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Ballast Water Management and Control: An Overview

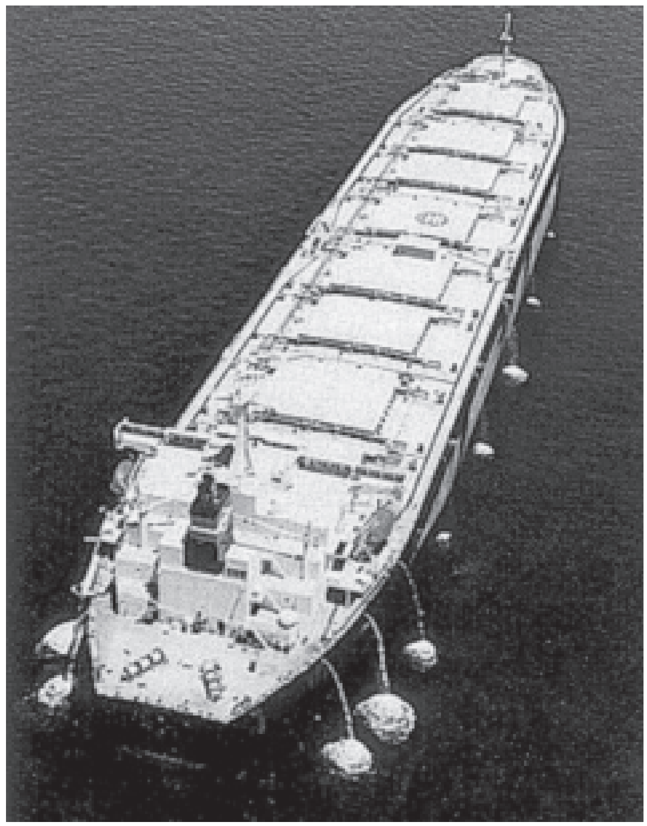
History and Background

Since the introduction of steel hulled vessels around 120 years ago, water has been used as ballast to stabilize vessels at sea. The amount of ballast carried on board ranges from several hundred liters to more than 100,000 tons, depending on the size and purpose of the vessel. Global shipping transports over 80 percent (IMO, 1997) of the world's commodities and in the process, transfers around 10 billion tons of ballast water across regions each year (IMO, 1997).

Ballast water is pumped-in to maintain safe operating conditions throughout a voyage. This practice reduces stress on the hull, provides transverse stability, improves propulsion and maneuverability, and compensates for weight lost due to fuel and water consumption. Since all ships are designed for a certain weight range, ballast is used to compensate for unloaded cargo.

Tankers and bulk-carriers are the largest vessels existing in the industry. They normally transport goods on the outward voyage and use ballast when they return. They then pump-out ballast water when they load cargo for the next voyage. Modern ships have several small ballast tanks, which allows flexibility in handling liquids onboard and ensures better stability and structural strength. In the case of bulk-carriers and older tankers (which have a few large tanks), a significant portion of their ballast water is carried in empty cargo holds.

Ballast water may contain suspended matter, such as sediment particles and organic debris. These may form layers in ballast tanks and cargo holds. The internal structure of a ballast tank is extremely complex and allows many locations for sediments to become trapped, accumulating during the voyage. In some cases, depending on the quality of water in the port of origin, sediment accumulation in ballast tanks may become severe.



Ship discharging ballast water.

Source: Steve Raaymakers.

The Problem

While ballast water is essential for safe and efficient modern shipping operations, it may pose serious ecological, economic and health threats. There are literally thousands of marine species carried in ships' ballast water. These include bacteria and other microbes, small invertebrates, eggs, cysts and larvae of various species. In some cases, healthy, living fish have been found in ballast tanks.

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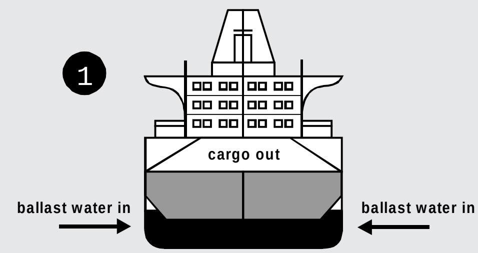
The introduction of invasive marine species into new environments by ships’ ballast water, attached to ships’ hulls and via other vectors has been identified as one of the four greatest threats to the world’s oceans. The other three are land-based sources of marine pollution, overexploitation of living marine resources and physical alteration/destruction of marine habitat.

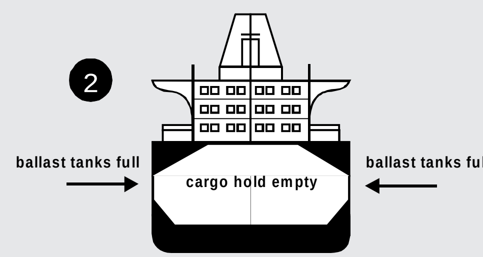
It is estimated that 4,500 different species are carried around the world at any one time in ballast tanks. The development of larger and faster ships, combined with rapidly increasing world trade, reduced natural barriers to the dispersal of species. Greater quantities are carried more quickly and frequently to a greater number of destinations. It is believed that a marine species invades a new environment somewhere in the world every nine weeks. Many species can be transferred in ballast water because virtually all marine species have a planktonic stage in their lifecycle. This means that while it is highly unlikely that an adult prawn, clam or shellfish will pass through in-take filters, their planktonic eggs or larvae could easily get through.

During the last three decades, a significant number of introduced, non-indigenous species have been transported through ships’ ballast tanks. As a result, whole ecosystems are being changed. In some cases, the economic impacts have been devastating. It is even feared that killer diseases such as cholera could be transported in ballast water. During the 1991 South American cholera epidemic, the bacterium that causes the disease was discovered in oysters and fish as far away as Mobile, Alabama. The US Food and Drug Administration then sampled the ballast water of 19 ships arriving in the Gulf of Mexico from Latin America. It found the South American epidemic strain of cholera in five of them. Some medical researchers believe that the strain that caused the epidemic was originally transported from Asia to South America through ballast tanks. The South American

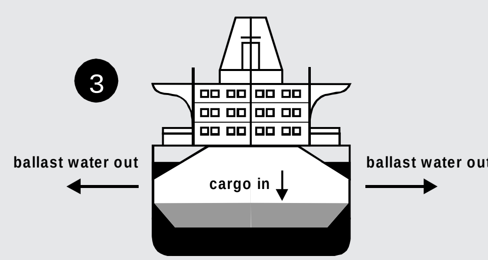
Figure 1.
Cross-section of ships showing ballast tanks and ballast water cycle.



1. At source port, unloading cargo, filling with ballast water (ballasting).



2. Voyage, empty of cargo, full of ballast water.



3. At destination on port, loading cargo, discharging ballast water (deballasting).

Source: GloBallast Project Coordinating Unit.

Don't let looks deceive you. The North Pacific Seastar may cause extensive destruction along Australia's coastal areas.

Source: Commonwealth Scientific and Industrial Research Organisation (CSIRO). (Used with permission)

epidemic resulted in over a million reported cases of cholera and over 10,000 deaths (Cohen, 1999).

There have been hundreds or perhaps thousands of introductions through ballast water. The following cases are only a few examples, and have been selected due to their severe environmental, economic and human health impacts.

North Pacific Seastar *(Asterias amurensis)*

This starfish was introduced to Australia in ballast water coming from Japan in the 1980s. It has no natural predators or competitors in Australia, which allows the population to multiply and spread rapidly, altering the native ecology. The Seastar is a voracious predator and consumes large quantities of native shellfish including oysters, mussels and scallops. It poses a potential threat to the commercial shellfish industry.

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European Zebra Mussel *(Dreisseina polymorpha)*

The Zebra Mussel is a small bivalve shellfish, which was introduced into the North American Great Lakes through ballast water from Europe in the 1980s. As an encrusting species, it grows in large colonies attached to hard surfaces such as rocks, wharves, pylons and within industrial cooling water intake pipes along the shores of the Great Lakes. The lack of predators facilitated rapid multiplication and dispersal. It currently infests over 40 percent of US inland waterways. It is estimated that since 1989, more than US$ 5 billion has been spent cleaning fouled waterways and structures.

Comb Jellyfish *(Mnemiopsis leidyi)*

The ctenophore was introduced to the Black Sea in the late 1970s through ballast water coming from North America. At times, it has reached densities of one kilogram of biomass per square kilometer throughout the entire infested area. The Comb Jelly consumes plankton through filter feeding. Their vast numbers in the Black Sea caused massive reductions of plankton in the 1980s and 1990s, which led to the collapse of the anchovy and sprat fisheries in the region. It is estimated that commercial losses amount to US $500 million per year, excluding the social problems suffered by traditional fisherfolk. The invasion of *Mnemiopsis leidyi* has changed the ecology of the Black Sea, compounding other impacts such as pollution.

The ctenophore has also been spotted recently in the neighboring Caspian Sea, where economic effects could be even more devastating due to the sensitivity of the local environment.

South East Asian dinoflagellates *(Gymnodinium and Alexandrium)*

This is probably one of the most notorious examples of harmful aquatic organisms introduced through ballast water in the Asia-Pacific region. The dinoflagellates are microscopic algae which spend a large part of their lives cocooned as extremely tough cysts in seabed sediments. When environmental conditions are favorable, the cysts may produce a motile planktonic organism which is released into the water column. The organism then reproduces in great numbers and may form into so-called "red tide." These planktonic algae contain paralytic toxins, which may be absorbed by filter feeding shellfish such as oysters, mussels, scallops and clams. When humans eat these contaminated shellfish, paralysis or even death may result. Toxic dinoflagellates may be transferred when ballast water is taken during a "red tide" bloom. The cysts may also be taken and transferred from sediments.

A number of countries have suffered from this introduction. In Australia, the commercial oyster industry had to be closed down. Expensive testing and monitoring activities are now being carried out on a permanent basis.

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The Global Response

During the last 10 years, the transfer of alien invasive species in ships' ballast water has received increasing attention. In 1991, the Marine Environment Protection Committee (MEPC) of the IMO adopted the Guidelines for Preventing the Introduction of Unwanted Organisms and Pathogens from Ships' Ballast Waters and Sediments Discharges. In 1992, the United Nations Conference on Environment and Development (UNCED) requested IMO to consider the adoption of appropriate, legally binding rules on ballast water discharges to prevent the spread of non-indigenous organisms.

The IMO member countries have developed voluntary guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens. These guidelines were adopted by the IMO Assembly in 1997, by resolution A.868(20). They replace earlier less comprehensive voluntary guidelines adopted in 1993. Management and control measures recommended by the guidelines include:

- Minimizing the uptake of organisms during ballasting, by avoiding areas in ports where outbreaks or populations of harmful organisms are known to occur, *e.g.*, in shallow waters and in the dark.

Enthusiastic volunteers standing on a skiff full of North Pacific starfish at Sullivan's Cove, Hobart, Australia during a clean-up drive.

Source: Center for Research on Introduced Marine Pests. (Used with permission)

- Cleaning ballast tanks and removing mud and sediments that accumulate on a regular basis.

- Exchanging ballast water at sea before arrival in port, replacing it with "clean" open ocean water. Any marine species taken on at the source port are unlikely to survive in the open ocean, where environmental conditions are different.

Significant research and development efforts are underway in a number of scientific and engineering research establishments around the world. These efforts aim to develop a more complete solution to the problem. Options considered include filtration and sterilization using ozone, ultra-violet light, heat treatment and chemicals.

Any control measure developed must meet a number of criteria, including:

- safety for the ship and its crew;

- environmental acceptability (not causing more environmental impacts than it can solve);

- practicability (compatible with ship design and operations);

- cost-effectiveness (economical); and

- biological effectiveness.

Recognizing the limitations of current IMO voluntary guidelines and the serious threats posed by invasive marine species, the IMO member countries are developing a mandatory international legal regime to regulate and control ballast water. The IMO's MEPC and its Ballast Water Working Group are well advanced in developing this regime.

The draft text of the proposed international convention for the control and management of the ships' ballast water and sediment recognizes the importance of regional cooperation in achieving the objectives of the convention. Its accompanying draft regulations provide, *inter alia*, criteria for establishing regional ballast water management areas.

During the last session of MEPC, the Working Group reviewed the consolidated text of the draft legal instrument and generally agreed with the principles contained therein. To facilitate the work needed to further develop the anticipated convention, the Committee has established a "Ballast Water Standards Correspondence Group," which will submit a report of its work and findings to the next MEPC in April 2002. All IMO member states were invited to contribute to the work of this correspondence group. It is hoped that the proposed convention will be agreed upon during a diplomatic conference in 2003.

GloBallast Programme

In addition to the aforementioned initiatives, the IMO has joined forces with the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), member governments and the shipping industry to assist less-industrialized countries to tackle the ballast water problem. The full title of this new programme is "Removal of Barriers to the Effective Implementation of Ballast Water Control and Management Measures in Developing Countries," or simply the "Global Ballast Water Management Programme" (GloBallast).

The programme assists developing countries in implementing effective measures to control the introduction of foreign marine species. Its six demonstration sites were chosen to represent the main developing regions of the world. A brief profile of the sites is provided below:

Dalian, China — East Asia

The Port of Dalian is located on the southern tip of Liaodong Peninsula in the Northeast coast of China. It faces the Bohai Sea in the west, the Yellow Sea in the east, and the Shandong Peninsula in the south.

About 5.5 million tons of ballast water was discharged in Dalian Port and its coastal waters in 1997. This ballast water came from ships visiting from Korea, Japan, Southeast Asia and to a lesser extent, from North America and Europe.

In 1993 and 1994, the prawn farming industry suffered severe losses due to an unknown bacterium or pathogen, and prawns died in great numbers causing a total loss of three billion yuan (around US$ 362,430,000 using the current exchange rate). While no direct correlation has been established between ship ballast water and losses to the fishing and prawn industry, the port is near the farming areas. The proximity of Dalian to valuable prawn farming areas is one of the reasons for its inclusion in the project.

During the second meeting of the Country Project Task Force held in January 2001 in Beijing, significant progress was noted in terms of institutional arrangements and planning. With the finalization of the National Workplan, implementation is ready to commence. A number of activities, including port baseline surveys and compliance monitoring, have been initiated and the IMO reporting form has been successfully adopted in four major ports.

The Chinese government is currently planning a 15-year project for the protection of the marine environment known as "Blue Bohai Sea." GloBallast shall provide information on its activities regarding risk assessment, port surveys and compliance, monitoring and enforcement.

Mumbai (Bombay), India - South Asia

The Port of Mumbai lies midway along the west coast of India. It possesses a deep harbor covering 400 square kilometers.

Many Indian vessels departing from Mumbai have been cleaning ballast water tanks in the high seas on a tank-by-tank basis for years. The reason for such

Figure 2.

GloBallast Water Management Programme

DEMONSTRATION SITES

1	Sepetiba	Brazil	South America
2	Dalian	China	East Asia
3	Mumbai	India	South Asia
4	Kharg Island	Iran	Middle East
5	Saldanha	South Africa	Africa
6	Odessa	Ukraine	Eastern Europe

Source: Globallast Project Coordinating Unit.

practice is that captains fear that mud and sediment mixed with ballast water would quickly settle and accumulate at the bottom of the tank. Such practice may, however, help reduce the possibility of introducing harmful organisms or pathogens, which live in shallow water or sediment. The Government encourages the practice of ballast water tank cleaning in the high seas and the Indian experience with this practice makes it an attractive participant for the GloBallast Programme.

Kharg Island, Iran – Middle East

Kharg Island is located on the Persian Gulf and is Iran's and the Gulf's largest port facility. The selection of Kharg Island as a demonstration site, aside from its location and importance, is due to the Gulf's sensitive environmental nature. Gulf waters are shallow, have substantial marine biodiversity, high water temperature, and experience little exchange of water with surrounding marine areas through the Ormuz Strait.

Port of Saldanha, South Africa – Africa

The Port of Saldanha is the largest port in the southern part of South Africa and covers 7,430 hectares of water area. It is the country's deepest port. Located in the southwest of the country facing the Atlantic Ocean, Saldanha Bay is considered to be a highly sensitive environmental area due to intensive aquaculture activities near the port. The surrounding area, meanwhile, has been declared officially as a "natural reservation."

Port of Odessa, Ukraine – Eastern Europe

Odessa is one of the largest ports in the Black Sea. Its location on historically founded merchant ways between West and East, closeness to Bosphorus and Dardanelles, convenient exit to Mediterranean Sea and Indian Ocean, year round navigation, and proximity to the big industrial and agricultural areas make it a particularly attractive, heavily used port.

The areas near the port are important nursery and feeding areas for Black Sea fisheries.

While exact information on the amount of ballast discharge in the port is not available, calculations from the oil products sector indicate large volumes. More than 14,400,000 tons of oil and oil products were transported through Odessa. It is calculated that a total quantity of 5,489,000 tons of ballast water were discharged into and around the port area.

A significant part of Ukrainian port traffic is oriented towards Europe (14 percent), China (6 percent) and the largest part represents the exchanges and transit with members of the Commonwealth of Independent States (42 percent). It may be, therefore, assumed that the largest amounts of ballast water discharged may originate from Europe and the Far East.

Sepetiba, Brazil - South America

The Port of Sepetiba is adjacent to Rio de Janeiro. Within 500 kilometers from the port, a concentration of industrial and commercial areas (producing 70 percent of Brazil's Gross Domestic Product) may be found. Sepetiba's coal and ore terminals have the capacity to handle 7,000,000 and 15,000,000 tons per year, respectively. The port was constructed in 1982 to meet the need of the Companhia Siderurgica Nacional and Valesul to move bulk cargo from their plants and thus, unburden the Port of Rio de Janeiro.

According to an evaluation of ports conducted by the Companio Docas do Rio de Janeiro, which acts as the Port Authority for Rio de Janeiro, Sepetiba, Angra dos Reis, Niteori and Fornu, Sepetiba will become Latin America's largest and the first Southern Atlantic Harbor to be a major cargo hub capable of handling over 20 million tons per year. Additionally, it is equipped with modern equipment and will accommodate the latest generation vessels up to 8,000 twenty-foot equivalent units (TEUs). Sepetiba is intended to be a model port highlighting concern for environmental management. The development of an Environmental Management Plan is a priority.

The efforts in these demonstration sites shall be replicated throughout each region. It is hoped that the project shall further catalyze the development of an international regulatory regime for ballast water through galvanizing action by IMO member states. More information on the GloBallast programme is provided in the website http://globallast.imo.org.

Conclusion

Unlike an oil spill, which can be cleaned up, the effects of marine species introduction are usually irreversible. The question "Which is the bigger threat?," however, has yet to be resolved. At the moment, opinions differ regarding this matter. But one thing remains certain: the transfer of unwanted organisms in ballast water may be the biggest challenge facing the global shipping industry this century. ▪

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