

Review

# Overview and Comparison of the IMO and the US Maritime Administration Ballast Water Management Regulations

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Received: 5 June 2019; Accepted: 14 August 2019; Published: 22 August 2019



**Abstract:** Along with the International Maritime Organization (IMO), the United States Maritime Administration has developed its own ballast water management legislation under the dual authority of the US Coast Guard and the Environmental Protection Agency. The IMO and US ballast water management regulations are globally recognized as the most significant and influential regimes. Complexity and certain regulatory differences pose considerable concern amongst all stakeholders in the shipping industry, predominantly ship owners and ship operators. This paper presents a conceptual study which overviews, emphasises, and compares key provisions of these two sets of regulations by targeting and unveiling significant points from their perspective since they represent the largest group of stakeholders. Therefore, the paper aims to support shipowners and operators in better understanding the Ballast Water Management regulations and their differences. In addition, the study may benefit in choosing an adequate ballast water treatment system to be installed onboard ships, considering the sea areas where ships intend to operate. Finally, the paper can also help policy makers understand those differences that could present a major barrier in the efficient and smooth ballast water management implementation.

**Keywords:** ballast water management convention; ballast water management system; type approval; discharge and performance standard; regulation differences

## 1. Introduction

Ballast water (BW) is a vital component of the ships' effective and safe functioning as it ensures stability and manoeuvrability under various operational conditions. However, a number of studies have classified BW as one of the greatest environmental concerns since it contains thousands of various aquatic species. Many of these may be capable of surviving in designated ships' tanks during the voyage and become invasive towards native organisms after being discharged in a new marine environment [1].

Canada and Australia, as some of the first countries that experienced certain problems with invasive organisms, addressed their issues to the International Maritime Organization (IMO). The Marine Environment Protection Committee (MEPC), IMO's body empowered for development and adoption of the regulatory provisions for prevention and control of pollution from ships, initiated and developed voluntary guidelines through Resolutions MEPC50(31), A.774(18), and A.868(20), aiming to prevent the spread of invasive aquatic species through BW and its sediments' discharge. MEPC formed the Ballast Water Working Group, which in 1999 gradually started with in depth improvement of existing and the development of new guidelines and regulations for effective international shipping BW management (BWM). On 13 February 2004, the MEPC commitment and efforts resulted in the adoption

of the *International Convention for the Control and Management of Ship's Ballast Water and Sediments*, or shorter, *Ballast Water Management Convention* (BWMC) [1]. The BWMC came into force on 8 September 2017, 12 months after Finland as the 52nd party to the BWMC reached 35.14% of the world's merchant shipping tonnage and thus achieved the stipulated enforcement condition: 30 contracting countries with more than 35% of world tonnage [2]. As of July 2019, 81 BWMC signatory countries have a 80.76% share in the world tonnage [3].

At the time of the BW regulations development, there was a lack of global awareness of BWM issues and insufficient national institutional regulations. Therefore, the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), and IMO joined forces with member governments and the shipping industry to launch two successful projects: the *GloBallast project* (2000–2004) and *GloBallast Partnership project* (2007–2017). The general aim of these projects was to help and assist developing countries and their maritime industries with growing BW issues and prepare them for the BWMC introduction and implementation [4–7].

During the same period and without any apparent intention to be a signatory country, the United States of America (US) was developing, adopting, and putting into force its own BW federal legislation aiming to enhance the control of the introduction and spread of harmful organisms via BW within US waters. Those regulations are primarily stipulated in the United States Coast Guard (USCG) *Final Rule entitled Standards for Living Organisms in Ships' Ballast Water Discharged in US Waters*. Some additional requirements are covered in the US Environmental Protection Agency's (EPA) currently valid *Vessel General Permit 2013* (VGP2013). Although generally aligned with the BWMC provisions, there are certain regulation differences and some additional and stricter stipulations stated in the US federal legislation [8–11].

The IMO BWM provisions are designed for international implementation by parties to the BWMC while those imposed by the United States Maritime Administration (USMA) are only applicable to ships operating in US waters. They are unarguably the two most recognized and influential global regimes on the BWM implementation and practices.

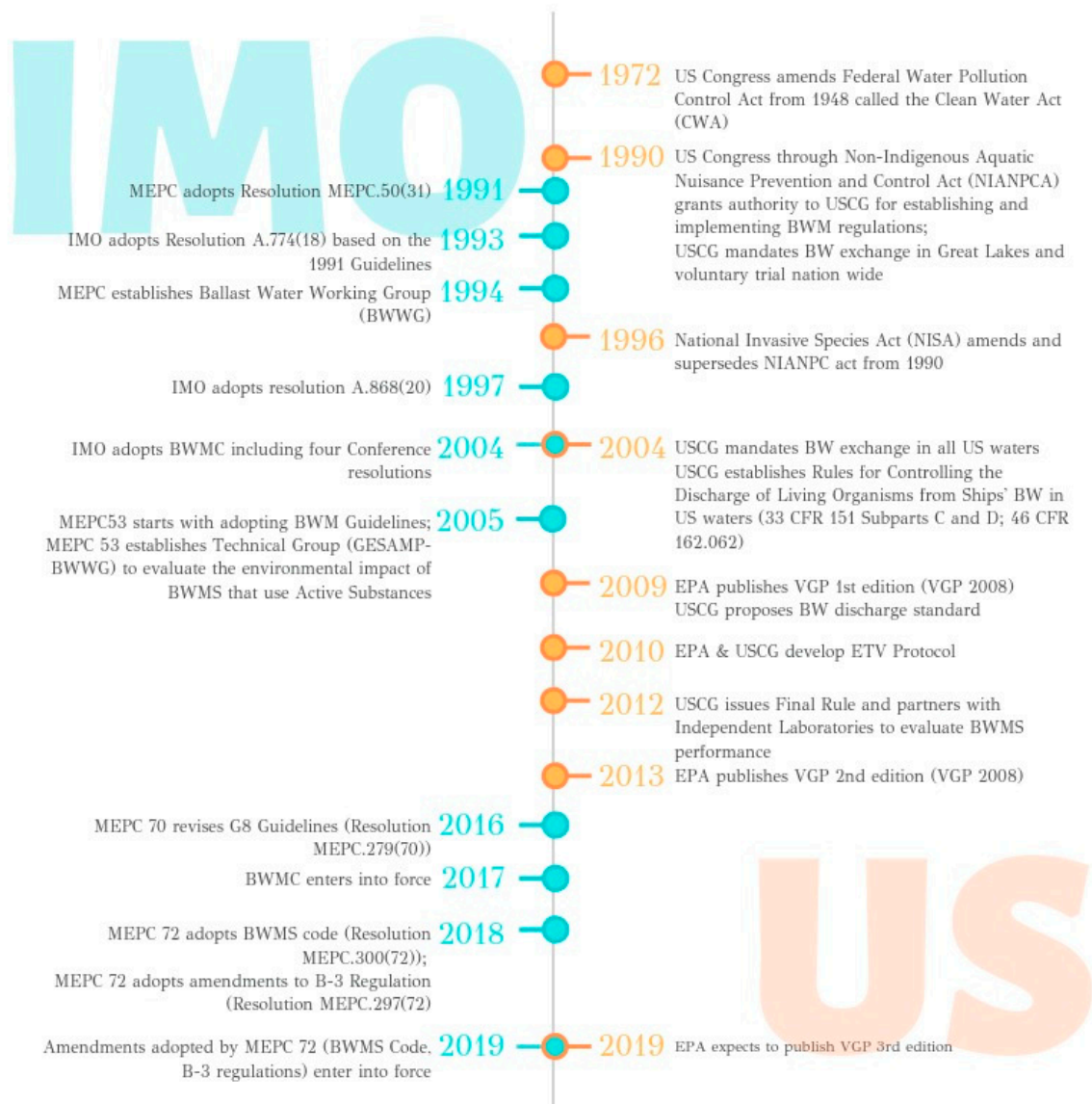
Some previous studies on BW Management elaborated challenges arising from BW [12] and identified BW discharge profiles of ports in order to enable effective BWM [13]. Studies on Ballast Water Treatment Systems (BWTS) include papers on the comparison of five BWTS and operational experiences on ships [14], reviews of technologies for BWTS [15], research on global BWTS market [16], and preview of BWTS market status [17]. Previous studies on BWM regulations include a critical review of the BWMC [18], a discussion about "same location" concept regarding exemption for compliance with BW regulations [19], a review of BWM policy and its implications for Alaska [20], a summary of BWM development in Brazil [21], and a review of key BWM regulations with an emphasis on a Ballast Water Management Systems (BWMS) type approval process [22].

Although IMO and US BW regulations are studied and explained in the above mentioned papers, their comparison has not yet been given. Therefore, the authors conducted a content analysis of the regulatory requirements and contributed to the topic with the conceptual paper which provides an overview and comparison of the IMO and the USMA major regulations. The foremost focus is on those regulations that are of most importance to and need to be easily understood by shipowners and ship operators in implementing satisfactory BWM practices. Additionally, the paper aims to emphasise these regulation differences to policy makers since their unification and applicable simplifications would be essential in accelerated and efficient BWM implementation and onboard practices.

## 2. Major Regulatory Provisions of IMO and US Ballast Water Management

Although all IMO and US BWM regulations have their important role in creating successful BWM practices for all shipping stakeholders, there are several provisions that should be emphasised as essential for shipboard BWM compliance. As they are the final step in implementing successful BWM practices, their understanding of the key BWM requirements is crucial for ships' BWM compliance.

The timeline scheme of major events in BWM regulations establishment for the purpose of better overview and comparison is presented in Figure 1 [1,23–26].



**Figure 1.** Timeline of the major events in the process of International Maritime Organization (IMO) and US Ballast Water Management (BWM) regulations establishment and implementation.

Since there are several institutions involved in the BWM process, there is a need for better clarification and explanation of their responsibilities. The differences between the IMO and USMA organisations’ institutional bodies mentioned by the BWM process and their responsibilities are depicted in Figure 2 [1,26,27].

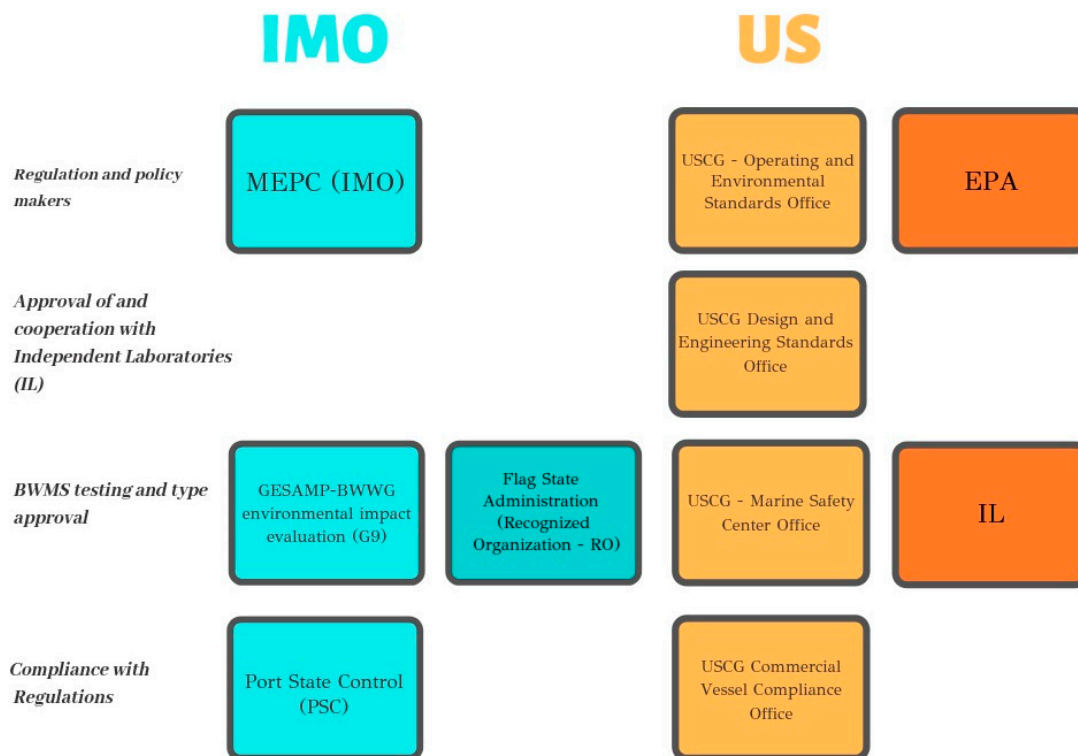


Figure 2. IMO and US BWM organisations’ institutional bodies’ responsibilities overview.

The main focus in the following sections of this chapter is on those regulations and requirements that are the most important for the shipowners and operators to be familiar with.

### 2.1. Status and Developments of the IMO BWM Regulations

From 8 September 2017, 12 months after BWMC came into force, all ships involved in international trade must manage their BW as per regulations stipulated in the BWMC. However, this does not apply to ships that operate in the territorial waters of their flag state, ships with permanent/sealed ballast, and warships. An additional alternative is the discharge of BW to approved on-shore reception facilities. Apart from ships, BWMC also obligates IMO and Flag State Administrations, or Recognized Organizations (RO) on behalf of Administrations, to comply with their regulatory provisions which are structured within BWMC [24,28]:

- 22 Articles designed to provide general information, development, improvement, enforcement, and implementation of the BWMC.
- An annex divided into A, B, C, D, and E sections containing 24 regulations in total, including two Appendixes to annex. The regulations stipulate technical standards and requirements to be followed in meeting BWMC objectives.
- 16 presently developed guidelines aimed for uniform implementation of BWMC regulations. They have been constantly developed and amended since 2005 in accordance with new BWM experiences, knowledge gained, and related technological developments. Furthermore, IMO has issued a number of supplementary resolutions and circulars related to the implementation of the BWMC.

Although all BWMC regulations have their important role in creating successful BWM practices for shipping stakeholders, there are several of them that should be emphasised as essential to be familiar with for shipboard compliance and operation. The two most significant are the regulations that define BWM standards:

- Regulation D-1, Ballast Water Exchange Standard, requires ships to perform the exchange of coastal BW with open sea water with at least 95% volumetric efficiency by using one or a combination of three accepted methods: the sequential method, the pumping through method, or the dilution method. Regulation B-4 requires that the exchange has to be carried out 200 nautical miles from the nearest land and in waters with a depth of at least 200 m [28].
- Regulation D-2, Ballast Water Performance Standard, sets a maximum permissible concentration of viable organisms and specified indicator microbes harmful to human health in the discharged BW. In order to manage D-2 limits, ships need to treat BW prior to discharge by installing an IMO approved treatment system [28].

D-1 standard presents a temporary measure until all ships eventually install the IMO certificated BWTS as the ultimate solution for compliance with D-2 Standard and overall BWM requirements. Amended Regulation B-3 sets out an implementation schedule for ships' compliance with D-2 standards. Retrofitting of a BWTS on existing ships is linked to the renewal of the International Oil Pollution Prevention Certificate (IOPPC), while new buildings need to have the system installed upon delivery [28–30].

As per BWMC, in order to ensure that onboard BWM is in accordance with regulated procedures, each ship must carry as follows [22,28,30,31]:

- Ballast Water Management Plan (BWMP)—Regulation B-1 is a document developed for each ship specifically and approved by the Flag State Administration/Recognised Organisation. It is comprised of detailed procedures for safe and efficient BWM regulations compliance and onboard practices such as crew familiarisation with their obligations and responsibilities, BW uptake and discharge timings, sediment management, and contingency procedures.
- Ballast Water Record Book (BWRB)—Regulation B-2 is either a paper or an electronic format book intended for recording all BWM activities. The BWRB form is given as Appendix II to the Annex. It can be included as part of the BWMP and must be available for Port State inspection at all times. All entries must be kept for at least three years from the time of writing.
- International Ballast Water Management Certificate is mandatory for all ships of 400 gross tons and above. It states which BWM standard is implemented onboard and thus confirms the ship's compliance with BWMC regulations. The IBWMC is part of the BWMC as Appendix I to the Annex.

Ballast Water Management System (BWMS) is defined by IMO as any system that treats BW in order to comply with biological limits set in D-2 Standard. It includes treatment equipment with all the accompanying piping arrangements, control and monitoring equipment as well as sampling facilities [32].

Systems installed on ships must be approved by the Administration/RO as per Regulation D-3, which requires all tests to be carried out in accordance with the *Guidelines for approval of BWMSs* (G8 Guidelines). These guidelines, revised in 2016 for the first time, were converted and adopted in April 2018 into mandatory *Code for approval of BWMS* (BWMS Code) which will come into effect in October 2019 [1,25]. However, revised G8 Guidelines are applied for approval of BWMSs on or after 28 October 2018. Therefore, BWMSs approved according to previous G8 Guidelines from 2008 may be installed onboard ships only prior to 28 October 2020, while after that date, the only systems that can be installed are those approved by the 2016 G8 Guidelines [32–34].

BWMSs using Active Substances must be approved in accordance with provisions contained in the *Procedure for approval of BWMSs that make use of Active Substances* (G9 Guidelines). As per IMO, Active Substance implies a substance or an organism, including a virus or a fungus, that has a general or specific action on or against harmful aquatic organisms and pathogens [1,25,35]. Guideline G9 consists of a Basic and Final approval process to determine that the BWMS performance does not jeopardise the environment, human health, property, or resources. These approval protocols are followed and

reviewed by *Ballast Water Working Group on Active Substances* (GESAMP–BWWG) established under the auspice of MEPC in 2005 especially for this purpose [1,22,25].

Specific technologies applied in BW treatment are not stipulated within BWMC. It is left to the choice of BWMSs manufacturers to utilise one or a combination of more available technologies and methods in order to comply with D-2 Standard requirements, following respective G8/BWMS Code or G9 Guidelines for testing and approval protocol. In addition to Basic and Final approval for BWMSs using Active Substances, all systems must carry out land-based and shipboard tests in order to be finally evaluated and approved by the Flag Administration/RO in the form of the Type Approval Certificate (TAC). Once TAC is obtained and onboard installed BWMS is surveyed, IBWMC can be issued [1,22,25].

The latest IMO update from January 2019 lists 59 and 43 BWMSs that obtained basic and final approval, respectively, while a Type Approval Certificate was issued for 76 BWMSs by their respective Administrations [36].

## 2.2. Status and Developments of the US Ballast Water Regulations

In addition to the 16 individual BWM state regulations [37], present US BWM federal requirements are enforced through the USCG *Final Rule* regulations mainly contained under the Codes of Federal Regulation (33 CFR 151 Subparts C—*Ballast Water Management for Control of Nonindigenous Species in the Great Lakes and Hudson River regulation*, D—*Ballast Water Management for Control of Nonindigenous Species in Waters of the United States regulation* and 46 CFR 162, Subpart 162.060—*Ballast Water Management Systems regulation*). Additional BWM regulatory provisions are contained in VGP 2013, issued and administrated by the EPA for the National Pollutant Discharge Elimination System (NPDES) program under the legal authority of the Clean Water Act (CWA) [10,11,37–41]. Currently valid VGP 2013 was due to expire in December 2018 and was replaced by a new VGP edition which was expected to be available for the 30 days comments period in March 2019. However, the existing one continues to remain in force until the new VGP edition is introduced [42]. The regulations of the two regulatory authorities are generally aligned with a few exceptions. They work closely together to implement, develop, and harmonize BWM requirements and standards wherever feasible and appropriate under their respective statutory mandates [43,44]. Whereas the EPA implements, administers, and conducts enforcement actions for the VGP, the USCG's role is to monitor and inspect ships' compliance with VGP provisions during regular Port State Control (PSC) surveys [38].

Unless specifically exempt, all ships equipped with BW tanks conducting BW operations in US territorial waters must comply with the US BWM regulations as per the Ballast Water Discharge Standard (BWDS) implementation schedule coupled to the ship's drydocking date as defined in the USCG *Final Rule* [10,45,46]. Regulations also include fouling and sediment management as well as detailed reporting and recordkeeping requirements. BWDS determines the permissible concentration of living organisms in ships' BW discharged into US waters, which is numerically equivalent to the BWMC D-2 standard. The range of acceptable BWM methods provided by regulations to enable ships to comply with the BWDS are as follows [9,47,48]:

- Perform complete BW exchange in an area 200 nautical miles from any shore prior to BW discharge. This option as a BWM method is acceptable only up to a ship's BWDS compliance date after which one of the further listed acceptable methods must be implemented. However, it may still be allowed by the USCG as a contingency measure in case of an emergency [45,48,49].
- Installation and operation of a BWMS evaluated and approved by the USCG type approval process defined in the 46 CFR 162, including a land-based testing according to the EPA's Environmental Technology Verification (ETV) protocol [48,50]. The USCG protocol requires BWMSs to be tested in both land based and shipboard testing environments. After the preliminary stage of extensive planning and logistical arrangements, all further required evaluations and testing programs must be carried out by the USCG approved independent laboratories (IL), meaning that the laboratory cannot be affiliated with manufacturers applying for the type approval tests [9,51–53]. Prior to

actual land based or shipboard efficacy tests, the manufacturers submit a Letter of Intent (LOI) to the USCG expressing their intention to start such testing at an IL [9]. Once all test results have been evaluated by the USCG Marine Safety Centre, the BWMS manufacturer can submit an application for system type approval [54]. As of 26 February 2019, there are 16 USCG type approved BWMSs available on the market and 7 more under review [55]. Some manufacturers have requested multiple amendments to their type approval certificates. Currently, including already approved BWMS, 50 manufacturers have submitted LOIs to pursue USCG type approval for their systems and more than 30 systems are currently undergoing testing [56].

- Use of BW obtained exclusively from a US public water system, thus meeting certain tank cleanliness requirements [48,49].
- Discharge of BW to an onshore reception facility or to another vessel for treatment purposes.
- No discharge of BW inside US territorial waters, which includes sea water extended to 12 nautical miles from the baseline.
- Utilisation of a foreign IMO type approved BWMS accepted by the USCG as an *Alternate Management System* (AMS) if installed on board prior to the ship's BWDS original compliance date as specified in 33 CFR 151.2035. This temporary option was included in the *Final Rule* as a bridging measure prior to the US regulations being published, thus allowing sufficient time for those systems to be eventually upgraded to USCG requirements and to obtain USCG type approval, or until USCG approved systems become widely available [57]. The foreign Administration type approval procedure is pursuant to the BWMC G8/G9 guidelines, which are not associated with US requirements. The AMS can be used as such for a period of up to five years from the ship's compliance date. Thereafter, the ship is required to comply with BWDS by employing another approved method or, preferably, by obtaining the above mentioned USCG type approval certificate, thus maintaining compliance [9,57]. The USCG AMS program granted an AMS status to 111 foreign type approved BWMSs [58]. Under the USCG regulations, the AMS may not be installed if a USCG type approved BWMS is available for a given class or type of ship.
- An extension of a ship's BWM compliance date is another interim measure granted by the USCG if the ship owner/operator provides documented evidence that compliance with one of the approved BWM methods is not possible despite all undertaken efforts [59]. At the time, this option was mainly granted to provide reasonable flexibility to shipowners/operators due to the unavailability of the USCG type approved BWMSs on the market, thus ensuring steady progress toward achieving BWM requirements [60,61]. As mentioned above, six approved BWMSs are currently available and more are expected to receive approval soon. Therefore, as per the March 2017 revised extension program regulations, further exemptions will be considered on a case by case basis while taking into account the ship's scheduled compliance date, market availability of the USCG approved BWMS, detailed installation plan, as well as the timeline to comply [59]. In general, extensions can be granted for a period of 18 to 30 months, while the USCG do not anticipate granting further extensions for ships with a compliance date equal to or greater than 1 January 2021 [59]. An extension application submitted to the USCG must contain an explicit statement supported by documentary evidence that it is still not possible to install the USCG type approved BWMS [49,62].

The USCG *Final Rule* requires BW reporting and recordkeeping via the Ballast Water Management Report (BWMR) form, which must be submitted no later than six hours after arrival or at least 24 h before arrival for vessels travelling to the Great Lakes or the Hudson River from outside the US Exclusive Economic Zone (EEZ). The BWMR form should contain information on the ship's particulars, voyage, BW capacity and tanks to be discharged, sediment disposal practices as well as all relevant Ballast Water Management Plan (BWMP) procedures and BWM activities. The assigned reporting form must be archived on board for at least two years [10,50]. In case a ship's applicable BWM method is unexpectedly unavailable during a voyage, the shipowner/operator must report the issue to the

nearest Captain of the Port as soon as practicable. They are also encouraged to include “contingency plans” in their BWMPs [46].

In addition to the aforementioned, USCG requires ships to have a BWMP, which does not have to be approved as per IMO requirements. It must be maintained by incorporating and updating the following BWM practices: the cleaning of BW tanks to remove sediments, rinsing anchors and chains when an anchor is retrieved, removing fouling from the hull, piping and tanks on a regular basis as well as maintaining records of ballast and fouling management [60,63].

The EPA is another US authority that, in addition to the USCG BWM regulations, has included specific requirements for BWM in its VGP 2013 edition. Jurisdiction of this permit covers BW discharges within US inland waters and territorial sea up to three nautical miles from the baseline for VGP 2013 defined ships [10,38,64].

To a large extent, EPA VGP 2013 BWM requirements match those established by the USCG. The BWDS and BWMS implementation schedule as well as an acceptable method to meet the regulation requirements are the same for USCG and EPA, while the usage of fresh water as BW under VGP 2013 is extended to include the Canadian public fresh water system [65]. However, VGP 2013 does not require BWMS to be type approved and has no power to grant extensions as the USCG. To accommodate this discrepancy, the EPA issued an Enforcement Response Policy stating that for ships operating with the USCG extension and of which are in full compliance with other VGP requirements, non-compliance with the 2013 VGP BW numeric discharge limits will be considered as a low enforcement priority [66].

Under the VGP 2013 requirements, the shipowner/operator of a ship that is equal to or greater than 300 GT, or has the capacity to hold or discharge more than 8 m<sup>3</sup> of BW, must submit a Notice of Intent (NOI) to the EPA seven days prior to the discharge in order to have uninterrupted VGP 2013 coverage [67].

Also, in accordance with VGP legislation, ships’ operators must perform certain self-monitoring procedures for the BWMSs which include: functionality monitoring to verify BWMS operation according to the manufacturer’s specifications including monitoring equipment calibration frequency, biological organisms monitoring for three listed indicator organisms (total heterotrophic bacteria, *E. coli*, and enterococci) to verify biological performance of the BWMS and concentration limit of residual biocide, and derivative monitoring for active substances used in the treatment process [50,68].

### 3. Comparison of the IMO and the USMA BWM Major Regulations Differences

Two major regulative frameworks on BWM clearly indicate that applicable requirements are not uniform and unique and their equal implementation is not possible. Although essentially aligned, certain differences between the IMO and the USMA BWM regulations exist. The primary difference is that the IMO has established BWM regulations on an international level which are eventually implemented in the legislation of the BWMC signatory Member States. The US is not party to the BWMC, but has developed national BWM legislation applicable to ships operating in US territorial waters. This legislation is generally considered to be more prescriptive and demanding than its IMO counterpart [69]. It combines the USCG and EPA’s VGP regulations. These US agencies signed a Memorandum of Understanding (MOU) in 2011 to merge BWM compliance efforts and share relevant information [49,68]. It is important to note that individual US States are entitled to develop and implement their own BWM provisions under CWA. Therefore, some of them, for example California and New York State, have imposed even stricter requirements and standards [70].

The major difference between two BWM regulatory regimes is in the BWMS testing and verification requirements which prove a system’s efficiency in meeting BWDS. Comparison of these two protocols in terms of major technical differences is presented in Table 1. IMO developed G8/BWMS Code and G9 guidelines for the BWMS type approval which are carried out by Flag Administrations and include a choice of laboratories to perform the required tests at the convenience of the BWMS manufacturers. The issue with G8 recommendatory guidelines from 2008 (MEPC 175(58)) was that they did not require tests to be conducted by a laboratory independent of the manufacturer. Revised G8 guidelines and newer



mandatory BWMS Code stipulate that testing facilities must be independent, meaning that laboratories cannot be affiliated with or owned by manufacturers, vendors, or suppliers of any BWMS or their major components [32]. The US type approval process is mandatory, strictly regulated, and more detailed. There is no direct comparison between the USCG and IMO with respect to the evaluation and approval of active substances as the USCG does not approve active substances for use in the BWMSs. Instead, the BWMSs must comply with several other EPA's VGP and BWMS ETV protocol testing requirements, which cover the utilisation of active substances in a treatment process [61,71,72]. While performing shipboard tests under the US type approval process, no experimentation is allowed and all operations must be carried out by the ship's crew, not by the manufacturer's personnel [49,71]. Even though new G8 guidelines have been revised and BWMS Code has been introduced to be more specific and detailed with the purpose of accomplishing greater consistency in land-based testing, the USCG type approval process is still considered to be more stringent [50].

**Table 1.** IMO and US Ballast Water Management Systems (BWMS) type approval process comparison [32,73,74].

Comparison items	IMO	US
Approval by	Flag or Class (Recognized Organizations (RO))	USCG
Test operator	Manufacturer	IL
Test laboratory	Laboratory not owned/affiliated with manufacturer/vendor of BWMS/major equipment components	United States Coast Guard (USCG) approved IL
Reporting of test results	Manufacturer/Laboratory	IL
Testing methods required	G8/G9 Guidelines	USCG BWMS Environmental Technology Verification (ETV) Protocol
Performance/Discharge standard	<10 <i>viable</i> organisms	<10 <i>living</i> organisms
Shipboard 3 consecutive successful testing cycles	3	5
Minimum holding time in the test tanks before discharge and sampling for the BWMSs not using Active Substances	Minimum holding time to be determined by the BWMS manufacturer (D-2 standard compliance); ≥5 days (regrowth evaluation)	≥1 day; If justified in Test/Quality Assurance Plan, shorter or longer tank hold times may be utilized
Component/Environmental test (vibration endurance test)	2 h	4 h

Another significant distinction between the IMO and the USCG requirements related to the assessment of the effectiveness of BWMSs is the methodology applied to determine compliance with the IMO BW performance standard and the USCG discharge standard. The numerical discharge limits for aquatic organisms and indicator microbes contained in BW water to be discharged are the same in both standards, as shown in Table 2 [50]. However, the BWMC requires measurement of viable organisms, whereas the USCG *Final Rule* requires measurement of living organisms, which results in significant implications in type approval testing [50]. IMO defines viable organisms as those with mobility and response to stimuli that can successfully generate new individuals to reproduce the species, while assessing the viability, structural integrity, and metabolism of organisms are taken into consideration as well [32,33]. In contrast, the USCG defines organisms as either living or dead [50]. Therefore, the USCG currently only approves the CMFDA (5-chloromethylfluorescein diacetate) and FDA (fluorescein diacetate) staining methods used in combination to determine these two conditions. The stains will penetrate into organisms, where functional esterase enzymes will convert them into

fluorescent products that are retained by cellular membranes. Using epifluorescent microscopy, fluorescing organisms are enumerated as living individuals. Any motile organisms observed are also counted as living [75,76]. IMO employed the accepted MPN (Most Probable Number) method which also accounts for organisms that are rendered unable to reproduce. This is a formal mathematical calculation based on binary scoring data from a set of dilutions and replicates from a sample measure. In a BWM application, it is used to determine the number of viable phytoplankton cells in a sample via their ability to reproduce, meaning that the binary result is reproduction or no reproduction of phytoplankton [50,60]. The issue for the USCG is that those dying or non-viable organisms, which are unlikely to establish themselves, are counted as living [60]. Therefore, in December 2016, the USCG announced a clear statement stating that the MPN method is an unacceptable way to prove the efficacy of a BWMS in an USCG type approval procedure [60,77].

**Table 2.** Discharge standard and USCG performance standard overview [49,78].

ORGANISM SIZE INDICATOR MICROBES	IMO D-2 Regulation BW Performance Standard	USCG Regulation BW Discharge Standard
Size ≥50 μm in min dimension	<10 viable organisms/m <sup>3</sup> of BW	<10 living organisms/m <sup>3</sup> of BW
10 ≤ Size < 50 μm in min dimension	<10 viable organisms/mL of BW	<10 living organisms/mL of BW
Toxicogenic <i>Vibrio cholera</i> (O1 and O139)	<1 cfu */100 mL, or <1 cfu/g (wet weight) zooplankton samples	<1 cfu/100 mL
<i>Escherichia coli</i>	<250 cfu/100 mL	<250 cfu/100 mL
<i>Intestinal enterococci</i>	<100 cfu/100 mL	<100 cfu/100 mL

\* cfu: colony forming unit.

Regarding the implementation of the discharge standard numerical limits in the US, in 2009, USCG initially proposed a phase two standard that was 100 times more stringent than the IMO D-2 standard. In addition, after completing the latest “practicability review” in 2016, it was concluded that at that point, stringent standard implementation as well as the assessment of available technologies to meet standard was not technically achievable and therefore its implementation was postponed [43,54,70]. However, the EPA does not have a practicability review process, so when the VGP 2013 expires, the EPA must reissue the permit in compliance with the CWA to include the “Best Available Technology” and water quality analyses review [43]. It is expected that the new VGP version will probably contain more rigorous permit requirements [69]. A similar or in places more stringent standard implementation postponement was carried out by California and New York State since they were delegated authority under the EPA to certify the 2013 VGP with additional conditions concerning BW [54,69].

Obviously, the IMO and the USCG have set a final schedule for compliance with their discharge/performance standard provisions. This implies installation of type approved BWMS as the ultimate compliance method. However, there are a few divergences in implementing these two regulations. The IMO’s implementation schedule for existing ships is linked only to the IOPP certificate renewal survey on or after 8 September 2018, the date when BWMC came into force, while new ships must have an installed IMO type approved BWMS upon delivery on or after that date [79,80]. Meanwhile, ships need to comply with D-1 BW exchange standard as a transitional mandatory method. Under the influence of the shipping industry, particularly shipowners and ship operators, MEPC amended the implementation schedule for existing ships by delaying BWMS mandatory installation for a further two years. Specifically, ships that have had their last IOPP renewal between 8 September 2014 and 7 September 2017 must install BWMS at the next IOPP renewal survey on or after 8 September 2017. Alternatively, if the completion date of the last IOPP renewal survey took place between 8 September 2012 and 7 September 2014, then BWTS installation must be carried out at the second IOPP renewal survey on or after 8 September 2017 [29,81,82].

The USCG established its final discharge standard compliance scheme in its *Final Rule* in 2012, which contrary to IMO requirements for existing ships depends on a ship’s BW tanks’ capacity and its scheduled drydocking. New ships, similar to IMO regulation, must in the case of USCG be equipped with its type approved system upon delivery. A detailed comparison of the two BWMSs installation regulations with implementation dates for applicable ships is presented in Figure 3. In addition to the BW exchange method and aforementioned compliance scheme conditions, ships entering US waters may either be granted extensions to the dates for fitting the required BWMS or they can obtain permission to install an AMS. These additional options represent the main differences between the IMO and the USCG implementation requirements [83,84].

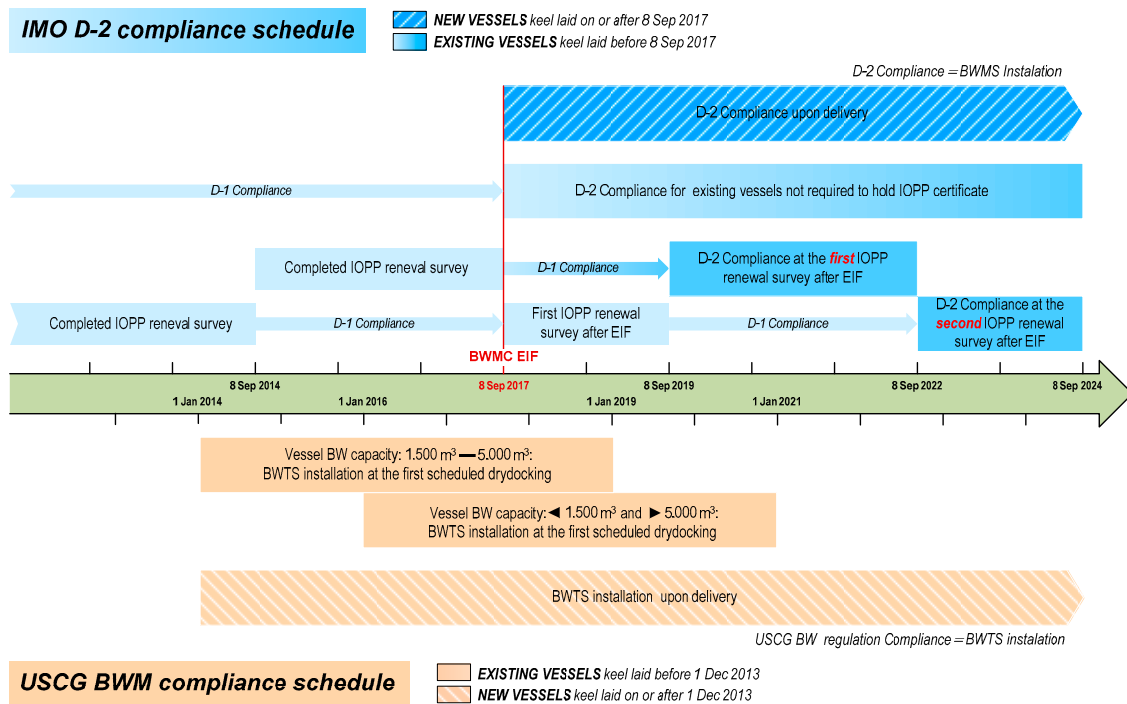


Figure 3. Comparison of the IMO and the USCG ship’s mandatory BWM compliance schedule.

When comparing differences and inconsistencies within the USMA regulations, it can be concluded that the EPA’s BW requirements differ from the USCG rules in that the EPA is not authorized to grant extensions for vessels to maintain compliance, so all ships are required to operate in accordance with the currently enforced VGP. Also, compliance with EPA discharge standards can be achieved by other means, not only by the type approval process. Furthermore, US states are authorized to establish their own water quality standards provided that they are at least as stringent as federal standards [69].

#### 4. Discussion

Although the IMO and USMA regulations imposed the same numeric discharge standards and required type approved BWMSs within their core regulations provisions, certain differences in the compliance protocols remain. Despite various doubts related to regulatory requirements and efficacy of currently available technologies, the use of BWMSs is accepted and established as a final solution for mitigating invasion risks associated with BW in both regimes [85]. The complexity and diversity of enforced IMO and US BWM regulations, in combination with a continuous improvement in the BWMSs testing requirements and possibly more stringent future discharge standards are a cause for considerable concern, primarily for shipowners, but also for other stakeholders in the shipping industry. In addition, ships must comply with the applicable port state requirements. Furthermore, BWMC ratification did not in any way assure shipowners that their IMO compliant BWMS would

eventually meet US BWM requirements [69]. Further concern for the shipping industry arises from the fact that IMO has not yet made it clear enough which systems, methods, and technologies will be considered suitable to pass the port inspections of other states, irrespective of their being BWMC parties [86].

The Commercial Vessel Incidental Discharge Act (VIDA) presented to the US Senate proposed to eliminate a dual USCG/EPA authority at the beginning of 2017 and make USCG the only BWM regulation enforcement institution as well as to eliminate the ability of individual states to enforce their own more restrictive BWDS. In contrast, the environmental lobby still wants to maintain their role in imposing restrictions and penalties. The proposal contains a provision that requires the USCG to use an MPN method instead of the current live or dead testing rule for type-approval testing. However, this decision is still pending and is to be further discussed, verified, and enforced, so we might expect some crucial USMA changes in the not so distant future, which many BWTS manufacturers and shipowners/operators are looking forward to [87].

The compromise made by IMO in accepting an extension to the D-2 standard compliance deadline for two additional years is, in essence, a recognition of the shipping industry's need for more time to prepare for BWMS installations and for a sufficient number of type-approved BWMSs to become commercially available. In practice, this means that a number of existing ships will have an extended deadline until 2024 to fully comply with the BWMC regulations. Some stakeholders, particularly environmental protection authorities, expressly argued that the delay to IMO BWM compliance will not lead to the improvement of BWMSs and the implementation of the BWMC regulation in two years' time but will, in fact, undoubtedly result in further deterioration of the marine environment [88,89].

Despite the IMO revised ships compliance schedule, there is still substantial concern amongst shipowners whether it is feasible to retrofit BWMS on more than 70,000 ships within this time window considering that there are insufficient shipyard resources and BWMSs available on the market [69].

An additional argument for postponing the compliance date was the possible lack of docking capacity. This argument was considered irrelevant at the time as most BWMS providers claimed that a treatment system could be installed during regular drydocking, i.e., during the IOPP renewal survey, along with and without interfering with other planned docking jobs. Retrofitting will not prolong the duration of docking or affect incorrect BWMS installation if a detailed engineering study and proper preparatory work is performed prior to docking and therefore, the final commissioning of the BWMS can be executed immediately afterwards [90]. In addition, a proper and reasonable procedure that shipowners should consider would be for shipowners to perform a comprehensive market analysis and feasibility study to identify the most suitable BWMS. Such analysis might conclude that scrapping is recommended instead of investing in a new BWMS [91].

Apart from the practical compliance challenges, shipowners must also face a substantial financial expense which the installation of BWMS imposes and which could eventually be rendered obsolete by the enforcement of more stringent measures [69]. For those ships that intend to operate in US waters, the challenge is even greater as there is an insufficient number of the USCG type approved BWMSs on the market. Therefore, shipowners are unwilling to take the risk of installing a non-USCG type approved system, which restrains progress towards BWM regulations compliance [76]. A number of ships that have already installed IMO approved BWMS and have been granted AMS status can only hope that their systems will eventually be USCG type approved, otherwise, they will need to be replaced.

It is important to note that treatment system manufacturers are dealing with a time consuming, rigorous, and quite costly USCG type approval process, which can reach up to four million USD [92]. Simply put, they need to improve their products to remain competitive and survive within this challenging market [93]. The estimated overall expense for purchasing, installing, and certifying BWMS ranges from half a million USD to five million, while retrofitting costs, depending on the type of ship, are estimated to be upwards of 30,000 USD [89].

Of vital importance, as emphasised by both BWM regulatory authorities, is adequate crew training and their familiarisation with the relevant BWM regulations and rules that should be incorporated within a ship's specific BWMP. Ship officers and crew must be fully competent in carrying out all BWM functions and assigned duties according to a ship's specific BWMP and company's Safety Quality Management system (SQM). Those tasks generally include, but are not limited to, the operation and maintenance of the ship's BWMS, emergency procedures, contingency plan, and the required recordkeeping [94]. In addition to this, due to the complexity of BWM regulations and the frequency with which they are updated and revised, further education, familiarisation, and training should be mandatory for PSC inspectors to enable them to identify irregularities and bad practices in the implementation of the BWM regulations on board ships.

## 5. Conclusions

Although both IMO and USMA are coordinated at a higher level, particularly with respect to the numerically identical BW discharge/performance standards limits as well as in some other BWM requirements, USMA regulations are considered to be more difficult to achieve. This mainly applies to the USCG BWMS type approval regime since its testing procedure is more complex and rigorous compared to IMO's.

Ships discharging BW into US territorial waters must comply with the US BWM regulations which incorporate the USCG and EPA provisions, regardless of their status under the IMO as the US is not party to the BWMC. Mainly due to an insufficient number of USCG type approved BWMS on the market, USCG has demonstrated flexibility by implementing AMS status for ships with IMO approved BWMSs as well as granting an extension to the compliance date program if the reasons for non-compliance with USCG approved BWM methods are properly elaborated and documented. The USCG also advised that BWE is not an acceptable compliance method for ships beyond the BWMS implementation date specified in its Final Rule.

The discrepancy of BWM requirements currently in force, related to different sea areas, present a serious challenge to shipowners in their decision-making process for a full and correct application of those requirements. Although one of the main goals of any regulation should be a simple and uniform practical implementation for all stakeholders, requirements related to BWM show that this is not the case.

Furthermore, despite extensive efforts by the shipping community, as well as by the maritime policy makers in the explanation and elaboration of proper BWM implementation, the following couple of years will inevitably be a period of further harmonisation and equalisation of the BWM requirements.

Therefore, shipowners/operators as well as other stakeholders should play a major role in providing appropriate training and familiarisation to those employees who are dealing with BWM enforcement and implementation in order to avoid non-conformance with BWM regulations and issuance of penalties.

The presented comparison of different BWM implementation requirements in the US and other sea areas under the auspice of the IMO indicates a high impact of the regulations' differences on efficient ship operation. In that respect, continuous research and monitoring of new or updated requirements is of great importance for easier and more efficient shipping without barriers and would resolve the potential confusion that discrepancy and lack of BWM requirements' uniformity bring to the shipping community.

**Author Contributions:** Conceptualization, L.Č.; Methodology, L.Č.; Validation, L.Č., V.F. and L.M.; Investigation, L.Č. and N.H.; Resources, L.Č. and N.H.; Writing—Original Draft Preparation, L.Č.; Writing—Review & Editing, L.Č., V.F. and N.H.; Visualization, L.Č. and N.H.; Supervision, V.F. and L.M.

**Funding:** This research received no external funding.

**Conflicts of Interest:** The authors declare no conflict of interest.

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