GloBallast Partnerships

WMU WORLD MARITIME UNIVERSITY

Identifying and Managing Risks from Organisms Carried in Ships' Ballast Water

GloBallast Monograph Series No.21

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IMO INTERNATIONAL MARITIME ORGANIZATION

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Identifying and Managing Risks from Organisms Carried in Ships' Ballast Water

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The GloBallast Partnerships Programme is a co-operative initiative of the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) and the International Maritime Organization (IMO) to assist developing countries to reduce the transfer of harmful aquatic organisms and pathogens in ships' ballast water and sediments and to assist the countries in implementing the International Convention on Ballast Water Management. For more information, please visit http://globallast.imo.org.

The World Maritime University is a graduate United Nations university, offering the degrees of MSc and PhD. Over the last quarter-century, WMU has educated almost 3,000 managers from 158 countries who now hold senior positions in maritime administrations, companies and training institutions, and make up a network of unparalleled influence and scope that stretches across the maritime world.

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DISCLAIMER

List of Abbreviations

ALARP	As Low As Reasonably Practicable
BWE	Ballast Water Exchange
BWWG	Ballast Water Working Group
BWM	Ballast Water Management
BWMS	Ballast Water Management System
BWRF	Ballast Water Reporting Form
CBD	Convention on Biological Diversity
CME	Compliance Monitoring and Enforcement
CMR	Carcinogenicity, mutagenicity and reproductive toxicity
DBP	Disinfectant by-product
EEZ	Exclusive Economic Zone
EMSA	European Maritime Safety Agency
EPA	United States Environmental Protection Agency
FAO	Food and Agriculture Organization
FMEA	Failure Modes and Effects Analysis
GEF	Global Environment Facility
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GloBallast	GEF-UNDP-IMO GloBallast Partnerships
HAB	Harmful Algal Bloom
HAZOPS	Hazard and Operability Study
HFO	Heavy Fuel Oil
IACS	International Association of Classification Societies
IOC-UNESCO	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization
ILO	International Labour Organization
IMarEST	Institute of Marine Engineering, Science & Technology
IMDG Code	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
ISM Code	International Safety Management Code
IUCN	International Union for Conservation of Nature and Natural Resources
MAMPEC	Marine Anti-foulant Model to Predict Environmental Concentrations

MEPC	Marine Environment Protection Committee
MSDS	Material Safety Data Sheet
NGO	Non-governmental organization
OECD	Organization for Economic Cooperation and Development
OSH	Occupational safety and health
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PBBS	Port Biological Baseline Survey
PPE	Personal Protective Equipment
PSC	Port State Control
SOLAS	International Convention for the Safety of Life at Sea
SPM	Suspended Particulate Matter
THM	Trihalomethane
UNCED	United Nations Conference on Environment and Development
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization

Executive Summary

The Ballast Water Management (BWM) Convention, adopted by the International Maritime Organization in 2004, recognizes that ballast water carried by ships has led to the transfer of aquatic organisms beyond their natural ranges, causing damage to the environment, human health, property and resources. The BWM Convention, including its Regulations and Guidelines, is designed to prevent, minimize and ultimately eliminate the *risks* of such negative impacts whilst avoiding unwanted side-effects from controlling and managing ballast water.

The BWM Convention is set against a background of shipping practices within which ballasting operations play an irreplaceable role. The present world fleet was designed to operate with ballast water; vessels require a simple and flexible system for onboard weight distribution thereby enabling them to navigate safely and maintain their stability. Thus, at present, an international instrument prohibiting the carriage of ballast water is not an option. Accordingly, the Convention requires States to minimize risks by regulating the quality of ballast water and sediments and by employing a range of management practices and treatment systems both on board vessels and on shore.

The BWM Convention contains a number of specific provisions for risk reduction and other potential risks are identified in guidance documents prepared under the auspices of the GEF-UNDP-IMO GloBallast Partnerships. To date, no single document has explored the broad range of risks to the environment, human health, property and resources that may be associated with introductions of alien species conveyed in ballast tanks, and the various techniques and technologies available to control such risks. No individual control method is likely to be 100% effective and hazard-free because different environments, vessels, voyages and control systems present different types and degrees of risk. Ballast water management strategies need to be comprehensive, flexible and innovative.

The partners and countries in the GloBallast Project have identified a need for better and more accessible/comprehensible information and guidance on risk assessments within the context of the BWM Convention. The aim of this Monograph is to aid maritime administrators or other lead agencies by identifying many of the commonly occurring, and some less obvious, risks that need to be addressed in ballast water management, including those presented by substances and equipment used to treat ballast water and by the removal and disposal of ballast tank sediments. This Monograph/is intended to be an additional source of information and complement the three previous GloBallast Monographs (17, 18 and 19).

The opening chapter outlines basic concepts applicable to risk management and unravels the sometimes confusing terminology surrounding this practice. It explains the interrelationships between hazard, exposure and risk and provides general advice on considerations and approaches relevant to risk assessment. It does not, however, attempt to assess individual risks or to provide a generalized approach to risk assessment because each case is different. Rather, it stresses the importance of specific, often local, circumstances in determining the types and degrees of risk and the need to take account of overlapping risks and control systems in selecting between options for risk mitigation.

Chapter 2 considers various hazards and risks associated with invasive species and the management of ballast water and sediments. It identifies factors that determine the survival of organisms in transit from one biogeographic region to another and the risks they present to such valuable assets as biodiversity, fisheries and human health. It examines the potential risks to vessels undergoing ballast water exchange at sea. It explains the occupational hazards that stem from ballast water treatment systems employing active substances, in handling and storing such substances, and the hazards faced by those required to inspect ballast tanks and associated treatment systems. Most of the risks identified are considered in the context of the BWM Convention requirements with references to the relevant information sources.

The limitations of ballast water sampling and analytical procedures, used in testing compliance with the ballast water performance standard (Regulation D-2 of the BWM Convention), are clearly identified and need to be considered in evaluating the adequacy of management strategies. The risk of potential economic losses to ports through delays incurred by inspections, sampling and testing of ballast water must also be considered. Therefore, emphasis is placed on prioritizing inspections, compliance testing and monitoring, focusing on the more high-risk vessels and voyages. The involvement of stakeholders representing major interest groups, both in assessing risks and developing mitigation measures, is strongly advocated.

Chapter 3 addresses options for mitigating identified risks that have been adequately assessed so that their severity and probability of occurrence is sufficiently well established. It discusses in some detail the powers and responsibilities conferred on the shipowner, the Flag State, Port State and Coastal State in implementing risk management, drawing attention to relevant parts of the Convention and other useful sources of information. The benefits of the Ballast Water Reporting Form as a pre-arrival risk assessment tool are explained, including its role in prioritizing inspection and enforcement activities. The chapter underlines the need to intercept the pathways by which alien species are introduced to new habitats using a mixture of legislative, administrative, technical and operational barriers. Other barriers may also be required to offset any negative side-effects that may result from these management measures.

The document notes that, as part of BWM, risk management has limitations. The uncertainties inherent in risk estimates, the many interacting factors involved in the control of ballasting operations and limited knowledge of the effects of certain substances and technologies must be recognized in formulating BWM strategies and programmes**. The BWM Convention embodies a precautionary approach and scientific research should steadily reduce uncertainty**. The elimination of available pathways for potentially invasive aquatic species demands the use of innovative ideas and technologies. Eradicating hazards is always the best option to suppress risks and is an integral part of risk management strategies, despite the fact that latent risks sometimes exist in the strategies themselves.

By providing a well-illustrated account of the critical steps in risk management, specifically linked to the complex task of reducing the global incidence of bio-invasions mediated by ballast water and sediments, this guidance document will constitute a valuable supplement to the Ballast Water Convention and related publications. It includes an extensive bibliography and links to websites from which many of the supporting documents can be obtained. The document should be of particular value to staff of national lead agencies responsible for preparing national and local ballast water management plans, as well as shipowners and shipping companies seeking concise explanations of international ballast water management requirements. It may also be of interest to designers of ballast water treatment systems and organizations contributing to, or affected by, measures to reduce the incidence and/or impacts of invasive species.

1

Introduction

The objective of this document is to provide guidance on the identification and mitigation of risks presented by ships' ballast water and sediments, as well as the consequential risks that may arise from ballast water and sediments management[1] (BWM). The document supplements the guidance contained in the BWM Convention and other publications in the GloBallast Monograph Series.

The scope of the document includes:

- background information on the unintentional introduction of alien species;
- principal components of the BWM Convention;
- the definition of terms, concepts and principles relating to risk management;
- an introduction to risk assessment and mitigation methods;
- the application of these methods in the context of aquatic species translocations as well as BWM;
- roles and practices of the Flag, Coastal and Port State in BWM.

The document focuses only on ballast water and sediments and does not address other **pathways**[2] for **alien species**[3] transfer, i.e. **biofouling**[4], **sewage**[5], etc.

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1 "Ballast water management means mechanical, physical, chemical, and biological processes, either singularly or in combination, to remove, render harmless, or avoid the uptake or discharge of harmful aquatic organisms and pathogens within ballast water and sediments" (IMO, 2004a).

2 A pathway is "any means that allows the entry or spread of a pest" (FAO, 2005).

3 An alien species is "a species, subspecies, or lower taxon introduced outside its normal past or present distribution. Synonyms : introduced species, non-native, non-indigenous, exotic" (Koike, Clout, Kawamichi, De Poorter & Iwatsuki, 2006).

4 "Biofouling means the accumulation of aquatic organisms such as micro-organisms, plants and animals on surfaces and structures immersed in or exposed to the aquatic environment. Biofouling can include microfouling and macrofouling" (IMO, 2011b). Biofouling may also be known as hull fouling.

5 "Sewage means drainage and other wastes from any form of toilets and urinals; drainage from medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs and scuppers located in such premises; drainage from spaces containing living animals; or other waste waters when mixed with the drainages defined above" (IMO, 2003b).

1.1 OVERVIEW OF THE ISSUES RELATING TO THE TRANSFER OF HARMFUL ORGANISMS, AS WELL AS THE MANAGEMENT OF BALLAST WATER AND SEDIMENTS

Biological invasions are a significant threat to the ecology and biodiversity of areas where they occur. **Invasive species**[6] are extending their ranges throughout the world and one new marine biological invasion is reported every nine weeks (IOC-UNESCO, IMO, FAO & UNDP, 2011). Once non-indigenous species have become established in a new environment, it is generally impossible to eradicate them.

Impacts on human and animal **health**[7], the environment and socio-economic activities appear gradually – e.g. disruption in ecosystem balance, food web disturbance, **habitat**[8] deterioration, disappearance of **native species**[9], decline in fisheries and disease epidemics.

Aquatic organisms and pathogens are transferred from one **biogeographic region**[10] to another over natural barriers – continents, differences in salinity or temperature – by various means of transport and other **vectors**[11].

In the late 1980s, several countries addressed the issue of invasive species through national legislation. The measures were in response to reported impacts of biological invasions on human and animal health, the environment and coastal activities, taking into account the **visible effects** of biological invasions and their likely causes.

Figure 1 illustrates the logic flow used in establishing these causes, showing that shipping activities can be important vectors of alien species.

6 "Invasive aquatic species means a species which may pose threats to human, animal and plant life, economic and cultural activities and the aquatic environment" (IMO, 2011b).

7 "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2006b).

8 Habitat designates "a geographic area that can provide for the key activities of life – the place or type of site in which an organism naturally occurs" (UNESCO, 2009).

9 A native species is "a species, subspecies, or lower taxon, living within its natural range – past or present – including the area which it can reach and occupy using natural dispersal out of its natural range even if it is seldom found there" (Koike, et al., 2006).

10 A biogeographic region is a "large natural region defined by physiographic and biologic characteristics within which the animal and plant species show a high degree of similarity. There are no sharp and absolute boundaries but rather more or less clearly expressed transition zones" (IMO, 2007c).

11 A vector is a "physical means or agent by which a species is transported" (Carlton, 2001).

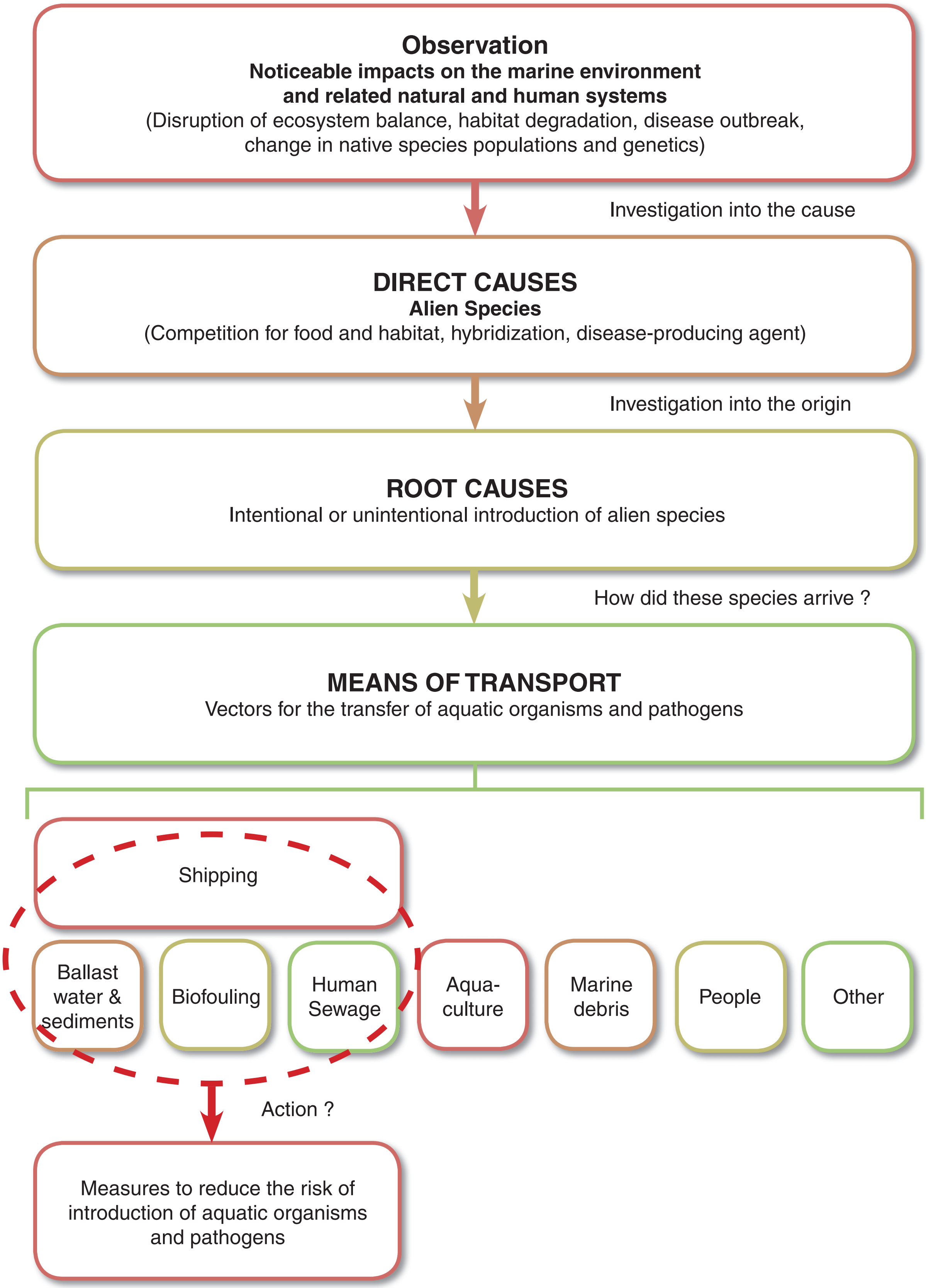

Figure 1: Identification of the causes responsible for damage to the marine environment and related natural and human systems

1.1.1 Ballast water – origins of the issue

By nature of their design, most ships must carry seawater in **ballast tanks**[12] to maintain seaworthy conditions.

Ballast water can be fresh, brackish – i.e. mixture of fresh and seawater – or seawater pumped into ships' tanks.

Ballast water can also be **a mix of waters coming from various sources, depending on the ship's operational constraints**.

During ship transit, a settling process takes place in ballast tanks whereby some aquatic organisms – including fish eggs, larvae and algal cysts – and other suspended particulate matter (SPM) sink and accumulate **on the bottom, as well as on transverse and longitudinal elements that form part of the ship's architecture** (figure 2). Thus, a consequence of sedimentation is organism **concentration**.

The aggregate settled organic material also provides a source of food for micro-organisms.

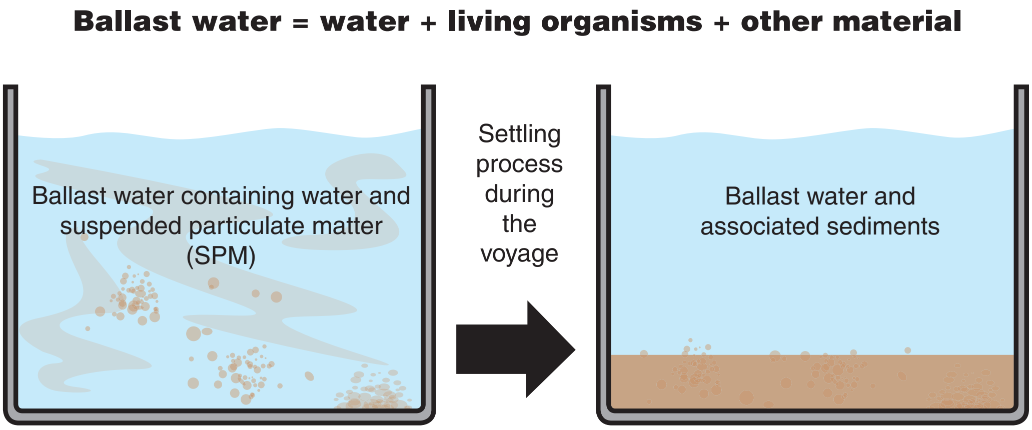

Figure 2: Settling process in ballast tanks

The presence of horizontal surfaces e.g. side frames, bottom longitudinal floor, side girder and stiffeners, contributes to the accumulation of sediment layers and makes it **difficult to get to and work inside ballast tanks which are** inherently **hazardous enclosed spaces.**

While ballast water uptake and discharge operations are mostly performed in ports, they can also occur at sea. In most cases, ballast water consists predominantly of coastal water which tends to support more abundant and diverse populations of phytoplankton and zooplankton than water from the open ocean.

The diversity of organisms conveyed by a ship is related to the geographic range of its trade routes. When species are able to survive the voyage and reach a new biogeographic region, their release in ballast water creates a hazard.

The IMO has addressed the risk of introducing non-native species through ballast water and sediments with the adoption of the **International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention)**.

The Convention requires that ballast water is managed in accordance with certain standards (Regulations D-1 and D-2) so as to reduce the risk of invasions of non-native species from ballast water discharges. These standards have been set at very low levels of organism size and density to mitigate the risk of invasions. However, it should be noted that the BWM Convention is based on risk reduction not risk

[12] A ballast tank is "a tank in the hold of the ship that can be pumped full of or free from water ballast" (Websters' Dictionary, 1993).

elimination. The BWM Convention also requires that all **ballast water management systems**[13] (BWMSs) "must be safe in terms of the ship, its equipment and the crew" (Regulation D-3.3).

New technologies and practices introduce new hazards: this calls for an **assessment of risks** and, if needed, **mitigation measures**.

In addition to the environmental risks associated with ballast water discharges and sediments disposal, the management of ballast water and sediments requires consideration of risks to the safety of ships and their crews as well as **public health risks**[14] and financial risks. Although some of these risks may be interrelated, for present purposes they will be split into two categories, as shown in Figure 3.

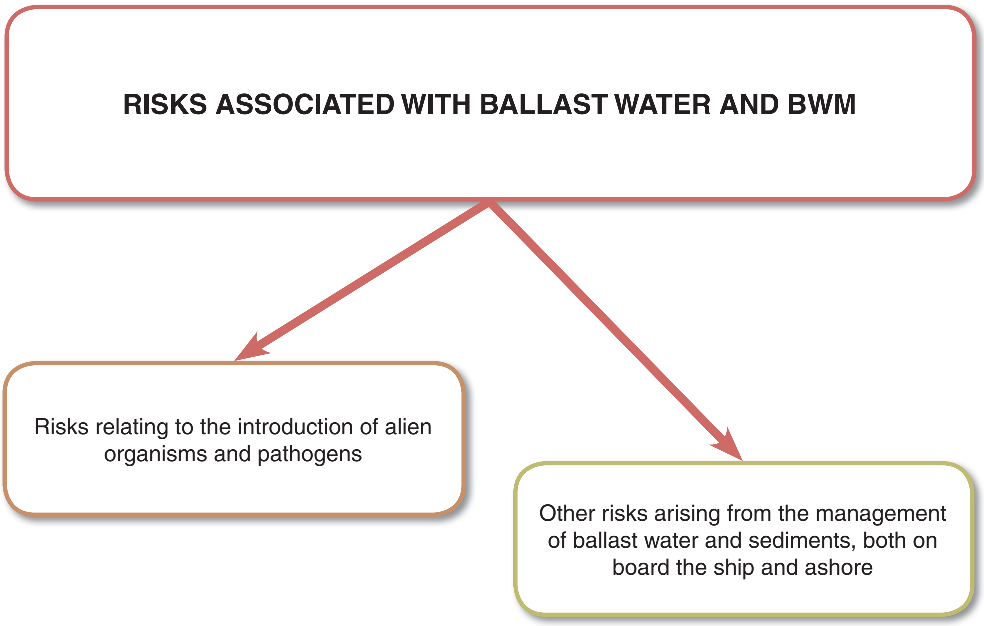

Figure 3: Risks to be considered with regard to ballast water and BWM

Hence, the assessment of risks associated with organism transfer and ballast water and sediments management must embrace biological, physical and social sciences, both to identify potential hazards as well as the circumstances in which hazards present particular degrees of risk, thereby to enable development of mitigation strategies.

1.1.2 International response to the issue of alien species

Regulations to prevent environmental damage are seldom drawn up before an accident occurs and are rarely binding. International environmental protection regulations tend to be stimulated by evidence of damage (i.e. **visible impacts** and **social perception** are important triggers for the initiation of a regulatory response).

Since the United Nations Conference on the Human Environment (Stockholm, June 1972), United Nations (UN) bodies and agencies have developed a global agenda to protect the environment.

In 1992, during the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, a number of multilateral agreements relevant to the BWM Convention were adopted:

- The Convention on Biological Diversity (CBD);
- The Agenda 21 Action Plan; and
- The Rio Declaration on Environment and Development.

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[13] "Ballast Water Management System (BWMS) means any system which processes ballast water such that it meets or exceeds the ballast water performance standard in regulation D-2. The BWMS includes ballast water treatment equipment, all associated control equipment, monitoring equipment and sampling facilities" (IMO, 2008a).

[14] 'Public health risk' means "a likelihood of an event that may affect adversely the health of human populations, with an emphasis on one which may spread internationally or may present a serious and direct danger" (WHO, 2008).

The IMO developed in parallel several instruments to minimize the negative impacts of shipping on the environment. The most significant ones are highlighted in Figure 4.

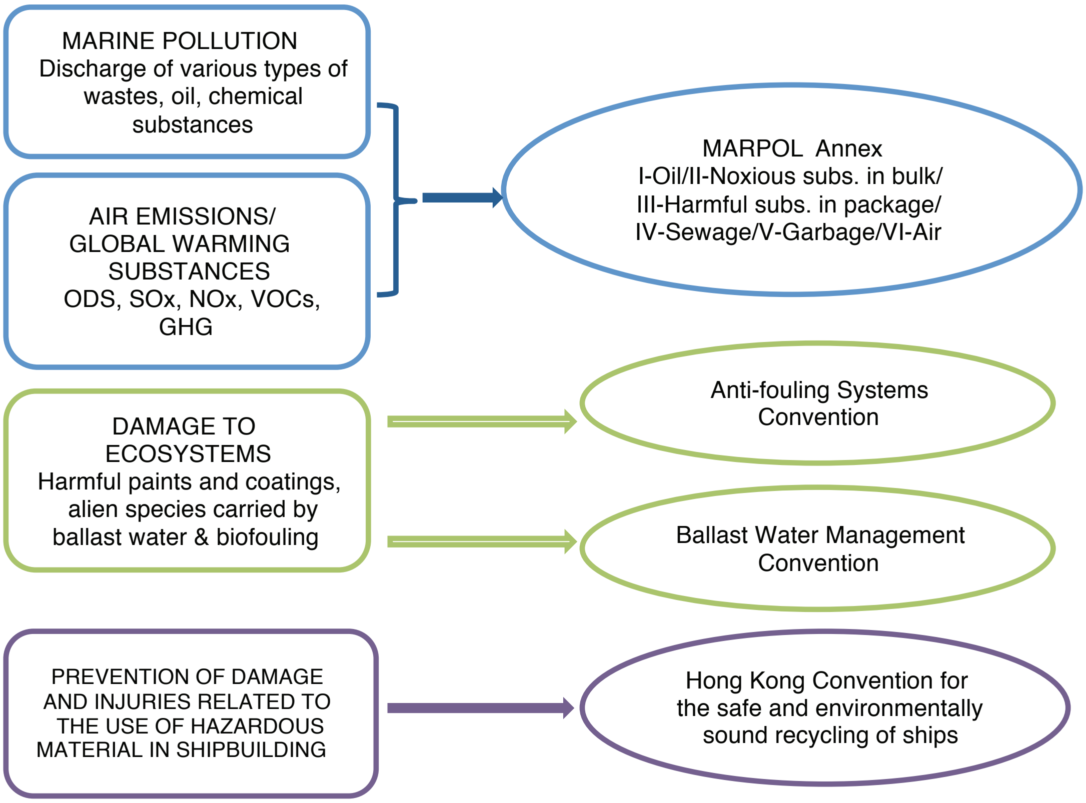

Figure 4: IMO instruments intended to minimize the impacts of shipping on the environment

The regulatory framework for BWM rests on three pillars:

- General environmental protection conventions and principles;
- Environmental protection instruments specific to the marine environment;
- Rules and standards applicable to international shipping.

Each pillar is made up of a set of measures designed to provide a cohesive approach to global issues.

At the international level, a variety of measures address the numerous interrelated aspects of risk management as it relates to the transfer of organisms through ships' ballast water and sediments:

- Marine environment protection and biodiversity conservation;
- Safety of ships;
- Occupational safety and health;
- Maritime training;
- Marine resources management, animal health and seafood safety;
- Water safety and public health protection; and
- Marine research.

Most of these measures emanate from UN specialized agencies which have specific, and complementary, roles and mandates. An overview of their respective roles is given in Figure 5.

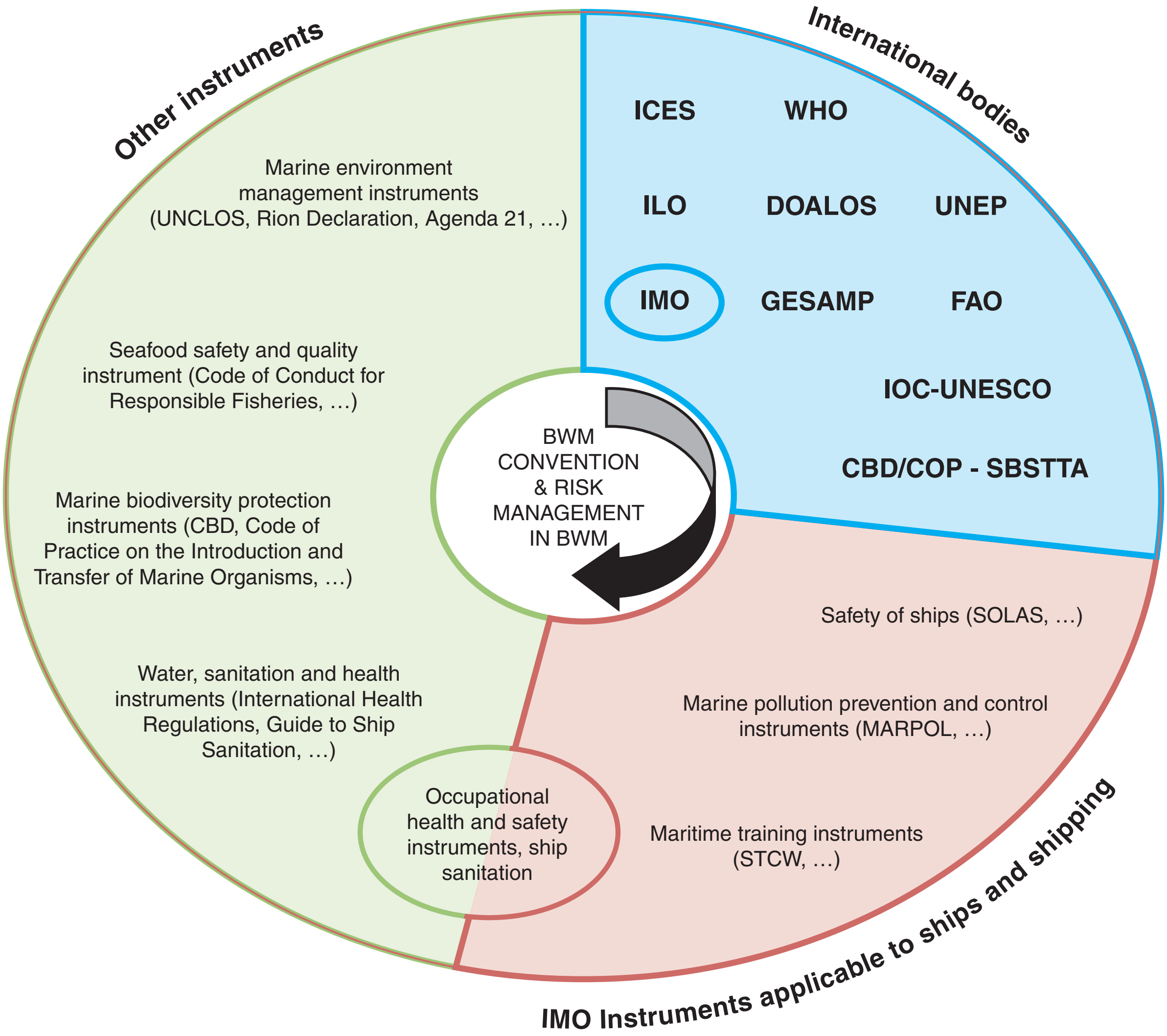

Figure 5: International bodies and instruments addressing the risks associated with species translocation and BWM

The main instrument regulating the introduction of alien species by ships' ballast water and sediments is the **BWM Convention**.

1.1.3 Importance of regional cooperation and technical assistance in environmental protection

In the environmental field, multilateral conventions and other instruments encourage States to cooperate.

The United Nations Environment Programme (UNEP) has promoted regional cooperation, including partnerships, as well as the transfer of knowledge and technology among countries.

Both the United Nations Convention on the Law of the Sea[15] (UNCLOS) and the BWM Convention[16] promote regional cooperation and technical assistance among States. Regional cooperation and coordination are strongly supported by the GEF-UNDP-IMO GloBallast Partnerships Programme.

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[15] UNCLOS Articles 197, 200, 201, 202 and 203.
[16] BWM Convention Articles 6 and 13.

Cooperation among States may consist of, *inter alia*:

- **assessing risks;**
- establishing a **consultative process** – e.g. exchange of information, creation of regional strategies to protect the marine environment, harmonization of national regulations and risk mitigation measures;
- **training, education and awareness-raising** for seafarers, enforcement personnel, port workers, etc.;
- **sharing knowledge and experience** – e.g. ballast water sampling and analysis, ballast water treatment, chemical spill emergency response;
- establishing **joint scientific research and monitoring programmes**;
- **pooling of equipment** – e.g. port-based reception and treatment facilities;
- **designating a marine protected area**;
- **designating Ballast Water Exchange (BWE) areas**;
- **improvements in national capacity-building**.

1.2 THE BWM CONVENTION AS A RISK MANAGEMENT TOOL

In 1988, Canada reported to the IMO on the threat posed by the transfer of harmful organisms through ballast water discharges to the Great Lakes (Fofonoff, Ruiz, Steves & Carlton, 2003; IMO, 2004a).

The environmental **hazards** posed by organisms in the ships' ballast water and sediments were **established**.

Because of the international nature of shipping, action to address this issue needed to be taken at the global level despite the existence of various national regulations. This prompted the IMO to adopt *Guidelines for preventing the introduction of unwanted aquatic organisms and pathogens from ships' ballast water and sediments discharges* (IMO, 1991).

In parallel with the efforts of the maritime community to address the issue of transfer of marine alien species, the Convention on Biological Diversity (CBD), adopted in Rio in 1992, set out broad commitments for the conservation of biodiversity. In addition, UNCED formally **recognized the global environmental risks** caused by the transfer of aquatic organisms through ballast water and assigned the issue to the IMO[17]. Thus, the potential of introduced species to adversely affect the biodiversity of receiving environments was firmly acknowledged.

Subsequently, the *Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens* (IMO, 1997b) and the BWM Convention both recognized the relevance of the CBD through explicit references in their preambles.

Adopted on 13 February 2004 at a Conference held in London, the BWM Convention resulted from a long and complex process of multilateral consultation and negotiation

The Convention contains twenty-two Articles and one Annex, which consists of twenty-four technical Regulations, classified in five sections:

- Section A: general provisions;
- Section B: management and control requirements for ships;
- Section C: special requirements in certain areas;
- Section D: standards for ballast water management; and
- Section E: survey and certification requirements for ballast water management.

[17] Agenda 21 Paragraph 17.30 reads "States, acting individually, bilaterally, regionally or multilaterally and within the framework of IMO and other relevant international organizations, whether subregional, regional or global, as appropriate, should assess the need for additional measures to address degradation of the marine environment from shipping, by considering the adoption of appropriate rules on ballast water discharge to prevent the spread of non-indigenous organisms".

The standards set out in the Regulations have the same force and effect as the Articles contained in the main text of the Convention[18] – i.e. they are **legally binding**.

Two Appendices supplement the Convention:

- Appendix I: form of International Ballast Water Management Certificate; and
- Appendix II: form of Ballast Water Record Book.

A set of fourteen guidelines was developed to provide technical recommendations and secure effective implementation and uniform interpretation of the Convention (table 1).

Table 1: Guidelines associated with the BWM Convention

Guideline	Subject
G1	Guidelines for sediment reception facilities
G2	Guidelines for ballast water sampling
G3	Guidelines for ballast water management equivalent compliance
G4	Guidelines for ballast water management and development of ballast water management plans
G5	Guidelines for ballast water reception facilities
G6	Guidelines for ballast water exchange
G7	Guidelines for risk assessment under Regulation A-4 of the BWM Convention
G8	Guidelines for approval of ballast water management systems
G9	Procedure for approval of ballast water management systems that make use of active substances
G10	Guidelines for approval and oversight of prototype ballast water treatment technology programmes
G11	Guidelines for ballast water exchange design and construction standards
G12	Guidelines on design and construction to facilitate sediment control on ships
G13	Guidelines for additional measures regarding ballast water management including emergency situations
G14	Guidelines on designation of areas for ballast water exchange

Although the Convention stipulates that States should refer to the guidelines, **these guidelines are not mandatory**.

In addition to the Convention Guidelines, IMO, in accordance with advice from the Group of Experts on the Scientific Aspects of Marine Protection (GESAMP), has issued a number of **circulars** and guidelines, some of which address the assessment of risks – e.g. *Guidance to ensure safe handling and storage of chemicals and preparations used to treat ballast water and the development of safety procedures for risks to the ship and crew resulting from the treatment process* (IMO, 2009a) and *Guidance document on arrangements for responding to emergency situations involving ballast water operations* (IMO, 2008b).

The Convention aims to reduce the risks arising from the transfer of harmful aquatic organisms and pathogens by ships' ballast water and sediments. This implicitly recognizes that, in the context of current shipping practices, the elimination of all such risks is impossible. Thus, Regulation D-2 sets out goals designed to achieve 'negligible risks'.

In accordance with a risk-based management approach, **the BWM Convention can be viewed as a set of barriers** elaborated to fulfill two objectives:

- Prevent, minimize and *ultimately eliminate* **the risks emanating from the transfer** of alien organisms and pathogens which can affect human and animal health, the environment and socio-economic activities;
- **Avoid unwanted side-effects from the control and management of ships' ballast water and sediments**, i.e. ensure BWM practices will not cause greater harm than they prevent.

[18] BWM Convention Article 2.2.

1.2.1 Provisions to address ballast water threats

The requirements of the Convention apply to all **ships**[19] engaged in international traffic carrying ballast water, without reference to tonnage, as well as to **floating platforms**.

Exemptions may be granted on a case-by-case basis to ships sailing between specified ports or locations (Regulation A-4); case studies are presented in Chapters 3.2 & 3.3. A **risk assessment** must be executed in support of application for exemption. The methods of how this should be done are presently being discussed by the member States of the IMO and different models are being considered. These range from an initial risk assessment by the **shipowner/operator or groups of shipowners/ship operators** followed by the **Port State** evaluating the risks before approval, to more complicated models being developed in some regional sea areas.

The BWM Convention provides various ballast water management options (figure 6):

- BWE (Regulations B-4 and D-1);
- Performance Standards to achieve (Regulation D-2), applicable *inter alia* to Ballast Water Treatment (BWT);
- Isolation, i.e. either discharge of ballast water to a port reception facility or at the place from which it originates (Regulation B-3);
- Retention of ballast water on board, whenever possible.

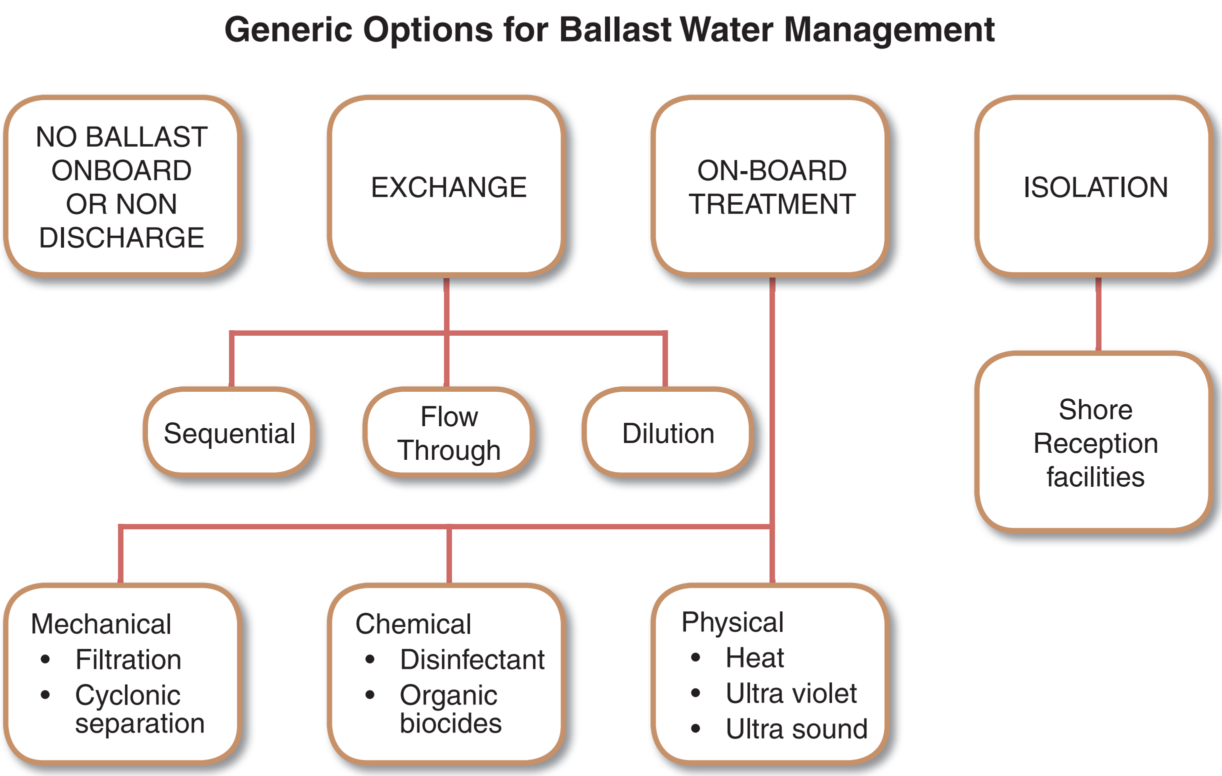

Figure 6: Ballast water management options
(Source: GloBallast Partnerships, Introductory Training Course)

It is noteworthy that **BWE is geographically limited** by two conditions (Regulation B-4):

- **Distance** of 200 nautical miles from the shore, to replace coastal waters by open-ocean waters and thus to remove coastal organisms; and

[19] "Ship means a vessel of any type whatsoever operating in the aquatic environment and includes submersibles, floating craft, floating platforms, FSUs and FPSOs" (IMO, 2004b).

- **Water depth** of 200 meters, which is beyond the limit of the photic zone[20] – i.e. the depth to which sunlight can penetrate, and of the thermocline which restricts water movement between the surface and the seafloor, depriving some species of the habitat they need.

In cases where the distance requirement cannot be met, it is permissible to perform BWE at a distance of 50 nautical miles from the shore.

It should be stressed that BWE is a **temporary risk reduction measure** (Carlton as cited in Committee on Transportation and Infrastructure, 2011). BWE was introduced to reduce the risk of invasions during the period needed for BWMSs to be further developed so that ships will achieve the stringent Ballast Water Performance Standard (Regulation D-2). Indeed, it is widely accepted that BWE "does not provide an adequate level of environmental protection and that it can be dangerous for vessels and crews" (King & Tamburri, 2010).

The second BWM option, namely the **treatment of ballast water with onboard systems**, is considered to be the ultimate management technique.

Once the BWM Convention comes into force, ships will be required to comply with the D-2 Standard (Regulation D-2) which sets limits on the number of viable organisms allowed in treated ballast water discharges. The actual application dates depend on the ballast water capacity and the construction date of the vessel; these can be found in Regulation B-3 of the BWM Convention. The implementation schedule was streamlined in 2007 through an Assembly resolution (IMO, 2007d) and has been reexamined at MEPC 65 (IMO, 2013a).

Treatment can be carried out using mechanical, physical, chemical or biological processes. In practice, most BWMSs use a combination of methods because no single technology is entirely effective against the great diversity of organisms.

Sediments management involves the removal of settled material from the ballast tanks and its discharge:

- **to a shore-based reception facility:** Port States are obliged to provide suitable equipment in ports and terminals where ballast tanks are cleaned and repaired[21].
- **at sea:** according to the *Guidelines for Ballast Water Management and Development of Ballast Water Management Plans (G4)*, disposal of sediments has to take place in areas outside 200 nautical miles from land and in water depths over 200 meters (IMO, 2005).

The Convention requires the development and implementation of a **Ballast Water Management Plan** (Regulation B-1), describing the methods used on board to mitigate the risks associated with ballast water and sediments, as well as their management. It must be ship-specific and approved by the Flag State.

Ships must undergo surveys performed by the Flag State and compliant vessels are issued with an **International Ballast Water Management Certificate** (Article 7). Ballast water uptakes and discharges must be set down in a **Ballast Water Record Book** (Regulation B-2). The Convention also requires the designation of a responsible officer (Regulation B-1.5).

In waters under their jurisdiction, Port and Coastal States must **monitor the effects of ballast water and sediments management** (Article 6) – this ecological monitoring allows early detection of ecosystem disturbance.

Port States may **inspect ships** while in ports or offshore terminals to verify compliance with the requirements of the BWM Convention. Such inspections include the verification of the International Ballast Water Management Certificate, the Ballast Water Record Book and/or sampling of ballast water (Article 9).

Flag States must determine **equivalent compliance** requirements for pleasure craft and search and rescue boats (Regulation A-5).

1.2.2 Provisions to ensure harmlessness of BWM methods

The Convention requires that BWMSs "must be safe in terms of the ship, its equipment and the crew" (Regulation D-3.3). This provision establishes the **need for risk appraisal and management** with respect to the approval, installation and operation of a BWMS on board a ship. Appropriate guidelines on

[20] In practice, this limit may vary in accordance with the turbidity of the water.
[21] BWM Convention Article 5.

this issue have been provided by the IMO in *Guidance to ensure safe handling and storage of chemicals and preparations used to treat ballast water and the development of safety procedures for risks to the ship and crew resulting from the treatment process* (IMO, 2009a). This topic is integral to the assessments provided to IMO by the GESAMP Ballast Water Working Group (BWWG) for approval, as outlined in Guideline G9.

This clearly demonstrates that, in accordance with Regulation D-3.3, **the BWM Convention does not restrict its requirements regarding risk assessment solely to environmental risks**.

The Flag State has an obligation to put adequate human, equipment and organizational barriers in place to reduce risks. This entails proper training for seafarers in the use of hazardous chemicals, as well as the operation and monitoring of BWMSs (IMO, 2009a), the type approval of BWMSs (Regulation D-3) and the verification that ship-specific health and safety procedures have been developed (IMO, 2009a).

The need for risk assessment is either **explicitly required** by the BWM Convention, for example prior to the granting of exemptions, **or <u>implied</u>** in the light of Convention requirements.

The provisions of the BWM Convention regarding risk assessment, with reference to the responsible private and public **stakeholders**[22], are summarized in Annex A.

In the event that hazards and risks are identified, and then assessed, the Convention requires[23] that mitigation measures be put in place to eliminate or reduce them. These measures are intended to minimize the potential for harm to the ship, human health and the environment.

1.3 BASICS OF RISK MANAGEMENT

In this document we define risk as ***the probability that a hazard will lead to loss, or injury/damage to life, property or the environment; it requires knowledge of the extent of exposure to the hazard concerned***.

The **risk concept,** and **risk management**[24] techniques including risk assessment, have been used successfully in various fields to support decision-making e.g. in economics, safety science and environmental protection. However, different fields tend to apply their own particular techniques and paradigms to handle the concept of risk, which may create misunderstanding. Risk is sometimes considered to be a **relative and subjective notion**, dependent on analyst interpretations and systems of reference. On the other hand, risk management refers to a series of concrete measures and actions.

Risk assessment is a mainly scientific process for analyzing risks and not an end in itself. It establishes the magnitude and variety of risks and whether and how risks should be suppressed, avoided, reduced or accepted (OECD, 2003b). This process includes identifying options for risk mitigation. Finally, risk assessments inform officials responsible for managing risks, defining policies and implementing mitigation measures.

Risk managers should carefully consider the results of risk assessments, which constitute scientific decision-making support. In addition, the managers should compare all viable options for the introduction of preventive/protective measures (e.g. barriers) with particular attention to efficiency and cost. The constraints imposed by social structures may limit choices and influence the nature and location of barriers. Risk management will also involve **communication of risks** to those affected.

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22 Stakeholders are "socially organized groups that are or will be affected by the outcome of the event or the activity from which the risk originates and/or by the risk management options taken to counter the risk" (IRGC, 2005).

23 Parties to the BWM Convention have committed themselves to "prevent, minimize and ultimately eliminate the risks to the environment, human health, property and resources arising from the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments, as well as to avoid unwanted side-effects from that control and to encourage developments in related knowledge and technology".

In addition, Article 2.7 states that "Parties should ensure that ballast water management practices used to comply with this Convention do not cause greater harm than they prevent to their environment, human health, property or resources, or those of other States".

24 "Risk management refers to the creation and evaluation of options for initiating or changing human activities or (natural and artificial) structures with the objective being to increase the net benefit to human society and prevent harm to humans and what they value" (IRGC, 2005).

The following diagram (figure 7) details the various steps to consider while implementing a risk management strategy, encompassing both risk assessment and risk mitigation.

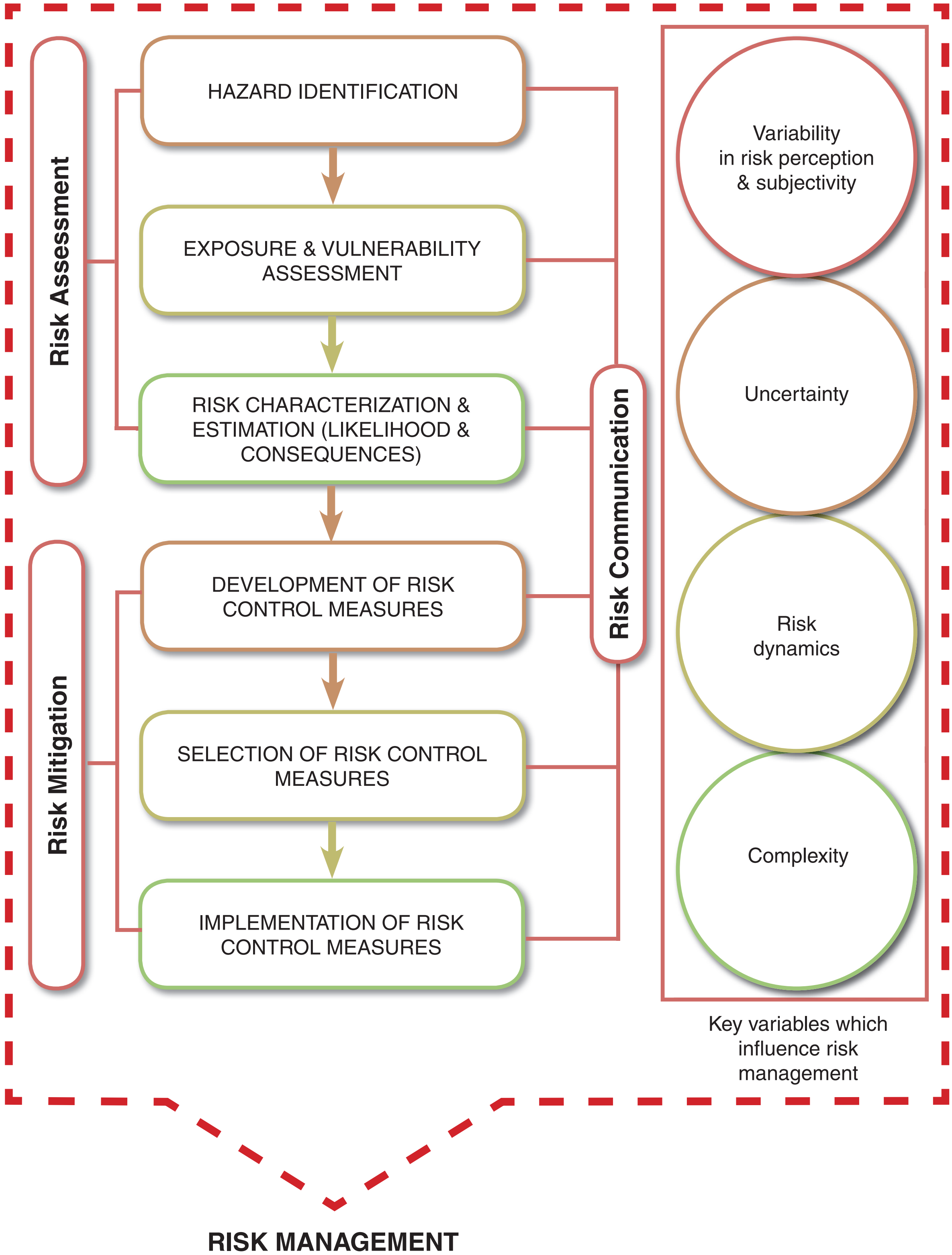

Figure 7: A step-by-step approach to risk management

A concise description of the steps forming the risk management process presented in Figure 7 is given below.

1.3.1 Risk assessment phase

Hazard identification

Hazards[25] are intrinsic properties or conditions which may jeopardize safety and cause someone or something to be harmed. Hazards vary in nature and may have cumulative/synergistic effects. Although hazards are latent – either visible or invisible – and need particular conditions to become active, they are nevertheless **dynamic** (i.e. constantly changing) in temporal, spatial and social terms. Hazard identification constitutes the referential structure of risk approaches. Therefore, the completeness and accuracy of this identification step determine the overall quality of the approach.

Exposure and vulnerability assessment

Depending on the **context** in which an event takes place, it may have different impacts.

It is important to establish the sensitivity of the system to the hazard – i.e. the extent to which it can be damaged. This sensitivity is as much a function of the **exposure**[26] of the system as its **vulnerability**[27] to the hazard concerned. Exposure is a function of **ambient environmental** conditions. Both exposure and vulnerability may change over time.

Risk characterization and estimation

Any hazard will present some element of risk – but the magnitude of the risk will always depend on the degree of exposure to that hazard. In other words, hazards may be contained, but not eliminated. The combination of a **hazard** – latent condition – and an **active failure**[28] can have **negative consequences**. Risk assessment needs to focus on a specific hazard under the most pessimistic set of circumstances – to minimize uncertainty – and must then estimate the probability that these circumstances will occur. This is the scientific contribution to the risk management process.

Risks are usually weighed by means of:

- **quantitative methods**, based on numerical values;
- **semi-quantitative methods**, using a scoring system;
- **qualitative methods**, based on expert and open judgments;
- a **combination of these methods**, using complementary approaches to cross-check estimates and reduce uncertainty.

Consequently, in the process of assessing risks, risk analysts may employ mathematical, graphical and verbal forms of reasoning. Examples of models and approaches that have been investigated for possible use in ballast water risk assessment are shown in Annex B and key considerations in undertaking these assessments are listed in Annex C.

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[25] A hazard is an unsafe latent situation "with the potential of causing injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform a prescribed function" (Maragakis, Clark, Piers, Prior, Tripaldi, Masson & Audard, 2009).

[26] The exposure of a system is the contact that its elements have with the hazard (IRGC, 2005).

[27] Vulnerability means "the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a [system] to the impact of hazards" (United Nations, 2004).

[28] "Active failures are actions or inactions, including errors and violations, which have an immediate adverse effect" (ICAO, 2012).

1.3.2 Risk mitigation phase

Risk mitigation may be seen as a means to ensure and restore the **safety**[29] of a system through the implementation of adequate contrivances. It is an active process which explores all options for reducing or eliminating identified risks and **develops appropriate risk control measures**.

It involves putting defenses or **barriers**[30] in place either before (prevention) and/or after (protection) a failure or harmful exposure occurs. The aim is to reduce or eliminate exposure and vulnerability to the hazard. The more numerous and complementary the barriers are, the more protected and safe the system will be.

Reason (1997) designed a model, called the **Reason model** or **Swiss cheese model** (Figure 8) to show that even though a system may include several defenses in successive layers, it will always contain weaknesses and gaps.

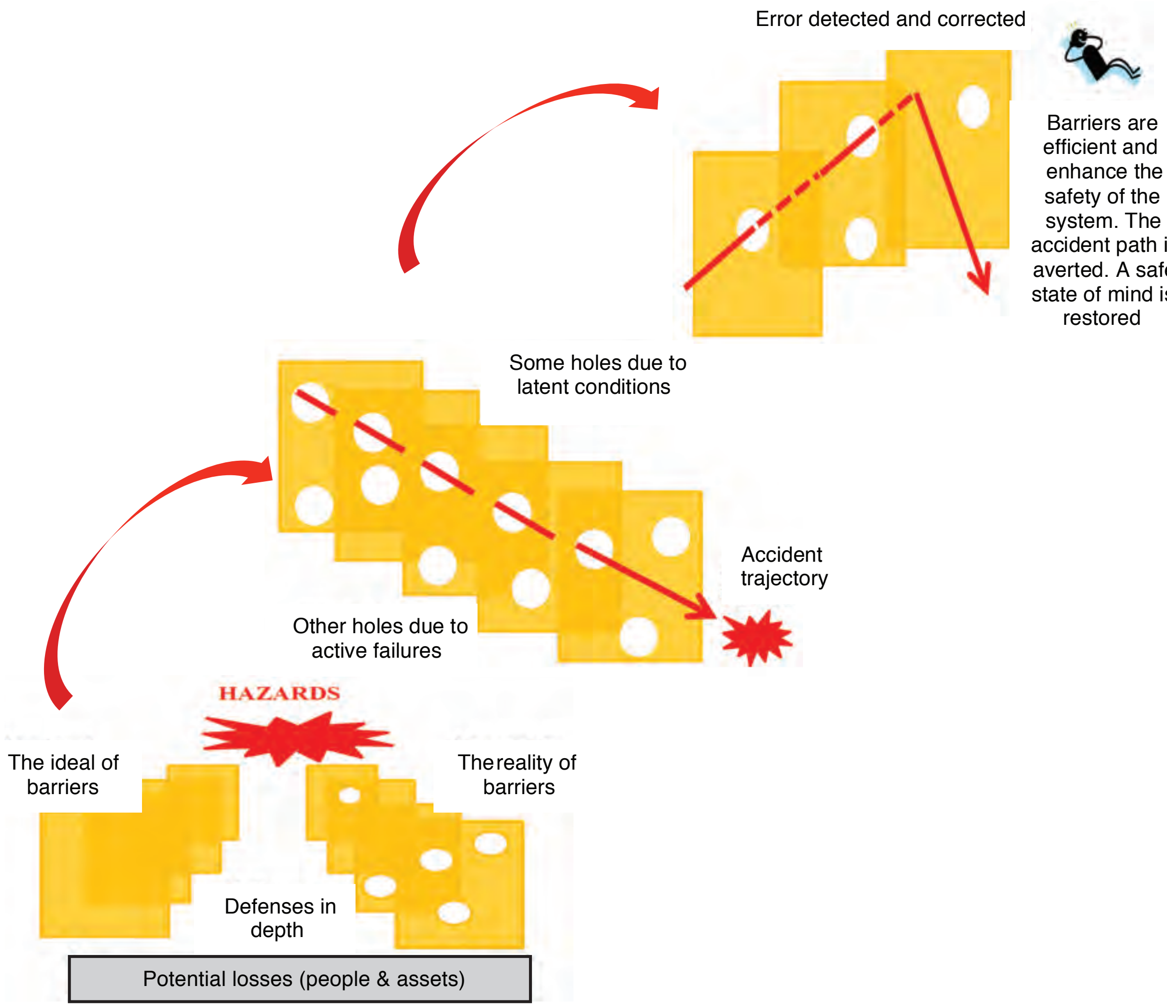

Figure 8: Safety management (Adapted from Reason, 1997 & ICAO, 2012)

Whereas risk control measures incur immediate expenditures, their benefits develop over time. Accordingly, **selection of risk mitigation and control measures** will normally require **cost-benefit analysis (CBA)** and **socio-economic decisions**. The costs involved in reducing risks will determine risk acceptance. As Hollnagel (2008a) states: “A risk is unacceptable as long as [an] organization can afford to eliminate it”. Safety is therefore contingent on the price society, or industry, is willing to pay to maintain it. An increase in

[29] Safety designates “the state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management” (ICAO, 2012).

[30] A barrier is “something that can either prevent an event from taking place or protect against its consequences” (Hollnagel, 2004).

competitive pressure might result in the reduction of safety budgets, which in turn leads to poorer safety performance (OECD, 2003b).

To ensure risk control measures produce the result intended, **proper implementation and monitoring mechanisms are required** that will initiate and perpetuate a process of continuous improvement.

Periodic monitoring of biological conditions in high-risk areas, as well as constant supervision of BWM procedures used in major ports, will provide essential feedback on the adequacy of measures implemented to date.

In controlling risks, opportunities should be provided to stakeholders (i.e. those subject to the hazards and risks concerned as well as those with related interests and responsibilities) to participate in the design, selection and implementation of risk mitigation measures. Imparting knowledge to the public enables individuals and communities to support risk analysis and make sound judgments.

The vulnerability of a community to hazards can be reduced through **preparedness**[31] – i.e. awareness, emergency planning, drills, surveillance, education and training.

1.3.3 Considerations in risk management

Risk managers inevitably will face difficulties due to the complexity of the system being managed and differences in human perception, interpretation and understanding of risks. Such difficulties can be reduced by ensuring that those responsible for risk assessment have given adequate consideration to the temporal variability of hazards and exposures, the subjectivity inherent in risk estimation and the uncertainty associated with conclusions and recommendations arising from the assessment process. The limitations of the risk concept should not be used to justify a rejection of risk management techniques.

1.4 SUMMARY

Shipping is one source of unwanted aquatic organisms. Ballast water acts as a vector for such organisms while, at the same time being absolutely essential to the safe and efficient operation of today's ships.

- Ballast water constitutes a hazard to human health, the environment and coast-dependent activities;
- The risks associated with ballast water transport stimulated the international community to provide a global response by way of a legally binding instrument, namely the Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004;
- The BWM Convention provides management and control measures – i.e. barriers – to reduce the transfer of alien organisms in ballast water tanks ;
- Ballast water management practices, however, may have negative and unexpected consequences for human and animal health, ship safety and the environment.

A comprehensive risk management strategy is therefore needed to prevent ballast water from causing harm and to avoid the negative side-effects of ballast water and sediments management.

- Risk mitigation strategies must be adaptable and continually strive for improved reliability.

[31] 'Preparedness' relates to "activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings (…)" (UN, 2004).

2

Analyzing risks associated with the transfer of harmful organisms and the management of ballast water and sediments

The risks associated with the transfer of harmful organisms and the management of ballast water and sediments should be assessed **systematically** in order to expose the complex interactions between human activities and the environments affected. This is in accordance with the 'human-in-nature' approach which puts an emphasis on social system and natural system interconnections (Berkes & Folke, 2000).

After a brief description of the systems involved – i.e. marine ecosystems and ships, the present Chapter outlines the risks associated with the transfer of harmful organisms and the management of ballast water and sediments.

The following Figure 9 illustrates the principal interactions between human activities and marine ecosystems.

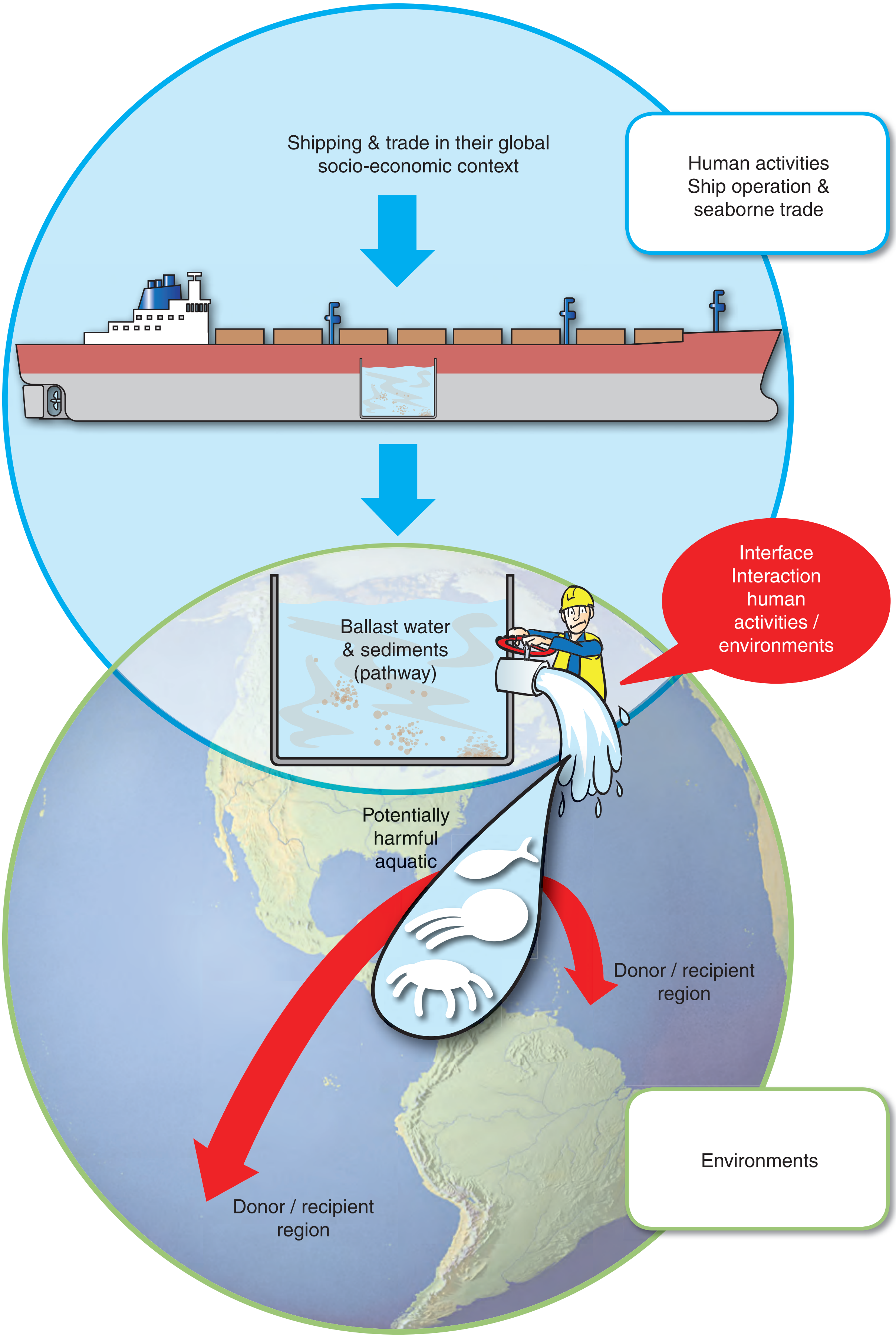

Figure 9: The transfer of ballast water entails interactions between human activities and the water environment

2.1 DESCRIPTION OF COMPONENT SYSTEMS AND THEIR INTERACTIONS

The approach for identifying, characterizing and understanding the risks in BWM starts with defining the main component systems involved in the transport of alien species i.e. the **donor biogeographic region**, the **ship** and the **recipient biogeographic region**.

2.1.1 Donor/recipient biogeographic region

For the purpose of this Section, 'donor biogeographic region' and 'recipient biogeographic region' are used interchangeably because they can be viewed as two sides of the same coin.

One way to describe the characteristics of a particular marine area or ecosystem (Box 1) is to divide the surface of the globe into portions or ecological units which have similar environmental and biological features. This process is called **biogeographic classification**[32]. It combines information on marine organisms, their distribution and associated biophysical parameters, and provides an appropriate framework for ecosystem-based management (UNESCO-IOC, 2009).

Box 1: Characteristics of an ecosystem

The key features of an ecosystem can be summarized in five points:

1. An ecosystem exists in a space with boundaries that may or may not be explicitly delineated. Ecosystems are distinguishable from each other based on their biophysical attributes and their locations.
2. An ecosystem includes both living organisms and their abiotic environment, including pools of organic and inorganic materials.
3. The organisms interact with each other and interact with the physical environment through fluxes of energy, organic and inorganic materials among the pools.
4. An ecosystem is dynamic: its structure and function change with time.
5. An ecosystem exhibits emergent properties that are characteristic of its type and that are invariant within the domain of existence.

(Source: United Nations General Assembly, 2006)

Ecological units have **no precise boundaries,** do not overlap with fixed social and political subdivisions – fish do not hold passports, nor respect human boundaries! – and can be shared by several countries. Hence, as with many environmental issues, transboundary cooperation is essential. BWM is often better addressed at the **regional level**.

Marine biogeographic regions are open systems in **continuous interplay** with other regions. They are characterized by complex internal and external interactions which provide various services to human society, e.g. **provisioning**[33], **regulating**[34], **cultural**[35] and **supporting**[36] **services** (Millennium Ecosystem Assessment, 2005).

[32] "Biogeographic classification is a classification process that aims to partition a large area into distinct geographical regions that contain groups of plants and animals and physical features that are sufficiently distinct or unique from their surroundings at the chosen scale" (UNEP-WCMC as cited in UNESCO, 2009).

[33] Ecosystem provisioning services provide products such as food, freshwater, genetic resources, etc. (Millennium Ecosystem Assessment, 2005).

[34] Examples of ecosystem regulating services include climate regulation and water purification (Millennium Ecosystem Assessment, 2005).

[35] Ecosystem cultural services provide humans with non-material benefits and make possible activities such as recreation and eco-tourism (Millennium Ecosystem Assessment, 2005).

[36] Ecosystem supporting services designate the services which are necessary for the aforementioned service categories to exist (Millennium Ecosystem Assessment, 2005).

Examples of such interactions and services are given in Table 2.

Table 2: Examples of services and interactions of a marine biogeographic region

Composition	Living and non-living marine resources – among them are protected species. Humans. Hydrological, physical, chemical, biological and socio-economic characteristics – e.g. open, enclosed or semi-enclosed marine area, geographical isolation, salinity, pH, temperature, sunlight, etc.
Internal interactions	Transfer of energy. Trophic interactions – complex food web including several food chains. Reproduction. Diseases. Human activities onshore, nearshore and offshore – e.g. maritime transport, tourism, aquaculture, fishing and industrial activities. Interactions between living things and pollutants, inputs to the marine environment, etc.
External interactions	Weather/climatic events/seasonal effects – e.g. warmer temperatures. Migrations. Air, road and maritime transport. Long-range air and marine pollution, etc.
Services	**Provisioning** • Sustenance of marine life – provision of habitat and food. • Source of water, energy and materials – e.g. fossil fuels, minerals. • Production of marine resources for human sustenance and cure – seafood, medicines, etc. **Regulating** • Climate regulation. • Water filtration/purification, etc. **Cultural** • Provision of amenities such as beaches, etc. **Supporting** • Primary production – phytoplankton is the basis of marine food webs. • Decomposition/degradation of wastes, etc.

The GloBallast Partnerships Programme has identified 204 marine **biogeographic regions**[37] on the basis of the bioregion system devised by the International Union for Conservation of Nature (IUCN). However, other classifications exist, such as **ecoregions**[38] and **Large Marine Ecosystems (LMEs)**[39]. The IMO discussed the concept of using marine biogeographic regions to simplify risk management during the formation of

[37] A biogeographic region is "a large natural region defined by physiographic and biologic characteristics within which the animal and plant species show a high degree of similarity. There are no sharp and absolute boundaries but rather more or less clearly expressed transition zones" (IMO, 2007c).

[38] An ecoregion is defined as an "area of relatively homogeneous species composition, clearly distinct from adjacent systems. The species composition is likely to be determined by the predominance of a small number of ecosystems and/or a distinct suite of oceanographic or topographic features. The dominant biogeographic forcing agents defining the ecoregions vary from location to location but may include isolation, upwelling, nutrient inputs, freshwater influx, temperature regimes, ice regimes, exposure, sediments, currents, and bathymetric or coastal complexity" (Spalding, *et al.*, 2007).

[39] Large Marine Ecosystems (LMEs) are extensive portions of ocean space, covering a surface of 200,000 km^2 or more, and characterized by common physical, chemical and biological parameters such as salinity, currents, temperature, primary productivity and food webs (Sherman, 1993).

the *Guidelines for risk assessment under Regulation A-4 of the BWM Convention* (G7). It is widely assumed that an organism which survives and colonizes one port in a marine biogeographic region has the potential to spread throughout that region. As the definition of biogeographic regions embraces the concept that all non-indigenous species can survive throughout the region, this can simplify risk assessments.

Whatever the ecological unit, the most important step is to characterize the area or ecosystem by identifying its components and their interactions, as well as the goods and services it provides.

2.1.2 Ship and ballast water

For the purpose of the BWM Convention, a ship is defined in Article 1(12) as "a vessel of any type whatsoever operating in the aquatic environment [including] submersibles, floating craft, floating platforms, FSUs and FPSOs" (IMO, 2004b).

The function of ballast water is to counterbalance the changing effects of weight distribution on the vessel structure. The heavy masses (cargo, bunker, spare parts, equipment, etc.) spread along the length of the vessel affect its resistance and stability. Ballast water ensures flexible weight management onboard ships.

Therefore, on today's ships, ballast water tanks are key elements of ship safety. Current ships **are dependent upon** the use of ballast water to ensure proper stability, trim, structural strength, maneuverability, and propeller efficiency – i.e. propeller immersion, especially when travelling without cargo.

From the design stage, ship's operations are constrained by designed structural strength and stability limits. These inherent limits make it impossible or hazardous for some ships to execute BWE (Isbester, 1993). It is expected that changes to the design of ballast tanks of new ships will take into account the risks associated with this technique.

Due to the links between ballast water, stability and structural integrity of the ship, the BWM Convention requires each ship to have a Ballast Water Management Plan (BWMP) (Regulation B-1). Approved by Flag State or Classification Society acting on its behalf, the BWMP details safety and operational procedures applicable to the specific ship and its associated crew. A comprehensive BWMP should encompass all the successive stages of ballast water utilization and consider the risks of transferring marine organisms. Full guidance on the contents of a BWMP can be found in the *Guidelines for Ballast Water Management and development of Ballast Water Management Plans* (G4).

Ballast water capacities[40] depend on ship type. Large tankers and bulk carriers carry the highest ballast water volumes.

On board containerships, ballast water is partially renewed in each port of call (see Box 2). Thus, in comparison with bulk shipping, **liner shipping inoculates coastal ecosystems with ballast water discharges at far higher frequencies.**

[40] "Ballast water capacity means the total volumetric capacity of any tanks, spaces or compartments on a ship used for carrying, loading or discharging ballast water, including any multi-use tank, space or compartment designed to allow carriage of ballast water" (IMO, 2004b).

Box 2: Ballast water exchange on board a Panamax containership

A Case History

After a rotation in Asia, the vessel heads towards Australia. Ballast water was taken up in the successive Asian ports of call, resulting in a mix of water coming from different sources.

The chief officer, who is in charge of cargo operations, knows that Australia implements stringent ballast water management regulations; so he endeavoured to reduce the volume of ballast water uptake in each port. To do so, the chief officer applied various 'home-made' strategies based on his knowledge of the ship and the shipping route.

One of the most common practices consists of the internal transfer of ballast water taken aboard in mid-ocean despite the difficulty encountered where a ballast system is not made for such continuous operations.

While leaving the last Asian port, the chief officer and the master drew up a BWE plan, in accordance with the Ballast Water Management Plan, taking into consideration:

Ship factors

- Ship safety – e.g. stability and strength limits;
- Volume of fuel consumed – which has an effect on the weight distribution on board and therefore on stability;
- Crew and fatigue management;
- Piping and pumping systems.

Context factors

- Weather forecast permitting BWE;
- Route characteristics and identification of possible locations – e.g. distance from the shore and water depth.

Planning is paramount since the possibilities of performing BWE are often restricted. Tank deballasting/ballasting sequences must be planned in accordance with stability calculations – ship stability is calculated on a daily basis taking into account materials (e.g. cargo, ballast water) 'remaining on board' (RoB) – i.e RoB is an updated list of weights on board; this list reassesses ship's parameter and stability elements on a daily basis or before any significant weight distribution adjustment – e.g. ballast movements or bunker internal transfer.

In comparison with bulk carriers, containerships have numerous and small ballast tanks. However, BWE can induce a workload of up to two days because a large number of operations are necessary to conduct, control, monitor and record each ballast water movement and the uptake conditions.

Ballast water treatment equipment[41] is commonly integrated into the ballast water piping system and may operate at the uptake or discharge of ballast water, during the voyage, or at a combination of these stages (IMO, 2008a).

Figure 10 shows a simplified version of the path taken by ballast water from the sea chest to ballast tanks and discharge line (left) and the possible locations for installing ballast water treatment equipment on board the ship (right).

[41] "Ballast Water Treatment Equipment means equipment which mechanically, physically, chemically, or biologically processes, either singularly or in combination, removes, renders harmless, or avoids the uptake or discharge of harmful aquatic organisms and pathogens within ballast water and sediments (IMO, 2008a).

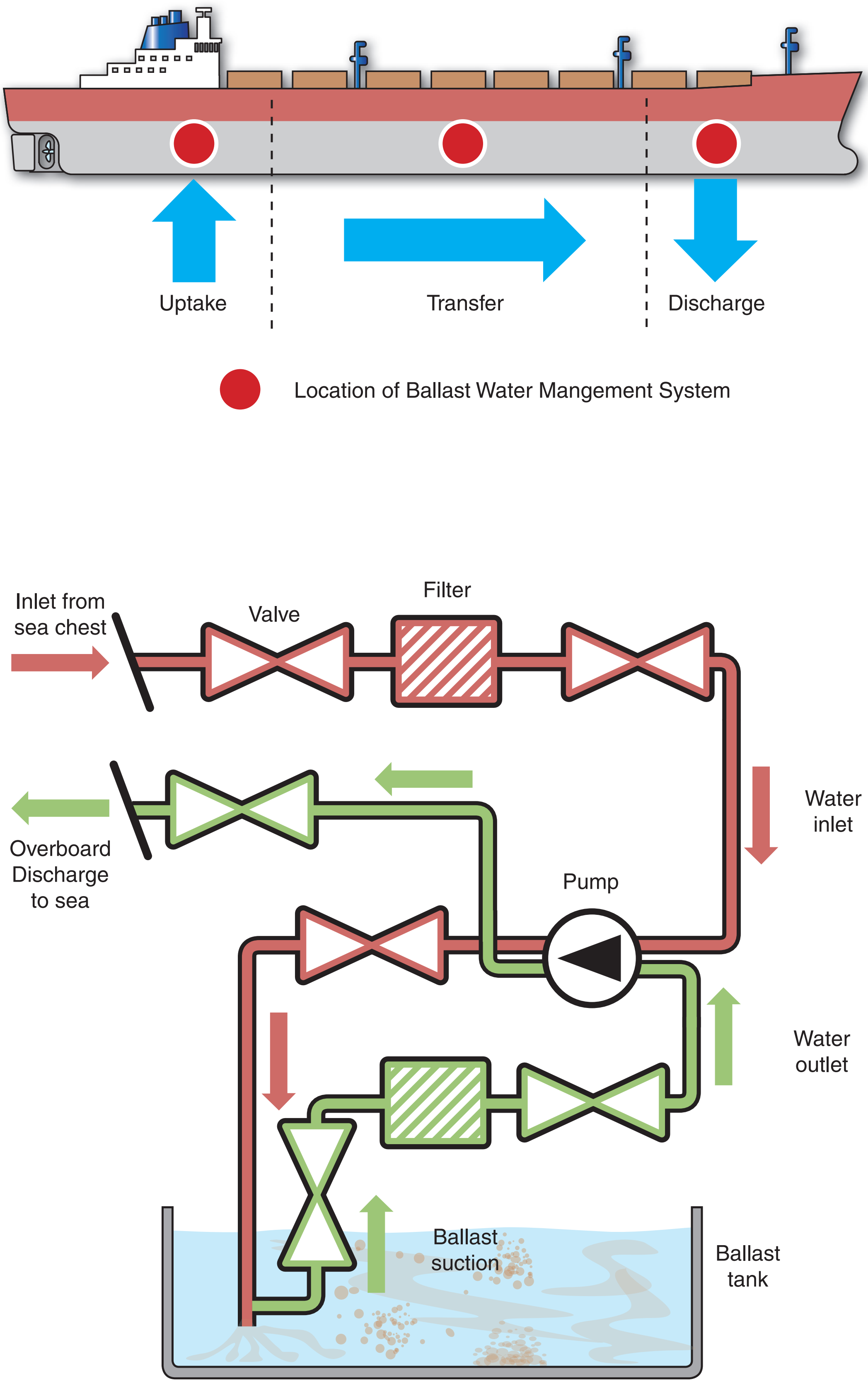

Figure 10: Possible locations of BWMS (above) and ballast system (below)

Both the use (e.g. for weight readjustment) and management (e.g. exchange) of ballast water are part of the ship's daily routine. Therefore, the management of ballast water must not be considered in isolation from the ship's operational management. Proper control of ballast water quality requires both **ballast water management** and **vessel management.**

2.1.3 Preparing the ground for risk assessment

The diversity of risks inherent in the systems – i.e. marine ecosystems and ship – demands an integrated and multidisciplinary approach to risk assessment.

The reliability of risk assessments can be greatly increased by involving representatives of all stakeholder groups with appropriate expertise. Each group will bring its own particular risk perception, experience and/or specific knowledge (IRGC, 2009). The involvement of diverse stakeholders increases the amount of information collected, which is particularly needed when the degree of scientific uncertainty is high and when stakeholders have different concerns and values (Ikeda, 2006).

One of the purposes of establishing a National Task Force is precisely to bring together a variety of stakeholders, to utilize their combined expertise (Tamelander, Riddering, Haag & Matheickal, 2010). This Task Force should focus on how to implement the requirements of the BWM Convention and identify how the roles of the Flag, Coastal and Port States should be implemented in the country concerned. **The National Task Force therefore constitutes a useful forum to assess and manage risks in an integrated way**, either directly or through the use of dedicated teams (see Box 3). Restricted groups of people, having the same background and monopolizing the risk assessment process, should be avoided. "No one is expert in all aspects of any risk decision, much less all risks. Technical specialists' knowledge of risks is limited to their area of expertise" (Fischhoff & Kadvany, 2011). The risk analysis should be wide open and not completely controlled by established experts (Beck, 1992; Eduljee, 2000; OECD, 2003b).

Box 3: Establishment of a working group to assess risks in relation to Regulation A-4

As an example, a working group can be established to focus on specific risks before granting or withdrawing exemptions (Regulation A-4). The workshop participants can be recruited among the following organizations and fields of activity (list inspired by the composition of the National Task Force), either nationally or within both interested countries:

Government authorities & policy stakeholders

- Maritime Administration
- Coast guard/Navy
- Port authorities
- Local authorities

Public health & environmental protection

- Public health services
- Laboratories
- Agency in charge of drinking water distribution
- Agency in charge of seafood safety, fisheries and aquaculture
- Veterinary/quarantine services
- Environmental protection services
- Hydrographic and oceanographic services

Industries & businesses

- Chamber of commerce
- Representative of pilots
- Representative of the shipping industry
- Representative of the fishing and aquaculture industries
- Representative of the tourism industry

Other stakeholders

- Universities and research institutes
- Non-governmental organizations and trade unions
- Etc.

2.2 RISKS ASSOCIATED WITH THE INTRODUCTION OF ALIEN ORGANISMS IN COASTAL ENVIRONMENTS

This Section addresses the threats posed by harmful organisms and pathogens when they are introduced into a new biogeographic region through ballast water and sediments.

2.2.1 Harm to environments – land and sea

Biodiversity supports life on Earth and consists of **species diversity**, **genetic diversity** within a species, and the **diversity of ecosystems** – including species' habitats.

Conserving biodiversity is paramount because it has "ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values" (Preamble of the Convention on Biological Diversity).

These benefits are **direct** – e.g. living marine resources – and **indirect** – e.g. climate regulation.

Although the measures intended to protect ecosystems are becoming more numerous, **biodiversity is currently declining** and this will impact on the services provided by ecosystems (UN, 2011).

The marine environment is the richest sector in terms of biodiversity with nearly 250,000 known marine species (Census of Marine Life, 2010).

When introduced into a new location, alien species may constitute a hazard to human and animal health and/or native biodiversity and ecosystem functioning. However, by no means all alien species become invasive and many have proved not to be damaging.

Some examples of negative ecological impacts resulting from biological invasions are given in Table 3. Adverse effects on human health are considered in the following section.

Table 3: Some examples of adverse ecological impacts resulting from biological invasions

Biological invasion	Disruption of ecosystem balance
	Change in nutrient cycles
	Food web disturbance
	Biological, chemical and/or physical alteration of habitats
	Change in indigenous species distribution
	Decline in indigenous species population (e.g. increased competition)
	Deterioration of water quality, etc.
Introduction of diseases and parasites	As examples, the parasite Myxobolus cerebralis can affect salmon (Wallentinus & Werner, 2008) and Salmonella can infect cattle (IMO, 2010a).
Genetic modifications in native species	Hybridization of species
	Loss of genetic diversity, etc.

For aquatic organisms to become established in a new environment, a number of conditions must be met. They must:

- be associated with the pathway at the donor port;
- survive the voyage;
- colonize the recipient environment;
- reproduce and spread (Orr, 2003).

The multiple uncertainties and complex interactions in aquatic ecosystems dictate that it is difficult to accurately predict the risks presented by species released from ballast tanks. James T. Carlton (2001) compares the introduction of an alien organism to "a game of ecological roulette".

The lack of scientific knowledge on the functions fulfilled by an individual species within its native ecosystem hampers the identification of the potential consequences of a biological invasion in this ecosystem – this makes it difficult to establish **cause-effect** relationships (Kullenberg & Lie, 2008) The ability of an ecosystem to resist and adapt to bio-invasions depends on the type of aggression and the **resilience** of the ecosystem.

> Resilience is fundamentally a system property. It refers to the magnitude of change or disturbance that a system **can experience** without shifting into an alternate state that has different structural and functional properties and supplies different combinations of ecosystem services that benefit people (Resilience Alliance, 2010).

The time frame must also be considered. While the resilience of living systems may be considerable in the medium or long term, existing ecosystem services may be damaged in the short term. Because humans become adapted to particular services provided by the ecosystems which they inhabit, the depreciation or eradication of such functions may severely affect human society. It is therefore especially important to assess the resilience to invasive species of those specific ecosystem functions that support and benefit human populations.

2.2.2 Adverse effects on public health

A current global trend is human settlement in coastal areas, due to the availability of water, raw materials, marine resources, transportation, recreation and tourism sites, as well as associated markets and socio-economic activities (World Bank, 1996; IPCC, 2007; IOC-UNESCO, *et al*., 2011).

Higher population density in coastal zones tends to increase public exposure to waterborne and seafood hazards.

Potential adverse impacts on public health include:

- **Diseases** caused by **pathogens** in water or seafood – e.g. *Escherichia coli*, *Vibrio cholerae* and *Cryptosporidium*. The transfer of pathogens through ships' ballast water and sediments increases concerns for public health (WHO, 2011a);
- **Food poisoning** caused by **biotoxins**. Some species of phytoplankton produce toxins that accumulate in fish and shellfish and may therefore be transmitted to humans (WHO, 2003). They have the potential to cause diarrheic, amnesic, paralytic and neurotoxic poisoning, and **possibly even** death.

Guidance to assess risks related to:

- **seafood safety** is provided by the Codex Alimentarius Commission acting under the Joint Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) Food Standards Programme;
- **drinking-water** and **recreational water quality** is provided by WHO.

2.2.3 Economic and social impacts of invasions on fisheries, aquaculture and tourism

Biological invasions interfere with economically and socially beneficial uses of marine ecosystems and their resources. Coastal and water-based activities – e.g. fisheries, aquaculture and tourism – are particularly vulnerable to biological invasions (IMO/UNDP-GEF GloBallast Partnerships Programme & IUCN, 2010). Some fish/shellfish species are the basis of important commercial or subsistence fisheries which are essential to a region's economy.

Fish/shellfish stocks may be adversely affected by biological invasions, for example, by:

- **voracious predators;**
- **pathogens, biotoxins or parasites;**
- **lack of food** because primary production is disrupted;
- **disturbance of their habitats.**

Catch size may be reduced or harvest for human consumption may be forbidden. The economic value of the affected species may diminish and there is potential for business losses and adverse consumer reactions (World Organization for Animal Health, 2011) (Rees, Karunasagar & Santo Domingo, 2010).

The proliferation of certain aquatic organisms, such as algae and jellyfish, can have negative visual impacts and lessen the **amenity value** of areas used for tourism and recreation e.g. beaches or bathing waters.

By setting an interim BWE standard (Regulation D-1) and a long term water quality standard (Regulation D-2), the BWM Convention aims to mitigate the risk of invasions, and therefore biological impacts, to acceptable – i.e. negligible – levels. However, this does not prevent individual countries from taking further initiatives if they perceive there is an increased threat to biodiversity from ballast water discharges in a certain area. The BWM Convention allows for additional measures, based on risk assessment, to be identified. It also allows for less stringent measures – i.e. exemptions – to be given to specific ships, where their trading routes pose a low risk of transferring non-indigenous species.

2.2.4 Disruption of port activities

Situated at the interface between land and ships, ports are directly exposed to ship-related hazards.

Situations may arise where port authorities are obliged to issue an order to cease ballast water uptake in certain areas[42] owing to hazardous events such as:

- epidemic disease outbreak (WHO, 2009);
- harmful algal bloom (Intergovernmental Panel on Harmful Algal Blooms as cited in IMO, 2003a);
- maintenance dredging resulting in the **resuspension**[43] of contaminated sediment and the **release**[44] of harmful organisms[45] and/or toxic substances – e.g. organotins (Bray, 2006).

Thus, under favorable conditions certain alien species have the capacity to temporarily impair port operations, with consequences for the transport chain. In addition, the control of biological invasions may incur costs – e.g. clean-up of structures and equipment such as waterways, wharves, drainage systems, water intakes, pipes, valves, etc. Additional guidance has been developed by the IMO to cover these eventualities in the *Guidance document on arrangements for responding to emergency situations involving ballast water operations* (IMO, 2008b).

2.3 RISKS ASSOCIATED WITH THE MANAGEMENT OF BALLAST WATER AND SEDIMENTS

Besides the prevention of risks arising from the transfer of aquatic organisms and pathogens, the objective of the BWM Convention is "to avoid unwanted side-effects from [the control and management of ships' ballast water and sediments]" (Preamble).

In other words, the management of ballast water and sediments **should not cause greater harm than it prevents** (Article 2.7).

The techniques required to manage ballast water may not be harmless and may have serious impacts on ship safety, human health, environment and industry. Therefore, the present section reviews the more salient risks emanating from the management of ballast water and sediments. Interrelated and non-exclusive, these risks may be considered cumulative.

For clarity, the risk review is organized on three broad categories: risk related to BWE, risks related to treatment systems and other effects of introducing BWM.

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[42] "Port States should provide ships with warnings concerning ballast uptake and any other port contingency arrangements in the event of emergency situations" (IMO, 2005).

[43] "Resuspension is defined as the processes by which a dredge and attendant operations dislodge bedded sediment particles and disperse them into the water column" (Bridges, Ells, Hayes, Mount, Nadeau, Palermo, Patmont & Schroeder, 2008).

[44] "Release is defined as the process by which the dredging operation results in the transfer of contaminants from sediment pore water and sediment particles into the water column" (Bridges, *et al.*, 2008).

[45] Some viruses are able to survive during several months in estuarine sediments (Monfort, 2006).

2.3.1 Risks relating to the exchange of ballast water on the high seas

Although the following risks refer primarily to BWE, some are also applicable to BWT.

- ***Impacts on the ship's stability, integrity and structural strength***

  Cargo ships are designed to operate with ballast water to ensure stability and safety. Open ocean BWE may not have been considered at the design stage, particularly with regard to the frequency of the operations involved. As a result, BWE may present safety hazards to the ship and its crew.

  Exchanging ballast water may take a long time, depending on ship type, ballast water volume, flow rate and piping arrangements. As an example, a bulk carrier in heavy ballasted condition may require up to forty-eight hours of continuous pumping to perform BWE using the sequential method (Akiyama, Uetsuhara & Sagishima, 2000).

  It is considered that "there is a real danger of overstressing the ship and damaging her if ballast is changed at sea in rough weather, and for this reason any requirement to change ballast (…) must be viewed with serious concern" (Isbester, 1993). Ships in high-tensile steel (HTS) have a hull that is more sensitive to structural fatigue and corrosion. Higher stress levels may increase the risks of tank deterioration and, in turn, affect the overall ship's integrity.

  The sequential method, as presented in the *Guidelines for ballast water exchange (G6)*, affects the ship's longitudinal strength, torsional deflection, dynamic loads, intact stability, bridge visibility, minimum draught forward and propeller immersion (Karaminas, *et al*., 2000; Jönsson, 2001).

  These risks should be identified and mitigated in the BWMP (see the *Guidelines for Ballast Water Management and development of Ballast Water Management Plans* – G4), which, when followed properly, should allow for the smooth execution of BWE whilst the ship is in transit.

- ***Issues related to navigational safety***

  Navigational safety considers the movement of the ship in relation to other ships.

  When undertaking BWE, the temporary reduction of the main ship functions – i.e. propulsion and maneuverability – and bridge visibility may increase the risks of collision.

  Again, these risks should be identified and mitigated in the BWMP (see the *Guidelines for Ballast Water Management and development of Ballast Water Management Plans* – G4).

- ***Inherent limits of BWE***

  Even when ballast water is exchanged at sea, there may be **latent risks** – e.g. cysts located in sediments.

  According to the IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB), BWE cannot be considered as a fully reliable option and "it is important to realize that large numbers of harmful organisms may still be present in the water discharged into the receiving port" (as cited in IMO, 2003a).

  The effectiveness of the exchange depends on the water depth and seasonal organism concentration of the area where water is taken aboard. It has been said that "a 95 % volumetric exchange of water may not always be equivalent to a 95 % organism removal as the organisms are not homogeneously distributed in a tank" (Gollasch et al., 2007).

  Additionally, ballast water can never be totally replaced because ships have not been designed to perform BWE. Therefore, the effectiveness of BWE depends on ballast tank and ship design (Jönsson, 2001), as well as ballast pumping arrangements.

  Trials have shown that, for some bulk carriers, "even after exchanging three tank volumes, some **five percent of the original water** and up to **twenty-five percent of settled plankton is likely to be retained**" (Isbester, 1993). In the remaining ballast water and sediments, organisms can still proliferate by using the organic material accumulated in the sediment layer (Hallegraeff, 1998).

2.3.2 Risks relating to the treatment of ballast water

Most of the technologies used to treat ballast water on board ships are derived from water and wastewater treatment technologies utilized ashore.

The technological processes and substances used for removing, killing or inactivating organisms in ballast water are not entirely new. What is new is that they take place **on board ships at sea.**

- ***Increased corrosion in ballast tanks and related arrangements***

  Treatment technologies that make use of oxidizing agents may have side-effects on the ship's structure and equipment. Two of them are **corrosion of the ballast water system** and **ballast water tank coating degradation** (Sassi et al., 2005; Stuer-Lauridsen, 2011; NACE International as cited in IMO, 2012f; IMO, 2012h).

  Some BWMSs might increase corrosion of ship structures, piping, fixtures and protective coatings (EPA, 2011; NACE International as cited in IMO, 2012f; IPPIC & NACE International as cited in IMO, 2012h). Besides, "the potential effects of these BWMSs have not been consistently evaluated across the various modes of corrosion" (EPA, 2011).

  Furthermore, ballast tanks are enclosed spaces[46] which are completely dark and not easily accessible. Therefore, detailed and reliable inspections of structural integrity and coatings are difficult. Such inspections are made even more difficult by the accumulation of sediments (Isbester, 1993).

  The corrosion risks associated with ballast water treatment are considered in both the basic and final approval assessments undertaken in accordance with the *Procedure for approval of ballast water management systems that make use of active substances (G9)*. Despite these assessments, corrosion is still a matter of concern and efforts continue to devise a standardized test.

- ***Transport, storage, handling, delivery and use of active substances***

  This paragraph focuses on the risks to the ship and also to onshore facilities. Occupational safety and health is dealt with in a following paragraph.

  Some BWMSs utilize, or generate, active substances, relevant chemicals or free radicals that are hazardous. "Chemicals such as chlorine, chlorine dioxide, ozone, peracetic acid, hydrogen peroxide and perchoric acid are all used in the treatment of ballast water and all need careful handling and safe storage" (Tan, 2011).

  Chemical hazards may stem from the substance's "flammable, explosive, toxic, corrosive, radioactive, carcinogenic or chemical reactive properties, or a combination thereof" (Carson & Mumford, 1988).

  In addition to their use in on-board equipment, chemical substances may be used in **port-based reception and treatment facilities**.

  Each chemical must be properly identified and documented with a **material safety data sheet (MSDS)** which is obtained directly from the manufacturer. It provides information on the hazardous ingredients of the substance, precautions, emergency and first aid procedures, adverse effects on human health and the environment, and so forth (ILO, 1993).

  All shipboard and shore personnel involved in the transport, storage, handling, delivery and use of active substances should be adequately trained, particularly with regard to **chemical identification, segregation**, **instability**, **ignition properties and containment.**

  Appropriate storage facilities must be provided for safety purposes, together with emergency procedures in case of **fire, explosion, loss of containment, leakage** or **spillage**.

[46] "Enclosed space means a space which has any of the following characteristics : limited openings for entry and exit, inadequate ventilation and is not designed for continuous worker occupancy ; [it] includes, but is not limited to, cargo spaces, double bottoms, fuel tanks, ballast tanks, cargo pump-rooms, cargo compressor rooms, cofferdams, chain lockers, void spaces, duct keels, inter-barrier spaces, boilers, engine crankcases, engine scavenge air receivers, sewage tanks, and adjacent connected spaces. This list is not exhaustive and a list should be produced on a ship-by-ship basis to identify enclosed spaces" (IMO, 2011d).

A **detailed characterization of the substance** and the circumstances surrounding its use is the basis for risk assessment. It includes the chemical and physical properties of the substance, its quantity/concentration – potential energy release, number of people likely to be exposed, as well as local conditions – presence of additional hazards and possible domino effect (Carson & Mumford, 1988).

These safety risks should be assessed and mitigated through discussions between the BWMS provider and the shipowner/master. Guidance on this matter is available from IMO in *Guidance to ensure safe handling and storage of chemicals and preparations used to treat ballast water and the development of safety procedures for risks to the ship and crew resulting from the treatment process* (IMO, 2009a).

In addition to safety issues, active substances may also pose a **security risk**.

In hostile regions overrun by terrorism or armed conflicts, chemicals may be used as weapons or for the production of weapons. For this reason, it is essential that appropriate security protection is arranged to **prevent the entry of unauthorized persons to storage areas**, both aboard ships and in warehouses on shore.

- ***Potential release of hazardous substances in the marine environment (accidental/chronic)***

GESAMP (2012b) recognizes that "the emission of [chlorination related] chemicals coming from ballast water management systems is a rather new potential threat to the marine environment". As a result, the GESAMP BWWG, during the assessment of systems using active substances under the *Procedure for approval of ballast water management systems that make use of active substances (G9)*, is applying and testing several models to assess the impact of residual chemicals in ballast water discharges.

Acute chemical pollution may occur when **hazardous substances**[47] end up in the marine environment as a result of spillages from the BWTS or chemical spillage (IMO, 2009a) during the transport, storage, handling and delivery of these substances. Subsequent dispersion of persistent substances may carry additional risks for the environment and/or human health.

Chronic chemical pollution relates to the release into the aquatic environment of hazardous substances in small amounts, on a continuous or intermittent basis – e.g. through **treated ballast water discharges**. It is noteworthy that "out of a list of more than 70 by-products, which have been detected during the treatment by various ballast water management systems (…), 18 chemicals [are] believed to pose a potential risk to the environment as well as to human beings exposed" (IMO, 2009b and IMO, 2012i).

In enclosed areas such as ports, the chronic release of **relevant chemicals** through treated ballast water discharges may have damaging impacts on marine life (European Maritime Safety Agency EMSA, 2008; Bowmer & Linders, 2010; De Souza, 2010). Additionally, there may be **combined effects/interactions** involving different kinds of hazardous substances in the vicinity of ports.

"The issue of cumulative effects of treated ballast water discharged in large volumes from multiple sources into relatively confined water bodies remains a concern" (GESAMP, 2012a).

Such risks can be assessed with chemical fate models – e.g. the Marine Anti-foulant Model to Predict Environmental Concentrations (MAMPEC model), which was initially developed to evaluate the environmental impacts of anti-fouling paints.

It is well-established that the use of biocides in anti-fouling paints – e.g. tributyltin-based products (TBT) – has produced damaging effects on marine organisms and will remain a concern for several years because of contaminated sediments (Bray, 2006).

In 2010, the **MAMPEC model for ballast water** (MAMPEC-BW) was further developed for IMO and GESAMP to assess **exposure to the chemicals released by treated ballast water discharges** (Institute for Environmental Studies – University of Amsterdam, 2012).

[47] The Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 (HNS Protocol) defines a hazardous substance as "any substance other than oil which, if introduced into the marine environment, is likely to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea".

Such techniques ensure that **uncertainty** regarding the long-term impacts of ballast water treatment chemicals is taken into account. As recommended by international principles and often integrated into national regulations, precautionary approaches should prevail. These principles are embodied in various instruments, in particular:

– Principle 15 of the Rio Declaration on Environment and Development (1992) provides that "(…) where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation".

– This obligation should be read together with the duty of States not to transfer damage or hazards, or transform one type of pollution into another, which is set out in Article 195[48] of UNCLOS, as well as Principle 18 of the Declaration of the UN Conference on the Human Environment (1972): "Science and technology, as part of their contribution to economic and social development, must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind".

- ***Inherent limits of BWT***

It is important to ascertain the reliability of treatment systems over time (Institute of Marine Engineering, Science and Technology, (IMarEST) as cited in IMO, 2011a), i.e. whether active substances are produced/dosed appropriately without atmospheric emissions and that treatment is effective.

The discharge of treated ballast water **after short voyages** might also be of concern. Some BWMSs require a minimum holding time, either for effective treatment or for degradation of chemical substances (De Souza, 2010; Stuer-Lauridsen, 2011; EPA, 2011). Depending on the BWMS, the GESAMP-BWWG can require that treated ballast water is maintained on board the ship **up to five days** (holding time) before discharge (as cited in IMO, 2010b).

It has to be remembered that treated ballast water discharges may still contain viable organisms because the BWMS might not be 100% effective. Because some treatment systems have proved unsatisfactory, the World Health Organization (WHO) (2011) recommends the use of multiple controls in ballast water management.

Experience shows that "there is no ideal or perfect disinfectant or disinfection technique (…), they do not kill all of the microorganisms, they fail to eliminate cysts or parasites (…), **they produce disinfection by-products**" (Solsona & Méndez, 2003).

Finally, the Ballast Water Performance Standard **does not limit the amount of viable organisms that are less than 10 µm in dimension** and thus does not provide protection against some organisms that are harmful to human health[49] (Swackhamer as cited in Committee on Transportation and Infrastructure, 2011; ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors, 2012).

Nevertheless, through the BWM Convention and the myriad of guidelines that have been developed, the IMO has made available a system where risks can be mitigated and reduced in appropriate ways. This includes procedures for ensuring that treatment systems are robustly tested and that the limitations of each system are transparent and known to the Flag, Coastal and Port States, as well as to shipowners.

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[48] "In taking measures to prevent, reduce and control pollution of the marine environment, States shall act so as not to transfer, directly or indirectly, damage or hazards from one area to another or transform one type of pollution into another" (UNCLOS Article 195).

[49] For example, viruses have a dimension ranging between 0.01 and 0.1 µm (http://www.epa.gov/).

Presently, most risks aboard vessels relate to:

- Periodic ballast tank inspections;
- Work executed inside enclosed spaces;
- Loss of stability and impact on ship strength;
- Intensive use of the ballast system including piping and pumping arrangements, valve activators and other mechanical or electrical equipment.

In addition, certain active substances used in ballast water treatment, including disinfection by-products (DBPs), have the potential to cause **genetic mutation, adverse reproductive effects** and/or **cancer** (WHO, 2004a; Richardson, *et al*., 2010; International Agency for Research on Cancer, 2008) and increasing exposure to such substances could generate new risks for workers, both on board ships and ashore.

2.3.3 Risks relating to the management of ballast water and sediments, on board ships and/or ashore

- ***Additional air emissions***

  BWE and BWT systems require the use of powerful equipment and thus involve a high consumption of electrical power. This increases **consumption of heavy fuel oil (HFO)** and results in additional **emissions of pollutants to the atmosphere** (EPA, 2011).

  Additionally, dangerous chemical vapours, such as the **trihalomethanes**[50] (THMs), **chlorine gas** and **ozone gas**, may be emitted into the atmosphere at the same time that the air is vented from ballast tanks (Sassi, *et al*., 2005 ; GESAMP-BWWG as cited in IMO, 2007b, 2011a; Bowmer & Linders, 2010; Richardson, De Marini, Kogevinas, Fernandez, Marco, Lourencetti, Ballesté, Heederik, Meliefste, McKague, Marcos, Font-Ribera, Grimalt & Villanueva, 2010 ; IMO, 2012b).

  Finally, safety concerns have been raised because some BWMSs may generate **hydrogen gas**, which increases the risk of explosion onboard ships (IMO, 2012h).

  These potential gas releases should be considered in the basic and final approval mechanisms dictated by the *Procedure for approval of ballast water management systems that make use of active substances (G9)* and the assessments carried out as outlined in the *Guidance to ensure safe handling and storage of chemicals and preparations used to treat ballast water and the development of safety procedures for risks to the ship and crew resulting from the treatment process* (IMO, 2009a).

- ***Occupational Safety and Health issues (OSH)***

  In the context of ballast water and sediments management, Occupational Safety and Health (OSH) risks refer not only to seafarers but also to numerous **onshore workers**, such as Flag State inspectors, Port State control officers, classification society surveyors, shipyard and repair yard workers, BWMS maintenance workers, port-based reception and treatment facility workers, ship recycling workers and so forth (Figure 11).

[50] “Trihalomethanes are a group of four chemicals that are formed along with other disinfection byproducts when chlorine or other disinfectants used to control microbial contaminants (…) react with naturally occurring organic and inorganic matter in water. The trihalomethanes are chloroform, bromodichloromethane, dibromochloromethane, and bromoform” (http://www.epa.gov).

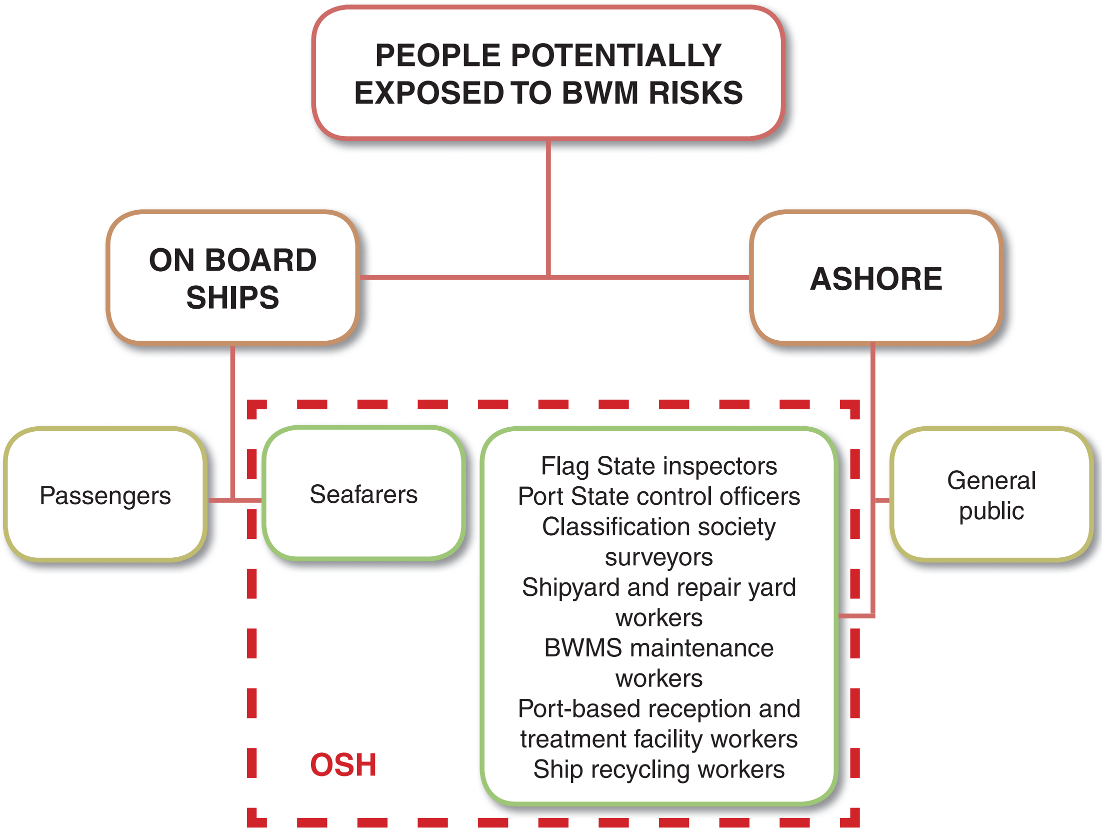

Figure 11: Scope of OSH in the context of ballast water and sediments management

Some examples of tasks performed by workers on board the ship and ashore to manage ballast water and sediments are provided in Figure 12.

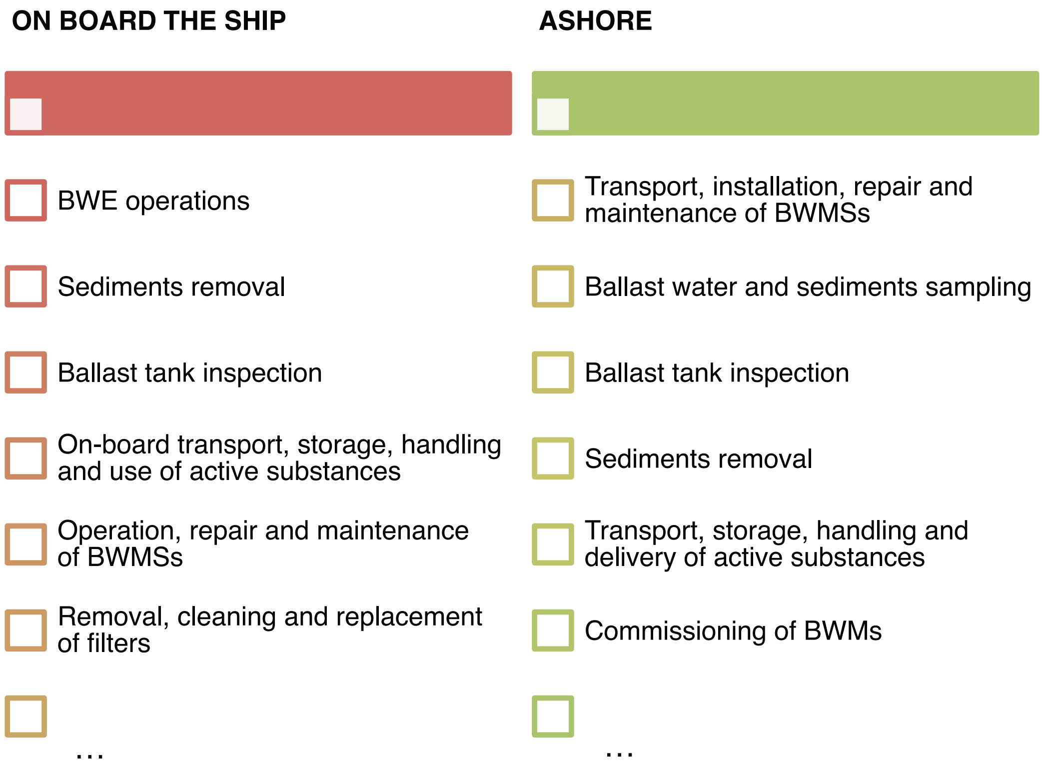

Figure 12: Examples of tasks performed by workers on board the ship and ashore to manage ballast water and sediments

Seafarers and onshore personnel may be exposed to mechanical, physical, electrical, chemical and biological hazards in various situations, as follows:

a) when inspecting, cleaning and repairing ballast tanks, removing sediments[51] and sampling ballast water.

   Ballast tanks are enclosed spaces and, as such, "considered to be hazardous until positively proved to be safe for entry" (IMO, 2011d). Inspecting ballast tanks is a high-risk and demanding operation. Their atmosphere may be unsafe because of oxygen depletion and/or the presence of toxic vapours (ILO, 1996). Enclosed spaces are poorly ventilated and illuminated, often have slippery surfaces and narrow openings to move through. In addition, "Ballast tank sediments constitute a large amount of organisms including viruses and bacteria that can be a threat to both human health and to the environment" (Andersen, 2001). It should be noted that ballast tanks are cleaned manually, resulting in greater worker exposure.

b) when operating, repairing or carrying out the **maintenance** of BWMSs.

   To ensure a safe human/machine interface, all phases of the BWMS's life cycle have to be considered – i.e. from design to the end of service life (IMO, 2009a). Some BWMSs that do not make use of active substances, such as filtration and cyclonic separation, may require manual intervention. Cleaning filters and/or purging accumulated particles may involve **contact with hazardous residues** and/or organisms. Other BWMSs may involve **exposure to heat, radiation or ultrasound**, with possible health effects – e.g. noise and vibrations (Sassi, *et al*., 2005).

c) where personnel are exposed to hazards while loading, handling, storing and transferring **chemical substances** to treat ballast water.

   For example, this may include operating a **BWMS using or generating hazardous substances**, including potential accidental leakage in the work area (IMO, 2009a).

d) when workers are in contact with treated ballast water or inhale chemical vapours that may be vented from ballast tanks.

Some examples of these vapours are shown in Box 4.

Box 4: Health hazards associated with water purification

Chlorine is "corrosive to eyes, skin, and respiratory tract. Inhalation of gas may cause pneumonitis and lung oedema, resulting in reactive airways dysfunction syndrome. Rapid evaporation of the liquid may cause frostbite. High exposures may result in death. Effects may be delayed and medical observation is indicated" (WHO, 2004a).

"The use of **chlorine** can give rise to a number of chlorinated by-products of which the short – and long-term effects are not fully understood" (Lees, *et al*., 2010).

"**Ozone** is an irritant and toxic gas that causes inflammation of mucous membranes and conjunctiva. Chronic exposure may cause pulmonary fibrosis" (Last, 1998).

"Almost all disinfectants produce disinfection by-products (DBPs). **Chlorine** generates a long list, the most obvious of which are trihalomethanes (THM), haloacetic acids (HAAs), haloacetonitriles and chlorophenols; chlorine dioxide produces over forty DBPs, including chlorates, chlorites and chlorophenols. **Ozone**, for its part, generates aldehydes, carboxilic acids, bromates, bromoethanes, bromoacetonitriles and ketones. The problem is that many of these DBPs are carcinogenic" (Solsona & Méndez, 2003).

[51] "The volume of sediment in a ballast tank should be monitored on regular basis (…) sediment in ballast tanks should be removed in a timely basis in accordance with the Ballast Water Management Plan and as found necessary. The frequency and timing of removal will depend on factors such as sediment build up, ship's trading pattern, availability of reception facilities, work load of the ship's personnel and safety considerations" (IMO, 2005).

It is therefore essential that seafarers and onshore personnel be adequately informed and trained[52] to allow them to understand risks and to protect themselves (e.g. PPE) and their surroundings.

Many of these issues are taken up in the *Guidance to ensure safe handling and storage of chemicals and preparations used to treat ballast water and the development of safety procedures for risks to the ship and crew resulting from the treatment process* (IMO, 2009a) and the *Revised recommendations for entering enclosed spaces aboard ships* (IMO, 2011d).

The risks posed to Port State Control (PSC) Officers and other surveyors are to be identified in the PSC procedures and guidance being developed by IMO.

- ***Impacts on the ship's resilience***

  'Resilience' can be defined as the ability to cope with the unexpected. Machines and equipment may not always be designed to withstand sudden, abnormal changes or pressures without damage or failure.

  "*I want to reserve resilience to refer to the broader capability – how well can a system handle disruptions and variations that fall outside of the base mechanisms/model for being adaptive as defined in that system*" (Woods & Hollnagel, 2006).

  The concept of 'resilience' is relevant to several aspects of ballast water management.

  First, ships are complex and dynamic systems operating far from shore support, with restricted resources, in an unstable and dynamic environment. Therefore, risks of disruption are higher on board ships than anywhere else and high resilience is paramount.

  Second, the resilience and safety of the ship *inter alia* are dependent on the reliability of the ballast water system. An unreliable ballast water system, operated in an unpredictable environment, will affect the resilience and integrity of the vessel as a whole. It follows that ships are highly vulnerable to disturbances in ballasting arrangements.

  For example, serious damage to the ship's ballast water pumping system not only jeopardizes the management of ballast water but also the ship itself, including its cargo. The possibility of such damage needs to be assessed because a large part of the world fleet is presently operating ballast systems under conditions that were not anticipated during the design and construction stages.

  Third, the resilience of the BWMS has to be considered. To make sure unexpected events will not compromise the operational requirements of the system, the inherent complexity, robustness and operational context of the BWMS – i.e. operation at sea, isolation and limited resources – should be carefully addressed.

  The addition of a treatment plant in ballast water arrangements increases the complexity of the whole system. This change in turn modifies the resilience of ballasting operations and consequently the resilience of the vessel itself. This underlines the importance of compiling a good BWMP and implementing it correctly.

- ***Limitations of ballast water sampling***

  Sampling and analysis for compliance testing is a complex issue. Used to assess that ballast water quality reaches requirement standards, they need to be accurate because important decisions, which may have legal and/or economic consequences, can be made on such analysis.

  Ballast water sampling procedures used during port operations need to be simple, fast and reliable in order to minimize the time vessels are detained in port. The IMO has issued a Guidance on ballast

[52] "Employers shall inform the workers of the hazards associated with exposure to chemicals used at the workplace, instruct the workers how to obtain and use the information provided on labels and chemical safety data sheets, use the chemical safety data sheets, along with information specific to the workplace, as a basis for the preparation of instructions to workers, which should be written if appropriate, train the workers on a continuing basis in the practices and procedures to be followed for safety in the use of chemicals at work" (ILO, 1990).

"Shipowners and masters should ensure crew are instructed and trained appropriately, specifically to familiarize themselves with the Safety Data Sheet for any chemicals or preparations used in the course of ballast water treatment. Crew should also be made aware of any potentially hazardous by-products (aqueous or gaseous) which may be produced during the ballast water treatment process" (IMO, 2009a).

water sampling and analysis for trial use in accordance with the BWM Convention and Guidelines (G2) (IMO, 2013b).

Regarding the D-2 standard, there are various reasons why ballast water sampling methods may result in inaccurate analytical results, such as the lack of representativeness of samples or '*taxonomic confusion*' (Gollasch & David, 2010; Jørgensen, Gustavson, Hansen & Hies, 2010; Eason, 2012a):

Human operators are prone to fatigue, increasing the mistake rate, but they are also prone to boredom and personal preferences regarding a certain organism group, leading to over or underestimations. These are factors often beyond the control of the individual and certainly not easy to quantify and analyse statistically (Fuhr, Finke, Stehouwer, Oosterhuis & Veldhuis, 2010).

Considerable research is being undertaken on sampling protocols to overcome uncertainties in analysis and risk assessment, or at least to recognize them, by using a gross non-compliance test (GNC; Bierman, de Vries & Kaag, 2012). GNC tests, that could substantially reduce costly errors in compliance testing, are currently being developed. A standard compliance testing methodology with a predictable level of reliability, taking into account known variability in organism counts from samples of ballast water discharges, can be used to set a GNC threshold above the D-2 standard. This will allow PSC Officers to accurately determine whether or not a ship is compliant with the standard.

- ***Economic impacts on the maritime industry***

Compliance with the BWM Convention incurs high costs for shipowners and operators as well as for port authorities and regulators. At least in the initial phases of implementing BWM, these costs may present a degree of financial risk to those concerned.

The management of ballast water and sediments increases the capital, operating and voyage costs of shipping (Table 4).

Table 4: Examples of costs borne by shipowners and operators

Capital costs	BWMS acquisition
	Retrofitting of pumping and piping arrangements
	Dry-docking of the ship for BWMS installation, etc.
Operating costs	Repair and maintenance costs
	Consumables – including chemicals – costs
	Hours of manpower involved in operation and maintenance
	Training, health care, personal protection equipment costs
	Insurance costs – e.g. accelerated wear of equipment, greater risk of injury on board
	Administrative workload, etc.
Voyage costs	Additional fuel/energy costs
	Port charges for the disposal of sediments and ballast water
	Loss of income due to delays, etc.

BWE entails higher fuel consumption. It may also require a retrofit of ballast pumping, piping and valve arrangements, which incurs costs for manpower and equipment, and sometimes dry-docking. Although a ship should not be required to deviate from its initial route to reach a suitable BWE area[53], delay costs may also arise (GEF-UNDP-IMO GloBallast Partnerships Programme & IUCN, 2010).

As far as BWT is concerned, the necessary equipment will involve a cost to install as well as to operate and maintain (King, Riggio & Hagan, 2009; Committee on Transportation and Infrastructure 2011; Osler, 2012). Supplementary crew may be needed to operate the installation without affecting the overall workload.

[53] BWM Convention Regulation B-4.3.

Potential delays to the operation, movement or departure of the ship – for example, as a result of sampling ballast water during a PSC inspection, lack of appropriate spares for BWMS maintenance (Eason, 2012c) or even delay in the installation of the BWMS (Osler, 2012) – may interfere with the ship's operations with resulting financial implications.

For Port States and/or port operators, the management of sediments and, possibly, ballast water, will incur infrastructure investments and operating expenses (Table 5). The implementation of a BWM control strategy requires investment in technical (e.g., equipment) and human (i.e., organizational) resources.

Table 5: Examples of costs borne by Port States and/or port operators

Capital costs	Acquisition of additional land
	Investment in reception and treatment facilities
	Investment in laboratory facilities in the vicinity of the port, when they do not exist
	Investment in storage facilities, etc.
Operating costs	Operational and environmental monitoring of ballast water and sediments management
	Consumables – e.g. chemical agents for treating water
	Compliance inspections
	Sampling and sample analysis
	Administrative work – e.g. maintenance of databases
	Need for additional staff, training, health care, personal protection equipment, etc.

The implementation of new environmental regulations always incurs compliance costs. "*With constantly changing laws and regulations, it is difficult for vessel operators to formulate and conduct a sound business plan*" (Jewell as cited in Committee on Transportation and Infrastructure, 2011). The uncertainties of the implementation phase create financial risks for those who must comply. Indeed, during the transition period, competition might be distorted because those who do not comply with environmental standards might gain unfair commercial advantage (OECD, 2003a). However, according to Principle 16 of the Rio Declaration[54], transitional risks are the price to be paid for internalizing the costs of practices which have an impact on the environment.

2.4 SUMMARY

This Chapter has briefly described the systems affected by the transfer of alien organisms as well as the management of ballast water and sediments. It has then identified some of the major hazards and risks in the respective domains:

- Invasive alien species impact upon ecosystem balance, human and animal health, coast-dependent activities and the continuity of port operations;
- On the other hand, the management of ballast water and sediments poses risks to ship safety, occupational safety, health and the environment and impacts on relevant organizations.

Both categories of risks need to be addressed by all stakeholders, particularly by States which have to consider their international obligations under UNCLOS when they are acting as Flag, Coastal or Port State.

[54] Principle 16 of the Rio Declaration on Environment and Development reads "national authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment".

3

Mitigation of risks

Having identified and assessed risks, the next step in the risk management process is to develop a **strategy** to control and reduce these risks. Since the two categories of risks identified are interrelated, they need to be addressed by means of an **integrated** approach (UN, 2003), as summarized in Figure 13.

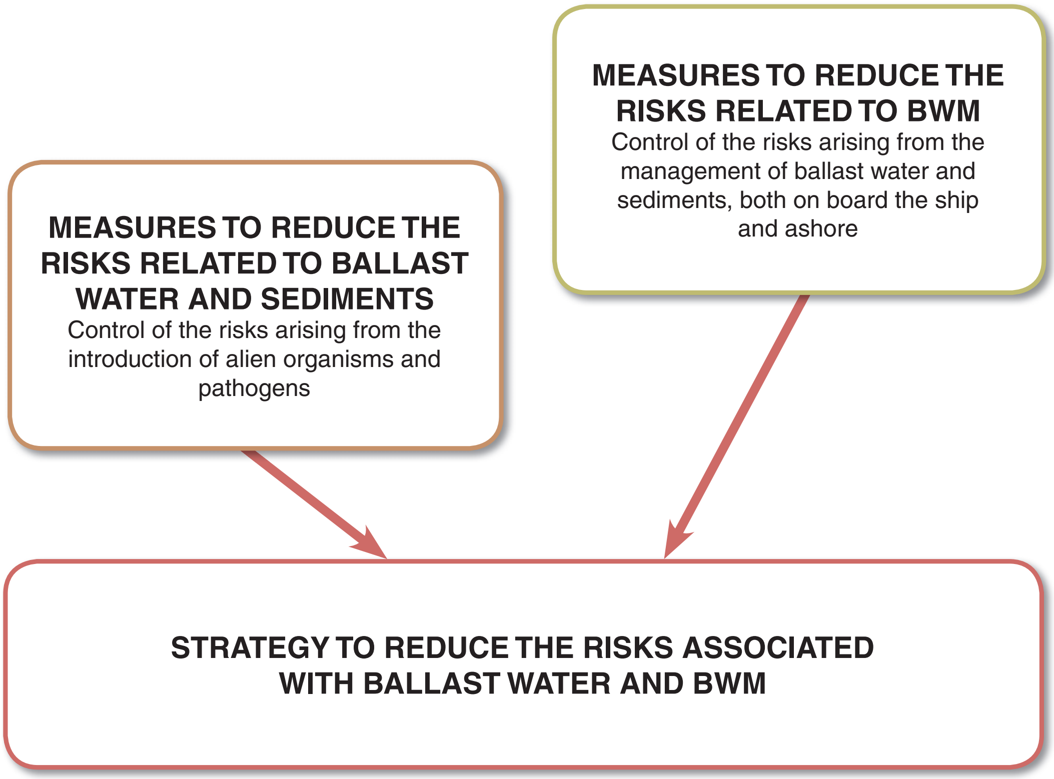

Figure 13: Integration of the risk mitigation strategy

Containing and controlling risks will consist of placing **preventive and protective barriers at three levels**, as laid out in the BWM Convention:

- **Ballast water arrangements[55];**
- Ship;
- Donor/recipient biogeographic region, including the port.

The imposition of barriers requires legal **authority** at all three levels.

As far as the ship is concerned, management authority belongs to the **shipowner** by virtue of his property right.

[55] Ballast water arrangements comprehend ballast tanks, ballast water, sediments, piping and pumping arrangements, as well as the interactions with the ship, its crew and working organisation.

On the other hand, because the ship is **registered**[56], has a **nationality**[57] and flies a **flag**[58], it belongs to a State and is subject to its jurisdiction and control[59]. The **Flag State** will adopt and enforce the necessary laws and regulations to ensure its national vessels comply with the requirements of the BWM Convention[60].

Two other institutions have also competence to exercise prescriptive and enforcement jurisdiction, namely the **Coastal State**[61] and the **Port State**[62]. The responsibilities of these entities are also dictated by the BWM Convention.

Figure 14 illustrates the interactions between the three systems considered – i.e. ship, port and coastal zone – together with the corresponding State competencies.

Since aquatic species are practically impossible to control or eradicate once they are established in a new environment (GEF-UNDP-IMO GloBallast Partnerships Programme & IUCN, 2010), the protection of an ecosystem after an introduction has occurred is not an option. Therefore, for purposes of risk management, **prevention** should be given priority.

When tracing the chain of causation, it is clear that preventive barriers – or standards in the BWM Convention – should focus on the **hazard source**, i.e. on the ship's ballast water, under the responsibility of the **Flag State** and the shipowner.

As for the **hazard receptor**, the **Coastal State should** monitor potential impacts and assess the effectiveness of barriers. When risk control measures are not effective or are not sufficient to reduce risks, the Coastal State may require that additional actions be taken to achieve the desired results.

The role of the **Port State** is to inspect foreign ships while in port, enforce regulations and ensure that, where necessary, corrective action is taken – often in conjunction with the Flag State of the ship – therefore breaking the chain of causation i.e. the source-pathway-receptor linkage (Fleming, 2001; Pollard, 2005).

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56 "Registration generally involves the public recognition and protection of the shipowner's title to the vessel as well as the conferment of nationality" (Coles & Watt, 2009).
57 "Nationality is attributed to vessels flying the flag of a State in which the vessel is publicly registered" (Coles & Watt, 2009).
58 "Ships have the nationality of the State whose flag they are entitled to fly" (UNCLOS, Article 91).
59 "Ships shall sail under the flag of one State only and (…) shall be subject to its exclusive jurisdiction on the high seas" (UNCLOS, Article 92).

"Every State shall effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag" (UNCLOS, Article 94).
60 "States shall ensure compliance by vessels flying their flag or of their registry with applicable international rules and standards" (UNCLOS, Article 217.1).
61 The coastal State "may exercise jurisdiction with respect to maritime zones over which [it has] sovereignty, sovereign rights or jurisdiction" (Molenaar as cited in Klein, 2011).
62 "The jurisdiction exercised by [the] port State will refer to authority over activities occurring outside the maritime zones of the coastal State and enforced in port" (Molenaar as cited in Klein, 2011).

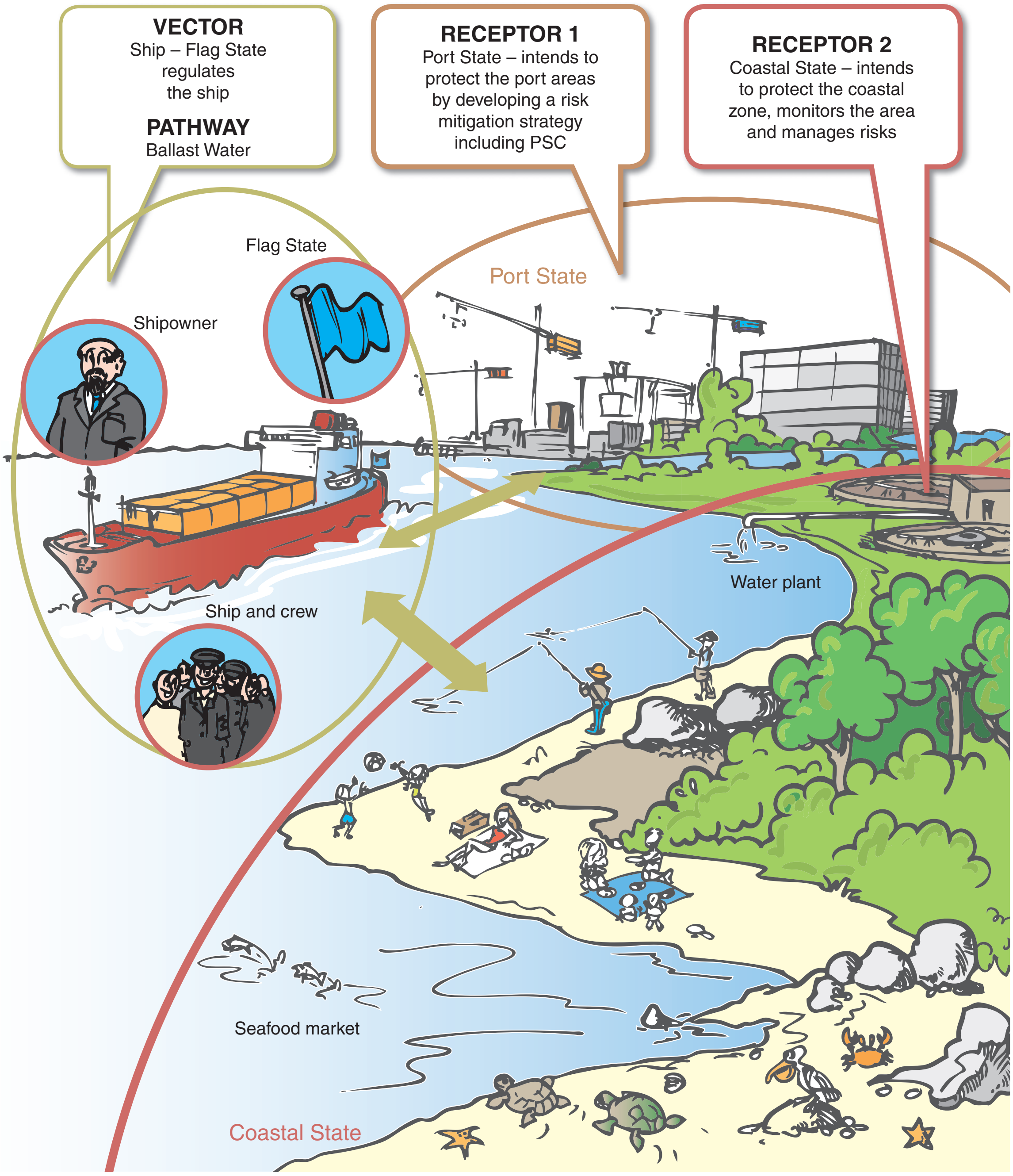

Figure 14: Interactions between the ship, port and coastal zone systems together with State competences

3.1 RISK MITIGATION FROM THE PERSPECTIVE OF THE FLAG STATE

The Flag State plays a strategic role in mitigating risks because it holds primary responsibility for regulating and controlling **ships**, their **equipment** and **crews**.

With regard to the BWM Convention, the Flag State has two main responsibilities:

- Prevent the transfer of harmful organisms through ballast water and sediments management; and
- Avoid unwanted side-effects from ballast water and sediments management; in particular, to make sure that BWMS are safe for the ship, its crew and the equipment.

Risk mitigation strategies are illustrated in Figure 15. In principle, they involve circumscribing the ship's ballast water arrangements, and/or the ship itself, with barriers – i.e. risk control measures of three types: human, technical and organizational.

These barriers are aimed at preventing the hazard from reaching the receptor (i.e. external environment).

The yellow box in Figure 15 lists roles and responsibilities in erecting and implementing such barriers.

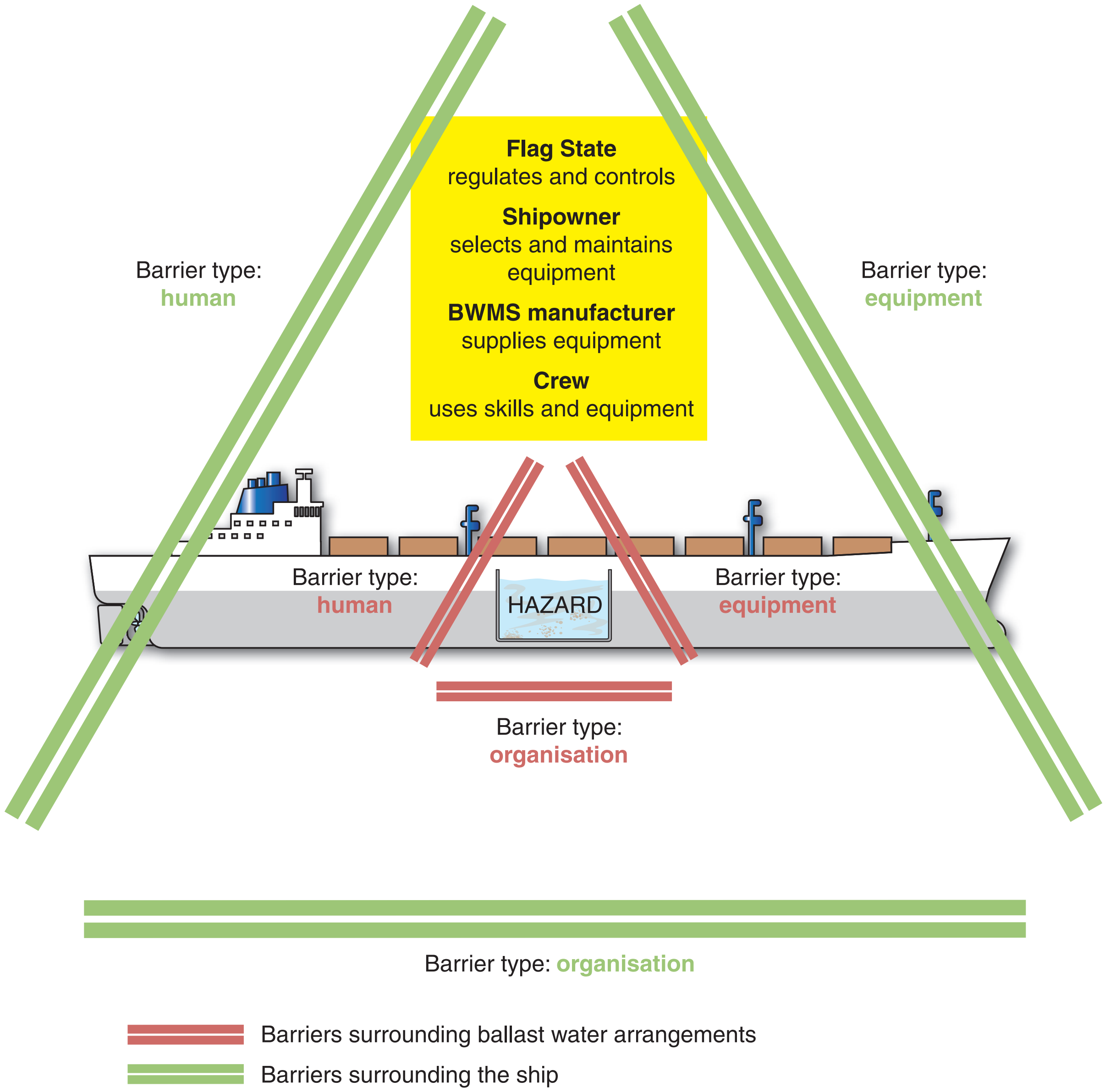

Figure 15: Risk mitigation measures applying to ballast water and sediments management, the ship, the equipment and its crew

Both the Flag State and the shipowner are key players for effective implementation of a risk mitigation strategy.

The activities of the Flag State in mitigating risks are summarized in Figure 16 and developed in the following sections.

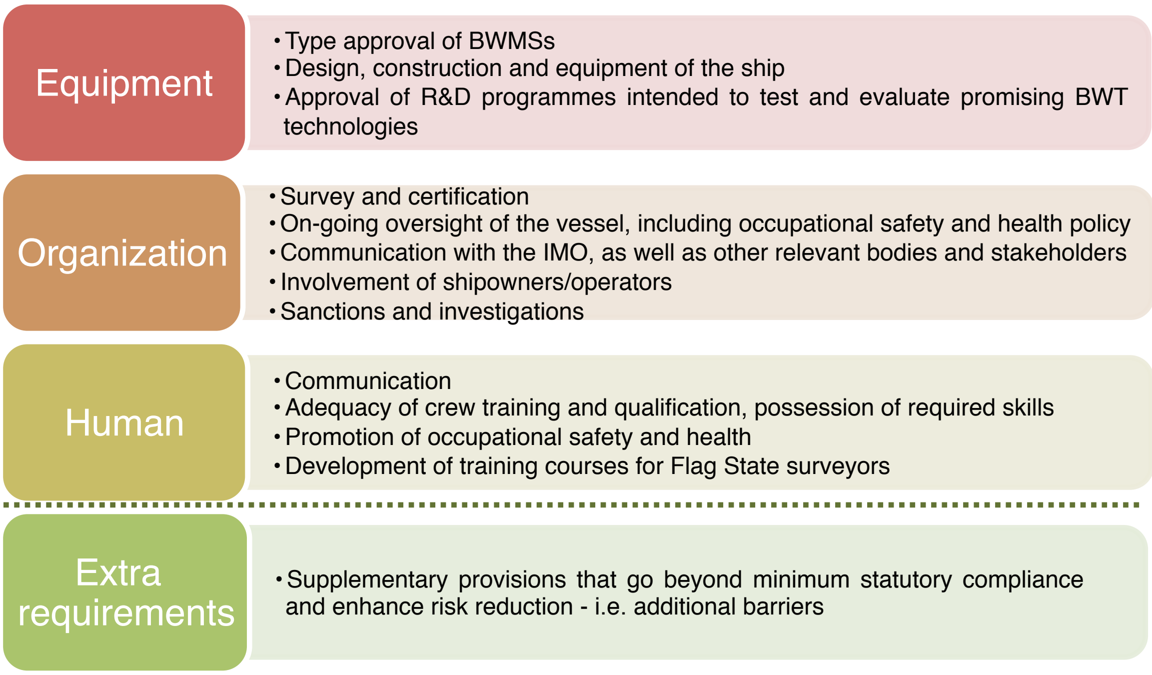

Figure 16: Key areas of Flag State action in risk mitigation

3.1.1 Legislative power and supervision as risk control mechanisms

The Flag State exercises jurisdiction and control over its fleet[63], and has the responsibility to make sure that ships flying its flag comply with international rules and standards[64].

The Flag State must develop and **enact appropriate domestic laws and regulations** to give effect to the provisions of the BWM Convention. In particular, the Flag State should verify **that the BWM regulations do not adversely affect other regulations** (e.g. Figure 17).

National legislation can be supplemented by specific guidance on key areas such as **safety and health issues**, **compatibility between BWMSs and ballast tank coatings** (IMO, 2007a ; International Paint and Printing Ink Council as cited in IMO, 2011c), as well as **alternative ballast water treatment methods** (GEF-UNDP-IMO GloBallast Partnerships Programme & GESAMP, 2011; IMO, 2012d). Such guidance could advise shipowners and also help them in determining the criteria to be applied in the assessment and mitigation of risks. This should be based on guidance developed by IMO.

The Flag State's prerogatives in the **control of ships**[65], the **direct verification and evaluation of the shipping company**[66] and the **issuance of certificates** can be seen as the **cornerstone of risk mitigation**. In this respect, the issuance of the International Ballast Water Management Certificate is conditioned by various documents, among which is the BWMP. This plan should be specific to the vessel and must be approved by the Flag State (IMO, 2005).

Through compliance supervision and enforcement, the Flag State not only fulfills its obligations under international law but also **contributes to the mitigation of risks** on board its ships.

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63 UNCLOS Article 94.1.
64 UNCLOS Article 217.1.
65 UNCLOS Articles 94.1 and 217.3.
66 ISM Code Section 13, paragraph 2.

In the implementation and enforcement of the BWM Convention, the Flag State has the power to intervene in four areas (figure 18):

- Survey and certification;
- Maritime training and education of seafarers;
- Management supervision; and
- Sanctions and investigations.

The prerogative of the Flag State to ensure that safety and environmental protection procedures carried out by its ships are properly managed[67], and to **ensure compliance with its own requirements based on the BWM Convention**, means the Administration has a responsibility in the management of risks.

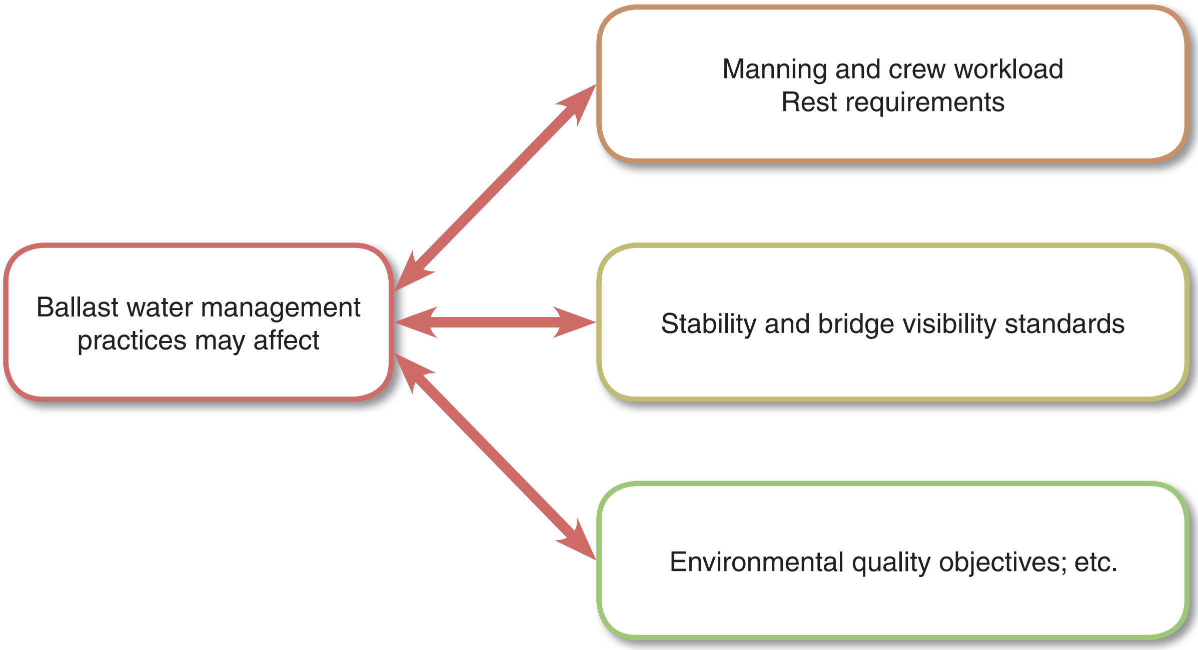

Figure 17: Examples of regulations and standards affected by BWM practices

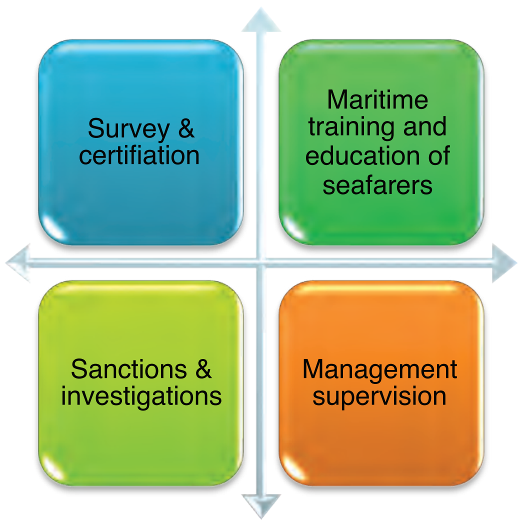

Figure 18: Four dimensions of Flag State implementation and enforcement

[67] ISM Code Section 2.

3.1.2 Alertness and prudence in the type approval of BWMSs

The Flag State has the obligation to oversee the systems which are installed on board the ships flying its flag; BWMSs are no exception.

During the type approval procedure, the Flag State should ensure that all aspects of the BWMS are given serious consideration before the **type approval certificate** is issued. It is noteworthy that this certificate can be suspended or revoked if **random checks** reveal that the requirements imposed on the manufacturer **to mitigate risks** are no longer met (IMO, 2006b). Extensive guidance has been developed by IMO to help the Flag State undertake this work – see the Amendments to the *Guidance for Administrations on the type approval process for ballast water management systems in accordance with Guidelines G8* (IMO, 2013c; see also Table 6).

BWMSs which utilize or generate **active substances,** chemicals or free radicals, require a more in-depth investigation than others. Such systems have to be approved by IMO based on advice from the GESAMP-BWWG[68], in accordance with the *Procedure for approval of ballast water management systems that make use of active substances (G9)*.

Occupational exposure to '**CMR**[69] substances' – i.e. substances which have the potential to cause cancer, genetic mutation or damage to fertility – should be given special attention (GESAMP, 2012a).

The Flag State determines whether or not the BWMS should be presented to the IMO/GESAMP-BWWG (IMO, 2010c; GESAMP, 2012a) and in assessing risks should always consider the **worst case scenario** (see Table 6).

Table 6: Some factors to consider during type approval process

Ship safety	Nature of the substance used (physical and chemical properties), substance storage, corrosion effects, safety devices, substances generated during the treatment process, reliability of electrical equipment, etc.
Occupational safety and health	Nature of the substance used (carcinogenic, mutagenic and endocrine disruptive properties), engineering controls, vibrations, accessibility for maintenance and inspection, substances generated during the treatment process, hot surfaces, electrical arrangements, waste disposal, etc.
Public health	Nature of the substance used (carcinogenic, mutagenic and endocrine disruptive properties), substances generated during the treatment process, bulk storage, waste disposal, etc.
Environment	Biological effectiveness, nature of the substance used (persistence, bioaccumulation and toxicity), substances generated during the treatment process, waste disposal, etc.

When the Flag State does not possess technical expertise in water treatment technologies and related risks, it can delegate the type approval process to '**designated bodies**' – i.e. recognized organizations/classification societies. However, **the Administration remains responsible for compliance** with the relevant requirement of the BWM Convention – i.e. the system "must be safe in terms of the ship, its equipment and the crew" (Regulation D-3.3).

BWMS testing programmes must be executed in **recognized testing facilities** (IMO, 2010c) with the requisite laboratories.

[68] Regulation D-3.2 of the BWM Convention provides that "ballast water management systems which make use of active substances or preparations containing one or more active substances to comply with this Convention shall be approved by the Organization, based on a procedure developed by the Organization".

[69] 'CMR' stands for carcinogenicity, mutagenicity and reproductive toxicity.

Before granting type approval and issuing the type approval certificate, the Flag State should ascertain that the BWMS:

- fulfills the technical requirements regarding treatment, control, monitoring and sampling. In particular the BWMS must be capable of meeting the D-2 standard in both **land-based**[70] and **shipboard testing**[71]; and
- does not cause harm to the crew, the public health, the ship safety and the environment, i.e. meets the requirements of Regulation D-3.3.

3.1.3 Human element and risk mitigation

The measures intended to reduce the risks to which crew members and Flag State inspectors are exposed fall into five main categories:

a) Adequate training and increased medical surveillance with regard to hazardous substances and/or technologies

Seafarers and Flag State inspectors may be exposed to hazardous chemicals, ultraviolet radiation, excessive heat, etc. which entail risks for their safety and health – particularly in the case of 'CMR substances' (GESAMP, 2012a). Hence, it is essential to train workers to increase their knowledge of chemical hazards and safe practices[72] (IMO, 2009a).

Additionally, it is necessary to reinforce medical surveillance for seafarers and Flag State inspectors. The ILO (1990) has provided recommendations for medical surveillance of workers exposed to hazardous chemicals.

b) Optimized human/machine interface to ensure safe operation, maintenance, repair and inspection of BWMSs

The ILO (2011) has developed a *Code of practice on safety and health in the use of machinery.*

c) Training for entry in ballast tanks, removal of sediments, sampling

The IMO provides guidance for entry into enclosed spaces (IMO, 2011d) as well as for the health and safety aspects of sampling (IMO, 2008a), in accordance with the G2 Guidelines.

d) Provision of adequate Personal Protective Equipment (PPE)

e) The Flag State should ensure that all incidents and accidents arising from the transport, storage, handling and use of chemicals, or during the operation, maintenance and inspection of BWMSs, or during work inside ballast tanks, are properly **investigated** so as to identify their causes and inform the shipping community.

Apart from Flag State jurisdiction, the second pillar supporting an effective risk mitigation strategy on board the ship is the **risk management regime established by the shipowner**.

Shipowners make important decisions affecting ship safety affecting:

- ship design and construction;
- the allocation of resources;
- selection of equipment;
- maintenance and repair progamme;
- selection of seafarers;
- occupational safety and health, as well as the development of safety procedures.

[70] "Land-based testing is a test of the BWMS carried out in a laboratory, equipment factory or pilot plant including a moored test barge or test ship (…) to confirm that the BWMS meets the standards set by Regulation D-2 of the Convention" (IMO, 2008c).

[71] "Shipboard testing is a full-scale test of a complete BWMS carried out on board a ship (…) to confirm that the system meets the standards set by Regulation D-2 of the Convention" (IMO, 2008a).

[72] "Shipowners and masters should ensure crew are instructed and trained appropriately, specifically to familiarize themselves with the Safety Data Sheet for any chemicals or preparations used in the course of ballast water treatment. Crew should also be made aware of any potentially hazardous by-products (aqueous or gaseous) which may be produced during the ballast water treatment process" (IMO, 2009a).

3.2 RISK MITIGATION FROM THE PERSPECTIVE OF THE COASTAL STATE

As part of risk management, the Coastal State has the duty to:

- take action to control risks to **human and animal health, the environment and coast-dependent activities** on its territory and in waters under its jurisdiction;
- avoid any harmful side-effect resulting from the implementation of such measures; and
- help other countries in reducing risks.

In regard to the BWM Convention, the Coastal State must:

- monitor the effects of ballast water and sediments management, including in designated BWE areas (G14); and
- prohibit violations and establish adequate sanctions.

In order to adapt the provisions of the BWM Convention to local circumstances and vulnerabilities, the Coastal State is given the right to take additional, **more stringent measures** (Regulation C-1 of the BWM Convention; also *Guidelines (G13) for additional measures regarding ballast water management including emergency situations*).

Such risk mitigation measures can be taken either on a national or regional basis, or both.

Additionally, Coastal States can derive advantage from **regional cooperation and networking** in the management of risks.

3.2.1 Environmental monitoring

Both the United Nations Convention on the Law of the Sea[73] (UNCLOS) and the Convention on Biological Diversity[74] (CBD) convey an obligation to **monitor and assess the environment**, such as when human activities are likely to **change** or harm marine ecosystems or resources. Marine monitoring is a **management tool** inasmuch as it allows the assessment of the effectiveness of risk mitigation measures (IOC-UNESCO, 2009).

State Parties to the BWM Convention are expected[75] to monitor, in waters under their jurisdiction, the impacts of ballast water and sediments management on human and animal health, the environment and socio-economic activities.

One way to evaluate the effects of ballast water and sediments management is to perform a **rapid biological assessment**[76] of areas most exposed to ballast water discharges e.g. ports, marinas, designated BWE areas. The Subsidiary Body on Scientific, Technical and Technological Advice (2003) has developed a five-module framework for rapid assessment. In addition, a GloBallast Monograph on Port Biological Baseline Surveys is being developed by the GloBallast Partnerships.

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[73] UNCLOS Articles 204 and 206.

[74] Article 7 of the CBD reads "each Contracting Party shall, as far as possible and as appropriate (…) monitor, through sampling and other techniques, the components of biological diversity (…) identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling and other techniques".

[75] Article 6.1 of the BWM Convention provides that "Parties shall endeavour, individually or jointly, to (…) monitor the effects of ballast water management in waters under their jurisdiction. Such (…) monitoring should include observation, measurement, sampling, evaluation and analysis of the effectiveness and adverse impacts of any technology or methodology as well as any adverse impacts caused by such organisms and pathogens that have been identified to have been transferred through ships' ballast water".

[76] "Rapid assessment can be defined as a synoptic assessment, which is often undertaken as a matter of urgency, in the shortest timeframe possible to produce reliable and applicable results" (SBSTTA, 2003).

An environmental monitoring programme should, at least, serve two purposes:

- Detection of changes in species distribution and/or environmental conditions, and presence of introduced aquatic organisms, including in designated BWE areas[77]; and
- Detection of hazardous chemicals released in coastal waters through treated ballast water discharges.

Surveys to detect the presence of alien species can sometimes be integrated with surveys for other purposes, such as water quality surveillance, food biosecurity management, **epidemiology**[78] etc.

Environmental monitoring contributes to **informed decisions** because it provides public authorities with the scientific data needed to assess risks and take appropriate risk control measures. This may consist, for example, in closing shellfish harvesting areas when toxic algal blooms are detected.

3.2.2 Public awareness and preparedness

To mobilize and assist people in taking action to avoid or reduce risks, it is necessary to raise awareness and disseminate information (UN, 2004). Media reports, advertisements, public meetings, educational campaigns, professional and institutional workshops can all help in disseminating advice and guidance.

Public information programmes should take account of local circumstances, especially any obvious **vulnerabilities** to biological invasions and related BWM measures. These vulnerabilities are determined by the level of exposure to hazards and the ability of people exposed to adapt to these hazards and the risks they present (UNEP, 2003).

Basic knowledge, good practices and precautions can prepare local communities to:

- contribute to environmental monitoring and violation reporting; and to
- recognize some public health hazards – e.g. chemical odors, coloration of surface water during an algal bloom event – and thus protect themselves.

Some examples of adverse events that may be related to ballast water and/or its management include:

- Disease outbreak;
- Harmful algal blooms (HAB) – e.g. red tides caused by the dinoflagellate *Alexandrium tamarense* along the eastern coast of the United States, as well as in Australia and New Zealand;
- Chemical leakage or spillage with impacts in water and/or the atmosphere;
- Fire in port chemical storage facilities; and
- Entry of unauthorized persons in port chemical storage facilities.

The task of raising public awareness about environmental health risks may be facilitated by the establishment of a specialized coordination mechanism embracing human resources, equipment and organizational support (WHO, 2007a).

Maintaining **environmental health**[79] depends not only on the involvement of people who are actually or potentially the most exposed to hazards, but also the participation of those who can help manage the risks (United Kingdom Cabinet Office, 2002 ; WHO, 2006b).

Emergency preparedness reduces risks inasmuch as it disseminates information, enhances awareness, creates structures and mechanisms, mobilizes resources, and thereby reduces the consequences of adverse events on human health, the environment and coast-dependent activities.

Emergency preparedness mobilizes a large amount of human, material and organizational resources and therefore requires coordination within the framework of an **emergency response plan**. Full guidance has

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[77] See the *Guidelines on designation of areas for ballast water exchange (G14)*.

[78] "Epidemiology designates the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control health problems" (Last, 1995).

[79] "Environmental health is concerned with all the factors, circumstances, and conditions in the environment or surroundings of humans that can influence health and well-being" (Last, 1998).

been developed on the preparation for emergency situations in the *Guidance document on arrangements for responding to emergency situations involving ballast water operations* (IMO, 2008b) which employs risk assessment procedures to focus on preparedness.

Amongst other things, the emergency response plan should identify the authority responsible for disseminating **warnings to ships** so as to inform mariners of areas where ballast water should not be taken aboard[80].

3.2.3 Adoption of additional measures

The BWM Convention empowers States to take more stringent or additional measures (Regulation C-1), either on a national or regional level[81], in accordance with **international law**.

According to UNCLOS, the Coastal State has the right to:

- take measures to **restrict the admission of ships to its internal waters and ports**[82]**; and regulate ships' transit in its territorial waters for the purposes of environmental protection**[83]**.**

Although Article 211.6 empowers the Coastal State to impose more stringent measures on ships to protect a vulnerable area within its Exclusive Economic Zone (EEZ) from pollution[84], this provision cannot be applied to prevent the introduction of aquatic organisms and pathogens in the marine environment. This is because neither the definition of pollution provided by UNCLOS, nor the provisions addressing marine pollution in Part XII, apply to the introduction of aquatic organisms and pathogens (United Nations Division for Ocean Affairs and the Law of the Sea as cited in IMO, 2003c).

The Coastal State can designate marine protected areas to safeguard sensitive ecosystems, characterized by their intrinsic vulnerability, importance for the sustenance and reproduction of endangered species, species richness or significance for the well-being of people. Currently, "only 3.5% of exclusive economic zones and less than 1.5% of the total ocean area are designated as marine protected areas" (UN, 2011).

Other vulnerable locations, such as municipal and desalination plant[85] water intakes (WHO, 2011a) and **aquaculture establishments**[86], may also warrant enhanced protection.

The *Guidelines for additional measures regarding ballast water management including emergency situations* (G13) offer advice for establishing additional measures.

The Coastal State is responsible for providing ships with necessary information about the additional requirements that have been adopted. It is essential to ensure compliance.

[80] BWM Convention Regulation C-2.

[81] BWM Convention Article 2.3 states "nothing in this Convention shall be interpreted as preventing a Party from taking, individually or jointly with other Parties, more stringent measures with respect to the prevention, reduction or elimination of the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments, consistent with international law". In addition, Section C of the Annex relates to the special requirements applicable to certain areas.

[82] UNCLOS Article 25.2.

[83] According to Article 21 of UNCLOS, such regulations cannot apply to the design, construction, manning or equipment of foreign ships.

[84] According to Article 211.6 of UNCLOS, additional laws and regulations should be enforced in a particular, clearly defined area of the State's EEZ ; should relate to discharges or navigational practices ; and should not require ships to comply with design, construction, manning or equipment standards other than applicable international standards.

[85] In arid regions, desalination plants are the main source of freshwater for the population.

[86] "Aquaculture establishment means an establishment in which fish, mollusks or crustaceans for breeding, stocking or marketing are raised or kept" (World Organisation for Animal Health, 2011).

3.2.4 Regional cooperation and networking

The BWM Convention encourages regional cooperation[87] and research[88]. Some Coastal States cannot afford to establish their own marine scientific research[89], training and monitoring programmes. In such cases, States would benefit from collaborating with **existing research, training or monitoring initiatives** undertaken at regional level – e.g. the White Water to Blue Water Initiative (WW2BW) in the Caribbean Region.

Improving scientific knowledge on oceans and seas, including marine resources, reduces the uncertainties which hamper effective risk assessment. Various international instruments recall the importance of scientific research (e.g. UNCLOS art.200 & 201, CBD art.12, BWM Convention, article6).

An inter-country partnership might comprise a forum to **exchange information** and experience, initiate joint research and development programmes, and arrangements for sharing resources and training facilities.

For example, risk assessments can be conducted within the framework of a regional partnership to assess whether exemptions (Chapters 3.2 & 3.3) from certain BWM requirements might be given to ships operating exclusively within a regional sea area.

This has been done in the Baltic, where regional cooperation has proven effective in addressing maritime and marine resource management issues (Box 5).

Box 5: Pilot risk assessment in the Baltic Sea

A pilot risk assessment has been conducted for the Helsinki Commission (HELCOM) in order to assess the risk posed by ballast water discharges within marine areas of the Baltic Sea.

Four shipping routes were brought into focus as examples for the study:

- Saint Petersburg (Russia)/Gothenburg (Sweden);
- Klaipëda (Lithuania)/Kiel (Germany);
- Kiel (Germany)/Gothenburg (Sweden); and
- Terneuzen (Netherlands)/Mönsterås (Sweden)/Karlshamn (Sweden).

The process was conducted on the basis of the IMO Guidelines for risk assessment (G7) and the *HELCOM Guidance to distinguish between unacceptable high risk scenarios and acceptable low risk scenarios – a risk of spreading of alien species by ships on Intra-Baltic voyages.*

The risk assessment methods outlined in the G7 Guidelines, and their applicability in the context of the study, were reviewed and analysed. The species biogeographical risk assessment method was set aside, whereas the species-specific and environmental matching risk assessment methods were used in combination. It is noteworthy that some port environmental parameters – e.g. salinity – were considered to be more relevant than others such as temperature, nutrients and oxygen.

With regard to the scope of the study, the LME approach was excluded because the Baltic Sea is not considered as a truly marine ecosystem due to its low salinity i.e. brackish waters.

Risk analysts had to confront the lack of data regarding the presence and abundance of species in most ports of the Baltic Sea. This observation reinforced the need for port baseline surveys, and thus further monitoring and research, to be undertaken.

(Source: Gollasch, *et al.*, 2011)

[87] BWM Convention Article 13.3 provides that "in order to further the objectives of this Convention, Parties with common interests to protect the environment, human health, property and resources in a given geographical area, in particular, those Parties bordering enclosed and semi-enclosed seas, shall endeavour, taking into account characteristic regional features, to enhance regional co-operation, including through the conclusion of regional agreements consistent with this Convention. Parties shall seek to co-operate with the Parties to regional agreements to develop harmonized procedures".

[88] BWM Convention Article 6.

[89] UNCLOS Articles 245 and 246.

3.3 RISK MITIGATION FROM THE PERSPECTIVE OF THE PORT STATE

"*Port State jurisdiction is a concept of an essentially corrective kind : it aims to correct non-compliance or ineffective Flag State enforcement of IMO regulations by foreign ships voluntarily in port and is an incentive for Flag State compliance*" (IMO, 2012a).

In mitigating risks, the role of the Port State includes the installation of additional barriers to confine hazards. This involves the intervention of certified and suitably-equipped inspectors, operating within an appropriate organizational framework.

The purpose of Port State Control (PSC) is twofold:

- To protect the local environment from ship's activities and related risks; and
- To contribute to the global implementation and enforcement of international standards.

PSC aims to ensure that ships fully comply with mandatory requirements and is therefore considered to be the ultimate mechanism for the safe operation of ships and risk management.

Although primary responsibility for regulating ship operations is assumed by the Flag State, the Port State can constitute an additional barrier in controlling the application of international standards with respect to maritime safety, marine environmental protection and maritime security (IMO, 2011e). It plays a significant role in compliance monitoring and enforcement, the ultimate purpose of which is to eliminate substandard shipping.

Port State actions in risk mitigation can be understood in two ways:

- On the one hand, they can **alleviate constraints** imposed on ships and grant exemptions.
- On the other hand, they can inspect ships and enforce **obedience to standards that are more stringent** than those set out in the BWM Convention.

Hence, the Port State is given some flexibility in the implementation of the BWM Convention as it applies to ships, and thus in risk management (Figure 19).

Furthermore, the Port State has the obligation to provide sediments reception facilities in shipyards or ship repair facilities.

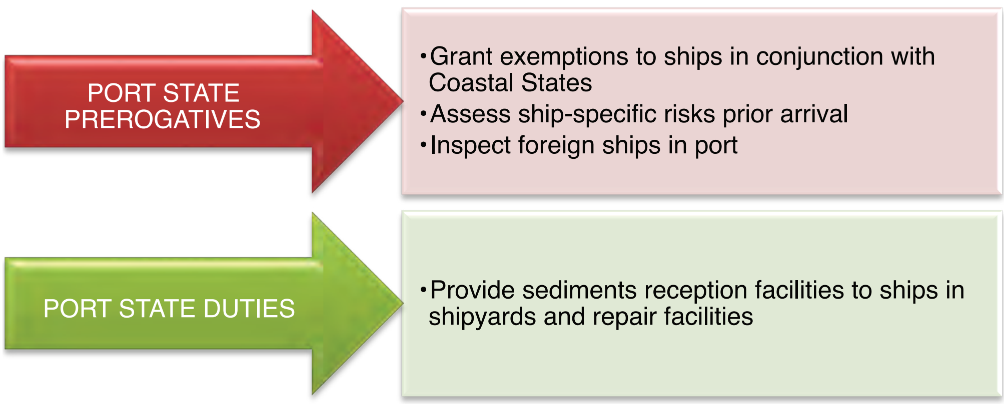

Figure 19: Port State prerogatives and duties in risk management

3.3.1 Evaluation of exemption applications

When a ship undertakes frequent voyages on a specific route, and where such voyages cover short distances and/or the ship carries limited ballast water volumes (e.g. ferries), the shipowner/operator can submit an application for exemption to the Port State. The purpose of this procedure is to reduce the burden of ballast water management operations imposed on low-risk ships.

Apart from the concessions granted to the shipowner, exemptions can also apply in situations where ships engaged in short voyages may not be able to carry out ballast water management operations. For example, conditions may be inadequate for BWE due to distance from shore and water depth or insufficient holding time in tanks for active substances to work effectively or degrade.

Regulation A-4 of the BWM Convention provides that exemptions may be granted to ships sailing between specified ports or locations, provided they do not pose risks to human and animal health, the environment, and coast-dependent activities in the Port State, but also in other States. This last requirement calls for consultation with neighboring countries; indeed, the transit of the ship may affect several States and each of them needs to be aware of the risks and decide whether or not to accept them.

An **individual risk assessment** must be executed in support of an application for exemption submitted to the Port State.

Such a risk assessment is carried out:

- by the applicant, i.e. the **shipowner** or **operator**, in the first instance; then the **Port State** carries out its own evaluation of risks before **making a decision**; or
- directly by the **Port State**.

The Port State makes the decision to grant an exemption with reference to **what is an 'acceptable risk'** (e.g. ALARP method) **for the country, but also for neighboring countries**. Consequently, cooperation and communication have paramount importance in the exemption process.

The shipowner should follow the methods outlined in the *Guidelines for risk assessment under Regulation A-4 of the BWM Convention (G7):*

- **Environmental matching risk assessment**: This involves the comparison of environmental parameters characterizing the donor and recipient biogeographic regions to evaluate the potential for species to survive and become established. Examples of environmental parameters include salinity, temperature, nutrients and oxygen.

  The purpose of this method is to determine whether the conditions prevailing in the donor region are compatible with those prevailing in the recipient region.
- **Species biogeographical risk assessment**: This involves the comparison of indigenous and non-indigenous species distributions, both in the donor and recipient biogeographic regions – i.e. examining records of previous invasions.
- **Species-specific risk assessment**: This involves the investigation of 'target species' that are already implicated in biological invasions, with particular reference to the environmental parameters characterizing the recipient biogeographic region.

Each method has some shortcomings when applied alone; it may embody a significant degree of uncertainty.

As far as the **environmental matching risk assessment** is concerned, the method does not take into consideration some risk factors such as the ability of a species to survive the journey and the minimum number of organisms necessary to establish a reproductive population (Gollasch, 2006).

The **species-specific method** requires, for a given species, a large amount of data on **biotic factors** – e.g. competition and predation relationship with other species, and **past biological invasion occurrences,** to enable the assessment of risks. Such data are often lacking (EPA, 2008).

The environmental parameters and species assemblages in a given biogeographic region are subject to temporal and spatial variability (Ruiz & Carlton, 2003). Because of this variability, it can be difficult to determine whether observed changes in biodiversity are more severe than those that might have occurred by chance (Magurran & Henderson, 2010). For example, climate change may create more favorable conditions for some species that are not considered harmful and are therefore omitted from risk assessments. In time, some of these species may become established and could out-compete native species (De Poorter, Darby & MacKay, 2009).

Before reaching a decision on exemption applications, the Port State should carefully examine the reliability of the underlying data and uncertainties of the risk assessment submitted. Exemptions are granted for a period of time that cannot exceed **five years** and are subject to **intermediate reviews**. Box 6 provides an example of an exemption process.

Box 6: Case history: risk assessment in practice by the Danish company Litehauz which conducted the project (exemption under regulation A-4 of the BWM Convention)

During 2011/2012, a private company (Litehauz) conducted two risk assessments (RA) for the ferry company Scandlines Danmark A/S on an intra-Baltic route between Denmark and Germany. The route comprises the ports of Gedser (Denmark) and Rostock (Germany), both located in Mecklenburg Bight in the south-western part of the Baltic Sea. The distance between the ports is less than 50km and the route has been operated for approximately 100 years. Gedser port has no commercial activity other than the ferry line to Rostock, whereas Rostock handles approximately 26 million tons of goods annually.

Methodology

The applied RA methodology is based on the species-specific risk assessment methodology described in the G7 Guidelines and the recommendations given in the Helsinki Commission's (HELCOM) guidance document for intra-Baltic voyages. The HELCOM guidance document includes an analysis of environmental conditions that basically entails the environmental matching RA in G7, where specific parameters are assessed with regard to environmental similarity – i.e. salinity, water temperature, and hydrodynamic conditions such as currents, water levels and proximity to freshwater. A considerable body of data were available on invasive species in the area and no new field surveys were conducted.

A major challenge was experienced with regard to selection of target species, as lists containing such species do not exist on a port-by-port basis for intra-Baltic voyages.

Consequently, two project-specific "Assessment Target Species" (ATS) lists were constructed, one for each port. The HELCOM alien species database was used as a basis for selection of ATS together with additional area or site-specific information and national black lists and observations lists. The criteria used to select the ATS were based on the G7 Guidelines selection criteria. In addition, it was decided not to include species introduced prior to 1945, as suggested in the RA guideline for the North Sea and Baltic Sea. More than 180 species were screened in total, resulting in two ATS lists containing seven species for Gedser and 31 species for Rostock. In the species-specific RA the identified ATS were assessed with regard to their status of establishment and their ability to disperse naturally. Secondly, the remaining ATS were assessed on their potential for being taken up by ballasting and on whether such species were likely to successfully establish in the recipient port. Species not likely to be taken up by ballast water and not likely to establish were assessed as low risk.

Case result

Assessment of environmental conditions

Not surprisingly, the assessment of environmental conditions showed that the ports are not sufficiently different based on the key environmental parameters, salinity and temperature, to rule out successful transfer of ATS on these grounds alone.

Species-specific risk assessment

Six out of seven species present in Gedser were either already present in Rostock or could disperse naturally in the area. The one remaining species would not be able to survive and establish viable populations in Rostock due to salinity restrictions imposed by influx of freshwater from the Warnow river. Consequently, the risk associated with transfer of ATS from Gedser to Rostock is low and ballast water from Gedser can safely be discharged in Rostock.

The RA for voyages from Rostock to Gedser showed that 29 out of 31 ATS present in Rostock qualify for low risk of transfer to Gedser based on either their ability to disperse naturally, likelihood to survive the salinity range at Gedser, or likely presence in ballast water loaded in Rostock.

The remaining two ATS identified in Rostock are not considered low-risk, neither are they deemed high-risk species (the HELCOM RA guidance document does not operate with a medium risk level). This is mainly due to a lack of information on their occurrence at the specific uptake locations and uncertainty regarding their occurrence in ballast water. There is a long history of ballast water discharges at Gedser and no evidence of previous transfers of these two species. The final ruling of the Administration is awaited.

3.3.2 Ship targeting: assessment of ship-specific risks prior to arrival

The development of information and communication technologies enables direct contact between ships and ports. Some port authorities require ships to provide information before arrival in port.

The information so communicated can include details about **ballast water status** on board the ship. The BWM Convention requires each ship to have on board a Ballast Water Record Book which is open for inspection (Regulation B-2). However, the Convention does not provide for a **Ballast Water Reporting Form (BWRF)**. This pre-arrival document contains details about ballast water history, with reference to each independent ballast tank and/or intention to deballast in the port. The BWRF is an essential tool to assess the ship's risk profile prior to arrival and to develop or advise on risk mitigation measures.

Pre-arrival notification is a procedure widely implemented in countries which developed national regulations before the BWM Convention was adopted. It enables assessment of ballasting arrangements, particularly whether BWE has been conducted or not. Use of the BWRF could be extended to other forms of ballast water management and may be considered an **additional measure** under Regulation C-1.

In reality, some countries which impose additional, **national** BWM requirements demand a BWRF. The objectives are to assess the risks associated with the ship's ballast water prior to arrival at the port and to acquire experience on ballast water management. Some Port States, either **nationally** e.g. Australia, India, New Zealand, or **regionally** e.g. ROPME Sea Area, already have reporting systems based on a BWRF.

Box 7 describes the implementation of a risk assessment system in Mauritius.

Box 7: The IOI-SA BWRADS system applied in Port Louis, Mauritius

The International Ocean Institute – Southern Africa (IOI-SA) and the Mauritius Oceanographic Institute have collaborated to install a customized Ballast Water Risk Assessment & Decision Support (BWRADS) system for the use of the Shipping Administration and Port Authority at Port Louis. As a follow-up to the comprehensive port survey and ballast water management efforts being supported by the government of Mauritius, the system is designed to support the Compliance Monitoring and Enforcement (CME) efforts associated with the implementation of the BWM Convention.

The system provides an assessment of risks of unwanted species introductions posed by vessels carrying ballast water to help in targeting control measures (e.g. ship inspections) at the highest risk vessels entering port. It then provides guidance for the type of inspection to be conducted, while archiving the data provided. **The system works on the basic information supplied by a vessel in the Ballast Water Reporting Form (BWRF)**. When the key information is entered by the user an assessment of the relative risk for invasive species introduction is produced, along with interpretation of the risk and application to the key decisions to be made.

The risk assessment has three basic components:

- Environmental similarity;
- Voyage-specific risk; and
- Presence of known invasive species in source waters.

Environmental similarity is assessed on an ecoregion basis using available international oceanographic and coastal ecosystem information. The ballast water source port is then compared to the intended port of discharge. The voyage risk is assessed by noting the volume of ballast water on board, the overall time since it was loaded and the number of recent discharges originating from the same source waters. Global records of invasive species presence and distribution are incorporated into the system; the assessed risk increases if the ballast water is sourced from ecoregions known to contain invasive species.

This system is designed specifically for use by port, maritime or environmental authorities to assist in CME and ballast water management generally. It is not intended to be used as a basis for exemptions under the BWM Convention. The system is however adaptable to any port or region of the world and is being further developed with a view to installation in other areas.

Figure 20 shows that the BWRF is the first step in conducting a ship-specific risk assessment.

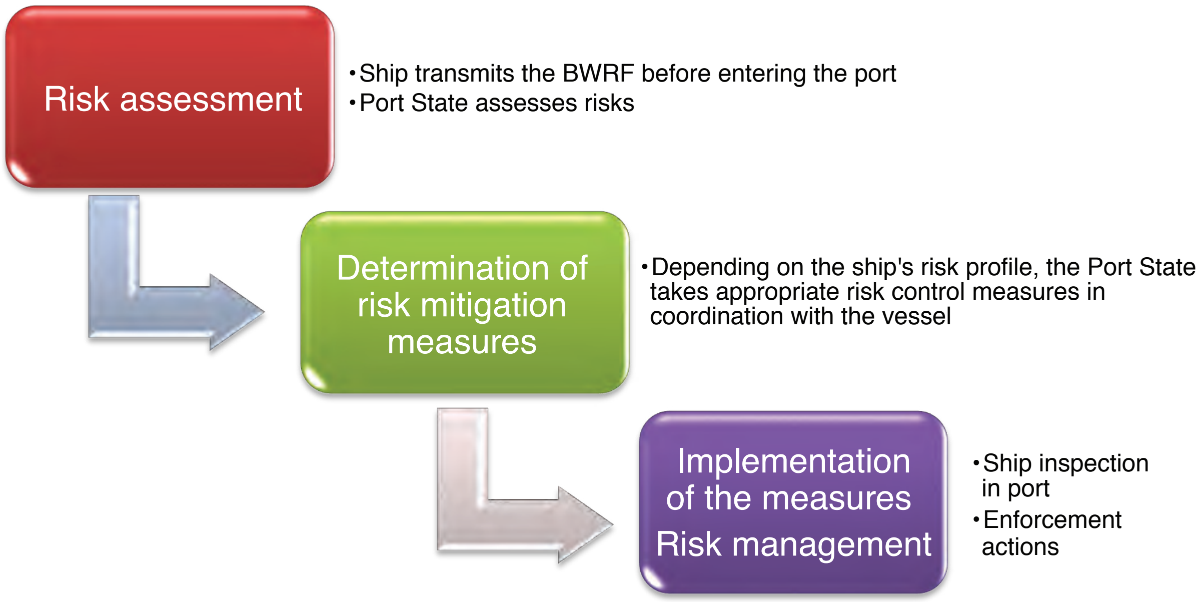

Figure 20: Main features of a Port State risk management strategy applied to arriving ships

On the basis of the information collected through a BWRF system and other databases, Turkey has developed a computerized risk assessment tool (Box 8).

Box 8: The Turkish Ballast Water Risk Assessment (BWRA) system based on the GloBallast BWRA methodology

Since 2006, the Scientific and Technological Research Council of Turkey (TÜBİTAK) has conducted a national project on invasive alien species transferred by ships' ballast water. This project aims to develop a computerized system to assess the risk of alien species introduction in Turkish ports through ships' ballast water, depending upon source ports.

Turkey experienced severe environmental and socio-economic damages due to the invasion of the ctenophore *Mnemiopsis leidyi*. The transfer of this jellyfish from the Americas to the Black Sea in the late 1980s has been attributed to ships' ballast water (GESAMP, 1997). The subsequent collapse of pelagic fish stocks, particularly anchovy and sprat, resulted in substantial economic losses for the Turkish fisheries – estimated up to USD 300 million per year (General Fisheries Commission for the Mediterranean, 2012).

In the first place, the project consisted of an experimental study conducted in the port of Botas. Arriving ships were required to exchange ballast water before calling in this port and to transmit a ballast water reporting form. Reported information was then entered in the internet-based Ballast Water Reporting Form System by ship agents. A Harmful Species Database, comprising existing global invasive species databases and a comprehensive scientific literature review, was also constructed. It includes information on distributions, habitats and related physico-chemical parameters.

The Reporting Form and Harmful Species Database were then combined into an internet-based Ballast Water Risk Assessment (BWRA) System. It is an application programme developed in accordance with the GloBallast BWRA User Guide (available to governments on request to IMO-GloBallast), including GIS details on ship traffic, vessel types, port parameters and information on biogeographic regions. Taking into account the source and recipient ports, as well as ship and voyage particulars, the system gives an estimated risk level for each vessel. Hence, inspections can be targeted on ships which are assigned the highest level of risk.

In summary, the BWRF has the following characteristics:

- It enables ports to propose a risk mitigation plan prior to the ship's arrival;
- It is a useful way of **targeting ships to be inspected in port,** focusing resources on the greatest risks;
- It is economical compared to other risk control measures; and
- It enables data collection.

3.3.3 Inspection of foreign ships in port – Port State Control

Port States may **inspect foreign ships** while in ports and offshore terminals **to verify compliance** with the requirements of the BWM Convention.

Such inspections include:

- Verification of the **International Ballast Water Management Certificate**;
- Inspection of the **Ballast Water Record Book;** and
- When appropriate, **sampling of ballast water**[90].

Besides the verification of documents and ballast water sampling regimes, Port State Control Officers (PSCOs) may also verify the Type Approval Certificate of Ballast Water Management System and inspect the BWMS to ensure it is safe.

The Port State must also ensure that **'no more favourable treatment'** is given to ships whose Flag States have not ratified the BWM Convention[91].

The Port State can impose **sanctions** on ships in case of violations[92].

Concentrated inspection campaigns can be conducted within the framework of a regional agreement – Memorandum of Understanding (MoU) – in order to target a specific subject and enhance compliance.

An example of a risk mitigation strategy for ships arriving in port is given in Annex D.

3.3.4 Provision of adequate facilities

The BWM Convention requires Port States to equip their ports, as necessary and feasible, with the following facilities:

- **Reception facilities for sediments** in ports and terminals where cleaning or repair of ballast tanks occur;
- **Storage facilities** for active substances; and
- **Laboratory facilities** to analyze BW samples.

This does not necessarily mean a particular facility has to be installed at the port. These services can be provided as a service or from a call-out facility. An appropriate level of service should be provided based on the expected level of use, preferably based on a risk assessment.

In order to suppress the risks posed by the disposal of ballast tank sediments at sea, Port States are required to provide ships calling at their ports – and where cleaning or repair of ballast tanks occurs – with **sediments reception facilities**[93]. Once such facilities have been provided, Port States are obliged to report their availability and location to IMO[94].

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[90] BWM Convention Article 9.
[91] BWM Convention Article 3.3.
[92] BWM Convention Article 8.
[93] BWM Convention Article 5.1 reads "each Party undertakes to ensure that, in ports and terminals designated by that Party where cleaning or repair of ballast tanks occurs, adequate facilities are provided for the reception of sediments, taking into account the Guidelines developed by the Organization. Such reception facilities shall operate without causing undue delay to ships and shall provide for the safe disposal of such sediments that does not impair or damage their environment, human health, property or resources or those of other States".
[94] BWM Convention Article 14.1.b.

The *Guidelines for sediment reception facilities (G1)* have been developed to help Port States in planning the installation of such structures.

The Convention requires that sediments reception facilities must "provide for the safe disposal of sediments that does not impair or damage [the] environment, human health, property or resources" (Article 5). This calls for an **assessment of risks to human health, the environment and coast-dependent activities**, before the construction and during the operation of sediments reception facilities. Sediments are viewed as contaminated waste and the risks generated by their disposal, handling and treatment must be managed to avoid unwanted side-effects (IMO, 2006a). Currently, few if any ports provide sediments reception facilities and they are most likely to be required in the vicinity of shipyards, dry docks and ship service areas.

It is worth emphasizing that Port States are **not** obliged to provide **ballast water** reception facilities. However, some ports already collect, or plan to collect, ballast water from ships (Pereira, Botter, Brinati & Trevis, 2010; Matthijssen as cited in Eason, 2012b). To support the implementation of such equipment, the Guidelines for ballast water reception facilities (G5) have been developed.

Operators working in sediments and ballast water reception facilities have to be provided with adequate **training** and **Personal Protective Equipment** (PPE).

Ships should not be unduly delayed by the use of reception facilities.

When determining fees for the reception of sediments, Port States should take into consideration the risk that the competitive position of their ports may be undermined (De Langen & Nijdam, 2007).

Besides reception facilities, adequate warehousing needs to be arranged for the **storage of active substances** in port areas. Such facilities should provide for safe chemical storage and security protection.

Finally, to enforce the BWM Convention in accordance with Article 9, the Port State should be able to analyze ballast water samples in **laboratory facilities**. Samples of ballast water play a key role in compliance monitoring and in determining the efficacy of mitigation measures. Uncertainties inherent in sampling and analysis – both avoidable and unavoidable – must be taken into account in assessing risks (Box 9). Laboratory staff should have sufficient experience and expertise to ensure **accuracy** and **reliability** in counting organisms in these samples. The BWM Convention provides that such testing must not cause any delay to ships[95]. In busy ports, it may prove **difficult to deliver test results promptly** due to dense traffic and short turnaround times (Fuhr, *et al*., 2010; Wright, 2011; IMarEST as cited in IMO, 2011a). Guidance on the sourcing and provision of analytical facilities has been prepared to support the PSC Guidelines to be issued by IMO.

[95] BWM Convention Article 9.1.

Box 9: Port State Control and sampling

Under Article 9 of the BWM Convention a Party has the right to inspect and/or sample a ballast water discharge from a ship at any time in a port or offshore terminal. However, sampling and analysis to test for compliance with the D-2 Standard are prone to errors that might lead to inaccurate judgements and therefore a risk that unwanted organisms are released. Sampling strategies are being developed to ensure that sampling is representative – as required by Section 6.2.2 of the G-2 *Guidelines for ballast water sampling* – and standardised (IMO, 2013d). These strategies include sampling methods that test for the D-2 Standard and others that recognise and incorporate the potential sampling and analytical errors, identifying unsatisfactory systems by testing for gross non-compliance. A list of standardised strategies for use by PSC Officers is being developed by IMO.

The sampling of ballast water and sediments, where required, may be one of the more complex and costly tasks in enforcing the BWM Convention. The uncertainties inherent in sampling strategies, as well as in sample analysis, dictate that compliance monitoring alone will not eliminate risk. However, because the PSC operation is risk-based, and uses some form of targeting to identify ships that should be inspected, these risks and costs can often be reduced significantly. The inspection itself is also risk-based, with the inspector undertaking a basic ballast water document check. If the ballast water documentation – e.g. the BWMP, the type-approval certificate, the ballast water record book – is incomplete, then the inspector may take enforcement action without the need for sampling, undertake further investigation of the ballast water management on the ship and/or initiate sampling.

Additionally, if sampling is undertaken, then according to Section 6.3 of the Guidelines G-2 : "*an indicative analysis of the ballast water discharge may be undertaken to establish whether a ship is potentially compliant or non-compliant. Such a test could help the party identify immediate mitigation measures, within their existing powers, to avoid any additional impact from a possible non-compliant discharge from a ship*". A rapid assessment of compliance with the D-2 Standard may obviate the need to mobilise a full sampling team, with the associated costs. Methods for indicative analysis are being developed by Flag/Port States.

None of these risk reduction strategies remove the right of a State to sample a ship's ballast water discharge at any time.

Guidance on evaluating and mitigating the risks involved will be found in the PSC guidelines, yet to be finalized by IMO.

3.4 SUMMARY

The BWM Convention confers powers and responsibilities on key participants, namely the Flag State, the shipowner/operator, the Coastal State and the Port State, to reduce risks associated with the transfer of alien species and the management of ballast water and sediments.

Since there are few options for protection against invasive species once established, risk mitigation strategies should be founded on prevention through adequate pathway management – i.e. should apply to the ship's ballast water. By breaking the source-pathway-receptor linkage, preventive barriers are aimed at controlling the hazard in order to avoid harm to receiving environments.

Certain BWM measures on board vessels entail the use of hazardous techniques and substances. It follows that another set of barriers should be erected to ensure the safety and health of workers, both on board and ashore, as well as the integrity of the ships' structure and internal spaces.

Overviews of risks, related control measures and stakeholders, associated with ballast water and sediments, and also with their management, are presented in Figures 21 and 22 respectively.

RISKS ASSOCIATED WITH BALLAST WATER AND SEDIMENTS AND THEIR MANAGEMENT

BALLAST WATER AND SEDIMENTS RISKS
Risks relating to the introduction of alien organisms and pathogens

BALLAST WATER AND SEDIMENTS MANAGEMENT RISKS
Other risks arising from the management of ballast water and sediments, both on board the ship and ashore

HARM TO ENVIRONMENTS

ADVERSE EFFECTS ON PUBLIC HEALTH

ECONOMIC AND SOCIAL IMPACTS ON FISHERIES, AQUACULTURE AND TOURISM

DISRUPTION OF PORT ACTIVITIES

Stakeholders
- Ministry of Transport
- Maritime Administration
- Ministry of Environmental Conservation
- Ministry of Health, Ministry of Fisheries
- Ministry of Labour
- Ministry of Defense (Coast Guards, Navy)
- Quarantine Service
- Ministry of Education and Research
- Ministry of Tourism
- Agency in charge of marine protected area management
- Hospitals, occupational medicine, public medical care providers
- Research institutes on water quality
- Marine science, infectious diseases, water plant, desalination plant and sewage plant managers
- Shipowners
- Seafarers
- Classification societies
- Ship designers and ship builders
- Port Authorities
- Terminal operators
- Veterinarians
- Aquaculturists
- Artisanal and industrial fishers, etc.

Risk control measures
- Environmental monitoring
- public awareness and preparedness
- adoption of additional measures
- regional cooperation and networking
- evaluation of exemption applications, assessment of ship-specific risks prior arrival – ship targeting
- inspection of foreign ships in port - Port State Control, provision of adequate facilities.

Figure 21: Overview of risks from ballast water and sediments including relevant control measures and stakeholders

RISKS ASSOCIATED WITH BALLAST WATER AND SEDIMENTS AND THEIR MANAGEMENT

BALLAST WATER AND SEDIMENTS RISKS
Risks relating to the introduction of alien organisms and pathogens

Stakeholders

- Ministry of Transport
- Maritime Administration
- shipowners and ship operators
- shipmasters and seafarers
- classification societies
- ship designers and ship builders
- ship agents
- BWMS manufacturers
- providers of active substances
- Ministry of Environmental Conservation
- Ministry of Health
- Ministry of Fisheries
- Ministry of Labour
- Ministry of Defense (Coast Guards, Navy)
- Ministry of Education and Research
- Agency in charge of marine protected area management
- hospitals, occupational medicine, public medical care providers
- research institutes on water quality, water plant, desalination plant and sewage plant managers
- Port Authorities, terminal operators, etc.

Risk control measures

- Legislative action and supervision
- alertness and prudence in the type approval of BWMSs
- adequate training and increased medical surveillance with regard to hazardous substances and/or technologies
- optimized human/machine interface to ensure safe operation
- maintenance, repair and inspection of BWMSs
- training for entry in ballast tanks
- removal of sediments
- sampling
- provision of adequate personal protective equipment (PPE)
- investigation of incidents and accidents so as to identify their causes and inform the shipping community

BALLAST WATER AND SEDIMENTS MANAGEMENT RISKS
Other risks arising from the management of ballast water and sediments, both on board the ship and ashore

- IMPACTS ON THE SHIP'S STABILITY, INTEGRITY AND STRUCTURAL STRENGTH
- ISSUES RELATED TO NAVIGATIONAL SAFETY
- INCREASED CORROSION IN BALLAST TANKS AND RELATED ARRANGEMENTS
- TRANSPORT, STORAGE, HANDLING, DELIVERY AND USE OF ACTIVE SUBSTANCES
- POTENTIAL RELEASE OF HAZARDOUS CHEMICALS IN THE MARINE ENVIRONMENT
- ADDITIONAL AIR POLLUTION
- OSH ISSUES
- IMPACTS ON THE SHIP'S RESILIENCE
- INHERENT LIMITS OF BWE, BWT AND BALLAST WATER SAMPLING
- ECONOMIC IMPACTS ON THE MARITIME INDUSTRY

Figure 22: Overview of risks from ballast water and sediments management including relevant control measures and stakeholders

4

Conclusions

Aquatic organisms are transferred across regions of the globe by various means; shipping and ships are important vectors in this regard. While ships' ballast water provides one of the main pathways for alien species to reach new environments, ballasting is nevertheless essential for the safe and efficient operation of ships and is irreplaceable within the present fleet.

Ballast water discharges may be hazardous to human and animal health, the environment and coast-dependent activities. The many documented impacts of invasive species prompted the international community to initiate a global response to mitigate the risk of species translocation. To this end, the BWM Convention was adopted. The principal aim of this Convention is the improved management of ballast water in order to reduce the risk of introducing potentially harmful alien species.

This legally binding instrument confers on the Flag, Coastal and Port States rights, prerogatives and obligations in the implementation of Convention regulations and therefore paramount roles in mitigating risks associated with ballast water transport and management.

Article 2 of the BWM Convention obliges the Parties to:

- "…undertake to give full and complete effect to the provisions of [the] Convention and the Annex thereto in order to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments"; and
- "…ensure that ballast water management practices used to comply with [the] Convention do not cause greater harm than they prevent to their environment, human health, property or resources, or those of other States".

The measures enshrined in the Convention are designed to control the risk of alien species transfer and are therefore clearly beneficial. Nevertheless, in the absence of careful planning and continued vigilance, ballast water and sediments management practices may have negative consequences for human health, ship safety and the environment i.e. they create other forms of risk.

To address all the risks related to ballasting operations, two categories have to be considered: risks generated by ballast water management practices and latent environmental risks. Because these two risk categories are interrelated, they need to be addressed jointly in a coherent and integrated risk mitigation strategy.

In accordance with the concept of "defenses in depth", the key players designated by the Convention, namely the Flag State, together with the shipowner/operator, the Coastal State and the Port State, should contain the various hazards associated with the carriage and management of ballast water by installing reliable barriers at all stages of the causation chain.

Once invasive species multiply within a new ecosystem, there are few, if any, options to halt their spread or reduce ecological impacts. Therefore, risk mitigation strategies must place maximum emphasis on preventive measures and efficient pathway management.

Risk management has limitations. The uncertainties inherent in risk estimates, the many interacting factors involved in the control of ballasting operations and limited knowledge of the effects of certain substances and technologies, must be recognized in formulating BWM strategies and programmes. **The BWM Convention embodies a precautionary approach and scientific research should continue to minimize uncertainty. Uncertainty should not be presented in a way that calls into question preventive measures and regulations. International standards are expected to evolve as time goes by, with the aim of achieving the best possible balance between economic activities, social development and environmental protection**.

Notwithstanding the extent of the task, the preservation of marine biodiversity and ecosystem function must remain a priority. The elimination of available pathways for potentially invasive aquatic species demands the use of innovative ideas and technologies. This goal must prevail over short-term considerations and interests. Eradicating hazards is always the best option to suppress risks and is an integral part of risk management strategies, despite the fact that latent risks sometimes exist in the strategies themselves.

5

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ANNEX A

Provisions of the BWM Convention regarding risk assessment

With reference to the Flag State

References	Subject	Purpose	Responsible stakeholders
Regulation B-1 Guidelines G4 BWM.2/Circ.20	Development, evaluation, review and update of the BWM Plan. Development of safety procedures for risks to the ship and crew resulting from the treatment process. Development of safety procedures for the safe handling and storage of chemicals and preparations used to treat ballast water.	Define the methods used to manage ballast water and sediments on board the ship. Draw up safe operational procedures for the transport, storage, handling and use of active substances. Identify responsible crewmembers, required training, equipment operation and maintenance.	Shipowner Ship's master and crew Supplier of the BWMS Supplier of the active substance(s) used Flag State
Regulation B-1 Guidelines G4	Approval of the BWM Plan	Check the plan is appropriate to the ship and complies with the requirements of the BMW Convention.	Flag State
Regulation B-1 Guidelines G6	Implementation of the BWM Plan	Control safety and stability of the ship during BWM operations.	Ship's master and crew Flag State
Regulation B-3.7	Approval of alternative ballast water management methods	Promote the development of safer and more effective ballast water management options.	IMO/GESAMP Flag State
Regulation A-3 Regulation B-4.4	Exceptions (emergency situations and accidental discharges) Avoidance of BWE	Take into account accidental discharges. Protect life at sea and ship safety, and minimize pollution incidents from the ship.	Ship's master Flag State
Regulation C-2	Designation of areas where ballast water uptake is not recommended	Warn ships of marine areas which likely contain harmful organisms and pathogens.	Port State Coastal State Flag State
Regulation D-3.1 Guidelines G8	Approval and certification of BWMSs	State in detail the procedure for BWMS approval.	Flag State
Regulation D-3.2 Guidelines G9	Approval of BWMSs which make use of active substances	State in detail the procedure for basic and final approval of BWMSs that make use of actives substances.	IMO/GESAMP Flag State

References	Subject	Purpose	Responsible stakeholders
Regulation D-3.3	Safety of BWMSs with regard to the ship, its equipment and the crew	Identify and reduce the risks posed by the installation and operation of a BWMS on board a ship.	Supplier of the BWMS Supplier of the active substance(s) used Flag State Shipowner Ship's master and crew
Regulation D-4 Guidelines G10	Approval and oversight of prototype BWT technologies	Development of R&D programmes on promising BWT technologies.	IMO/GESAMP Flag State
Article 7 Regulation E-1 Regulation E-2	Survey and certification of ships	Enforcement of the provisions of the BWM Convention.	Flag State

With reference to the Coastal State

References	Subject	Purpose	Responsible stakeholders
Article 6	Scientific and technical research and monitoring	Monitor the effects of BWM in waters under jurisdiction	Coastal State Port State
Regulation B-4.2 Guidelines G14	Designation of BWE areas	Enable ships to exchange ballast water in sea areas where the conditions of water depth and distance from the shore cannot be met.	Port State Coastal State (individually or in association with adjacent States)
Regulation C-1 Guidelines G13 BWM.2/Circ.17	Promulgation of additional measures in certain areas	Enable State parties to take prompt action, in accordance with international law, to put into force control measures concerning ballasting and/or deballasting operations in case of an emergency or epidemic. Protect vulnerable areas.	Port State Coastal State (individually or in association with adjacent States)
Regulation C-2	Designation of areas where ballast water uptake is not recommended	Warn ships of marine areas which likely contain harmful organisms and pathogens.	Port State Coastal State Flag State
Article 10	Detection of violations and control of ships	Cooperation in the detection of violations and in the enforcement of the provisions of the BWM Convention.	Port State Coastal State

With reference to the Port State

References	Subject	Purpose	Responsible stakeholders
Article 5 Guidelines G1	Provision of sediment reception facilities	Disposal of sediments without damage to the environment, human health, property and resources.	Port State
Article 6	Scientific and technical research and monitoring	Monitor the effects of BWM in waters under jurisdiction	Coastal State Port State
Regulation A-4.1.4 Guidelines G7	Exemption for ships operating between specified ports (case-by-case risk assessment)	Avoid burdening vessels with unnecessary measures.	Shipowner/Ship operator Port State
Regulation B-3.6 Guidelines G5	Discharge of ballast water to a reception facility Treatment of received ballast water	Avoid discharges of hazardous ballast water in port areas.	Port State Crew
Regulation B-4.2 Guidelines G14	Designation of BWE areas	Enable ships to exchange ballast water in sea areas where the conditions of water depth and distance from the shore cannot be met.	Port State Coastal State (individually or in association with adjacent States)
Regulation C-1 Guidelines G13 BWM.2/Circ.17	Promulgation of additional measures in certain areas	Enable State parties to take prompt action, in accordance with international law, to put into force control measures concerning ballasting and/or deballasting operations in case of an emergency or epidemic. Protect vulnerable areas.	Port State Coastal State (individually or in association with adjacent States)
Regulation C-2	Designation of areas where ballast water uptake is not recommended	Warn ships of marine areas which likely contain harmful organisms and pathogens.	Port State Coastal State Flag State
Articles 9 & 10 Regulation B-2.4 Regulation B-2.6 Guidelines G2	Inspection and control of ships OSH aspects of PSC inspections	Cooperation in the detection of violations and verification of compliance with the requirements of the Convention. Protect PSC officers' safety and health.	Port State Coastal State

With reference to the IMO and the GESAMP-BWWG

References	Subject	Purpose	Responsible stakeholders
Regulation B-3.7	Approval of alternative ballast water management methods	Promote the development of safer and more effective ballast water management options.	IMO/GESAMP-BWWG Flag State
Regulation D-3.2 Guidelines G9	Approval of BWMSs which make use of active substances	State in detail the procedure for approval of BWMSs that make use of actives substances.	IMO/GESAMP-BWWG Flag State
Regulation D-4 Guidelines G10	Approval and oversight of prototype BWT technologies	Development of R&D programmes on promising BWT technologies.	IMO/GESAMP-BWWG Flag State
Regulation D-5	Review of the Ballast Water Performance Standard	Determine the availability of ballast water treatment technologies, their efficiency, environmental, safety and economic impacts.	IMO/GESAMP-BWWG

ANNEX B

Examples of models and approaches to ballast water risk assessment

The following Table provides examples of models and approaches that have been developed to explore a variety of possibilities for ballast water risk assessment.

Name	Method summary	Approach	Number of variables	Endpoint	Time unit	Purpose	Date
Australian Decision Support System	Models four steps in the bioinvasion process: source port infection, vessel infection, journey survival, and survival in the recipient port	Species-specific, quantitative	1	Target species life cycle completion in recipient port	Monthly	Identify low risk routes, vessels and tanks	1997 – ongoing
GloBallast	Environmental similarity between localities, weighted by target species presence in the donor location and inoculation factors	Environmental similarity, semi-quantitative	37	Identify and rank high and low risk ports	Seasonal	Enhance awareness and recommend ballast water management strategies between ports	2002 – 2004
Norwegian ballast water risk assessment	Alt. 1 Environmental match between donor and source localities Alt. 2 Models four steps in the bioinvasion process: source port infection, vessel infection, journey survival, and survival in the recipient port	Species-specific, quantitative	2	Target species life cycle completion in recipient port	Monthly	Identify low risk routes, vessels and tanks	1998 – ongoing
Nordic ports risk assessment	Environmental match between donor and source localities and listing of potentially hazardous species	Environmental similarity and species-specific, qualitative	5	Hazard analysis	Annual	Identification of high risk routes and species in Nordic countries	1998 – 1999

Name	Method summary	Approach	Number of variables	Endpoint	Time unit	Purpose	Date
Ports Corporation of Queensland	Environmental similarity between localities, weighted by target species presence in the donor location and inoculation factors	Environmental similarity, semi-quantitative	37	Identify and rank high and low risk ports	Seasonal	Enhance awareness and recommend ballast water management strategies between ports	1995 – 1997
Dinoflagellate bioeconomic risk assessment	Estimates probability of establishment, bloom, and impact of toxic dinoflagellate species	Species-specific, quantitative	1	Tourism and aquaculture impact	Annual	Economic impact of Gymnodium catenatum on aquaculture and tourism	1993 – 1994
German ballast water risk assessment	Environmental match between donor and source localities and listing of potentially hazardous species	Environmental similarity and species-specific, qualitative	2	Hazard analysis	Annual	Identification of high risk routes and species in German coastal waters	1992-1996
Great Lakes risk assessment	Species-based tolerance and taxa concentrations in vessels with no-ballast on board (NOBOB)	Quantitative	2	Journey survival of target species	Per journey	Estimate risk associated with NOBOB vessels entering the Great Lakes	2002

(Source: Barry et al., 2008)

ANNEX C

Risk assessment: Basic considerations

There is neither a standard process, nor ideal method, to assess risks because risks are contingent upon a particular context, evident at a particular time and location with variable and often limited resources. However, risk analysts should ensure that the following items are given serious attention. The rationale behind this selection can be found in the main text of this document.

CHOICE OF THE APPROPRIATE REFERENCE SYSTEM	**Definition of the reference system(s)**	Ecosystem : small ecological unit for precision and large ecological unit for regional cooperation
		Ship : focus on a specific piece of equipment and on the ship as a whole - including the crew
	Identification of the interactions with other systems and hierarchy of systems	Ecosystem : ecological processes, species dispersal mechanisms, sub-system relationship with the whole, etc.
		Ship contexts : social, economic, political, technological, natural, etc.

EXPOSURE & VULNERABILITY (of the defined system)	**Measurement and characterisation of exposure**	Routes of exposure
		Targeted/systemic exposure
		Existing barriers to reduce exposure
	Assessment of system(s) vulnerability	Human, environmental and economic vulnerability
		Resilience capacity
		Existing prevention & protection measures to decrease vulnerability

IDENTIFICATION OF HAZARDS, TRIGGERS AND POTENTIAL ADVERSE CONSEQUENCES	**What are the sources of potential harm – hazard identification ?**	Biological, electrical, mechanical, physical, chemical, financial and natural hazards
	What can go wrong – triggers ?	Unwanted events and their probability of occurrence
	What may be the potential adverse consequences – extent of damage?	Severity of direct and indirect impacts

CHOICE OF THE APPROPRIATE METHODS OF ASSESSMENT	**Qualitative methods**	Allow multiple approaches, interdisciplinarity, sharing knowledge and experience
		Require large and open expertise and skills
		May involve a high degree of subjectivity
	Semi-quantitative methods	Allow easier comparison of risk assessment results than qualitative methods
		Involve assigning numerical value to subjective and simplistic judgements
	Quantitative methods	Essential requirement : a sufficient set of reliable data
		Might be applicable to some technical elements whose operation can be modelled
		Not considered fully suitable for assessing evironmental risks because it oversimplifies system functioning

INTEGRATION OF THE HUMAN-RELATED DIMENSIONS	**Political and social aspects**	International regional, national and local organisations, policies, administrations, decision-making and regulatory processes, private and public stakeholder involvement, risk perception, societal priorities, trade-offs, etc.
	Economic aspects	World economy, exploitation of natural resources, trade patterns, globalisation, cost/benefit analysis, allocation of resources, etc.

KEY INFLUENCES ON THE VALIDITY OF RISK ASSESSMENT OVER TIME	**Dynamics**	Temporal
		Spatial
		Social
	Complexity	Complex systems
		Multiple and intricated risk factors
		Difficulty of establishing risk scenarios
	Uncertainty	Scanty and unreliable data
		Assumptions
		Subjectivity

ANNEX D

Summary: A risk mitigation strategy for ships arriving in ports

Objectives

- Reduce the risk of introduction of harmful aquatic organisms and pathogens (HAOP)
- Avoid introduction of unmanaged ballast water in ecosystems
- Develop preventive and protective measures to protect the shoreline from ships' ballast water
- Verify ships' compliance with (national) standards
- Enforce the rules and develop a sanction system
- Establish a contingency plan
- Develop a communication and feedback plan for continuous improvement

Details and limitations of this approach are available in sections 1.3 and 3.3 of the main report.

Identify risks

The participation of numerous stakeholders is required to identify risks with accuracy. The list must be dynamic and able to accept data from all fields. The context is paramount. The following list is indicative:

- Introduction of HAOP through unmanaged ballast water
- Ballast water not complying with required standards
- Ship not complying with required standards
- Exposure of the officers in charge of verification
- Economic impacts of Compliance Monitoring and Enforcement (CME)
- Risks associated with the judicial process for those involved in the CME
  Etc.

Risk identification triggers the strategy for action by the decision-making Authority.

Exposure and vulnerability assessment

The degree of exposure and vulnerability, which form an important part of the risk assessment process, has to be established either simultaneously or sequentially. This requires scientific input from a knowledge of local ecosystems as well as human dependency on these ecosystems.

The outcome of the (environmental) analysis depends on local or national political and social choices. The National Task Force should advise decision-makers concerning exposure and vulnerability levels.

As an example, Australia is a large island with unique ecosystems and is dependent on sea-related activities. Consequently, the country is considered as seriously exposed to HAOP and its coasts are seen as highly vulnerable. It was decided to define any ballast water loaded outside Australian waters as being a high risk. In some areas that receive particular attention from local authorities, specific approaches are developed – e.g. in the State of Victoria.

Exposure and vulnerability assessment serves to establish priorities and the stringency of measures to be implemented at national and local levels.

Risk characterization and estimation

Risk characterization and estimation must be determined for all risks identified in the first step. To explain this stage, we focus on the estimation of risks from the vessel and its ballast water on arrival in port.

The best strategy is to establish the risks in advance by targeting high risk ships and ballast water. In order to do so, matrices should be developed to focus the resources available on identified high risk ships. Such targeting systems exist for the various PSC Memoranda of Understanding (MoUs). However, the existing systems do not yet possess dedicated provisions to address ballast water. Consequently, local or national authorities need to develop such systems, in accordance with the provisions of the Ballast Water Management (BWM) Convention.

Pre-assessment systems based on ballast water reporting are mandatory in many countries (see GloBallast Monograph Series No.18). Such systems use standard Ballast Water Reporting Forms (BWRF) and decision support systems (DSS). Although not referred to in the Convention, this document has proved to be an efficient tool to assess the quality of ballast water carried by a ship arriving in port.

Each vessel must submit a BWRF to a dedicated agency at least 24 hours before arrival in order to allow sufficient time for the agency to identify high-risk ballast water and eventually advise the vessel if any specific ballast water management is required. By means of this procedure, the risk of improperly managed ballast water reaching the port is reduced.

The analysis of the data recorded in the BWRF may be supported by a local, national or international database. Careful consideration of the content of each ballast tank is essential, with a particular focus on unmanaged water coming from areas known to be contaminated or having similar physical conditions to the area of discharge. In this respect, some countries, such as Turkey, have developed a comprehensive database to help in assessing risks from ballast water i.e. a type of DSS.

Development of risk control measures

Multiple barriers must surround the hazard to avoid harmful effects. Such barriers constitute lines of defense protecting the coast and the port. Some examples are listed below:

- Pre-arrival assessment through the implementation of a BWRF and risk analysis system
- Proper monitoring of ships' activities as soon as they enter the territorial sea, with particular emphasis on vulnerable areas
- Port State Control regime in charge of CME
- Develop and implement an investigation and sanction system
- Regular monitoring of local ecosystems with feedback to responsible agencies
- Maintain a contingency plan, including a suite of protective measures, in case of a detected threat. The plan should identify suitable ballast water exchange areas.

Selection of risk control measures

Each barrier must be analyzed and developed in the context of local and national circumstances. The necessary resources including manpower, organization and equipment, are often limited and must therefore be managed efficiently.

It is sometimes more practical to introduce barriers in phases, in which case simple, low-cost barriers may be established first. The implementation of a BWRF system should be straightforward and cost-efficient for most States and local entities.

As an example, the island of New Caledonia developed its own BWRF and entrusted the local pilot station with its management, thus avoiding an additional workload for the local administration.

Implementation of risk control measures

The proper implementation of risk control measures requires commitment, adequate allocation of resources, continuous monitoring and improvement. In addition, proper feedback and communication regarding the quality of implementation is required as part of a continuous improvement strategy.

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