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The hitchhikers : an analysis of the introduction into the marine environment of harmful aquatic organisms through ballast waters

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THE HITCHHIKERS: AN ANALYSIS OF THE INTRODUCTION INTO THE MARINE ENVIRONMENT OF HARMFUL AQUATIC ORGANISMS THROUGH BALLAST WATERS

By

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in

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2000

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no materials is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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[1] **See Appendix VIII.**

ABSTRACT

Title of Dissertation: **The hitchhikers: An Analysis of the Introduction into the Marine Environment of Harmful Aquatic Organisms through Ballast Waters.**

Degree: **Master of Science**

The problem of transport of harmful aquatic organisms (HAO) to new locations *via* ballast waters (BW) is increasing with potentially catastrophic implications for humans and creating a tremendous problem in the ecosystem of many areas throughout the world. Furthermore, great concerns were expressed by the growing awareness of those risks and their intensification. For this reason, the International Maritime Organization (IMO) is preparing a new Convention [while previously, discussions were about adding a new Annex — probably ***Annex VII*** — to the International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 relating thereto, (hereinafter referred to as MARPOL 73/78)].

This dissertation is an analysis of the impact of the introduction into the marine environment of those species through BW. Firstly, a study of their effect on human beings and on the marine environment is provided, by giving some examples of areas that they have affected. Secondly, an introduction of the proposed new Convention (PNC) is developed as well as the impact of such a proposition. Thirdly, an examination of a ballast water management (BWM) scheme and some methods of treatment with a description of their weaknesses and strengths is presented.

The objective of this dissertation is to focus on the role of IMO, the impact of the PNC, and why it is urgent and critical to implement it. In addition, it is recognized that the rate of implementation of international conventions is rather slow due to the speed with which Governments act. Is it their fault or is it the fault of the system? Moreover, IMO acts as co-ordinator between Member States: This role should change and more power should be given to this specialized agency of the United Nations.

As discussions are still going on at IMO and some decisions are probably being taken while this work is under assessment, it will be difficult to have a final updated dissertation. Furthermore, the author had in mind to present a variety of points of view about the topic from different countries visited during the seventeen months of study at WMU. Unfortunately, with few exceptions, the experts did not want to unveil the opinions of their countries before the creation of the PNC. Moreover, for the impact on human beings, some statistics might have better illustrated the disastrous effects, but for various reasons including shortage of time, it has not been easy to find any statistical information on the matter.

KEYWORDS: Harmful aquatic organisms, Aliens, Hitchhikers, Invaders, Ballast water management, MARPOL 73/78.

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LIST OF ABBREVIATIONS

BW	Ballast Water
BWE	Ballast Water Exchange
BWM	Ballast Water Management
GEF	Global Environment Facility
GUIDELINES	Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens
HAO	Harmful Aquatic Organisms
IACS	International Association of Classification Societies
IMCO	Intergovernmental Maritime Consultative Organization
IMO	International Maritime Organization; or The Organization.
INTERTANKO	International Association of Independent Tanker Owners
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978
MEPC	Marine Environment Protection Committee
MSC	Maritime Safety Committee
R&D	Research and Development
PNC	Proposed New Convention
PSA	Port State Authority
UNCLOS 82	United Nations Convention on the Law of the Sea 1982
UNDP	United Nations Development Programme
USCG	US Coast Guard
WG	Working Group
WHO	World Health Organization

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Figure 1 Discharge of harmful aquatic species into the sea through ballast water.

Figure 2 Introduction of Non-indigenous Species in the Great Lakes.

Figure 3 Example of the Flow-through Method

Figure 4 Probability of Organism Survival and Reproduction in Water

Figure 5 No room at the intake

I hear the ocean roar so loud,

I hear the waves crashing here and there,

I can feel the splashes hit my soft cold face,

I can see the fish jumping out of the beautiful ocean,

I am so lucky to live near the ocean!

Kristin RODDY

CHAPTER I

> **States shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control, or the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto.**
>
> ***UNCLOS Article 196.***

1 INTRODUCTION

In a year literally billions of tonnes of oil are carried around the world in tanks. Moreover, coal, iron ore or wheat bulk carriers are crossing oceans, seas and rivers to deliver different types of cargoes. To maintain a vessel's safety and stability on a ballast voyage, its propeller has to be kept submerged to have maximum performance without excessive vibrations. This is necessary particularly after discharging cargo. A ship, empty or partly loaded, has to fill its ballast tanks with sea water. In addition, ballast water (BW) is often used to permit allowances for the distribution of cargo for stability concerns.

> Ballast is defined as any solid or liquid placed in a ship to increase the depth of submergence of the vessel in the water (the draft), to change the trim, to regulate the stability, or to maintain stress loads within acceptable limits. For the purposes of this study, the term ballast also includes sediment [2].

2 National Research Council (1996). Stemming the Tide: Controlling introductions of non-indigenous species by ships' ballast water. National Academy Press: Washington, D.C.

For years, this operation, at least in theory, was thought to be very simple, without any indication of a problem or danger. Unfortunately, in the course of ballasting, some unwelcome passengers can enter the ballast and be merged with sea water. These are commonly called alien species and are often referred to as exotic, nuisance, hitchhiker, invaders or non-indigenous species. They consist of invertebrates (crustaceans, molluscs, jellyfish, crabs, polychaete worms), toxic dinoflagellates, bacteria and plankton and even, according to Admiral Loy (2000, p.100), free-swimming fish.

> The terms alien species or unwanted aquatic organism are used to define species which normally are not harmful in the environment where they are living but, when they are discharged into their non-native habitat, can cause destruction of the local ecosystem [3].

Ballast is taken usually after cargo has been discharged and the ship is low in draft and deadweight. In the loading port, the ship has to discharge into the sea that BW mixed with those non-indigenous species in order to load the designated cargo again. By conducting such operations, the ship moves those hitchhikers, even in small quantities (BW dumped from a single ship can contain hundreds of species), from one place to another, which can create serious problems. These problems will be discussed shortly. In addition, once these invaders establish themselves, it becomes impossible to eliminate them without causing damage to the environment caused by their detrimental effects.

As it is said, "small streams make big rivers." After a few comings and goings, there is a significant risk of invasion and adverse effects on the ecosystem. By a simple calculation, considering the number of tankers and bulk carriers, and bearing in mind the relationship between the dead weight tonnage (DWT) of the ship and the quantity of BW discharged: DWT x 0.6 = BW (tonnes) (Jones, 1991), it will be obvious that billions of tonnes of BW are carried every year [4].

3 **Pardo, F. (1999). <u>Principles of ship pollution prevention.</u> Unpublished lecture handout, World Maritime University, Malmö, Sweden.**

4 **About 10 billion tonnes [IMO (October, 1998) & Fairplay, October 15, 1998].**

Many places in the world suffer from such operations. In San Francisco Bay more than 230 of such species were found, which affected the native species and even caused them to disappear. Moreover, bacteria have been transported from one continent to another. For example, the *Gymnodinium* or the *Alexandrium* moved from Southeast Asian to Australian waters causing paralytic shellfish poisoning.

Figure 1 **Discharge of harmful aquatic species into the sea through ballast water** [5]

What is amazing, is that such catastrophes were discovered at the beginning of this century, but only in those latest years Governments seemed to be concerned. Discussions on the matter are being held at the International Maritime Organization (IMO) aimed at developing a new Convention [6]. It is perplexing as to why those who are responsible have been waiting so long to make decisions regarding the reduction or eradication of this problem.

5 **National Research Council (1996). <u>Stemming the Tide</u>: Controlling introductions of non-indigenous species by ships' ballast water. National Academy Press: Washington, D.C.**

6 **Previously, it was considered that a new Annex added to MARPOL 73/78 would be appropriate.**

Usually, experience has shown, that when a catastrophe is reached, it is at that time that voices sound their alarm, ask for more regulations, new conventions and quick decisions. Perhaps in a few years, the international community will find out that it is already quite late.

The sea has always been considered an infinite receptacle for wastes, and whatever humans generate, nothing can affect the flora, the fauna or in general the marine environment. Nevertheless, great concerns have arisen in recent years due to the impact of public opinion, and especially because of the real danger in some affected areas. The conscientiousness has also increased and awareness of people that serious and urgent decisions need to be taken.

It is well known that several important international conventions have come into force after major disasters. For example, the TORREY CANYON disaster led to the creation of the Civil Liability and Fund Conventions and the TITANIC to the first International Convention for the Safety of Life at Sea (SOLAS) adopted in 1914.

For BW, discussions have been taking place at IMO and are still going on. Hopefully this will not be for a long time. At the rate those areas are being affected, it is imperative that this proposed new Convention (PNC) has to be implemented. It is regrettable that a real disaster is needed to facilitate the creation of such an important decision, or at least to expedite the discussions.

IMO — a specialized agency of the United Nations — has two main objectives, namely, improvement of safety at sea, and the prevention of pollution from ships [7]. Unfortunately, this role of being a co-ordinator has to change, and more power needs to be given to IMO to take decisions instead of leaving them to Member States, who are guided by their disparate national interests. They relate their opinions only to their countries instead of looking forward and sharing a problem together. Each Member State has only one voice, and it does not matter if that State is a developed or a developing country. To implement an international Convention, powerful States should not impose their wishes by direct or indirect ways and means; otherwise, there is no need for the Organization.

Without any doubt shipping safety and the marine environment have improved tremendously since the creation of IMO even since the time it was IMCO (The Intergovernmental Maritime Consultative Organization). However, IMO has not finished its work; a great deal more needs to be done. The policy of the Organization needs to change, and there should be increased ability to take decisions.

The introduction of harmful aquatic organisms (HAO) into the marine environment has affected many areas. Consequently, significant problems have been created threatening all biological diversity, human health and public property. Species, which successfully survive, have the ability to damage native habitat, menace the diversity and abundance of native plants and animals, and cause disorder to human, social and economic activities dealing with aquatic resources.

[7] **Its slogan "Safer shipping and cleaner oceans".**

Sling me under the sea.

Pack me down in the salt and wet.

No farmer's plow shall touch my bones.

No Hamlet hold my jaws and speak

How jokes are gone and empty is my mouth.

Long, green-eyed scavengers shall pick my eyes,

Purple fish play hide-and-seek,

And I shall be song of thunder, crash of sea,

Down on the floors of salt and wet.

Sling me…under the sea.

Carl SANDBURG

CHAPTER II

2 THE EVOLUTION OF THE PHENOMENON

2.1 Background

Before giving a brief history about the phenomenon, it should be kept in mind that not all those species transported in BW and brought to other environments will be automatically harmful and considered as invaders. To the contrary, most of them will not survive the trip, and this due to, for instance, the conditions of salinity, temperature or nutrient levels in the receiving area (studies indicate that usually less than 3 % of these species survive). On the other hand, those that do survive and establish themselves try to provide themselves with the best possible living conditions. When this occurs, they can be very harmful, aggressive and can displace and even extinguish native species due to their exponential rates of reproduction in the new environment.

Since the beginning of the 20th century, the problem of transport of alien species in BW has been recognized. An early event was when some scientists discovered the introduction in the North Sea of the Asian phytoplankton algae *Odontella (Biddulphia sinensis*), but it was not before the 1970s that these invaders were conceived as a critical problem (Focus on IMO, 1998).

In 1973, during the first MARPOL 73/78 conference, huge efforts were made to investigate the phenomenon. During the same conference, IMO Resolution 18 was adopted, in which, for the first time, the problem was raised. It was recognized in that Resolution that "ballast water taken in waters, which may contain bacteria of epidemic diseases, may, when discharged into the sea in another location, cause a danger of spreading of the epidemic diseases to other countries." Not only IMO, but also the World Health Organization (WHO) recognized the adverse effects of BW discharge. In addition, to ensure the involvement of both these Organizations, the resolution states that IMO and WHO should "initiate studies on that problem on the basis of any evidence and of proposals which may be submitted by any Government [8]."

Since the 1980s research and studies have been made throughout the world and many cases have been discovered. Among the countries that have suffered much due to this problem, Canada and Australia should be mentioned. According to Goggin (1999), it has been estimated that about *3000* (emphasis added) species are transported in BW *every day* (emphasis added) around the world.

[8] **IMO (October, 1998).**

As mentioned previously, discussions on the topic have been going on since the 1980s. By the late 1980s, Canada and Australia took the initiative to discuss the problem at the MEPC meetings. In 1990, a working group was set up by the MEPC which drafted the "International guidelines for preventing the introduction of unwanted organisms and pathogens from ships' ballast water and sediment discharges", which was adopted by Resolution MEPC 50 (31) in July 1991, and as an Assembly Resolution A.774 (18) in 1993. The purpose of the guidelines is to help Governments to minimize the transfer of HAO and pathogens, to take urgent actions in applying these guidelines and at the same time, to provide recommendations on training, the form of reporting BW and some safety aspects of ballast water exchange (BWE) at sea. BWE in the open sea has been verified as a means of limiting the introduction of unwanted species. Few organisms are contained in deep ocean water.

In 1992, in Rio de Janeiro, the United Nations Conference on Environment and Development (UNCED) recognized the issue as of major and serious international concern. Furthermore, in March 1997, the Maritime Safety Committee (MSC) approved a document entitled "Guidance on the safety aspects relating to the exchange of ballast water at sea," and in 1998, a new draft on "Regulations and code for the control and management of ships' ballast water and sediments to minimize the transfer of harmful aquatic organisms and pathogens" was made by the Working Group (WG).

2.2 Role of IMO

IMO, by means of its MEPC, has considered different options for introducing the PNC, which is still under debate. IMO has determined that BWE is the most efficient method right now to control the spread of harmful species and has promulgated guidelines to be used by vessel operators and Port States in the development of guidelines and regulations.

It was recognized that near shore and in ports, where ships usually take on BW, a higher diversity and number of species are found than in the open ocean. Because it provides an economical and effective means of reducing the risk of infection, managers, regulatory agencies and the shipping industry prefer the BWE concept.

BWE is a necessary operation, especially for ships sailing empty or with a light load. It was admitted that this simple and normal requirement could be made dangerous and unsafe by heavy seas and adverse meteorological conditions. For that reason, in 1993 when adopting Resolution A.774 (18), IMO was deeply concerned as to how to guarantee that the measures that were introduced to protect the environment did not threaten the safety of ships and their crews.

Among the suggestions aimed to reduce the effect of BW is to make the exchange of BW away from land where sea water contains less marine life. However, taking into account the possible effects of weather on the ship's structure, the guidelines also give guidance as to the precautions that need to be taken for the safety of the ship. They also take into consideration the training and the familiarisation of the crew required to conduct such operations safely.

In this way, the transfer of unwanted organisms from one place to another can be stopped or at least reduced so as to prevent catastrophes. For this reason, IMO is doing its best to introduce new international regulations and methods so as to raise this problem and to emphasise its real danger value.

I am pessimistic about the human race because it is too ingenious for its own good.

Our approach to nature is to beat it into submission.

We would stand a better chance of survival if we accommodated ourselves to this planet and viewed it appreciatively instead of sceptically and dictatorially.

E. B. WHITE

C H A P T E R III

3 IMPACT OF ALIEN SPECIES

3.1 Definition of harmful aquatic organisms

At the 44th session of the Marine Environment Protection Committee (MEPC), a report of the results of considerations and discussions made during the 42sd session of the Working Group on BW was issued. In Annex II of the "Draft Text of the International Convention for the Control and Management of Ships' Ballast Water and Sediments," this definition was given:

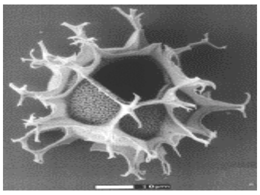
> "Harmful Aquatic Organisms and Pathogens" means aquatic organisms or pathogens which, if introduced into a particular sea area including estuaries or fresh water courses, may create hazards to human health, harm living resources and aquatic life, damage amenities, impair biological diversity or interfere with other legitimate uses of such areas."

3.2 Examples of harmful aquatic substances

The lists of alien aquatic life forms are innumerable and increasing from day to day. It will be difficult to explain in detail all kinds of HAO transported in BW. In this section, only a limited idea through examples is given and a more detailed list is included at *Appendix I.*

To appreciate the importance of the phenomenon in terms of its seriousness, it is to be noted that ships from Japan to Oregon carried in BW at least 367 kinds of aquatic organisms. More than 200 marine species have been introduced to the Australian coastal waters, more than 145 to the Mediterranean Sea (Gollasch, 1997), and more than 139 have been discovered in the Great Lakes (Glassner-Shwayder, 1998).

Among harmful aquatic substances, some species have to be mentioned because they have become well known case studies, especially the first three following examples, which have caused animated discussions at IMO:



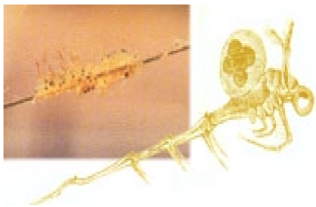
- ***The Toxic Dinoflagellates***:

Marine algae transported from Japan and Korea to northern and eastern Tasmania and specifically into three ports namely, Philip Bay, Adelaide and Lincoln. They are capable of rapid growth, leading to contamination of shellfish and producing both toxins and de-oxygenation, that is harmful for human beings, birds and mammals, causing mortalities and morbidity. Contact with water containing the toxic dinoflagellates causes contact dermatitis or allergy. Some 2,000 cases of human sickness due to dinoflagellate toxins with an average of 15% mortality occur each year. It is responsible for red tides and outbreaks of paralytic shellfish poisoning (INTERTANKO, 1999 & Jones, 1991).

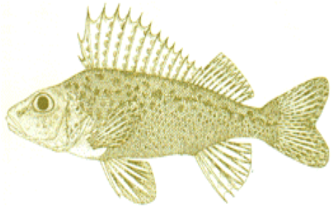
- ***The European Zebra Mussel (Dreissena Polymorpha)***:

A fouling organism from the Caspian and Black Seas introduced into Lake St. Clair in 1986. It affects the fish population causing an imbalance in the entire food chain and blocking the water intake pipes of factories for instance. It has been a cause of the blocking of fresh water inlets, and has infected buoys and beaches. Moreover, Dochoda (1990) stresses that it can attach itself to any solid surface such as spawning reefs, boat hulls, power plants and water intake pipes, abating their use. *Appendix III* gives more detailed information about this harmful species (Dochoda, 1990; Glassner-Shwayder, 1998 & IMO, 1999a).

- ***The Spiny Water Flea (Bythotrephes cederstroemi)***:



Considered among the permanent residents of the Great Lakes. It was discovered for the first time in Lake Huron in 1984. It is a predaceous planktonic crustacean that has the power of reducing both the food supply for larval fish and water clarity (Dochoda, 1990; Glassner-Shwayder, 1998).

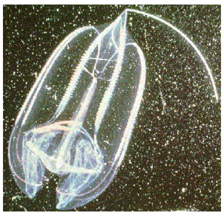


- ***The Ruffle (Gymnocephalus Cernuus)***:

Introduced into Duluth Harbor (Great Lakes) in 1983, it is, like the *Zebra Mussel* and the *Spiny Water Flea*, very prolific. It attacks the eggs of whitefish and has caused a significant reduction in their abundance. It is considered a real threat to commercial and sport fishing (Dochoda, 1990; Glassner-Shwayder, 1998 & IMO News, 1999a).

- ***The Round Goby (Neogobius Melanostomus)***:

Brought from the Black and Caspian Seas to the Great Lakes, was first found in 1990. A goby can eat more than five mussels within an hour (Ambrosa,1999); it is an aggressive fish and voracious feeder. Furthermore, it also destroys the eggs and fry of any kind of fish in their environment in addition to smallmouth bass, walleye and perch (IMO, 1999a).

- ***The American Ctenophore (Mnemniopsis Leidyi),*** and the ***Comb Jelly***: 

Introduced into the Black and Azov Seas. The first is responsible for the extinction of the zooplankton population in the region and the second, for the extinction of the anchovy and the sprat fishing industry.

- ***The Northern Pacific Seastar (Asterias Amurensis)***:
  Introduced in 1986 to Tasmania, causing severe damage to aquaculture industries. It is a prolific breeder, which grows very large and is a voracious predator. It has proved impossible to eradicate (CSIRO Australia, 1999; Haley, 1999 & IMO, 1999a).
- ***The Large Brown Kelp (Undaria Pinnatifida)***: discovered first in New Zealand waters in 1987, originates in Japan and Korea, where it is cultivated as a fresh and dried food plant. Very abundant seaweed with significant ecological effects and impacts on commercial fisheries, namely, abalone and sea urchins (Jones, 1991).
- ***The Asian Phytoplankton Algae Odontella (Biddulphia Sinensis)***: among the pioneer harmful species, introduced into the North Sea in 1903 (Gollasch, 1997).

3.3 Impact on humans

The effect of non-indigenous species on human beings is so obvious that it hardly needs mentioning. Any effect on the environment has, or will have, a direct or indirect impact on humans.

In 1991, IMO issued voluntary "Guidelines for preventing the introduction of unwanted aquatic organisms and pathogens from ships' ballast waters and sediment discharges." This means that for almost one decade, some States have been reflecting on the matter, when they should instead be complementing solutions.

During the past few years, areas have been affected and people have suffered. They are still suffering. Many jobs dependent on aquatic resources have been lost due to the introduction of those HAO. The economic losses from aquatic nuisance species are significant. When invasive species spread, they can cause enormous damage.

To give more weight to the impact of such a catastrophe on human beings, some examples will clearly illustrate why it is urgent and necessary to have such guidelines internationally implemented.

As seen previously, the industry in Canada and the United States has suffered from the *Zebra Mussel*, and in the year 2000, US$5 billion has been estimated as the cost to get rid of this invader from pipes, screens, conduits, buoys, boat bottoms, and submerged objects in general (Loy, 2000).

In Australia, due to the introduction of exotic organisms, huge financial losses have been incurred by the industry that in turn have become losses in the national economy. Aquafarming has been closed, workers in the field have lost their jobs. Furthermore, because of one toxic alga, all the New Zealand shellfish industry has been closed to domestic markets as well as to international ones not to mention the impact on people, the industry of the region, and the economy of the country in general.

In addition, the oyster and mussel farms in Australia's Tasmanian East Coast have been threatened by the rapid and disastrous spread of the Japanese seaweed *Undaria Pinnatifida*.

In 1991, the US Coast Guard discovered in Movile Bay, Alabama, a human bacterial pathogen, the *Vibrio Cholera 01*, introduced *via* ships' BW coming from South America. In late 1992 and early 1993, a new Cholera strain was discovered, the *Vibrio Cholera 0139,* which has caused an epidemic disease in southern Asia (Casale & Welsh, 1997).

The underestimation of the capacity of pathogens to adapt to changing conditions, and hence encourage the quick spread of diseases even by ships, has led to the following:

- In 1991, *El Tor Cholera* was transported from the coastal waters of Bangladesh to the Pacific coastal waters of South America. This Cholera strain was noted in three different Peruvian ports separated in distances exceeding 1200 km. A few weeks after its discovery, *El Tor Cholera* caused 30,000 cases and 114 deaths (Casale & Welsh, 1997).
- Another example, in Milwaukee, Winconsin in 1993, 403,000 cases were recorded during the epidemic of *Cryptoporidium*. About 4,000 people were hospitalized and there were 110 deaths (Casale & Welsh, 1997).
- In 1998, the Government of Texas was obliged to close the commercial oyster harvest in Galveston Bay for a period of four months because hundreds of persons became ill after eating raw oyster. Scientists found two kinds of bacteria including one native to Southeast Asia (Terhune, 1999).

As can be seen from these examples, the impact of such disasters has no borders. They can occur not only in developing countries but also in developed countries, and the magnitude of the result can be very unpleasant.

It should also be noted that only in Australia, sixty million tons of BW are discharged into the coastal waters every year. In the USA about fifteen billion gallons of BW are discharged annually. In 1995, more than 55,000 vessels called at ports in the USA. Bearing in mind that in average between 3,000 and 4,000 species are transported every day in BW (Gollasch, 1997), it is not difficult to forecast the result.

3.4 Impact on the environment

3.4.1 Examples of affected areas

As ships are becoming greater in size and the quantities of BW are consequently increasing, it is obvious that the invasion of HAO will follow the same increase. More than 40 species have appeared in the Great Lakes since 1960 [9], and more than 50 have appeared in San Francisco Bay since 1970 [10].

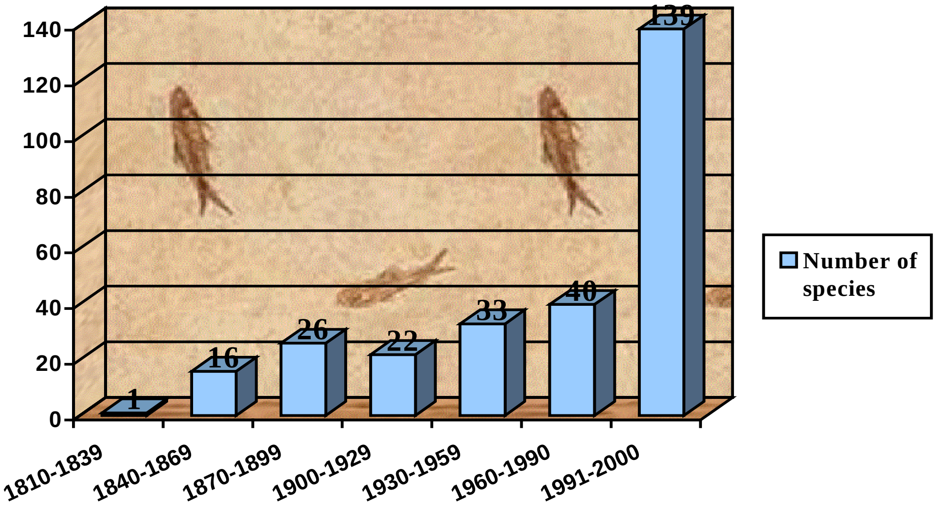


Figure 2 Introduction of non-indigenous species in the Great Lakes

[9] National Research Council (1996). Stemming the Tide: Controlling introductions of non-indigenous species by ships' ballast water. National Academy Press: Washington, D.C.

[10] See Appendix IV.

As seen previously, the Great Lakes is considered as a disaster area. The proliferation of three non-native and harmful marine species namely, the *European ruffle*, the *spiny water flea* (normally the *Bythotrephes cederstroemi*), and the *Zebra Mussel*, have had a significant negative impact and have caused damage to the ecosystem of the area. Recently, a new invader has been discovered, the *Cercopagis pengoi*, a small spiny water flea. For that reason, the United States and Canada have introduced new regulations in that area (Ambrosa, 2000).

New Zealand too has been affected and its shellfish industry has suffered a lot due to toxic algae blooms, which have obliged the country to close all its domestic and international markets (IMO, October,1998).

The Black Sea has also been contaminated with more than 35 non-indigenous species, and many jobs, especially in the fishing industry, have been terminated. The *Comb Jelly* (*Mnemniopsis Leidyi)*, the *American Ctenophore*, the soft-shell clam *(Mya Arenaria)*, and the Japanese predatory snail *(Rapana Thomasiana)* were among the most devastating predators in that area, that have had a catastrophic impact.

In San Francisco Bay, the world's most invaded estuary, more than 220 non-indigenous species have been found (Hamilton, 1997). In addition, in the United States, more than 40 states have been affected by different kinds of aquatic species.

In particular, the following can be cited:

- The *Asian Clam*, responsible for the disturbance of the food chain in northern San Francisco Bay; and

- The aquatic plant *Purple Loosestrife* that has invaded 40 states causing the native vegetation to disappear and creating a problem in the ecosystem (SERC, 1998).

Australia has been obliged to introduce guidelines on BW. Its farming industries on the Tasmanian, Victorian and New South Wales coastline have been threatened by the introduction of a kind of algae called *Toxic Dinoflagellates*. The latter has already affected many other countries such as Argentina, Japan, Mexico, Portugal, Spain, Venezuela, China, India, South Africa and the Mediterranean. Furthermore, the Japanese seaweed *Undaria Pinnatifida* in the Tasmanian East Coast has had catastrophic effects on the abalone industry and mussel farms.

Alaska has been contaminated, and studies made over the last three years have established that 14 alien species – 13 crustaceans and one fish – may now be found in the area (Lloyd's List, 2000, March 27, p.8). At present, these invaders are not causing any damage in that icy region, but if their ability to adapt is taken into consideration, those responsible will need to think about this problem again, and strengthen their rules and regulations to mitigate the impact.

During 1990, the city of Monroe in Michigan lost electricity for two days. Zebra mussels had blocked the water intakes for the cooling system of the city's power plant. To rectify and solve the problem US$500.000 were needed (American University, 1999).

In addition, a toxic algae transported by BW has menaced the caged salmon in Norway, and a large number of Asian organisms transported by ocean-going vessels are invading California. France, Spain, Italy and Croatia have been invaded by the tropical green alga *Caulerpa Taxifolia* and thousands of hectares of coasts have been covered.

As shown in *Appendix I*, it is clear that almost all the continents have been contaminated in the same way. It is true that some countries are more affected than others, but as a general view, it can be said that all the world is threatened. Urgent decisions need to be made and more energy should be expended to slowing the rate of such disasters.

3.4.2 New regulations

The goal of the Guidelines was to provide Administrations and Port State authorities with information on procedures to minimize the risk of the introduction of unwanted aquatic organisms from ships' BW and sediment. Furthermore, the Guidelines noted that, with small differences in ambient conditions, namely salinity, temperature, nutrients and light intensity, the probability of those aliens surviving could clearly be reduced. On the other hand, the lack of mandatory regulations has led to a series of national and regional regulations. The following are examples:

- In 1989, Canada implemented standards for ballast water exchange (BWE) in the Great Lakes and St. Lawrence River.
- In 1992, the Australian Quarantine and Inspection Service (AQIS) established mandatory reporting and voluntary compliance requirements for BWE. In July 1999, it was announced that new rules would be introduced to keep marine invasive species out of Australian waters. It is expected that these rules will come into force in mid-2001 (Haley, 1999, p.34).
- In May 1993, mandatory regulations replacing joint voluntary Canadian/ US guidelines became effective for ships entering the Snell Lock on the St. Lawrence Seaway, bound for the Great Lakes. Ships can only discharge BW that was taken on in the open Ocean and where depths exceed 2,000 metres.

- In 1994, Israel stipulated that ships conducting ballast operations along the Israeli coast or in Israeli ports must first perform open ocean BWE outside the Mediterranean or Red Sea.
- In 1995, Chile implemented requirements for BWE for ships entering Chilean ports.
- In May 1996, oil tankers exporting Alaskan crude oil outside the US were required to conduct open-ocean BWE on their return voyage.
- On October 26, 1996, the US Congress enacted the National Invasive Species Act of 1996 (NISA). To comply with this law the US Coast Guard (USCG) developed an interim rule that went into effect on July 1, 1999. It was made mandatory for all ships that had been outside U.S. waters to replace their BW at sea prior to entering U.S. waters.
- In 1998, New Zealand only mandated open-ocean BWE for any BW to be discharged in its territorial seas.
- On January 1, 2000, California implemented a BW Control and Management Programme under which all ships carrying BW must:
  - Complete a mid-ocean BWE (in accordance with the guidelines of the law);
  - Submit a BW report form to the California State Lands Commission;
  - Maintain a BWM plan, and
  - Submit a fee of US$600 per vessel per voyage to the California's Board of Equalization.
- The State of Washington has now imposed new regulations on BWE requiring that coastal ships, which sail between 25 and 30 miles from shore, should exchange BW at least 50 miles offshore (Fairplay Solutions, December 1999).
- Buenos Aires, Argentina, Orkney Islands, the United Kingdom, Vancouver, Canada and Humboldt Bay, have all mandated requirements for BE.

Man has lost the capacity to foresee and to forestall.

He will end by destroying the earth.

Albert SCHWEITZER

CHAPTER IV

4 BALLAST WATER MANAGEMENT AND METHODS OF TREATMENT

> **Treatment means a process or mechanical, physical, chemical or biological method to kill, remove or render infertile, harmful or potentially harmful organisms within ballast water.**
>
> ***IMO Res. A.868 (20)***

In this chapter, and before debating the BWM plan and methods of treatment, some procedures for ships as well as for Port State(s) have to be mentioned. For both, an overview will be given without going into detail, as all the needed information can easily be found in Resolution A.868 (20).

As a result of the adoption of the "Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens" (GUIDELINES), Member States are requested to keep in close contact with IMO. Relevant information, such as copies of current domestic laws and regulations, shore reception facilities, any research and development (R&D) studies with respect to HAO and pathogens in BW, and fees, are to be provided to the Organization.

In addition, under the GUIDELINES the master is required to inform, as soon as possible, the Port State Authority (PSA) when he cannot change ballast for any reason. If an exchange is made, an officer is to be present to ensure that all the necessary and adequate procedures are followed and ballast operations recorded.

The threat of BW movements has led to the development of a number of BWM strategies and some national and regional guidelines and regulations that IMO is actively developing and doing its best to raise to the international level.

4.1 Procedures for ships

In order to comply with the GUIDELINES, all ships carrying BW are expected to follow certain procedures and regulations. Each ship is required to have on board a specific BWM plan as part of its operational documentation. In addition, and to keep a record of the maximum information when ballasting/de-ballasting, a form [11] is to be completed in order to bring it to the PSA. A responsible officer is to be appointed to supervise this task.

These regulations/guidelines/procedures were introduced by IMO in order to let people interact on the same wave length. Unfortunately, many States have not implemented them and have made their own regulations, which seems to be short-sighted if the potential impacts are taken into consideration. The following provide some examples of States setting their own rules:

AUSTRALIA

Exchanges are to be undertaken where practicable, in deep water, in the open ocean, as far as possible from shore and outside Australian waters (i.e. more than 200 nautical miles from shore). A certificate is required before discharging BW in Australian waters.

CANADA

The exchange of BW should be taken as far as possible from land, in awater depth exceeding 2,000 metres.

[11] **See Appendix V.**

MICHIGAN

A proposed bill requires that all BW arriving from outside Michigan should be sterilised before entering the Great Lakes bordering the State. For non-compliance with the rules, fines could reach up to US$25,000 a day and there may be criminal charges (Montreal, 2000). This provision has not yet been introduced, but according to some official sources, it will be soon, to some degree.

STATE OF CALIFORNIA

For vessels of more than 300 GT, exchange of BW is to be made outside the Exclusive Economic Zone (EEZ), at least 200 nautical miles from any shore, and in a water depth in excess of 2,000 metres.

These examples illustrate clearly the need for an international entity to make global rules and to avoid each country setting its own laws, with the risks that wide diversity incur. To illustrate, the California State Lands Commission approved a US$400 BW fee for any ship entering any port in California. This fee was originally US$600, but was changed due to pressure from shipping associations (Fairplay, 2000 March, p.30).

4.2 Procedures for Port State(s)

As a further contribution to the resolution of the problem, in the case of non-compliance of a ship to execute its ballasting before arriving at a port due to a *force majeure* situation, each Port State should provide adequate reception and/or treatment facilities. Examples of *force majeure* include: bad weather, unsafe sea conditions or operational impracticability. In addition, each Port State is expected to promulgate its domestic laws and regulations with respect to BW and sediment management, treatment procedures where BWE is prohibited, the location of the reception facilities and the associated fees.

On the other hand, some precautionary operational procedures must be understood by each seafarer dealing with BW, as an important step in ensuring the minimum, or if possible, total avoidance of harmful aquatic organisms (HAO), pathogens and sediments in the ballast.

It has been well demonstrated that very shallow waters can have higher levels of HAO, and that propellers stir up a lot of sediment. For instance, harbours and coastal waters are generally rich in living organisms while in the open ocean it is the opposite. Moreover, areas where the amount of HAO and pathogens is known to be high should be avoided, and it is the duty of the Port State(s) to inform all the users of those areas and where instead they may take on uncontaminated water.

4.3 Ballast water management plan

In order to reduce the impact of transport of HAO through BW, each ship is to have on board a specific BWM plan in accordance with the GUIDELINES adopted by IMO [This form was developed by the International Chamber of Shipping (ICS) and INTERTANKO]: "Every ship should have a BWM plan with safe and effective procedures for the mid-ocean exchange of BW." By Circular Nº 342 (MEPC/Circ.342) of the 28th of April 1998, a questionnaire on BWM was distributed to all Member States to be completed and returned to the Director of the Marine Environment Division [12]. The purpose of this questionnaire is to collect information about BW control methods by each State or Port State. Once these data have been gathered together, they will be assessed and the results shared with all Member States.

[12] **See Appendix VII.**

As will be developed and mentioned later on, a serious dilemma is facing IMO and mid-ocean ballast exchange. On the one hand, this operation is environmentally desirable, but on the other hand, it is clearly very risky, as most ships sailing today have not been built to allow for a mid-ocean ballast exchange.

The reason for developing strategies for managing BW is, of course, to contain the probability of new invasions to a reasonable level taking into account ship safety. Recognizing that there are no international agreements or regulations for either a mid-ocean BW exchange or an interdiction to discharge within port/coastal waters, the only way to deal with such a dilemma is to follow the Annex to Resolution A.868 (20), adopted on 27 November 1997.

Efforts are being made by the International Chamber of Shipping to develop a model BWM plan. This will help shipowners in developing their own plans, which should then be part of their ship's operational documents, and name the responsible personnel for the task, while setting out the relevant guidelines and treatment method(s), the records required and the location of possible sampling points.

4.3.1 Management options

As the problem continues to become more and more serious, and as Member States – particularly those who did not pay much attention in the beginning, begin to think twice about the serious risk – many options for taking care of BW are now being proposed. For the purpose of this dissertation, only the principal methods of treating BW will be discussed.

- An arrangement whereby all the users of seas could manage not to discharge BW and sediment, and to keep them on board, would be a complete solution to the problem. However, this option is only valid in limited cases and circumstances, and this dream is clearly not an option for most bulk cargo vessels due to their need to carry and discharge large volumes of BW.
- Another approach to minimize the release of unwanted organisms is to avoid the elimination of BW altogether, for example, one tank or two in one area. This method could be the best for international voyages, but unfortunately it is risky, costly and impractical.
- A possible method, considered by some experts as the best, could be considered a theoretical possibility and is not able to address real life situations on board ships in some circumstances. It consists of reducing the amount of HAO by minimizing the intake of BW in shallow waters, stagnant areas, near sewage outflows and dredging operations, and in areas where HAO or known pathogens are present [13]. The majority of masters are aware of the risks due to mid-ocean exchange, so before entering the high seas, especially if there is a forecast of bad conditions, they will try to get their BW as soon as possible even if they know that that area is contaminated.
- While still at the experimental stage, some new technologies – which will be explained in detail in *paragraph 4.4* – can be used to reduce invading organisms, while not removing them entirely.
- Discharge of BW and sediment into an onshore treatment plant is an option that may require further consideration, particularly in high-risk areas. For the present purpose, however, only options without need for storage facilities will be discussed.

[13] **See Paragraph 4.4 for more examples.**

- Some studies related to BWE demonstrate that in de-ballasting mid-ocean waters near ports, estuaries and coasts, there is a little risk that some species will survive; the converse is also true. Thus the risk of introducing exotic organisms may be reduced by following this procedure.

4.3.2 Practical methods followed

Since the last method (ballasting/de-ballasting in mid-ocean waters) is the most commonly used when the sea conditions allow such operations, it is useful to describe two practical methods that may be followed to reduce the transfer of HAO and pathogens.

4.3.2.1 Sequential method

As its name indicates, this method consists of completely emptying and refilling the tanks with clean sea water in sequence. Notwithstanding the practical aspect and the frequency with which this method is used, it should be recognized that it is very risky due to the hazardous effect of free surface, and the high stresses on the ship's structure. Furthermore, such operations should only be authorised under the strict control and supervision of a responsible person, normally, an officer, and in favourable sea conditions.

The responsible person should be aware of the complexity of his task with regards to:

- the hazardous stability of the ship due to the effects of free surface;
- the limits of its shear forces and bending moments;
- the movement of weights in tanks and cargo holds; and
- the over and under pressurization of ballast tanks and holds.

In addition, while the ship is engaged in this method, and to avoid any surprise in case of deterioration of weather and sea conditions, or the failure of any equipment (very frequent at sea), a contingency plan and associated procedures should be ready and in place for use if required.

4.3.2.2 Flow-through method

This method consists of taking sea water and filling the tanks from the bottom of the ship, and discharging into the sea the original ballast through air pipes or other equipment at the top. Most of the hazards of the previous method are applicable here too. In addition, according to some research, it may be necessary for water from one tank to be changed at least three times in order to get really clean water and achieve 95% effectiveness in eliminating HAO (Armstrong, 1999).

Figure 3 Example of the Flow-through method (SERC, 2000)

It has been argued and widely accepted that the flow through method does not affect the stability of the ship, as does the sequential method. Nevertheless, precautions must be kept in mind especially with regard to pressurization of tanks. In addition, to improve this method, a heat treatment process or UV radiation can be included, since these two methods are both environmentally acceptable.

4.4 Ballast water treatment

As the problem of invasion by HAO is growing day by day, it is clearly necessary to develop some treatment technologies that can control this disaster, or at least to reduce the rate of its spread. On the other hand, it is obvious that the shipping industry cannot be treated in the same way as land-based industries dealing with harmful substances.

Indeed, the requirements for the BW treatment on board ships are quite different and complex due to the space needed; the limited power available; and most importantly, the safety measures required for the ship and its crew. Furthermore, even if some industries have been trying to prove that the efficacy of their products is 100% sure, IMO has not accepted these often far-fetched claims and is waiting for more serious results.

Among the best suggestions that have been made to avoid taking on board HAO, are some that could be regarded – when circumstances allow them – as safe, practicable, technically feasible, cost-effective and environmentally acceptable:

- The easiest way is to avoid taking on BW;
- Taking on BW only by daylight as more species are deeper in the water column;
- Avoid taking BW:
    - in very shallow water, in areas affected by dinoflagellate blooms, and in the vicinity of sewage outfalls;
    - where dredging operations are occurring;
    - near cities and inhabited areas;
    - near areas with a high level of suspended sediments, such as river mouths or delta areas;
    - before leaving the port, the vessel should take city water as ballast; and

- when cleaning the ballast tanks to get rid of sediments, such operations should be carried out at sea or under controlled conditions in port or dry dock.

Other possibilities are still at a research stage where treatments such as biocides, ozone, heat, UV light or ultra sound and even sterilization are being tested. The goal of all those procedures is to avoid taking on board harmful bacteria and non-indigenous marine species in the BW or removing them from it. Another aim is, of course, to reduce the costs of ballast treatment and operation.

Mr. George Ryan, president of the Cleveland-based Lake Carriers Association stressed that there is no existing technology able to get rid of all HAO (Montreal, 2000, p. 5). Moreover, he added: "The best we can do is 60%-80% with mandatory ballast exchange."

For BW treatment, 3 arrangements are possible, but only the first one will be discussed:

- Ship-board treatment : Treatment facilities on board the ship itself.
- Port-based treatment : Use of a dedicated ship or barge fitted with BW treatment equipment.
- Land-based treatment : Use of a connecting pipeline from the berth to a storage facility and treatment plant.

Shipboard treatment offers the potential advantage of being able to remove or render inactivate all marine organisms from the BW prior to entry to any port. Its main disadvantages are that the space available for treatment facilities on board is limited and that each ship needs to be fitted out with the equipment. In addition, supervision of treatment equipment could be inadequate and there may be problems enforcing proper operation.

The treatment of BW and sediment could be applied at one of four different stages in the ballasting process. The options are:

- treatment during ballast intake;
- treatment *en route*;
- treatment during de-ballasting; or
- treatment after discharge into a storage system

A range of treatment processes is available for possible use in BW treatment. These processes have been divided into three broad categories:

- Physical treatment;
- Chemical treatment; and
- Residue treatment.

(a) Physical treatment involves application of mechanical, thermal or radiation energy to the water. Examples of physical treatment methods include UV light radiation, heat application and solids separation processes such as straining, sedimentation and filtration.

(b) Chemical treatment involves adding chemicals to the BW. These chemicals can perform a variety of functions. For example, a category of chemicals known as biocides can be added to the water to kill the marine organisms present. Chlorine, ozone and other commercial biocides are examples of this class of chemical. Following biocide addition, further chemical dosing may be required to deactivate the excess biocide and to render the dosed water safe for disposal. Other chemical processes include the use of coagulant chemicals to assist particle agglomeration, acids and bases for pH adjustment, and chemicals which extract oxygen from the water to make it oxygen-deprived.

(c) Residual treatment may involve either physical or chemical processes or both. Examples include pasteurisation by heat application, thickening by evaporation, and dewatering by mechanical press or centrifuge either with or without chemical addition.

Various factors related to the ship have a significant influence on the feasibility of BW treatment. The BW arrangements and capacity in any ship is dictated by the type and design of the ship. This could influence significantly the selection of the most appropriate BW treatment system depending on BW volumes, pumping rates and engine room arrangements.

In addition, ships voyage times vary from a minimum of one day for short coastal voyages to 30 days for long international voyages. This influences the type, size and cost of possible *en route* treatment systems. A ship's voyage time will be a factor if an *en route* treatment system is required. It will influence the flow capacity of such a treatment system or, for biocides, the combination of biocide concentration and contact time. As noted earlier, ship stability and strength aspects are the main disadvantages associated with *en route* treatment arrangements involving physical treatment methods.

The major potential advantage of *en route* treatment is that it can be carried out over a number of days, which would minimize the size and cost of any treatment system required. In contrast, the major constraint for shipboard treatment facilities is space, particularly on existing vessels. An additional key constraint is that the treatment facility needs to be relatively simple with minimal impact on normal shipping operations and require minimal attention from the ship's crew.

4.4.1 Examples of recent technologies

Due to the recent recognition of the seriousness of the problem of HAO transported in BW, efforts have been made in the development of alternative treatment technologies. It should be kept in mind that some of the following treatment methods are in the experimental phase, and none have been approved by IMO.

1- One company has found an original way to solve the problem of HAO. It uses a centrifugal vortex separator and when BW is pumped through it, the heaviest particles are separated out and returned to their original environment. Then the collected water is treated with UV radiation. From an ecological point of view, this method is quite attractive. Even the P&I Clubs share this perspective and are trying to test it in real life (Gard News 157, March/May 2000, p. 43).

2- Japan and Australia have various valuable research projects into different methods of treating BW, such as electrolysis, chemical, UV light and even heating the BW. Unfortunately, due to the huge quantities of water and the complexity of tank internals, no promising solution can presently be recommended.

3- Among the very few systems to treat BW that have been commercialised is the OptiMarin (OptiMar) ballast system (Källstrom, 2000 & Fairplay Solutions, June 1999, p.18), made jointly by Norwegian and Canadian experts. The principle is quite simple:

- They use hydrocyclones [14] in each ballast system to remove particles from the water intake.
- After this first step, they use UV radiation to kill micro-organisms and bacteria.

14 **Hydrocyclone technology is not totally new; it has been in use for around 70 years, and is used widely in the oil industry to separate oil from water (Fairplay Solutions, June 1999, p.20).**

4- In Singapore and to develop shipboard BW treatment options, a dockside pilot plant was constructed incorporating the following:

- sea water intake systems;
- pressure medial filtration and automatic air-augmented backwash;
- horizontal self-cleaning screen filter; and
- vertical self-cleaning filter with pleated cartridges.

Among the advantages of this novelty, each of the systems mentioned above can be activated independently or in combination with another or others. In addition, it is a fully automated system (Shipping World & Shipbuilder, May 2000).

5- To combat the problem of introduction and dispersion of HAO, Det Norske Veritas (DNV) developed, in 1998, a geographical information system called "Risk atlas." The latter is an international internet-based system, where masters can plot in the area where they have taken on board BW and where they envisage to de-ballast it.

This project was mostly financed by the Nordic Council of Ministers (co-operative body of the Nordic governments), and is " based on a risk assessment linked to bio-geographical compatibility, the master can be warned of any possible risk of transferring organisms, and measures to avert." (Halvorsen, 2000).

4.4.2 Options for treating ballast water

4.4.2.1 Deep sea exchange

Deep-sea exchange in depths of 2,000 metres or more could be considered the most effective option to minimize the risk of transfer of HAO. Indeed, only a few organisms can be found in deep-sea waters. This technique is fairly effective but has several limitations associated with it.

For instance, existing ships are not designed for such operation due to safety concerns for the ship and her crew, especially in bad weather and adverse sea conditions. BW exchange in mid-ocean is a method of reducing but not eliminating the risk of HAO introductions.

4.4.2.2 Clean ballast

As explained previously, clean ballast may be achieved by avoiding shallow water, dredging operations and areas of known outbreak of disease or plankton bloom [15].

4.4.2.3 Screening/straining

Screens are barriers designed to remove solids from water. The amount and type of solids removed is determined mainly by the slot size in the screen, which can vary from about 0.05 to 100mm.

Screening equipment varies from a simple set of bars to a rotating mesh drum or self-cleaning strainer device. Most equipment nowadays incorporates automatic cleaning systems.

Fine strainers, typically with a slot size of 0.05 to 2mm, are used extensively in the oil industry on offshore platforms. The advantages of strainers are that they are relatively compact and simple to operate. As a result this is one of the only technologies that could be practically retrofitted to existing ships.

[15] **See Paragraph 4.4 for more examples.**

4.4.2.4 Filtration

Even if this technology is widely used ashore by different manufacturers and in the industry in general, it has only limited application to BW for the following reasons. Among technologies used in onboard treatment, filtration could be considered as the most adequate and attractive in relation to the other methods. Further, by using filters large organisms can be removed, but not microscopic ones. In addition, filter systems necessitate frequent cleaning hence the high cost of maintenance. The cost of filters is proportional to the quantities of organisms removed; thus the more the quantity of material removed increases, the more the price increases.

4.4.2.5 Ballast water heating

This option consists of changing the temperature of the water to kill any kind of HAO. It has been proved that keeping BW above 40º C for 8 minutes ensures that no aquatic organisms can survive. But to reach such a lethal temperature in bulk carriers, for instance, where thousands of tonnes of water could be taken on as ballast, presents a major technological challenge.

Even if the waste heat from engines and ship's equipment was to be used, by means of additional pipes, such temperatures could not be reached unless the power used on board was multiplied by a factor of 4 to 5 (additional heat generation power). This option is therefore not very cost-effective.

Furthermore, it is not practicable for several other reasons, *inter alia*:

- this lethal temperature could possibly be reached easily during a long voyage, but it would be impossible for a short period;

- there would be limitations on the quantity of waste heat that could be used, hence only a certain quantity of BW could be treated; and
- the temperature of water differs from one area to another. Indeed, waters from tropical zones need less heat to reach the lethal temperature than waters from the Baltic Sea for instance, where the heat requirement would be more demanding.

4.4.2.6 Use of chemicals

The most compelling reason to consider biocidal treatment is its ease of application by adding biocides to BW. Complete mixing can be assured by a pumping system. In addition, biocide treatment is relatively simple; there is no need for a lot of room, and maintenance requirements, normally a big burden for the crew, would be quite limited.

The main disadvantages of this method are:

- any addition of biocides to BW will be discharged back to the ocean;
- not all biocides are effective with all target organism(s);
- the need to store the biocides on board increases the shipboard safety hazards;
- the residual biocides left in ship's ballast tanks after the treatment can cause corrosion of piping, pumps, and the structure, which adds to ship maintenance costs and hazards;
- effectiveness is influenced by temperature, contact time and pH level;
- a risk exists of environmental damage due to accidental discharge of biocide-treated BW prior to addition of a de-activating agent; and
- given the likely large doses required, the costs are high.

The two most common biocides are as follows:

Chlorine:

Chlorine is probably the most common biocide in use today due to its cost-effectiveness. Chlorine can be added to water in a variety of forms including as chlorine gas, sodium hypochlorite liquid or calcium hypochlorite powder or tablets. BW with excess free chlorine is generally not suitable for discharge in an untreated condition. To overcome this problem de-chlorination is required prior to discharge. This can be achieved by dosing sodium sulphite or sulphur dioxide, which reacts with the residual chlorine to form a chloride. Chlorine is an effective biocide, but there are environmental concerns about discharge of chlorinated BW. The reaction of chlorine with some organic compounds produces carcinogens.

Ozone:

Ozone is a powerful oxidant, which does not produce chlorinated organic compounds. Its applications include the disinfection of drinking water or cooling water in power plants, and odour, taste and colour removal from drinking water. In addition, ozone is considerably more effective as a biocide than chlorine. However, the capital costs are high compared to chlorine. Ozone treatment is very effective, but large onboard ozone generators would be required and the crew would need specialized training in the operation of the plant. Moreover, as it is extremely corrosive, special tanks, pumps and piping systems would be required.

4.4.2.7 Ultra violet radiation

UV radiation can be used to destroy bacteria and viruses. It is very effective for micro-organisms, but not for waters with suspended organisms due to absorption and screening effects. This option could be very effective when preceded by the filtration. An important advantage is that it does not have toxic or adverse effects on pipes, pumps or coatings.

4.4.2.8 De-oxygenation

Most HAO require oxygen to survive. Oxygen deprivation or de-oxygenation is toxic to a range of fish, invertebrate larvae, and aerobic bacteria. However, it is likely to be ineffective against organisms such as seaweeds, algae, spore stages including dinoflagellate cysts, anaerobic bacteria and possibly virus. Oxygen can be removed from water by purging it with an inert gas or by binding oxygen to a chemical additive such as sulphur dioxide or sodium sulphite. De-oxygenation would therefore be only a partial treatment solution and for this reason it is not considered to be a suitable process.

4.4.2.9 PH adjustment

Some organisms are sensitive to pH change and many would be susceptible to large variations in pH. One option may be to temporarily raise the pH to 12 or more by addition of alkali (lowering pH is generally undesirable due to increased corrosion problems). A disadvantage of this treatment is the large quantity of residue that would be produced. Prior to discharge of the BW to receiving waters, acid addition would be required to restore the pH balance. For the reasons set out previously, pH adjustment by chemical treatment would not be suitable for shipboard treatment and would be best carried out at a land-based installation. The quantity of chemicals required and residue produced make a port-based system difficult.

4.4.2.10 Salinity adjustment

Salinity adjustment involves increasing or decreasing the salinity of the water with the aim to inactivate or to kill the marine organisms present in the BW, and has been suggested as a possible treatment method for BW. Significant changes in ambient conditions between take-up/receiving area can affect the ability of HAO to survive.

This means, if the original ballast is fresh water, the high salinity of ocean water will normally destroy any organisms after the exchange. Unfortunately, when the original BW is salt or brackish, residual organisms may survive the exchange [16]. For these reasons, salinity adjustment is considered inappropriate and not considered a practical option.

From\To	**Fresh**	**Brackish**	**Salt**
Fresh	High	Medium	Low
Brackish	Medium	High	High
Salt	Low	High	High

Figure 4 Probability of organism survival and reproduction in water [17]

3.4.2.11 Keeping ballast water for long periods

Another simple method consists of keeping water in ballast tanks for more than 100 days. This is a safe option, with no risk, and in the absence of light, most organisms do not survive. But tankers and bulk carriers may not have the option of maintaining BW for more than three months.

4.4.2.12 Reception facilities

As noted in the beginning of this chapter, discharge of ships' BW into reception facilities will not be discussed. However, it is an option that requires further consideration, especially in contaminated areas. Furthermore, it may provide an adequate means of control.

16 **See Figure 4.**

17 **Haley C. W. (1999). The ballast water problem. BIMCO BULLETIN (94), 6, 32.**

4.4.3 Summary

Based on the remarks made throughout the different options presented, it can be concluded that:

- Although a wide variety of technologies for treating BW have been identified, there are no off-the-shelf technologies available and suitable for use on board ship without some modifications and re-design.
- Filtration, biocides, and thermal treatment are not currently the most promising options for shipboard application.
- Strainers will probably be the most widely applicable approach due to their ability to be accommodated in limited space, but the treatment efficacy is not as ideal as one would wish.
- UV radiation, pH/salinity adjustment, and de-oxygenation are inappropriate for shipboard treatment of BW.
- Some other techniques such as biological treatment, sediment disposal, ultrasound, photo-chemistry, heavy metal ions, acoustic systems, coagulants, magnetic fields, and anti-fouling coatings have not been mentioned for the following reasons:
  - they are not the appropriate technology for the removal of marine organisms;
  - they are relatively expensive;
  - they are not considered suitable due to their status as priority pollutants;
  - for their accumulation characteristics

In summary their disadvantages clearly outweigh their advantages!

4.5 Monitoring

Monitoring BW has two major purposes with respect to efforts to control introductions of HAO. First, when it is supported by appropriate record keeping, monitoring is needed to audit methods of controlling BW for compliance with regulations or guidelines. Therefore, it is an integral part of the process for managing BW. Second, monitoring is a R&D tool for assessing the effectiveness of BW treatment, increasing understanding of the HAO problem, and developing plans for managing BW.

Shipboard monitoring systems need to be safe, inexpensive, strong, compact, easy and quick to operate, particularly for personnel with little training. Onboard monitoring imposes more constraints and requirements than land-based monitoring. Because implementing measures for managing BW require practical measures for verification, accountability, and responsibility, automated monitoring methods are desirable.

Monitoring of shipboard BW treatment will most likely involve three steps:

- Records of equipment operation will need to be kept. This could involve for example, log records, hour-run meter readings, totalised flow readings and chemical usage records. This information is required to confirm that all BW has received the appropriate treatment and can be checked by the PSA if there is a need.
- Samples of treated BW and sediment will need to be taken as necessary to check the actual performance of the treatment facility.
- Unannounced inspections of facilities will need to be undertaken to ensure that these have been appropriately maintained and operated.

4.6 Training and education

In line with the IMO Guidelines, training for ships' masters and crews, as appropriate, needs to be encouraged. This should include instructions on the application of BW and sediment management and treatment procedures. Instructions should also be provided on the maintenance of appropriate records and logs.

Taking into consideration the seriousness of the problem, education has a strategic role to play because the oceans are too vast to monitor comprehensively. Seafarers need to be convinced to comply voluntarily by giving them the knowledge, training, and motivation to do so. A number of successful education and training programs need to be carried out including research, execution, evaluation, and innovation.

Education and training have important strategic roles to play in reducing/eliminating the problem of HAO. Due to the immensity of the sea, violation is and will continue to be difficult to detect and prosecute; hence, implementation must rely heavily on motivation and the education of seafarers.

Educational aims should be structured to let the seafarers be voluntarily engaged in taking care of the environment instead of imposing penalties for any violation. They should be persuaded to collect and provide information, but on the other hand, they should be provided with the requisite compliance methods as tools to make it as easy as possible for them to follow the rules.

4.7 Safety concerns

Of the multitude of methods described in *paragraph 4.4*, the only practice at present which appears to offer promise is ballasting/de-ballasting in the open sea. Unfortunately, this operation has proved to be a dangerous practice especially for big ships, which need safe shelters to execute such manoeuvres.

When sailing empty, ships are obliged to take sea water as ballast to keep their stability. A study made by the American Bureau of Shipping (ABS) − Member of the International Association of Classification Societies (IACS) − confirmed that this operation is considered to be the most dangerous not only for the ship, but also for the crew on board (Wheaton, 2000). During these operations, there is an increase in shear stress, bending moments and a tremendous effect on vessel stability.

The safety of the ship is regarded as paramount at all times and it remains the ship master's responsibility. If a master refuses to exchange BW because he considers that the operation could jeopardize the safety of his vessel, its crew, or its passengers, it is not only his right to do so, but it is an obligation for him to refuse to exchange ballast.

On the other hand, even if the regulations do allow such a possibility and accept that a master may choose not to follow the procedures, the State's Coast Guard can require a proof of a "*bona fide*" decision of the master and why the exchange would have been unsafe.

Furthermore, a BWE process can take between 15 and 24 hours for a handysize vessel, or up to 48 hours for a capesize vessel. The weather is the seafarers biggest enemy and even with the most sophisticated technology, only forecasts can be produced. In addition, it is quite possible that a ship could start its exchange in good weather, but by the time the tanks are empty the weather could have deteriorated badly.

IMO recommends the open sea BWE as it provides a means of limiting the introduction of HAO. Unfortunately, any seafarer knows that it takes only a few hours for sea conditions to change from a smooth sea to a nightmare; from what is called by IMO "allowable seagoing conditions" to a real threat to the ship's safety.

Human errors and failure of equipment can be fatal and place a ship in serious danger. As Dr. Donald Liu, ABS Senior Vice President, Technology says (ABS Activities, 1999, p.14): "This is an issue which needs a lot of attention and very careful handling." In addition, he adds: "Several of the vessels studied incurred bending moments approaching 100 % of allowable values during the exchange sequence." For this reason, proper training is needed for the master as well as all the crew, and this training should be part of the BWM Plan.

As mentioned earlier, some countries have imposed their own regulations and laws, which have created, in some areas, severe tensions and a serious threat to maritime commerce.

As is the sea marvellous

From God's hands which sent her forth

To sleep upon the world

And the earth withers

The moon crumbles

One by one

Stars flutter into dust

But the sea does not change

And she goes forth out of hands

And she returns into hands

And is with sleep…

Love,

The breathing of your soul upon my lips.

E. E. CUMMINGS

C H A P T E R   V

> **In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. 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.**
>
> ***Principle 15 of the Rio Declaration***

5 IMPACT OF THE PROPOSED NEW CONVENTION

5.1 The content of the proposed new Convention

IMO through its MEPC Working Group (WG) has considered a variety of options to introduce new regulations dealing with the protection of the environment from the introduction of unwanted aquatic organisms and pathogens transported in ships' BW. The paramount need to control, manage and prevent introductions of HAO *via* BW and sediments has led to the following options:

- A new protocol to add an Annex to MARPOL 73/78;
- A new Annex adopted *via* amendments to MARPOL 73/78; or
- A completely new Convention on BW management.

Until the 42nd Session of the MEPC, discussions were about making a new Annex – probably ***ANNEX VII*** – to MARPOL 73/78. In the 43rd Session, discussions about drafting regulations for BW management took another orientation and the option of preparing a legal instrument changed from a new ***ANNEX*** to a new ***CONVENTION***.

The idea behind such a decision was that a new Convention could be smoothly changed into a new Annex – if at any time a Member State decides to do so – while the opposite will be more difficult.

After considerations and discussions, the MEPC WG on BW made a report taking into account suggestions made by some Member States namely, Argentina, Australia, Germany, Greece, Japan, New Zealand, Norway, the Netherlands, the United States, ICS and INTERTANKO. As an annex to this report (MEPC 45/2), the WG submitted the following:

1 "Draft text of an international Convention for the control and management of ships' ballast water and sediments"; and
2 "Regulations for the control and management of ships' ballast water and sediments to minimize the transfer of harmful aquatic organisms and pathogens".

The ***first*** draft contains twenty Articles:

Article 1: Objective
Article 2: General obligations under the Convention
Article 3: Application
Article 4: Definitions
Article 5: Violation
Article 6: Detection of violations and enforcement of the Convention
Article 7: Control with respect to requirements for ships' structure and equipment
Article 8: Control with respect to operational requirements
Article 9: Undue delay to ships
Article 10: Promotion of technical co-operation
Article 11: Regional co-operation
Article 12: Settlement of disputes

Article 13: Other treaties and interpretation

Article 14: Communication of information

Article 15: Signature, ratification, acceptance, approval and accession

Article 16: Entry into force

Article 17: Amendments

Article 18: Denunciation

Article 19: Deposit and registration

Article 20: Languages

The ***second*** draft is composed of seven sections and seven appendices:

SECTIONS:

Section A: General provisions

- **Regulation A-1:** Definitions
- **Regulation A-2:** General applicability
- **Regulation A-3:** Exceptions

Section B: Applicability to ships

- **Regulation B-1:** Applicability
- **Regulation B-2:** Exceptions (to applicability)

Section C: General requirements for all ships

- **Regulation C-1:** Ballast water management plan
- **Regulation C-2:** Ballast water record book
- **Regulation C-3:** Ballast water management for new ships
- **Regulation C-4:** Ballast water management for existing ships
- **Regulation C-5:** Sediment management for new ships
- **Regulation C-6:** Sediment management for existing ships
- **Regulation C-7:** Best management practices

Section D: Special requirements in certain areas

Regulation D-1: Procedures and criteria for the designation of control areas

Regulation D-2: Ballast water discharge control areas

Regulation D-3: Ballast water loading (uptake) control areas

Regulation D-4: Regional agreements for ballast water discharge and loading

Section E: Standards for ballast water management

Regulation E-1: Procedures and requirements for approval of standards

Regulation E-2: Standards for ballast water management options

Regulation E-3: Standards for verification

Regulation E-4: Standards for sampling of ballast water

Regulation E-5: Standards for sediment management

Section F: Survey and certification

Section G: Shore-based reception and treatment facilities

APPENDICES:

APPENDIX I : Criteria for establishing ballast water discharge control areas

APPENDIX II : Criteria for establishing ballast water loading (uptake) control areas

APPENDIX III : Criteria for best ballast water management practice

APPENDIX IV : Model ballast water management plan

APPENDIX V : Model ballast water management certificate

APPENDIX VI : Model ballast water record book

APPENDIX VII : Standards

The proposed new draft is intended to address the environmental damage caused by the introduction of HAO and pathogens by minimizing their transfer through the control and management of ships' BW and sediments. The new draft can be seen as totally different from the one made after the 41st session. It is obvious that the last one (the draft Convention) is more detailed and more efficient, but few remarks and suggestions should be mentioned while comparing both drafts and discussing the second one.

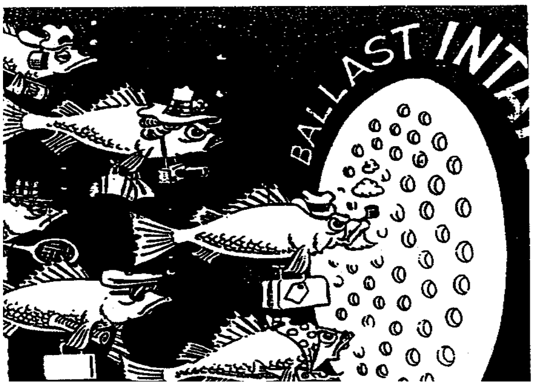
Article 3:

In the first draft, the provisions of the Annex must be applied to all ships that carry BW, while in the draft of the PNC, some exceptions were issued [18] and it was specified, besides ships carrying BW, they should be on international voyages.

As seen previously, it was discussed that one ship is enough to contaminate huge areas. Furthermore, even ships operating exclusively in waters under the jurisdiction of one party could endanger the ecosystem stability of another neighbouring State.

There are no physical borders at sea and it was stipulated in Principle 19 to the Rio Declaration on environment and development (1992): "States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith." More care and further considerations should be given to this point and especially during bilateral or regional agreements.

[18] Point 2 of the Article gives the list of ships that the draft Convention does not apply to.



"No room at the intake." By Steve Lindstrom. Reprinted with permission from the Seaway Port Authority of Duluth.

Figure 5 No room at the intake [19]

Point 2(b), "Ships of [a certain size and type]" should be cancelled as the size has nothing to do with the harm that the ship can provoke. The quantity of HAO transported in a small ship can be more than that transported in a huge tanker, and for instance if the BW was taken in an affected area or area containing viruses.

Article 5:

Article 5 deals with violation and sanctions. Not all violations should be considered as a violation. It should be kept in mind that *force majeure*, such as a deliberate discharge for the safety of the ship and her crew – when it can be proved – or an accidental discharge, should not be considered as violation and States should not apply any penalties. In Regulation A-3 these exceptions and a few more were developed. The obvious question that is raised is why the WG did not combine both of them.

19 National Research Council (1996). Stemming the Tide: Controlling introductions of non-indigenous species by ships' ballast water. National Academy Press: Washington, D.C.

Article 8:

With respect to operational requirements, there is no mention, in the Articles of the new draft Convention, of reception and/or treatment facilities in case where the ship did not deballast before reaching the port due to bad weather conditions or any another reasons. This option was mentioned in Section G (Shore-based reception and treatment facilities), which will be subsequently developed by the WG.

Training & Education:

Article 10 deals with the promotion of technical co-operation such as training of scientific and technical personnel and necessary equipment for the treatment and reception. Training and education of officers and crews in charge of BW operations should be mentioned and encouraged.

The PNC has been prepared though a number of questions and remains open for further considerations and suggestions, including:

- harmonization of the system of control;
- designation of Ballast Water Management Areas;
- standards for evaluation/acceptance of new BW management and control options; and
- extent of application of the provisions to fishing vessels, pleasure boats, etc.

5.2 The impact in the short term

In the short term, the PNC can be seen as a momentary solution due to the impact and burden on Port State Authorities and shipowners. As for Annex IV to MARPOL 73/78, it will take time for this Convention to enter into force, especially due to the same problem regarding reception and treatment facilities.

This PNC, as it is organized, will solve a few problems, but at the same time it will be a challenge to deal with the national and regional initiatives, which were implemented without waiting for any approval from IMO. An increasing number of Port States require that ships arriving at their ports should submit reports regarding their BW practice, e.g. the State of Michigan.

As IMO has no power to impose its conditions, each country has the right to decide and to impose restriction(s), to ban ballast discharges, and promulgate regulations on ballast loading practices, in waters under its jurisdiction. Furthermpore, each country can use special measures that are different from, or more stringent than, those required by IMO, such as the United States' OPA (Oil Pollution Act 1990), or introduce special BWM controls through bilateral or regional agreements.

A BWM plan has the following advantages:

- It gives masters information about the requirements for each port.
- If a BWM plan is well documented and is provided properly to the port authorities, delays in ports will be avoided.
- It assists masters on how to exchange BW safely.

For at least the next couple of years, the PNC will be discussed to reach a final consensus culminating, hopefully, in a Diplomatic Conference. Different Member States have different points of view, but until now (MEPC 45/2), one agreement was reached related to the "two tier program".

If BWM is to be done, it should be done in a standardized format. Unfortunately, from an environmental point of view, this approach is not very scientific or effective at actually preventing the transfer of exotic species and unlikely to push shipping companies to install (or spend money on research) BWM technologies on their ships.

In the short term, and in respect of Resolution A. 868(20), it is recommended, *inter alia*, that a BWM plan should be prepared for every ship that carries BW. In the same vein, classification societies have started to offer a few services, *inter alia*:

- the preparation of the BWM plan;
- calculation of acceptable intermediate stages of loading and unloading BW in open sea (sequential exchange of BW); and
- Calculation of pressure drop in air pipe arrangements when applying the flow-through method.

In addition, classification societies, shipbuilders and industries will provide adequate and maximum help to shipowners with regards to the efficient ways in which to solve and be in harmony with the PNC.

In the short term, and to assist developing countries with the problem of BW, IMO in collaboration with the GEF and the UNDP (United Nations Development Programme) launched a programme called “Removal of Barriers to the Effective Implementation of Ballast Water Control and Management Measures in Developing Countries”, otherwise referred to as “Global Ballast Water Management Programme” (hereafter GloBallast).

5.3 The impact in the long term

In the long term, discussions will continue to solve problems such as:

- the contents of the BWM plan;
- the criteria which states wishing to establish more rigorous BW controls, should follow;
- the standards for evaluating newly developed BW control techniques;
- basic requirements for sediment management; and
- the responsibilities of ports and the role of Port State Control.

IMO is the international body under whose auspices international marine pollution and safety of navigation are developed. As noted above, the MEPC is currently drafting regulations for a PNC ancillary to MARPOL73/78. Such regulatory co-ordination by IMO has notable advantages over the introduction of unilateral legislation and regulations by individual nations or by individual States or port authorities.

Uniformity (standardization) in operational procedures and training standards in accordance with the international law will reduce confusion and risks for human error and will provide safe and economic operation. In contrast, mandatory BW control measures at the port or regional level, in the absence of a governing international framework, would lead to a complicated patchwork of different requirements, which would harm compliance and effectiveness.

As the existing GUIDELINES do not provide a complete solution to the problem of prevention of the introduction of HAO through BW, further R&D of BWM and treatment options is still required. It will help shipowners to be conscientious about the risk and to be more vigilant when opting for a new design or equipment. Moreover, it will provide Administrations and Port State Authorities with guidance on procedures that will minimize the risk from the introduction of HAO.

The BWM techniques in the PNC should not be limited to what is available today, but should also include expected or possible new options. This means that it should encourage the development of new methods and technologies. On the other hand, in the long run (a few decades perhaps), the IMO Convention might be effective as the standard will be defined in the most stringent manner and technologies will be designed to meet such requirements.

Member States and non-governmental shipping organizations should provide to the Organization (IMO) for circulation, details of any R&D studies that they carry out with respect to the control of aquatic organisms and pathogens in BW and sediment found in ships. These data should be circulated and infected zones avoided.

For the longer term, more effective strategies, possibly involving structural or equipment modifications to ships, may need to be considered. Changes in ship design may help limit the uptake of unwanted pathogens and organisms in BW. In addition, the shipping companies will make their BWM technology just a part of their new ships; just like they do now with oily water separators, and of course, will incorporate the cost as part of the freight rate.

In the long term, when taking on BW, records of the dates, geographical locations, salinity and amount of BW taken on and recorded in the ship's log book to permit the monitoring by IMO and Port State Authorities, will permit having an overview of the location of different dangerous aquatic substances and prohibited areas.

5.4 Problems to solve

<u>Number 1</u>

Without being unduly pessimistic, the author would like to focus on the following facts to clarify his point of view. ***Firstly***, the problem of HAO *via* BW is no more a national or regional problem, it has reached the international level. ***Secondly***, its impact was clearly explained in Chapter II, admittedly only through a few examples, but enough to highlight the distress signal and the urgency of all Member States to react and as soon as possible.

Thirdly, there is no more time for discussions and bargaining. Regulations should be prepared and applied by all operators of the maritime sector. ***Fourthly***, years were spent in discussions to elaborate a legal instrument, which was changed from a new Annex to MARPOL 73/78 to a new Convention, which will take time to develop and to agree upon. ***Fifthly***, last year, it was proposed to convene a Diplomatic Conference by the end of this year (2000).

Annex 4 to the MEPC 45/2 gives an idea about the progression towards a Diplomatic Conference on BW management, and it was suggested the year 2002, which probably means 2003 or beyond.

After all these observations, the question arises as to "What is needed to speed up the process and attain decisions?" The answer is simple, but distressing "a disaster, perhaps."

Number 2

The question of "application of the ballast management arrangements" posed a difficult issue for the WG and blocked discussions. To overcome the obstacle and to satisfy all participants, the WG developed a two-tier approach consisting of the following:

- some requirements will be applied to any ship carrying BW on an international voyage; and
- when the ship reaches a defined area or areas, it may be subject to further controls with regards to BW.

This second point should be discussed with due and adequate attention and the WG must focus on one particular area that is the harmonization of the system agreed upon.

With regards to the areas, this means the areas under the jurisdiction of one State or more. In this respect, if each State starts to impose its proper controls in its own way, without an international framework and according to international law, it will be easily understood how hard and complex it will be for sea users, and especially masters in international trade. It will be a horrible labyrinth with infinite exits but only one being accessible at a time, and in a specific area in the world.

Number 3

It is desirable to improve and introduce new technologies and to use sophisticated equipment for the control and monitoring of BW, but such progress will not be without compensation. Appropriate training of masters, officers and crews in charge of BW will be needed simultaneously with educational programs to boost the alertness of the HAO problem.

Officers and crews will need to be qualified in the use of new procedures and the use and maintenance of new equipment for treating and monitoring BW. Moreover, the personnel ashore in charge of BW treatment facilities will also need adequate training as well as the personnel dealing with administrative or regulatory tasks on BW regulations.

Number 4

Risks associated with mid-ocean exchange remain to be resolved. The WG should carefully examine this especially in respect of existing ships. On this matter, Dr. Donald Liu (2000) states that:

> "Existing vessels were not designed to undertake complete ballast water exchange on voyages in the open ocean. As a consequence, exchange sequences can be quite complex, and a wide range of issues including stability, hull girder strength, resonant sloshing, slamming and propeller immersion must be considered."

Furthermore, and in the same vein, Captain Jack Isbester (December 1998, p.11) notes:

> "Mid-ocean ballast changing is environmentally desirable, but most ships at sea today were built before that was realised. They were not designed to change ballast in mid-ocean and to do so is always expensive and inconvenient and sometimes hazardous or unsafe."

Number 5

At present, BWE in the open sea is the only practical option, but masters and shipowners fear that the risks of the operation have been miscalculated. "If a tanker breaks up, that will be the day the shipping world wakes up the possibility that the cost of BWE exceeds the benefits," warnes INTERTANKO's Alex Smith (Fairplay 15 October 1998, p.28)

Number 6

Few questions should be considered with regards to risks of introductions of HAO, *inter alia*:

- standards to assess the effectiveness of one treatment option;
- the precise percentage of unwanted organisms to declare clean ballast;
- the sampling techniques;
- the delimitation of responsibilities of Port and Flag State(s); and
- if there is no overlap or contradictions with other legal instrument.

Number 7

An ideal and safe solution to solve the problem of contaminated BW is the shore-based reception and treatment facilities, where water can be treated more efficiently than it can be done on board ships.

Annex IV to MARPOL (Prevention of Pollution by Sewage from Ships) is not yet in force as not two thirds of the Parties, which constitute 50% of the gross tonnage of the world's merchant fleet, have ratified it. The major problem with this Annex lies in the fact that Parties try to avoid to be implicated in the costly oily water reception facilities ashore. As it will take years for Member States – especially those who did not ratify Annex IV to MARPOL 73/78 – to think about *other* (emphasis added) kinds of reception and treatment facilities (Port States Authorities would be expected to provide reception and treatment facilities), the author did not elaborate fairly this option in his previous chapter.

Decades of discussions among IMO and Member States have passed. The efforts are still being expended, but we are not out of their woods as yet even if great work has been done. The obligation for Member States to reception and treatment facilities is seen as one problem hindering ratification. But for how long? And what about the unilateral actions being imposed while discussions are going on? Furthermore, the sensitive point of reception facilities should be avoided at the start of discussions and could be amended when the PNC will enter into force; it will be much easier to deal with one problem at a time.

Give me the sunlight and the sea
And who shall take my heaven from me?
Light of the Sun, Life of the Sun,
O happy, bold companion,
Whose golden laughers round me run,
Making wine of the blue air
With wild-rose kisses everywhere,
Browning the limb, flushing the cheek,
Apple-flagrant, leopard-sleek,
Dancing from thy red-curtained East
Like a Nautch-girl to my feast,
Proud because her hold, the Spring,
Praised the way those anklets ring;
Or wandering like a white Greek maid
Leaf-dappled through the dancing shade,
Where many a green-veined leaf imprints
Breast and limb with emerald tints,
That softly net her silken shape,
But let the splendour still escape,
While rosy ghosts of roses flow
Over the supple rose and snow.

Alfred NOYES

C H A P T E R   VI

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In the last decade, much has been written about the introduction of non-indigenous species into different parts of the world. Their impact can be highly significant in social, ecological and economic terms. The biological impacts can include the following: the introduction of diseases (Vibrio Cholerae), parasites, and toxins; eradication of native species; and biological pollution, e.g. physical blockage of pipes, bad smells or algal blooms.

As a result, many introductions of HAO in new areas have occurred, and more often with disastrous consequences for the local ecosystem. However, it is important to remember that these unwanted species did not come or travel on their own accord, ***humans*** – the primordial cause of most trouble to the ecosystem – took them and displaced them either intentionally or unintentionally.

Shipping is an international industry and represents an important element in world trade. More than 80% of the world's commodities are transported by sea. Hence, States, the public and scientists have focused their attention on the role of shipping as a sensitive element of distribution of HAO. For example, in Oregon, at least 367 kinds of aquatic plants and animals have been found in the BW of vessels coming from Japan.

In this respect, the significant rates of transfer of HAO have been attributed to an increase in:

- numbers of ships;
- amount of ballast carried per ship (bigger ships);

- ships’ speeds with shorter voyage times and a better chance for HAO to survive the trip.

The environment was left out of the business picture for centuries. But, as the problem of contaminated BW lead to disastrous consequences and created severe problems throughout the world [according to the Global Environment Facility (GEF), it is one of the four greatest threats to the oceans], efforts were taken to reduce the chances of foreign organisms making their home in new areas. The threat emanating from the introduction and spread of non-indigenous species is viewed as the most urgent marine environmental problem facing the entire world.

The HAO phenomenon is becoming more and more popular and as public opinion has tremendously changed *vis-à-vis* the environment, the awareness of the harm caused by HAO to the ecosystem has led to the introduction of new regulations to protect the environment.

The invasion of HAO is not like the other major forms of ocean pollutants such as oil, sewage or garbage. HAO and pathogens, once established, are almost impossible to eradicate and can have serious and permanent consequences for the marine environment, the marine industry and public health. An oil spill can be cleaned up even if it takes time to recover the initial state of the affected zone, but with HAO, it is hard and nearly impossible to remove them from the ecosystem.

The continuing high rate of aquatic invasions and the theory that BW is the main pathway for their transfer stress the utmost urgency for an effective management of BW. It has been estimated that between 3,000 and 4,000 species of animals and plants are transported in BW daily around the world (Gollasch, 1997). Some of these species prosper in new waters to a point where they seriously disrupt the ecosystems of an area. They can have surprising impacts on food supply, economy, health, and overall bio-diversity.

It is clear that for this moment, there is no efficient solution to the question of how to reduce to an acceptable level the risks associated with HAO. The issue is very complex because of the huge amount of species involved and the interactions between factors that influence their introduction, establishment and resulting impacts. However, these difficulties do not mean that it is impossible to find way(s) of reducing the risks. The following are the conclusions derived from this study.

(1) The dumping of BW by ships has resulted in huge changes in the ecosystem and large economic costs. The introduction of unilateral legislation and regulations by individual nations will result in a complicated "patchwork" of national requirements that operators of ships in international trade will find difficult to understand and to comply with.

Member States of IMO took the process more seriously and are currently drafting the PNC. In the meantime, a growing number of those individual States are actively practising their proper, unilateral control measures of BW introductions. Such unilateral controls could have notable negative impacts for ships in worldwide trade and can create considerable measures of confusion and may cause complexities in port operations and in shipping in general.

To be more efficient, and considering the diversity of ships, trade routes and ecosystems, the development of such regulations should be at an international level. Without an international framework, controls will be tailor-made to national interests, leading to a patchwork of national regulations and resulting in difficulties for sea users to comply with. In addition, the involvement of all Member States is important to the successful development and implementation of guidelines and regulations for the control of BW. The problem of HAO has implications for the *whole world* (emphasis added) and not only the shipping industry.

(2) As all Member States are aware of the seriousness of the HAO issue, it will be easier for IMO to expedite the discussions, overcome some specific problems and hopefully finish by having the PNC adopted.

It should be kept in mind, that the PNC is no guarantee that the risk of the transfer of HAO will be totally eliminated. It will be a tool, and guidelines will help, at least, to reduce the risk of damage to the environment, and hopefully limit the number of cases. Moreover, full compliance is necessary since *one ship* (emphasis added) is enough to introduce enough HAO to devastate immense areas.

(3) The MARPOL 73/78 Convention sets limitations on discharges from ships. Annex I deals with oil, and Annex II regulates pollution by “noxious” liquid substances including chemicals. MARPOL 73/78 categorises these chemicals (about 250 substances were evaluated and included in the list appended to the Convention) in terms of their hazard to aquatic life and human health, and provides acceptable concentration levels for discharge to the sea. Using chemicals as an option to eliminate HAO, if utilized in an inappropriate way, could create a dilemma between the PNC and Annex II to the Convention.

(4) The IMO GUIDELINES and the PNC take full account of the safety of the ship and its crew. During its last meeting (MEPC 45), the IMO MEPC renewed its pledge to respect the paramount importance of safety, while developing the PNC.

The implementation by all parties should not present any problems. They should sympathize with such an obvious idea. It is better to have an international system, accepted worldwide, than a number of different systems with conflicting requirements.

In the same vein, Mr. Gilles J. Bélanger, President and Chief Executive of the Shipping Federation of Canada, noted: “We have been trying to get the legislation set aside because this issue must be treated at least on a region-wide basis, and ideally internationally” (O’Mahoney, 2000).

Furthermore, Hindell (1996, p.371) states that: "The sea is obviously an area where nation States, acting individually, cannot cope. Solutions have to be devised internationally and should be applied co-operatively and universally." However, one thing is clear: the discussions still have a long way to run.

(5) Technically, a variety of methods of making BW innocuous remain under consideration. All are being considered but mid-ocean BWE, despite its costs and limitations, remains the preferred option in most cases. BWE in the open sea provides a means of restraining the introduction of HAO. Moreover, the IMO has settled that the most efficient method right now to control the spread of HAO is the BWE. Guidelines were promulgated to be used by vessel operators and especially while developing guidelines and regulations for Port State(s).

Near shores, river mouths, delta areas and ports, it has proved that a higher diversity and number of species can be found than in the open ocean. Generally, species from the high seas cannot survive if they are moved to a near shore environment.

Unfortunately, due to safety considerations, this method will never be popular with shipping people, because if the exchange is incorrectly carried out, it has the potential for catastrophic damage with possible loss of lives. In this respect, some organizations qualify IMO's motto "Safer shipping and cleaner oceans" as being a contradiction in terms. Finding a solution to an environmental problem should not bring any kind of risk to human lives. Furthermore, after completing such operation, there are always some residues of coastal organisms in ballast tanks.

(6) From the assessment of treatment techniques explained in Chapter IV, some important conclusions can be made:

- On board ships, treatment options are less effective than on shore due to significant constraints in space.

- There is no system or option that can totally prevent the introduction of HAO. The currently available technologies, suitable for use on board ship, are designed for treating BW, but after some changes in design and modifications.
- Certain ship types and designs could be placed in danger by the regulations/guidelines that impose BWE requirements to prevent HAO spread.
- The complexity of exchange sequences on certain vessels pose serious safety concerns as human error and equipment failures can potentially jeopardize the vessel.
- All the BW treatment options discussed in this dissertation create some residues in one way or another.
- Existing ships are not designed to undertake complete BWE in the open ocean. As a consequence, exchange sequences can be quite complex, and a wide range of issues must be considered including ship's stability, hull strength, sloshing, slamming and propeller immersion. Furthermore, when existing ships were built, neither designers nor builders thought or were asked to provide solutions for the increased stress emanated from BWE at sea.
- The majority of the treatment options demonstrated are either too expensive or inefficient on board ships under some circumstances and conditions.
- A combination of two or more techniques would be more profitable and fruitful in controlling BW.
- A number of treatment methods are being developed, but most of them are in the very early stages of development, and none has been approved until recently by IMO.

(7) To be effective, any method for treating BW must be monitored to ensure that the risk of introductions is being reduced. Moreover, it is a way to check if operators of vessels are complying with regulations. Monitoring is essential from both regulatory as well as biological perspectives.

(8) Mid-ocean BWE is not yet a standard practice and therefore it does not exist in the training syllabus of any maritime training programme. In the same vein, maritime schools must introduce some information in this field into their programmes. Every country should properly train its officers and crews to deal with BWM operations and treatment procedures, and be familiar with the BWM Plan of ships on which they serve.

(9) Some Port States have imposed IMO's draft recommendations prematurely. This could be a serious danger. There is a pressing need for these states to reconsider their regulations until all Member States have implemented them. Port States should ensure that their established rules (domestic law) are based on international regulations and especially those developed by IMO. Unfortunately, it is not always desirable or possible to establish domestic rules when discussions are still going on internationally, and when Port States are competing with each other to impose their own laws and regulations

(10) BWM is considered one of the most urgent and important issues among the topics on the MEPC's Agenda. However, some countries are not taking into consideration a potential disaster. Australia, for example, is acting for the development of an international regulatory instrument for BWM to be mandatory by mid-2001, which means before the IMO diplomatic conference (De Bièvre, 2000) [20].

(11) By all accounts, it seems that a cash crisis at IMO is threatening to postpone the development of new regulations for the protection of the environment. IMO did not increase its budget to maintain its "zero growth policy," which will probably leave not enough funds for the 2000/2001diplomatic conference for the adoption of new BWM rules (Grey, 1999). Hence, it will delay to the biennium 2002/2003 the implementation and the entry into force of the PNC.

20 See Conclusion 11.

(12) Ballasting is a necessary requirement for the ship's safe operation when sailing empty to pick up a cargo, or with a light load. It has been recognized that currently the only effective way to stop the spread of unwanted organisms is to prevent them being dumped in foreign ports.

(13) The distribution of weight on board a ship, at all times, is critical, very meaningful and subject to permanent calculations to conclude bending moments, shearing forces and the stability of the ship. For instance, bending moments and shearing forces are crucial on large bulk carriers and tankers.

(14) For existing ships, the requirement for additional equipment on board ships treatment will be more difficult than for new ships due to the wide variety and sizes of ship's design, ballast arrangements, and trading routes implicated.

(15) The economic losses from HAO are a direct reflection of an environmental perturbation.

5.2 Recommendations

The problem of marine pollution began to be taken into consideration after the 1920s. At that time IMO did not exist, neither did the United Nations. But some countries introduced certain measures, generally unilaterally, to avoid oil discharges in their territorial waters.

As the prevention of HAO introductions *via* BW become an international issue, regulations for its management will be more effective if they are applied internationally. In the same vein, it will be more important that an international organization such as IMO takes the lead in the management of HAO internationally to achieve a set of acceptable, common control measures and harmonized arrangements.

All Member States should support and encourage the current international activities for the elaboration of a new Convention conducted under the auspices of IMO. Furthermore, they should work together to focus attention on the problem and find solutions on a *worldwide* (emphasis added) basis. The following are the recommendations derived from the study.

(1) All Member States should sponsor and encourage further R&D for reducing or removing HAO transported in BW. In this regard, options for treating BW should not be limited to technologies on board ships; land-based treatment should be investigated as a possible alternative. R&D should be undertaken to address long-term solutions for the control of HAO introductions.

(2) With regard to HAO, a wide range of tactics have been suggested for reducing the risk of introducing exotic organisms *via* BW, involving physical, chemical or residual treatments. Other possibilities in use should be more and more developed such as:

- Control where and how ballast can be taken on board or discharged;
- Reduce or eliminate sediment in tanks before taking on ballast;
- Treatment of the water at port of discharge; or
- Use of land-based facilities (As a starting point, experience with land-based wastewater treatment systems could be used in the R&D technologies for treating BW).

(3) To deal with HAO, there are two basic approaches:

- To stop them from coming, or
- To eliminate organisms that have invaded.

To get rid of established and existing HAO is practically impossible, difficult and expensive. However, stopping invasions before they occur is obviously more logical, interesting, easier in practice and less expensive. It is the only long-term practical and economical solution, even if unfortunately, no methods of treatment can today completely eliminate the risk of introducing HAO.

"The goal of managing BW must be to minimize the risk."

(4) To stop HAO introductions, each State should take into account a few objectives while preparing the BWM Plan, namely:

- Identify responses that can prevent introductions of any invasive species;
- Detect and respond rapidly to the spread of such species in a cost-effective and environmentally practical method;
- Limit the spread of established HAO into non-overrun waters.
- Reduce harmful ecological, economic, social and public health impacts due to the infestation by HAO;
- Monitor invasive species populations precisely and seriously;
- Provide restoration of native species in invaded habitat;
- Conduct R&D on invasive species to prevent new introduction;
- Develop techniques and ways to get rid of HAO; and
- Encourage public education on invasive species.

(5) Strategies for preventing HAO introductions and the management of HAO threat *via* BW and sediment should include the following:

- control when and where BW can be taken on or discharged;
- treatment of BW by a range of physical, chemical and residual processes;
- determination of BW characteristics (this will provide data to allow appropriate selection of treatment method); and
- the problem should be addressed on a national, regional and a worldwide basis.

In conjunction with these issues, the questions of operational practicability, seafarer and ship safety, biological effectiveness, environmental impact, monitoring, assessment and cost-effectiveness of different options, must be considered.

(6) The expenses needed to fit existing ships with adequate installation of BW treatment equipment will be a real burden for shipowners. In this respect, the slogan "No More Favourable Treatment (NMFT)" should ***NOT*** be kept in mind. New international regulations should ***NOT*** ensure that all shipowners would be treated in the same way; at least in the start of the application of new regulations. Indeed, quality standards of some ships have decreased through the transfer of ships to flags of convenience. Crew numbers on board have also been reduced over many years and this critical policy is unlikely to be changed in the future.

In this respect, BW treatment equipment is subject to operation, repair and maintenance by the crew. Unfortunately, with few standards of ship maintenance in some instances having problems with hull or machinery, it may be understood in some situations that for BW treatment systems, it would not be accorded a high priority and could be easily shunted or considered as a secondary issue.

(7) The purpose of focusing on new design for ships in relation to BW equipment is to follow in perfect harmony with ballast regulations and to fulfil as much as possible the requirements of the term "Ballast friendly." Some design newness will improve considerably the BWE. For instance, separation of top wing tanks from double bottom tanks to reduce stress and bending moments during the exchange of BW and shorter tanks to reduce the amount of residual ballast during exchange at small trims. Architects and ship builders might take a few years to improve or to find more adequate ways to solve the problem, but they will finish by reaching their goal and find solutions.

(8) Even if there is no control options practised today that totally prevent the unintentional introduction of non-indigenous aquatic organisms through ships' ballast operations, technologies should be evaluated in a way that they meet the safety and effectiveness criteria during their use on board to achieve the following goals:

- Commercial availability of the system(s);
- Safe for the ship and its crew;
- Environmentally acceptable;
- Minimum manning requirement;
- Reasonable capital and operating cost;
- Effective in destroying potential invading organisms;
- Possibility of increasing the effectiveness;
- Adaptable size;
- Practicable in application and easy to maintain;
- Easy to monitor;
- Cost-effective; and
- Compatible with normal ship operations

(9) Another recommendation consists of taking into account while establishing future international regulations to include guidelines for the sampling of port water for specific organisms. Samples should be tested to agree upon international standards to facilitate comparisons of the BW on board from one port with the water of receiving port(s).

(10) Although this is a biological problem, the solution lies with management and education. Maritime Institutes can help in three ways:

- In the short-term, through education, maritime institutes must ensure that mid-ocean ballast exchange is carried out in a seamanlike manner.

- In the medium-term, classification societies, Flag States and naval architects must ensure optimum "ballast friendliness" in new buildings.
- In the long-term, all Member States must deploy all their means on R&D to develop a cost-effective way to take care of the introduction of HAO through BW.

(11) Due to the difficulties associated with total elimination of introductions of HAO, efforts should be focused on its prevention and reduction through the design of advanced techniques for their eradication, transport and storage.

(12) On board treatment systems for existing vessels cannot be guaranteed given the low standards of some ship maintenance being experienced. In this respect, to be effective, any on board equipment needs to be specific for ships, trustworthy, and easy to repair and maintain.

(13) At present, BWE is the only management tool used to reduce the risk of invasion. BWE involves replacing coastal water with open sea water during a voyage. There have been objections to this on safety grounds where a ship's stability and stresses may be affected by changing ballast at sea. This method is not fully effective. Organisms continue to survive in the sediment and residual water in the ballast tanks. It has been estimated that there is about a 36% organism survival rate, but until today, it is the best method that could be used.

(14) All BW movements and any management practices used must be recorded and ships' logs maintained. Such information could be helpful when used in combination with measurements of water-quality parameters to check if the BW has been correctly treated.

(15) Among the available and most effective measures that can reduce the risk of discharge of HAO into the marine environment, is changing BW loaded in port (or taken on board during the transit of inshore waters) with open ocean water that is loaded during passage between ports of call.

(16) In the longer term, changes in ship design may help limit the uptake of HAO in BW. It would be beneficial if workshops are organized and all institutions concerned or dealing with BW issues be invited to share and exchange views, and provide any information and advice.

(17) Due to the scientific and technological revolution, BW regulations should be continuously updated. They need to be in harmony with R&D novelties from all States, especially those with a better understanding of the problem and with improved techniques for controlling BW.

In order to follow the evolution, some options should be incorporated in the BWM plan. New technologies should be:

- **COMPREHENSIVE:** For coastal as well as international voyages, and loaded and unloaded vessels.
- **DIVERSE:** The system should have a diverse set of treatment alternatives to be adjusted, at least, to the well-known HAO.
- **FLEXIBLE:** As trade and shipping are quite active, and invasive species are also fanciful, options should be geographically flexible and could be accommodated to any changes in any kind of shipping as well as the nature of invasions.
- **SAFE & PRACTICABLE:** It should be safe for the crew and ship, and does not need or create huge maintenance and operational difficulties.

(18) For the future BWM in shipping, the following could be used as a basis for work:

- The development of control systems to eliminate the serious and ongoing problems with HAO should be encouraged.
- Studies predicting the long-term effects of established and introduced species should be encouraged and supported.

- Any organization dealing with marine management should be involved.
- The development of economic motivation making the shipping industry contribute to the control of BW organisms should be encouraged.
- An international maritime HAO database that includes a reporting framework should be developed.

(19) Instead of thinking of laying down civil and criminal penalties, regulations should encourage the sea users to participate in good faith in their application. Furthermore, the opportunity should be given to the citizen to prove that he/she can co-operate on a voluntary basis. More participation will lead to better information. Better information will lead to better conclusions. Better conclusions will lead to better harmonization and co-operation concerning the legislator/citizen (sea user).

This does not mean that the PNC strategy should only focus on cheering on voluntary assent, but it should settle strict enforcement means and mandatory controls.

(20) Most engine rooms on board existing ships have very limited space for extra equipment such as BW treatment facilities. For new ships, it will be more achievable as piping systems and engine room plants can be designed and adjusted according to the demands and wishes of shipowners.

In addition, a BW operations plan, developed in conjunction with the ship cargo plan for each voyage, would provide flexibility in managing BW. Such a plan would take account of available information on locations and times when ballast should not be taken due to HAO.

(21) The reliability of the system may also be a concern, particularly on older ships; and of equal importance, new vessel designs should take into account the BWE requirements. At the design stage, careful planning may relieve most of these safety concerns.

Considerable research has been undertaken on a range of issues by a number of organisations resulting in management solutions currently being developed. Among them it is suggested that ship builders and ship owners building new ships should be encouraged to immediately include the best ballast options in ship design and work together with classification societies.

(22) When implementation of BW treatment becomes mandatory, more appropriate treatment technologies will be improved and created. All parties will involve themselves, in one way or another and for diverse reasons, to find the best way to overcome this threat.

(23) For oil spills, the R&D of new equipment and products to improve means of fighting the pollution has been complemented with:

- the development of contingency planning guidelines;
- the arrangement of courses and seminars;
- the fulfilment of exercises and simulations; and
- the publication of studies, reports and brochures to make aware and prepare people in case of emergency.

The same procedure must be applied to non-indigenous species.

(24) Under special circumstances and especially in areas known by their populations of HAO or their high level of suspended sediments, a ship might take "potable water" or "inactivated water" as BW. "There might also be possibilities to uptake ballast water after it has undergone a process of inactivation, i.e. whereby any aquatic organisms and pathogens in the water and associated sediments have been killed, removed or otherwise inactivated." (IMO, 2000b).

(25) While preparing a BWM plan, a port contingency plan should be developed for situations where contaminated BW enters a port. All the procedures to apply and to undertake should be clearly explained in detail in the plan and all operators should be aware about it and familiar with the operation and all the steps they should follow.

(26) Since starting to deal with IMO conventions and regulations, the author found, as a rule of thumb that it is difficult to have a wide idea about any convention or regulation. To be able to discuss any IMO legal instrument, the user should be an expert in that area and should have enough experience.

New regulations should be easily understood, smoothly manipulated and clearly applied. When Member States are invited to prepare any kind of regulation, they should make it as simple as possible.

(27) When developing the PNC, Member States should try to find a rational and equitable balance between environmental, safety and economical concerns.

“Prevention is the best medicine.”

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IMO (1998c) MEPC 42/8/9: Harmful aquatic organisms in ballast water: Comments on the report of the working group on ballast water convened during MEPC 41 (MEPC 42/8). London, IMO.

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APPENDIX I

(1/4)

Invasions of non-indigenous species discovered 1979 - 1983

SPECIES	INTRODUCED TO
American razor calm *Ensis directus*	Germany / Denmark
Japan/China hydroid *Cladonema uchidai*	San Francisco Bay
Atlantic mysid *Neomysis americana*	Argentina / Uruguay
Japan Cumacean *Nippoleucon hinumensis*	Oregon
Asian copepod *Oithona davisae*	San Francisco Bay / Chile
Chinese copepod *Limnoithona sinensis*	San Francisco Bay
Japan mussel *Musculista senhousia*	New Zealand / Australia
Indonesian mysid *Rhopalopthalmus tattersallae*	Arabian Golf
Indo-Pacific jellyfish *Phyllorhiza punctata*	Southern California
Japan shipworm *Lyrodus takonoshimensis*	British Columbia
Mediterranean Algae *Polysiphonia breviarticulata*	North Carolina / Dominica
American comb jelly *Mnemniopsis leidyi*	Black Sea
Asian clam *Theora fragilis*	San Francisco Bay
American sea slug *Doridella obscura*	Black Sea
Japan copepods *Centropages abdominalis* and *Acartia omorii*	Chile
Pacific clam *Scarpharca cornea*	Black Sea
Indo-Pacific goby *Butis koilomatodon*	Nigeria / Cameroon
American worm *Marenzelleria viridis*	Germany
Indonesia shrimp *Exopalaemon styliferus*	Iraq / Kuweit
European nudibranch *Tritonia plebeia*	Massachussetts
European shorecrab *Carcinus maenas*	South Africa
Mediterranean mussel *Mytilus galloprovincialis*	Hong Kong

APPENDIX I

(2/4)

Invasions of non-indigenous species discovered 1984 - 1988

SPECIES	INTRODUCED TO
Chinese worm *Teneridrilus mastix*	San Francisco Bay
European waterflea *Bythotrephes cederstroemi*	Great Lakes
Atlantic shrimp *Hippolyte zostericola*	Colombia (Caribbean)
Tropical green alga *Caulerpa taxifolia*	Mediterranean
American blenny *Hypsoblennius ionthas*	Hudson River
Atlantic copepod *Centropages typicus*	Texas
Indian seabream *Sparidentex hasta*	Australia
European seasquirt *Ascidiella aspersa*	New England
Asian clam *Potamocorbula amurensis*	San Francisco Bay
Japanese sea star *Asterias amurensis*	Australia
Asian copepod *Pseododiaptomus marinus*	Southern California
Japan read alga *Antithamnion nipponicum*	Long Island Sound
South Africa / Australian worm *Desdemona ornata*	Mediterranean
Asian shrimp *Salmoneus gracilipes*	Southern California
Japan dinoflagellate *Alexandrium catenella*	Australia
European (probably) dinoflagellate *Alexandrium minutum*	Australia
Japanese dinoflagellate *Gymnodinum catenatum*	Australia
South American mussel *Mytella charruana*	Florida
Indo-Pacific crab*Charybdis helleri*	Colombia (Caribbean)
Chinese copepod *Pseudodiaptomus forbesi*	Southern California
European bryozoan *Membranipora membranacea*	Maine / New Hampshire
European ruffe *Gymnocephalus cernuus*	Great Lakes

APPENDIX I

(3/4)

Invasions of non-indigenous species discovered 1984 - 1988

Japanese goby *Rhinogobius brunneus*	Arabian Gulf
Philippine / Taiwan goby *Mugilogobius parvus*	Hawai
Japanese kelp *Undaria primatifida*	New Zealand
Japanese crab *Hemigrapsus sanguineus*	New Jersey
European zebra mussel *Dreissena polymorpha*	Great Lakes
Japanese red alga *Antithamnion nipponicum*	France (Mediterranean)
Atlantic clam *Rangia cuneata*	Hudson River
Japanese kelp *Undaria pinnatifida*	Australia
Japanese brown alga *Sargassum miticum*	North Sea

APPENDIX I

(4/4)

Invasions of non-indigenous species discovered 1989 - 1993

SPECIES	INTRODUCED TO
European zebra mussel *Dreissena bugensis*	Great Lakes
South American mussel *Perna perna*	Texas
Asian copepod *Pseudodiaptomus inopinus*	Columbia River
American comb jelly *Mnemniopsis leidyi*	Mediterranean
Black Sea goby *Proterorhinus marmoratus*	Great Lakes
Mediterranean goby *Neogobious melanostomus*	Great Lakes
European oyster *Ostrea edulis*	Rhode Island
South American *Vibrio cholera 01*	Alabama
Sarmatic hydoid *Blackfordia virginica*	San Francisco Bay
Sarmatic hydoid *Maeotias inexspectata*	San Francisco Bay
New Zealand sea slug *Exopalaemom carinicauda*	San Francisco Bay
Mysid *Hemimysis anomala*	North Baltic Sea

IMO (October, 1998). Alien invaders – putting a stop to the ballast water hitch-hikers. Focus on IMO. London, IMO.

APPENDIX II

(1/4)

Development of ballast water regulations and guidelines at IMO

International Conference on Marine Pollution, 1973	Adopted Resolution 18 on *Research into the effect of discharge of ballast water bacteria of epidemic diseases*, calling for research on the issue
Marine Environment Protection Committee 26th Session (MEPC 26) September 1988	Canada presents paper with study on *The presence and implication of foreign organisms in ship ballast waters discharged into the Great Lakes.* United States also expresses concern. Canada invites Member States with problems of foreign species to communicate this information to them.
MEPC 29 March 1990	Australia presents a paper giving evidence that toxic dinoflagellates may have been dumped in Australian waters via ballast water. An informal discussion group (Australia, Canada, Denmark, Germany, Japan, Norway, United States and International Chamber of Shipping) debates the issue. The Committee agrees to include the issue in its work programme and establish a working group (WG) at its next session.
MEPC 30 May 1990	A WG reviews and modifies draft guidelines on the control of ballast water, submitted by Canada. Committee agrees Members should review them intersessionally with a view to adopting them at the next session.
MEPC 31 July 1991	WG finalises guidelines and these are adopted as MEPC.50(31) ***Guidelines for Preventing the Introduction of Unwanted Organisms and Pathogens from Ships' Ballast Waters and Sediment Discharges.***
MEPC 33 October 1992	Australia submits paper containing information on Australia's experience in dealing with the introduction of harmful marine organisms. An informal WG meets during the session and agrees to form an intersessional correspondence group (with Australia as lead country) and circulate a questionnaire on the issue to all Member States.

APPENDIX II

(2/4)

Development of ballast water regulations and guidelines at IMO

MEPC 34 July 1993	Australia presents the results of the survey. An informal WG discusses how to proceed and the Committee agrees to establish a WG at the next session with a view to further developing the existing IMO guidelines. The Committee also approves a draft Assembly Resolution, incorporating the existing guidelines.
IMO Assembly 18th Session November 1993	Assembly adopts Resolution A.774(18) on ***Guidelines for Preventing the introduction of Unwanted Organisms and Pathogens from Ships'Ballast Waters and Sediment Discharges.***
MEPC 35 March 1994	A WG begins looking at developing legally binding regulations on ballast water control and management. Members of the WG include: Australia, Canada, India, Japan, Liberia, New Zealand, Norway, Sweden, united kingdom, United States, Hong Kong, China, ICS, International Association of Classification Societies (IACS), Oil Companies International Marine Forum (OCIMF), Friends of the Earth International (FOEI).
MEPC 36 October-November 1994	WG continues looking at developing legally binding regulations on ballast water control and management.
MEPC 37 September 1995	WG continues looking at developing legally binding regulations on ballast water control and management.
MEPC 38 July 1996	WG reviews preliminary draft regulations for the control and management of ships' ballast to minimize the transfer of harmful aquatic organisms and pathogens and begin to work on implementation guidelines related to the regulations.
MEPC 39 March 1997	WG continues work on draft regulations and updating the 1991 guidelines. Committee approves joint MEPC/MSC circular on *Guidance on safety aspects relating to the exchange of ballast water at sea.* MEPC also agrees an updated version of the 1991 Guidelines on ballast water as a draft Assembly Resolution.

APPENDIX II

(3/4)

Development of ballast water regulations and guidelines at IMO

MEPC 40 September 1997	WG continues work on draft regulations with highest attendance so far, with experts from Argentina, Australia, Brazil, Canada, China, Denmark, Finland, Germany, Greece, India, Japan, Liberia, Malaysia, Malta, Netherlands, New Zealand, Norway, Panama, Poland, Republic of Korea, Russian Federation, Singapore, South Africa, Sweden, United Kingdom, United States, Hong Kong, China, UNDP, ICS, International Association of Ports and Harbours (IAPH), Baltic and International Maritime Council (BIMCO), IACS, OCIMF, FOEI, International Association of Independent Tanker Owners (INTERTANKO), International Union for Conservation of Nature and Natural Resources (IUCN), International Council of Cruise Lines (ICCL), World Wide Fund for Nature (WWF)
IMO Assembly 20th Session November 1997	Assembly adopts Resolution A.868(20) *Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens*, revoking and updating Resolution A.774(18). The revised Guidelines incorporate further recommendations on tackling the problem, including how to lessen the chances of taking on board harmful organisms along with ballast water.
MEPC 41 March-April 1998	WG of 25 countries and 10 organizations with consultative status continues work on draft regulations and guidelines. Committee requests that draft regulations and the associated draft Code or guidelines be circulated as soon as possible in order to allow all members of the WG to submit comments and proposals for additional amendments.
MEPC 42 September 1997	WG to continue finalising draft regulations and code/guidelines and proposed format of legal instrument.

APPENDIX II

(4/4)

Development of ballast water regulations and guidelines at IMO

MEPC 43 January 1999	Finalization of outstanding issues.
MEPC 44 December 1999	Results of considerations and discussions of the BW Working Group of the MEPC 43.
Conference Year 2000 (Subject to change)	Conference to adopt mandatory regulations on BWM.

IMO (October, 1998). Alien invaders – putting a stop to the ballast water hitch-hikers. <u>Focus on IMO.</u> London, IMO.

APPENDIX III

(1/6)

Concerns about a successful invader -- The Zebra Mussel

Zebra Mussel Biology

Although organisms have been arriving since the 1800s, real interest in this problem by society at large, was sparked primarily by the arrival of the zebra mussel in Lake St. Clair in 1985/86. The zebra mussel was one of the few introductions causing not only environmental upheaval, but also inflicting substantial economic penalties on many different users of the Great Lakes water.

The origin of this organism is the fresh waters in the Black Sea and Caspian Sea region. From this area, the mussels have spread throughout Europe, following the path of the industrial revolution in 1770. This was the time of canal building and much waterborne commerce, which assisted the movement of the mussels into new bodies of water. By the 1830s the mussels were found throughout most of Europe including the British Isles. In the last five years, much has been written about the introductions of non-indigenous (exotic) species into different parts of the world, including the Great Lakes. However, it is important to remember that plants, animals and diseases have followed since humans started to travel.

Zebra mussels feed on plankton, including algae, bacteria, larval animals, and other tiny particles of organic matter suspended in the water. The mussel pumps water into its body through a siphon tube and filters out the food. The water is pumped out through a second siphon. An adult zebra mussel filters an average of one litre of water each day.

APPENDIX III

(2/6)

Concerns about a successful invader -- The Zebra Mussel

Although they are freshwater animals, zebra mussels can survive in slightly brackish water (0.5 parts per thousand). Some adult zebra mussels have survived for several days in water with salinity as high as 12 parts per thousand under controlled laboratory conditions.

Zebra mussels grow and reproduce best in water which is 12 to 26º C with a calcium content of at least 20 parts per thousand. The calcium is important for the growth and maintenance of the shell. Zebra mussels are either male or female. Mature females can produce 30,000 eggs each year. Some females have produced as many as one million eggs per year. Spawning occurs when water temperatures warm to 12 to 23º C. If the water temperature remains suitable, spawning may occur several times during the season.

A fertilized zebra mussel egg becomes a microscopic, planktonic larva. The larval mussel spends two to three weeks swimming about, feeding on phytoplankton. During this stage, downstream currents can easily transport the larval zebra mussel from one body of water to another.

About two to three weeks after hatching, the larva begins to settle to the bottom. To survive, it must settle on a hard surface. Almost anything will do, including rocks, pier pilings, boats, concrete, another animal's shell, aquatic plants, or submerged logs. It attaches to the surface with strong fibers called byssal threads. Zebra mussels frequently grow in large colonies, with hundreds of individuals attached to an object and to each other. Moreover, Zebra mussels can crawl from place to place by secreting temporary byssal threads which the mussels attach and detach as they move along!

APPENDIX III

(3/6)

Concerns about a successful invader -- The Zebra Mussel

Zebra Mussel Optimal Habitat Characteristics

water temperature	6 –28º C (spawn at 12 - 23º C; die above 32º C)
PH	7.4 – 9.4
Salinity	Less than 5 parts per thousand (ppt)
calcium (from $CaCO3$)	Greater than 20 parts per million (ppm)
Substrate	Need firm surface for attachment

NOTE: Larval forms are more sensitive than adults, especially to cold water temperatures.

Zebra Mussel Impacts

Zebra mussels can reproduce in large numbers in suitable habitats. Although individual zebra mussels are small, they attach to each other to form large colonies, which grow on almost any solid underwater material. These colonies can grow to contain as many as 100,000 mussels per square meter!

Large populations of zebra mussels in many parts of the United States have caused serious problems, such as the following:

- Clog intake pipes in water treatment plants, power generating plants, and industrial facilities, reducing waterflow and causing occasional shutdowns.
- Attach to pier pilings, navigational buoys and markers, and docks, interfering with navigation and increasing corrosion.

APPENDIX III

(4/6)

Concerns about a successful invader -- The Zebra Mussel

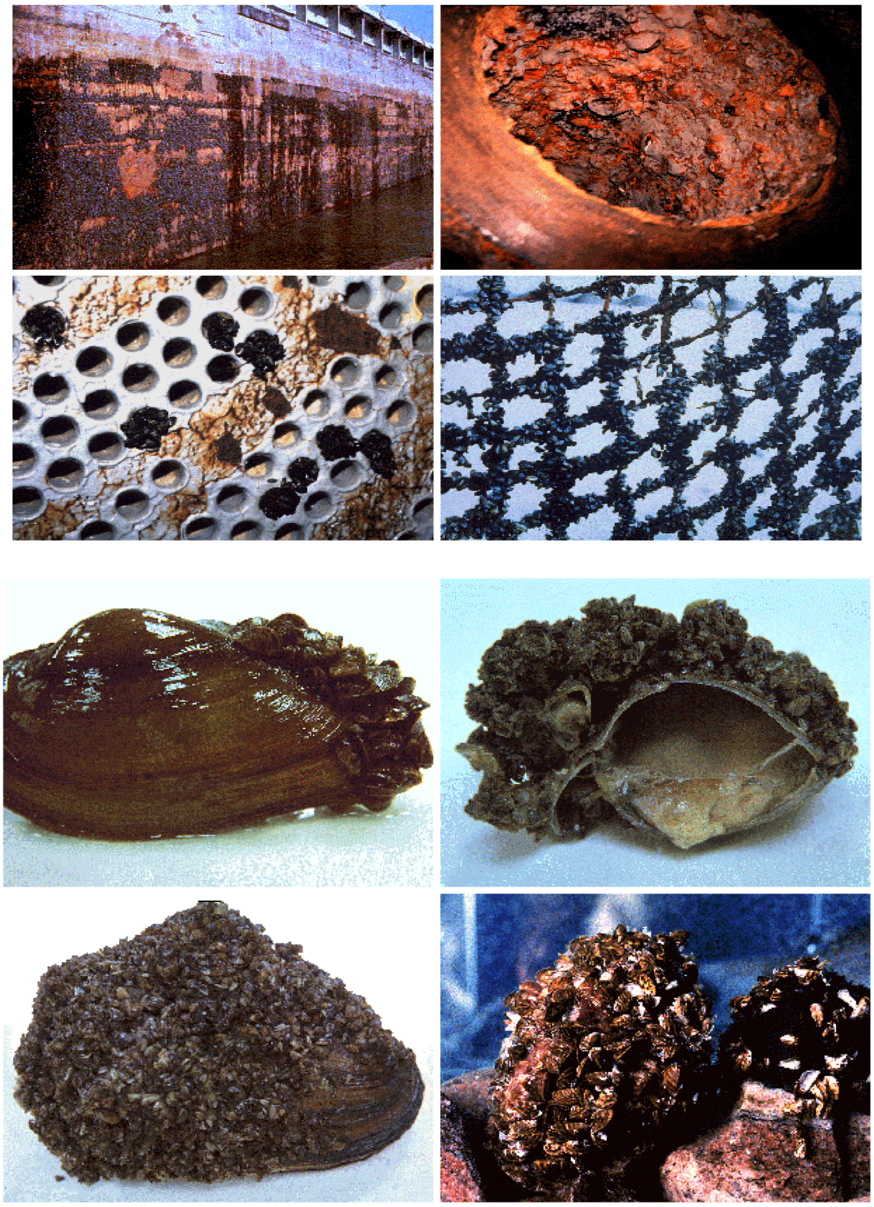
- Grow on boat hulls and inside engine systems, decreasing fuel efficiency and damaging engines.
- Attach to shells of native freshwater mussels, weakening or killing them by interfering with the mussels' ability to open or close their shells, as well as competing for food.
- Filter large amounts of phytoplankton from the water, reducing food available for other filter-feeding organisms and many fish.

Clark, V. P. & Miller, T. J. (2000). Invasion of an Exotic Species: Stop the Zebra Mussel! Activities and Resources. Virginia Institute of Marine Science School of Marine Science.

APPENDIX III

(5/6)

Concerns about a successful invader -- The Zebra Mussel

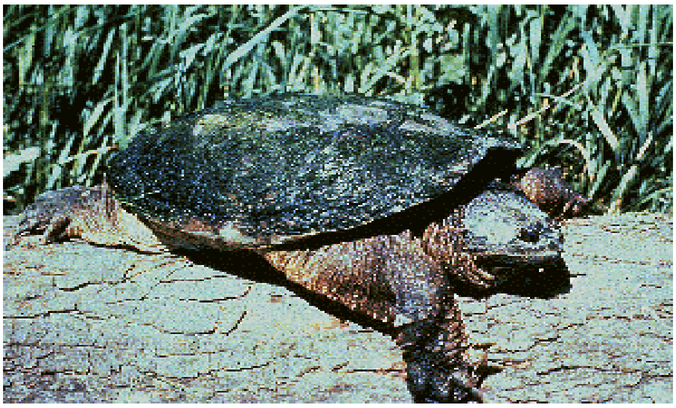


Ram, J.L. (2000). The Zebra mussel page. Detroit: Wayne State University. Dept. of Physiology. Retrieved June 26, 2000 from the World Wide Web: http://www.science.wayne.edu/~jram/zmussel.htm

APPENDIX III

(6/6)

Concerns about a successful invader -- The Zebra Mussel

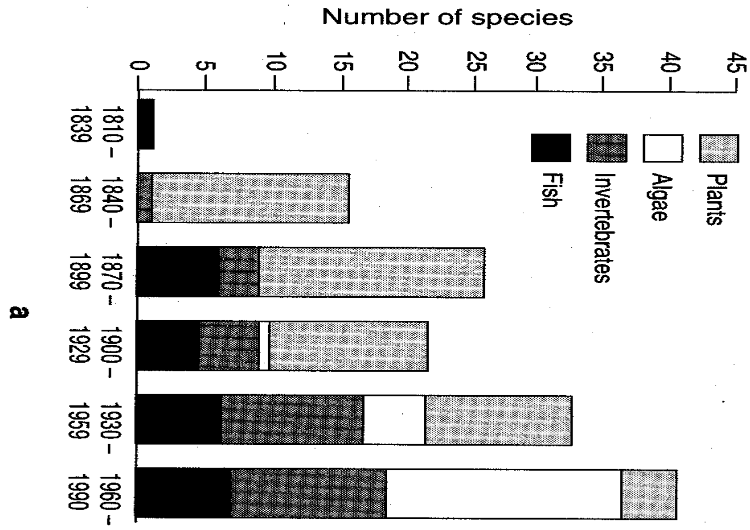


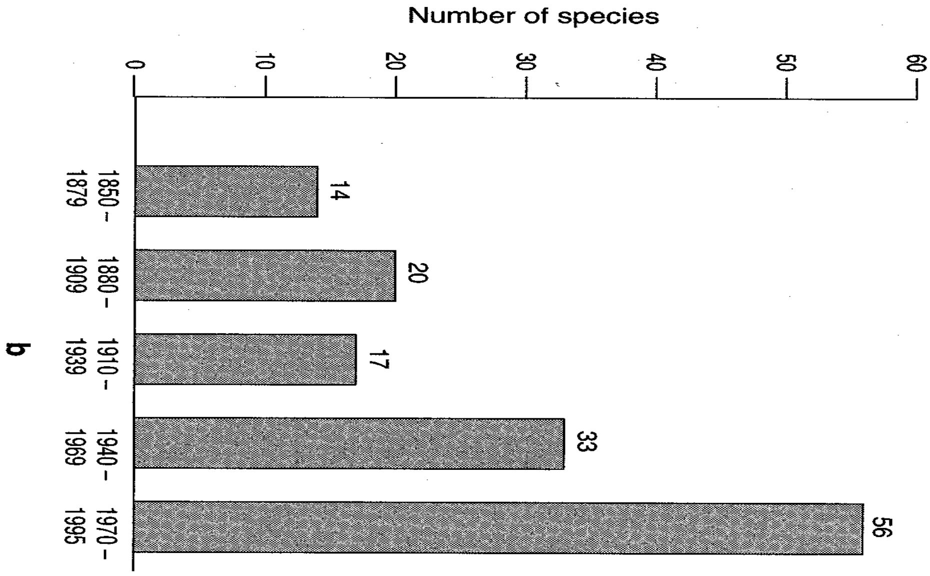
Ram, J.L. (2000). <u>The Zebra mussel page.</u> Detroit: Wayne State University. Dept. of Physiology. Retrieved June 26, 2000 from the World Wide Web: <u>http://www.science.wayne.edu/~jram/zmussel.htm</u>

APPENDIX IV

(1/1)

Introduction of non-indigenous species in :





- **(a) The Great Lakes**
- **(b) The San Francisco Bay region**

Note: **Introductions shown as the date of first collection of newly discovered exotic species. Mills et al., 1993; Cohen and Carlton, 1995.**

National Research Council (U.S.). Marine Board (1996). Stemming the tide: Controlling introductions of nonindigenious species by ships' ballast water. Washington D.C.: National Academy Press.

APPENDIX V

(1/1)

Ballast Water Reporting Form

BALLAST WATER REPORTING FORM
(TO BE PROVIDED TO PORT STATE AUTHORITY UPON REQUEST)

1. VESSEL INFORMATION / **2. BALLAST WATER**

Vessel Name	Type:	IMO Number:	Specify Units: m^3, MT, LT, ST
Owner	GT:	Call Sign:	Total Ballast Water on Board:
Flag:	Arrival Date:	Agent	
Last Port and Country:		Arrival Port:	Total Ballast Water Capacity
Next Port and Country:			

3. BALLAST WATER TANKS BALLAST WATER MANAGEMENT PLAN ON BOARD? YES ______ NO____ HAS THIS BEEN IMPLEMENTED?
TOTAL NO. OF TANKS ON BOARD ____ NO. OF TANKS IN BALLAST ____ IF NONE IN BALLAST GO TO NO.5 YES _____ NO _____
NO. OF TANKS EXCHANGED ________ NO. OF TANKS NOT EXCHANGED ________

4. BALLAST WATER HISTORY: RECORD ALL TANKS THAT WILL BE DEBALLASTED IN PORT STATE OF ARRIVAL; IF NONE GO TO NO. 5

Tanks/Holds (list multiple sources/tank separately)	**BW SOURCE**				**BW EXCHANGE** circle one: Empty/Refill or Flow Through					**BW DISCHARGE**			
	DATE DDMMYY	PORT or LAT. LONG.	VOLUME (units)	TEMP (units)	DATE DDMMYY	ENDPOINT LAT. LONG.	VOLUME (units)	% Exch	SEA Hgt. (m)	DATE DDMMYY	PORT or LAT. LONG	VOLUME (units)	SALINITY (units)

Ballast Water Tank Codes: Forepeak=FP, Aftpeak=AP, Double Bottom=DB, Wing=WT, Topside=TS, Cargo Hold=CH, O=Other

IF EXCHANGES WERE NOT CONDUCTED, STATE OTHER CONTROL ACTION(S) TAKEN: ______________________

IF NONE, STATE REASON WHY NOT. ______________________

5. IMO BALLAST WATER GUIDELINES ON BOARD (RES. A.868(20))? YES ____ NO ____

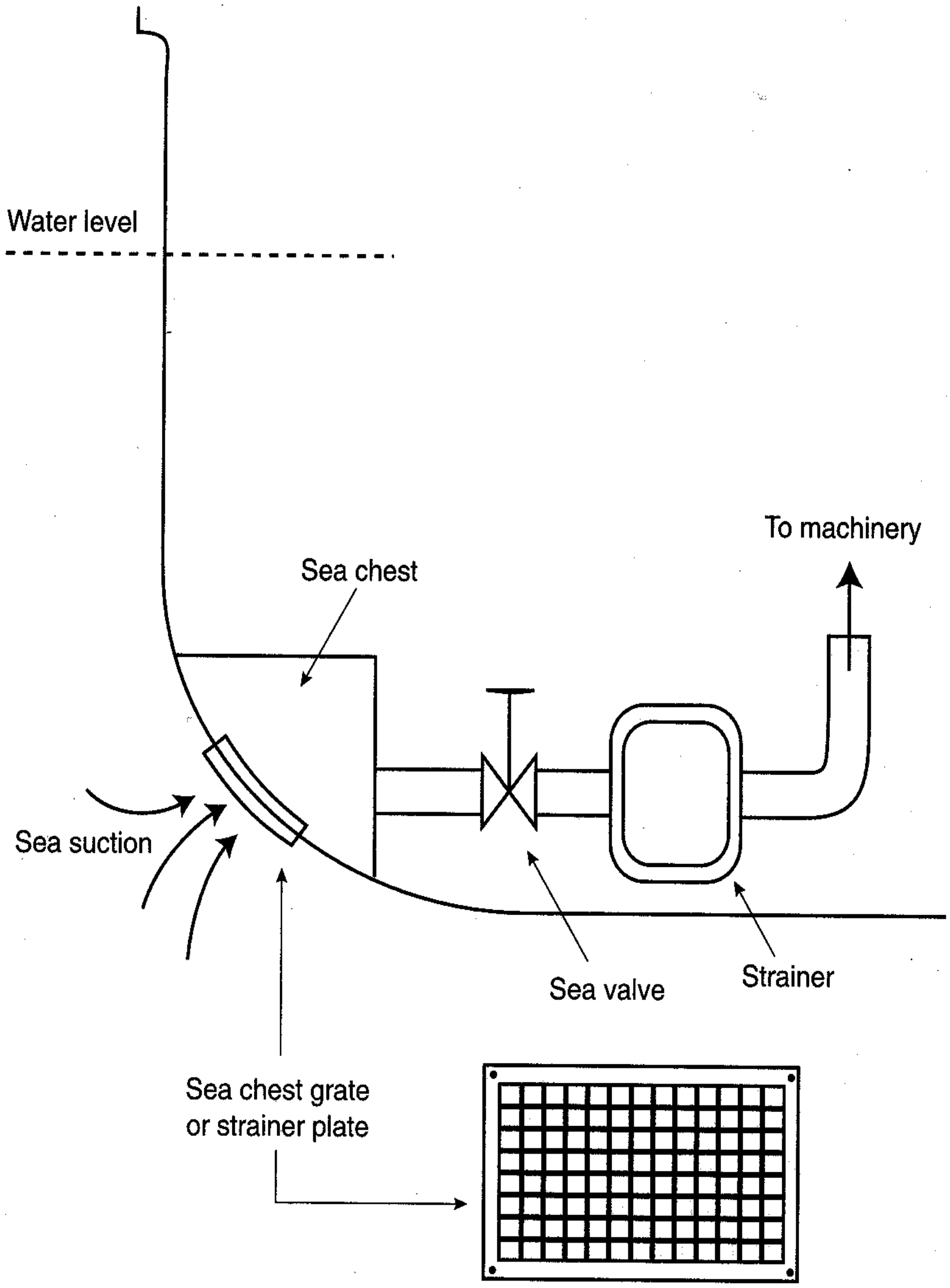
RESPONSIBLE OFFICER'S NAME AND TITLE (PRINTED) AND SIGNATURE ______________________

IMO (1998a). Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens. London, IMO.

APPENDIX VI

(1/1)

Typical Ballast System



National Research Council (U.S.). Marine Board (1996). Stemming the tide: Controlling introductions of nonindigenious species by ships' ballast water. Washington D.C.: National Academy Press.

APPENDIX VII

(1/5)

Questionnaire on Ballast Water Management

INTERNATIONAL MARITIME ORGANIZATION
4 ALBERT EMBANKMENT
LONDON SE1 7SR

Telephone: 0171-735 7611
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Telex: 23588 IMOLDN G

IMO

E

Ref. T5/1.01

MEPC/Circ.342
28 April 1998

QUESTIONNAIRE ON BALLAST WATER MANAGEMENT

1 In 1991 the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) adopted Guidelines for Preventing the Introduction of Unwanted Organisms and Pathogens from Ships' Ballast Water and Sediment Discharges.

2 In 1992, the United Nations Conference on Environment and Development (UNCED) requested IMO to consider the adoption of appropriate, i.e., legally binding, rules on ballast water discharge to prevent the spread of non-indigenous organisms. The eighteenth IMO Assembly in 1993, noting that the above MEPC Guidelines had been used only by a very few countries, and that the uncontrolled discharge of ballast water containing aquatic organisms remained a major international problem which has continuously worsened, adopted the MEPC Guidelines through Assembly resolution A.774(18), thus emphasizing the importance of this matter. The resolution requested the Marine Environment Protection Committee (MEPC) and the Maritime Safety Committee (MSC) to keep the guidelines set out in the resolution under review, "with a view to further developing the guidelines as a basis for a new Annex to MARPOL 73/78", i.e., to develop internationally applicable legally binding provisions as part of the MARPOL 73/78 Convention.

3 In 1994 MEPC started to prepare legally binding provisions together with guidelines that should advise IMO Member States on the effective implementation of the regulations. In addition, MEPC prepared the text of a new Assembly resolution on Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens, which was adopted by the IMO Assembly at its twentieth session in 1997 as resolution A.868(20). In carrying out the above work, MEPC noted that in a number of countries unilateral action had been taken by individual IMO Member States in the form of requirements adopted with a view to minimizing the risks of introducing aquatic organisms and pathogens with ballast water and associated sediments discharged from ships.

4 In light of the above situation, IMO is increasingly being requested to provide information on requirements concerning ballast water control practices developed by individual countries or port authorities. It is the purpose of this questionnaire, which is annexed hereto, to collect such information, to have this evaluated by MEPC and to distribute the results of such an evaluation to all Member States.

5 Member Governments are therefore requested to complete the questionnaire annexed to this circular and return it to the Director, Marine Environment Division, IMO as soon as possible.

***

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APPENDIX VII

(2/5)

Questionnaire on Ballast Water Management

2 Do your national control measures apply to:

(a) all ships? Yes/No*

(b) specific ship types? Yes/No*

If "yes", please list exemptions: ....

(c) any ballast water amount per ship? Yes/No*

If "no", please note exempt limits: ....

(d) only ballast water originating from defined countries, ports, regions? Yes/No*

If "yes", please attach outline or principles of relevant risk analysis.

3(a) Are the above control measures supported or enforced through national legislation? Yes/No*

If "yes", please note title and year of relevant act, ordinance, decree, etc. ....

....

....

3(b) Are any or all aspects of ballast water management control measures mandatory in your country, region or port? Yes/No*

If "yes", list mandatory measures in regions and ports to which they apply. ....

....

....

4 Do the measures applied in your country:

(a) accept all ballast water management options set out in the guidance provided by IMO? [4] Yes/No*

---

[4] IMO resolutions A.774(18) and/or A.868(20)

* Delete as appropriate

APPENDIX VII

(3/5)

Questionnaire on Ballast Water Management

If "no", please note restrictions: ....

....

....

(b) accept additional ballast water options?

If "yes", please indicate alternatives that are acceptable: ....

....

....

(c) include any specific measures which must be undertaken if en route management or treatment was not possible?

(d) require any specific reporting procedures? Yes/No*

If "yes", please indicate alternatives that are acceptable: ....

....

....

5 Are national ballast water control measures based on:

(a) examination of records and log? Yes/No*

(b) visual inspection of ballast tanks? Yes/No*

(c) ballast water sampling, *in situ* measurements and/or laboratory analyses? Yes/No*

6 Please note the location and capacities of any facilities for the reception, treatment or safe disposal of ballast water and sediments ....

....

....

---

* Delete as appropriate

APPENDIX VII

(4/5)

Questionnaire on Ballast Water Management

7 Please indicate name and address of your national control authority for ballast water management ....

....

....

8 Provide addresses (including e-mail, fax) of other national focal points (institutions, departments) through which information on national requirements concerning ballast water management may be obtained ....

....

....

....

....

C. Introductions of aquatic species, their impacts and counter measures

1 Are introductions known to have occurred in your country involving harmful aquatic species:

(a) through maritime shipping (e.g., ballast water discharges, fouling on ships' hulls)? Yes/No* [5]

(b) with aquaculture or as ornamental products? Yes/No*

2(a) Has the degree of impact been evaluated? Yes/No*

2(b) If "yes" to 2(a) above, what is the degree of impact evaluated in regard to:

(i) human health, ecosystem, biodiversity? slight/medium/serious* [5]

(ii) economics, e.g., through effects on aquaculture, tourism, industrial uses of water, etc.? (please indicate estimated annual cost in US$) US$ .... [5]

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[5] Please attach available information or submit list of information sources (in printed or electronic form).

* Delete as appropriate

APPENDIX VII

(5/5)

Questionnaire on Ballast Water Management

3 Have measures been taken, or are measures planned, to control further spreading, or to mitigate unwanted effects, of introduced species? Yes/No* [5]

D. Research and Education

1 Research conducted in your country concerning alien aquatic species, their mode of introduction, identification, ecological impact, and mitigation. [5]

2 Awareness programmes for seafarers, port authorities and for public information purposes. [5]

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APPENDIX VIII

(1/2)

Special Thanks

I am greatly indebted to all the experts, friends and members of my family who supported me during my stay at WMU. I apologize if I forget to mention any names due to the shortage of time and lack of memory.

To all mentioned below and those forgotten, thank you very much from the bottom of my heart.

May God bless you.

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BEN SMIDA Mouldi, Mr.
BLIX Arne Peder, Mr.
BOLGER Leah, Mrs.
BOND Margaret, Mrs.
BOUDABBOUS Brahim, Mr.
BOUZAIANE Nadia, Mrs.
BOUZGUENDA Amjed, Mr.
BRATHAUG Henning, Mr.
CHRIGUI Jamel, Mr.
ELLIOTT Jenny, Mrs.
ERIKSSON Per, Mr.
EMANUELSSON Bengt, Mr.
GRÅBERG Johan Mr.
GUILLOT Monique Mrs.
HALLOY-STASSIN Chantal, Mrs.
HALLOY Fabienne, Ms.
JÖNSSON Jan-Åke, Mr.
KAYAL Diana, Ms.
KORHONEN Pekka, Mr.
KRAIEM Moflah, Mr.
MAGHRAOUI Béatrice, Mrs.
O'NEILL William, Mr.
PERSSON Göran, Mr.
RAAYMAKERS Steve, Mr.

APPENDIX VIII

(2/2)

Special Thanks

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WILEY Chris, Mr.
WAGNER Bertil, Mr.
WORT Sharon, Mrs.