

**BALLAST WATER EXCHANGE IN THE NORTH ATLANTIC**

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# **Ballast Water Exchange in the North Atlantic**

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## Ballast Water Exchange in the North Atlantic

### *Introduction*

Ballast water has been identified as one of the major vectors that introduce marine and coastal organisms to new localities. Marine bioinvasions have caused ecosystem degradation (e.g. *Caulerpa taxifolia* in the Mediterranean) and economic loss (e.g. *Mnemiopsis leidyi* in the Black Sea). One study estimates that across all taxa, over \$127 billion is spent annually to control and manage invasive species (Pimentel et al. 2000). This amount underestimates the costs associated with marine introduced species. The number of scientific papers, books, and meetings on invasions sciences has increased over the past decade. The topics include marine bioinvasions research and management, ecological and economic impacts, patterns of distribution and dispersion, risk assessments, and vectors of introduction have (see e.g. Pederson, 2000, 2003) Human health may also be affected as microorganisms are spread by ballast water, including *Cholera vibrio* in temperate waters (Ruiz et al. 2000). Although there are several human-mediated vectors that may introduce new species, ballast water is a leading mechanism in the introduction of these species (Carlton 2001).

Ballast water is ubiquitous and unavoidable in the shipping industry. It is used for stability, to increase draft, alter trim, and optimize stress loads. Species enter ballast tanks through intake pumps or when ships "gravitate" water into holds. While grates may prevent pumping anything over a centimeter or two in diameter, nearly all marine taxa have a pelagic life stage, as resting stages, larvae, juveniles, or adults, which are small and easily pumped through the grate. Ballast water release and management are global issues that require international solutions. Currently the preferred option for reducing or preventing introductions from ballast discharge is to exchange ballast at sea, although new technologies to treat ballast water are being developed and tested throughout the world.

Various technologies are undergoing research, development, and testing to limit the number of species able to survive in ballast tanks. Examples include biocides (e.g. chlorine, ozone, osmium, and antifouling paints), mechanical removal (through filtration or centrifugation), physical destruction (by heat or UV radiation), and creation of azoic conditions (e.g., anoxia). Some treatments may target larger organisms such as plankton, juveniles or small adults, while others may be more effective against viruses and microbes. While few treatments have been thoroughly tested, there is a growing market for technological treatments, especially once performance standards are adopted (Pederson and Carlton 2002). One management option for ballast water exchange is the "complete" exchange of ballast water, at sea or in areas designated when at sea exchange is not possible.

This paper (1) reviews the current regulations and guidelines affecting ballast water exchange (BWE) and notes a few areas for future strengthening, (2) describes the risks to and concerns for the Gulf of St. Lawrence ecosystem, (3) summarizes vessel traffic and BWE in this region and in the Gulf of Maine, and (4) recommends coordination and cooperation to identify a regional ballast water approach for Canada and the U.S. that (a) examines the feasibility of alternate ballast exchange areas within the Exclusive

Economic Zone (EEZ) for the Northwest Atlantic, (b) supports continued data collection on ship traffic and ballast exchange, (c) continues support for research on risk assessment, and (d) supports development of alternative ballast water treatments.

### *Current Regulations and Guidelines*

The United States and Canada have each adopted regulations (U.S.) and guidelines (Canada) to limit introductions into the Great Lakes, Gulf of St. Lawrence, and other territorial waters, while providing for the safety of ships and their crew members. In addition to these efforts, the International Marine Organization (IMO), the International Association of Independent Tank Owners (INTERTANKO), and the Marine Environmental Protection Committee (MEPC) have initiated efforts to manage ballast. The international community supports voluntary guidelines and is proposing standards for ballast water discharge that will serve as the performance measures for new ballast water treatment technologies. The international community has developed model ballast water management plans and each vessel is to have one on board. In addition, several monitoring activities and pilot projects to manage ballast have been initiated. Nonetheless, the lack of regulations or enforceable practices at the international level has frustrated those concerned about the growing number of introductions.

The U.S. has passed regulations that require ballast water exchange before entering the Great Lakes and the Hudson River and several states have passed or are considering passage of regulations that require reporting and/or management of ballast water. Under the National Invasive Species Act of 1996 (NISA P.L. 104-332), the United States requires vessels traveling to the Great Lakes and the Hudson River to exchange ballast water, recommends that exchange take place outside the 200 mile limit of the EEZ, and mandates all (not just those entering the Great Lakes) affected vessels to complete and submit a Ballast Water Reporting Form to the United States Coast Guard (USCG). Vessels traveling along the coast are exempted from both reporting and exchange. In July 2004, the USCG adopted more stringent regulations that require all vessels, including coastal traffic, to complete ballast water forms and all vessels crossing the EEZ to exchange ballast water at sea.

Canada has adopted guidelines encouraging vessels to exchange outside the EEZ, preferably in waters deeper than 2000 meters. Yet these guidelines allow vessels bound for ports along the Great Lakes, domestic Canadian voyages, or ships facing adverse conditions, to use the Gulf of St. Lawrence, in areas deeper than 300 meters and southeast of 63° W longitude, as an alternative exchange zone (Canadian Guidelines 2002). The guidelines require sequential exchange to be discharged until suction is lost using stripping pumps or eductors, while flow-through exchange must pump a volume three times that of the tank. Canada is currently reviewing its regulations.

Guidelines put forth by the United States and Canada, without enforcement, do not prevent comprehensively the introduction of species via ballast water. Locke et al. (1993) found that while voluntary measures reduced the risk of introduction, they did not eliminate risk because some ships did not comply and because even those that did could introduce viable species into the Great Lakes (see also Carver and Mallet 2002; Gollasch et al. 1996; Gollasch 2002). Discharging ballast water does not completely empty tanks

of either water or sediment, so even vessels claiming no ballast on board (NOBOB) may carry organisms in various life stages. Vessels traveling only within the EEZ are exempt from reporting their ballast water management practices (Pederson and Carlton 2002). This gap in the record keeping does not recognize that an introduction may occur when a foreign vessel arrives, and either does not exchange or only partially exchanges water, continues with a domestic leg of the voyage, and then exchanges water from the foreign source in a secondary or even tertiary port of call. Essentially, this means that even with full compliance, only a fraction of ships will be required to exchange ballast water, and not all vessels must report their practices, leaving a variety of possibilities for potentially introducing organisms.

In the United States, there are low reporting rates in areas of mandatory reporting. Ruiz et al. (2001) found about 30% compliance with reporting for the east coast of the United States. With a national average of 33% reporting, it is impossible to reliably extrapolate ballast water management practices for ships entering the United States. In western portions of the United States, this is compounded with inaccurate or dishonest reporting practices by admission of those submitting the report (Harkless 2003). Thus, even with the high western region compliance rate of 66.5% (Ruiz et al. 2002), the accuracy of the reports in the National Ballast Information Clearinghouse (NBIC) is questionable and further complicates analysis. Reasons given for the violations were many: anonymity of report author, responding to what the USCG expects, and lack of enforcement was among these responses.

On July 30, 2003, a proposed rulemaking, Mandatory Ballast Water Management Program for U.S. Waters (33 CFR part 151) was announced in the Federal Register (a final version was adopted July 28, 2004). The USCG (now transferred to the Department of Homeland Security) under the authority of the National Invasive Species Act (1996) evaluated the effectiveness of the voluntary ballast water management. It also had the authority to develop additional regulations to make the voluntary program a mandatory program. Because voluntary compliance is so low, the USCG has proposed new regulations that would affect all vessels (including those traveling within the EEZ) with ballast tanks entering U.S. ports or waters (Department of Homeland Security, 2003; 33 CFR part 151). The proposed rules address several important issues. It affects all vessels with ballast water tanks – both those traveling coastwise and entering those entering the EEZ. It provides four alternatives for ballast water management, but recognizes that ballast water exchange is the most likely option. It strikes the depth requirements for areas appropriate for BWE because there is no consensus has been made correlating depth with adverse environmental effects. The proposed rules specifically do not require vessels to deviate from voyage routes or schedules to conduct BWE, and if a vessel cannot practically meet any of the four ballast management options, it may discharge the operational minimum in locations other than the Great Lakes and the Hudson River, and a record of such circumstances must be kept (Department of Homeland Security, 2003).

Canada has found significantly higher rates of compliance with ballast water guidelines. According to a study conducted by Transport Canada, Marine Safety, in the second half

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\* For the purposes of this paper, the term 'foreign' shall refer to the country in question. That is, foreign vessels arriving to Canada may originate anywhere outside Canada, including the United States, while foreign vessels arriving to the United States may originate anywhere outside the United States, including Canada.

of 2001 Canada had compliance rates between nearly 70% to over 80% (RNT Consulting 2002). In part, these high compliance rates are due to investigations through boarding ships, and enforcement of guidelines (Balaban, pers. comm. 2003).

### *The Gulf of Maine and the Mid-Atlantic Bight*

Both the Gulf of Maine and the Mid-Atlantic Bight are complex, highly dynamic areas that are driven by winds, tides, and buoyancy forcing. There are areas of upwelling and regions where coastal waves are trapped. Beeton et al. (1998) reviewed regions around the U.S. and examined them as potential back-up zones for ballast water exchange in the context of the physical oceanography of the region and potential to introduce marine organisms. Beeton et al. (1998) reviewed these areas based on the following criteria:

- Nearshore and inshore circulation that would impact shoreward transport of biota
- Wind stress, coastal buoyancy fluxes, tidal fronts, along coast currents, eddies, shingles and filaments, coastal-trapped waves, convergence and divergence, unpredictable flow reversals and other phenomena.
- The overarching criterion is the definition in the National Ballast Water Control Program as those “areas...if any, where exchange of ballast water does not pose a threat of infestation or spread of aquatic nuisance species in the Great Lakes and other waters of the United States.” (Beeton et al. 1998, p. 15).

### *Risks and Concerns for the St. Lawrence Environment*

The Estuary and Gulf of St. Lawrence (EGSL) that includes the Laurentian Channel was designated as an alternate ballast water exchange location for ships that were not able to exchange at sea before entering the Great Lakes (Figure 1). There is expressed concern that local environments are put at greater risk for introduction of species as a result of the increased use of this area, (especially the Laurentian Channel), as an alternate ballast water exchange zone. This area was and continues to be the focus of several scientific studies that examine ballast water composition and documentation of introduced species in the ballast released area (Harvey et al. 1999; Carver and Mallet 2002).

Risk assessments examine sources of ballast, the volume discharged, and the use of the EGSL for regular exchange compared with discharge elsewhere within or outside of the EEZ. Approximately 20% of traffic heading to the Gulf of St. Lawrence traverses warm waters (16-20°C) in the summer, and discharge ballast water into areas where summer temperatures of shallow areas fall within this range. Nearshore areas within the Laurentian Channel area provide a favorable environment for species originating from multiple sources, often further south. Moreover, a significant volume of ballast water, 11.5 million tons in 1995, is being discharged in the EGSL (Harvey et al. 1999). Ballast volumes are increasing along with ship capacities and ship size. Bourgeois et al. (2000) found that the ballast capacity bound for the EGSL in 1996 was twice that of 1978, including a listing of the number of source countries. Yet only 13% of ballast water discharged was determined to come from the previous port of call, resulting in unknown sources of ballast and decreasing the ability to predict specific invading species (Harvey



et al. 1999). Furthermore, Locke et al. (1991) found that not all ships that discharge in the alternate exchange zone come from U.S. ports or justify their usage by reporting extreme circumstances.

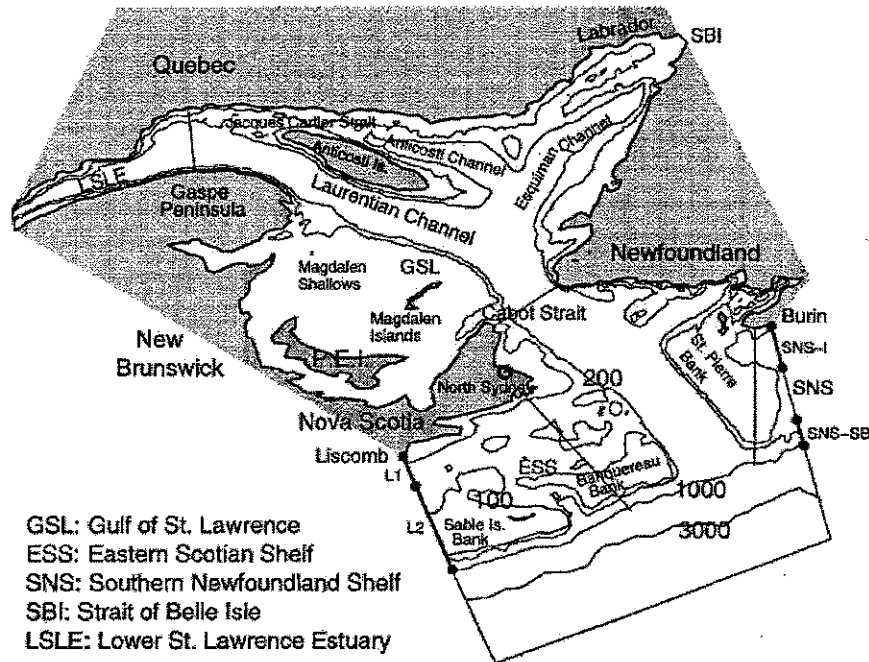


Figure 1: Map showing the study domain, bathymetry, and section locations; isobaths shown are 100, 200, 1000, and 3000 m. The Gaspé, Cabot Strait, Burin, and Banquereau sections are shown in solid lines. SNS-I and SNS-SB are the inner and shelf-break segments of the upstream SNS boundary. L1 and L2 are the inner and outer segments of the Liscomb line on the downstream ESS boundary (reprinted with permission from Han et al. 1999).

Various physical oceanographic features of the EGSL suggest that the region is significantly susceptible to introductions via ballast water exchange. Geographically, the area in question is small, and easily traversed in one day, while it may take two to three days to completely exchange ballast water. Currents within the region have been modeled with seasonal variability (see Figures 2a, 2b). The modeling studies demonstrate that EGSL currents carry particles, such as phytoplankton or zooplankton, towards coastal areas or trap them within the EGSL (Gilbert and Saucier 2000). This model identifies a few areas at particular risk at different times of the year, specifically Anticosti Island, the west coast of Newfoundland, Cape Breton, and Magdalen Islands (Gilbert and Saucier 2000). Suggestions have been made to move the alternate ballast water exchange zone eastward, beyond Magdalen Islands. Due to hydrology and current flow, released ballast water and the particles it might bring would still circulate and flow towards coasts (Han et al. 1999). This would effectively move the problem eastward, but not necessarily solve it.

Introductions of various species have indeed been found in the EGSL. A survey of ballast water discharged into the EGSL by 94 different ships showed that 60% of phytoplankton and 57% of zooplankton found were non-native (Harvey et al. 1999), although the zooplankton were not identified to species. Because identification was not to species, these values may be overestimates. A ballast water study conducted in 2000 for Transport Canada, Marine Safety analyzed ballast water discharged in three Nova Scotian ports and found 349 phytoplankton taxa and 75 microzooplankton organisms (excluding larger sized animals such as copepods). Of the total, 105 were classified as nonindigenous, five of which were classified as toxic non-indigenous phytoplankton, and were relatively rare. Another nine organisms were potentially harmful (Carver and Mallet 2002). Another survey reported significant health risks to the region in 1992, when it found 60% of the ballast water tanks surveyed at Magdalen Islands carried toxic algae in the ballast water (Gosselin et al. 1995). One model quantifying the risk of introducing species into the Gulf of St. Lawrence found that the greatest relative risks were in Area I, the river stretch of the St. Lawrence, and the Laurentian Channel (RNT Consulting 2002).

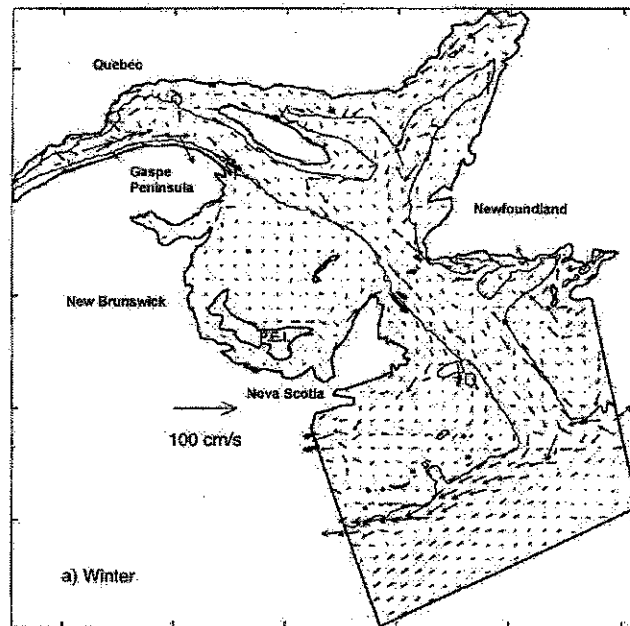


Figure 2a: Mean current (thin arrows) circulation for near-surface (averages between 5 and 30 m of the surface) waters within the Gulf of St. Lawrence region. Winter patterns are gathered from model solutions. Thick arrows represent observed near-surface (within 30 m of surface) currents (reprinted with permission and modified from Han et al. 1999).

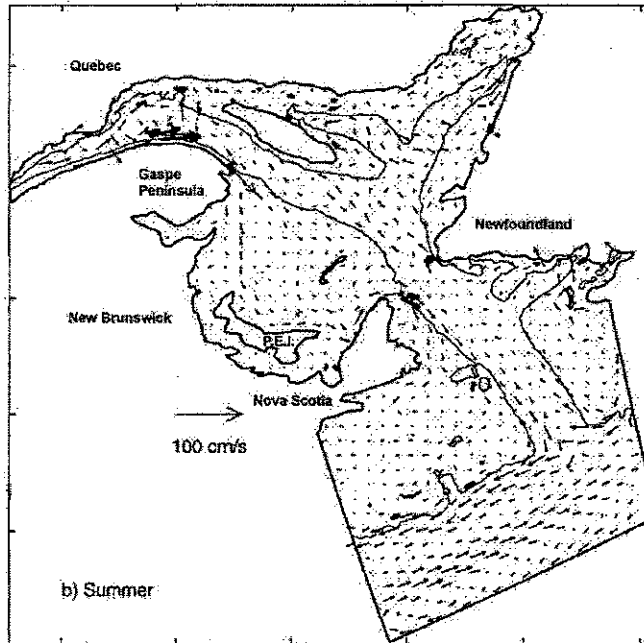


Figure 2b: Mean current (thin arrows) circulation for near-surface (averages between 5 and 30 m of the surface) waters within the Gulf of St. Lawrence region. Summer patterns are gathered from model solutions. Thick arrows represent observed near-surface (within 30 m of surface) currents (reprinted with permission and modified from Han et al. 1999).

### *Vessel Traffic and BWE in the Gulf of St. Lawrence and New England*

Understanding the patterns of shipping traffic is vital to more precisely determining the risks from and solutions to introductions via BWE. Canadian vessel traffic studies divided the Atlantic region into four geographic areas defined by the distribution of international ports, and they correlate roughly to oceanographic subdivisions. The boundaries are: Area I - Bay of Fundy and southwest Nova Scotia (with Yarmouth as its eastward limit); Area II - Nova Scotia and Cape Breton Island; Area III - Prince Edward Island, the Gulf of St. Lawrence side of New Brunswick and Quebec, the Saint Lawrence Basin, and the Great Lakes; and Area IV - the east and west coasts of Newfoundland (Balaban 2001). For the United States, data are from the National Ballast Information Clearinghouse (NBIC, housed within the Smithsonian Environmental Research Center), which organizes data by state and then port.

In 2000, as Figure 3 depicts, 3,386 vessels arrived from foreign ports and visited 35 ports within Atlantic Canada. 47% of these foreign vessels were bound for ports within Area II, primarily in Halifax Harbour, while 37% entered Area I, bound mostly for Saint John, Yarmouth, and Hantsport (Balaban 2001). Figure 3 also shows that fewer ships were in ballast than carrying cargo for both Areas I and II. While the proportion of vessels in ballast was higher for ports with fewer vessels entering, the actual number was smaller. For example, while Saint John (n=534) had 49% in ballast and Hantsport (n=119) had 100% in ballast, Halifax-Dartmouth (n=1215) had 13% in ballast and Yarmouth (n=341) had 0% in ballast (Balaban 2001). This held true for small ports as well. Liverpool, NS (n=12) in Area I had 83% in ballast, Little Narrows, NS (n=33) in Area II had 100%



the northeast Atlantic contributed 13.5% of the total traffic. Note that for all areas, more traffic originated in Western Europe than in Northern Europe.

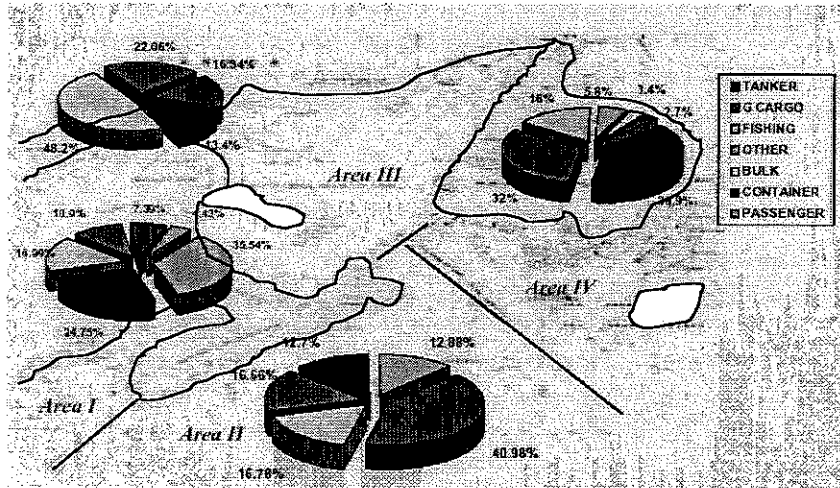


Figure 4: Breakdown of vessel types, in percentage of the number of vessels bound for Areas I – IV in the Atlantic Region of Canada. Data source: ECAREG –VTS data (Balaban 2001). Area I is the Laurentian Channel; Area II is Nova Scotia and Cape Breton Island; Area III is Prince Edward Island, the Gulf of Saint Lawrence side of New Brunswick and Quebec, the Saint Lawrence Basin and the Great Lakes; Area IV is the east and west coasts of Newfoundland.

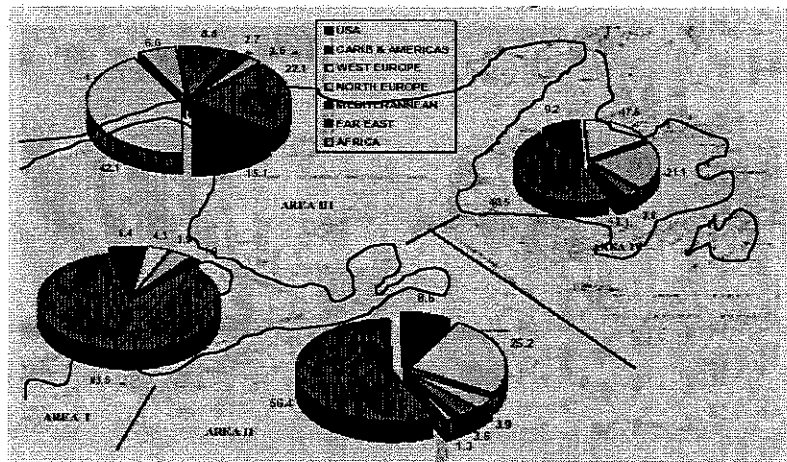


Figure 5: Origin of vessels (in percentage of arrivals) for Areas I – IV of Atlantic Canada. Data source: ECAREG –VTS data (Balaban 2001). See figure 4 for description of Areas I – IV.

RNT Consulting (2002) created a mathematical model to assess the risk of introducing species via ballast water. The study found that based upon vessel traffic and voyage length, the greatest potential for introductions for Atlantic Canada was from the North Atlantic coast (FAO Region A) and from Europe/Scandinavia (FAO Region B).

Specifically, the biggest risks were to the Laurentian Channel, Area I, and then the River Stretch (RNT Consulting 2002). The model only considered the potential for introduction, made no distinction between species, did not consider salinity, and ignored survival rates and adverse effects upon introduction. Further, it assumed that the only difference between the port of origin and the destination was travel time, rather than including any combination of environmental or logistical details unique to either port. Voyage length significantly affected the organism mortality within the ballast water, such that after 5 days in continuous transit, only 50% of species survived (RNT Consulting 2002). Several estimates suggest that the longer the duration of the voyage, the lower the risk for introductions due to high mortalities.

There were several recommendations made based on the data in the Carver and Mallett (2002) Report. These recommendations are:

Recommendations from Carver and Mallett (2002)

- A. Continue to support the principle of ballast water exchange but delay the decision to establish an Alternative Ballast Water Exchange Zone off Nova Scotia until more data are available.*
- B. Discourage discharge of ballast water from brackish-water ports in the US into the Bras D'Or lakes (Little Narrows).*
- C. Develop educational materials to promote mid-ocean exchange and improve ballast water management practices, particularly for ships carrying water from Europe, Asia or the west coast of North America.*
- D. Support efforts to develop ballast water treatment methods.*

Future research (from Carver and Mallett 2002)

- A. Expand the scope of sampling and develop sampling techniques to better assess the risks associated with other types of organisms including cysts, bacteria, parasitic protozoans, and benthic invertebrates.*
- B. Assess the risks associated with undertaking ballast water exchange in various regions and in different seasons.*
- C. Conduct surveys of potentially-impacted areas to determine whether non-indigenous taxa are being introduced.*

Between August 1999 and December 2002, ships that entered the 22 New England ports from outside the EEZ discharged 658,827 m<sup>3</sup> of ballast (see Figure 6). The trends in shipping traffic and ballast water exchanges appear to be different from that of Atlantic Canada. It is difficult to draw conclusions about where ballast water is frequently

exchanged or where it originated in New England, because the rate of mandatory ballast management reporting is around 30%. Of the five coastal New England states, only Maine and Massachusetts had reports of ballast water discharge for all years in the study. Based upon the information that is available, we are able to make a few statements.

In New England, Maine received the most ballast water discharge, which generally increased across the three and a half years of study. Between August 1999 and December 2002, a total of 551,695 m<sup>3</sup>, or 83.7% of the total volume of ballast, was discharged within the Maine ports of Bar Harbor, Bucksport, Eastport, Portland, and Searsport. Portland Harbor was the recipient of 503,992 m<sup>3</sup> ballast discharged, which is 91.3% of the volume discharged in Maine and 76.5% of the total volume discharged in New England (see Figure 7).

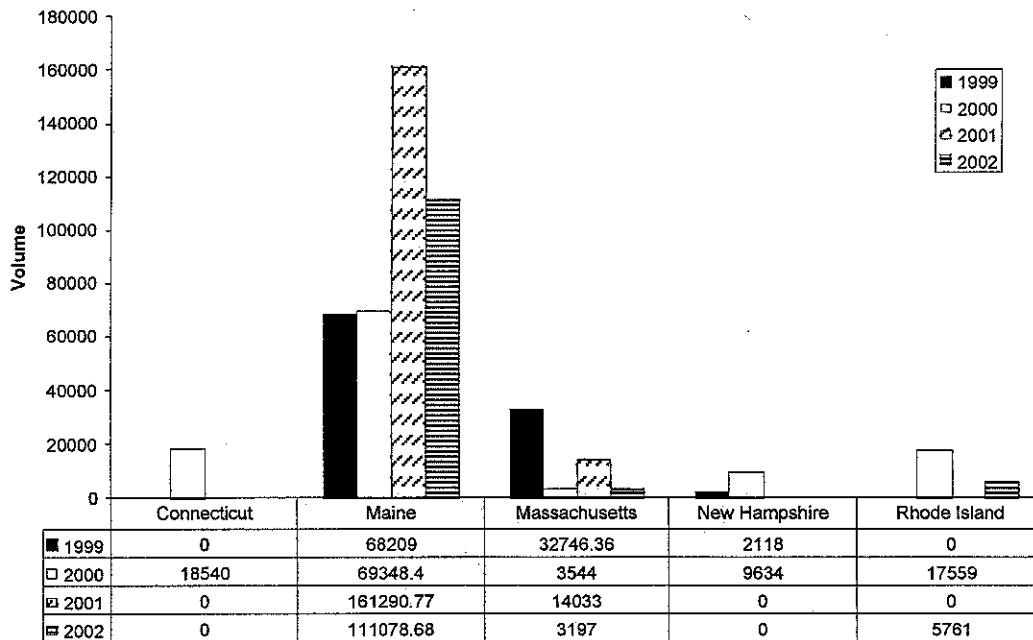


Figure 6: Reported volumes (in m<sup>3</sup>) of ballast water discharged in New England ports, arranged by state, during 1999-2002. Reports in 1999 spanned from July-December, while other years included all months. Reported volumes are based on low voluntary compliance rate (30%) recorded by the National Ballast Information Clearinghouse Database ([http://invasions.si.edu/NBIC/nbic\\_database.htm](http://invasions.si.edu/NBIC/nbic_database.htm), 2003; Ruiz et al. 2002).

Massachusetts reported the second greatest volume of ballast discharged between August 1999 and December 2002, with a total of 53,520 m<sup>3</sup>, or 8.1% of the total volume discharged to New England (see Figure 6). The majority of ballast in Massachusetts was discharged in Boston (49,120 m<sup>3</sup>, or 91.7%), which represents 7.5% of the total volume discharged in New England (see Figure 7). Based upon these data, Maine reported about

10 times more ballast discharged than Massachusetts, just as Portland, Maine reported roughly 10 times more ballast discharged than Boston, Massachusetts.

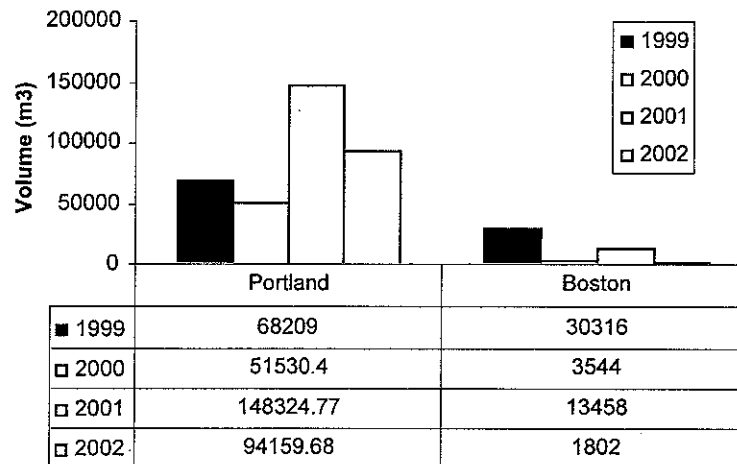


Figure 7: A comparison of volume of ballast water discharged in the ports of Portland, Maine and Boston, Massachusetts. These two ports are reportedly the most significant New England contributors of ballast water to the Gulf of Maine. Data source: National Ballast Information Clearinghouse Database ([http://invasions.si.edu/NBIC/nbic\\_database.htm](http://invasions.si.edu/NBIC/nbic_database.htm) 2003).

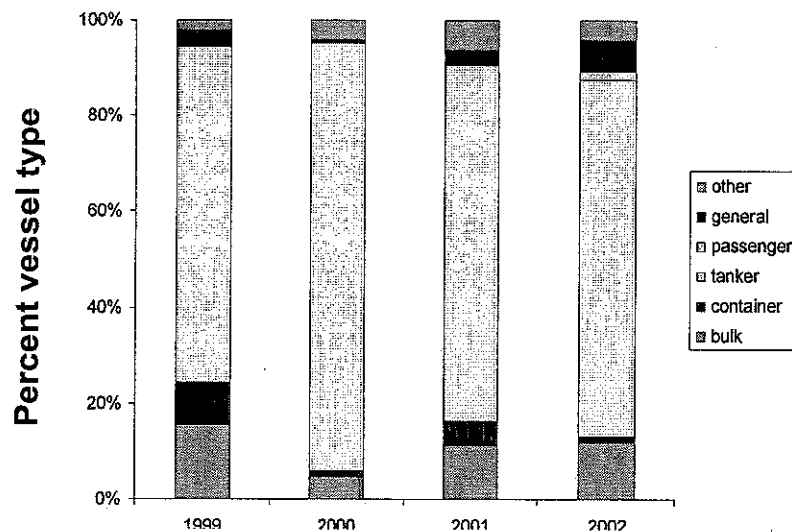


Figure 8a: Relative classification of vessel types to all ports within Maine. Data source: National Ballast Information Clearinghouse Database ([http://invasions.si.edu/NBIC/nbic\\_database.htm](http://invasions.si.edu/NBIC/nbic_database.htm) 2003).





Figure 8b: Relative classification of vessel types to all ports within Massachusetts. Data source: National Ballast Information Clearinghouse Database ([http://invasions.si.edu/NBIC/nbic\\_database.htm](http://invasions.si.edu/NBIC/nbic_database.htm) 2003).

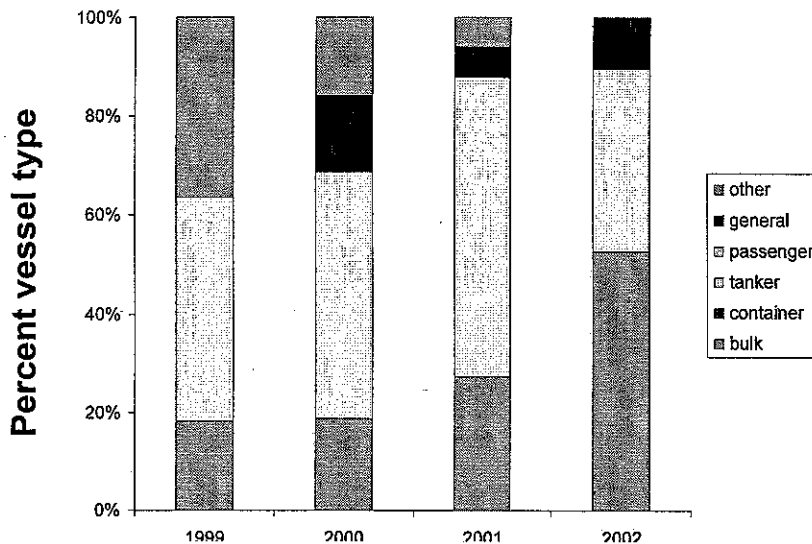


Figure 8c: Relative classification of vessel types to all ports within Connecticut. Data source: National Ballast Information Clearinghouse Database ([http://invasions.si.edu/NBIC/nbic\\_database.htm](http://invasions.si.edu/NBIC/nbic_database.htm) 2003).

During the study period, the vessel types that reported data varied between New England states, but remained relatively consistent over time for each state. Maine ports (Figure 8a) saw mostly oil/bulk ore, which was reported as 46% in 2000 and 40% in 2002, and tankers, which comprised 44% of Maine traffic in 2000 and 34% in 2002. Because reports were only collected for half of 1999, and because data cannot be accurately extrapolated due to low reporting rates, vessel types for this year have been disregarded. Massachusetts ports were visited by the most relatively diverse vessel types. Of

Massachusetts traffic (Figure 8b), passenger vessels (including cruise ships) made up 22% in 2000 and 20% in 2002, tankers made up 10% in 2000 and 8% in 2002, and container ships made up 35% in 2000 and 40% in 2002. Connecticut traffic (Figure 8c) was mostly made up of oil/bulk ore (29% in 2000 and 2002), tankers (29% in 2000 and 12% in 2002), and bulk carriers (23% in 2000 and 59% in 2002). New Hampshire and Rhode Island vessel types were not analyzed in this manner due to the significantly lower volume of reported ballast carrying vessels. Given the low reporting response, these changes are not considered trends.

Within each state, vessel types varied among ports. In Massachusetts, for example, the ports of Boston, Gloucester, and Salem each showed a different type of vessel that most significantly contributed to their traffic. Massachusetts vessel frequency is based on 4 months of 1999 data and 12 months for 2000-2002 (Figure 9). Passenger vessel increased over the past couple of years and is consistent with the observations of a national survey (The Ocean Conservancy 2002). Boston is the most diverse port according to the data reported through the NBIC, with different frequencies for the smaller ports such as Gloucester (container and general cargo ships) and Salem (container and bulk cargo).

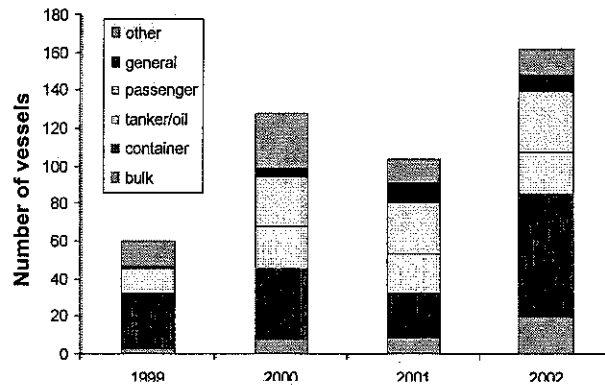


Figure 9. Breakdown of different types of vessels, in terms of frequency, contributing to shipping traffic Massachusetts between August 1999 and December 2002. Data source: National Ballast Information Clearinghouse Database ([http://invasions.si.edu/NBIC/nbic\\_database.htm](http://invasions.si.edu/NBIC/nbic_database.htm) 2003).

However, the compliance rate limits interpretation. To more fully understand the risks of introducing non-native species to the New England environments via ballast water, more data must be gathered and analyzed. Rates of compliance with reporting guidelines or potential future regulations must increase substantially to gain a better sense of how much ballast water is discharged to New England and to understand better ballast water sources.

## *Summary*

There are several challenges to reducing or preventing introductions from ballast water; the issue is global and regional. This white paper focuses on the regional component of ballast water management and offers recommendations for future action. The international community relies on voluntary compliance, which is not enforceable. Even in areas where activities are mandatory, e.g. reporting ballast water on board and treatment as required by the U.S. Coast Guard, without enforcement compliance remains low. The compliance rate is high in states and countries that enforce reporting requirements (e.g. California and Canada) and risk assessment is possible.

The lack of required ballast reporting and lack of ballast water treatment for vessels traveling within the EEZ is a weakness in the current regulations and guidelines. The reporting information will assist with identification of the extent of the contribution of coastwise traffic to ballast water discharge. A larger question about the exchange within the coastal area remains for both coastwise traffic and vessels unable to exchange at sea. A few locations have been identified as suitable for ballast exchange, e.g. the ESGL. More information is needed about risks associated with ballast exchange and the use of designated areas. This could include prohibiting ballast uptake in areas where highly invasive species are prevalent or avoiding discharge in environmentally sensitive areas.

## *Recommendations*

### **1) Develop a regional ballast water management plan.**

Ballast water concerns in Canada and the United States are closely related and linked. Due to the close proximity between the Gulf of St. Lawrence and the Gulf of Maine, species introduced to one may ultimately impact the other. The United States and Canada have a common interest in preventing the introduction of foreign species to the coasts of the Northwest Atlantic Ocean. Therefore, it may be most expedient to encourage cooperation, sharing of information, and coordination of efforts for both countries. Ultimately, this may best be implemented by an international Northwest Atlantic Regional Ballast Water Management Plan that is simple, clear, and establishes consistency among existing efforts. Such a regional plan would provide one set of regulations and clear enforcement procedures that promote more holistic protection rather than confusion and loopholes.

### **2) Make reporting ballast water practices mandatory for all vessel traffic.**

It is vital to have information regarding the ballast water management practices of vessels entering ports within the United States and Canada, from both outside and within the EEZ of each country. Gaps in this record inhibit understanding the risk of introduction posed to each area and ultimately the prevention of these introductions. Voluntary ballast management reporting should become mandatory with appropriate enforcement measures as necessary for vessels arriving from ports outside and inside the EEZ.

### **3) Continue the advancement of ballast treatment technologies.**

Several methods of ballast treatment, as mentioned earlier, are being developed to minimize the survival of species within ballast tanks. Though such solutions will likely be costly in the short run, efforts in research and development of technology and

standards should be pursued. Most likely, a combination of management efforts will be needed to most effectively minimize the risk of introducing foreign species.

**4) Explore the potential for alternate areas for BWE, within the EEZ, to minimize introductions.**

Based upon the studies discussed in this paper, recent data suggest that ballast water exchange may not decrease the number of all nonindigenous species (e.g. copepods may increase in number) in tanks. In addition, Canadian studies suggest that the Gulf of St. Lawrence may not be the most appropriate area for an alternate ballast water exchange zone. Due to the relatively high risk of invasion and the large volumes of vessel traffic and ballast water discharged in this region, the Gulf of St. Lawrence waters may not effectively prevent new marine introductions. In order to make a decision, scientific information on the physical and biological oceanography in the Gulf of Maine and the larger North Atlantic coastal region are needed as a first step. Thus information on water movement in these highly dynamic areas as well as biological data on sources of invasive species, dispersion potential, and other data are needed for risk assessment.

**5) Risk Assessment**

Research should focus on improved sampling technologies, improved species identification, and locations of species with potential to be transported to other areas. Other environmental features, such as salinity should also be considered when identifying an alternate ballast water exchange zone. Any factors that inhibit survival of species once introduced such be accounted for and further studied. Furthermore, proposed alternate ballast water exchange zone should primarily be available for coastwise traffic within the EEZ of the United States and Canada to facilitate and be considered as safety zones for vessels that are arriving from outside the EEZ. A good selection of an alternate BWE zones may minimize the possibility of introducing species and not simply displace introductions from one area to another. This is an area where additional research is needed to provide better guidance to managers.

In addition to these five recommendations, other specific recommendations are identified in the various reports listed in the literature cited section. As we gain greater understanding, our efforts and recommendations should reflect this new knowledge.

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