipbuilding Co., Ltd. 2013, p.12.)

Under regulation B-4 of the Ballast Water Management Convention (International Maritime Organization 2017, p. 6), ballast water exchange should be done:

- ''At least 200 nautical miles from the nearest land and in water at least 200 meters in depth; if this point is not possible
- As far from the nearest land as possible and at least 50 nautical miles from the nearest land and in water at least 200 meters in depth; or

- In the designated area by Port State’’.

All national legislation and regulations should be taken into account as they might differ and specify different distances from the land and depth in water.

2.3.1 Requirements for ballast water exchange

As many regulations and conventions have been introduced, vessels need to follow and operate in accordance with the regulations and conventions governing them. The Ballast Water Management Convention entered into force in 2017, obliging all vessels to manage, control and exchange ballast water, as well as indicating the corresponding documentation and the process of record-keeping onboard. (IMO n.d. – a.)

The Ballast Water Management Convention, under Section B – Management and Control Requirements for Ships, obliges all vessels to have onboard Ballast Water Management Plan and Ballast Water Record Book (International Maritime Organization 2017, pp. 4-5).

According to the Ballast Water Management Convention (International Maritime Organization 2017, p.4), the Ballast Water Management Plan should be made individually for each vessel. The Plan should be written in the working language of the vessel. If English, French or Spanish languages are not the working language of the vessel, translation in one of these languages should be provided. The plan should include:

- The safety procedures for the vessel and crew.
- A detailed description of corresponding actions for applying requirements of ballast water management to the vessel.
- Sediment disposal procedures.
- Procedures on communication and cooperation with authorities of the place where ballast water exchange or discharge will be done.
- Name of the officer who will be responsible for the plan and will follow set rules.
- Requirements for the process of reporting.

2.3.2 Methods for ballast water exchange

There are two main methods for ballast water exchange – the sequential method and the pump-through method. The pump-through method, in turn, includes two sub-methods – the flow-through method and the dilution method. (STX Offshore & Shipbuilding Co., Ltd 2013, p. 12.)

The sequential method is done with the help of a specific procedure when the ballast water tank is emptied and then refilled with ballast water to have at least 95 percent of volumetric exchange. All tanks should be emptied until pumps are lost and stripping pumps or eductors should be used if it is possible. Those pumps need to be used to let the organisms occupying the bottom of the tank to be discharged, preventing them from being carried along for the whole voyage. (STX Offshore & Shipbuilding Co., Ltd 2013, p.12.)

The flow-through method is done with the help of a specific procedure when the tank is filled with ballast water "allowing it to overflow through the air vent or dedicated overflow vents". In order to have 95 percent of exchange, the tank should be pumped through three times. (Sanguri 2010.)

The dilution method is performed with the help of a specific procedure using two openings in the ballast water tank and the ballast water is pumped through one opening and it flows out through another one (Sanguri 2010).

2.3.3 Ballast water exchange in the Baltic Sea

As mentioned before, ballast water may be discharged at least 200 nautical miles from the nearest land and at least 200-meter-deep areas in water. Unfortunately, in the Baltic Sea, these requirements are impossible to meet. (Pyć 2012, p.102.)

The average depth of the Baltic Sea is only 55 metres. The deepest area of the sea is the southeast coast of Sweden – 459 metres. (New World Encyclopedia 2016.) As it is a coastal area, it is prohibited to discharge ballast water due to not meeting the requirement of 200 nautical miles from nearest land (International Maritime Organization 2017, p. 6).

2.4 Ballast Water Management Standards

According to the Ballast Water Management Convention (International Maritime Organization 2017, p.9), there are two standards for ballast water management:

- D-1 – Standard for ballast water exchange; and
- D-2 – Standard for ballast water performance.

Standard D-1 explains how the vessel is supposed to exchange ballast water using one of three methods, while standard D-2 determines the number of organisms and microbes which cannot be exceeded when discharging ballast water (Table1).

Table 1. IMO D-2 standard for discharged ballast water (Lloyd's Register 2007, p.4).

Organism category	Regulation
Plankton, > 50 µm in minimum dimension	< 10 cells / m3
Plankton, 10-50 µm	< 10 cells / ml
Toxicogenic Vibrio cholera (O1 and O139)	< 1 colony forming unit / 100 ml
Escherichia coli	< 250 colony forming unit / 100 ml
Intestinal Enterococci	< 100 colony forming unit / 100 ml

The Ballast Water Management Convention entered into force (EIF) on 8 September 2017; in view of this, both standards will henceforth be acceptable until the D-2 standard becomes obligatory. With regards to regulation B-3 Ballast Water Management for Ships, the Convention has stated that all new vessels (keel laid/vessels constructed on or after 8 September 2017) are obliged to comply with standard D-2, but as for the existing vessels (keel laid/vessels constructed before the convention entering into force), once the vessel has first International Oil Pollution Prevention (IOPP) renewal survey completed after EIF, the vessel shall commence its transition to the D-2 standard (Figure 2). (Urdahl 2017.)

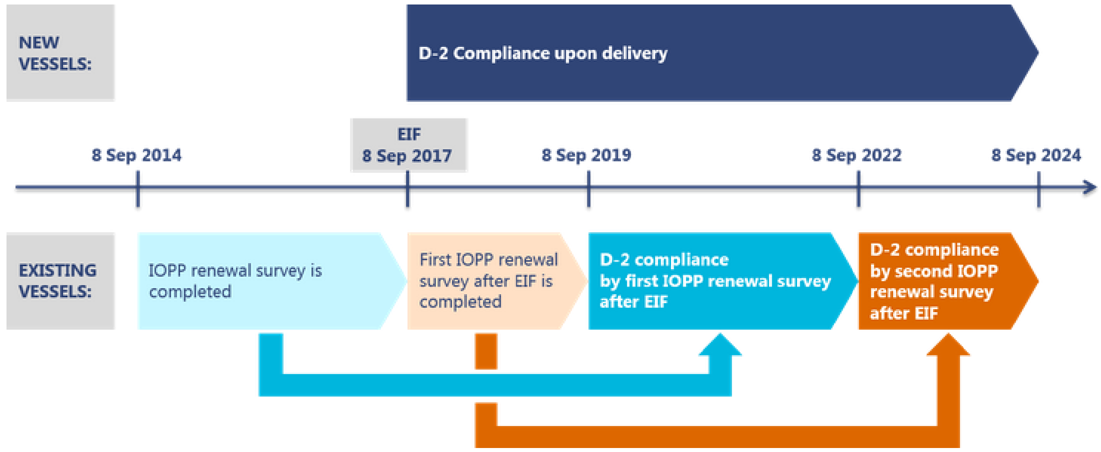

Figure 2. Schedule for compliance with the D-2 standard (Urdahl 2017).

2.5 Sediment Management

According to the Ballast Water Management Convention (International Maritime Organization 2017) and the Ballast Water Management Plan, all vessels are obliged to remove the sediments carried in the ballast water tanks. Vessels built in or after 2009, but before 2012, and in or after 8 September 2017 should reduce the intake of sediments while loading ballast water, manage sediment removal, and allow safe access for sampling. (International Maritime Organization 2017.)

The volume of sediment in ballast water tanks should be monitored regularly. Regular cleaning and removal of sediments from ballast water tanks should be done in mid-ocean or under the control of port or dry dock authorities. Flushing using water inside a tank will only remove a part of mud. Removal would be more effective during scheduled dry dockings of the vessel as this process includes other mandatory activities and could be incorporated therein. (STX Offshore & Shipbuilding Co., Ltd 2013, p.191.)

2.5.1 Occasions when sediment removal is necessary

With a reference to ballast water sediment management in ports (Maglić 2017, p.3), the removal of sediment from ballast water tanks should be done if:

- the amount of sediment has a negative impact on the economic efficiency of the vessel;

- the ballast water tanks need to be inspected during the regular maintenance;
- ballast water tanks need to be repaired; and
- the ballast water intake valve is blocked and/or it is impossible or difficult to load ballast water.

2.5.2 Methods of sediment removal

Most of the time, sediment will be removed from ballast water tanks manually using shovels. All personnel entering ballast water tanks should be properly instructed and trained in the sediment removal process and equipped with appropriate personal protective equipment to ensure health protection and safety. The removed sediment must be put into small containers which then will be lifted up to the main deck and transferred to the shore. (GloBallast, Monograph No. 23 2017, p.14.)

Sediment can also be removed using water to make it liquefied. In this case, pipes should be installed to transfer the liquefied sediment into safe, secured and waterproof containers or into trucks for transporting it to a disposal site. One benefit of this process is that it allows to collect sediment in hard-to-reach areas. However, at this point the handling and disposal of the extra water becomes problematic. (GloBallast, Monograph No. 23 2017, p.14.)

2.6 Invasive species introduced in the Baltic Sea

Due to the rapid growth of the shipping industry, the number of goods transported by sea is increasing and invasive species are being transported from different locations more frequently, thus finding their way into the Baltic Sea. Most of them are capable of adapting in the Baltic Sea. These species can change the marine environment and even cause harm to human health (Figure 3). (HELCOM 2014, p.11.)

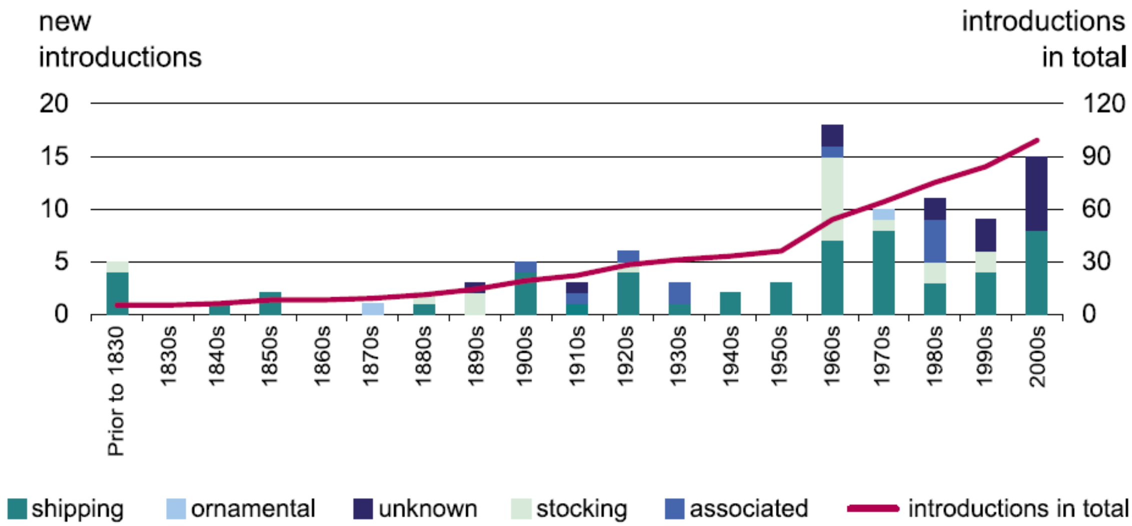

Figure 3. Alien and cryptogenic species introductions (HELCOM 2014, p.11).

Table 2 shows the main types of invasive species introduced to the Baltic Sea through shipping in ballast water and sediment. The origin of most invasive species is North America. The impacts caused by invasive species are competition, habitat change, community dominance and transfer of parasites and diseases. (Baltic Sea Alien Species Database 2010.)

Table 2. Invasive species introduced in the Baltic Sea by shipping (Baltic Sea Alien Species Database 2010).

Invasive Species name	Founded in	Origin country	Impact
Cercopagis pengoi (Crustacea)	1992	Ponto-Caspian	Competition
Marenzelleria viridis (Polychaeta, Spionidae)	2005	North America	Unknown
Mnemiopsis leidyi (Ctenophore, comb jelly)	2006	North America	Community dominance
Neogobius melanostomus (Fish, round goby)	1990	Ponto-Caspian	Competition; Habitat change

Gammarus tigrinus (Crustacea, Amphipoda)	1975	North America	Community dominance; Competition; Transfer of parasites and diseases
Rhithropanopeus harrisii (Crustacea, mud crab)	1936	North America	Community dominance; Competition
Eriocheir sinensis (Chinese mitten crab)	1926	China Seas	Competition; Habitat changes; Transfer of parasites and diseases

HELCOM is the Baltic Marine Environment Protection Commission (Helsinki Commission) which has been made to protect the marine environment in the Baltic Sea (HELCOM n.d.).

OSPAR is the Oslo Convention unified with Paris Convention (‘’OS’’ for Oslo and ‘’PAR’’ for Paris) and has been made to protect the marine environment of the North-East Atlantic. (OSPAR n.d.)

Since 2008, HELCOM have made and regularly update a list of species introduced to the Baltic Sea. Table 2 presents only a small part of the whole list. The information which HELCOM includes in the list is based on data taken from e.g. the Black Sea Commission, the OSPAR Commission and the Great Lakes Commission. (HELCOM 2014, p.9.)

2.7 Ballast water reception facilities

Notwithstanding the development of onboard ballast water treatment systems, any vessel is at the risk of being non-compliant with the convention requirements because of equipment, operations, logistics failure, water content conditions or unexpected occurrences. (GloBallast Monograph No. 25. 2017, p.63.)

Ballast water reception facilities should comply with the Ballast Water Management Convention and the guidelines for Ballast Water Reception Facilities (G5). The guidelines objectives are to offer guidance on providing ballast water reception facilities and make a unity between such reception facilities. The guidelines do not oblige the parties involved to establish and provide these reception facilities. (International Maritime Organization 2017, p.31.)

According to the GloBallast Monograph No.25 (2017, p.63), two workshops were held by the Global Industry Alliance in which all parties involved found development and innovation ideas for ballast water management in the ports:

- ‘’a ballast treatment boat;
- a barge-based treatment system;
- an onshore solution where the treatment system is placed into the container;
- a mobile treatment kit to be used onboard the vessel; and
- an onshore ballast water treatment facility’’.

Also, the port could establish and combine these ideas instead of choosing and implementing only one of them.

2.7.1 A ballast treatment boat

The first idea is to supply with treated or receive untreated ballast water in the port area. This boat could be pre-loaded with already treated ballast water, supplying it to the vessels that discharge cargo in the port. On the other hand, it could receive the untreated ballast water from the vessel that is loading cargo in the port. (GloBallast Monograph No. 25 2017, p.63.)

The second idea is to supply with treated or receive untreated ballast water in the port’s anchorage sites. The first step would be for the vessel to treat the ballast water while waiting for mooring in the port. The second step would be receiving authorization to enter the port area and going to the mooring site for cargo loading or discharge. (Pereira, Brinati, Antunes 2017, p.44.)

Some vessels may discharge part of the ballast water during navigation from the anchorage site to the mooring site, thus influencing the port’s environment (Pereira, Brinati, Antunes 2017, p.44).

2.7.2 A barge-based treatment system

This system would connect directly to the vessel's hull at the ballast water discharge pipe. The treatment system would be installed onboard and would treat the ballast water while the vessel discharges it to the barge. (GloBallast Monograph No. 25 2017, p.63.)

2.7.3 An onshore solution where the treatment system is placed into a container

This system would be mobile and could be delivered to the necessary location, for example, on board a barge, truck or pontoon, as well as, onshore, next to the vessel from the berth side. Thus, the vessel would be able to discharge the ballast water to the system for treatment. (GloBallast Monograph No. 25. 2017, p.63.)

2.7.4 A mobile treatment kit to be used onboard the vessel

The idea behind is to have a device with active substances and lowering it into the ballast water tank for a fixed time. The active substance would mix with the ballast water killing the invasive species, had such been carried along, and treat the ballast water to meet the requirements. (GloBallast Monograph No. 25 2017, p.63.)

2.7.5 Onshore ballast water treatment facility

The pipelines of treatment facility would be installed next to the loading arms and cranes, allowing vessels to discharge the ballast water while loading cargo. The pipelines would connect to the vessel's ballast water discharge pipe. (Satir, Dogan-Saglamtimur. 2014.)

Untreated ballast water would go to a ballast water treatment facility for treatment. Afterwards, if the contents of the water comply with requirements and do not exceed the permitted limits, the water could be discharged into the sea; if, however, it do not comply with the mentioned indicators, the water would be stored in onshore tanks until they are transported for further treatment. (Satir, Dogan-Saglamtimur 2014.)

According to the Satir and Dogan-Saglamtimur (2014), the facility would consist of the following:

- pipelines
- treatment equipment
- onshore tanks for ballast water storage
- valves
- pumps

The treatment equipment would have measuring devices which would indicate when the water has treated and can be discharged into the sea. During the treatment process would be adding the active substance to the ballast water.

Another way would be to combine the onshore treatment facility with treatment boats and/or barges. For example, the boat would receive untreated ballast water from the vessel at the port's anchorage site and then go to an onshore treatment facility to discharge the ballast water for treatment. The ballast water treatment process would be done onshore. (Water and wastes digest 2007.)

2.8 Sediment reception facilities

Sediment reception facilities should comply with the Ballast Water Management Convention and the Guidelines for Sediment Reception Facilities (G1). The objectives of this guideline are similar to the guidelines for ballast water sediment reception facilities – to offer guidance on providing sediment reception facilities and to make a unity between such reception facilities. (International Maritime Organization 2017, p.1.)

The first alternative could be to build a dry dock or repair yard which would also serve as a sediment reception facility. This would great amount of money the port cost. (GloBallast, Monograph No. 23 2017, p.9).

The second alternative would be to remove sediment from the ballast water tanks while the vessel is full of cargo and the ballast water tanks are empty. This process would not need the vessel to be placed in a dry dock but it would require making a temporary storage area to store the sediment removed from the ballast water tanks until it could be transported to a permanent disposal site outside the port area (GloBallast, Monograph No. 23 2017, p.10).

The third alternative would be a mobile treatment kit to be used onboard the vessel. It would consist of a device with active substances that, when mixed with ballast water, could partly remove sediment from the tank walls and the bottom to be discharged together with the ballast water. Also, these substances would kill invasive species living in the sediment and/or ballast water. (GloBallast Monograph No. 25 2017, p.63.)

According to the GloBallast Monograph No. 23 (2017, p.28), the design of the sediment reception facility should be based on and take into account the types of expected vessels which would use the facility. The details to be determined are as follows:

- the amount of available locations for the vessels wishing to use the facility and the approximate time to be spent in the facility;
- the maximum amount of sediment which the facility can receive from one vessel;
- the sediment removal methods available in the facility;
- the sediment removal request process and the approximate time for the beginning of removal; and
- the fees when using the facility.

A detailed plan for the sediment reception facility should be made, and the main procedures which should be included are the disposal, handling and treatment methods that would be applied. All personnel should be properly instructed and trained as well as be adequately equipped to ensure health protection and safety. (GloBallast Monograph No. 23 2017, p.29.)

2.9 Ballast water and sediment sampling and analyzing

Sampling and analyzing are needed for the environmental safety of the port. Information gained from the ballast water samples will show whether the onboard treatment system is in compliance with all applicable regulations and allow or prohibit the discharge of the ballast water in the port area. Sediment samples will provide information as to how it should be disposed of – as hazardous waste or non-hazardous waste. (Maglić 2017, p.4.)

2.9.1 Ballast water sampling and analyzing

The aim of the Guidelines for Ballast Water sampling (G2) is to provide guidance on ballast water sampling and analyzing to define if the vessel is in compliance with the Ballast Water Management Convention (International Maritime Organization 2017, p.5).

In order to receive information whether the vessel meets the requirement of standard D-1 or not, samples should be taken by using pumps, sampling bottles or other water containers from sounding or air pipes and manholes. The ballast water discharge line is another option to take a ballast water sample. For standard D-2, ballast water discharge line is the only option for sampling. (International Maritime Organization 2017, pp.6-7.)

Table 3 shows the minimum amount of information which should be included in the sampling documentation, and other necessary information should be added (International Maritime Organization 2017, pp.11-12).

Table 3. Sample data form. (International Maritime Organization 2017, pp.11-12.)

Sampling date	
Ship particulars	Name of ship: Distinctive number or letters Port of registry: Gross tonnage: IMO number: Date of construction: Ballast water capacity:
Identification of sampled tank*	
Type and position of sampled tank*	
The capacity of sampled tank*	(m^3)
Type of ballast water management undertaken	(a type of exchange or treatment)
Make of ballast water management system	

Date of ballast water management undertaken	
Sample identification code	(including a number of replicate)
Sample type	(larger, smaller plankton, microbes)
Sampling techniques used	net (including depth of vertical net haul, net opening size, mesh size) pumps (including sampling depth, pumping capacity in l/min.) bottle (incl. sampling depth, bottle capacity in l.) specify other sampling technique if used
Sampling time/start	
Sampling end time	
Origin of water sampled*	(lan/lon/port)
Type of sampling access point	
Water volume sampled	(by volume)
In case the sample is concentrated on board specify a filter or net sizes (if applicable)	(µm)
Presentative (if used)	
Transport to laboratory	cooling container, dark storage, etc.
Sample results	

*if appropriate.

Sampling can be done by the crew of the vessel or by an independent surveyor. Analyses should be done in special laboratories for ballast water sampling. The basic parameters for sampling include:' temperature, salinity as well as amount of organic matter, chlorophyll, discharge and sediment, zoo and phytoplankton. In accordance with international environmental standards, healthy plankton and marine life levels can be inspected. (SGS n.d. – a.)

2.9.2 Sediment sampling and analyzing

A sampling of sediment is needed to define the content of heavy metals and toxic elements. The analysis will provide information about how and where sediment should be disposed of. (Maglić 2017, p.4.) If the sediment is defined as non-hazardous waste, it will be disposed in a landfill (GloBallast Monograph No. 23. 2017, p.22).

Before and during the disposal process, sediment sampling should be done if it is required by authorized personnel of the port. The vessel's crew should provide safe access for personnel of the port to collect the sediment samples. (GloBallast Monograph No. 23. 2017, p.17.)

Unfortunately, there is no analysis of the sediment to determine the content of invasive species in it. The focus is primarily on sediment toxicity, as per landfills requirements. (GloBallast Monograph No. 23. 2017, p.24.)

2.10 Ballast Water Exemptions Decision Support Tool

OSPAR and HELCOM together have made and released an online risk assessment tool for evaluating the effect of invasive species transferred with the ballast water (OSPAR 2014).

The countries within HELCOM are Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden, Russia, and within OSPAR are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Also, the European Union is a member of both HELCOM and OSPAR. (HELCOM, OSPAR 2014.)

The tool provides a joint harmonized procedure to assign exemption from ballast water treatment regulations of the Ballast Water Management Convention. It is a database with information about the consideration of invasive species and the physical characteristics in ports, a list of target invasive species, a list of all species found in port surveys and an agreed risk assessment model. (OSPAR 2014.)

The database provides a means for the potential risk on available routes. For example, if Port of Kotka (KOT) been chosen as the port of departure and Port of Hamina (HAM) been chosen as the port of destination, the tool provides risk assessment calculation details for a voyage from KOT to HAM (Figure 4). (HELCOM, OSPAR 2014.)

Check the potential risk on available routes.

You can do this by selecting in the drop down menus (below) a starting and ending port for a route among those ports where we have comparable data.

From Kotka (KOT) to Hamina (HAM) Show more details: ☑ yes Show Diagram: ☑ yes

Go

Risk assessment calculation details for trip from KOT to HAM

1) Presence of target species for region HELCOM in both harbours.

1 **HAM** Cercopagis pengoi
2 **HAM** Dreissena polymorpha
3 **HAM** Gammarus tigrinus
4 **HAM** Marenzelleria neglecta
5 **KOT** Cercopagis pengoi
6 **KOT** Gammarus tigrinus
7 **KOT** Marenzelleria neglecta
8 **KOT** Palaemon elegans

2) 1 target species for region HELCOM in start harbour (KOT) not present in finish harbour (HAM).

Palaemon elegans

3) Salinity ranges in both harbours (PSU):

HAM: 3.7 -- 6.1
KOT: .2 -- 4.2

4) 1 species tolerate wide ranges of salinity (PSU):

Palaemon elegans: .5 - 5

Figure 4. Risk assessment calculation details for a trip from KOT to HAM. (HELCOM, OSPAR 2014.)

Also, the tool shows a risk assessment decision path diagram (Figure 5) (HELCOM, OSPAR 2014).

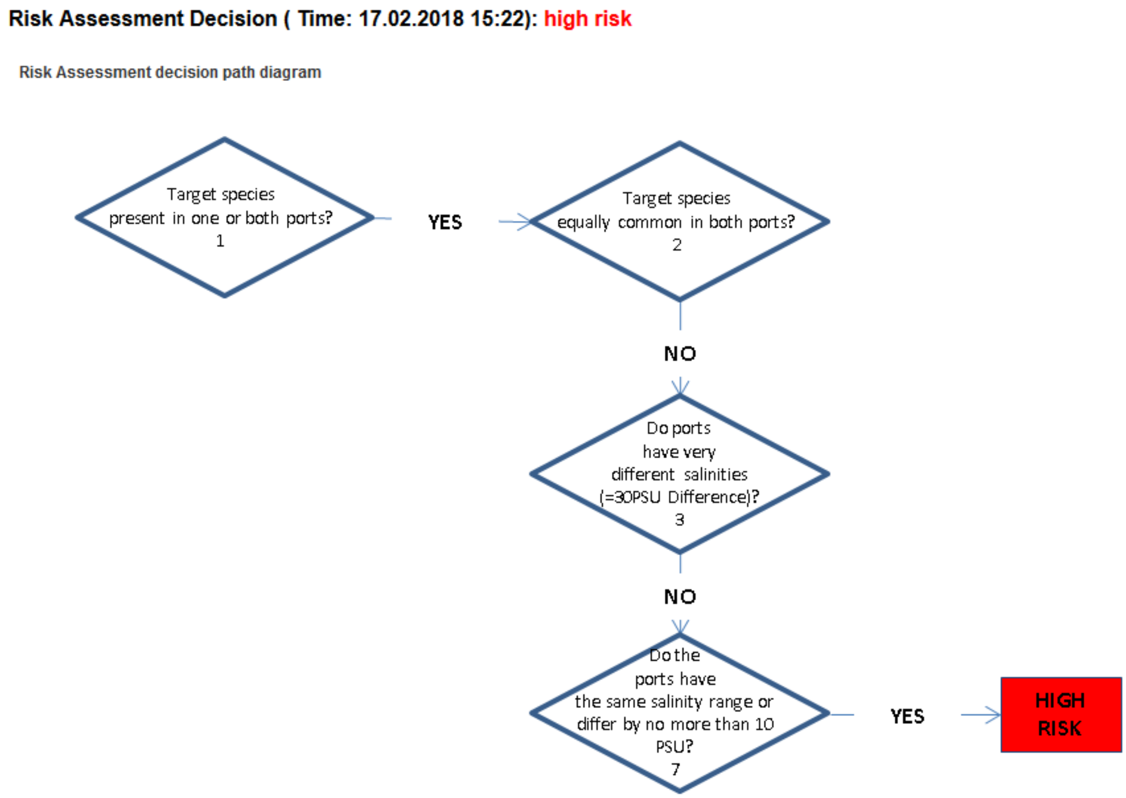

Figure 5. Risk Assessment decision path diagram. (HELCOM, OSPAR 2014.)

Because of the type of target species ‘’Palaemon elegans’’ found in the Port of Kotka, but not present in the waters of the Port of Hamina, the risk assessment diagram shows a high risk. This means that it is impossible to have an exemption for the route Kotka–Hamina because exemptions are only possible on low-risk routes. (HELCOM, OSPAR 2014.)

3 ESTABLISHMENT OF BALLAST WATER AND SEDIMENT RECEPTION FACILITIES IN PORT OF HAMINAKOTKA

Many methods have been introduced to solve the issue of unwanted invasive species. In order to implement some of these methods, a port would require substantial funds.

The treatment boat and/or barge method would prevent the discharge of untreated ballast water in the port area. Both systems could be combined by using them at the port's anchorage site, ensuring less impact on the port environment. From an economical point of view, however, a question would arise – how many boats and/or barges would a port need for this operation? Also, ballast water exchange takes a long time and it would pose unwanted costs for the ship owners and increase the time vessel remains at the anchorage site.

A containerized treatment system to onboard the barge or onshore along the vessel would ease the job for barge or pontoon owners. They would not have to change their barges to fit and comply with the treatment system. With the help of a port crane or floating crane, it would be possible to install the treatment system on a barge. When used onshore, this method would require space for putting the container alongside the vessel. For example, the tanker is waiting for the beginning of cargo operations. A truck, which would take the treatment container to the berth, is not small. With all pipelines on the berth, it would be quite complicated for the truck to maneuver. Also, the truck should be EX-proof, which means it must not make any sparks or cause a fire in the hazardous area of vessel cargo operations. EX-safety classification electrical equipment is very expensive.

A mobile treatment kit to be used onboard the vessel could be implemented not only in port areas but also during the vessel's voyage. The active substance would affect all invasive species in the ballast water and the sediment. This method would be more preferable to the ship owners, not so much for the ports.

Building a dry dock or ship repair yard, in the author's opinion, is the most expensive method. On one hand, this would give the port of HaminaKotka a chance to become more competitive to other Finnish ports, but on other hand, Finland already has a very well-known repair yard called Turku Repair Yard, which has a better location and easier access from other Baltic Sea countries.

Building a sediment reception facility would be unnecessary because vessels are built with a less or no intake of the sediment while loading ballast water into the ballast water tanks. During a long operating period, sediment layers could build up inside the tanks, but as the vessel is scheduled to go into the dry dock once every 5 years, the sediment is cleaned out of ballast water tanks.

Therefore, one reception and treatment facility for ballast water and sediment would be the best option. When ballast water is discharged to the reception facility, sediment is discharged as well.

The one solution for a ballast water and sediment reception facility might be an onshore ballast water and sediment treatment facility. It could have some similarities with the Kymen Vesi Oy wastewater treatment plants. In the first stage, the water would be sent through the treatment facility and after the treatment it would be delivered by pipeline back to the sea.

3.1 Port of HaminaKotka and its potential

The waste management instructions of the Port of HaminaKotka include a notice that the port is not equipped with special reception facilities for ballast water. That could mean that they lack sediment reception facilities as well. The vessel must order this service through the available agent or a waste management company which provides this service. (Port of HaminaKotka Ltd 2017.)

With the Ballast Water Management Convention's entering into force, the port should think about the possibilities to provide ballast water and sediment reception facilities to stop the invasion of unwanted species in the Baltic Sea and especially in the Gulf of Finland.

In the port of Mussalo, the vessel’s wastewater is collected by sewage pipes or suction sewage trucks and transported to the Mussalo city wastewater treatment plant which is operated by Kymen Vesi Oy. The port of Mussalo does not have a wastewater treatment plant. This collection method via pipelines could be used for ballast water and sediment collection from the vessel. Treated water goes directly to the sea by a 750-meter-long discharge pipe. Kymen Vesi Oy buys after-treatment services for dried sludge from Gasum Oy which make gas from dried sludge in their own treatment plant in Turku (Appendix 1). (Räsänen 2018.)

Tankers are mainly the vessels whose maneuverability and stability depends on the ballast water, especially when they are without cargo. Port development by establishing ballast water and sediment reception facilities could open a new way to increase the revenue. For example, in the liquid bulk terminal, a few tankers are fixed-route tankers and they would find that using onshore ballast water and sediment reception facilities is more cost-effective than installing an onboard ballast water management system. (Lloyd’s Register 2016, p.26.)

3.2 Ballast water and sediment treatment technology

The background of the treatment technologies is the urban or industrial water treatment plants. The difference between urban or industrial water treatment and ballast water and sediment treatment is that ballast water and sediment treatment is restricted by International Maritime Organization regulations of discharged ballast water standards. (Lloyd’s Register 2007, p.7.)

In ballast water and sediment treatment, there are two main methods to be used: solid-liquid separation and disinfection (Figure 6) (Lloyd’s Register 2007, p.7).

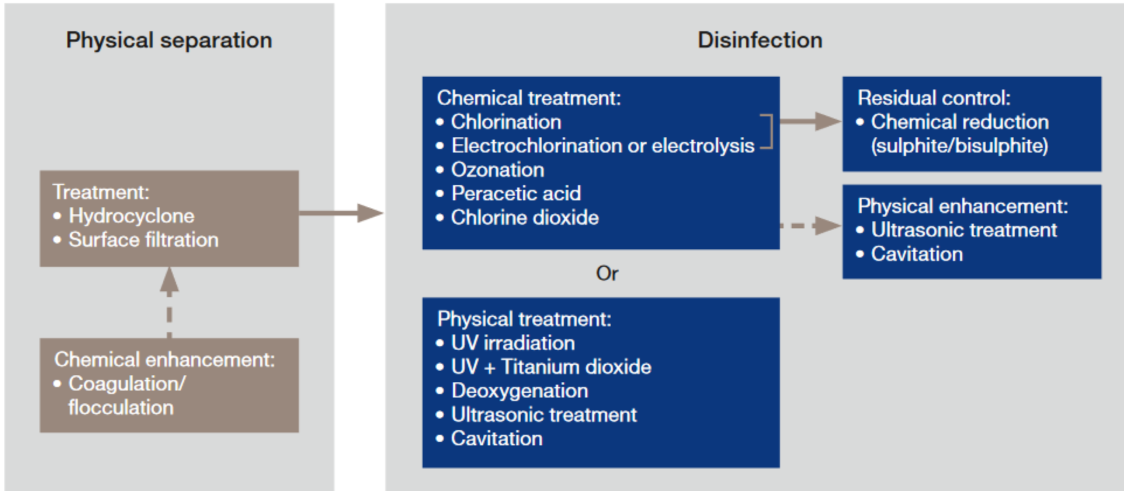

Figure 6. Ballast water treatment methods (Alfa Laval 2017, p.17).

Coagulation/flocculation is a pre-treatment process which makes the next stage (filtration) more effective by adding chemicals to make layers which will settle down faster. (Lloyd's Register 2007, p.8.)

Solid-liquid separation is a method where solid material is separated from the ballast water. It includes sedimentation, where solid material can settle to the bottom under its own weight, and surface filtration, where filter pores are smaller than the solid material particles or organisms. The disinfection method is based on the removal and/or inactivation of microorganisms. (Lloyd's Register 2007, p.7.)

3.2.1 Coagulation/flocculation

For the coagulation/flocculation treatment of ballast water and sediment, the port could use Poly-aluminum Chloride (PAC) aided by Anionic Polyacrylamide as a flocculant for effective removal of chemical oxygen demand (COD), total suspended solid (TSS) and heavy metals such as iron (Fe), zinc (Zn) and nickel (Ni). (Halim, Bakar 2013, p. 524.)

''PAC is claimed as more advantageous coagulant over continental coagulants, because of high removal of particulate and/or organic matters, lower alkalinity consumption and lesser sludge production''. (Halim, Bakar 2013, p. 524.)

In the conclusion of the Halim and Bakar's research (2013, p. 529) where Poly-aluminum Chloride (PAC) was compared with Ferric Chloride ($FeCl_3$) and Aluminum Sulfate (alum), PAC showed the effectiveness on COD, TSS and heavy metal removal. ''At defined optimum experimental conditions (coagulant dose: 70 mg/L, coagulant aid dose: 2 mg/L and pH 7), PAC showed 70% removal for COD and 98% of TSS. Heavy metals removal using PAC also showed better results in which 98% of iron was removed, 83% of zinc removed and 63% of nickel removed under optimum conditions''.

3.2.2 Filtration

Filtration has proved to be a reliable method for removing organisms larger than 50 micrometers. Sediment removal is an added value to different types of filters. Back-flushing is used to filter the sediment and larger organisms from water to prevent filter blockage and to keep the system's intact. (Latarche 2017.)

The filter pores of surface filtration are smaller than solid material particles or organisms and will not allow large particles and organisms to follow the flow of the ballast water in the treatment facility. (Latarche 2017.)

In a gravity flow, sand and gravel sand can be used as filters due to their inexpensiveness, but in surface filtration it is advisable to use quartz sand or a carbon layer as a filter which is put on the surface and is also relatively inexpensive. The process is carried out with the use of external pressure or vacuum and is 40-50 times faster than the gravity flow filtration. Coal filters are easy to clean, replace and maintain even years of operation. (Kļaviņš, Cimdiņš 2004, p.156.)

3.2.3 Ultra Violet (UV) irradiation

The Ultra Violet method is usually used in shore-based water treatment systems and is taken into account as an effective way to destroy microorganisms and prevent them from reproducing on fixed wavelengths, particularly on 245 nanometres. Ozone can also be used as a useful biocide at other UV wavelengths. (Latarche 2017.)

Filtration is the first stage of the UV system process. Without it, sediment and large organisms would greatly affect the effectiveness of the irradiation process. Onshore based system lamps need to be maintained annually no matter the operating condition because their ability to radiate required UV wavelengths will deteriorate fading. (Latarche 2017.)

Also, is the most commonly used method in urban and wastewater treatment facilities (Lloyd's Register 2007, p.9).

Ultra violet light can be used to destroy small organisms and particles which are able to escape from the filtration stage and are smaller than the filter pores. Unlike chemical disinfection, UV light does not create harmful by-products. From the environmental standpoint, a UV system has little or no negative impact on the environment. (Alfa Laval 2017, p.24.)

3.2.4 Oxidation

Oxidation includes chlorination, electrochloronation, ozonation and peracetic acid substances and consists of electron transfer together with organisms that destroy the cell wall structure (Latarche 2017).

According to Latarche (2017), ‘’chlorination can also be achieved through electrochlorination and there are many systems available that use this method. Electrochlorination is achieved by passing a DC electric current through the ballast water with chlorine being produced by the electrolytic reaction.’’ The method is effective in ballast water with high salt content and may not be effective in fresh water. In latter case, salt water should be added to the ballast water flow.

In water treatment processes, ozone is usually used which is another oxidizing biocide that is effective in destroying microorganisms (Latarche 2017).

Peracetic acid forms hydrogen peroxide in reaction with water. These chemicals are freely available but expensive. This method would not be suitable for the port because of the great amount of ballast water treated and the need for large storage spaces in the port area. (Latarche 2017.)

3.2.5 Cavitation / Ultrasound

These methods are used as support for the further treatment to make it more effective. With gas or liquid entering the ballast water flow area, cavitation may occur. Organisms are damaged or destroyed by forces caused by cavitation. Ultrasound is another way how to eliminate organisms and can be introduced directly into the pipeline. (Latarche 2017.)

Because of other more common disinfection methods, cavitation and ultrasound are not well understood. Some systems use cavitation and ultrasound together with chemical disinfection to provide the necessary biocidal efficacy. (Lloyd's Register 2007, p.10.)

3.2.6 Deoxygenation

Removing oxygen or adding inert gases to the ballast water in order to lower the oxygen levels resulting in the elimination of living organisms, deoxygenation can be used alone or together with other disinfection treatment methods. This method has a sub-benefit in that it restricts corrosion extending the operating life of the pipeline and the treatment facility. (Latarche 2017.)

Deoxygenation requires a specific number of days to be efficient due to the time needed to destroy the organisms via oxygen deprivation. This method would not be applicable to the onshore systems because ports are in need of fast water treatment methods and technologies. (Lloyd's Register 2007, p.10.)

3.2.7 Summary of treatment technologies

Table 4. Summary of treatment technologies (Kļaviņš, Cimdiņš 2004, pp.154-167).

Treatment method	Treatment time	Advantages	Disadvantages
Physical separation			
Filtration	Instant effectiveness	Reliable method for removal of organisms larger than 50 micrometers and above. Inexpensive, easy installation and maintenance.	Small particles and organisms are not separated. At low pressure drops, it is necessary to use backwashing.
Coagulation/ flocculation	Up to 12 hours	Effectively removes particles with an interval of 100nm -1nm, bacteria, viruses and organic macro-molecular substances, improves filtration efficiency.	The technological time of the process must be precisely observed.
Disinfection			
Chlorination (with Cl_2; NaClO, ClO_2)	10 – 24 hours	Destroys the cellular membrane wall of the microorganisms (bacteria, viruses, protozoan and their cysts). Comfortable transportation substances, simply dosed.	Chlororganic compounds, some of which are mutagens and carcinogens, such as chloroform (CHCl3), have been formed. Effectiveness is influenced by the performance technology: concentration, water pH, temperature.
Ozonation	5 – 12 hours	Destroys microorganisms.	Ozone rapidly decomposes in water, does not destroy entirely larger organisms. Bromine, which destroys the proliferation of microorganisms, is produced as adjacent product only at a certain concentration
Hydrogen peroxide	2 hours	Effectively destroys microorganisms. Relatively stable substance with unlimited water solubility.	Dangerous substance and requires special storage.
UV irradiation	Instant effectiveness	Very effectively destroys microorganisms. Ease of use and maintenance, automatic cleaning.	Disturbed UV irradiation reduces the effectiveness of the method.
Reduction of oxygen concentration or O_2	24 – 120 hours	Makes oxygen level very low that living organisms are destroyed Slows down corrosion processes (in tanks, equipment).	An inert gas generator is required. Time-consuming method.
Cavitation	-	An effective pre-treatment method for the partial destruction of living organisms.	Applicable in combination with other methods.

Table 4 above shows a summary of available ballast water and sediment treatment technologies. Advantages and disadvantages should be taken into account when choosing a desired treatment system. None of the methods alone can provide compliance under the Convention, hence they need to be combined and used in a specific order. Each combination should consist of two or three main stages – separation followed by chemical or physical treatment methods.

3.2.8 Financial consideration

CAPEX and OPEX should be taken into account. CAPEX is capital expenditure and OPEX is operational expenditure. Rastogi (2017) has stated points which should be included under CAPEX and OPEX:

- Cost of unit;
- Cost of installation;
- Operating costs – chemical and power requirements;
- Maintenance requirements; and
- Cost of personnel training.

OPEX can be divided in two main sub-categories: the running costs and the maintenance costs (Argo Navis Ltd n.d.).

The running costs are dependent on each system type and could comprise power consumption, while treating water, chemical costs which depend on the price of the chemicals, and cost of neutralization agent if the system uses active substances in the treatment process (Argo Navis Ltd n.d.).

The maintenance costs may be dependent on UV lamp replacement, filter consumables, preventive maintenance of equipment and electrical equipment and sensor replacement (Argo Navis Ltd n.d.)

3.3 Advantages of Onshore treatment versus Onboard treatment

Many researchers have found considerable advantages for onshore water treatment facilities in comparison with onboard treatment systems (Cohen 2010, p.14).

Onshore treatment needs fewer treatment plants and less total capacity. An onshore treatment plant can maintain a large number of vessel's. The required treatment capacity usually will be less than the sum of the vessel's maximum ballast water discharge rates because the vessels will not arrive at the port on the same time. (Cohen 2010, p.15.)

Onshore treatment is not affected by the limitations which onboard treatment has. Major limitations of onboard treatment are limited space, power and time as well as an unsteady platform. These limitations do not affect the onshore treatment process due to more space on land, and therefore treatment plants can be built in larger scales. (Cohen 2010, p.17.)

A larger number of methods for treatment are available onshore. There are methods that can be used onshore but cannot be used onboard the vessel because of space, stability and safety restrictions. These methods include basic and not expensive water and wastewater treatment processes, such as ''settling tanks, flotation processes and granular filtration and the use of chlorine gas for disinfection''. (Cohen 2010, p.17.)

Onshore treatment plants can be maintained by trained wastewater treatment plant personnel. All personnel operating in the wastewater treatment plants must be professionals and have knowledge of the treatment plant, the methods used, and understand the system as a whole and know how to maintain it. Unfortunately, onboard the vessel the maintenance of every operation connected with the ballast water and treatment system would fall on the vessel's crew, in addition to their duties. (Cohen 2010, p.18.)

Onshore treatment is more secure. As mentioned before, the monitoring and maintenance of the wastewater treatment plant done by professionals would result in the more secure, safer and better performance of the system. Also, better access and more space for the maintenance operations is an advantage for the onshore treatment system, while onboard treatment has to deal with the limited space. (Cohen 2010, p.18.)

Onshore treatment is more effective. Many of the advantages mentioned above make onshore treatment more effective in destroying and removing microorganisms contained in the ballast water. Cost factors make it possible to combine more treatment methods in one facility, ensuring the control of the whole treatment process and compliance with zero discharge standards. (Cohen 2010, p. 19.)

Onshore treatment is safer. Onboard treatment has to deal with limited space and difficult and hazardous operating conditions at sea. The storage of chemicals and biocides can cause more harm to the crew of the vessel than the personnel working onshore. Also, onboard the vessel there is a greater risk of an accidental discharge into the environment. (Cohen 2010, p.19.)

Onshore treatment equipment is easier to change. If some changes or maintenance is needed to the systems equipment, it is easier to do it onshore due to more space and easier maneuverability. Financially, it is more inexpensive to upgrade or replace equipment onshore than onboard. (Cohen 2010, p.20.)

3.4 Ballast water and sediment reception and treatment facilities in the liquid bulk terminal

In the Port of HaminaKotka, the suitable area for ballast water and sediment reception and treatment facilities would be on the jetties N1 and N2 (Figure 7).

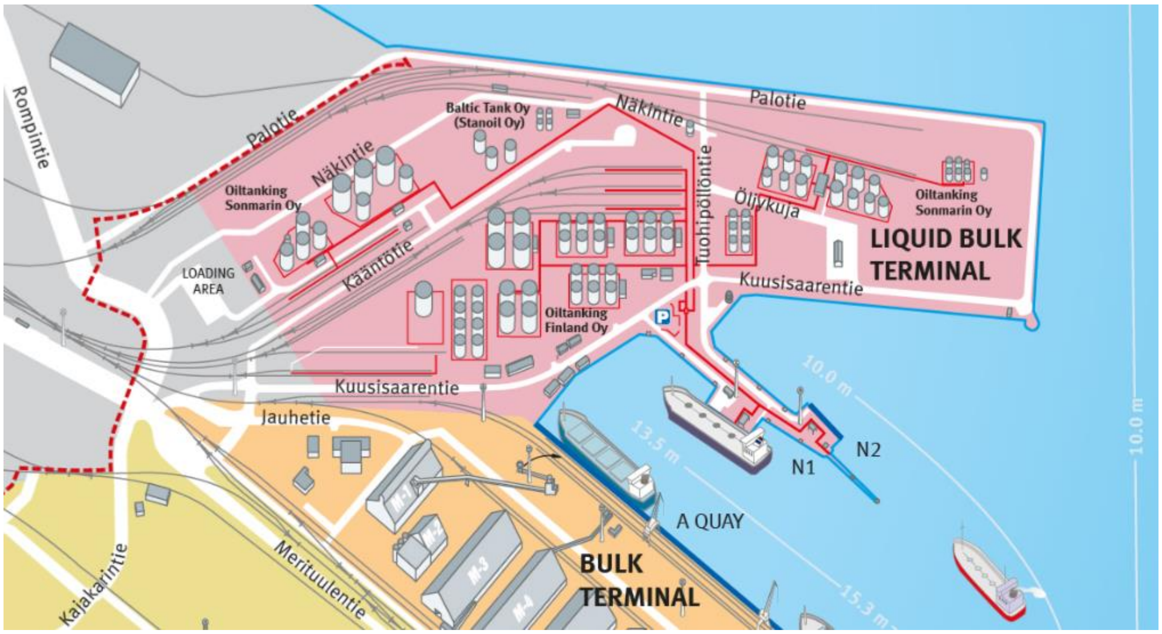

Figure 7. Map of the Liquid Bulk terminal (Port of HaminaKotka Ltd 2018).

These facilities would be accessible to terminals operating in the liquid bulk terminal such as Oiltanking Sonmarin Oy, Baltic Tank Oy (Stanoil Oy), Oiltanking Finland Oy and Oiltanking Sonmarin Oy.

3.4.1 Reception and treatment facility operability

The ballast water and sediment would be pumped from jetties to the reception facility for treatment (Figure 8).

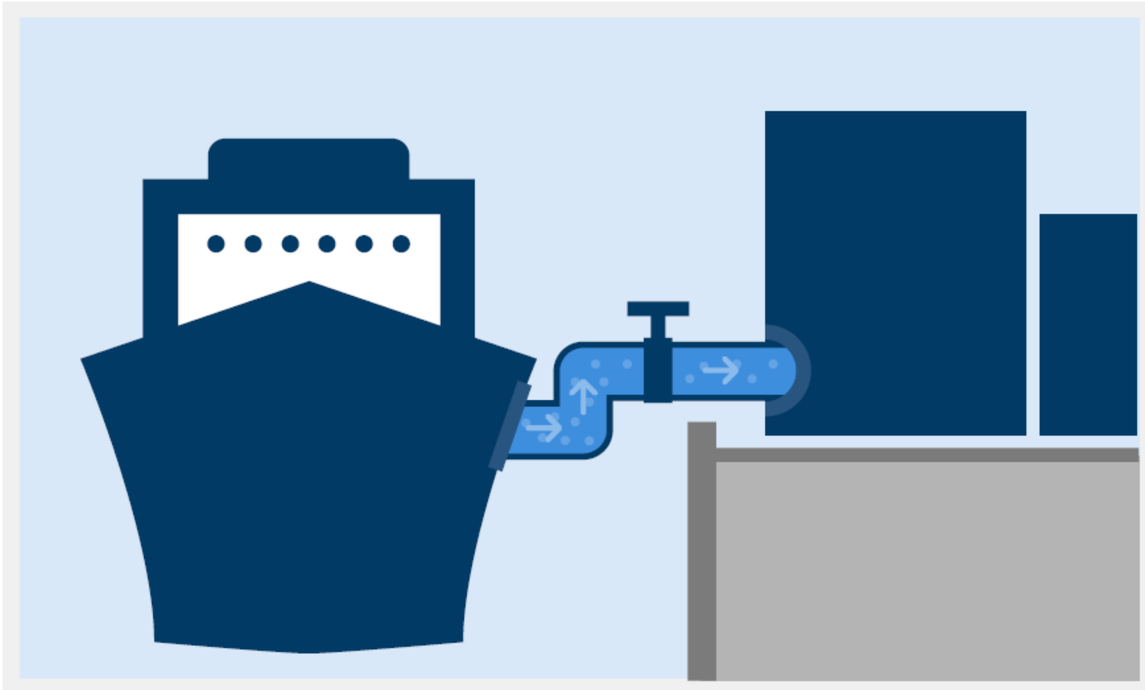

Figure 8. The vessel’s connection with reception facility (Lloyd’s Register 2016, p.27).

The last stage of the whole treatment process would be discharging the treated water back into the sea. If the treated water exceeds the specified amounts, it would have to be transferred back to the first pre-treatment stage and go through all stages again until it would no longer exceed the limitations set by the BWM Conventions D-2 standard. The facility could be equipped with corresponding measuring devices which would measure the water compliance and the numbers of allowed organisms to be discharged back to the sea.

Sampling and analyzing could be made by SGS which provides ballast water sampling services. They have an office in Finland SGS Finland Oy and laboratory in Port of HaminaKotka, Mussalo harbor. (SGS n.d. – b.)

Sludge from all treatment stages could be collected and dried in one place. In the drying process, polymer is fed to centrifuges in order to improve the drying performance. The dried sludge could be dropped into the silos from centrifugal dryers where it would wait to be transported for further processing. The port of HaminaKotka could make an agreement with Gasum Oy, as Kymen Vesi Oy has done, for of after-treatment service for dried sludge. For example, Gasum Oy makes gas from dried sludge in their own treatment plant in Turku (Appendix 1). (Räsänen 2018.)

3.4.2 Available information about reception facility

The guidelines for ballast water reception facilities (G5) in the Ballast Water Management Convention (International Maritime Organization 2017, p.33) contain information on the reception facilities which should be made available to the vessels. These details should include but not be limited to:

- maximum volumetric capacity of the ballast water;
- maximum volume of the ballast water that can be handled at any one time;
- maximum transfer rates of ballast water (cubic metres per hour);
- hours of operation – facility should be available 24/7 to operate at the same time as cargo loading/unloading operations;
- ports, berths, areas where access to the facility is available – Port of HaminaKotka, Mussalo harbor, Liquid Bulk terminal, jetties N1 and N2;
- ship-to-shore pipeline connection details (pipeline size and reducers available) – the facility should provide the standard ship-shore flange and connection methods stated by the Oil Companies International Marine Forum (OCIMF);
- if the ship or shore crew are required for additional duties such as connecting or disconnecting the hoses – the shore crew is in charge of connecting and disconnecting the hoses;
- contact details for the facility – Traffic Unit of the Port of HaminaKotka Ltd;
- how to request use of the facility including any notice period and what information is required from the ship – facility use can be requested through the vessel’s agent or straight from the Traffic Unit, a notice to the port authorities should be given 24 hours before the arrival at the anchorage site, with information about the volumetric capacity of the ballast water tank and the maximum transfer rates of ballast water (cubic metres per hour);
- all applicable fees; and
- other relevant information.

3.4.3 Ballast Water Management Plan

The Ballast Water Management Plan can be made by following the guidelines for ballast water management and development of ballast water management plans (G4) – Appendix Standard format for the ballast water management plan (International Maritime Organization 2017, pp. 27-30). The Convention states requirements for Ballast Water Management Plan onboard the vessel, but some of the main points can be applied to the Ballast Water Management Plan onshore reception facility:

- preamble;
- introduction;

These points are the same as the text in guidelines G4, amended for onshore reception facility, which can be found in Appendix 2.

- facility particulars – facility name, ports, berths, areas where access to the facility is available, total ballast water capacity that facility can intake, a brief description of the main ballast water management methods used in the reception facility and identification (rank) of the appointed ballast water management personnel;
- purpose – information about ballast water management and proper record keeping;
- plans/drawings of the ballast water reception and treatment facility;
- description of the ballast water reception and treatment system;
- ballast water sampling points – lists and/or diagrams showing sampling points for safe and easy access in pipelines and in the reception and treatment facility;
- operation of the ballast water management system – description of the ballast water management system used onshore;
- safety procedures for the vessel and the vessel's / onshore crew;
- description of the methods used in the reception and treatment facility for ballast water management and sediment control;
- methods of communication – how the vessels crew and onshore crew is communicating in the process of ballast water and sediment reception;
- duties of the ballast water management personnel;

- recording requirements of the Convention;
- crew training and familiarization; and
- authorizing authority – details and stamp of approving authority.

3.4.4 Permits under water legislation

All actions influencing constructions in water or water supply are in need of a water permit under Finland's water legislation. Also, application fee must be paid. (Regional state administrative agencies 2017.)

Dredging, disposal of sediments and port construction are not included in the port operation permit. These activities require a different permit based on the water legislation. (Brunila 2017, p.10.)

An appropriate application should be sent to the Regional State Administrative Agency. Afterwards, this application is made public in order to make proposals related to the permit requirements and to be commented by the relevant authorities. Full permit procedure can be found in Appendix 3. If there are any complaints against the permit decisions, it can be submitted to the Administrative Court of Vaasa, then to the Supreme Administrative Court. (Regional state administrative agencies 2017.)

3.4.5 Approval of facility by International Maritime Organization

The guidelines for approval of ballast water management systems (G8) are set for onboard systems but they could be set for onshore systems as well. Guidelines are made for the Administration or other related body in order to verify whether the ballast water management system complies with the D-2 standard of the Convention. (International Maritime Organization 2017, p.54.)

If the system is found to be in full compliance with the requirements and procedures, the facility should have a Type Approval Certificate of ballast water management system issued by the Administration (Appendix 4) (International Maritime Organization 2017, p.56).

4. CONCLUSION

1. As the vessels sail all around the world and use ballast water to control draught, stability and maneuverability, they transfer invasive species into new regions. Invasive species brought into new environments can change its, become dominant over native inhabitants and spread diseases which can harm human health.
2. The Ballast Water Management Convention entered into force 8 September 2017. This means that, when the IOPP renewal survey is completed after the Convention EIF, all existing vessels need to begin the installation of Ballast Water Treatment Systems (BWTS) onboard, whereas the BWTS of new vessels with keel laid on or after the Convention's entering into force, should already comply with D-2 standard of the Convention.
3. Various methods for ballast water and sediment reception and treatment methods for onshore have been introduced, i.e. a ballast water treatment boat / barge, an active substance treatment kit to be used in the ballast water tanks, building a dry dock and mobile treatment system inside the container.
4. The authors suggest is to build a facility next to the loading arms on the jetty. While undergoing cargo operations, the vessel could perform ballast water and sediment discharge to the reception facility at the same time.
5. Ballast water and sediment treatment technologies are coagulation/flocculation, filtration, UV irradiation, chlorination, deoxidation, cavitation. These methods should be combined to have the maximum compliance with BWM regulations.
6. An onshore treatment facility has more advantages over an onboard treatment system. It has more space, whereas on board there is limited space for the treatment system. This would also mean easier maintenance and replacement or system upgrades. The personnel are professional employees who have knowledge about the treatment facility and the onboard crew does not have to deal with the treatment process along their normal duties.
7. A ballast water and sediment reception and treatment facility should comply with the International Maritime Organization requirements and guidelines and should have a Type Approval Certificate for the ballast water management system

issued by the Administration and a permit under Finland’s water legislation issued by the Regional state administrative agencies.

8. The research/development objective of this thesis was to compare and choose suitable treatment methods for establishing ballast water and sediment reception facilities in a liquid bulk terminal. In order to accomplish this objective, three main points had to be determined: the part of the Mussalo harbor where a reception facility could be established, the methods that should be used for ballast water and sediment treatment and ways to dispose of the after-treatment dirt. The objective that was set for the study was achieved since the study has shown the most suitable place for the treatment facility, the main methods in ballast water and sediment reception and treatment and provided suggestions as to how a port can dispose of the after-treatment dirt.
9. The thesis also discussed and aimed to answer the questions stated in the theoretical framework. The Ballast Water Management Convention and its requirements explained, the ballast water exchange methods been highlighted, the main invasive species introduced in the Baltic Sea discussed, and the methods for onshore ballast water and sediment reception and treatment been elaborated.
10. Sources are reliable because the information used in this thesis was published by Organizations – IMO, HELCOM, OSPAR. A possible reason for unreliability could be that a particular publication or research paper was made at a time when the Convention was not in force. No changes were made later in research paper or publication. This was the difficulty in this thesis writing process in general.
11. The qualitative research method was used in this thesis. In the theoretical part, means for ballast water and sediment reception were described. In the empirical part, the most suitable means for Port of HaminaKotka were analyzed and chosen. Also, ballast water and sediment treatment technologies described. The author’s discussion of suitable treatment technologies for Port of HaminaKotka is included in proposals.

5. PROPOSALS

In the author’s opinion, if the Port of HaminaKotka wants to establish their ballast water and sediment reception and treatment facilities, they should begin in the liquid bulk terminal since tankers are mainly the vessels which use ballast water for maintaining stability, especially when sailing without cargo.

As treatment methods alone do not provide the needed compliance with the Convention, they should be combined together to ensure faster and more effective treatment. The author proposes to choose treatment facilities which provide three stages of treatment:

- 1^{st} stage – coagulation/flocculation for faster settlement of large organisms and particles;
- 2^{nd} stage – filtration to remove organisms and particles larger than 50 micrometres;
- 3^{rd} stage – Ultra Violet irradiation to remove and destroy living microorganisms.

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LIST OF FIGURES AND TABLES

APPENDICES

Appendix 1 Interview with Kymen Vesi Oy pumpman engineer Panu Räsänen via email 27.02.2018.

1. In the port area, how is water collected from all berths at the Mussalo harbour?

In port of Mussalo the vessels wastewater is collected by sewage pipes or suction sewage trucks and transported to Mussalo city wastewater treatment plant. Port of Mussalo doesn´t have own wastewater treatment plant.

2. Do city treatment plants use the same methods for water treatment as the port treatment plants? (If no, could you explain more?)

Mussalo city wastewater treatment plant is an active sludge plant.

3. What are the next steps after the water has been treated and where does it go?

Treated water goes straight to the sea by 750-meter-long discharge pipe.

4. Where is the dirt disposed of after water treatment and how it is disposed?

We buy after treatment service for dried sludge from company named Gasum. They make gas from dried sludge in their own treatment plant in Turku.

The following includes the author’s homework assignment from Merja Mäkelä’s “Renewable Energy Supply” course. It contains the principle of Mussalo wastewater treatment plant.

Kymen Vesi Oy handles approximately the wastewater amount generated by about 90 000 residents at Mussalo wastewater plant in Kotka. The annual amount of wastewater processed is about 11130000 m³. The plant processes waste water from areas of Kotka, Hamina Kouvola (Anjalankoski) and Pyhtää. The customers are households, water supply co-operatives as well as industrial plants operating in accordance with the industrial wastewater agreements.

The Mussalo wastewater plant incorporates three treatment stages: mechanical, chemical and biological.

The mechanical stage contains the separation of the roughest solids (screened waste and sand) from the wastewater via screening and pre-aeration.

In the chemical stage the phosphorus contained in the wastewater is precipitated by ferrous sulphate.

The plant is a typical activated sludge treatment facility, so the biological stage of the cleaning process is aeration, where the organic materials dissolved in the wastewater are converted into biomass by using microbes.

Favorable conditions for the microbes have been created by the "Fine bubble aeration discs", which is placed at the bottom of the aeration tank. Air is pumped into the aerators by four turbo compressors.

In the process of drying, polymer is fed to the centrifuges in order to improve the drying performance. The dried sludge has an average solid content of 25 %, and about 15000 Tkg is produced in one year. The dried sludge is dropped into the silos from the centrifugal dryers, where it waits to be transported for further processing, which is performed in accordance to the service agreement with Gasum Oy. The costs of Kymen vesi Oy for further treatment of dried sludge amount to approximately € 820 000 on an annual basis.

Appendix 2 Preamble and Introduction from Guideline G4 (International Maritime Organization 2017, pp. 27-28).

PREAMBLE

The ballast water management plan should contain the information required by the Convention.

For guidance in preparing the plan the following information is to be included. The plan should be specific for each reception facility.

INTRODUCTION

At the beginning of each plan, wording should be included to reflect the intent of the following text.

1. This Plan is written in accordance with the requirements of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (the Convention) and the associated Guidelines.

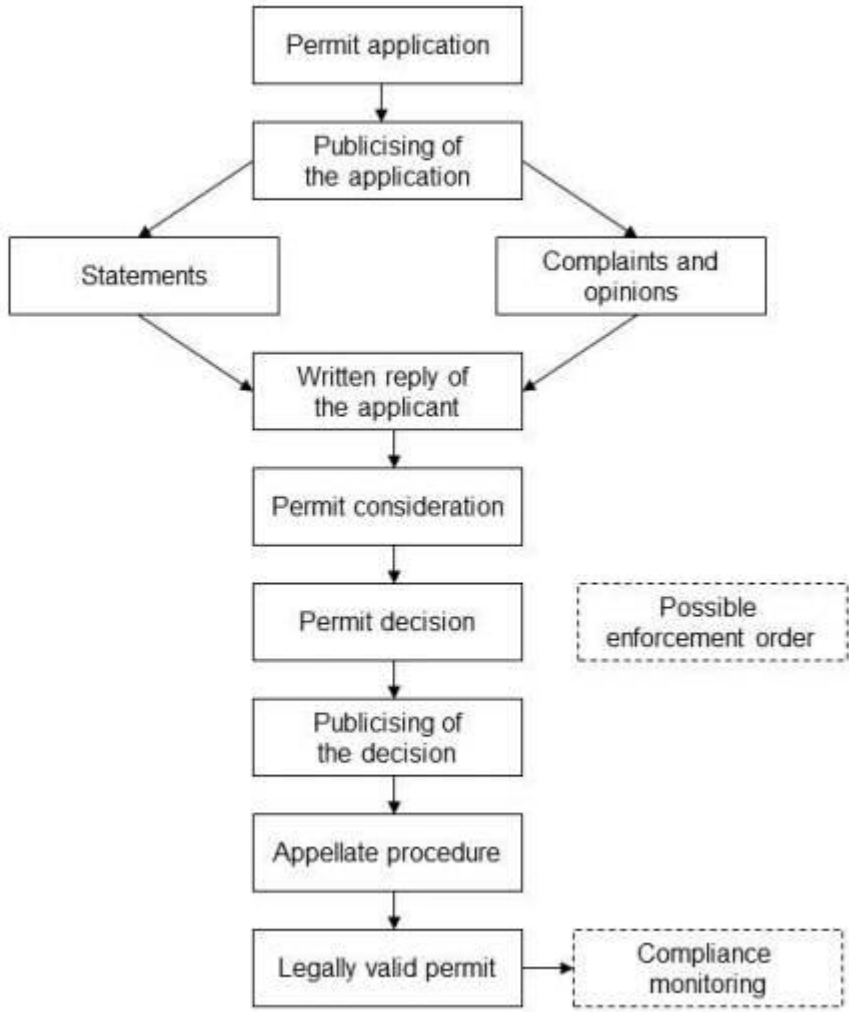
2. The purpose of the Plan is to meet the requirements for the control and management of the vessel's ballast water and sediments in accordance with the Guidelines for Ballast Water Management and the Development of Ballast Water Management Plans resolution MEPC XX(YY) (The Guidelines). It provides standard operational guidance for the planning and management of the vessel's ballast water and sediments and describes safe procedures to be followed.

3. This Plan has been approved by the Administration and no alteration or revision shall be made to any part of it without the prior approval of the Administration.

4. This Plan may be inspected on request by an authorized authority.

Note: The Plan is to be written in the working language of the operating crew, if the text is not in English, French, or Spanish, the plan is to include a translation into one of these languages.

Appendix 3 Diagram of the permit procedure (Regional state administrative agencies 2017).



Appendix 4 Type Approval Certificate of Ballast Water Management System (International Maritime Organization 2017, p.72).

APPENDIX

BADGE OR CIPHER NAME OF ADMINISTRATION

TYPE APPROVAL CERTIFICATE OF BALLAST WATER MANAGEMENT SYSTEM

This is to certify that the ballast water management system listed below has been examined and tested in accordance with the requirements of the specifications contained in the Guidelines contained in IMO resolution MEPC...(..). This certificate is valid only for the ballast water management system referred to below.

Ballast water management system supplied by ....

under type and model designation ....

and incorporating:

Ballast water management system manufactured by ....

to equipment/assembly drawing No. .... date ....

Other equipment manufactured by ....

to equipment/assembly drawing No. .... date ....

Treatment rated capacity .... m³/h

A copy of this Type Approval Certificate, should be carried on board a vessel fitted with this ballast water management system at all times. A reference to the test protocol and a copy of the test results should be available for inspection on board the vessel. If the Type Approval Certificate is issued based on approval by another Administration, reference to that Type Approval Certificate shall be made.

Limiting Conditions imposed are described in the appendix to this document.

Official stamp Signed ....

Administration of ....

Dated this .... day of .... 20..........