Limiting biological invasions of aquatic organisms

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Aquatic species colonize new habitats either by natural means (e.g. distribution by currents) or via human-mediated vectors (e.g. shipping and aquaculture). As far as northern Europe was concerned, the first invasion of non-indigenous species as a result of human activity might well have been that of the North American soft shell clam *Mya arenaria*, which was probably introduced with solid ballast as a result of Viking voyages to North America. The introduction of alien species outside their native distributional range is considered to be one of the most important anthropogenic threats to the biodiversity of the world's oceans, and has resulted in negative consequences for both ecology and economies. International forums have recognized this problem and regulations have been drafted accordingly. This article provides an overview of existing regulations relevant to biological invasions, with particular reference to Europe, and is directed to science policy makers, politicians, lawyers, science administrators and interested biologists; it is intended as a basis for discussion, and does not provide an interpretation of international law. As shipping and ballast water form one of the most important vectors of anthropogenically mediated biological invasions, I have concentrated on these, but for purposes of comparison, intentional species introductions for (say) aquaculture purposes are briefly included.

Negative impacts of biological invasions have frequently been reported from almost all of the world's seas and oceans. The total number of non-indigenous aquatic species in northern Europe was estimated in 1998 to exceed 100, including fish, algae, molluscs and crustaceans (cf. Figure 1), of which the majority were unintentionally introduced. Successful invaders tend to spread, and may change the natural environment by competing with native species or predating on them. As a result they may threaten the functioning of ecosystems, and affect public health and economic activities such as tourism, fishing and aquaculture.

Natives of China and Korea, mitten crabs reached German waters via ballast water, and are now found throughout Europe

Figure 1 *Chinese mitten crabs (*Eriocheir sinensis*) spread throughout northern Europe in the 1920s and 1930s. They spend most of the lives in freshwater environments, where their burrowing can cause serious erosion. They mate in tidal estuaries, where the eggs and young develop; juveniles actively migrate upstream towards freshwater systems.*

As mentioned above, a major cause of a unintentional introduction of species is release of ballast water. Species have been transported with ballast water and associated sediments ever since the 1870s when water began to be commonly used as ship's ballast, for stabilization and trim, and to submerge the propeller. Ships' ballast pumps usually have their intake opening below the water-line near the bottom of the ship. Aquatic organisms are pumped on board when ballast water is taken up, and are frequently transported across natural migration boundaries, i.e. between oceans, and across salinity barriers (e.g. between freshwater ports). Most organisms die in the ballast tanks during the first days of the voyage, but some individuals survive voyages of several months' duration. Upon arrival, the organisms are discharged along with the ballast water (Figure 2).

Organisms transported in ships' ballast include truly planktonic taxa and benthic species that have a larval form which is free-living in the water column. According to shipping studies, more than 1000 different taxa have been found in ballast tanks, ranging from fish to unicellular algae (including forms known to cause harmful algal blooms). The majority of these taxa are algae and

coastal invertebrates, such as crustaceans, gastropods and bivalves.

Unilateral voluntary recommendations and mandatory regulations aimed at minimizing the introduction of species via ballast water have been implemented in various regions throughout the world. New Zealand and Australia were the first countries to implement voluntary ballast-water guidelines in the late 1980s and early 1990s. Indeed, most regulations are of a voluntary nature and currently favour exchange of ballast water in the open ocean.*

Ballast-water exchange may be done by: (1) emptying and refilling the tank at least three times; (2) applying the overflow technique (Figure 3) where water is pumped into ballast tanks allowing an overflow on deck, until three times the volume of the tank has been pumped through; or (3) the dilution method, where extra pipe-work allows a continuous addition of water to the tank while the same amount of water is discharged, so that the water level in the ballast tank does not change. In contrast to the overflow method, the dilution method can be used for partially filled ballast tanks.

At present, only a few European countries recommend voluntary exchange of ballast water in mid-ocean areas.

Legal instruments

Internationally agreed legal instruments may be binding or non-binding. Binding instruments are usually mandatory agreements between States, such as treaties or conventions. Non-binding instruments ('soft-law') take the form of resolutions such as guidelines and action programmes.

The following international instruments relevant to the unintentional introduction of aquatic species are listed chronologically. The lists are not fully comprehensive, but provide an overview of current legislation.

Voluntary international instruments

Worldwide, there are a number of non-binding regulations and recommendations, and not surprisingly, their success depends on the extent to which the relevant authorities act on them. Some of these regulations do not refer to specific vectors such as ballast water, and these are covered first, followed by instruments that specifically address ballast water and other vectors.

Voluntary general instruments

As early as the 1970s, the International Council for the Exploration of the Sea (ICES) considered species invasions to be a problematic issue. It established the Working Group on Introductions and Transfers of Marine Organisms (WGITMO), which focusses on planned introductions (e.g. oysters for use in aquaculture) and unwanted imports of associated disease agents and parasites. In 1994–95, ICES developed a Code of Practice on the Introduction and Transfer of Marine Organisms. The

*Some countries (e.g. Argentina and Chile) require chemical treatment (chlorination) of ballast water when there are outbreaks of human pathogens (e.g. cholera) in the ballast-water uptake area.

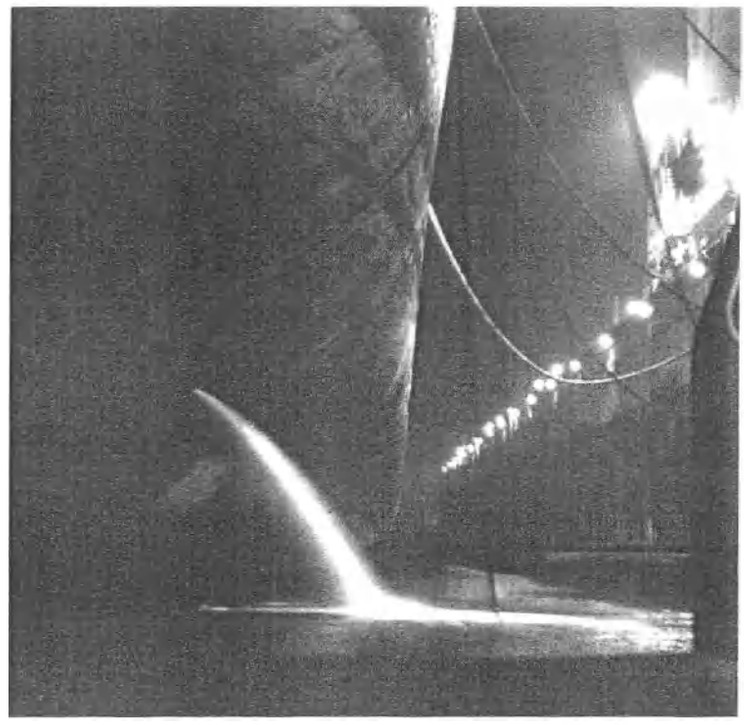

Figure 2 *Ballast-water release from an ocean-going merchant vessel, after dry-docking in the Port of Hamburg, Germany.*

When ballast water is released, so are organisms living in it

Code recommends the application of appropriate quarantine measures in donor and recipient countries to avoid the introduction of non-target species (e.g. disease agents and pathogens). An updated and revised version of the Code was published by ICES in 2003 on www.ices.dk. This Code includes all concerns expressed in the previous Code of Practice, follows the precautionary approach to minimize the spread of exotic species, and covers genetically modified organisms in greater detail than the earlier version.

In 2000, the Species Survival Commission (SSC) of the World Conservation Union* published guidelines for the prevention of biodiversity loss caused by alien species. These guidelines were intended to increase awareness of the problem and alert States to the fact that preventing the spread of alien species is a priority issue requiring national and international action. They aimed to minimize the number of unintentional introductions and prevent unauthorized introductions of alien species, and encouraged development, implementation and improvement of suitable eradication and control programmes. This would involve developing a comprehensive framework for national legislation and international cooperation to limit introduction of alien invasive species, as well as their eradication and control. The guidelines encouraged relevant research and development and sharing of an adequate knowledge base to address the problem of alien invasive species worldwide.

Voluntary ballast-water instruments

In 1973, the International Maritime Organization (IMO) – the United Nations body that deals with shipping issues – created the Marine Environment Protection Committee (MEPC). Australia was the first country to bring the ballast water

* Formerly the International Union for Conservation of Nature and Natural Resources, and still referred to as the IUCN.

problem into focus and in the early 1990s played a key role at the IMO in proposing the development of mechanisms to control the release of ballast water. MEPC formed the Ballast Water Working Group (BWWG) to evaluate information and consider solutions proposed by the Member States and by non-governmental organizations. The BWWG concluded that voluntary guidelines were the appropriate first step in addressing this problem. It recommended an exchange of ballast water in mid-ocean areas, as far as possible from any shoreline, in order to considerably reduce the number of organisms and taxa inside ballast tanks. Mid-ocean organisms, pumped onboard during the water exchange, are unlikely to survive coastal conditions.

As safety is of paramount importance it was stipulated that mid-ocean exchange of ballast water should only be undertaken at certain sea states and if cargo conditions permit. The MEPC adopted the guidelines by resolution in 1991, and in 1993 they were adopted by the IMO Assembly as a resolution entitled 'International Guidelines for *Preventing* the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships' Ballast Water and Sediment Discharges'. However, it was recognized that complete prevention of organism release cannot be achieved, and in 1997 this was replaced by Resolution A.868(20) 'Guidelines for the Control and Management of Ships' Ballast Water to *Minimize* the Transfer of Harmful Aquatic Organisms and Pathogens'. This resolution intends to 'assist Governments and appropriate authorities, ship masters, operators and owners, and port authorities, as well as other interested parties, in minimizing the risk of introducing harmful aquatic organisms and pathogens from ships' ballast water and associated sediments while protecting ships' safety.' In the resolution, the IMO proposed guidelines to limit the movement of organisms by ballast water world-wide. The guidelines recommended:

- informing ships of areas where ballast-water uptake should be avoided due to the presence of harmful algal blooms and known unwanted contaminants;
- precautionary procedures to be adopted when taking on ballast water in shallow areas;
- exchange of ballast water at sea as far as possible from the coast;
- ballasting with freshwater;
- discharging ballast water and sediments to onshore facilities (if available); and
- provision for ballast-water reporting forms.

The guidelines further recommend avoiding taking on ballast in shallow areas and at night when deep-living organisms may migrate towards the sea-surface and be more likely to be pumped onboard.

The BWWG at IMO has since developed a mandatory IMO Ballast Water Management Convention as a stand-alone instrument (see below).

The United Nations Conference on Environment and Development (UNCED), held at Rio de Janeiro (Brazil) in 1992, resulted in the *Convention on Biological Diversity* (see below), the Rio Declaration on Environment and Development, and Agenda 21. The Rio Declaration consists of 27 key principles providing guidance for future development of national and international legal decision-making, and actions aimed at achieving both socio-economic development and environmental protection. Among the 27 principles are: the Prevention Principle, the Precautionary Principle, and the Polluter-Pays Principle.

Regarding prevention, reduction and control of degradation of the marine environment as a result of sea-based activities, Agenda 21 calls upon all States to better implement and even strengthen existing conventions, and to support the work of the IMO (see above) and other agencies in developing international instruments to protect the marine environment from shipping-related pollution.

In the mid-1990s, the ICES/IOC (International Oceanographic Committee)/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV) was initiated. This group deals with unintentional species introductions via ships. Annual meetings update members on newly recorded ship-mediated biological invasions, and on impacts of invaders, and offers opportunities to initiate concerted international activity. The group further recommends appropriate actions to its parent committees (i.e. ICES, IOC and IMO).

The issue was tackled at the Fifth North Sea Conference held in Bergen (Norway) in 2002. The text of Article 42, agreed at the Conference, is given in the box opposite (top right).

The overflow technique is one way of exchanging ballast water in the open ocean

Figure 3 *Ballast-water exchange using the tank overflow technique, in which the tank is flushed out by pumping through three times its volume of seawater.*

Binding international agreements

The following instruments are not all strictly focussed on the marine environment, but the broader ones are included for completeness.

- The *RAMSAR Convention* (*Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971*) requires Contracting Parties to wherever possible address the environmental, economic and social impact of invasive species on wetlands within their jurisdictions. Contracting Parties are further urged to 'review existing legal and institutional measures and, where necessary, adopt legislation and programmes to prevent the introduction of new and environmentally dangerous alien species and the movement or trade of such species within their jurisdictions'.
- The *Bonn Convention for the Conservation of Migratory Species of Wild Animals* (1979) urges Contracting Parties 'to the extent feasible and appropriate, to prevent, reduce or control factors that are endangering or are likely to further endanger the [indigenous] species, including strictly controlling the introduction of, or controlling or eliminating, already introduced exotic species.'
- The *Bern Convention on the Conservation of European Wildlife and Natural Habitats* (1979) recommends 'each Contracting Party to strictly control the introduction of non-native species'. Parties should initiate regional cooperation to coordinate the control of invasive species.
- Chapter XII of the 1982 *UN Convention on the Law of the Sea* (UNCLOS) focusses on protection and preservation of the marine environment and requires that '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.'
- The 1992 *Convention on Biological Diversity* (*CBD*) is the first international agreement obligating States to conserve and use their biological resources sustainably. It states that 'each Contracting Party shall, as far as possible and as appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.' The jurisdictional scope of these obligations applies also to the biodiversity in neighbouring and other countries.

In 1995 the second meeting of the Conference of the Parties to the *CBD* was held in Jakarta (Indonesia). The *Jakarta Mandate on Conservation and Sustainable Use of Marine and Coastal Biological Diversity* includes living modified organisms resulting from modern biotechnology and recommends applying the precautionary approach.

- The OSPAR Convention (*Convention for the Protection of the Marine Environment of the North East Atlantic, 1992*), ratified 1998, states that decisions relating to international shipping, and the resulting spread of alien species, should be left to the IMO. However, the OSPAR Commission was requested to express its concerns to the IMO and to rely on decisions taken by IMO Member Parties to achieve appropriate responses.

Article 42 of the Fifth North Sea Conference (2002)

To prevent, reduce and mitigate adverse effects on the ecosystem and indigenous species from the introduction and transfer of non-indigenous species via ships' ballast water and sediments, the Ministers agree:

i) to actively support the development of the *International Convention for the Control and Management of Ships' Ballast Water and Sediments*, and work towards its finalization in 2003, and its rapid entry into force;

ii) to take coordinated action within IMO to establish adequate mitigation and control measures for the North Sea under the framework of the coming pre-said *IMO Convention*, and to support OSPAR's work on regional matters regarding ballast water;

iii) to take urgent coordinated steps to reduce the problem of spreading of non-indigenous invasive organisms to and within the North Sea in accordance with international law and in order to fully implement IMO Guidelines (Resolution A 868(20)), in the light of the forthcoming *International Convention for the Control and Management of Ships' Ballast Water and Sediments*, and decide upon national and/or regional measures by, if possible, the end of 2004, taking into account the progress within IMO. Such measures could, *inter alia*, include monitoring programmes, information exchange, early warning systems, combating actions, control and enforcement; and

iv) to enhance and support actively research on and the development of treatment technologies, decision support systems, and other issues related to preventing the spreading of non-indigenous organisms via ships' ballast water and sediments and to cooperate in those activities.

- The *Convention on the Law of Non-Navigational Uses of International Watercourses* (1997) is the basic document of international water law. Part 4 of the Convention, entitled 'Introduction of Alien or New Species', states:

> Watercourse States shall take all measures necessary to prevent the introduction of species, alien or new, into an international watercourse which may have effects detrimental to the ecosystem of the watercourse resulting in significant harm to other watercourse States.

- As mentioned earlier, the IMO BWWG has developed a stand-alone Ballast Water Management Convention (i.e. this new Convention is not annexed to an existing IMO Convention). Initially the MEPC was requested to develop legally binding provisions entitled 'Draft Regulations and Code for the Control and Management of Ships' Ballast Water and Sediments to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens' with the intention of creating a new Annex to MARPOL 73/78* – MARPOL provisions deal with pollution from ships, including oil, noxious liquid substances in bulk, harmful substances carried by sea in packages, sewage from ships, garbage and air emissions. Subsequently, however, it was decided not to regard ballast water as a pollutant for the purposes of MARPOL, and preparation of the stand-alone IMO Ballast Water Management Convention began.

The IMO Ballast Water Management Convention

The *International Convention for the Control and Management of Ships' Ballast Water and Sediments* was adopted at a Diplomatic Conference at IMO Headquarters, London, on 13 February, 2004. The Diplomatic Conference was attended by representatives from 74 IMO Member States,

*MARPOL 73/78 = *The International (IMO) Convention for the Prevention of Pollution from Ships, 1973*, as modified by the relevant Protocol of 1978.

one Associated Member, and two observers from intergovernmental organizations (IGOs), as well as representatives from 18 non-governmental organizations (NGOs).

The Convention includes many elements that are also present in the relevant IMO Resolution A.868(20) mentioned above. In addition, it aims for standard guidelines on ballast-water management and includes provisions for technical solutions to the problem, and the possibility of port entry requirements or coastal state prescriptions. In this context, ballast-water management includes water exchange, treatment and discharge to (land-based) reception facilities.

In the case of ballast-water exchange in mid-ocean, the Convention adds to the requirements outlined in IMO Resolution A.868(20) by requiring a minimum water depth of 200 metres and a distance of at least 200 nautical miles (n.m.) from the nearest land. Ships that cannot meet these requirements need to exchange the water as far as possible from the nearest land (at a distance of at least 50 n.m.) in a minimum water depth of 200m. The concept of regional implementation further includes ballast-water discharge control areas and ballast-water uptake/exchange areas.

Most IMO Member States agreed that it is preferrable to have a universal global approach in shipping regulation. However, it was recognized that for certain areas, regional implementations according to international law may be necessary to adequately address particular circumstances. Nevertheless, variations in the implementation of international regulations, or unilateral legislation on a geographical scale smaller than that of the North East Atlantic region, could create extra problems and would therefore not be beneficial.

For regions like the north-east Atlantic, cooperation between States is essential. Article 13 of the the Convention ('Technical Assistance, Cooperation, and Regional Cooperation') states that:

> ... Parties with common interest to protect the environment, human health, property and resources in a given geographical area, in particular, those Parties bordering enclosed or semi-enclosed seas, shall endeavour, taking into account characteristic regional features, to enhance regional co-operation, including through the conclusion of regional agreements consistent with this Convention. Parties shall seek to co-operate with the Parties to regional agreements to develop harmonized procedures.

Special Considerations for Regional Seas

Scientific studies have shown that in shallower regional seas (e.g. shelf seas such as the North Sea) ballast-water exchange is not an effective way of removing organisms. As a result, the number of organisms in ballast water is relatively high and trials have shown that there may even be more organisms inside ballast tanks after an exchange of water than before. Consequently, ships calling at (say) North Sea ports may need to exchange their ballast water in deeper regions such as the open Atlantic, or apply alternative ballast-water management techniques.

Inner-European and domestic shipping within the North Sea cannot employ ballast-water exchange measures according to the IMO regulations, as either water depth or distance from shore would not meet the requirements. Also, it is stated in the IMO Convention that ships shall not be required to delay or deviate from their intended voyage in order to comply with any particular requirement for ballast-water exchange. As a result, most European coastal shipping would be excluded from ballast-water exchange requirements, mainly for practical reasons. However the risk of introducing species persists. It is therefore recommended that ballast water is discharged to reception facilities, or is required to be treated prior to release in European waters; alternatively, European ballast-water exchange zones need to be identified.

Treatment of ballast water involves using mechanical, physical or chemical processes to extract, inactivate or otherwise render harmless, ballast-water organisms during, or prior to, release of the water. Treatment measures need to be proven environmentally sound, to ensure that they do not cause more problems than they solve. This is especially true for chemical treatment where ballast water may need to be decontaminated prior to release.

Two basic ways are being considered for identifying ballast-water exchange zones. One is to identify areas where ballast-water operations (exchange of water, discharge of water) are permitted; the other is to define areas where ballast-water operations are prohibited. Either way, regional agreements are essential.

It is questionable whether exchange zones for ballast water can easily be identified in northern Europe, as most European waters are shallow-water bodies (e.g. the North Sea). However, it may be feasible to establish ballast-water exchange zones in the open Atlantic off western Europe. Ships from overseas (and the Mediterranean) intending to discharge ballast water originating outside northern Europe could be asked to carry out a water exchange in these zones. However, short regional voyages will have to be addressed separately. One might assume that short-distance or domestic traffic would not promote species introductions as the organisms in question would spread by natural means anyway. This is certainly the case for many marine organisms, but certain short-distance shipping routes should not be excluded from any ballast-water requirement: ballast water moved between freshwater ports in Europe (e.g. St Petersburg to Hamburg) would allow freshwater species to spread. In these cases, ballast-water treatment may be an appropriate approach to reduce the risk of species invasions.

The text in Section C of the IMO Ballast Water Management Convention includes provision for additional measures in case parties wish to add to the basic requirements of the Convention. It clearly states that affected neighbouring countries should be consulted, indicating the need for a regional approach. It further recommends the implementation of 'early warning systems' to notify mariners of areas where ballast-water operations should be avoided.

The Convention further states that all ballast-water management areas should be consistent with international law, i.e. with UNCLOS: 'Any additional measures adopted by a Party or Parties

shall not compromise the safety and security of the ship and in any circumstances not conflict with any other convention with which the ship must comply.' The establishment of ballast-water management zones would not limit the rights and duties of a government under international law, nor the legal regimes of straits used for international shipping.

Particular Sensitive Sea Areas (PSSAs)

PSSAs are unique marine habitats which have to conform to certain IMO requirements. Initially, this environmental protection initiative focussed on the prohibition against discharging oil-contaminated water. However, its extension to protect PSSAs from ballast-water discharges has not been discussed at IMO.

The Wadden Sea, located in the south-eastern North Sea, off the coasts of Denmark, Germany and the Netherlands, is an example of a unique marine habitat. It is one of the world's most important tidal wetlands and is characterized by high biological productivity and high natural dynamics. With various resource-users (e.g. fishing, shipping and tourism) there is potential for conflict of human interests and a need for conservation of nature. To protect and conserve the environment of the Wadden Sea, the trilateral Wadden Sea Plan, involving cooperation between Denmark, Germany and the Netherlands, was adopted in 1997. Additionally, parts of the area are identified as Wetlands of International Importance (Ramsar Areas), as Bird and Habitat Directives areas, and as Man and Biosphere Reserves. Furthermore, the progress report of the 5th International Conference on Protection of the North Sea (Bergen, 2002) identified 60 Sites of Community Importance (SCI) for protection in the North Sea. These sites are mostly located in coastal regions and cover about 900 000 hectares.

A proposal to identify the Wadden Sea as an IMO-approved PSSA was submitted during MEPC48 and adopted at MEPC49 in 2003. After that, the north-western European seas as a whole (with the exception of the Baltic) were proposed, with the approval of the IMO. Then all countries with a Baltic coastline (except those under Russian jurisdiction) prepared a joint proposal to classify the Baltic as a PSSA. At the most recent meeting of MEPC (MEPC51 in March/April 2004) several new PSSAs were adopted, including the Baltic – one of the very few brackish seas in the world.

Measures to protect PSSAs may include: identification of certain areas to be avoided by tankers or other ships carrying hazardous cargoes; traffic separation schemes; no-anchoring areas; mandatory piloting requirements; and vessel traffic-management services. The IMO will adopt individual measures to protect particular PSSAs at upcoming meeings of MEPC.

Recommendations

Biological invasions are of global concern. Although a global uniform and mandatory ballast-water regulation is a desirable tool it should be noted that in certain areas, including regional seas, additional measures might be necessary to protect the environment from future species introductions with ballast water. Nevertheless, limiting biological invasions could become 'Mission Possible' if certain actions are taken. These include:

- **A Europe-wide awareness campaign**
The campaign should cover the problems caused and the risks posed to the environment and economies, and should be addressed to all relevant stakeholders. It should promote the development and implementation of relevant regulations.
- **Regional agreements**
These could promote a more comprehensive strategy in policy-making and in designing scientific and technical studies to focus on minimizing unintentional introductions into European waters.
- **A European 'Non-Native Species Council'**
Based on the model of the US National Invasive Species Council, this body could: facilitate research and avoid duplication of research efforts; assign responsibilities to appropriate bodies on a national and international basis and promote their cooperation; provide technical and scientific advice to governments; and aid the decision-making process. The European coordinating body could include representatives of European governments and universities and ministerial departments concerned with legal aspects and relevant scientific research.
- **A 'Ballast Water Tax'**
Funds gathered by the tax could be used to finance ballast-water research, in particular to improve ballast-water treatment systems with a view to further reducing the number of organisms being discharged. (The tax would be levied on the basis of the volume of ballast water discharged, but might be extremely difficult to calculate.)

Outlook

Much work needs to be done, and implementation of the IMO Ballast Water Management Convention is critical. Significant outstanding issues include:

- approval of guidelines for ballast-water treatment systems (and guidelines for prototype-testing);
- guidelines for sampling to assess whether a vessel is in violation of the Convention (Port State control);
- a procedure to approve active ballast-water treatment substances (e.g. chemical treament);
- design, construction standards and operational guidelines for ballast-water exchange;
- ballast-water and sediment reception facilities;
- risk assessment;
- designation of ballast-water exchange areas.

A review of ballast-water management technologies, and how effective they are at removing, inactivating or rendering harmless organisms in ballast water, will be carried out by MEPC before 1 January 2006. Governments are requested to consider developing appropriate working groups to ensure implementation of the Convention as soon after ratification as possible, to protect our waters from biological invasions and their unwanted ecological and economic impacts.

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