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BALLAST WATER CLEANING SYSTEMS VERSUS STANDARD D-2 OF WATER CLEANLINESS REQUIREMENTS

Jerzy Herdzik

Gdynia Maritime University, Marine Power Plant Department
Morska Street 81-87, 81-225 Gdynia, Poland
tel.:+48 58 5586430, fax: +48 58 5586399
e-mail: j.herdzik@wm.am.gdynia.pl

Abstract

The ballast water treatment systems are installed on vessels according to International Maritime Organization (IMO) and other marine administrations requirements. The aim is to minimize the risk of environment contamination from ships' ballast water and sediments.

The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM 2004 Convention) is adopted in 2004 to introduce global regulations to control to transfer potentially invasive species. The BWM Convention will enter into force on 8th September 2017 on vessels with small exceptions.

It was discussed the ballast water treatment standards and technology for fulfilment of IMO, EMSA, USCG and other regulations. The standard D-2 of ballast water cleanliness should be reached after proper treatment through the BWMS.

Some BWMS packs were presented with their advantages and disadvantages. The existing problem is the ballast water cleanliness discharged outboard and the state of cleanliness of ballast water tanks and installation.

It was mentioned some problems to solve during the choice of BWMS.

It was discussed the threats for BWMS effectiveness of ballast water cleanliness.

Keywords: *ballast water, ballast water management, sediments, cleaning systems, cleanliness quality, standard D-2*

1. Introduction

Shipping in internationally voyages transfers about three to five billion tons of ballast water every year. Ballast water is essential to the safe and efficient ships' operations. Due to the transfer of invasive aquatic species poses a serious ecological, human health and economic threat. In February 2004, the International Maritime Organization (IMO) adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention). There are regulations of ballast water discharges and methods of risk reducing of introducing non-native species [3, 7]. To complement the BWM Convention, the IMO has adopted the guidelines prepared as resolutions and circulars by Maritime Environment Protection Committee (MEPC) [8-21]. In addition to the IMO, other national or regional bodies have introduced own regulations for example the United State Coast Guard rules (2012).

The BWM Convention will enter into force in 8th of September 2017 after one year when were fulfilled conditions: ratifications by 30 states, representing 35 percent of world's merchant shipping tonnage [3, 22].

All ships of 400 gross tonnes and above will be required to have on board and approved the Ballast Water Management Plan and a Ballast Water Record Book, and to be surveyed and issued with an International Ballast Water Management Certificate. For existing ships, it ought to be done during the International Oil Pollution Plan (IPPP) Certificate renewal survey, for ships constructed after 7th of September 2017 the compliance ought to be fulfilled on delivery.

Some exemptions are possible for ships, which operate exclusively within one "Captain of the Port" (COTP), zone, non-seagoing vessels, vessels that takes on and discharge ballast water exclusively in one COTP zone or without any water ballast tank or with only closed ballast tanks.

2. Ballast water treatment standards

The D-1 standard was the first one required from February 2004 by BWM Convention. The method for fulfilment of D-1standard was the ballast water exchange at mid-ocean. There are two possibilities to achieve it:

- the sequential method – in each tank, all of the ballast water should be discharged until suction of the pumps is lost, and stripping pumps or eductors should be used if possible. The emptied tanks are then refilled. Three times emptying and filling allows for at least 95% water exchange,
- "flow-through" method – tanks are overfilled by pumping. There is little change to the condition of the ship. It is necessary to pump in three times the volume of the tank to achieve at least 95% change of water.

Some species may survive in the sediment of ballast water tanks. For the reason, some port states did not allow use of stripping pumps when emptying a ballast tank in the harbour, even if the ballast water was exchanged in mid-ocean. The routine ought to be the cleaning of the ballast tank to remove sediments, possible in mid-ocean or under controlled arrangements in port or dry dock. The tank cleaning should be logged in the Ballast Water Record Book also.

From 1st of January, 2017 the BWM Convention requires the regulation D-2 as a standard for discharged ballast water. The requirements for D-2 standard are presented in Tab. 1.

Tab. 1. The IMO D-2 standard for discharged ballast water [3, 7, 14, 21]

Organism category	Regulation
Plankton, >50 μm in minimum dimensions	<10 cells/m^3
Plankton, 10-50 μm	<10 cells/ml
Toxicogenic Vibrio cholera (O1 and O139)	<1 colony forming unit (cfu)/100 ml or less than 1 cfu/g (wet weight)
Escherichia coli	<250 cfu/100 ml
Intestinal Enterococci	<100 cfu/100 ml

Ballast water treatment systems must have a type approval certificate in compliance with the IMO Guidelines [14, 21]. It should be noted the difference between the USCG treatment discharge standard and the BWM Convention D-2 standard. The BWM Convention standard specifies measurement of "viable" organisms, while the USCG standard specifies measurement of "living" organisms.

3. Generic ballast water treatment technology

The problems of ballast water treatment technology have been tried to solve by many manufacturers of marine equipment. The classification societies [3, 5-7] give their own propositions. The generic ballast water treatment technology process option is presented on Fig. 1 [3]. The process is divided into two stages:

- physical solid-liquid separation (mainly filtering) with possibility of chemical enhancement,
- disinfection by using different methods (presenting on Fig. 1).

Similar proposition is presented on Fig. 2. There are three stages of ballast water treatment that may work singularly or in combination. The arrangement of cleaning process has an essential influence on the standard for discharged ballast water (outboard).

The marine market is so considerable and important for manufacturers that they prepared full ready systems and still tried them to develop as to:

- the effectiveness of cleaning process,
- the fulfilment of cleanliness standard,

– the minimal mass and dimensions of the pack,
– the minimal required electric energy,
– automatic operation with very little crew attention,
– series of types (different capacities) – the most often proposition is only with one capacity, for bigger capacity there is a possibility by using more than one pack,
– the long term life,
– the total cost of investment and operation.

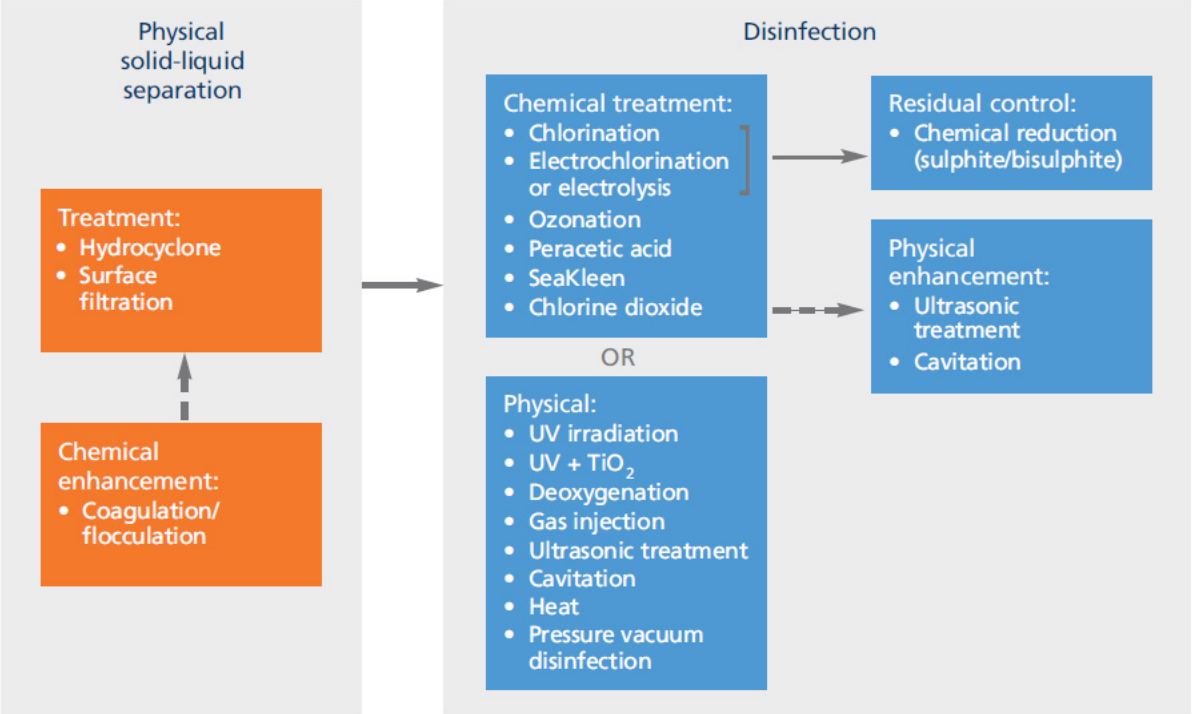

Fig. 1. Generic ballast water treatment technology process option [3]

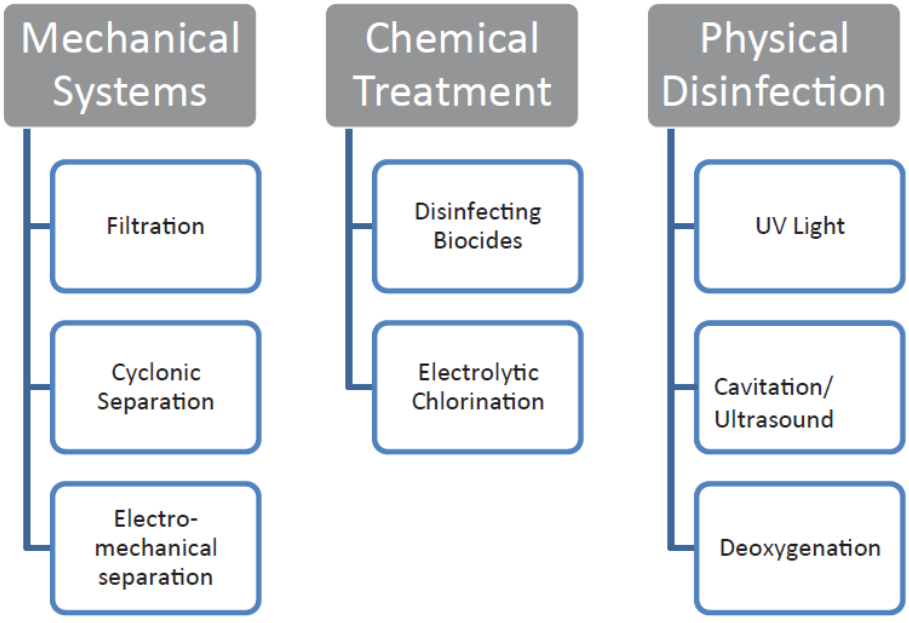

Fig. 2. Ballast water-cleaning systems – singularly or in combination [5]

An example of such system of Hyde Marine is presented on Fig. 3.

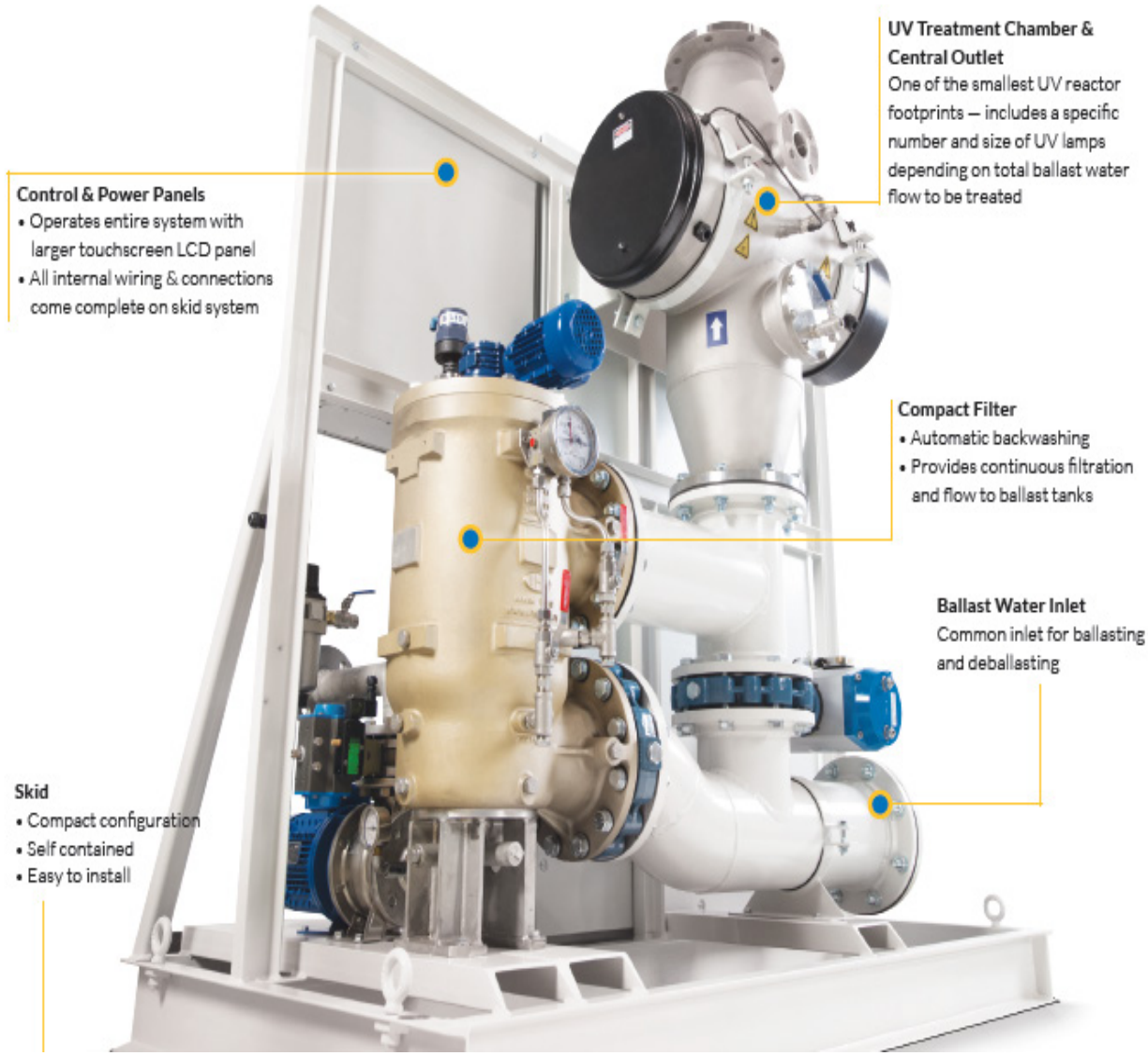

Fig. 3. HG250GS BWMS, Hyde Marine [1]

The cleaning system used in HG250GS is the most popular at present. An automatic backwashing filter with continuous filtration and flow to ballast tanks is the first stage. The second stage uses high intensity of ultraviolet (UV) treatment for disinfection. UV dosage results from a combination of lamp power flow path and exposure time. The cleanliness of UV lamp glasses is very important, so the washing systems for lamp glasses ought to be installed. The advantages of UV disinfection are:

– low corrosion risk (without using of chemical oxidants),
– without using any chemicals,
– no danger of overdosing (no effect on killed organisms),
– no harmful toxic or significant nontoxic products after disinfection process,
– safe to the crew and environment.

The mechanical filtering of ballast water may be efficient. The zooplankton removal efficiency is 20 µm or 40 µm (on request). An example of such system is presented on Fig. 4.

There is presented the process of filtration of ballast water and parallel process of filter cleaning (when the pressure drop on filter activated the cleaning process of the filter).

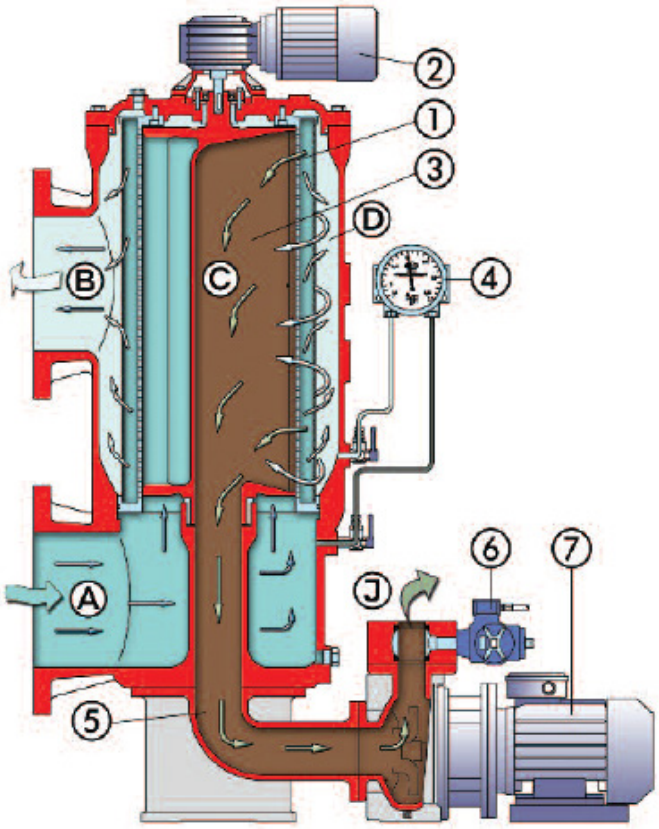

Fig. 4. Filtration and cleaning of ballast water [2]: A – entrance of ballast water, B – exit of ballast water, C – cleaning chamber (inside), D – cleaning chamber (outside), J – cleaning duct (outlet); 1 – filter element, 2 – backwashing system (electric motor in "on" position, 3 – backwashing shaft, 4 – pressure gauge, 5 – duct of filter cleaning, 6 – backwashing valve, 7 – backwashing pump with electric motor (optional)

4. Cleanliness of ballast water tanks − possibility of checking

The cleaning process is always active during ballasting operations. Some ballast water systems work only during the ballasting operation, others during ballasting and de-ballasting operations. Ballast Water Managements Systems (BWMS) arrangement depends on method approved by the Administration. The idea of BWMS, which does not require after treatment, is presented on Fig. 5. During de-ballasting operation the ballast pump works directly from ballast tank to the sea chest.

The idea of BWMS, which require after treatment, is presented on Fig. 6. There is a small difference during de-ballasting process. The ballast water is pumped again through the BWMS pack.

The standard D-2 of ballast water cleanliness should be reached after proper treatment through the BWMS. Certificates of BWMS inform that the cleanliness requirements were fulfilled during certification process at first examined installation of such type and such manufacturer. For other installations, we received in reality the copy of mentioned certificate [4].

The effectiveness of ballast water treatment depends on many factors:

- used type of BWMS,
- the degree of water contamination,
- proper parameters of BWMS work,
- autoregulation system of BWMS pack on different temperature, salinity of seawater, etc.

The final effect ought to be reached during the de-ballasting operation by measuring the cleanliness of ballast water in the outboard outlet pipeline. At sea during ballast operation there is a big problem to measure continuously the cleanliness of discharged water (see Tab. 1). Moreover, what to do when the parameters of cleanliness exceeds the limits.

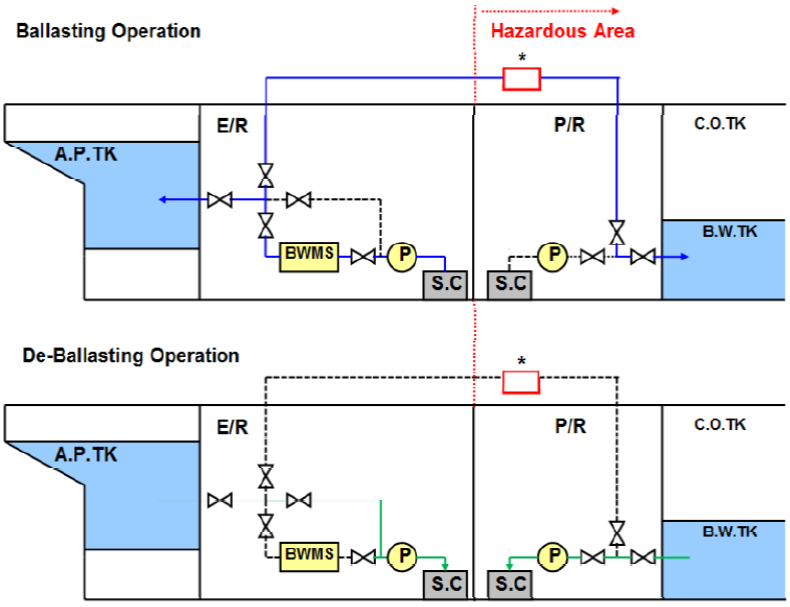

Fig. 5. BWMS which does not require after treatment [6]; S.C – sea chest, P – ballast water pump, E/R – engine room compartment, P/R – pump room compartment, A.P.TK – after peak ballast tank, B.W.TK – ballast water tank

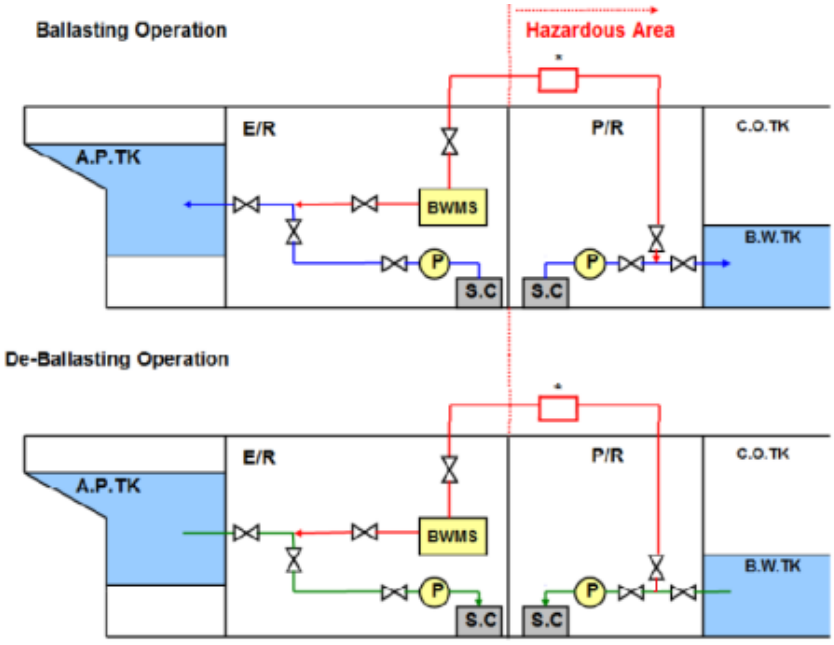

Fig. 6. BWMS which require after treatment (injection type) [6]

5. Operational problems of ballast water systems

An exchange of ballast water and the process of cleanliness may be the reasons of potential dangerous situations for ship safety and crew health and life. It should be done where the sea state, vessel operational state etc. allow for such operations [23, 24].

Due to International Safety Management Code (ISM Code), the BWMS needs to prepare appropriate procedures to avoid above-mentioned threats and to provide proper operation, service and routine maintenance [4].

The unsolved problem is the cleanliness state inside the ballast tanks and inside the ballast water pipelines. There is a real possibility of corrosion (contact with seawater), contamination of plankton, bacteria and viruses not killed by BWMS, other substances (chemicals) produced into

the ballast tanks during voyage. It should decrease the effectiveness of BWMS and make under the question mark the reasonableness of utilization necessity such systems.

The possible solution is a frequently inspection of ballast tanks but it may be done only when the ballast tank is emptied. How to check the tank cleanliness (and the pipelines) when there is no visible contamination but still possible from the bacteria and viruses. If the ballast tank should be contaminated it is a necessary to wash it (only by water or with chemicals?) and what to do with the tank washings. The next questions who will decide about the evaluation of ballast water tank cleanliness, when and where to do it.

The most simple solution is to treat the ballast water during ballasting and de-ballasting operation (it doubles the time of BWMS work, waste energy etc.) but it does not still recognize a state inside the tank.

6. Final remarks

The BWMS will be installed on vessels according to required regulations. Some answers on above-mentioned questions should be done before the decision of BWMS type choice. It needs some calculations to choose the best (maybe the cheapest) solution. The experience and opinions about considered type (and manufacturer) from crew or superintendents may be helpful for correct decision.

Certainly, the next regulations from IMO about the BWMS will be prepared soon for improving and developing the systems.

The BWMS should be friendly to the environment and the crew. The next essential cost for ship-owners or operators should be justify by the benefits for the environment and all of us.

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