Ballast Water and Aquatic Nuisance Species Introductions to the Great Lakes

Over the last two centuries the Great Lakes have been invaded by aquatic nonindigenous species (ANS) moving via a broad array of vectors, including transoceanic shipping. Ships are believed to be responsible for ANS additions starting in the 1860's through disposal of solid ballast. The opening of the St. Lawrence Seaway in 1959 resulted in a substantial increase in the importance of ballast water as a vector for the introduction of nonindigenous species. Ballast water is used to supply stability on ships that have no load. It is loaded on before departure and often carries stowaways in the form of tiny organisms. Ship discharge of ballast water is considered the most likely source for the majority of ANS additions in the Great Lakes since 1959. Due to the invasion of zebra mussels in the late-1980s, mandatory ballast water management regulations were established in 1993 for all ships entering the Great Lakes with pumpable ballast water. Under these regulations, ships are required to replace ballast water with saltwater from the middle of the ocean in a process known as ballast water exchange (BWE).

BACKGROUND

Propagule pressure, which is another way to say the number of introduced organisms capable of establishing a new population, helps to determine the success of ANS introductions. Therefore, one way to assess the effectiveness of ballast water exchange is to determine its effect on the delivery of propagules to the Great Lakes ecosystem.

There are two categories for ships entering the Great Lakes from the ocean. One is those carrying pumpable ballast-on-board (BOB). The second is ships that are full of cargo and not carrying pumpable ballast (NOBOB, "NO Ballast On Board). When ships take in ballast water, they also take in organisms in the water, and often take in sediment and sediment-dwelling organisms with it. Even with complete deballasting, some residual ballast water and accumulated sediments remain in the tanks of most ships. Originally (1993-2006) ballast water exchange regulations applied only to BOB ships. NOBOBs were not regulated under BWE requirements because they did not contain pumpable ballast water.

Recent studies indicate that much higher densities of organisms may be associated with sediments than with water in ballast tanks. Depending on many things such as operational constraints, location, and attentiveness to ballast tank condition, accumulation of sediments and sediment-associated organisms can be significant.

Water overflowing from a ballast tank deck hatch during ballast water exchange at sea (top).

Sediment accumulation in ballast tank (center).

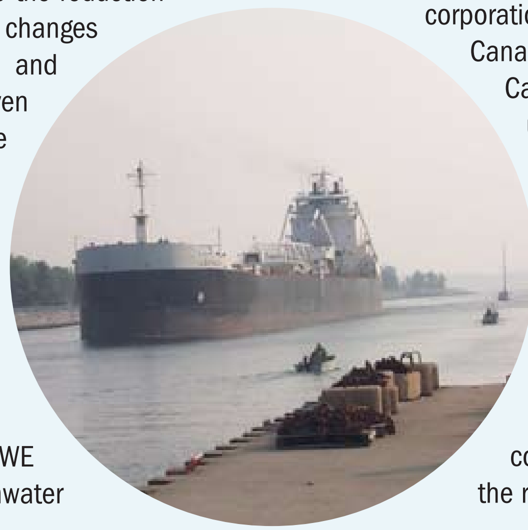
Tunicate organisms in a ballast tank of a cargo vessel in the Pacific Ocean (bottom).

Additional Considerations

Amount of sediment and numbers of organisms within ballast sediments are highly variable from ship to ship, tank to tank within a ship, and even within sections of a single ballast tank. Practices contributing to this variability have not been thoroughly studied and are not well understood. The risk associated with sediment in ballast tanks was not addressed except qualitatively. The study concluded that ballast sediment load most likely decreased (thus decreasing their potential contribution to propagule supply) between pre- and post-BWE periods. Shipkeeping improved, and the accumulated sediment in ballast tanks decreased over this time period for all categories of ships, but the magnitude of this change, or the associated risk could not be reliably estimated.

Although BWE has been a major contributor to the reduction in risk of ANS introductions to the Great Lakes, changes in the economics of the Great Lakes trade and improvements in ship management had an even greater effect. The number of ships entering the Great Lakes, and the percentage of those that were carrying pumpable ballast water (BOBs) decreased dramatically between the late-1970s and the late 1980s. Modern ships are far less likely to be fully ballasted – current economics make carrying cargo in only one direction unprofitable.

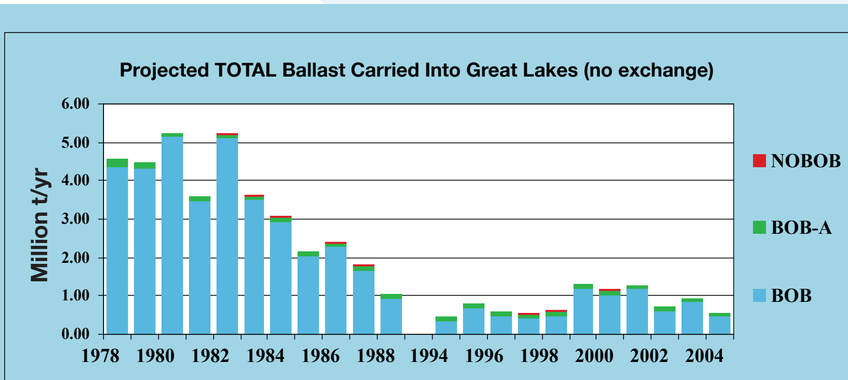
Salinity shock (salt poisoning) associated BWE is highly effective in killing many of the freshwater organisms that pose the most risk to the Great Lakes, especially if exposure is at least 24 hours.

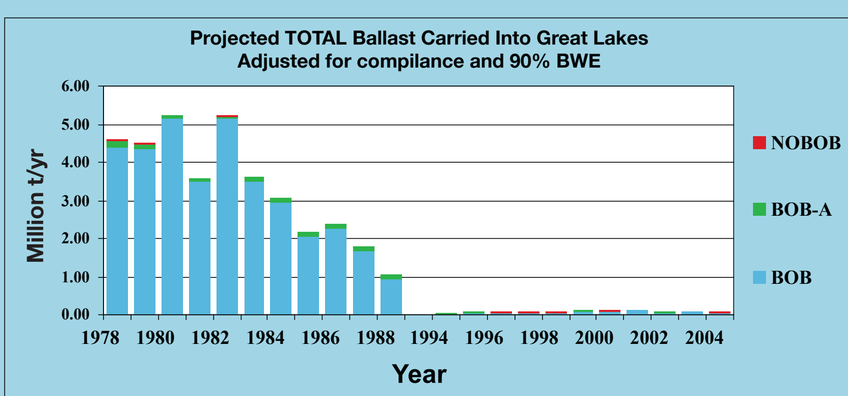


In addition to NOBOB ships, coastwide ships (those not traveling beyond the U.S. and Canadian Exclusive Economic Zones (EEZs)) were not subject to ballast management and ballast water salinity requirements until 2006.

Hope for the Great Lakes Ecosystem

An important step forward in protecting the Great Lakes was the implementation in 2006 of Canadian requirements that all ballast water, including NOBOB residual water, is at a salinity of 30 or greater. In 2008, the St. Lawrence Seaway management corporations harmonized their entry rules with the Canadian regulations. According to U.S. and Canadian officials, as of 2009 there is no unmanaged ballast water entering the Great Lakes, including that associated with coastwise vessels. If salinity and flushing requirements are consistently applied and enforced for all vessels entering the Great Lakes, we expect that a very significant reduction in the risk of ballast-associated ANS introductions to the Great Lakes will be achieved, especially compared to the risk prior to 2006. However, the risk will not be zero.





Effectiveness of BWE

GLERL researchers compiled estimates of the annual ballast quantity potentially entering the Great Lakes during equal periods before and after 1993 (implementation of BWE regulations) to examine the potential effects of BWE on the risk of ANS introductions associated with ballast water. We estimated that sediment load was only a small percentage (<5%) of the total ballast quantity.

Total potential ballast quantity was used as a rough surrogate for propagule supply and thus relative risk. Quantities after 1993 were adjusted for the estimated effects of BWE on organism density. Based on the assumptions and data we used, the estimated overall decrease in total potential ballast load (and therefore, potential propagule supply) from pre- to post-BWE periods was ~97%, equivalent to eliminating ~3.3 millions t per year of unexchanged ballast water.

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