Assessment of Transoceanic NOBOB (no-ballast-on-board) Vessels and Low-Salinity Ballast Water as Vectors for Nonindigenous Species Introductions to the Great Lakes

This is a 3 yr. research program that will end in 2003. Sponsors include the Great Lakes Protection Fund, National Oceanic and Atmospheric Administration (NOAA), U.S. Environmental Protection Agency-Great Lakes National Program Office, and the U.S. Coast Guard. Participating institutions are NOAA, University of Michigan, University of Windsor, Old Dominion University, Smithsonian Environmental Research Center, and Philip T. Jenkins and Associates, Ltd.

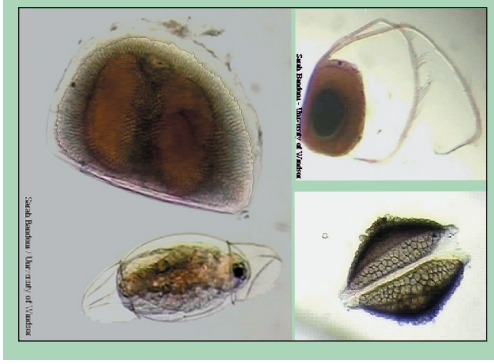
Objectives

Specific objectives are to:

- Assess the risk of invasive species introductions posed by transoceanic vessels entering the Great Lakes with "no-ballast-on-board" ("NOBOB").
- Develop a database of transoceanic vessel operations in the Great Lakes on an annual basis (i.e., where they go and where they take-on and discharge ballast).
- Assess whether the organisms resident in ballast tank residual water and sediment can invade the Great Lakes under actual ship operating conditions.
- Evaluate the effectiveness of open-ocean exchange for vessels arriving from fresh and brackish water European ports to the Great Lakes.

What are "Resting Stages?"

The life cycles of many aquatic plants, invertebrate animals, and microbes include the capability of producing resting stages (eggs, cysts, spores), which are extremely resistant to conditions such as lack of oxygen, exposure to toxic chemicals, low and high temperatures, and even survive passage through the digestive systems of fish and waterfowl. Resting stages may remain in sediment in a state of virtual suspended animation for decades or even centuries. Once exposed to the right combination of favorable environmental conditions, they can hatch or germinate to produce live organisms capable of reproducing.



Resting eggs and cysts found in ballast tank residual sediments.

Background and Issues

A ship taking-on ballast water also takes-on the biota and sediment in that water. Ships inbound to the Great Lakes with ballast water must exchange it with open-ocean seawater, conditions permitting, or use an alternate ballast water treatment approved by the U.S. Coast Guard. However, over 75% of vessels entering the Great Lakes each year have declared no pumpable ballast water on board ("no-ballast-on-board", or "NOBOB"). NOBOB vessels have not been subject to ballast management regulations.

"Empty" ballast tanks may hold residual water and mud containing live organisms, their resting stages (see sidebar), and microorganisms, including human pathogens. When a NOBOB vessel unloads cargo, ballast water is pumped aboard to compensate for the loss of cargo weight and mixes with any residual ballast material. In the Great Lakes, ballast operations may occur several times during a single ship transit, giving residual foreign organisms or resting stages several opportunities to be discharged into the lakes.

New species found since the implementation of mandatory ballast exchange have raised questions about the effectiveness of open-ocean ballast exchange in protecting the Great Lakes. The freshwater regions of Europe have been implicated as source regions for many ballast-related Great Lakes invaders found since 1985. The effectiveness of the process for exchanging freshwater with saltwater is an important, largely unresolved question.

Looking into the entry hatch of a double-bottom ballast tank. Note accumulation of mud and water.

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Seawater flow-through ballast water exchange in progress during the August 2002 experiment.

Activities and Progress through Sept. 2002

Task 1: Characterize the biota, including resting stages, present in NOBOB tanks and evaluate the relationship between ship management practices, mud accumulation, and invasion risk.

- Tank entries started in May 2001 (one prior entry in December 2000).
- 34 vessels boarded through mid-September 2002; 68 ballast tanks sampled, 84 ballast tank management surveys completed; sampling to continue to the end of the 2002 shipping season.
- 63 water samples, 63 sediment samples obtained.
- Salinity of residual water: 1-37 ppt plus a few >40 ppt due to evaporation.
- All samples examined to date contained varying densities of bacteria, virus-like particles, live invertebrates and phytoplankton, and/or viable resting stages of zooplankton and phytoplankton.
  - Bacteria and virus-like-particles were at about the same concentration as would be found in the environment; no enteric bacteria were found in samples analyzed to date.
  - Two water samples tested positive for the presence of cyst forms of the intestinal parasites *Cryptosporidium and Giardia*.
  - Many zooplankton and phytoplankton eggs and cysts from residual sediments readily hatched or germinated in freshwater or saltwater culture media.
  - Diatoms were dominant species in almost all phytoplankton germination (hatching) experiments, with fewer green algae, small flagellates and dinoflagellates; at least 20 species of non-indigenous diatoms have been identified from germination experiments, including both marine and freshwater species; several non-indigenous harmful marine dinoflagellate cysts were identified in some residual sediment samples (of interest to marine coastal ports).
  - Nematodes, crustacea, and rotifers were the most common zooplankton in ballast tank residuals; at least four nonindigenous freshwater zooplankton species that are not presently found in the Great Lakes were hatched from resting eggs.
- Access to vessels and cooperation of captains and crews has been quite good

Task 2: Experimentally evaluate the potential for introduction of nonindigenous organisms when Great Lakes water is added to a NOBOB tank containing residual sediment and water, and later discharged.

- One 11-day experiment was conducted in 2001.
- Significant settling of suspended particulate material in the ballast water was observed. By the 11th day suspended sediment concentration was only ~5% of that measured immediately after the tank was filled, indicating that the energy environment was low enough to allow rapid sediment accumulation on the tank bottom.
- The concentrations of naturally occurring viruses, bacteria, and chlorophyll a (plant pigments) were greater in the incoming ballast water than in the tank's residual water, but all decreased over the duration of the experiment, suggesting that they either died or settled out. Other measurements showed that the composition of the bacterial community changed little during the experiment. These results indicate that the ballast tank was not an incubator for microbial organisms and merely held them as they decayed.
- Additional biological analyses are in progress; another experiment is planned for 2002 and one more in 2003.

Task 3: Experimentally test the effectiveness of open-ocean exchange in decreasing the diversity and concentration of species in exchanged fresh or low-salinity ballast water originating from Europe.

- One experiment was conducted in August 2002; results pending.
- Two experiments are projected for 2003.

The results to date for Task 1 demonstrate that NOBOB vessels are a potential vector for introduction of nonindigenous species. An assessment of risk, as well as management practices that appear to reduce risk, will be developed in 2003 after all data collection and sample analyses are completed and evaluated. These Task 1 results to date have also elevated the importance and significance of the Task 2 experiments.