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Alien Flotillas: The Expansion of Invasive Species Through Ship Ballast Water

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Alien or exotic species - organisms that are foreign to a location or ecosystem - have migrated from their native habitats for hundreds of years. However, because of globalization and technological advances, goods and people now move at a much faster rate and to far more distant locations than in earlier times. As a direct or indirect result of human activities, plants, animals and other organisms are transported to new habitats with a speed and efficiency that thousands of years of evolution have not facilitated (IMO 2006a). Alien species are not necessarily harmful; intentionally introduced non-indigenous species have proven to be beneficial to the world's agricultural and livestock industries. Crops such as potatoes, wheat, rye, rice, corn, soybeans and peanuts were spread throughout the world to feed its growing population. Similarly, animals such as cows, chickens, ducks, horses, sheep, goats and buffalo were dispersed to provide the world's meat, milk and egg products (Pimentel 2002: 3-4).

There are, however, alien species that can be "invasive." These organisms pose a serious threat to existing ecosystems if the natural predators of an introduced species are not present to control the population. Invasive species thrive in their new environment, competing with the habitat's naturally-occurring species, and may replace keystone species or potentially cause the decline or extinction of one or more indigenous species, severely disrupting the ecosystem (CBD 2001a: 5; Boudouresque and Verlaque 2002: 34; Clout and De Poorter 2005: 523). The impact of introducing alien species can be particularly severe for endangered biota; consequences of invasive species introductions are considered either partially or directly responsible for the placement of 35-46 percent of the species on the endangered species list (Jewell 2000: 2). Currently, alien invasive species are the second greatest cause of biodiversity loss, behind human population growth and its related activities (Pimentel 2002: 4).

Additionally, invasive species are financially detrimental; it costs billions of dollars worldwide to prevent, control and eradicate these organisms (McGee 2001: 146). The United States Environmental Protection Agency (EPA) estimates that invasive species are responsible annually for $100 billion in damages in the United States (U.S.) alone (Cangelosi 2002-2003: 69).

Alien invasive species can have catastrophic effects, threatening biodiversity and causing economic harm. The introduction of alien species often precipitates environmental repercussions which may well be irreversible. Their unpredictable expansion can interrupt or devastate plans for sustainable development in communities without the resources to combat them and may also decimate the local flora or fauna upon which local inhabitants depend. It has only been in the last two decades or so that the negative effects of alien invasive species have been recognized by the international community *(see Text Box 1)*. Their global expansion will continue to increase unless the pathways and mechanisms facilitating their spread are identified and adequate methods of combating them are implemented.

Ballast Water as a Mode of Introduction

The introduction of alien species to a new environment often occurs via "hitchhiking", the unintentional transport of species via airplanes, ships, trucks, packing materials and shipping containers (McGee 2001: 144). The ballast water of ships is one principal pathway of this type of introduction, a direct consequence of the rapid worldwide expansion of global trade and shipping (CBD 2001a: 7). Ballast is any material whose weight is utilized to balance or stabilize an object (IMO 2006a). A ship takes in water as ballast when its hold is empty for balance and stability and discharges it when it loads new cargo, maintaining equilibrium. It usually picks up ballast water at port, where water is shallow and living organisms, particularly larvae and eggs, abound. Under favorable conditions, these hitchhikers survive their migration to a new destination. When the water is discharged, these species have the potential to become invasive species in their new environment, although decades may pass before they expand and become invasive (Clout and De Poorter 2005: 523).

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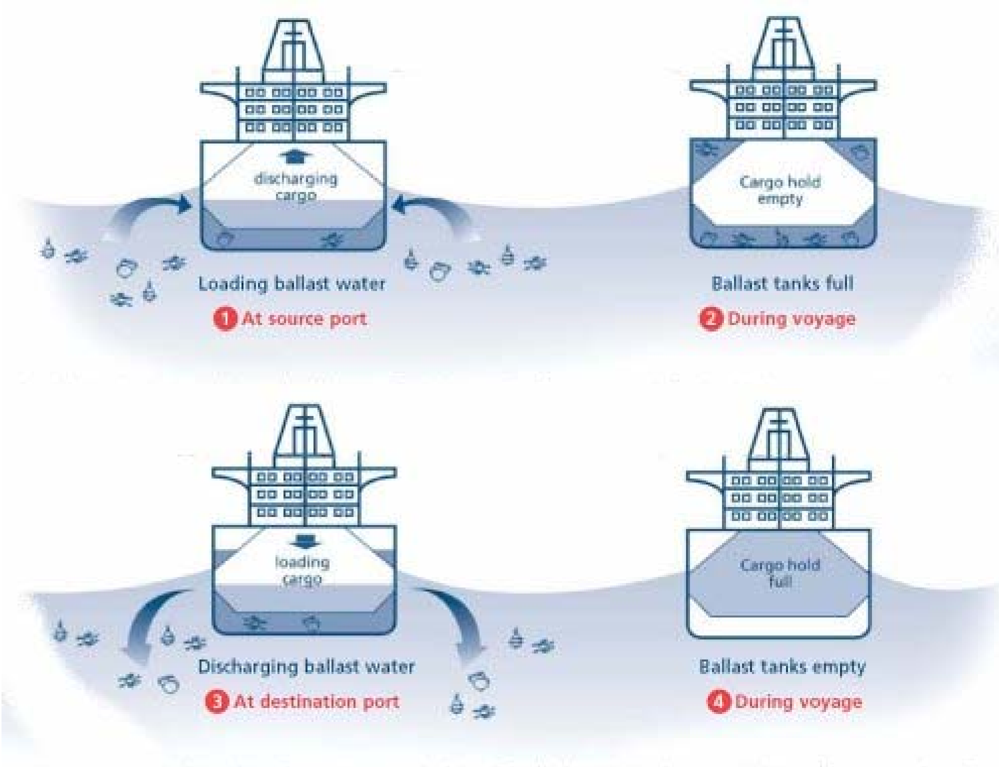

Figure 1. Cross section of a ship showing ballast tanks and ballast water cycle. Source: Global Ballast Water Management Programme (GloBallast), The International Maritime Organization. Online at http://globallast.imo.org/index.asp?page=problem.htm&menu=true.

The shipping industry is principally responsible for transporting goods internationally, overseeing the trans-shipment of an estimated 80 percent of the world's commodities (IMO 2006a). Shipping vessels transport approximately 10 billion tons of ballast water globally per year (IMO 1999). This traffic increases the potential for the accidental transfer of unwanted species; an estimated 3,000 species are transferred to new environments each day in ballast water (IMO 1999). The International Maritime Organization (IMO), a specialized United Nations agency entrusted with decreasing ship pollution and improving maritime safety (IMO 2006b), contends that the introduction of invasive species is one of the greatest threats to Earth's oceans, alongside marine pollution, overexploitation of marine resources and the physical alteration/destruction of marine habitats (IMO 2006a). The shipping industry and the ballast water of its vessels clearly play a critical role in the conservation or destruction of global ecosystems.

Illustrating the Urgency of Regulating Ballast Water: The Zebra Mussel and the Chinese Mitten Crab

Zebra mussels (Dreissena polymorpha), native to the Black, Caspian and Azov Seas, were introduced into the Great Lakes in the mid-1980s through the ballast water of vessels from Europe, and have subsequently become one of the most injurious invasive species to affect the U.S. (USGS 2006). In only two decades these mussels have spread from a handful of states adjacent to the Great Lakes to as far as Louisiana. They have even been found as far west as Washington; it is believed that zebra mussels traveled over land via the hulls of ships (USGS 2006). The map below *(Figure 2)* depicts the mussels' spread from the Great Lakes to the streams and estuaries of neighboring states and Canada.

Zebra mussels have altered the ecosystems of the Great Lakes by reducing phytoplankton, the foundation of the local food chain (McGee 2001: 145). They are particularly destructive to unionid mussels, a freshwater mussel native to the Great Lakes and a vital component of North American biodiversity (Drake and Bossenbroek 2004: 931). Zebra mussels compete with the indigenous unionid mussels for food and resources and also prevent unionid mussel reproduction by attaching to them (McGee 2001: 145). These impacts have caused an overall decline in unionid mussel abundance and North American biodiversity (Drake and Bossenbroek 2004: 931). Moreover, zebra mussels have negative economic impacts; they attach to and damage the hulls of ships, docks and other structures and clog water intake pipes and irrigation ditches (IMO 2006c). The introduction of zebra mussels has been referred to as the "poster child" of biological invasions (USGS 2006), producing some positive effects. It has served as impetus for U.S. action to combat alien invasive species and brought their destruction of biodiversity and ecosystems to the attention of the international community.

The zebra mussel is only one of many alien invasive species that have negatively affected global ecosystems. Although the zebra mussel features prominently on the IMO "Ten Most Wanted" list of invasive species transported via the

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ballast water of ships, another of the most wanted, the Chinese mitten crab, has had extremely negative impacts on biodiversity in Europe (IMO 2006c). The Chinese mitten crab (Eriocheir sinensis), originally a native of east Asia, has spread via the ballast water of ships to Continental Europe, the United Kingdom, and even to the U.S., where it has become a classic example of invasive species (Herborg et al. 2003: 21). Its negative impacts on biodiversity and local industry are many: interference with commercial fishing, soil erosion caused by burrowing or digging, and competition with indigenous fish and invertebrates (Herborg et al. 2003: 22). Additionally, the Chinese mitten crab directly harms fishing communities and livelihoods by damaging nets and catches (Normant et al. 2002: 124). Chinese mitten crabs are also the intermediate hosts for parasitic lung flukes, which can infect humans (Normant et al. 2002: 125).

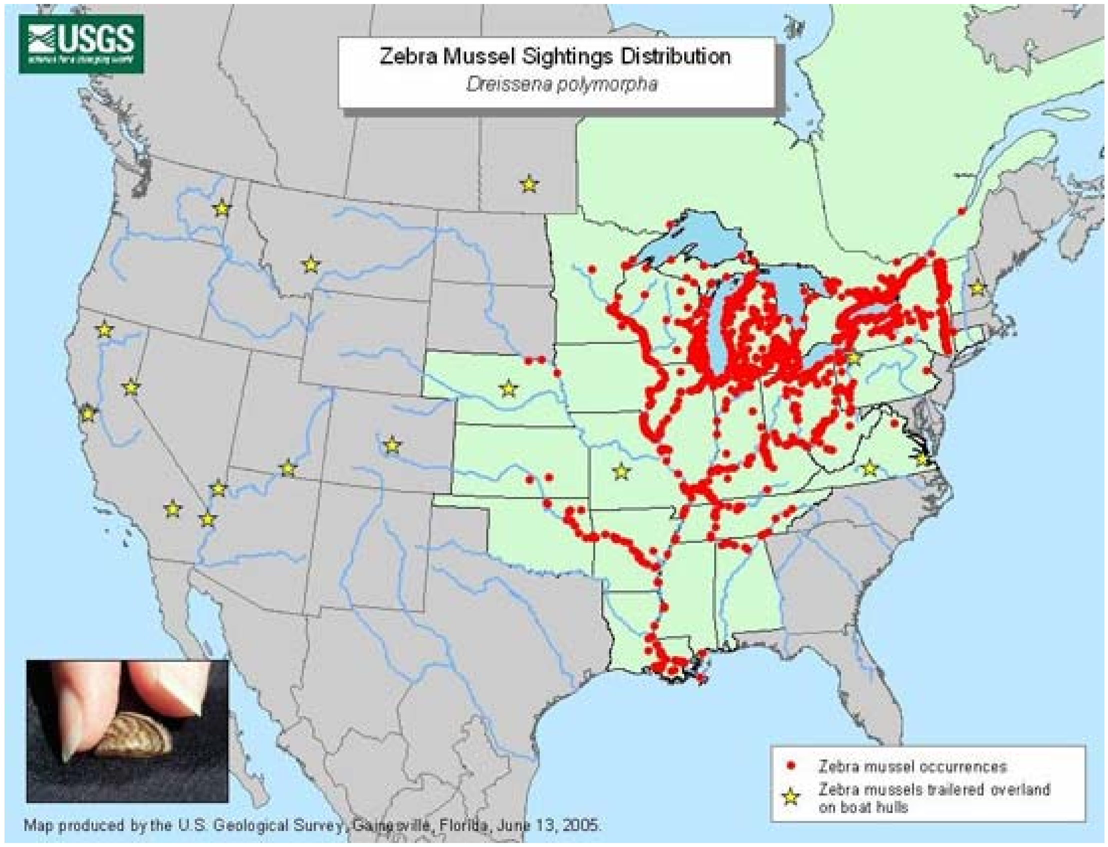

Figure 2. The distribution of zebra mussels in the United States in 2005. Source: USGS. Online at http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/maps/current_zm_map.jpg. An interactive map depicting the spread of zebra mussels in the U.S. over time is also available from the USGS.

Technological Efforts

Although the present technique of ballast water exchange is the safest and most efficient way to discharge a ship's ballast, it is not completely effective (U.S. House 2004). New technologies for handling ballast water are being developed *(see Table 1 below)*, including heat treatment, hydrocyclones, biodegradable chemicals and electrochemical control (INTERTANKO 2006). While these are all innovative, concerns persist about their effectiveness and economic cost.

The International Convention for the Control and Management of Ships' Ballast Water and Sediments

Over the past decade, the IMO has developed legislative mechanisms to further control the introduction of alien invasive species into coastal waters and elsewhere and to regulate species already introduced (BWC 2005). The work of the IMO with the international community has culminated in the "International Convention for the Control and Management of Ships' Ballast Water and Sediments" (BWC 2005; IMO 2006e), a multilateral, binding document to regulate ballast water and combat marine alien invasive species. The Convention will enter into force 12 months after 30 nations that represent greater than 35 percent of the world's shipping tonnage have ratified it (BWC 2005: Article 18). As of March 2006, there are six Contracting Parties that represent 0.62% of the world's shipping tonnage (IMO 2006f). They are Maldives, Saint Kitts and Nevis, Spain, Nigeria, Tuvalu and the Syrian Arab Republic (IMO 2006g). The IMO website indicates that as of July 2005, Argentina, Australia, Brazil, Finland and the Netherlands had signed but not ratified the Convention (IMO 2006b).

The Ballast Water Convention creates an integrated regimen for contracting parties to "give full and complete effect to the provisions of this Convention and the Annex"

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to prevent and eventually eradicate aquatic alien species. States must pass national legislation to implement the Convention's ballast water plan (BWC 2005: Article 4(2)) but are encouraged to take more stringent measures (BWC 2005: Article 2(3)). The Convention prescribes ballast water standards, dates of compliance, and ballast exchange procedures, and provides that the standards will be reviewed as technologies improve (BWC 2005: Annex Section B, D & E). These standards must be implemented in all vessels constructed after 2009 (BWC 2005: Regulation B3); vessels built prior to 2009 have until 2014-2016 to comply, depending on their size (BWC 2005: Regulation B3). Ballast water exchange must take place at 200 nautical miles and not any closer than 50 nautical miles from shore (BWC 2005: Regulation B4), minimizing the intake of species.

The new Convention ensures stability, consistency, clarity and uniformity. It fills the gap left by piecemeal domestic legislation *(see Text Box 1)* and removes conflict between the respective requirements of the States. However, technology has yet to catch up with the Convention's objectives (U.S. House 2004). If effective ballast water removal methods are not created, many States will be in violation of the Convention. Reliance on the development of new technologies may therefore render the Convention ineffective. Some even contend that the measures adopted by the Convention are not stringent enough to be protective (U.S. House 2004). In addition, the fixed dates are set far in advance, and Parties have a decade or more to achieve the standards. If the rate of transfer of aquatic invasive species continues to rapidly increase, the efforts of the Convention may be futile.

Conclusion

The world's biodiversity and ecosystems are vulnerable to acute disturbances. Alien invasive species can disrupt the food chain, with disastrous effects for sustainable development in affected communities. The establishment of the Ballast Water Convention is a promising collective step to combat incursions of alien invasive species. This document sets clear and consistent standards for the international community, and furthermore, provides aspirational goals. However, the Convention will be ineffectual if it never enters into force. Prevention is clearly the best course of action, but if these invasions cannot be completely prevented, the minimization of their impacts is imperative. International cooperation is imperative if alien invasive species are to be reduced or eradicated. The preservation of world ecosystems will safeguard their diversity and the lives of people who depend upon them.

About the author (June, 2006): Ms. MacPhee recently graduated with an M.S. degree in Global Affairs from New York University, with a concentration in International Law and a regional focus on Latin America. She also holds a B.A. degree from Franklin and Marshall College. An extended version of this article, which will analyze international legal and policy solutions to the problem of alien invasive species, will be published in the Journal of International Wildlife Law and Policy.

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Table 1. Technical methods used to reduce the transfer of harmful aquatic organisms. Source: Adapted from The International Association of Independent Tank Owners (INTERTANKO), "Environmental Issues: Ballast Ballast Water and Invasive Species." Online at http://www.intertanko.com/tankerfacts/environmental/ballast/ballast.htm. Last accessed: May 2006.

Method	Description
Ballast Water Exchange	This is deemed the most practical method at present and is recommended in most ballast w ater legislation. The tw o methods are the sequential method and the flow -through method.
1. Sequential Exchange	The ballast tanks are purged of their original ballast and refilled w ith different ballast w ater, w hich hopefully does not contain the unw anted aquatic organisms.
2. Flow Through Exchange	Water is pumped into the bottom of the ballast tank via the suction head and overflow w ater exits through the air pipes and access hatches. Flushing w ith three tank volumes in this w ay w ill displace approximately 95 percent of the original ballast w ater.
Freshwater Ballast	The use of freshw ater rather than seaw ater ballast could provide an inexpensive source of freshw ater for irrigation and industrial usage in several major oil-exporting countries. This method has received no further attention.
Heat Treatment	Australia has developed this method in w hich heated salt w ater from the main engine cooling circuit is rerouted to the ballast w ater tank. A full-scale test on a bulk carrier proved successful, but INTERTANKO is concerned about the damage that could be caused to ballast tank coatings by the heated w ater.
Filtration	The method utilizes a filter, placed over the ballast w ater pipe inlet, as a means of controlling organism transferal. During tests using different size filter meshes, the build-up of organisms and sediment on the filtration screen w as minimized by using a backw ash procedure, but ballasting is inevitably slow ed. A secondary treatment, such as the use of ultraviolet light or heat, w ill probably be necessary to eliminate unw anted organisms like bacteria and viruses. One benefit of filtration is that the amount of sediment taken onboard is reduced.
Hydrocyclones	A joint Norw egian/Canadian project uses hydrocyclones, (i.e., centrifugal separators), backed by a secondary ultraviolet light treatment. The former process eliminates the sediments, w hich are pumped out, w hile the latter kills the unw anted organism. Such systems, w hich w ould cost approximately US$2.5 million per ship, have been used onboard offshore installations for a number of years.
Biodegradable Chemicals	Germany is developing a biodegradable ballast w ater treatment chemical. Approximately 50 litres of the chemical, costing US$150, w ould be needed to treat 1,000 tonnes of ballast w ater.
Electrochemical Control	Japan is considering an electrochemical control concept in w hich low potential electric pow er is applied to ballast w ater flow ing through porous graphite electrodes in order to kill any micro-organisms present. Fullscale tests are planned.

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BOX 1

Alien Invasives: International and Domestic Legislation

Action by the international community has not kept pace with the spread of alien invasive species through ballast water, despite their often well-publicized threat to the world's ecosystems. One possible reason for the lack of proactive policies may be because the activities of these alien species typically occur in the world's waters, where they are not readily observed. It will take sustained international cooperation to address the issue of alien invasive species in an efficient and effective manner to prevent further damage to biodiversity and ecosystems.

At present, no comprehensive multilateral mechanism exists to combat alien invasive species. The most important measures to date enacted to protect biodiversity - the Convention on Biological Diversity (CBD) and the United Nations Convention on the Law of the Sea (UNCLOS) - are limited. The CBD stresses conservation, citing the "intrinsic value" of biodiversity (CBD 1993: Preamble). Article 8(h) of the CBD specifically calls upon parties to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" (CBD 1993). The CBD entered into force in 1993, and there are currently 188 States party to it, demonstrating the commitment of the international community to addressing issues of protecting and conserving biodiversity (CBD 2006). However, there are limitations to the convention. The U.S. is only a signatory, not a party, to the Convention, and therefore is not bound by its provisions. Furthermore, although the CBD is a binding document, it does not provide any mechanism for compliance or enforcement. It does, however, urge nations to financially assist those that lack implementation means (CBD 1993: Article 8(m)).

In an effort to address the limitations of the CBD, specifically Article 8(h), the CBD's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) created "Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species" (CBD 2001b). These principles were created so that the parties to the CBD would have guidelines to follow in implementing Article 8(h), but these principles are not binding and do not provide a standard to follow. They also fail to provide any language or terminology regarding a comprehensive and sustained solution to the problem of alien invasive species.

UNCLOS provides the most comprehensive document to date dealing with the prevention of marine pollution, including alien species. There are currently 149 parties to the Convention, which was initially drafted in 1982 and entered into force in 1994 (UN 2006). Article 196(1) provides that "States shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from…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 1994). However, it does not define specific policy recommendations or how these objectives should be achieved.

Domestic legislation governing shipping vessels could ultimately fill the gap between the identification of an international invasive species plan and its implementation on the ground, but is currently limited by disparate legislation in different countries. For instance, there are inconsistent regulations between international jurisdictions for the discharge of ballast water (IMO 2006d): the U.S. has a depth requirement of 2,000 meters, Australia 200 meters, and Israel has no depth requirement (Ciesla 2003: 113).

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