Estuarine, Coastal and Shelf Science xxx (2016) 1–8

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

How to approach ballast water management in European seas

Matej David [a, *], Stephan Gollasch [b]

[a] Dr. Matej David Consult, Korte 13e, SI 6310, Izola, Slovenia
[b] GoConsult, Grosse Brunnenstr. 61, DE 22763, Hamburg, Germany

ARTICLE INFO

Article history:
Received 22 March 2015
Received in revised form
27 January 2016
Accepted 14 October 2016
Available online xxx

Keywords:
Ballast water management
Harbours
Risks
Introduced species
Decision support

ABSTRACT

The latest research continues to show that the ballast water issue is very complex, which makes it very challenging to manage. In 2004, the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted to globally harmonize action against the transfer of harmful aquatic organisms and pathogens via ships' ballast water and related sediments. Analyses of the BWM Convention requirements, conducted through different research projects mainly aiming to provide support for the implementation of the BWM Convention, have shown that there are different steps countries need to take and that there are still some open issues which need to be solved. This paper presents some of the main issues identified and the core theoretical and applied measures required to solve these issues, with the aim to support more efficient and coordinated implementation of the BWM Convention requirements in EU seas. The approaches recommended here for the EU may be universally interesting for similar application in other areas of the world.

Regional index terms

European seas, Baltic sea, North sea, North-eastern Atlantic, Western Mediterranean sea.

1. Introduction

Commercial vessels are built to transport cargo or passengers. In case a vessel is not fully laden with cargo, additional weight is needed to ensure the vessel's seaworthiness, for example, to compensate for (a) increased buoyancy which can result in a lack of propeller immersion, (b) inadequate transversal and longitudinal inclination or (c) other stresses on the vessel's hull and structure. The material used as additional weight on a vessel is referred to as ballast. In former times ballast material was solid, but, once iron was used as basic vessel construction material in the middle of the 19th century, water was used in cargo holds or tanks as ballast. The loading of water was much easier and more time efficient. Even when a vessel is fully laden with cargo, ballast water operations may be needed due to (a) an unequal distribution of cargo on the vessel, (b) adverse weather and sea conditions, (c) an approach to shallower waters, and (d) to compensate for fuel consumption during the voyage. As a result, vessels fundamentally rely on ballast water for safe navigation and operations as a function of their design and construction (David et al., 2012; David, 2015).

Aquatic organism transfers occur unintentionally (e.g., with vessels) or intentionally (e.g., for aquaculture purposes). When considering the shipping vector globally, aquatic organisms are predominantly transferred with ballast water and related sediments (Carlton, 1985; Hallegraeff and Bolch, 1991; Gollasch, 1996; Ruiz et al., 2000; Hamer et al., 2000; David, 2007; McCollin et al., 2008), but are also found attached to the vessels' hull or sea chests (Gollasch and Riemann-Zürneck, 1996; Gollasch et al., 2002; Fofonoff et al., 2003; Hewitt et al., 2004a,b; Otani, 2006; Coutts and Dodgshun. 2007).

In Europe, a total of slightly more than 1000 marine and brackish water non-indigenous and cryptogenic species, which are species with unknown status as native or introduced, were known when the situation was summarized in 2006 (Gollasch, 2006). At that time it was concluded that shipping was the most important species introduction mechanism, with ballast water being the dominant vector. Subsequently, a total of 1369 marine alien and cryptogenic species have been reported in European seas (Katsanevakis et al., 2013a); more than half arrived with shipping (Nunes et al., 2014). In a more recent overview, the number of coastal non-indigenous species increased to more than 1400, documenting a rising trend of new species findings (Reker et al., 2015). Biofouling was identified as a more important introduction vector until the 1980s, when ballast water-mediated species introductions prevailed (Katsanevakis et al., 2013b). The importance of ballast

* Corresponding author.
E-mail address: matej.david@siol.net (M. David).

http://dx.doi.org/10.1016/j.ecss.2016.10.018
0272-7714/

Please cite this article in press as: David, M., Gollasch, S., How to approach ballast water management in European seas, Estuarine, Coastal and Shelf Science (2016), http://dx.doi.org/10.1016/j.ecss.2016.10.018

water as a species introduction vector is also highlighted by the fact that severely harmful species, such as toxin producing phytoplankton and gelatinous zooplankton, have arrived with ballast water. In general, the transfer of harmful aquatic organisms and pathogens (HAOP) with vessels has resulted in unwanted negative impacts on natural environments and human health, and has also caused drastic economic losses (Gollasch et al., 2002; Casale, 2002; Kettunen et al., 2009; Vila et al., 2010). By IMO[1] definition "*Harmful Aquatic Organisms and Pathogens*" are *aquatic organisms or pathogens which, if introduced into the sea including estuaries, or into fresh water courses, may create hazards to the environment, human health, property or resources, impair biological diversity or interfere with other legitimate uses of such areas* (IMO, 2004). It is important to note that HAOP in this context are not limited to non-indigenous species, but include all potentially harmful species irrespective of their origin, i.e., non-indigenous, cryptogenic or harmful native species (David et al., 2013).

Noting the problems caused by introduced species, IMO started developing instruments to address the issue in 1973 (IMO, 1973). After some ballast water management (BWM) related guidelines were agreed at IMO initially, the work continued and eventually, in 2004, the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted. It's aim is to prevent, minimize and ultimately eliminate the risks to the environment, human health, property and resources which arise from the transfer of HAOP via ships' ballast waters and related sediments (IMO, 2004).

Among the key principles of the BWM Convention are Ballast Water Exchange (BWE) and the Ballast Water Performance Standard (Regulation D-2, or D-2 standard) as protective measures. The rationale behind BWE is that coastal organisms pumped on board during ballast water uptake are unlikely to survive when they are discharged at sea because of, for example, salinity issues and the absence of hard substrates to complete their life cycles. Further, high sea organisms pumped on board during BWE at sea will be unlikely to survive when they are released in coastal waters due to possible salinity changes and the lack of suitable habitats. Another reasoning for BWE as a species introduction risk-reducing measure is that organism concentrations are much lower in high seas compared to coastal waters. Studies have shown, however, that BWE will not deliver complete protection from species introductions and also that BWE sometimes may be impossible due to safety reasons and other limitations; as a result, the D-2 standard was developed. The D-2 standard specifies a limited number of viable organisms that may be contained in discharged ballast water. The D-2 standard may be achieved by the use of ballast water management systems (BWMS) installed on board vessels.

Knowledge about the quantity of ballast water to be discharged in a port is of multiple uses for port authorities and enhances the management process by enabling appropriate management measures. For example, this knowledge will enable assessment of the suitability and dimensions of (land-based) ballast water reception facilities. In addition, ballast water discharge estimates enable an environmental impact assessment for ballast water which was treated with active substances, e.g., chemical treatment, also considering a worst-case scenario and possible long-term accumulation of such substances in the recipient port. Ballast water discharge assessments may also support management measures based on the level of the risk assessed: for higher risk ballast water, more stringent BWM requirements may be imposed, or risk level may be used as a trigger for inspections to verify compliance with ballast water requirements. In cases when a low (or acceptable) risk is identified, the authorities may allow some relaxation of requirements so that unnecessary costs and burden on vessels is avoided. For port States which require ballast water reporting from vessels, a ballast water discharge assessment (BWDA) model can be used to verify the reported data. Lastly, historical ballast water discharge data may be helpful to study vessel and ballast water patterns through time. These data, when related to known introduced species, may be used to calculate the relative importance of ballast water releases as a species introduction vector (David et al., 2012).

Knowledge of the aquatic organism transfer process (i.e., entering ballast tanks, voyage survival and unmanaged ballast water discharge) is a critical component of effective ballast water management (BWM) (Hewitt and Hayes, 2002). A crucial element of BWM is risk assessment (RA), as it enables the identification of appropriate management measures according to the risk level identified, e.g., in high risk cases additional control requirements may be implemented, while for low risk situations ballast water management may not be needed (Hewitt and Hayes, 2002; Gollasch and Leppäkoski, 2007; David, 2007; Hewitt and Campbell, 2007; David et al., 2015). There are two very different RA approaches under the BWM Convention: the selective and the blanket approach. In a blanket approach, all ships intending to discharge ballast water in a port are required to conduct BWM measures. The selective approach means that different BWM measures are required depending on different risk levels posed by the ballast water intended for discharge. Consequently, ships may be exempted from BWM requirements provided the risk level of the ballast water intended for discharge is acceptable according to the IMO G7 Guidelines (IMO, 2007a). On the other hand, if the risk of the ballast water to be discharged is identified as (very) high or extreme, these ships may be required to take additional measures based on the IMO G13 Guidelines (IMO, 2007b).

Decision Support Systems (DSS) are supporting tools enhancing a (complex) decision-making process. The DSS approach was introduced in BWM to facilitate decisions under a selective BWM approach. Decision-makers are faced with the difficulty of making timely decisions especially on very complex issues, which usually require input of large data sets. DSSs are multi-facetted tools that provide decision makers with an instrument to (a) reduce uncertainties, (b) simplify and speed-up the decision process, (c) avoid subjectivism induced by the decision-maker and (d) guarantee transparency of the entire decision-making process. More precisely, it was quickly recognised that a supporting tool is needed to provide transparency and consistency on BWM requirement-related decisions with the aim to improve environmental protection and to lessen the BWM burden on vessels (David and Gollasch, 2015a,b).

In this paper we summarise ballast water discharge profiles of two EU ports, introduce key principles of RA under the BWM Convention including a RA model flowchart, and we introduce the importance of DSSs to support complex decision making in ballast water management. We conclude with recommendations on how to approach the BWM issue in Europe which may also be considered for application in other areas of the world.

2. Materials and methods

BWM information was gathered by participating in different national and international projects, expert, scientific and/or governmental working groups or organisations (e.g., IMO, MEPC[2],

[1] International Maritime Organization, the United Nations body to deal with shipping.

[2] Marine Environment Protection Committee (of IMO).

Please cite this article in press as: David, M., Gollasch, S., How to approach ballast water management in European seas, Estuarine, Coastal and Shelf Science (2016), http://dx.doi.org/10.1016/j.ecss.2016.10.018