

# Great Lakes Shipping, Trade, and Aquatic Invasive Species

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Since its opening in 1959, the St. Lawrence Seaway has provided a route into the Great Lakes not only for trade, but also for aquatic invasive species (AIS), which have had severe economic and environmental impacts on the region. The governments of Canada and the United States have introduced prevention measures, but reports of newly discovered AIS continue, and the impacts that these species may have are yet unknown. Pressure to solve the problem has even led to proposals to close the seaway.

A committee of experts, convened by the National Research Council (NRC) of the National Academies through the Transportation Research Board and the Division on Earth and Life Studies (see box, page 25), recommends that trade should continue on the St. Lawrence Seaway but with a more effective suite of prevention measures that evolves in response to lessons learned and to new technologies. The study committee's findings and recommendations are detailed in TRB Special Report 291, *Great Lakes Shipping, Trade, and Aquatic Invasive Species*.

## Unintended Effects

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. The lakes are vital to the economy of the 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.

The completion of the St. Lawrence Seaway in 1959 promised important economic benefits for Canada and the United States through enhanced navigation and associated trade and by the generation of much-needed hydroelectric power. Years later, people became aware of an unintended effect—the introduction of AIS inadvertently taken aboard at previous ports of call. The rapid spread of the European zebra mussel (*Dreissena polymorpha*), discovered in Lake St. Clair in 1988 and soon throughout the Great Lakes, drew public attention to the problem. According to recent estimates, AIS in the Great Lakes number more

PHOTO: PHIL JENKINS



Oceangoing bulk carrier transits the St. Lawrence Seaway, which has provided a trade route to the Great Lakes region but also has led to environmental impacts from aquatic invasive species.



Zebra mussels (*above*) 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, with some estimates 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, shown in an accumulation (*right*).

than 180 and include algae, fish, invertebrates, and plants.

At the request of the Great Lakes Protection Fund, the NRC study committee identified and explored options for the Great Lakes region that would meet two criteria:

1. Enhance the potential for global trade in the Great Lakes region, and
2. Eliminate further introductions of AIS into the Great Lakes by vessels transiting the St. Lawrence Seaway.

The report reviews research and efforts to reduce AIS introductions and identifies ways to strengthen these efforts for an effective solution.

### Ballast Water, Ships, and AIS

Ships' ballast water has accounted for 55 to 70 percent of reported AIS introductions into the Great Lakes 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 stability for safe operations in a range of conditions. In contrast, ships fully laden with cargo contain only unpumpable residual water and sediment in their ballast tanks and are described as having no ballast on board (NOBOB). At one time NOBOBs were not considered to be a source of AIS introductions into the Great Lakes, but research in the past decade has shown that this assumption was not correct.

Predicting which species might be introduced is difficult. 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; however, not all AIS are evident. Analyses of beach sand, for example, have revealed introduced species that are inconspicuous and that have low impact. Plants and microorganisms also can be invasive, and the introduction of a species as damaging as the zebra mussel is always possible. Therefore continual monitoring and research are needed to identify species that have arrived or that could arrive.

### Prevention Measures

Efforts have been under way since 1989 to prevent further introductions of AIS into the Great Lakes by focusing on steps that ships can take to manage their ballast water (see box, next page). The Canadian and U.S. federal governments and the joint seaway authorities have issued rules and regulations specifying ballast water management requirements for ships entering the Great Lakes–St. Lawrence Seaway sys-



Ballast water from ships has been the source of more than half of the AIS reported in the Great Lakes since 1959.

The round goby was first reported in the Great Lakes in 1990. A bottom-dwelling fish, it is 4 to 10 inches long, eats voraciously, and reproduces rapidly.

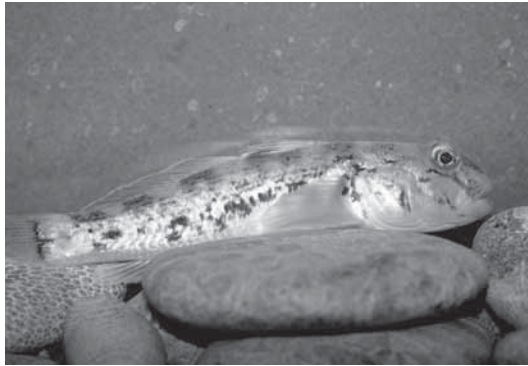


PHOTO: ENVIRONMENTAL PROTECTION AGENCY



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Bloody-red shrimp (*Hemimysis anomala*), 1.5 in. in length, is native to eastern European seas, but was discovered in the Muskegon Lake channel in late 2006, and soon after in Lake Ontario.

tem. The International Maritime Organization also has proposed a set of requirements for managing ballast water worldwide.

Vessels operating into the Great Lakes manage their ballast water by ballast water exchange and by saltwater flushing. Prototype shipboard ballast water treatment systems have been installed on several vessels trading into the Great Lakes but have yet to be proved in an operational environment. Systems that can meet the International Maritime Organization's proposed requirements for ballast water management, however, are expected to become commercially available by 2009.

Time is needed to assess the effectiveness of prevention measures. Newcomer species may take time to manifest themselves, and the time taken to identify new AIS may well depend on the level of effort devoted to surveillance.

### No "Silver Bullet"

One possible goal is to eliminate all further AIS introductions via ships' ballast water, recognizing that AIS may continue to be introduced by other means.

Achieving this goal would require closing the St. Lawrence Seaway to all vessel traffic, an action that clearly would not enhance the potential of the Great Lakes region for global trade. Moreover, closing the seaway appears impractical from a political perspective, potentially taking years to accomplish, if it could be accomplished at all.

The committee therefore focused on identifying compromises that would reduce—instead of eliminating entirely—further ship-vectored AIS introductions into the Great Lakes. Two different alternatives were identified:

- ◆ Close the seaway to traffic at the highest risk for introducing AIS—namely, transoceanic vessels engaged in trade with countries outside of Canada and the United States; or
- ◆ Require the use of ballast water management technologies—namely, 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 means of transferring AIS from locations such as the Baltic, Black, and North Seas. Although closing the seaway to these vessels would reduce the risk of further AIS introductions substantially, the committee concluded that serious disadvantages outweigh the benefit. Most notably, the action could not be implemented in a timely way. 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 from alternative transportation modes and routes, as well as reprisals by the trading partners of the United States and Canada.

### Suite of Prevention Measures

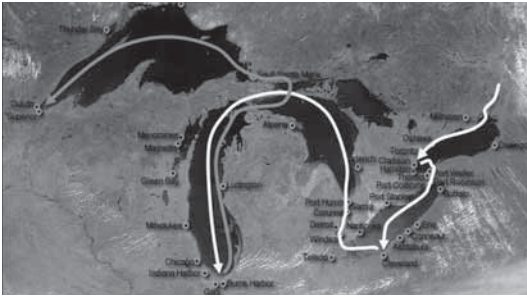
As an alternative to closure, the committee recommends restricting access to the Great Lakes through the St. Lawrence Seaway to vessels that have taken protective measures aimed at ensuring they do not harbor living aquatic organisms. The use of ballast water management technologies should be mandatory 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 also can introduce AIS; these vessels therefore should be required to manage ballast water as well. Effective vessel monitoring and enforcement are needed to support these requirements, including an AIS surveillance and containment program for the Great Lakes.

## Ballast Water Management Techniques

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

**Saltwater flushing**, an alternative to ballast water exchange for vessels with no ballast on board, allows a limited amount of saltwater to slosh around in an individual ballast tank with the ship's rolling and pitching during passage. The agitation resuspends trapped sediments and provides a salinity shock to the biota—that is, the flora and fauna—which then are discharged into the open ocean.

**Shipboard treatment** to kill organisms in ballast water offers greater operational flexibility than either ballast water exchange or saltwater flushing and may offer greater effectiveness. A variety of proven water treatment technologies is available, but shipboard application presents technical challenges; progress has been made in recent years to meet the ballast water treatment standard proposed by the International Maritime Organization.



Typical transit of a transoceanic vessel on the Great Lakes: the inbound leg includes stops in Hamilton, Ontario; Cleveland, Ohio; and Burns Harbor, Indiana, where cargo is discharged and Great Lakes' ballast water is loaded, mixing 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 the Twin Ports of Duluth, Minnesota, and Superior, Wisconsin.

The committee identifies nine actions to reduce further ship-vectored AIS introductions. To avoid unacceptable delays, U.S. and Canadian organizations should undertake the recommended actions under expanded mandates, if necessary. 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 exercise the necessary political will.

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 immediately adopt and implement for the Great Lakes the ballast water exchange and performance standards 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.** Establish a binational science-based surveillance program to monitor the Great Lakes for new AIS. The program should involve dedicated lake teams, as well as academic researchers, resource managers, and citizen groups, and should leverage current monitoring activities wherever possible.

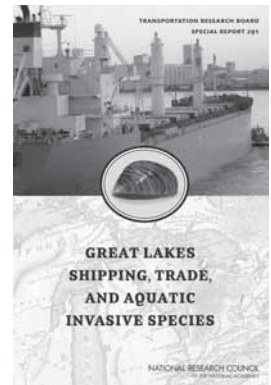
4. **Create feedback mechanisms for improving the program.** Establish an adaptive process to ensure

that policies designed to prevent further AIS introductions into the Great Lakes are updated periodically in a timely way to reflect practical experience and research findings. The organization responsible for this process should have a binational mandate, adequate resources to conduct the work, and the ability to draw on the advice of scientific and policy experts in Canada, the United States, and elsewhere as needed. The organization also should be perceived as independent and remain free from conflicts of interest.

## Meeting the Criteria

Uncertainty about future ballast water management regulations for the Great Lakes may hinder investment in the transportation system. Timely implementation of the committee's recommendations on ballast water management and associated standards, therefore, could reduce barriers to the development of trade-enhancing transportation infrastructure and services through the removal of regulatory uncertainties.

In the committee's judgment, the recommended suite of actions comes closer than any other options to meeting the two project criteria of enhancing the potential for global trade in the Great Lakes region and eliminating further introductions of AIS into the Great Lakes by vessels transiting the St. Lawrence Seaway.



TRB Special Report 291, *Great Lakes Shipping, Trade, and Aquatic Invasive Species*, is available from the TRB online bookstore, [www.trb.org/bookstore](http://www.trb.org/bookstore); to view the book online, go to <http://onlinepubs.trb.org/onlinepubs/sr/sr291.pdf>. The background papers commissioned by the study committee are available online at [http://trb.org/news/blurb\\_detail.asp?id=9281](http://trb.org/news/blurb_detail.asp?id=9281).

## Committee on the St. Lawrence Seaway: Options to Eliminate Introduction of Nonindigenous Species into the Great Lakes, Phase 2

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