Critical Review of the IMO on Ballast Water Convention and its Impact on Shipping

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Abstract– **Today, 90 percent of global trade is carried out by sea transport. According to statistics, every year, about 10 billion tons of ballast water is carried by ships and it is estimated that, on a daily basis, at least 7,000 species of living organisms are transmitted in this way from one place to another. Regarding to this global crisis, the International Maritime Organization (IMO) commenced its activities from 1973 through its country members in regard to formulate a convention to address the issue of Ballast Water contamination problem, known as MARPOL convention. Finally, in February 2004, an International Convention on "Control and Management of Ballast Water and Its Sediments" was legislated. Ballast water, has always caused substantial economic losses and environmental degradation. One of the best ways to tackle this global problem is to avoid using ships with Ballast Water tanks which are designed by Research Centre of Japan. The naval Japanese engineers have invented a new hull system known as the Non Ballast Water Ship (NOBS).**

Keywords– **Ballast Water, Ballast Water Management, Non Ballast Water Ship and Critical Review**

I. INTRODUCTION

Almost two thirds of traded goods worldwide are transported by ship Based on an estimation that the world seaborne trade in 2013 amounted to 9.35 billion tons of cargo [1], Shipping is the primary mode of transport of the world's commodities and has been recognized as a major vector in the intercontinental transfer of aquatic organisms, particularly through ballast water discharges. It has been estimated that 3 to 5 billion tons of ballast water is transferred each year around the world, transporting at least 3000 different marine and coastal species daily [2].

To reduce the risk of bringing invasive marine organisms into local marine ecological systems, the International Marine Organization (IMO) adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments in February 2004 (called the "Convention" henceforth). The Convention determined that all ships will be required to manage their ballast water on every voyage by either exchanging or treating it using approved ballast water management system (BWMS). Ballast water exchange is being phased out of typical marine service and will eventually cease completely, depending on ballast water capacity and the year of ship construction. For example, vessels with a capacity of ballast water tanks greater than 5000 m3 built after 2012 will be required to install a ballast water management system no later than their first renewal survey that will take place after the Convention becomes enforced. In this article the author has tried to collect the materials from library studies, laws and regulations related to ballast water and its impact on "NOBS".

II. BALLAST WATER

Shipping is essential to the global economy, providing the most cost-effective means of transporting bulk goods over great distances. Over 90% of all global trade – including everything from food and fuel to construction materials, chemicals and household items – is carried by ships, with some 50,000 merchant ships sailing the world's oceans, with a combined tonnage of around 600 million gross ton Ships are specifically designed and built to move safely through the water while carrying this cargo [3]. But, when the ship is travelling either without cargo, or only partially laden, it must take additional weight on board to enable it to operate effectively and safely by, for example, keeping the ship deep enough in the water to ensure efficient propeller and rudder operation. This additional material is called ballast. The IMO Ballast Water Management Convention defines ballast water as water with its suspended matter taken on board a ship to control trim, list, draught, stability or stresses of the ship [4].When ships were first built years ago, they carried solid ballast, in the form of rocks, sand or metal. However, since around 1880, ships have used water as ballast principally because it is more readily available, much easier to load on and off a ship, and is therefore more efficient and economical than solid ballast. When a ship is empty of cargo, it fills with ballast water. When it loads cargo, the ballast water is discharged.

Ballast is taken onboard a ship for the following purposes:

1) to maintain stability of the ship;
2) to keep the hull stresses of the ship within permissible limits;
3) for operational reasons such as reducing air-draft, adjusting trim, correcting list or producing list for stripping of tanks etc.

Table I: Ballast water capacities for different types of ships

Vessel type	DWT	Normal (tones)	% of DWT	Heavy (tones)	% of DWT2
Bulk carrier	250,000	75,000	30	113,000	45
Bulk carrier	150,000	45,000	30	67,000	45
Bulk carrier	70,000	25,000	36	40,000	57
Bulk carrier	35,000	10,000	30	17,000	49
Tanker	100,000	40,000	40	45,000	45
Tanker	40,000	12,000	30	15,000	38
General cargo	17,000	6,000	35	n/a	n/a
General cargo	8,000	3,000	38	n/a	n/a
Passenger/RoRo	3,000	1,000	33	n/a	n/a

It is estimated that some 3-5 billion tons of ballast water is transferred throughout the world each year with an individual ship carrying anything from several hundred litters to more than 130,000 tons of ballast water, depending on the size and purpose of the ship A potentially serious environmental problem arises when this ballast water contains marine life Since just one cubic meter of ballast water may contain up to 50,000 zooplankton [5] specimens and/or 10 million phytoplankton [6] cells ,and the majority of marine species include a planktonic phase in their life cycle, there are literally thousands of different marine species that may be carried in ships' ballast water – basically anything that is small enough to pass through a ships' ballast water intake ports and pumps. This includes bacteria and other microbes, small invertebrates and the eggs, cysts and larvae of various species, including most fish, although not all of these will survive in the ballast tank because it is a hostile environment with considerable disturbance, lack of food and light. Closely associated with ballast water are ballast sediments. When a ship takes on ballast water it also takes on material contained in the water. In turbid or shallow waters this often includes solid material. When this material enters the ballast tank it settles to the bottom as 'sediment' and provides a substrate for a variety of marine species, notably din flagellates. According to the Convention sediments are defined as "Matter settled out of ballast water within a ship".

Ballast water is thus recognized as one of the principal vectors of potentially invasive alien species, and is estimated to be responsible for the transfer of between 7,000 and 10,000 different species of marine microbes, plants and animals globally each day [7].

III. BALLAST WATER MANAGEMENT CONVENTION

Agreements reached on a global level usually represent a compromise—this Convention is not an exception. During the Convention negotiations many issues were controversial and in certain cases it proved extremely hard to reach agreement. The following review highlights certain aspects of the Convention and its Guidelines which are of concern to the authors who have participated in the development of the Convention and Guidelines as members of national delegations to the IMO MEPC Ballast Water Working Group. It should be noted however that this review is solely the view of the authors and does not necessarily reflect the views of their delegations.

The Convention consists of 22 Articles followed by five sections with Regulations. Two Appendices show standard formats regarding the issuance of the International Ballast Water Management Certificate as well as operational recording for reporting and verification, i.e. the Ballast Water Record Book.

Regulations for the control and management of ships' ballast water and sediments are presented in five sections:

- *Section A:* General provisions: Definitions, general applicability, exceptions, exemptions, equivalent compliance
- *Section B:* Management and control requirements for ships: Ballast Water Management
- *Section C:* Special requirements in certain areas
- *Section D:* Standards for Ballast Water Management
- *Section E:* Survey and certification requirements for Ballast Water Management

There are obligations to be met by all stakeholders including the ship, the Administrations (both in the capacity as Flag State as well as Port State and as the representative of a Party) and the IMO.

Standards for BWM are dealt with by the Convention in Regulations D-1 and D-2. The Convention introduces these two different protective regimes as a sequential ''phase-in'' implementation:

1). Regulation D-1 Ballast Water Exchange Standard requiring ships to exchange a minimum of 95% ballast water volume
2). Regulation D-2 Ballast Water Performance Standard requires that the discharge of ballast water have organism concentrations below specified limits [8]. This Convention shall enter into force 12 months after the date on which not less than 30 States, the combined merchant fleets of which constitute not less than 35% of the gross tonnage of the world's merchant shipping, have signed the Convention. As of July 2006,six countries have ratified or acceded to the Convention with less than 1% of the world's merchant shipping gross tonnage (for an update visit ''Status of Conventions'') [9].

IV. TREATMENT PROCESSES

The technologies used for treating ballast water are generally derived from municipal and other industrial applications. However, their use is constrained by key factors such as space, cost and efficacy (with respect to the IMO discharged ballast water standards). There are two generic types of process technology used in ballast water treatment:

- solid-liquid separation, and

- disinfection

Solid-liquid separation is simply the separation of suspended solid material, including the larger suspended micro-organisms, from the ballast water, either by sedimentation (allowing the solids to settle out by virtue of their own weight) or by surface filtration (removal by straining; i.e. by virtue of the pores in the filtering material being smaller than the size of the particle or organism). All solid-liquid separation processes produce a waste stream containing the suspended solids. This waste stream comprises the backwash water from filtering operations or the underflow from hydro cyclone separation. These waste streams require appropriate management and during ballasting they can be safely discharged at the point where they were taken up. On de ballasting, the solid-liquid separation operation is generally bypassed. Disinfection removes and/or inactivates micro-organisms using one or more of the following methods:

Chemical inactivation of the micro-organisms through either:

- oxidizing biocides – general disinfectants which act by destroying organic structures, such as cell membranes or nucleic acids; or
- Non- oxidizing biocides – these interfere with reproductive, neural, or metabolic functions of the organisms.

Physic chemical inactivation of the micro-organisms through processes such as UV light, heat or cavitation

Asphyxiation of the micro-organisms through de oxygenation. All of these disinfection methods have been applied to ballast water treatment, with different products employing different unit processes. Most commercial systems comprise two or more stages of treatment with a solid-liquid separation stage being followed by disinfection (Fig. 1) [10].

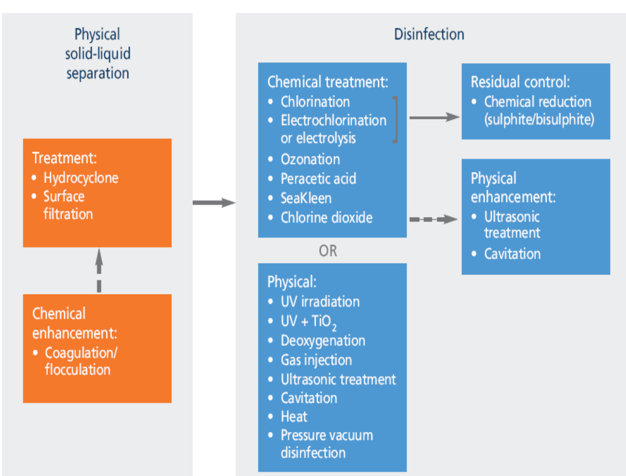

Fig. 1: Generic ballast water treatment technology process options

While disinfection by-products are an issue, and central to the approval of ballast water management systems that make use of active substances, suppliers are confident that the levels generated are unlikely to be problematic. There is a large amount of scientific and technical information on the formation of disinfection by-products that is likely to support this. Where chemicals are used as part of the treatment process, they are typically provided as concentrated solids or liquids, so that they may be easily stored on board a ship.

V. BALLAST WATER TREATMENT SYSTEM PROCESSES

The range of system processes employed for ballast water treatment is shown in Table 4 with examples of filtration and UV systems shown in Fig. 2 and Fig. 3 [10] respectively. As tends to be the case, systems which employ active substances will treat on uptake only (with the exception of neutralization prior to discharge) whereas other mechanical methods tend to treat on both uptake and discharge.

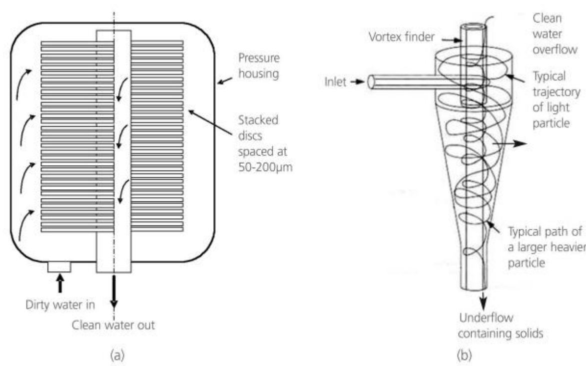

Fig. 2: Filtration (a) and hydro cyclone (b) processes

Commercial systems differ mainly in the choice of disinfection technology and the overall system configuration (i.e., the coupling of the disinfection part with solid-liquid separation, where the latter is used). Almost all have their basis in land- based systems employed for municipal and industrial water and wastewater and thus can be expected to be effective for the treatment of ballast water, albeit subject to constraints in the precise design arising from space and cost limitations.

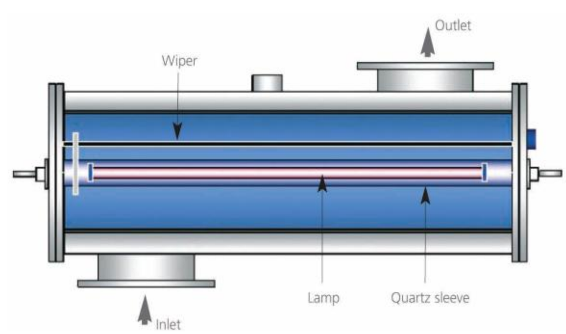

Fig. 3: UV tube and system

VI. TREATMENT TECHNOLOGIES AND SUPPLIERS

This publication considers only suppliers of complete systems for ship-based ballast water treatment rather than suppliers of unit operations, although individual proprietary unit operations (e.g., filters, electro chlorination devices, disinfectant chemicals and UV sterilizer) may be included as part of the systems reviewed.

Facts and figures:

- Basic information is available from 61 companies.
- 35 companies took part in the survey compared to 31 in June 2001
- Technology suppliers increased from 55 in 2001 to 61 in 2012
- In total, there are 68 systems on the market (some companies producing more than one system).
- 14 different countries are represented by these 61 companies, with the predominant nation being the US (Fig. 4) [11].
- For systems employing active substances, the IMO has granted a total of 37 Basic Approvals and 25 Final Approvals.
- In total, 26 systems on the market have now obtained Type Approval under the G8 Guidelines.

About each supplier. It is apparent from Fig. 1 that since September 2008 the number of suppliers of ballast water treatment systems has increased significantly and Summary of treatment technologies show in Fig. 5 [11].

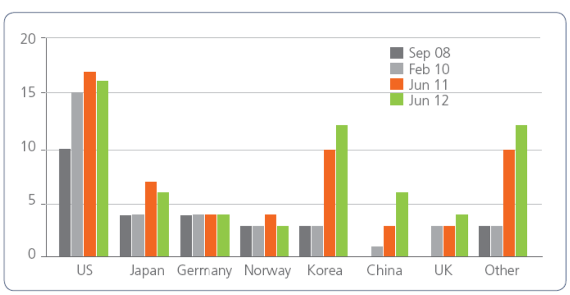

Fig. 4: Technology suppliers increased from 55 in 2011 to 61 in 2012

VII. NON BALLAST WATER SHIP

NOBS concept, introduced by the Shipbuilding Research Center of Japan, provides an extremely transversely raked hull bottom to maintain a sufficient draught in the light loading condition. This design claims a sufficiently deep enough transit draught without ballast water when the ship is light, carrying cargo. Widening the ship's breadth compensates the decreased displacement and reduced deadweight. A comparative illustration is indicated in Fig. 6 [12].

A comparison of principal dimensions between a NOBS and conventional (Suez max) tanker shows that maintaining the same length and draught, the breadth is substantially increased, from 43 meters to 56 meters. As for this type of ship no ballast is available to compensate for uneven load distribution, extra steel is required to increase the longitudinal strength. For a Suez max design the hull steel weight increase is understood to be in the order of 15%.

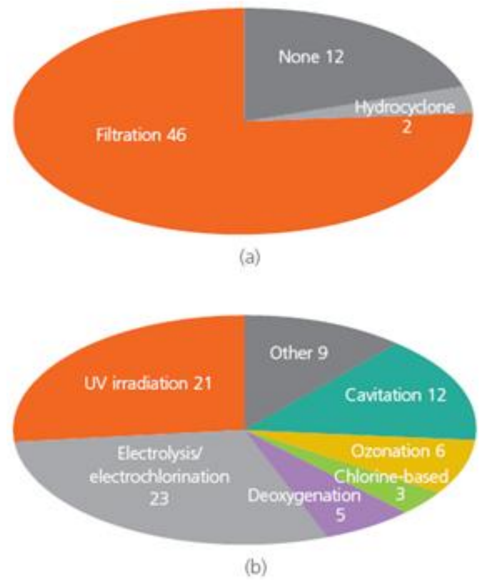

Fig. 5: Summary of treatment technologies used for (a) physical pre-treatment, and (b) disinfection

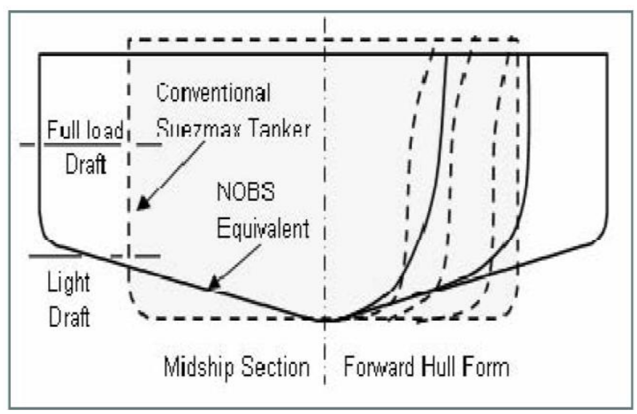

Fig. 6: NOBS Concept compared with traditional hull

Table II: Comparison between conventional and NOBS ship design [12]

Dimensions	Conventional ship	NOBS ships
Length between pp (m)	265	267
Length waterline (m)	271	271
Breadth (m)	43	56
Bottom rake (deg)	0	15
Draught (m)	16	16
Displacement (tons)	160,000	162,500
Draught aft (m)	8.8	7.9
Draught fore (m)	5.8	3
Lightship displacement (tons)	68,650	28,100
Light water Bst (m)	43,000	0

VIII. CONCLUSIONS

Based on statistics and evidences, the transfer of invasive species from ships ballast water discharge to the sea, has become a global problem in such a way that the damage caused by ballast water is much greater than other contaminations which affects directly on the environment and indirectly on the economic sphere. Therefore, by adopting necessary strategies regarding invasive species that have the potential to enter the country's waters the aforementioned damages can be minimized. Introduction of NOBS systems can significantly affect the reduction of pollution by ships which can be one of the best preventing ways alongside other solutions. However, for not being profitable for ship owners, NOBS systems have not been attractive. With the evolution and the universalization of this system in all types of vessels and presentation of similar systems in the forthcoming years this global problem can be solved.

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