

Great Lakes Shipping, Trade, and Aquatic Invasive Species

Since its opening in 1959, the St. Lawrence Seaway has provided a route into the Great Lakes not only for trade, but also unfortunately for aquatic invasive species (AIS) that have had severe economic and environmental impacts on the region. Prevention measures have been introduced by the governments of Canada and the United States, but reports of newly discovered AIS continue, and only time will tell what impacts these species may have. Pressure to solve the problem has even led to proposals that the Seaway be closed. This report concludes that trade should continue on the St. Lawrence Seaway but with a more effective suite of prevention measures that evolves over time in response to lessons learned and new technologies.

The Great Lakes are the largest unfrozen reservoir of fresh water on earth, accounting for almost one-fifth of the world's fresh surface water. They are vital to the economy of the Great Lakes region and to the quality of life of its residents, providing drinking water for more than 33 million people in Canada and the United States, supplying hydroelectric power, supporting industries, providing waterborne transportation, and offering a variety of recreational opportunities.

When the St. Lawrence Seaway was completed in 1959, it promised important economic benefits for Canada and the United States through enhanced navigation and associated trade, as well as the generation of much-needed hydroelectric power. It was not until much later that people became aware of an unintended effect of the Seaway: the introduction of aquatic invasive species (AIS) inadvertently taken aboard at previous ports of call. The rapid spread throughout the Great Lakes of the European zebra mussel (*Dreissena polymorpha*), discovered in Lake St. Clair in 1988, drew public attention to this problem. Recent estimates put the total number of AIS in the Great Lakes at more than 180, including algae, fish, invertebrates, and plants.

At the request of the Great Lakes Protection Fund, the National Research Council assembled a committee of experts to identify



Photo courtesy Phil Jenkins

and explore options for the Great Lakes region that would meet two criteria: (a) enhance the potential for global trade in the Great Lakes region and (b) eliminate further introductions of AIS into the Great Lakes by vessels transiting the St. Lawrence Seaway. The report reviews existing research and efforts to date to reduce AIS introductions, and identifies ways that these efforts could be strengthened toward an effective solution.

Ballast Water, Ships, and AIS

Ships' ballast water has accounted for 55–70 percent of reported AIS introductions since 1959. Other means of introducing AIS include deliberate releases, aquaculture, home aquaria, water gardens, and recreational boating. Ships with little or no cargo aboard carry ballast water to provide the stability needed for

safe operations under a range of conditions. Ships fully laden with cargo, on the other hand, have only unpumpable residual water and sediment in their ballast tanks and are described as having no ballast on board (NO-BOB). Although it was previously thought that NOBOBs did not introduce AIS into the Great Lakes, research over the past decade has shown that this is not the case.

It is difficult to know what species might be introduced in the future. While invaders such as the zebra mussel—and more recently the quagga mussel—are impossible to ignore because of their abundance, size, and readily observable impacts, the same cannot be said of all AIS. Analyses of beach sand, for example, revealed introduced species that are both inconspicuous and low impact, but the possibility always exists that a species as damaging as the zebra mussel might be introduced. Plants and microorganisms can also be invasive. Continuing research and monitoring are needed to identify species that have arrived or could arrive.



Zebra mussels (left) have become emblematic of the problem of AIS in the Great Lakes. The cost of removing them from piping in power generation plants, public and private drinking water plants, and industrial facilities, as well as from lock and dam structures and marinas, has been estimated at more than US\$1 billion since 1989, and some put it as high as US\$5 billion. In addition, zebra mussels have modified the aquatic food web and led to a suite of indirect effects. Other introductions include the spiny water flea (right).

Box 1. Ballast Water Management Techniques

Ballast water exchange involves replacing a vessel's ballast water with ocean water. It removes organisms from a ship's ballast tanks by dilution and also exposes freshwater organisms to salt water, thereby killing many of them.

Saltwater flushing is an alternative to ballast water exchange for NOBOBs, and is accomplished by allowing a limited amount of salt water to slosh around in an individual ballast tank as a result of the ship's rolling and pitching motion during passage. This agitation resuspends trapped sediments and provides a salinity shock to biota, which are then discharged into the open ocean.

Shipboard treatment to kill organisms in ballast water is widely viewed as offering greater operational flexibility than either ballast water exchange or saltwater flushing, as well as the potential for greater effectiveness. A variety of proven water treatment technologies are available, but adapting them for shipboard application presents major technical challenges. However, important progress has been made in recent years in response to the ballast water treatment standard proposed by the International Maritime Organization.

Prevention Measures to Date

Efforts have been under way since 1989 to prevent further introductions into the Great Lakes of AIS in ships' ballast water. These efforts have focused on the steps ships can take to reduce the risk of introductions by managing their ballast water (see Box 1). Rules and regulations specifying ballast water management requirements for ships entering the Great Lakes St. Lawrence Seaway system have been issued by the Canadian and U.S. federal governments and by the joint Seaway Authorities. The International Maritime Organization has also proposed a set of requirements for managing ballast water worldwide.

Both ballast water exchange and saltwater flushing techniques are currently used by vessels operating into the Great Lakes to manage their ballast water. Prototype shipboard ballast water treatment systems have been installed on several vessels trading into the Great Lakes, but are not yet proven in an operational environment. Systems capable of meeting proposed International Maritime Organization ballast water management requirements are, however, expected to become commercially available by 2009.

It is important to note that time is required to assess the effectiveness of any prevention measures. New species may take time to manifest themselves, and the identification of new AIS is affected by the level of effort devoted to surveillance.

Examining the Options: No "Silver Bullet"

One possible goal is to eliminate all further AIS introductions by ships' ballast water, keeping in mind that AIS will continue to be introduced by other

means. The only way to achieve this goal is to close the St. Lawrence Seaway to all vessel traffic. However, such an action clearly would not enhance the Great Lakes region's potential for global trade and appears impractical from a political perspective, potentially taking years if it could be accomplished at all.

The committee therefore focused on identifying compromise actions that would reduce—but not eliminate entirely—further ship-vectored AIS introductions into the Great Lakes. Two very different alternatives were identified:

- Close the Seaway to the “riskiest” component of traffic from an AIS perspective, namely, transoceanic vessels engaged in trade with countries outside of Canada and the United States; or
- Use ballast water management technologies (ballast water exchange, saltwater flushing, and ballast water treatment) to kill or remove organisms in ships' ballast water.

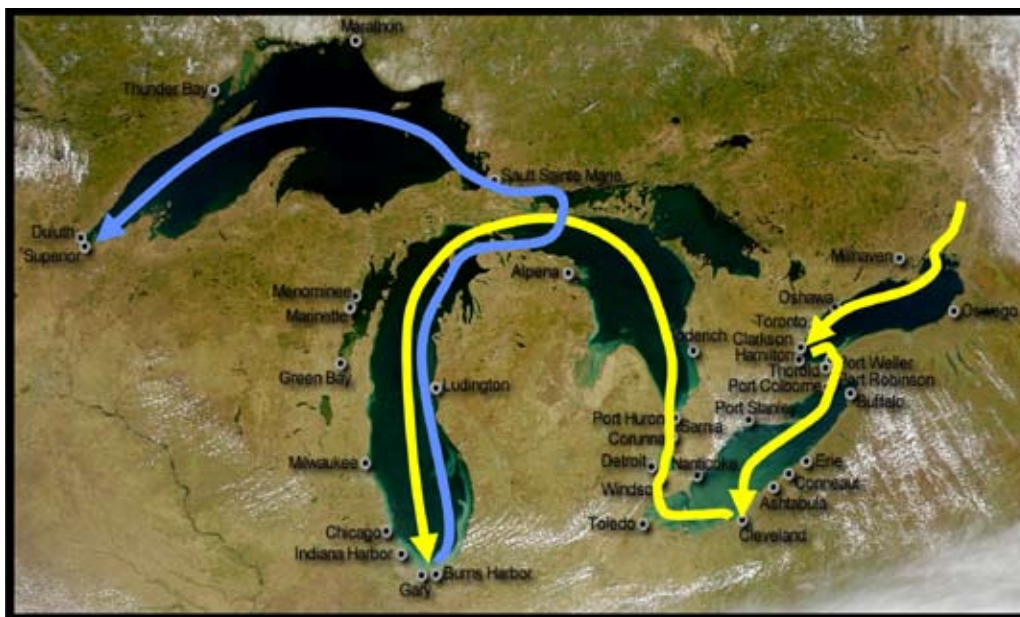
Research has shown that the ballast water of transoceanic ships—those engaged in international trade—is a major way that AIS can be transferred from locations such as the Baltic, Black, and North Seas. Although closing the Seaway to these vessels would result in a substantial reduction in the risk of further AIS introductions, the committee concluded that it would be outweighed by a number of serious disadvantages. Most notably, this action could not be implemented in a timely fashion. Moreover, economic principles indicate that eliminating a transportation option would increase the cost of moving goods and

therefore would not enhance trade. Other disadvantages could include adverse environmental impacts associated with alternative transportation modes and routes, and reprisals by the United States' and Canada's trading partners.

Recommended Approach: A More Effective Suite of Prevention Measures

As an alternative to closure, the committee recommends that access to the Great Lakes through the St. Lawrence Seaway be restricted to only those vessels that have taken protective measures aimed at ensuring they do not harbor living aquatic organisms. The use of ballast water management technologies should be mandatory for all categories of vessels known to pose a risk, not just for transoceanic vessels. Recent research has shown that vessels involved in North American coastal trade can also introduce AIS and should be required to manage ballast water as well. These requirements would need to be supported by effective vessel monitoring and enforcement and by an AIS surveillance and containment program for the Great Lakes.

The report identifies nine actions to reduce further ship-vectored AIS introductions. To avoid unacceptable delays, the recommended actions making up the control program should be undertaken by existing organizations, in some cases with expanded mandates. In the committee's view, many of these actions could be implemented within the next 2 to 3 years if Canada and the United States have the necessary political will.



Typical transit of a transoceanic vessel on the Great Lakes. The inbound leg includes stops in Hamilton, Cleveland, and Burns Harbor, where cargo is discharged and Great Lakes' ballast water loaded, which mixes with residual water in the ballast tanks. The inbound leg terminates in Lake Superior, where mixed ballast water is discharged (along with surviving species) when outbound cargo is loaded in Duluth-Superior.

To establish a solid foundation for the control program, the following four actions should be undertaken as quickly as possible:

- 1. Prevention measures for all ships that pose a risk.** Transport Canada and the U.S. Coast Guard should ensure that all vessels entering the Great Lakes after operating in coastal areas of eastern North America take protective measures similar to those required for transoceanic vessels, notably ballast water exchange for ballasted vessels and saltwater flushing for vessels declaring no ballast on board.
- 2. Create uniform standards.** The United States should follow Canada's lead and take immediate action to adopt and implement ballast water exchange and performance standards for the Great Lakes that are identical to those specified in the International Maritime Organization's International Convention for the Control and Management of Ships' Ballast Water and Sediments.
- 3. Improve monitoring for AIS.** A binational science-based surveillance program should be established to monitor for the presence of new AIS in the Great Lakes. The program should involve dedicated lake teams, as well as academic researchers, resource managers, and local citizens groups, and should leverage existing monitoring activities wherever possible.

- 4. Create feedback mechanisms for improving the program.** An adaptive process should be established to ensure that policy measures designed to prevent further AIS introductions into the Great Lakes are updated in a timely and periodic fashion to reflect practical experience and knowledge gained through research. The organization responsible for this process should have a binational mandate; adequate resources to conduct its work; and the ability to draw on the advice of scientific and policy experts in Canada, the United States, and elsewhere as needed. It should also be widely perceived as independent and free from conflicts of interest.

Uncertainty about future ballast water management regulations for the Great Lakes may well be hindering investment in the transportation system. Thus, timely implementation of the committee's recommendations with regard to ballast water management and associated standards could help reduce regulatory uncertainties and the associated barrier to the development of trade-enhancing transportation infrastructure and services. In the committee's judgment, the recommended suite of actions comes closer to achieving the two project criteria than any other options it identified.

Committee on the St. Lawrence Seaway: Options to Eliminate Introduction of Nonindigenous Species into the Great Lakes, Phase 2. **Jerry R. Schubel** (*Chair*) Aquarium of the Pacific, Long Beach, California; **Richard M. Anderson**, Duke University, Durham, North Carolina; **Stephen W. Fuller**, Texas A&M University, College Station; **Trevor D. Heaver**, University of British Columbia, Vancouver, Canada (emeritus); **Geoffrey J. D. Hewings**, University of Illinois, Urbana–Champaign; **Philip T. Jenkins**, Philip T. Jenkins and Associates, Ltd., Fonthill, Ontario, Canada; **Hugh J. MacIsaac**, University of Windsor, Ontario, Canada; **Steven W. Popper**, Rand Corporation, Santa Monica, California; **Frank H. Quinn**, Consultant, Tecumseh, Michigan; **Thomas D. Waite**, Florida Institute of Technology, Melbourne; **M. Gordon Wolman**, Johns Hopkins University, Baltimore, Maryland; **Joy B. Zedler**, University of Wisconsin, Madison; **Ann P. Zimmerman**, University of Toronto, Ontario, Canada; **Jill Wilson** (*Study Director*) and **Stephen R. Godwin**, Transportation Research Board; **Lauren Alexander** (*Senior Program Officer*), Water Science and Technology Board.

This report brief was prepared by the National Research Council based on the committee's report. Copies of *Great Lakes Shipping, Trade, and Aquatic Invasive Species* are available from the Transportation Research Board, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-3213; fax 202-334-2519; or e-mail TRBsales@nas.edu).



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