

**2009 Project Abstract
For the Period Ending June 30, 2011**

PROJECT TITLE: Ballast Water Technology Testing and Sampling in Freshwater

PROJECT MANAGER: Rebecca Walter, MPCA;
Principal Investigator, Allegra Cangelosi (NEWMI)

AFFILIATION: Minnesota Pollution Control Agency

MAILING ADDRESS: 520 Lafayette Road North

CITY/STATE/ZIP: St. Paul, MN 55155

PHONE: 651 757-2807

E-MAIL: Rebecca.walter@state.mn.us

WEBSITE: www.pca.state.mn.us

FUNDING SOURCE: Environment and Natural Resources Trust Fund

LEGAL CITATION: M.L. 2009, Chp. 143, Sec. 2, Subd. 6a

APPROPRIATION AMOUNT: \$300,000

Overall Project Outcome and Results

Safe and effective ballast water treatment (BWT) is the best way to prevent ship-mediated introductions of invasive species in the Great Lakes. However, knowing whether a proposed BWT works in freshwater, and whether it is used properly by a ship is a difficult challenge for the Minnesota Pollution Control Agency (MPCA) and other regulators. BWTs with International Maritime Organization (IMO) approval have never been tested in natural fresh water, and there are no agreed methods for monitoring ballast discharge from ships. This project assisted the MPCA through accomplishing a) IMO-consistent freshwater validations of two promising BWTs at the Great Ships Initiative (GSI) freshwater testing facility, and 2) design, installation and demonstration of a credible and feasible ballast discharge sampling method for Great Lakes ships. The IMO-approved PureBallast system (AlfaLaval), performed well in tests overseas, but did not function effectively in the GSI test, likely due to clogging by freshwater filamentous algae (see <http://www.nemw.org/GSI/GSI-LB-F-A-2.pdf>). This outcome informs MPCA that IMO-approval does not by itself assure freshwater effectiveness. The other BWT tested, a lye-based system aimed at US lakers, performed better (see <http://www.nemw.org/GSI/GSI-LB-F-A-3.pdf>), warranting refinement and shipboard testing. The project's ship sampling system proved a) applicable to the Great Lakes fleet, as demonstrated by project installation plans for 10 ships; b) cost-effective, as demonstrated by installations on 5 ships; and c) feasible, as demonstrated by sampling exercises on 2 ships. A detailed guidebook (see <http://www.nemw.org/GSI/ballastDischargeMonitoringGuidebook.pdf>) equips MPCA with the project method. All sample ports are permanent installations. The remaining four installations and seven tests will take place in 2012 using Department of Transportation, Maritime Administration funds. GSI will collect and analyze data on live organisms in ballast water discharge sampled in 2011 and 2012, and will post outcomes on the GSI website (<http://www.greatshipsinitiative.org>) and forward them to the MPCA.

Project Results Use and Dissemination

Final reports on ballast treatment tests performed pursuant to this grant, and the guidebook developed for ship discharge sampling, have been posted on the GSI public website (www.greatshipsinitiative.org). The project forwarded final reports on ballast treatment performance tests to the United States Environmental Protection Agency (USEPA) Science Advisory Board which reported to the USEPA and the USCG on availability of ballast treatment technology in 2011. NEMWI presented the sampling method developed through this project to an international gathering of ballast discharge researchers and regulators (Global R&D Forum and Exhibition on Ballast Water Management in a session on ballast treatment testing and compliance monitoring in Istanbul Turkey in the fall of 2011), and will submit the guidebook as a manuscript for the conference proceedings.

**Environment and Natural Resources Trust Fund 2009 Work Program
Final Report**

Date of Final Report: November 23, 2011
Date of Work Program Approval: June 16, 2009
Project Completion Date: June 30, 2011
PROJECT TITLE: Ballast Water Technology Testing and Sampling in Freshwater
PROJECT MANAGER: Rebecca Walter, MPCA;
Principal Investigator, Allegra Cangelosi (NEWMI)
AFFILIATION: Minnesota Pollution Control Agency
MAILING ADDRESS: 520 Lafayette Road North
City / State / Zip: St. Paul, MN 55155
Telephone Number: 651 757-2807
E-mail Address: Rebecca.walter@state.mn.us
Fax Number:
Web Site Address: www.pca.state.mn.us
Location: Northeast Region; St. Louis, Lake, Cook Counties; City of Duluth and others

Total Trust Fund Project Budget:	Trust Fund Appropriation	\$	300,000
	Great Lakes Protection Acct	\$	66,000
	Minus Amount Spent:	\$	366,000
	Equal Balance:	\$	0

Legal Citation: M.L. 2009, Chp. 143, Sec. 2, Subd. 6a

Appropriation Language:

\$300,000 is from the trust fund and \$66,000 is from the Great Lakes protection account to the commissioner of the Pollution Control Agency in cooperation with the Department of Natural Resources to conduct monitoring for aquatic invasive species in ballast water discharges to Minnesota waters of Lake Superior and to test the effectiveness of ballast water treatment systems.

Final Project Summary (Abstract)

Safe and effective ballast water treatment (BWT) is the best way to prevent ship-mediated introductions of invasive species in the Great Lakes. However, knowing whether a proposed BWT works in freshwater, and whether it is used properly by a ship is a difficult challenge for the Minnesota Pollution Control Agency (MPCA) and other regulators. BWTs with International Maritime Organization (IMO) approval have never been tested in natural fresh water, and there are no agreed methods for monitoring ballast discharge from ships. This project assisted the MPCA through accomplishing a) IMO-consistent freshwater validations of two promising BWTs at the Great Ships Initiative (GSI) freshwater testing facility, and 2) design, installation and demonstration of a credible and feasible ballast discharge sampling method for Great Lakes ships. The IMO-approved PureBallast system (AlfaLaval), performed

well in tests overseas, but did not function effectively in the GSI test, likely due to clogging by freshwater filamentous algae (GSI, 2011a; attached as Appendix A). This outcome informs MPCA that IMO-approval does not by itself assure freshwater effectiveness. The other BWT tested, a lye-based system aimed at US lakers, performed better (GSI 2011b; attached as Appendix B), warranting refinement and shipboard testing. The project's ship sampling system proved a) applicable to the Great Lakes fleet, as demonstrated by project installation plans for 10 ships; b) cost-effective, as demonstrated by installations on 5 ships; and c) feasible, as demonstrated by sampling exercises on 2 ships. A detailed guidebook (GSI, 2011c, attached as Appendix C) equips MPCA with the project method. All sample ports are permanent installations. The remaining 4 installations and 7 tests will take place in 2012 using Department of Transportation, Maritime Administration funds. GSI will collect and analyze data on live organisms in ballast water discharge sampled in 2011 and 2012, and will post outcomes on the GSI website (www.greatshipsinitiative.org) and forward them to the MPCA.

Outline of Project Results

This project helped prepare the MPCA for implementation of its ballast water discharge permit by providing hardware design and sampling methods and actual sample port installations for monitoring live organisms in ballast water discharge from ships in the Great Lakes. This project also generated important new information on treatment technology performance in fresh water to assist the MPCA in approving technologies between 2011 and 2016. In addition, this project influenced international, federal and other Great Lakes states' efforts to prevent the introduction and spread of invasive species.

Result 1: Install and trial inline sampling devices on ten ships, develop a methods guidebook for effective ship discharge monitoring, and categorical data on ballast biological constituents of subject ships.

Results from this part of the study build Minnesota's capacity to monitor ships' discharges into Minnesota ports (i.e., Duluth, Two Harbors, Taconite Harbor, Silver Bay) for invasive species. Launch of this portion of the LCCMR grant was delayed by about 12 months in hopes of consolidating GSI project activity with other national and international ship discharge monitoring methods development efforts. Two groups internationally, the IMO and the International Standards Organization (ISO), had indicated that they too would be developing proposed standard approaches to ship discharge monitoring at the time the grant was awarded to NEMWI. Meanwhile, the United States Coast Guard (USCG) had begun an internal review and development process for the same purpose, though not focused on fresh water ships. Initially, it appeared that the best way to optimize project effort would be to adopt and trial on Great Lakes ships methods recommended by the USCG, IMO and ISO, which according to those organizations were to be issued imminently. As it turned out, these governmental processes encountered delays. Rather than continue to await the output of the design stage of these efforts, GSI undertook its design effort independently, in consultation with these national and international groups. By doing so, the LCCMR-funded GSI project ultimately provided important input into the national and international design processes, accelerating their progress. At the same time, it provides invaluable information on how ship discharge monitoring can work in practice.

Once the effort fully launched, GSI readily developed a proposed ballast discharge sampling design for standard, consistent and representative measurement of live organism densities in ballast discharge across Great Lakes-relevant ship types, and for a variety of purposes, including compliance monitoring, ship board type approval testing, and research. The GSI design is intentionally a low-technology (i.e. affordable) approach to make ship discharge monitoring readily available across Great Lakes ships. The design was peer-reviewed by ship owners, federal and state officials and international ballast discharge sampling experts, and revised prior to finalization. GSI then tested the approach on a number of ships.

The Guidebook for installation and use of this sampling approach is contained in Appendix C. Sampling events, data collection and analysis using these sample port installations will continue into 2012 with MARAD support. These results will be forwarded to the MPCA and published on the GSI website (www.greatshipsinitiative.org) for public viewing as they are finalized during 2012.

Also as a result of this project, ballast discharge sample port installation is well underway for the Great Lakes fleet. GSI completed inspections, reports, fluid mechanics, and drawings for ten ships as of November 2011. The ten Great Lakes relevant ships span subject to engineering design effort through this project span the range of sizes, types and designs that ply the Great Lakes, including four Canadian lakers, four US lakers, and two salty vessels.

The sample ports have been installed on five of the ten ships so far, and four more installations are pending in the near future. The completed installations are on the Indiana Harbor and the Edwin H. Gott (American Steamship and Keystone Shipping Company, respectively), the Niagara (Canada Steamship Lines), the Herbert C. Jackson (Interlake Steamship Company) and the Federal Hunter (Fednav Limited). The Oberstar is on track for installation, and the Tim S. Dool is poised to install pending resolution of unrelated ship equipment issues that are causing delays. CSL has decided to install the sample port on a sister ship (the Richelieu) instead of the Saguenay, still using the GSI design and installation guidelines and report, in support of CSL plans to install a BWTS on the Richelieu in the near future for certification testing purposes. The Polsteam's Isolda or a sister ship will receive the installation at the first dry-docking opportunity. One of the ships was removed from the study after GSI completion of the inspection and report due to a finding that explosion proof equipment would be necessary (James R. Barker, Interlake Steamship Company).

So far, GSI has trialed its sampling approach on two US laker ships (Indiana Harbor and Edwin H. Gott). A sampling date of December 3, 2011 is in place for the Canadian laker Niagara. GSI deployed a team to conduct sampling exercises three additional times, in 2011 but delays and weather obstructed their completion. Sampling events on remaining ships will occur in 2012 using MARAD funds.

Ship Name	Ship Type	Inspected	Report Submitted to Ship Owner	Flanges Installed	Test Date
Niagara	Canadian Laker	11/17/2010	Yes	Yes	12/3/2011* **
Saguenay*	Canadian Laker	11/17/2011	Yes	No*	
M/V Tim S. Dool	Canadian Laker	1/19/2011	Yes	Yes	
M/V Indiana Harbor	US Laker	1/8/2011	Yes	Yes	8/18/2011
Edwin H. Gott	US Laker	2/6/2011	Yes	Yes	10/7/2011
Str. Herbert C. Jackson	US Laker	2/7/2011	Yes	Yes	
M/V James R. Barker**	US Laker	2/28/2011	Yes	No	
M/V Hon. James L. Oberstar	US Laker	4/6/2011	Yes	Pending	
Federal Hunter	Salty	N/A****	N/A****	Yes	
Isolda	Salty	4/26/2011			

*Sample Flanges to be installed on sister ship Richelieu instead; **Removed from study due to requirement of explosion-proof equipment;***Tentative sample date;****Installed by ship owner per GSI guidelines.

The GSI project achieved the target (as revised and approved by LCCMR in April 2011) of 10 installation inspections and designs in the project period, and this design and installation work was more than adequate to inform development of the sampling system and methods guidebook required for this project. GSI has presented the sampling methods developed through this project at the Global R&D Forum and Exhibition on Ballast Water Management in a session on ballast treatment testing and compliance monitoring in Istanbul Turkey in the fall of 2011. The installations, which are on-going, are facilitating ship-based BWTS testing on Great Lakes relevant-ships. For example, the Indiana Harbor and the Richelieu will host treatment system installations within a year, whose performance can be monitored using these sample ports. These GSI sampling ports also will deliver quality information on an on-going basis to the State of Minnesota on the nature of biota in ballast discharge generally. GSI will forward all such data to the State of Minnesota, and will post it for public access through the GSI website, as it is collected and analyzed during 2012.

Result 2: Land-Based Testing of Promising BWTS at GSI's Freshwater RDTE Facility

NEMWI, through the GSI project, operates the only ambient fresh water ballast water treatment testing facility in the world. The GSI testing facility, funded largely by MARAD and other DOT funds, is located in the Duluth/Superior Harbor and benefits greatly from technical support from the University of Wisconsin, University of Minnesota and AMI Consulting Engineers. During the project period, GSI tested two BWTSs that have received or are likely to seek final approval under international guidelines.

NEMWI first lined up the Sedna System by Hamann, an IMO-approved treatment system, for testing under this grant in 2009, but Hamann withdrew its application just prior to testing as a result of newly discovered problems with residual toxicity in cold water systems. (The company has just re-contacted GSI for testing in 2012 using a revised treatment process which is designed to eliminate this toxicity problem). GSI then lined up respected marine technology vendor Alfa Laval for tests on its PureBallast® BWTS. This BWTS was the first system to receive IMO approval, and is suitable for use on Canadian lakers and salty vessels that visit the Great Lakes. The treatment method employs filtration and a UV-based advanced oxidation system. It does not employ an active substance, *per se*, but produces lethal radicals that kill organisms and then degenerate after a short period of time. GSI conducted preliminary trials at the bench scale to assure that the discharge met state and federal water quality requirements, and then proceeded to plan, implement and analyze land-based tests. In addition to the IMO-approved version of the BWTS, Alfa Laval requested trial of an updated version that optimizes operational conditions. The same BWTS unit had just received IMO certification testing at a Norwegian land-based facility (NIVA) in brackish and salt water prior to shipment to GSI.

The land-based fresh water tests at GSI of the optimized PureBallast® BWTS took place in summer, 2010. GSI testing yielded a negative outcome for treatment performance in freshwater. The treatment process encountered filter performance problems early in the test regime under ambient conditions of Duluth-Superior Harbor, and never successfully completed valid IMO tests. GSI then conducted a set of research and development trials to help the treatment developer determine the root cause of the operational problem, and to help diagnose why GSI's negative results differed from NIVA's positive results. Attachment A contains the final report on treatment performance which covers all of these trials. While disappointing, this negative testing outcome is extremely important to progress toward effective BWTSs in the Great Lakes. It signals the need for ambient freshwater testing under highly transparent circumstances to avoid unwarranted confidence in poorly functioning systems. It also helps treatment developers better understand how to design successful and effective treatment processes applicable to the Great Lakes.

The second treatment system subjected to land-based testing at GSI under this grant was a lye (NaOH) based system. The BWTS, developed by United States Geological Survey scientists, is contemplated specifically for use by the United States laker fleet. GSI conducted preliminary bench tests on the proposed process with positive outcomes, and a ship owner expressed interest in the treatment concept, so larger scale land-based testing was well warranted. The treatment process was not ready for certification testing, so the tests performed by GSI were in the research and development category,

providing the treatment developer with a better sense of treatment performance during the process development stage.

This lye-based treatment process involves raising the pH of the ballast water significantly, holding the pH at that high level for an exposure period, and then neutralizing the pH using carbon dioxide gas prior to discharge. The tests showed the treatment system to be promising but still in need of additional development and refinement to fully answer all questions of residual toxicity and biological effectiveness. The final report on this testing is provided as Attachment B. Since completion of these GSI land-based tests, the treatment system has been installed at the pilot scale on a laker ship (MV Indiana Harbor) and will undergo further technical development prior to a prospective full-scale installation on the same ship for United States Coast Guard's (USCG) Shipboard Technology Evaluation Program (STEP) or type approval.

In short, the testing conducted using LCCMR funds underscored the importance of rigorous fresh water testing at the land-based scale using ambient assemblages to determine performance prospects of a BWTS in the Great Lakes, irrespective of IMO approval. The testing also corroborated promising bench scale tests findings on the NaOH BWTS performance, and the need for further development and testing to refine this system. In both cases, the work expedited development of BWTSs that could prove effective and safe in fresh water, and helped establish the degree to which other testing facilities in the world may be providing findings relevant to Minnesota waters.

Project Results Use and Dissemination

Final reports on ballast treatment tests performed pursuant to this grant, and the guidebook developed for ship discharge sampling, have been posted on the GSI public website (www.greatshipsinitiative.org). The project forwarded final reports on ballast treatment performance tests to the United States Environmental Protection Agency (USEPA) Science Advisory Board which reported to the USEPA and the USCG on availability of ballast treatment technology in 2011. NEMWI presented the sampling method developed through this project to an international gathering of ballast discharge researchers and regulators (Global R&D Forum and Exhibition on Ballast Water Management in a session on ballast treatment testing and compliance monitoring in Istanbul Turkey in the fall of 2011), and will submit the guidebook as a manuscript for the conference proceedings.

TOTAL TRUST FUND PROJECT BUDGET:

Contracts: \$ 366,000 for Northeast Midwest Institute (lead for Great Ships Initiative)

See Attachment A – Budget Sheet.