Great Lakes Maritime Research Institute

A University of Wisconsin - Superior and University of Minnesota Duluth Consortium

A National Maritime Enhancement Institute

Annual Report to Congress, the U.S. Department of Transportation and the U.S. Maritime Administration

October 2007-October 2008

The Great Lakes Maritime Research Institute is a National Maritime Enhancement Institute designed by the U.S. Department of Transportation Maritime Administration

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Overview and Background

Great Lakes Maritime Academy cadets train aboard the T/S State of Michigan.

The transportation research centers of the University of Wisconsin-Superior (UW-Superior) and the University of Minnesota Duluth (UMD) have, for several years, jointly pursued transportation and logistics research, public forums, and funding. In March 2004, these universities formally agreed to form a research consortium that would focus on Great Lakes maritime research.

The two universities are located in the largest ports on the Great Lakes, the Twin Ports of Duluth, Minnesota, and Superior, Wisconsin. The communities have been a transportation hub for more than 150 years. In addition to the maritime industry, the Twin Ports is serviced by four Class 1 railroads, is the terminus of the longest pipeline in North America, is the headquarters to more than 30 trucking companies, has an international airport and is home to the largest single engine airplane manufacturer in the U.S. The Twin Ports has a U.S. Coast Guard (USCG) Marine Safety Unit and is the home port for the new USCG Cutter Alder. The Twin Ports is also a Port of Entry with the U.S. Customs Office and The Immigration and Naturalization Service.

In March 2004, UMD and UW-Superior formed the consortium, the Great Lakes Maritime Research Institute (GLMRI). Federal funding to support GLMRI was first received in May 2005. The U.S. Maritime Administration designated GLMRI as a National Maritime Enhancement Institute (NMEI) on June 1, 2005.

$750,000 was federally appropriated in FY 2005 and $2,000,000 in FY 2006 for maritime research. These appropriations provided partial funding to support the research objectives in the Coast Guard and Maritime Transportation Act of 2004 authorizing a U.S. designated Great Lakes NMEI. This report summarizes the second year of the research performed under the FY 2006 appropriation. Previous annual reports are available on the GLMRI web page (www.glmri.org).

GLMRI combines the strengths of two universities and their academic and research expertise. This dynamic combination provides a program area with tremendous breadth as a National Maritime Enhancement Institute serving the Great Lakes Region.

GLMRI draws staff from two universities with experts in marine transportation, logistics, economics, engineering, technology, computer management, management, marine environmental planning, geography, and port management. The consortium can also draw on expertise in a wide range of other areas including air and rail transportation management, operations research, mathematics, and social sciences. Both universities are members of federally nominated University Transportation Centers: UW-Superior is an affiliate member of the University of Wisconsin-Madison's National Center for Freight and Infrastructure Research and Education, and UMD is an affiliate member of the University of Minnesota's Center for Transportation Studies.

The faculty and administrators of GLMRI have had a long-term involvement with the maritime industry including shippers, carriers, ports and government agencies. The consortium is committed to improving the maritime system of the Great Lakes and the United States. ❍

RIGHT: Loading grain in the Superior, Wisconsin CHS grain elevator.

Participants in the T/S State of Michigan Duluth/Superior Harbor tour.

Mission Statement

The Great Lakes Maritime Research Institute is dedicated to developing and improving economically and environmentally sustainable maritime commerce on the Great Lakes through applied research.

Overview and Background

Vessel movement in Great Lakes ports.

Research Focus

Initial broad research focus areas for GLMRI were mandated by Congress and have been refined with input from the Maritime Administration and various stakeholders. Each year at the GLMRI annual meetings, discussion is held with the Advisory Board as to future areas of research that can build upon completed studies and take into consideration current issues and opportunities for research within the Great Lakes maritime community.

Loading grain.

BELOW: R/V Blue Heron, UMD's research vessel entering the harbor in Duluth.

Co-Directors' Statement

Over the past year, we reflect on the progress that GLMRI has made, and review our strategic vision for the future.

We have been successful at bringing a team of area experts together from around the Great Lakes in our affiliate university program. Over the year, we've added the University of Wisconsin-Green Bay to the complement, and funded a project to review the possibilities of opening the Great Lakes ports to container shipping routes. In addition to the affiliate universities, we have ensued discussions to support research collaborations with universities in Canada and Finland.

The GLMRI Advisory Board meets formally every year, but also maintains an active role in defining the research agenda for the Institute. Most of the member agencies also provide reviews for the research proposals, and engage with the GLMRI management staff for inclusion of GLMRI in their agency's public research initiatives and long-range planning activities. GLMRI was invited to be a member to the Maritime Transportation System National Advisory Council (MTSNAC) in November 2007, and has been a primary advocate for Great Lakes shipping. GLMRI membership has ensured that MTSNAC keeps abreast of maritime research within the Great Lakes region and throughout the U.S. Maritime Administration's (MARAD) National Maritime Enhancement Institutes.

We have gained support from MARAD and the Saint Lawrence Seaway Development Corporation. The Administrators have formally supported and expressed their interest in finding a long-term arrangement for funding GLMRI and providing a funding profile for maritime research. The Great Lakes Maritime Task Force has also endorsed the Institute.

Although our primary mission is to provide applied research in developing sustainable commerce and shipping for the Great Lakes, we have provided several venues for education and outreach in support of the mission. For the third year, GLMRI has funded a week-long program for K-12 teachers to learn about maritime shipping and commerce on the Great Lakes while earning continuing education credits. This program has developed a significant resource to aid teachers with lesson plans and tools for educating their students. We are looking to expand this program to a new area in the summer of 2009 by bringing it to Toledo, Ohio.

In taking a look at new markets for the Great Lakes, the University of Michigan's Naval Architecture and Marine Engineering Program faculty had students take a look at designing a new vessel for shipping slab steel from the Duluth/Superior area to the lower lakes. Their concept was presented at the GLMRI Fall Affiliate Universities meeting in September.

In conjunction with the American Great Lakes Ports Association, GLMRI funded research at Purdue University in developing an Environmental Management System model to share Best Management Practices for Great Lakes ports. We expect that the findings will be transferrable to ports beyond the Great Lakes, both on the coasts and the inland waterways.

The Great Lakes Maritime Data Clearinghouse, managed by the University of Toledo's Geography Department, is in its third year of development. A mass of data has been validated and reviewed. GLMRI is now developing the analysis tools to show the impacts of maritime commerce by equating the data to jobs supported and economic factors for extended implications of regional

GLMRI
Co-Directors
Richard D. Stewart
James P. Riehl

employment and freight transportation. The products that will be developed will assist with educating the public and government on the opportunities and benefits of shipping on the Great Lakes.

University of Minnesota Duluth and University of Wisconsin-Superior biologists have partnered with the Northeast Midwest Research Institute's Great Ships Initiative researchers to work on projects to validate the tests for the Ballast Water Treatment Testing Facility and also analyze the promulgation of species within the harbor waters. Also, GLMRI host universities are making progress in identifying the sources of bacteria that are promoting the advanced corrosion of steel within the harbor infrastructure in the port of Duluth/Superior. We expect the findings from these research projects to be key in the identification of effective methods to control invasive species and bacteria, and, ultimately, limit the effects to the Lakes and to port infrastructure.

In the upcoming year, we will be working with Administration Offices to secure a plan for long-term funding of the Institute, and also a plan to consider a funding arrangement for the National Maritime Enhancement Institutes. We will continue to work to develop our research expertise and work with our board member agencies to secure a meaningful research agenda that will expand the shipping markets for the Great Lakes and provide an environmentally sustainable transportation means for the movement of freight across the United States. ❍

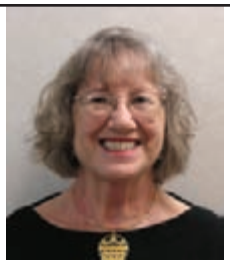
Richard D. Stewart

James P. Riehl

Advisory Board

Lake Carriers' Association
James H.I. Weakley
President
Cleveland, OH

The Saint Lawrence Seaway Development Corporation
Craig Middlebrook
Deputy Administrator
Washington, D.C.

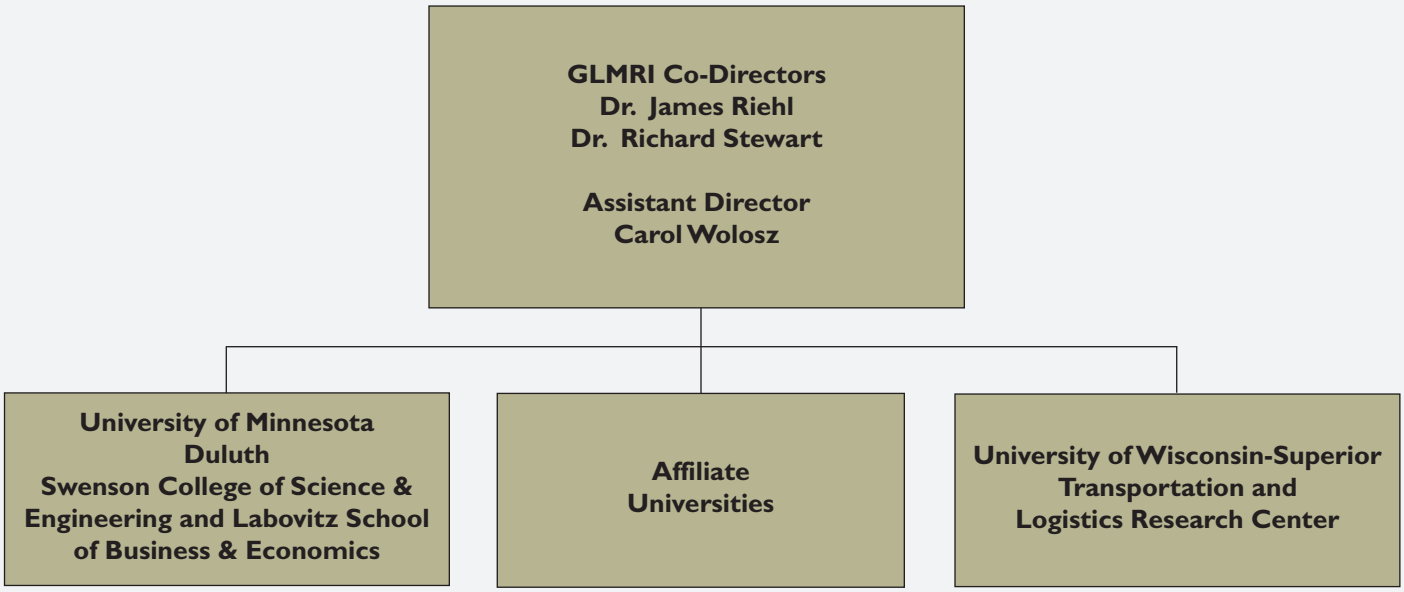


U.S. DOT Maritime Administration, Great Lakes Gateway
Doris J. Bautch
Director, Maritime Administration
Great Lakes Gateway
Schaumberg, IL

Advisory Board

GLMRI's Advisory Board consists of experts in maritime commerce, marine environmental issues or other segments of the Great Lakes marine transportation system. The membership was designed to bring together industry, academia, and government leaders to advise the Co-Directors on the research agenda and to provide input on topical priorities. The Advisory Board can be expanded to include additional relevant stakeholders that agree to participate. The advisory organizations, board members or their delegated representatives are shown above.

Organizational Chart

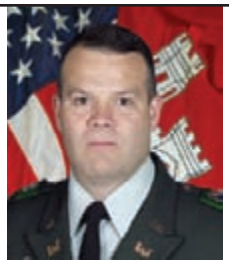


The Society of Naval Architects and Marine Engineers, Great Lakes Section
James Sharrow
Duluth, MN

American Great Lakes Ports Association
Adolph Ojard
Chairman
Duluth, MN

U.S. Coast Guard, Ninth District
Commander Michael Lebsack
U.S. Coast Guard, Marine Safety Unit
Duluth, MN

Great Lakes Commission
David Knight
Special Events Manager
Ann Arbor, MI



U.S. Army Corps of Engineers
Lieutenant Colonel James B. Davis
District Engineer, Detroit District
Detroit, MI

Fall 2008 GLMRI Meetings

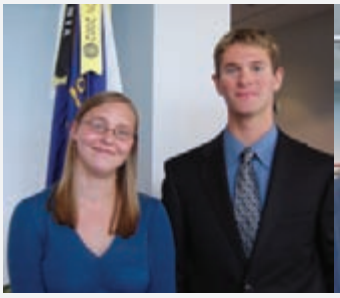
On September 25, 2008, the GLMRI Advisory Board met at the Fairlawn Mansion in Superior, WI. Participating in this year's meeting were: Mr. Craig Middlebrook (Saint Lawrence Seaway Development Corporation), Commander Michael Lebsack (U.S. Coast Guard), Mr. Floyd Miras (U.S. Maritime Administration), Mr. Steven Fisher (American Great Lake Ports Association), Mr. David Knight (Great Lakes Commission), Mr. James Sharrow (Society of Naval Architects and Marine Engineers), Mr. Ken Gerasimos (Lake Carriers' Association) along with Dr. Richard Stewart, Dr. James Riehl, and Ms. Carol Wolosz from GLMRI. Due to a critical maintenance issue at the Soo Lock, the U.S. Army Corps of Engineers advisory board member had to cancel at the last minute.

The group engaged in an open discussion and each agency representative provided an overview of their interests and ties to the GLMRI research agenda and long-range plan for the Institute.

On September 26, a meeting of the affiliate universities was held in the Richard I. Bong World War II Heritage Center in Superior, WI. The agenda for the day's meeting was filled with research presentations on projects from the past year, along with student projects and a presentation on the Finland Collaboration Trip.

A dinner with the combined groups was held on Thursday evening. The gathering provided a venue for individuals to talk and network to share research and ideas for extension of the project results.

The meetings for the coming year have been tentatively scheduled for September 24 and 25, 2009. ❍



FAR LEFT: Lora Skarman and Brad Peot, UW Superior students. LEFT: Ray Hutchison, UW Green Bay and David Doorn, UMD.

Research Affiliates

Universities in the Great Lakes region (states bordered on the Great Lakes and in the Great Lakes watershed) with expertise in the research focus areas may be offered affiliations to partner in applicable areas. Researchers and other relevant assets from the affiliated universities are included as part of the research portfolio of GLMRI, and the affiliate may serve as project researchers based on submitted proposals in response to an annual request for proposals.

In 2008, the University of Wisconsin-Green Bay applied for and was granted affiliate status in the Institute. Also, GLMRI is working with U.S. Maritime Administration personnel to advise other U.S. universities seeking status as National Maritime Enhancement Institutes to build a national platform for university maritime research. In addition to the Finland collaboration, we have initiated discussions with Canadian universities and academics.

Affiliate universities meet annually with GLMRI Directors and the Advisory Board to provide input on future research topics and to discuss current research results. GLMRI maintains an open and continuous dialogue between affiliates to address evolving issues regarding maritime commerce. Research affiliates are encouraged to leverage GLMRI resources to secure independent and joint funding opportunities for Great Lakes maritime research. Matching funding is a significant consideration.

University of Wisconsin-Green Bay

Fritz J. Erickson, Academic Dean
College of Professional and Graduate Studies
2420 Nicolet Drive, WH303
Green Bay, WI 54311-7001

The University of Wisconsin-Green Bay is unique among other state universities in its emphasis on an interdisciplinary, problem-focused educational experience that prepares students to think critically and address complex issues in a multicultural and evolving world. The university enriches the quality of life for students and the community by embracing the educational value of diversity, promoting environmental sustainability, encouraging engaged citizenship, and by serving as an intellectual, cultural and economic resource. UW-Green Bay's Urban and Regional Studies Program, Center for Biodiversity, and Institute for Environmental Management and Business are just a few examples of how the university facilitates research on social and economic development and community development in the greater Green Bay region and beyond.

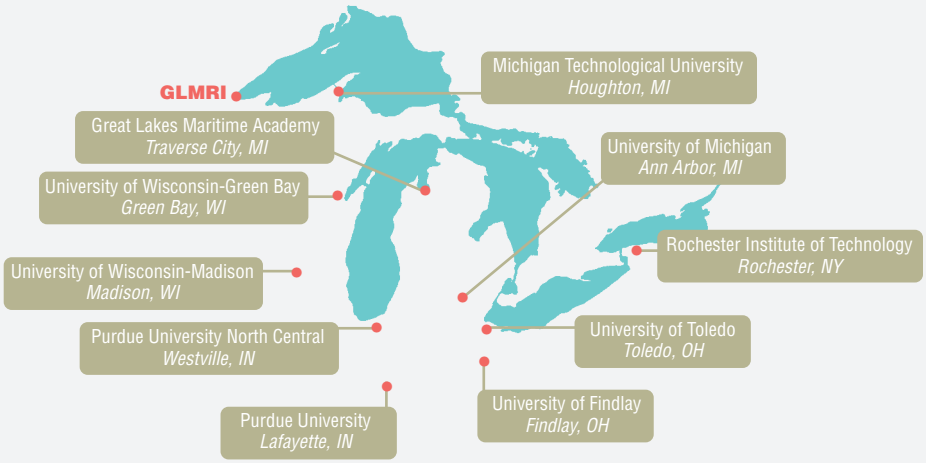
University of Findlay

Mark Alliman, Program Manager
School of Environmental and Emergency Management
1000 North Main Street
Findlay, OH 45840

The School of Environmental and Emergency Management (SEEM) was established as a department within the University of Findlay in 1986 with the initiation of the Bachelor of Science in Hazardous Materials Management Degree.

SEEM's education and training programs include: environmental, safety and occupational health (ES&H); emergency management; public health; school safety and security; and law enforcement. SEEM's maritime security program has developed three courses approved by the U.S. Maritime Administration and is currently developing a course entitled Port & Vessel Security for Public Safety Officials for Department of Homeland Security approval.

Since its inception, SEEM has awarded degrees to more than 1,100 people from the Academic Degree Programs. Also during that time, more than 100,000 people have been trained coast-to-coast.



Great Lakes Maritime Academy

RADM John Tanner, USMS, Superintendent
1701 East Front Street
Traverse City, MI 49686

The Great Lakes Maritime Academy (GLMA) is a division of Northwestern Michigan College (NMC) and a partner of Ferris State University. The Academy trains men and women to serve as business professionals and Merchant Marine officers aboard Great Lakes and ocean ships.

The program is unique among other state maritime academies. GLMA is designated as a regional maritime academy and the nation's only freshwater academy. Upon graduation, mariners are qualified to sail the Great Lakes or oceans and are awarded both a Bachelor's Degree in Business Administration and an Associate's Degree in Maritime Technology. This dual degree combination offers employers the finest maritime personnel who are fully compliant with STCW 95 standards.

Successful cadets will be qualified to take the U.S. Coast Guard examination for a Third Mate Great Lakes or Oceans Unlimited Tonnage, First Class Pilot Great Lakes (Deck Program) or Third Assistant Engineer, Steam and Motor Vessels of any Horsepower (Engineering Program).

University of Michigan

Dr. Armin Troesch, Chair
Department of Naval Architecture and Marine Engineering
2600 Draper Drive
Ann Arbor, MI 48109

Students in the Department of Naval Architecture & Marine Engineering at the University of Michigan learn how to design/analyze ships and the other complex marine systems for a demanding and often harsh environment. In addition to the more traditional disciplines of naval architecture and marine engineering, the program offers courses and research opportunities in offshore engineering and coastal engineering. Graduates can be found in the U.S. Navy and other navies of the world, the U.S. Coast Guard, offshore companies, shipyards, marine design firms, shipping companies, research laboratories, peer academic institutions, etc.

Michigan Technological University

William J. Sproule, Professor
Department of Civil and Environmental Engineering
1400 Townsend Drive
870 Dow Environmental Sciences and Engineering Building
Houghton, MI 49931-1295

Michigan Technological University is located in Houghton, Michigan on the Keweenaw Peninsula of Michigan's Upper Peninsula. Michigan Tech was founded in 1885 as a mining school to support the copper mining industry. Since then the university has grown to over 7,000 students and has become one of the leading technological universities in the country with outstanding degree programs in arts, humanities and social sciences, business and economics, computing, engineering, forestry and environmental science, natural and physical sciences, and technology.

The Department of Civil and Environmental Engineering has 25 faculty, 25 professional staff, and over 500 undergraduate and 100 graduate students. Annual research funding in the department exceeds $4.5 million and faculty are involved with several research institutes and centers on campus including the Michigan Tech Transportation Institute, University Transportation Center, Michigan Tech Research Institute, Sustainable Futures Institute, Remote Sensing Institute, and the D80 Center which includes a graduate partnership with U.S. Peace Corps. The department is also the home for Michigan's Local Technical Assistance Program, a Tribal Technical Assistance Program, and the Western Upper Peninsula Center for Science, Mathematics and Environmental Education for K-12 science and mathematics teaching and outreach programs. The department owns and operates the research vessel, *R.V. Agassiz*, for research work on Lake Superior.

Research Affiliates

How to become an affiliate

Universities seeking to obtain affiliate status should provide a request to the GLMRI Program Office with details on the capabilities and assets that they would bring to support the mission of GLMRI, along with an expected interest area for future research endeavors. Requests are evaluated by the Institute co-directors for affiliate status in GLMRI. University Affiliates' Agreements are reviewed annually.

GLMRI funding for research proposals is granted only to University Research Affiliates, and only proposals from GLMRI University Research Affiliates will be accepted for funding consideration.

Purdue University North Central

Dr. Thomas F. Brady
Department Chair, Engineering Technology
1401 South U.S. Hwy 421
Westville, IN 46391

The Purdue University North Central College of Engineering and Technology provides degree programs in technical disciplines and engagement assistance in economic development for citizens in north central Indiana. The college has conducted research in the areas of coal transportation infrastructure, electricity distribution and control, and simulation of large scale systems.

Purdue University

Dr. Lynn A. Corson, Director
Clean Manufacturing Technology Institute
Center for the Environment
2655 Yeager Road, Suite 103
West Lafayette, IN 47907-2108

The Clean Manufacturing Technology Institute (CMTI) was established at Purdue University in 1994 as the successor organization to the Environmental Management and Education Program founded there in 1984. CMTI staff provide technical assistance, outreach, training and research services to manufacturers and government entities on environmental regulatory compliance, process engineering efficiencies, pollution prevention/clean manufacturing, energy conservation and ISO 14001 Environmental Management System conformance.

CMTI is supported by grants and agreements with federal and state government agencies, trade associations and private and non-profit corporations. It has provided services to more than 3,500 manufacturers and 250 local, state and federal government entities.

R•I•T

THE UNIVERSITY OF TOLEDO 1872

THE UNIVERSITY of WISCONSIN MADISON

CFIRE

Rochester Institute of Technology
Dr. James Winebrake, Co-Director
Laboratory for Environmental Computing and Decision Making
92 Lomb Memorial Drive
Rochester, NY 14623

Rochester's Great Lakes Research Program is housed in the RIT Laboratory for Environmental Computing and Decision Making (LECDM). The LECDM has a central focus of studying freight movement, transportation logistics, environment, and cyberinfrastructure. Its' goal is to improve freight-related transportation decision-making by advancing and integrating environmental cyberinfrastructure tools and modeling techniques into supply chain logistics analyses. The Great Lakes Research Program is aimed at understanding and improving the efficiency and environmental footprint of intermodal cargo flows in and around the Great Lakes.

University of Toledo
Richard Martinko, Director
Intermodal Transportation Institute & University Transportation Center
2801 West Bancroft Street
Toledo, OH 43606

The Intermodal Transportation Institute at The University of Toledo as a partnership focuses on Transportation for Economic Security and Development: Alternate Energy, Infrastructure Utilization, and Supply Chains. These are critical transportation issues that substantially impact the ability of the U.S. to compete in an increasingly competitive global marketplace. Future economic growth and development are closely linked to the capability to move goods and people rapidly and efficiently while avoiding negative environmental impacts. The University of Toledo is designated as a U.S. Department of Transportation University Transportation Center with these same focus areas.

University of Wisconsin-Madison
Dr. Teresa Adams, Director
National Center for Freight and Infrastructure Research and Education
1415 Engineering Drive, Room 2205
Madison, WI 53706

The University of Wisconsin-Madison is home to the National Center for Freight and Infrastructure Research and Education (CFIRE). CFIRE is a USDOT National University Transportation Center with a research, training, education, and outreach focus on Sustainable Freight Transportation Infrastructure and Systems. CFIRE has an annual budget of approximately $6 million. CFIRE coordinates the Mississippi Valley Freight Coalition, a 10-state regional organization to cooperate in the planning, operation, preservation, and improvement of freight transportation infrastructure and networks in the AASHTO Mississippi Valley Conference region.

2008 Special Projects

By Stacey Carlson
Associate Researcher

TOP: Delegation visiting the Saimaa Canal in Lappeenranta, Finland.

ABOVE: Jorma Rytkönen, Captain Kari Riutta, and Richard Stewart standing by the Finnish naval ship, the SUOMEN JOUTSEN in the Port of Turku.

RIGHT: Container operations in the Port of Kotka.

Tour of Finland's Maritime Community

In June 2007, a partnership was formed that would bring together maritime interests from the Great Lakes and Finland. Dr. Richard Stewart, Co-Director of the Great Lakes Maritime Research Institute (GLMRI), and Professor Jorma Rytkönen, Research Director of Maritime and Port Operations for the Kymenlaakso University of Applied Sciences, understood that with the similarities of the environment, climate, and industry of the Great Lakes and the Baltic Sea, a partnership would benefit government and maritime industry officials, researchers, and students. Among the collaborative program's goals is the initiative to coordinate joint research projects, provide outreach to the maritime industry, and facilitate student, faculty, and researcher exchange.

In September 2008, GLMRI furthered that initiative by organizing and co-sponsoring a tour of Finland's maritime industry. The week-long agenda brought Great Lakes and coastal shipping advocates to the Baltic Sea to observe maritime operations. The six person group traveling to Finland consisted of Dr. Richard Stewart and Stacey Carlson from GLMRI; Adolph Ojard, Duluth Seaway Port Authority; Dave Knight, Great Lakes Commission; Craig Middlebrook, Saint Lawrence Seaway Development Corporation; and James Frost of CPCS Transcom, Ltd., Canada. Professor Jorma Rytkönen accompanied the group throughout the week.

Wanting to incorporate the interests of the participants while creating partnerships to further the goals of the GLMRI/Finnish cooperative, it was determined the week-long agenda would include multiple port tours and meetings with port personnel and maritime industry representatives, an introduction into both Baltic and Finnish governmental and non-governmental agencies, and discussions with academic and research personnel. Overall, the main focus of the trip was an in-depth look into shipping operations on the Baltic Sea, and specifically those surrounding the Finnish maritime industry.

Map of Baltic Sea region.

U.S. - Canadian Delegation (left to right): Stacey Carlson and Dr. Richard Stewart from GLMRI, James Frost of CPCS Transcom, Ltd. Canada, Adolph Ojard, Director of the Duluth Seaway Port Authority and Chairman of the American Great Lakes Ports Association, Craig Middlebrook, Deputy Administrator from the St. Lawrence Seaway Development Corporation and David Knight from the Great Lakes Commission.

Ports

Port visits included the Finnish ports of Vuosaari, Kotka, and Turku, and the Estonian Port of Tallinn where the group met with Port Directors and other port personnel. In visiting these ports, the delegation observed many aspects of maritime shipping: containerization, bulk and liquid cargo, passengers, and railcars.

The Port of Vuosaari has been a decade-long project in the making and scheduled to commence operations in November 2008. The development of the port, roughly 15 km east of Helsinki, began when sustainable growth in Helsinki was identified as a key point in long-term planning. The idea to move current operations out of the City of Helsinki to an outlying location was initiated in order to decrease congestion, noise, and emissions in the city center. The population of Helsinki is roughly 570,000 with a population of 1.3 million in greater Helsinki. Compare that to Milwaukee, Wisconsin, with a population over 602,000 and 1.96 million in the greater Milwaukee area. Current port-operated land in Helsinki will be turned into condominiums, marinas, and public parks in the future. The Port of Vuosaari will be 370 acres, have 20 new berths, and primarily handle ro-ro and feeder vessels with an expected annual throughput of 450,000 TEUs. Passenger traffic will remain in the city center.

The Port of Kotka handles over 10 million tons of cargo a year and is the largest container handling port in Finland, surpassing the 460,000 TEU mark in 2006. Kotka is the largest port near the Russian border, through which products are moved to Russia and the Finnish hinterland. Kotka has traditionally been the largest export handling port in Finland; exports through the port include forestry and liquid bulk products while imports include general cargo and dry bulk products. 2007 statistics show that of the traffic moving through the Port of Kotka, 46% is export cargo, 28% is import cargo, and 26% is transit cargo. The population of Kotka is 54,000, nearly half the population of Green Bay, Wisconsin at just over 100,000.

More than four million tons of cargo move through the Port of Turku each year, along with four million passengers. Eighty percent of the traffic moving through the Port of Turku is ro-ro traffic, of which 20% are rail cars. (Turku is the only train ferry port in Finland.) Daily scheduled liner service includes five vessel transits from Turku to Sweden, and one from Turku to Germany. In addition, transits from Turku to England and other North Sea countries occur once every few days. These transits consist of both passenger and cargo movements. Additional cargo handled includes nearly 100,000 cars on a yearly basis, with 39% being shipped to Russia. The population of Turku is just over 175,000, compared to populations of the cities of Duluth, Minnesota and Superior, Wisconsin at 112,000.

The delegation saw firsthand the lively ferry and cruise ship industry in the Baltic Sea when riding the Tallink Lines ferry, the *Superstar*, from Helsinki to Tallinn, Estonia. The two hour ferry ride was one of nearly 30 ferry trips scheduled that day between Helsinki and Tallinn. The Port of Tallinn consists of five harbors handling 40 million tons of cargo annually. The majority of the traffic calling on the Port of Tallinn, however, is passenger traffic. To give you an idea of the extent, consider that Estonia as a country has a population of 1.3 million people and every year, roughly 7 million people travel to Tallinn either by ferry or cruise ship.

Government and Non-governmental Agencies

Compared to the eight U.S. states and two Canadian provinces that border on the Great Lakes St. Lawrence Seaway System, the Baltic Sea region includes nine countries that work together to ensure safe navigation, environmental stewardship, and sustainable maritime commerce on the Baltic Sea. The delegation was introduced to the Finnish Maritime Administration (FMA) and the Helsinki Commission (HELCOM), two such agencies that work across borders to provide for sustainable maritime shipping.

With the similarities between the St. Lawrence Seaway and the Saimaa Canal, a trip to the operational headquarters in Lappeenranta was a natural fit. The Saimaa Canal, 43 km in length, was opened with the current eight lock system in 1968 though the canal connected the Saimaa Lake District to the Baltic Sea as early as 1856 with smaller locks. While five of the eight locks are in Russia, the canal is leased to Finland and operated and maintained by the FMA. Similar to the St. Lawrence Seaway, the Saimaa Canal is closed to navigation for 2½ months every winter. It is a fully-automated system, with the Vessel Traffic Service (VTS) and Operational Command Center in Lappeenranta.

With roughly 110,000 ship transits in the Baltic Sea every year and nearly 40,000 into Finnish ports, the Helsinki VTS, operated by the FMA, is a busy place. The FMA controls over five sectors, including three on the west coast of Finland, the Gulf of Finland, and the Saimaa Canal. Ships must follow mandatory reporting requirements via both VHS and the Automated Identification System (AIS) once in Finnish waters.

2008 Special Projects

RIGHT: A Unifeeder vessel, the ANNE SIBUM, is 152 meters in length with a 1,036 TEU capacity and operates in the Baltic.

Icebreaking and winter navigational operations are maintained by the FMA through a partnership with neighboring Sweden. FMA controls the movements of eight Finnish icebreakers by supplying navigational information through satellites provided by an icebreaking network called IBNET. This network is used and maintained by both Finland and Sweden and provides data on ice coverage, thickness, and wind direction to assist icebreakers and merchant ships transiting Finnish waters.

HELCOM's primary focus is to protect the marine environment of the Baltic Sea while supporting sustainable economic and social activities. HELCOM was established in 1974 and represents 10 entities, the nine countries bordering the Baltic Sea and the European Community. HELCOM, which works closely with the International Maritime Organization (IMO), unanimously adopts recommendations that mirror its primary goals which individual countries, in turn, must then act on through legislation.

Academic and Research Programs

The Great Lakes and the Baltic Sea region share physical similarities, such as the climate, flora, fauna, and topography, while also paralleling on social, economic, environmental, and political issues like the introduction of exotic species, impacts of global climate change, winter navigation, freshwater shipping, pollution, and the visibility and increased use of maritime commerce. Throughout the week, the delegation and its Finnish partners discussed the possibilities of joint research projects and student, researcher, and faculty exchange programs.

Research presentations were provided by the Kymenlaakso University of Applied Sciences in Kotka and Dr. Richard Stewart provided a presentation to a group of sea cadets, faculty and staff members on GLMRI research, U.S. maritime education, and Great Lakes operations. Kymenlaakso University's undergraduate and graduate studies include Finnish curriculum in Logistics Engineering, Seafaring, Maritime Administration, and Marine Technology. Kymenlaakso University currently offers three degrees in English: undergraduate degrees in International Business and Design, and a graduate degree in International Business Management.

Researchers at the VTT Technical Research Centre of Finland provided an in-depth look at past and current research projects that focus on winter navigation, icebreaking operations, ballast water research, and AIS/VTS systems. Established in the 1940s, the VTT Technical Research Centre in Espoo, Finland, is an impartial, expert organization that participates in research and development of areas such as transportation and logistics, engineering, environmental planning, energy, and information and technology services.

The delegation also traveled to the Radio Frequency Identification (RFID) Lab in Vantaa, outside of Helsinki, a facility that focuses on RFID research in the logistics industry. The delegation was provided demonstrations on inventory management, showing the increased RFID capabilities in tracking, inventory control, and security.

Maritime Industry Companies

The delegation also had the opportunity to visit with privately-owned companies operating throughout the Finnish maritime community. Two of the goals for this trip were to visit with short sea shipping and shipbuilding companies. Meetings with Unifeeder, the Aker Arctic Research Center, and Aker Yards provided insight into company histories, primary business initiatives, and operations in Finland.

Unifeeder is the largest feeder vessel line operating in the Baltic Sea. The Danish company, established in 1977 with offices in six countries, provides feeder service from the European continent to Baltic Sea ports on feeder ships that carry upwards of 1,000 TEUs. Feeder service (port to port movements) accounts for 90% of Unifeeder's business while short sea shipping (door to door movements) covers the remaining 10%. Unifeeder moves roughly 2 million TEUs annually, with 400,000 of those TEUs moving through Finnish ports.

The Aker Arctic Research Center in the new Port of Vuosaari houses the world's only privately-owned ice testing facility. Aker Arctic is involved in field research, model and full scale testing, ship designs, and consultation in icebreaking operations and ship movements. Aker Arctic Research Center has been involved in the design and testing of icebreakers and ice-going vessels, including U.S. Coast Guard icebreakers and the oil tanker/icebreaker *SS Manhattan*, the first ship to cross the Northwest Passage in 1969.

Aker Yards operates three shipyards in Finland: the Helsinki yard which specializes in car-passenger ferries; the yard in Rauma which specializes in ferries, icebreakers, and naval craft; and the yard in Turku which specializes in cruise ships. Aker Yards employs nearly 3,800 in these three yards and has 300 more employees in other facilities throughout Finland. The delegation visited the yard in Turku where they received a rare tour of a cruise ship currently under construction, the *Oasis of the Seas*. The cruise ship, set to launch in 2009, is 360 meters long, 16 decks high, and will carry over 5,000 passengers. A sister ship, *Allure of the Seas*, was in the beginning building stages and is set to launch in 2010. ❍

RIGHT: GLMRI Co-Director Richard Stewart picks a student to be a "Captain for a Day" while discussing how ships navigate safely in the Duluth-Superior Harbor.

BELOW: A group of sixth-graders point out the Duluth-Superior Harbor on a chart of Lake Superior while GLMRI Associate Researcher Stacey Carlson helps "navigate" the discussion.

2008 St. Louis River Quest

GLMRI participated in the 16th annual St. Louis River Quest in Duluth, Minnesota, on May 14-16, 2008. River Quest is an educational program for area sixth-graders to help them understand and better appreciate the Duluth-Superior harbor and St. Louis River by teaching them about making good environmental decisions, being safe on the water, and understanding local shipping activities. GLMRI presented information on aids to navigation in the harbor, navigational charts, and how a ship's captain safely navigates when entering the Duluth Ship Canal. Other presenter topics during the three-day event included boating safety, pollution prevention, surface water runoff, water quality, and loading and unloading practices for ships. ❍

2008 Special Projects

LEFT: Carol Wolosz, MTSNAC Member

RIGHT: Dr. Michael Parsons

Marine Transportation System National Advisory Council Membership

In October 2007, GLMRI was appointed by the Secretary of the Department of Transportation, Mary Peters, to a 3-year term on the Marine Transportation System National Advisory Council. The council was established in 2000 to advise the Secretary on matters relating to the Marine Transportation System—waterways, ports, and their intermodal connections. It is comprised of 30 representatives for transportation-related organizations.

Carol Wolosz attended the meetings and provided updates on GLMRI research and activities in January and June. In June, Dr. Stewart also attended the Council meeting and provided a presentation on a proposal to establish true marine intermodal service throughout the Great Lakes and also discussed the minimal focus on maritime transportation through university research and the University Transportation Centers (UTCs). He also asked the Council to build support for federal funding for the DOT/MARAD National Maritime Enhancement Institutes. ❍

Media Coverage

Dr. Michael Parson's GLMRI-funded project at the University of Michigan is highlighted in a 5-minute video describing Ballast-Free Ship model testing. The video, which shows the model during the hydrodynamic tank testing, is receiving a great amount of interest from regional, national, and international news outlets. The news release has been picked up by the UPI and the Washington Post, along with gleaning interest from the Discovery Channel Canada and Down to Earth science magazine in India. The press release and video link are accessible from the GLMRI web page.

Great Lakes/Seaway Review has been a great venue for GLMRI research dissemination over the past few years. In the September-December 2008 edition, the magazine was full of GLMRI projects, along with an article written by Dr. Stewart on short sea shipping on the Great Lakes. The magazine covered Dr. Parsons' Ballast-Free Ship Design, Dr. Pope's Bio-Diesel research, Dr. David Singer's Ship Building Analysis and the GLMRI-sponsored trip to Finland. In the January-March 2008 edition, the magazine published an article highlighting the progress of the GLMRI data project at the University of Toledo under Dr. Peter Lindquist's management. In the October-December 2007 edition, *Great Lakes/Seaway Review* highlighted Dr. Stewart's career—a must read! ❍

Samir Dhar, Outstanding Student of the Year.

GLMRI Project Grad Student Receives Award

Samir Dhar was selected as the 2007 Outstanding Student of the Year and was recognized by the Council of University Transportation Centers at the January Transportation Research Board meeting. Samir is the primary programmer for the University of Toledo's Great Lakes Maritime Data Clearinghouse. Congratulations Samir! ❍

Loading coal at Midwest Energy Resources Company, Superior, Wisconsin.

Key Maritime Leaders' Breakfast

In January 2008, U.S. Maritime Administration (MARAD) Administrator Sean Connaughton paid a visit to the Twin Ports of Duluth, MN and Superior, WI. GLMRI sponsored a breakfast meeting with key area leaders to discuss issues impacting maritime commerce in the Great Lakes region. Attendees included Administrator Connaughton; local staff directors from Congressmen Oberstar's and Obey's regional offices; Rear Admiral Crowley, Commander of the Coast Guard Ninth District; the mayors from the cities of Duluth, MN and Superior, WI; the Port Director from U.S. Customs and Border Protection; President of Fraser Shipyards; President of Lake Carriers' Association, and many other key agency representatives. Potential topics for future GLMRI involvement were considered and will be researched as possible focus areas.

Administrator Connaughton also toured the Midwest Energy Resources Co. facility and the Ballast Water Treatment Testing facility in Superior. This was the first visit by a MARAD Administrator to the Twin Ports since the 1990s. ❍

2008 Special Projects

RIGHT: Richard Bibby.

BELOW: WWII Veterans with event officials (l to r): Robert Fuhrman, Melvin Hall, Leo Franklin, Floyd Miras, Richard Bibby, Ken Johansen, and Richard Stewart.

WWII Merchant Marine Veterans Recognized and Honored

In conjunction with the September Annual Meetings, GLMRI co-sponsored, along with the Richard I. Bong WWII Heritage Center, a reception and program to honor Merchant Marine Veterans in the Duluth-Superior area.

Dr. Richard Stewart, Master Mariner, former Captain in the Naval Reserves and a graduate of the U.S. Merchant Marine Academy at Kings Point, NY, was Master of Ceremonies for the event. Mr. Floyd Miras, from the U.S. Maritime Administration Great Lakes Gateway Office, presented a slate of medals for the Richard I. Bong WWII Veterans Heritage Center to WWII Merchant Marine Veteran Mr. Richard Bibby of Duluth. Mr. Robert Fuhrman, Director of the Bong Heritage Center provided an overview of the museum and the collection initiative.

During WWII the merchant marine fleet cargo and the destinations were controlled by the U.S. government. Also, the government contracted with private companies to operate the ships, and put guns and NAVY personnel on board. The U.S. Maritime Service trained the mariners to operate the ships and assist in manning the guns. According to the War Shipping Administration, a total of 1,554 merchant ships were sunk due to the war conditions and over 8,000 merchant marines lost their lives which was the highest casualty rate of any branch of service. After a long court battle, some WWII merchant mariners received veteran status on January 19, 1988. ❍

RIGHT: Richard Bibby, Wes Harkins, Adm. John Tanner, Superintendent at the Great Lakes Maritime Academy, and Gil Proter.

MIDDLE: Onboard tour of 1,000-foot self-unloader.

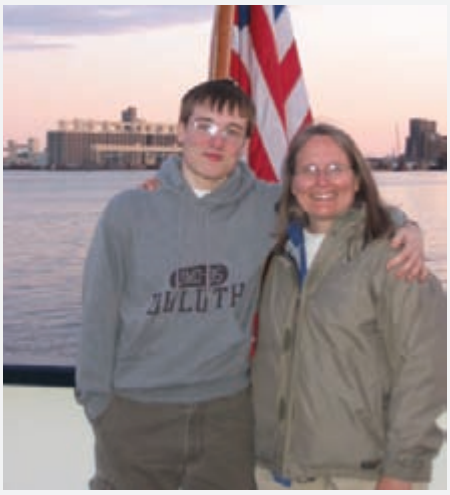
BOTTOM: Alex Stewart & Kathy Collins.

Great Lakes Maritime Academy Visit

In May, the *Training Ship State of Michigan* had its third visit to the port of Duluth/Superior. GLMRI co-hosted a reception and harbor tour on the ship with the Great Lakes Maritime Academy. This year's reception focused on local educators, teachers, advisors and administrators from area K-12 schools were invited to learn about career opportunities in shipping, and meet the staff and cadets on the *TIS State of Michigan*. Coincidentally, one of the Maritime Academy Cadets onboard was a graduate from Duluth's East High School.

In addition to the ship's staff and cadets, about 45 guests participated in the evening tour. Many were able to see the ship leave the harbor and pass under the Aerial Duluth Lift Bridge on its return voyage to Traverse City, MI.

Over the 2 days that the ship was in port, in addition to the reception, the ship was open for guided tours and landside viewing behind the Duluth Entertainment and Convention Center. ❍



Research Focus FY 08

FAR RIGHT: Climbing aboard the AMERICAN INTEGRITY for the K-12 Teachers' Workshop tour.

RIGHT: Joan Chadde, MTU and Tom Nicodemus, Midwest Energy Resources Co., Superior, Wisconsin view self-unloader technology.

This annual report depicts nine projects that were selected through a competitive process and review that commenced in April 2007. The annual call for proposals was released to the consortium and affiliate universities with proposals due in June. A total of 20 proposals were received from nine of the eleven consortium and affiliate universities, requesting over $1.3 million. An initial review was performed by the staff and co-directors. External reviewers were selected based on the content/topic of the proposal. Maritime experts participated from the Maritime Administration, U.S. Coast Guard, Great Lakes port authorities, and academia. Proposals were prioritized, and a funding plan was developed within constraints of available resources. Proposers were notified of the decisions regarding their individual requests, along with a summary of the reviewer feedback. Since many of the projects were offered a lesser dollar amount than their requests, the proposers were asked to provide an updated work plan and budget to allow for the reduced funding.

The following nine projects were awarded fo FY 08:

- Great Lakes Maritime Education Program for K-12 Teachers, Students and Communities (**Michigan Technological University**)
- Application of an Environmental Management System "Model" to Examine Port and Tenant Operations and Provide a Tool to Small Public Port Authorities for Enhancing Environmental Initiatives (**Purdue University**)
- Intermodal Freight Transport in the Great Lakes: Development and Application of a Great Lakes Geographic Intermodal Freight Transport Model (**Rochester Institute of Technology**)
- Further Development and Optimization of the Ballast-Free Ship Design Concept (**University of Michigan**)
- Erie Pier Process Re-Use Cost and Market Analysis (**University of Minnesota Duluth**)
- Year 2: Building Sustainable Solutions to the Issues of Ballast Water Treatment: Testing Relationships Between Propagule Pressure and Colonization Success of Invasive Species (**University of Minnesota Duluth** and **University of Wisconsin-Superior** with The Great Ships Initiative under the Northeast Midwest Institute)
- Development and Succession of Microbial Communities Associated with Corroding Steel Pilings in the Duluth-Superior Harbor (**University of Minnesota Duluth**)
- Shipboard Testing of B-20 (**University of Minnesota Duluth**)
- The Great Lakes Maritime Information Delivery System: A Resource for the Regional Analysis of Intermodal Freight Flows in the Great Lakes Region (Phase III) (**University of Toledo**) ❍

Research focus topics included:

- Evaluate short sea shipping market opportunities on the Great Lakes
- Evaluate export and import markets for foreign trade between ports on the Great Lakes and foreign ports such as those located in Europe and Africa
- Evaluate the environmental benefits of waterborne transportation in the Great Lakes region and assist in developing sustainable solutions to the environmental effects of maritime transportation and port operations
- Analyze the methods and effects of taxes and fees imposed on Great Lakes shipping
- Evaluate the state of shipbuilding and repair bases on the Great Lakes and the impact to the industry and national security
- Analyze the origin-to-destination flow of freight in the Great Lakes

FY 09 Research Project Selections

- Analyze the economic viability of establishing transshipment facilities and intermodal for ocean-going and intra-lake cargoes on the Great Lakes, which may include the evaluation of 12-month operations of the locks and shipping lanes
- Evaluate new vessel designs for domestic and international shipping on the Great Lakes
- Develop new products and technologies to enhance port security and port operations
- Provide education and outreach activities to the public on Great Lakes maritime shipping, port security and intermodal operations
- Identify ways to improve the integration of the Great Lakes Marine Transportation System (MTS) into the national transportation system
- Examine the potential of expanded seasonal operations on the Great Lakes MTS
- Identify ways to include intelligent transportation applications into the Great Lakes MTS
- Analyze the effects and impacts of aging infrastructure and port corrosion on the Great Lakes MTS
- Establish and maintain a model Great Lakes MTS database
- Identify market opportunities for, and impediments to, the use of U.S.-flag vessels in trade with Canada on the Great Lakes

GLMRI released the fourth annual request for proposals (RFP) on March 12, 2008. The program office received a total of 16 proposals from 9 of the 12 affiliate and consortium universities totaling over $1.1 million. After an extensive review process by officials from academia, the maritime industry and governmental agencies, GLMRI announced the following eight project awards for FY 09:

- Development of a Performance Evaluation Methodology for the Port/Terminal Sector Participation in the Green Marine Voluntary Environmental Program of the Saint Lawrence and Great Lakes Maritime Industry (**Purdue University** - Dr. Lynn Corson)
- Energy, Economic, and Environmental Tradeoffs associated with Freight Transport in the Great Lakes Region: Development and Application of the Great Lakes Geospatial Intermodal Freight Transportation Model (**Rochester Institute of Technology** - Dr. James Winebrake)
- Cold Flow Testing of Biodiesel Blends with Additives (**University of Minnesota Duluth** - Dr. Daniel Pope)
- Determining if Microbiologically Influenced Corrosion is Responsible for the Accelerated Loss of Port Transportation Infrastructure (**University of Minnesota Duluth** - Dr. Randall Hicks)
- Erie Pier Process Re-Use Facility Phase II: An Optimized Cost-Effective Strategy for Increased Transport and Handling of Dredged Materials (**University of Minnesota Duluth** - Drs. Hongyi Chen and Rodger Brannon)
- Year 3: Building Sustainable Solutions to the Issue of Ballast Water Treatment: Testing Relationships between Propagule Pressure and Colonization Success of Invasive Species (**University of Minnesota Duluth** - Dr. Donn Branstrator, along with the **University of Wisconsin-Superior's** Lake Superior Research Institute and Great Ships Initiative)
- The Great Lakes Maritime Information Delivery System: A Resource for the Regional Analysis of Intermodal Freight Flows in the Great Lakes Region (Phase IV) (**University of Toledo** - Dr. Peter Lindquist)
- Great Lakes Marine Container Service Feasibility, Study: Connecting Green Bay to Global Container Service providers serving ports on the St. Lawrence Seaway (**University of Wisconsin-Green Bay** - Dr. Earl Ray Hutchison) ❍

Erie Pier Process Re-use Facility Cost Analysis

Principal Investigator
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Although many ports face Confined Disposal Facility (CDF) capacity pressure, the Duluth-Superior Port has an urgent need to implement an alternative plan to the status quo for dredged materials. This project was proposed to determine cost accounting and capital budgeting for a proposed Process Re-use Facility (PRF). Previous work, such as the U.S. Army Corps of Engineers' Dredged Material Management Plan (DMMP) for the Duluth Superior Harbor, April 1999, and the Duluth Superior Metropolitan Interstate Council's Erie Pier Management Plan, June 2007, identified possible re-uses for dredged material. The possible customer list included mine-land reclamation projects, construction sites, road construction, daily landfill cover, topsoil creation and enhancement, habitat restoration, and habitat creation.

For budgetary purposes, it could be appropriate to assume that annually, 48,000 yards of coarse material (sand) and 50,000 yards of fine material (clay and other material) are available from the Erie Pier. In addition, the pier contains a removable total accumulation of 1,250,000 yards of fine material. These and other assumptions were estimated with the help of the Duluth-Superior Harbor Technical Advisory Committee's Dredging Sub-committee.

A wide range of possible customers were considered, and feasible customers were determined from potential customers, through phone interviews, and data collection on landed cost, competition, and supply chain for various markets. Of special interest were long-term projects such as the 21st Avenue West Habitat Restoration. Potential customers were drawn from the industry sectors of Compost, Topsoil, Construction, Ground Cover, Soil Enrichment, Land Fill, and Mine Reclamation.

Discussion covered aspects of product markets for feasible partners and the demand market for Erie Pier fines. Given that transportation is the largest cost for any of the identified applications of dredged material from Erie Pier, estimations were offered to compare transportation time per project. Distances ranged from more than a hundred miles, such as landfill cover at distant sites and reclamation at mines on the Iron Range, to projects in direct proximity to Erie Pier and the Duluth-Superior Harbor, such as Sky Harbor Airport and the CN Railroad Ore Docks. The ranked list of projects included travel times between four hours and several minutes.

Possible projects also included the perception that the scale of the project (in cubic yards) is of interest, given the amount of material currently stock piled at the CDF. The estimation of project scale in terms of cubic yards was presented and ranked by demand in cubic yards. Based on assumptions suggested in phone interviews with possible customers, total cubic yards of demand per project ranged from nearly six thousand cubic yards (for small-scale mine reclamation test projects) to a million cubic yards (for construction fill associated with power plant development).

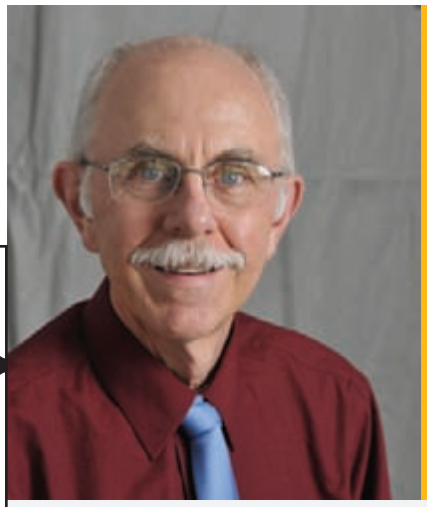
Recurring projects are of interest given that distance and time are greater drivers of cost than scale. Recurring projects lend themselves to getting the existing material out. Non-recurring projects assume the use of subsequent years' dredging (to avoid moving material twice). Erie Pier managers may need to establish an optimal steady-state between recurring and non-recurring re-use projects for fines material.

Although possible customers have alternatives to using Erie Pier materials, the most competitive attributes of the fines materials include: 1) easy access to site from I-35 with the possibility of improved infrastructure so that rail could be used to transfer large quantities, 2) a product relatively free of contaminants such as heavy metals and present but manageable noxious weed infestation, and 3) the price for material as a commodity could be minimal, or zero for the customer.

Important competitive disadvantages of Erie Pier fines material include: 1) customers may be unaware of materials and its availability, 2) seasonality of the site with regard to dewatering, dredging scheduled and climate related hardships, 3) regulation requirements, 4) application difficulties related to the clay component of the fines material, 5) tipping fees, and 6) the possible need for public funding to improve the site and accessibility to materials.

Two estimates are presented in this analysis. The first estimate is for total cost of fixed and variable costs. The second estimate is for incremental or out-of-pocket costs for fixed and variable costs. These two analyses differentiate between purchasing new equipment for the facility and using existing equipment.

Cost-Volume-Profit (or break-even without revenues) calculations are based on an identification of the total costs. We identify the cost per yard to move a specific amount at a specific distance, in order to estimate the least cost per yard. This calculation also suggests the



Rodger L. Brannan BA, MIM, MBA, Ph.D., CPA (Inactive) is an associate professor of accounting in the Labovitz School of Business and Economics at the University of Minnesota Duluth. He received his Ph.D. in business administration (accounting and public administration) from the University of Nebraska-Lincoln. He also holds a Master's of Business Administration from the University of Puget Sound and a Master's in International Management from the American Graduate School of International Management (Thunderbird). His current research interests include government and not-for-profit, accounting and business history, and cost and strategy.

TOP: Sand ready for removal at entry to southwest.

BOTTOM: Filtering lagoon at Erie Pier Confined Disposal Facility, Duluth-Superior Harbor. (Source: Jean Jacobson)

appropriate subsidy to cover that cost.

The analyses show that the faster the trucks move, the more cost-effective it is to truck the material. A calculation for total cost and incremental cost shows at what point it is cost effective to switch to RailMate, which connects multiple semi-trailers to a train for a point-to-point road to rail delivery of commodity products. (As a practical limitation, this is feasible only if you have access to a railroad and the RailMate technology.) The Total Cost turning point to switch from truck to RailMate, at 40 mph, intersects RailMate at 101.56 miles; and at 50 mph, intersects RailMate at 128 miles. The Incremental Cost turning point to switch from truck to RailMate, at 40 mph, intersects RailMate at 101.56 miles; at 50 mph, intersects RailMate at 128 miles.

The total landed cost per yard for the RailMate System, or the cost per yard to move the material via the RailMate system for distances of 100, 150, and 200 miles (no data for 50 miles) is estimated at $19.44 per cubic yard. The total landed trucking cost per yard, or the cost per yard to move the material via a truck at a given average speed for a given distance, with one half hour of transit time to the move for loading and unloading, is estimated at between $16.33 and $49.67 for speeds of 25 mph; at between $12.17 and $33.00 for speeds of 40 mph; and between $10.78 and $27.44 for speeds of 50 mph.

The incremental (out-of-pocket) landed cost

continued

Full research reports are available at www.glmri.org

Erie Pier Process Re-use Facility Cost Analysis

(Continued)

per yard for the RailMate System, or the cost per yard to move the material via the RailMate system for distances of 100, 150, and 200 miles (no data for 50 miles) is estimated at $18.73 per cubic yard. The total landed trucking cost per yard, or the cost per yard to move the material via a truck at a given average speed for a given distance, with one half hour of transit time to the move for loading and unloading, is estimated at between $15.62 and $48.96 for speeds of 25 mph; between $11.46 and $32.29 for speeds of 40 mph; and between $10.07 and $26.73 for speeds of 50 mph.

The cost analysis shows that the decision to use a particular transportation system will be predicated first by the distance of the customer from Erie Pier. At 200 miles total distance, it will always be more cost effective to utilize the RailMate system. At 150 miles, it will likewise be cost effective to use the RailMate system. At 100 miles, efficiency depends on the assumed speed of the truck. If the speed is less than 50 mph, it is more cost effective to use the RailMate system. If one is using incremental costs, it is better to use a truck at any speed greater than 40 mph and at 100 miles distance. At a total distance of 50 miles it appears to be more cost effective to use trucking, although there is no data on the cost of using RailMate at distances less than 100 miles.

The findings of the cost analysis are useful for an estimation of least cost alternatives. In evaluating whether to build a new CDF one must first consider the cost of a new facility. The U.S. Army Corps of Engineers estimates that it would cost (in today's dollars) $30,000,000 to build a new CDF. However, this cost does not include externality costs, which could double or triple the estimated cost. These external costs are difficult to estimate and can be subjective in nature, and the cost benefit analysis necessary to estimate these external costs is not within the scope of this project. The cost of building a new facility also assumes, perhaps incorrectly, that it would be politically possible to situate a new CDF in the Duluth-Superior Harbor.

Presently there are not more than 1,500,000 cubic yards total of material in the Erie Pier facility. The estimation of least cost could suggest that a realistic scenario would be to remove 100,000 cubic yards per year. This would take a total of 15 years to draw down the quantity in Erie Pier to zero stored on site. Fifteen years is therefore used as the discount period in doing present value calculations. An appropriate discount rate is 4%. This is consistent with historical trends. The most conservative estimate of annual operating costs to remove the 100,000 cubic yards and transport it a total of 200 miles is $2,673,000 per year.

The present value of an annuity of $2,673,000 at 4% for 15 years is $29,719,450. This would indicate that it is slightly less expensive to remove the materials than it is to build a new facility. If one considers externality costs, it is clear that the low-cost alternative is to remove the materials from the site and not wait to build a new facility.

In addition, the cost of imminent alternatives could include finding low-cost ways to take the current dredged material to other locations. This could assume no additional capital costs, no railroad spur, and no other new technologies, but the possible inclusion of RailMate. (In these scenarios, there would be no added fixed costs.)

The report considered the usefulness of this study for other Great Lakes ports. We note that the Duluth-Superior port may be unique in some ways from other ports. For instance, in the Duluth Harbor, dredged materials are not significantly polluted, the seasonality of port activity is a significant factor, and re-use projects have been already considered and in some cases plans are under discussion.

However, the following points from this study may be of interest to other ports on the Great Lakes:

- Transportation costs should be considered (almost) the entire cost.
- Feasible customers have competing suppliers.
- Given a CDF with a short remaining life, non-recurring projects of most interest will be long-term projects near the CDF (or new PRF), and include using largest amounts of material (wetlands and habitat creation).
- Timing of opportunities can be crucial; the business of cycle of the customer is significant..
- Minimizing transportation time is the most cost effective principle.
- Cost per yard shows what the government (or other funder) might be willing to subsidize.
- Assume that choosing customer(s) who will take the maximum yards doesn't compare with the cost saving of using a closest customer.

Finally, without the availability of a complete impact study, we note that the largest economic impact that may be seen is how Erie Pier and other Great Lakes ports view CDFs. Erie Pier should be viewed as a Process Reuse Facility. This switch would result in turning a current environment disposal problem into an

TOP: Sluice canal, for hydraulic separation of dredged material. Erie Pier Confined Disposal facility, Duluth-Superior Harbor

BOTTOM: Accumulated sluiced and piled dredge material to be removed. (Source: Jean Jacobson)

economic impact or benefit. The PDF would generate much more positive economic activities and benefits. The "greening" of the CDF will create products that will meet the demands of the construction, habitat creation and restoration, agriculture, forestry, and mining industries.

Dredging, processing and transporting the Erie Pier materials will generate direct, indirect and induced economic impacts. The direct impacts will be created in the dredging, processing and transportation sectors. Their expenditures will result in new business-to-business spending, or indirect impacts. These indirect impacts would include increased activity in sectors such as fuel supply and maintenance and repair services. In addition, the workers in these impacted industries would spend their wages and create new induced impacts.

A second phase of this project has been awarded to model and identify the most cost-effective way(s) to transport dredged materials to customers: Erie Pier Re-Use Facility Phase II: An Optimized Cost-Effective Strategy for Increased Transport and Handling of Dredged Materials. The continuing study will investigate how to control operating costs for Erie Pier CDF by optimizing the handling and distribution of re-use of dredged material. The study will also propose optimal changes, additions, and improvements to the existing facility, and provide financial estimates of cost for suggested changes. ❍

Building Sustainable Solutions to the Issue of Ballast Water Treatment:

Testing Relationships Between Propagule Pressure and Colonization Success of Invasive Species

Principal Investigator
Donn K. Branstrator, Ph.D.
Biology Department
University of Minnesota Duluth

Co-Principal Investigator
Matthew C. TenEyck
University of Wisconsin-Superior
Lake Superior Research Institute

This multi-year project addresses the issue of ballast water treatment by examining the efficacy of the standards that will be applied concerning permissible levels of biological pollution. The over-arching objective of the project is to quantify the relationships between propagule pressure and the colonization success of zooplankton in the Duluth-Superior Harbor and St. Louis Estuary through dose-gradient experiments that bracket International Maritime Organization standards.

Burgeoning human transportation and trade networks are disrupting the natural range boundaries of flora and fauna on a global scale. Ballast water ferried by ships and used to correct imbalance in cargo is believed to be the leading dispersal agent of coastal non-native aquatic species in North America (Ruiz et al. 2000). Foreign ships arriving in U.S. ports alone discharge in excess of 70 million metric tons of liquid ballast annually (Minton et al. 2005), representing a massive potential ongoing courier of non-native aquatic species into the country.

In an effort to prevent additional species introductions via this vector, the U.S. Congress passed and reauthorized legislation in the 1990s that requires vessels to manage their ballast water in one of two ways. Ships are required either to carryout Ballast Water Exchange (BWE) by flushing ballast tanks in the open ocean or to perform Ballast Water Treatment (BWT) by proactive decontamination. BWE policy suffers from enforcement loopholes (Grigorovich et al. 2003, Duggan et al. 2005) and ignores the possibility that saltwater tolerant life stages of some species will survive. Researchers are currently developing and testing ballast water treatment technologies that will kill organisms upon entrance or exit from ballast holding tanks. Ballast water treatment promises effective interception of dispersing non-native organisms but demands thorough evaluation of the physiochemical thresholds of a wide diversity of organisms before it can be enacted.

It is widely recognized that no BWT technology can be expected to perform with 100% effectiveness all of the time. Hence, accepted standards will still allow a certain level of biological pollution (viable non-native organisms) to escape in the post-treated water. The post-treatment standards required of BWT technologies will be guided by standards agreed upon by the IMO.

Both theoretical and conceptual models predict that higher numbers of viable organisms in post-treatment discharge (propagule pressure) increase the likelihood of colonization success (MacIsaac et al 2002, Minton et al. 2005, Colautti and MacIssac 2004, Colautti et al. 2006). Nonetheless, few experimental data are available from which to quantify levels of invasion risk associated with specific levels of propagule pressure (MacIsaac et al 2002). This presents a serious challenge in identifying target permissible pollution thresholds for ballast water treatment technologies that will prove to be environmentally protective (Minton et al. 2005).

The Great Ships Initiative recently secured funding to establish a Ballast Water Testing Facility in the Duluth-Superior Harbor. Scientists at the facility will carryout scientific testing of BWT technologies at the bench, pilot and shipboard scales. It is anticipated that results will expedite identification of BWT technologies that meet IMO standards of biological pollution.

In an effort to enhance the work of the GSI, and more broadly inform ballast water treatment issues on a global scale, we need to address a gap in our basic scientific understanding which regards the functional relationship between numbers of viable organisms that escape destruction (propagule pressure) and their eventual colonization success (Colautti et al. 2006) in recipient ecosystems. Our project begins to fill this gap and should provide valuable experimental-based information that can guide the IMO regarding post-treatment standards for BWT technologies.

This project has three interrelated objectives:

1- Assess the seasonal density and diversity of zooplankton at the species level in the Duluth-Superior Harbor and its connected waters including the St. Louis Estuary and Lake Superior adjacent to the Duluth-Superior Harbor.
2- Test the hypothesis that seasonal density and diversity of zooplankton in the Duluth-Superior Harbor (a measure of colonization success) as determined under Objective 1, is temporally and spatially correlated with seasonal shipping traffic and ballast discharge (volume, port of origin) statistics (a measure of propagule pressure).
3- Quantify relationships between propagule pressure and colonization success of zooplankton in the Duluth-Superior Harbor through dose-gradient experiments that bracket International Maritime Organization (IMO) standards.

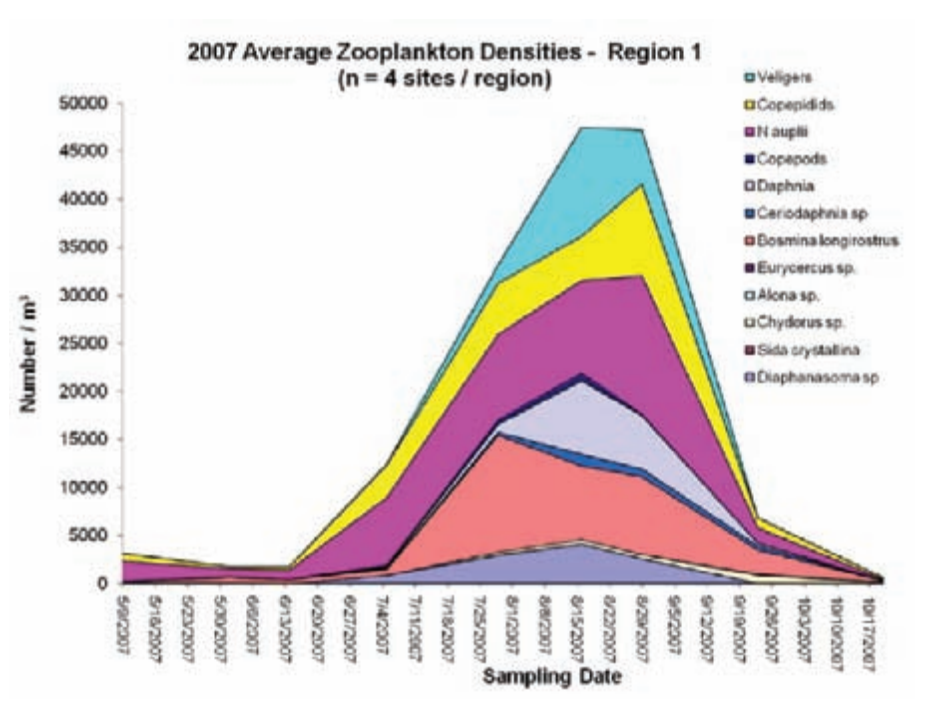
The main objective of the first and second years of work was to characterize the density and diversity of crustacean zooplankton in the

Dr. Donn Branstrator leads a team of undergraduate and graduate students that study zooplankton ecology and evolution at the University of Minnesota Duluth. He teaches courses in ecology and plankton biology, and won a Young Teacher Award in 2006. Donn received his Ph.D. in Biology from the University of Michigan in 1993.

Duluth-Superior Harbor and St. Louis Estuary, a necessary first step in developing the experimental context. Twelve locations were selected for sampling based on a simple random design but constrained in such a way to ensure wide geographic coverage spanning from the Oliver Bridge to the Duluth Harbor entry. On each of 10 May-October dates in 2007 and 10 May-October dates in 2008, 12 locations were sampled during the day for crustacean zooplankton and a suite of physio-chemical variables.

Our preliminary analysis of the 2007 data indicate that patterns of zooplankton density at the study sites peak in midsummer, coincident with peak summer water temperatures, reduced discharge volumes on the St. Louis River, and peaks in ship ballast water discharge volumes in the harbor. The likelihood of cause-effect relationships between these factors requires further analysis, which will include the incorporation of 2008 data, and a detailed analysis of the species diversity of crustacean zooplankton among study sites and between years. The results are providing valuable information for the development of experiments in the coming year that will evaluate the relationships between propagule pressure and colonization success by invasive species. ❍

Preliminary Sample Data. Seasonal mean densities of the most abundant taxa of crustacean zooplankton occurring at Region 1 during 2007. Note x-axis indicates weekly dates, 10 of which were actually sampled.



Full research reports are available at www.glmri.org

Environmental Effects of Marine Transportation:

Develop an Environmental Management System Model

Principal Investigator
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Clean Manufacturing Technology Institute

Co-Principal Investigator
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The American Great Lakes Ports Association (AGLPA) partnered with the Clean Manufacturing Technology Institute (CMTI) at Purdue University in West Lafayette, Indiana to examine the environmental management aspects of port operations, including the oversight of tenant operations that could negatively impact the environment. As a component of the Great Lakes-St. Lawrence Maritime Industry's "Green Marine" initiative, AGLPA approached Purdue University (CMTI) in 2006 to assist them in developing a project to: 1) survey environmental practices at Great Lakes ports, 2) compile a catalogue of best management practices for port operations, and 3) develop a simplified Environmental Management System tool that would help small port entities improve environmental performance.

The project evaluated twelve U.S. and Canadian ports with regard to a host of environmental issues. The goal was to identify areas of opportunity at Great Lakes ports for environmental improvement. Perhaps of greatest use, the project developed a manual of best practices that will assist small ports in finding ways to manage environmental issues within limited budget and staff resources. The research was conducted via two-day site visits to each of the 12 ports and interviews with port and tenant personnel, tours of port/tenant facilities and internet and other document research.

As the owners and stewards of considerable tracts of land in many Great Lakes cities, the ports are eager to address any environmental liabilities and, also, to identify opportunities for possible new restoration projects.

The research and the analysis of operations at the 12 ports revealed:

- The form of governance (municipal unit, independent public authority, state/federal chartered) may influence the oversight of tenant operations;
- In some cases, the provisions of port lease agreements with tenants pertaining to environmental protection could be strengthened;
- The issuance of environmental permits to ports and their tenants are not uniform among the states/provinces;
- Ports would benefit from developing a "master" plan for controlling storm water run-off and responding to spills/releases of hazardous materials, both of which are regulated activities;
- Ports have engaged in environmental projects of various types, individually and with partners, affecting their property and neighboring property;
- Community outreach programs to engage, involve and respond to the public vary considerably among the ports.

The research has produced an environmental management system "model" for adoption by small, public ports and a manual of best management practices to prevent or reduce negative impacts on the environment from port and tenant operations.

The major operations analyzed included:

Lynn A. Corson, Ph.D., is the Director of the Clean Manufacturing Technology Institute at Purdue University. He earned a Baccalaureate degree in Biological Science Education from the University System of New Hampshire, a Master of Science degree in Community Development from the University of Missouri, and a Doctor of Philosophy in Adult and Continuing Education from the University of Michigan. Dr. Corson served as Director of the Environmental Management and Education Program at Purdue from 1984 until his appointment in January 1994 as Institute Director. Prior to his employment at Purdue, he was a member of the Lifelong Education (Continuing Education) Program faculty at Michigan State University.

- Dry bulk storage and handling
- Liquid Bulk storage and transfer (loading/unloading)
- Non-bulk chemical storage and handling
- Port cargo handling equipment and rail/truck operations powered by diesel engines
- Vehicle and equipment fueling
- Port authority oversight of tenant activities through lease agreements
- Management of hazardous and non-hazardous waste generated by port/tenant activities
- General operations that can impact neighboring areas: noise, light, odor, trash, dust
- Building and grounds maintenance

Each operation was analyzed in terms of its potential environmental impacts to air, water, groundwater and land. Over 180 best management practices (BMPs) are recommended for the nine operations; 40 regulatory citations supporting the BMPs are included and 40 sources (references) of information are provided to assist the ports/tenants with implementation of the recommended BMPs.

The "model" Environmental Management System (EMS) produced by the project used the ISO 14001: 2004 Environmental Management System Standard as the guide. All 17 elements of the Standard are included and tailored to port operations. An abbreviated EMS form was also prepared: the Environmental Management Program form allows port authority personnel to organize and manage their port operations with consideration given to the environment in which those operations occur.

The relationship between the port/tenant operations and the BMPs pertinent to those operations is strengthened by inclusion of both in the port's EMS. The Best Management Practices Manual produced by the project can be used by ports seeking to implement operational controls (BMPs) to reduce the actual or potential environmental impacts resulting from an aspect of a port operation.

The BMP manual is available at www.glmri.org ❍

FAR LEFT: Arthur M. Clure Public Marine Terminal in Duluth, Minnesota.

LEFT: Steel coil movement in Cleveland, Ohio.

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Development and Succession of Microbial Communities Associated with Corroding Steel Pilings in the Duluth-Superior Harbor

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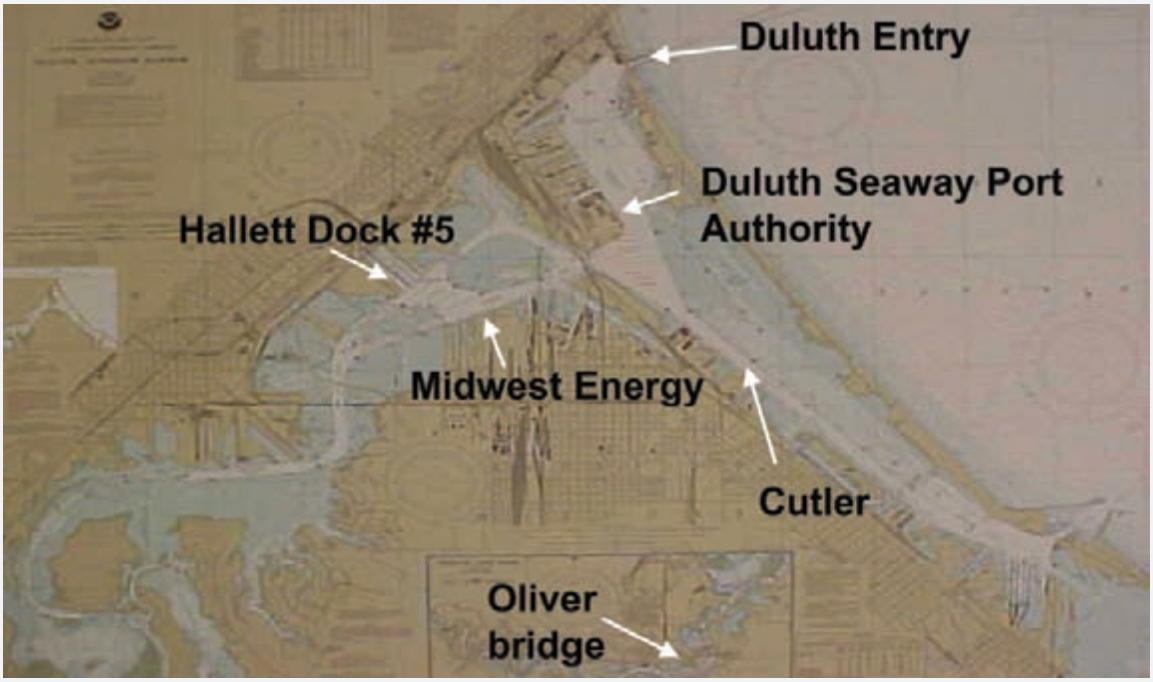
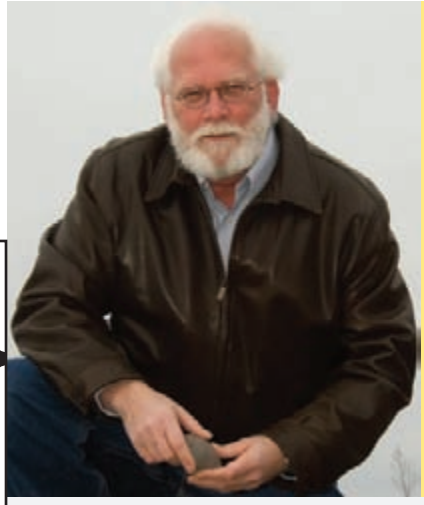
The overall objective of this research is to determine if corrosion of sheet steel pilings observed in the Duluth-Superior harbor is accelerated by microbiologically influenced corrosion (MIC). This report provides the progress-to-date on a multi-year effort.

Steel sheet piling material used for docks, bridges and bulkheads in the Duluth-Superior harbor (DSH) has been reported to be corroding at an accelerated rate (Marsh et al. 2005). The increased rate of corrosion appears to have begun in the late 1970s in the DSH and will require expensive replacement if the cause and possible remedies cannot be identified. About 20 kilometers of steel sheet piling appear to be affected in the DSH, which an initial analysis in 2005 estimated may cost more than $100 million to replace (Marsh et al. 2005), but which now may cost more than twice as much as this initial estimate (A. Ojard, Duluth Seaway Port Authority, pers. comm.).

Most of the corrosion in the DSH is confined to the first 1.5 meters below the water line and decreases from 1.5 to 3 meters below the surface. Extensive zebra mussel colonization occurs on these pilings from about 3 meters to the bottom of the steel pile, where little or no corrosion is observed. The steel sheet piling reported to be corroding at an accelerated rate has an orange



Locations of sheet steel coupon trays in the Duluth-Superior Harbor. (Source: AMI Consulting Engineers)



Dr. Randall E. Hicks is Director of the Center for Freshwater Research and Policy and a Professor in the Department of Biology and at the University of Minnesota Duluth. He completed a Ph.D. in Ecology at the University of Georgia and did postdoctoral work at Woods Hole Oceanographic Institution before joining the faculty at the University of Minnesota Duluth. Dr. Hicks is an environmental microbiologist who studies the diversity and productivity of aquatic microbial communities, their role in the degradation and transformation of organic compounds, and the survival and virulence of pathogenic microbes in these communities. This work has taken him to the bottom of the Great Lakes using a manned submersible, to Russia and various oceans. His current research efforts in his lab focus on the North American Great Lakes and watersheds in northern Minnesota.

rusty appearance characterized by blister-like, raised tubercles on the surface. These tubercles vary in diameter from a few millimeters to several centimeters and when removed, large and often deep pits (6 to 10 millimeters) are revealed in the steel piling, which is sometimes perforated. This pattern of corrosion is consistent with the appearance of corrosion caused by iron-oxidizing bacteria (Hamilton 1985).

Three lines of evidence indicate that the rate of corrosion of steel materials is very fast in the DSH. First, the pit depths in steel pilings within this harbor are deeper than the average pit depths for comparable corroding materials in freshwater (Marsh et al. 2005). More recently in early September 2006, Bushman & Associates, Inc. (Bushman 2006) measured corrosion rates of 5 to 6 millimeters per year using a linear polarization resistance method at sites that appeared most affected by corrosion in the DSH. They indicated that these rates were considerably higher (approx. 2 to 12 times) than normally measured in potable waters and can only be explained by some factor accelerating the corrosion rate such as microbiologically influenced corrosion (MIC). Finally, orange corrosion tubercles rapidly appeared on unprotected steel sheet pilings that were replaced at the Superior Entry to the DSH during June and July 2006. By September 2006, there were already 2 to 3 millimeter deep pits below these corrosion tubercles on these steel sheet pilings.

The corrosion in the DSH appears similar to accelerated low water corrosion (ALWC) reported during the past decade on marine steel pilings in the United Kingdom and Baltic Sea (Christie 2001, Graff and Seifert 2005), which may be accelerated by the action of sulfate-reducing bacteria. MIC is rarely caused by a single microbial group, but more often by consortia of microbes, including iron-oxidizing and sulfate-reducing bacteria (Hamilton 1985, Rao et al. 2000, Starosvetsky et al. 2001). Thus, we examined bacterial communities in biofilms attached to sheet steel coupons at corroded sites and areas less affected by corrosion to understand the colonization and development of these communities and determine if differences in the composition of bacterial communities at these sites indicate the participation of different bacterial species in the accelerated corrosion process ongoing in the DSH.

The corrosion of sheet steel coupons was compared at 6 sites in the Duluth-Superior harbor, ranging from a low corrosion site (Oliver Bridge), sites in the outer harbor (DSPA berth 4, Cutler Magner), to sites in the inner harbor (Midwest Energy, Hallett Docks 5 and 7) where corrosion is several times higher than expected in freshwater. Microbial biofilms that developed on the sheet steel coupons at these sites were sampled in August 2007 and again in October 2008. DNA was extracted from biofilms collected in 2007 and a preliminary comparison of the molecular diversity of these bacterial communities was completed using T-RFLP, a DNA fingerprinting method. This comparison revealed that different bacterial communities had developed on steel coupons from three sites in the inner and outer harbor during the first ten months of exposure. DNA has yet to be extracted from the samples collected in early October 2008. DNA fingerprints of the bacterial communities in these samples will be constructed, compared to each other to determine if different communities develop at various sites in the harbor affected by corrosion, and compared to samples collected from the same sites in 2007 to evaluate the development and succession of these communities. In addition, the structure of bacterial communities that develop on these steel coupons in the harbor will be compared to those that develop on identical coupons in the laboratory to help verify that a separate laboratory experiment mimic conditions that control the development of bacterial communities in the Duluth-Superior harbor. ❍

Full research reports are available at www.glmri.org

Expanding Regional Freight Information Resources for the Upper Midwest

Phase III: The Great Lakes Maritime Information Delivery System
A Resource for the Regional Analysis of Intermodal Freight Flows in the Great Lakes Region

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Professor
The University of Toledo
Department of Information Operations and Technology Management

This project marked the third phase of a long-term endeavor to develop and manage the Great Lakes Maritime Transportation Delivery System (GLMTDS). The GLMTDS is designed to serve as a comprehensive data repository and information clearinghouse in support of intermodal maritime commerce in the Great Lakes and St. Lawrence Seaway region. The system is further envisioned to serve as a resource for public policy decisions and for drawing the link between maritime freight movements, economic viability, and environmental quality throughout the Great Lakes and St. Lawrence Seaway.

This data gateway is focused on providing support data for analysis in several key areas:

- Economic impact of Great Lakes shipping
- Safety issues associated with diverting freight traffic to GLMTDS
- Environmental impacts/benefits compared to other modes
- Shipper savings associated with GLMTDS
- Congestion effects of other modes in comparison to GLMTDS
- Competition effects of maritime transportation and rate increases in other modes
- Shift in intermodal connections and transshipment costs (e.g., "full cost" studies – pavement damage, fuel, savings, crashes, etc.)
- The value of shipping to states, cities, regions, etc.
- Regional employment

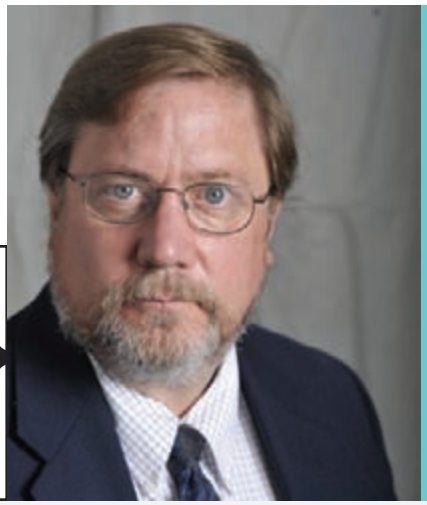
This project originally dealt with expanding an existing detailed GIS-based multimodal regional freight data reporting system named Midwest FreightView (MWFV). MWFV was developed in conjunction with the Upper Midwest Freight Corridor Study, a joint project carried out between the University of Wisconsin-Madison, The University of Illinois-Chicago, and The University of Toledo. Users can access MWFV with a web browser and Internet connection. All operations are carried out seamlessly on the Toledo server—the users' computers simply act as a terminal. MWFV is presently undergoing a major transformation to accommodate the greater volumes of data added to the repository over the past three years and to improve the user interface in working with a more comprehensive database. This newly restructured delivery system will be introduced in a series of user workshops beginning in February 2009. Presently the MWFV can be accessed through the Great Lakes Maritime Research Information Clearinghouse at HYPERLINK http://maritime.utoledo.edu/

In its present form users can take advantage of the GIS location-based query and selection capabilities as well as mapping functions to illustrate the linkage between freight movements to population characteristics and economic activity. In addition, work continues on the system to support advanced analysis capabilities such as routing, travel time and cost computations, location optimization and site selection. As a result, the system will continue to evolve into an effective tool for economic impact analysis and economic development planning using its capabilities in measuring accessibility to markets, locating bottlenecks in the network that restrict freight flows, and identifying feasible locations for warehousing, manufacturing, retail and intermodal connection facilities.

When fully developed, this system will include:

- A detailed data repository for vessel movements, port functions, commodity flows, economic activities and environmental impacts, etc.
- A GIS data viewer for advanced users to view and analyze a variety of data.
- An information delivery site for maps, tables, graphics, text and other features in the form of the "Atlas of Great Lakes Maritime Commerce."
- Assembly of data and report information among different geographic areas of impacts and jurisdictions (e.g., States and Provinces, Congressional districts, Cities, Counties, Ports, etc.).
- A data exchange to support user inquiries and furnish information on demand.
- Establishment of a communication link within the system (e.g., email access) for regional stakeholders to request specific information to be posted on the site.

University of Toledo members participate in GLMRI affiliates meetings.



Dr. Peter S. Lindquist is Associate Professor of Geography and Chairman of the Department of Geography and Planning at The University of Toledo. He received his Ph.D. from The University of Wisconsin-Milwaukee. His research interests focus on geographic information systems applications in operations research, freight planning and location analysis.

- Establishment of a system for data exchange to analysts in maritime agencies and organizations; also develop a site in the system for analysts within the region to publish the results of their analysis—particularly with regard to public policy issues of interest to the Great Lakes maritime industry.
- Development of a library function in the form of a data clearinghouse that reviews and summarizes data from diverse sources–both public and commercial–and provide links for users to branch to from the site.
- Development of a comprehensive centralized resource for providing linkages to additional data resources that do not necessarily represent core functions of the data repository (e.g., links to taxes, fees, and other tangential data); this portion of the site would also serve as a gateway to maritime agencies (e.g., Coast Guard, USACE, etc.).

Acquisition of data continues to be a critical component in the development of the system. The project team has been able to acquire funds from additional sources to contribute to additional components of this comprehensive intermodal system. These sources include the U.S. Army Corps of Engineers, The Center for Freight Infrastructure Research and Education (CFIRE) at The University of Wisconsin-Madison, and The University of Toledo Intermodal Transportation Institute and University Transportation Center.

The project team has entered into a contract with the U.S. Army Corps of Engineers to assist in the development of a new system for collecting piers, wharves, and dock data for the new Master Docks Plus Database. The project team has been charged to develop and test new methods for data collection that include the use of satellite imagery and air photos, web-based data entry and telephone surveys. Site visits are to be kept to minimum. These methods are to be tested at selected ports in the Great Lakes region. This parallel project interfaces well with the current data collection efforts currently underway. This contract also allows the Toledo site to maintain collected data and to gain access to additional data for this data exchange system.

An additional direction in data collection has focused on the compilation of aerial photography of Great Lakes docks and terminals and incorporating them into the database. Docks and terminals are spatially registered to the GIS database as a means to provide a backdrop for connecting the waterway, highway and rail networks into a comprehensive intermodal network. This "last mile" approach to establishing connectivity between modes provides a means for directly linking each mode within the system together in order to support the simulation transshipments of commodities and simulating wider flows over the entire transportation system. Other efforts by the project team are currently involving acquisition of AIS data to track vessel movements directly in the lakes.

One of the charges to the project team early in this process was to find a means for long-term sustainability of the repository and information delivery system. The project team responded early in the process to this challenge by proposing that GLMRI and its partners in the industry consider the establishment of a Great Lakes Maritime Exchange (GLMX) in the form of a non-profit organization that would be financed through subscription fees by its partners in the industry. There are a number of such exchanges in the coastal regions of the United States and in British Columbia. These exchanges partner with one another through MISNA (Maritime Information Services of North America), an umbrella organization of non-profit 501(c)(6) maritime exchanges in the United States and British Columbia. Among the many functions specified by MISNA, data collection, management and analysis are identified as key components of maritime exchanges' responsibilities in supporting maritime commerce. The project team has worked with MISNA and with the Lake Carriers' Association to establish an exchange in the Great Lakes.

The vision for the Great Lakes Maritime Information Delivery System has evolved over the course of the project to produce a multidimensional system that can support a wider array of functions that include data storage, delivery of prepared documents, GIS functionality, and a clearinghouse of information for maritime commerce. The main objective originally envisioned for the project remains the same: to maintain long-term database and data distribution system that is available for port authorities, state transportation agencies, regional planning agencies and economic development organizations, as well as other interested decision makers and stakeholders within the region. The project team solicits feedback and suggestions for continuous improvement of the information delivery system; communication with the industry has been and will continue to be a major objective as this resource evolves and expands over the next several years. ❍

Full research reports are available at www.glmri.org

Intermodal Freight Transport in the Great Lakes

Development and Application of a Great Lakes Geographic Intermodal Freight Transport Model

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Rochester Institute of Technology

The Great Lakes region is an important corridor for freight transportation in the United States. The region serves as a connection between the Midwest and the Eastern seaboard and includes such major industrial cities such as Detroit, Chicago, Cleveland, Buffalo, and Toronto, among others. Within this region, three modes of freight transportation dominate: rail, truck, and ship. Each of these modes presents a different set of attributes to shippers, consumers, and society, including: economic costs, time-of-delivery, environmental impact, reliability, and energy use.

For the most part, shipping decisions in the Great Lakes region (as in other parts of the country) are made by considering economic costs, reliability, and time-of-delivery. Unless mandated by law, environmental impacts are usually ignored, as they represent social costs that are not captured in the market prices for transportation services. Moreover, few tools exist that can help decision makers characterize and evaluate the environmental impacts of their shipping decisions.

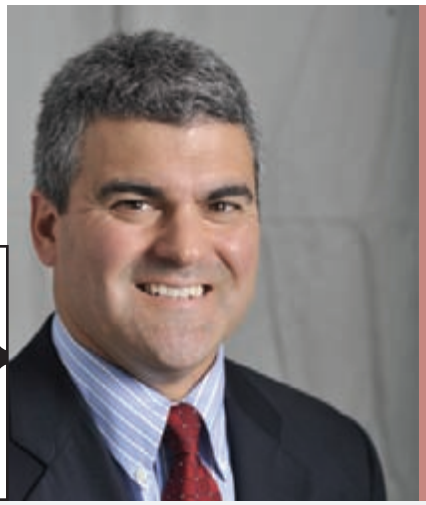
This project provides such a tool for the Great Lakes region by enhancing the Geospatial Intermodal Freight Transport (GIFT) model currently under development in a joint research collaborative between Rochester Institute of Technology (RIT) and the University of Delaware. GIFT is a Geographic Information Systems (GIS) based model that integrates water, rail, and road transportation networks and intermodal transfer facilities to create an intermodal network that can be used to solve a variety of interesting problems. In particular, GIFT calculates optimal routing of freight between origin and destination points based on user-defined objectives. GIFT not only solves for typical objectives such as costs and time-of-delivery, but also for energy and environmental objectives, including emissions of carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NOx), sulfur oxides (SOx), particulate matter (PM10), and volatile organic compounds (VOCs).

In this project, we develop a detailed network characterization for the Great Lakes region (GL-GIFT), and demonstrate how one can use GL-GIFT for answering important transportation planning and policy decisions. GL-GIFT connects U.S. and Canadian highway, rail, and shipping networks through ports, rail yards, and other transfer facilities to create an intermodal, international freight transportation network. This network is developed in ArcGIS 9.2, and captures network attributes such as costs, time, energy, and emissions. GL-GIFT allows for the analysis of optimal freight routing across a host of objective functions within the Great Lakes region. In this way, users can evaluate the tradeoffs associated with different goods movement choices, as well as explore how infrastructure development, technology adoption, and economic instruments may affect freight transport decision making.

In order to validate and demonstrate our model, we explore a case study involving the transportation of containerized freight from outside of Cleveland, Ohio to Toronto, Canada. We have conducted three types of analyses using this case to illustrate different applications of GL-GIFT:

Example 1: We optimize for one single-objective function which is to minimize PM10 emissions. This example demonstrates a general use of GL-GIFT with an environmental objective.

Example 2: We optimize on three different



Professor James J. Winebrake, Ph.D., is Chair of the Department of STS/Public Policy and co-Director of the Laboratory for Environmental Computing and Decision Making at Rochester Institute of Technology (RIT) in Rochester, New York. His research focus is on sustainable goods movement. Dr. Winebrake holds a B.S. in Physics (Lafayette College), a M.S. in Technology and Policy (M.I.T.), and a Ph.D. in Energy Management and Policy (University of Pennsylvania).

single-objective functions: (1) minimize operating cost; (2) minimize time-of-delivery; and (3) minimize CO_2 emissions. This example demonstrates how GL-GIFT can be used to show tradeoffs associated with different decision objectives.

Example 3: We optimize for two single-objective functions: (1) minimize NOx and (2) minimize NOx accounting for stricter emission standards which will take effect in 2014. This example demonstrates how GL-GIFT can be used to evaluate the potential impact of new technologies on affecting route decisions under environmental objectives.

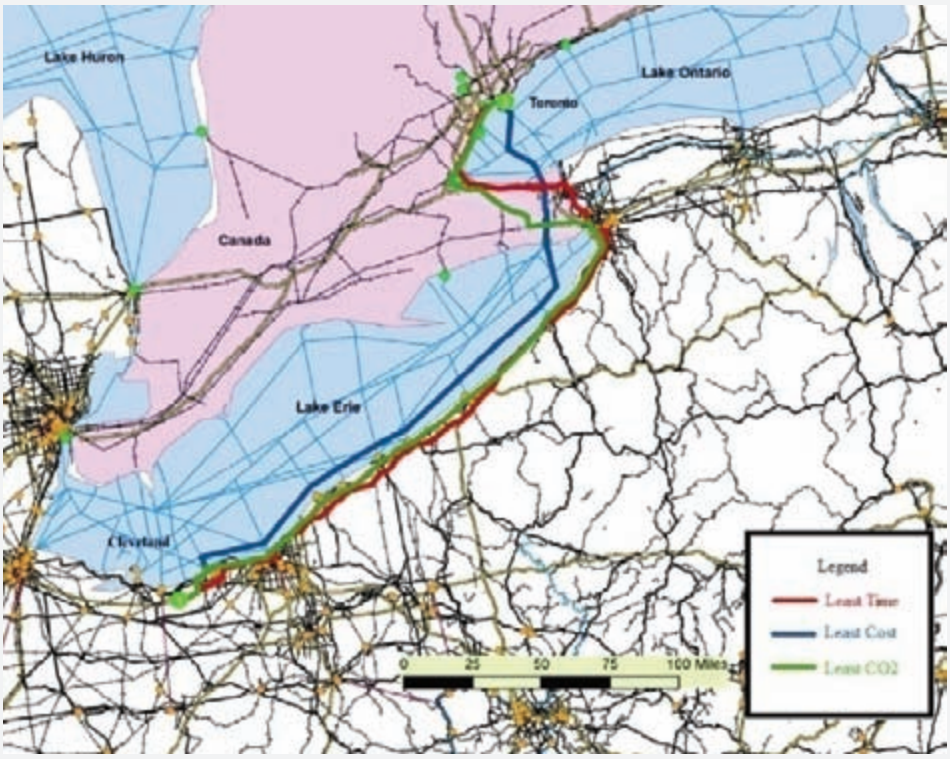
The case study results can be depicted in both graphical and tabular form. Figure ES-1 depicts a graphical representation for the second example. These examples serve as illustrations on how GL-GIFT can be used in the Great Lakes region to determine optimal intermodal route choices and to model the introduction of new technologies and policies (such as the NOx emission standard reductions).

We plan on continuing to update and improve GL-GIFT and will be working to integrate it as an important tool in sustainable shipping decision making in the Great Lakes region. The following areas are likely areas of continued improvements and are discussed in more detail in the report:

1. Ensure transportation network database and objective cost evaluators are robust and flexible.
2. Refine speed limit data.
3. Improve intermodal transfer time estimates.
4. Incorporate speed, traffic control, and congestion constraints.
5. Verify the capabilities of intermodal transfer facilities.
6. Conduct freight systems modeling.

With these and other improvements, we expect GL-GIFT to be an important tool for policymakers, planners, shippers, and others interested in sustainable shipping in the Great Lakes region. ❍

Figure ES 1. Results of example 2 – Optimal routes for least time, least cost, and least CO_2 for moving freight from Cleveland, Ohio to Toronto, Canada.



Further Development and Optimization of the Ballast-Free Ship Design Concept

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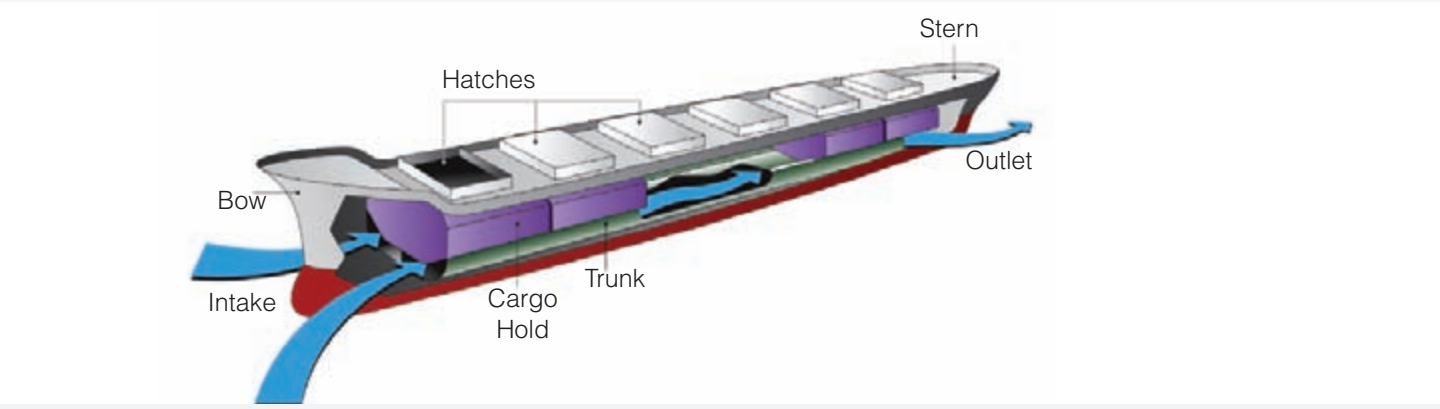
The initial investigation of the Ballast-Free Ship concept demonstrated the feasibility of the concept though a thorough examination of various design aspects. The effectiveness of the concept, in terms of eliminating the transport of foreign ballast water from ships operating in the ballast condition, was also demonstrated by utilizing Computational Fluid Dynamics (CFD) software to simulate the flow in the double bottom ballast trunks of the vessel. Nevertheless, this initial investigation did not succeed in showing the full cost-effectiveness of the concept. The main reason was a significant fuel penalty that resulted from an increased power requirement found in the initial hydrodynamic testing of a non-optimized discharge configuration on an existing, higher-speed vessel with a non-optimum propeller.

The ongoing GLMRI-sponsored research project has undertaken further hydrodynamic investigation of the Ballast-Free Ship concept; both experimental and numerical. The experimental investigation was performed by utilizing the Seaway-size bulk carrier model that was designed and built as part of the initial phase of this project. Resistance and propulsion tests were performed with this model in the towing tank of the University of Michigan Marine Hydrodynamic Laboratory in January 2007. The initial numerical investigations were performed utilizing the commercial CFD software FLUENT®.

The computational results were utilized both as guidance for the experimental setup and also to corroborate the experimental results. Specifically, the selection of the trunk flow inlet and outlet locations utilized in the towing tank experiments was guided by the numerical results. The ballast trunk flow inlet was located in the center of the bulbous bow. Two different locations were tested for the water discharge: one at the level of the upper part of the propeller disk close to Station 17 (near the forward engine room bulkhead, full

Schematic of the Ballast-Free Ship Concept.



Michael G. Parsons is an Arthur F. Thurnau Professor Emeritus in the University of Michigan Naval Architecture and Marine Engineering Emeritus. He earned his Ph.D. from Stanford University. He joined the Department of Naval Architecture and Marine Engineering of Michigan in 1972 and has served as department Chair, College Associate Dean for Undergraduate Education, and Director of Michigan Sea Grant College Program. Research interests included design decision-making, marine engineering, and ballast water technology. He is a Fellow and Webb Medalist of SNAME.

scale) and one lower close to Station 19 (near the aft engine room bulkhead).

The experiments in the towing tank consisted of detailed resistance and propulsion testing with and without the ballast trunk flow. The analysis of the model test data revealed that the experimental results were in good agreement with the numerical results. Overall, discharging water at the stern of the model slightly increases ship resistance, but proper design of the discharging arrangements can overcome this negative effect. Another source of modest ship resistance increase is the trunk inlet at the bow. Given the limited positive-pressure region at the bow of the full form bulk carrier under consideration, an inlet location other than that currently utilized will probably result in a significant reduction in the available pressure differential, without providing a noteworthy benefit in terms of ship resistance.

Nonetheless, the proper water discharge at the stern of the vessel can have a favorable effect on the propulsion characteristics for the Seaway-size bulk carrier design investigated. The reduction in powering requirements, relative to the initial unmodified design, at an assumed ballast speed of 15.5 knots was found in the January 2007 experiments to be 7.3% for water discharge close to Station 17 and 2.1% for water discharge close to Station 19. The gain in overall propulsive efficiency outweighs the increase in ship resistance. The large power decrease of 7.3% was, however, suspect leading to additional work during in the current year.

Additional numerical work was performed during the past year using the Star-CCM+® CFD software that includes the v2-f turbulence modeling that has been found to be more effective for fuller hull forms as in the Seaway-sized bulk carrier under consideration. Additional model-scale experiments were also undertaken in the towing tank of the University of Michigan Marine Hydrodynamic Laboratory in July 2008. These experiments utilized improved methods for the resistance testing and this provided more consistent results and higher total resistance increases with the use of the Ballast-Free trunk flow than found in the January 2007 experiments. With the discharge at Station 19, the resistance increase in the ballast condition at 15.5 knots was found to be 2.44% full scale. With the discharge at Station 17, the resistance increase at the ballast condition at 15.5 knots was found to be 4.61%.

When the required propulsion power was determined, it was found to decrease by 1.63% from the unmodified case with the preferred discharge at Station 17. This results from a change in the propeller operating point and changes in the flow over the stern due to the ballast trunk flow introduction into the boundary layer so that it increases the flow into the upper part of the propeller disk. Also the results showed an increase in the propeller operating efficiency and the hull efficiency that are large enough to offset the increase in the total resistance measured without the propeller. These results confirm the required power decrease found in the January 2007 experiments, but show that those results were unrealistically high.

In order to investigate the economic benefit of the aforementioned propulsive improvements, an operating scenario for the grain trade to Europe was adopted for the Ballast-Free bulk carrier. The change in the Required Freight Rate (RFR) with respect to an alternative filtration and UV ballast treatment system was estimated. The net savings would be about $1 per metric ton of cargo for the Ballast-Free bulk carrier with the water discharged close to Station 17. The overall ship design would also benefit from placement of the water discharge near the forward engine room bulkhead. A different operating scenario could result in even lower savings. Nevertheless, cost-effectiveness combined with a numerically-demonstrated foreign-ballast-elimination capability confirms the Ballast-Free Ship concept will be a viable alternative to more costly ballast treatment systems. Even though the current project focuses on a smaller Seaway-size bulk carrier, the concept should also be applicable to other new-construction ships of different types and sizes. ❍

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Shipboard Testing of B20

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University of Minnesota Duluth (UMD) *Research Vessel Blue Heron*, which is shown in Figure 1, was used as a test bed to study fuel consumption and emissions when B20 and diesel fuel are used as the primary fuels. Periodic inspections of the vessel's equipment and reviews of the engineering logs were also performed to check for an operational or material compatibility issues associated with the use of B20.

Main engine emissions and fuel consumption were monitored on *R/V Blue Heron* from 14 May 2008 to 30 October 2008. Two different primary fuels were used during the test period; no. 2 diesel and B20 (a mixture of 20% biodiesel and 80% diesel). The goals of the project were to determine the change in emissions and fuel consumption associated with switching from no. 2 diesel to B20 and to investigate any operational issues, including material compatibility, that are associated with the use of B20.

R/V Blue Heron is an 86-foot-long former Grand Banks fishing trawler operated by the Large Lakes Observatory (LLO) at UMD. The diesel-powered systems onboard include the main engine (CAT 3508 TA) and two generator sets (CAT 3304 and CAT C4.4 DITA). A data acquisition system and associated equipment were installed on the ship to continuously monitor and log the following parameters during main engine operation: main engine speed (RPMs), exhaust temperature, exhaust pressure, fuel consumption, and emissions (HC, CO, O_2, CO_2, NO_X). The fuel consumption for both generator sets is also monitored and recorded. Main engine speed, exhaust temperature, and exhaust pressure are recorded every 2 seconds, fuel consumption is recorded every 5 seconds, and the emissions are recorded in 30 second intervals.

Testing with no. 2 diesel occurred from 14 May 2008 to 20 July 2008. B20 was used as the primary fuel from 21 July 2008 to 30 October 2008. The *Blue Heron* has refueled with B20 three times, July 21, August 25, and September 22, taking on about 2,000 to 2,500 gallons during each refueling. The refueling process for the *Blue Heron* is complicated by the fact that B20 is not readily available locally. The B20 is mixed at the refinery while it is being loaded into a large tanker truck. The B20 is then transferred from the large tanker truck to a small tanker truck for final delivery to the *Blue Heron* at the pier. The additional steps in the refueling process increase the likelihood of contamination of the fuel.

Data available in the literature for dynamometer tests conducted with on-road diesel engines using B20 shows a decrease in unburned hydrocarbons (HC), carbon monoxide (CO), and particulate matter (PM) emissions, and a slight increase in oxides of nitrogen (NO_X) emissions when compared to no. 2 diesel. Dynamometer tests are conducted under controlled conditions and

The Large Lakes Observatory operates the largest university-owned research vessel in the Great Lakes, the R/V Blue Heron. Built in 1985 for fishing on the Grand Banks, the Blue Heron was purchased by the University of Minnesota in 1997, and converted into a limnological research vessel during the winter of 1997-98. She is outfitted with state-of-the-art research equipment. The Blue Heron has berthing for 11 crew and scientists, and can operate 24 hours per day for up to 21 days in between port calls.

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generally consist of two types; constant speed with a varying load, and constant load with a varying speed. Neither of these two tests can be recreated onboard a ship that is underway. Thus, a direct comparison between the on-road engine tests from the literature and the current test is problematic. The data presented in the current study was analyzed based on main engine speed. The main engine speed is related to, but is not equivalent to, the load on the engine. There are other factors that cause variations in the load on the main engine at a given speed such as current, sea state, and wind velocity. No attempt was made to separate out the effect of these additional factors on the data. The data was time-averaged over periods when the main engine was operated at constant speed. These periods ranged from 10 minutes to several hours.

The data for main engine fuel consumption and oxides of nitrogen (NO_X), oxygen (O_2), carbon monoxide (CO), carbon dioxide (CO_2), and unburned hydrocarbons (HC) emissions were analyzed as a function of main engine speed in revolutions-per-minute (RPM). A majority of the data points fell within two speed ranges; 400 to 700 RPM and 1000 to 1400 RPM. The lower operating speeds are consistent with cruising and "trolling" during research operations and the higher speeds are consistent with high-speed transit at, or near, full throttle. General trends observed in the data include the following:

- B20 and diesel usually exhibited similar fuel consumption rates, as expected.
- Some of the higher RPM data points indicated a higher rate of fuel consumption for B20 when compared to diesel. These higher readings for B20 are believed to be caused by clogging of the fuel filter, which can cause higher readings from the fuel log systems.
- Soundings taken of the fuel tank and a review of the amount of fuel taken onboard during refueling indicated a similar rate of fuel consumption for B20 and diesel.
- NO_X, O_2, CO, and CO_2 emissions were similar for both B20 and no. 2 diesel use at the same engine speed.
- All of the emissions data were consistent with expected trends for diesel engine operations.
- HC emissions are expected to be very small for a diesel engine operating at a constant engine speed. The emissions analyzer employed in the current study only registered HC emissions during evolutions involving rapid and large changes in engine speed. The inability to measure any HC emissions at steady operating conditions may be due to instrument accuracy (which for HC emissions is less than 400 ppm), instrument response time, or the location of the emissions probe.

One of the goals for the current study was to investigate any operational issues involved with the use of B20. No material compatibility issues were observed over the period July 21 to October 30 when B20 was used as the primary fuel. However, there was a significant decrease in the operational lifetime of the primary fuel filter when using B20. The *Blue Heron* uses a 2-micron Racor filter as its primary fuel filter. The filter is replaced when the fuel pressure drops to below 50 psi when the engine is at full throttle. When no. 2 diesel is used, the first fuel filter installed after refueling sometimes exhibits a shortened lifetime, on the order of hours. This has been attributed to contaminated fuel in the past. Subsequent fuel filters have typical lifetimes from 100 to 200 hours. The use of B20 resulted in a very short fuel filter lifetime (on the order of hours) for the first fuel filter installed after refueling, with filter lifetime gradually increasing for each subsequent filter. In some cases, the filter lifetime eventually increased to 100 to 200 hours. Several factors may contribute to the observed behavior, including, but not limited to, "cleaning" of the fuel system by the biodiesel component in B20, the use of a fine (2-micron) primary fuel filter, and the complicated refueling process employed for B20 which may have resulted in contamination of the fuel.

The data acquisition system employed in the present study will allow for continued monitoring of emissions and fuel consumption on the *Blue Heron*. Two issues that have been noted are the inability to measure HC emissions (except during engine transients) and the reduction in filter lifetime observed when using B20. Future work will focus on resolving these issues. ❍

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Student Design Project at The University of Michigan, Naval Architecture and Marine Engineering

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In the spring of 2008, three graduate students in the Department of Naval Architecture and Marine Engineering at the University of Michigan worked with the Duluth Seaway Port Authority on a concurrent marine design project to design a steel slab carrier for operation on the Great Lakes. The design group included Robin Madsen, Johan Kemnitz, and Anders Hammersborg, under advisement from Dr. David Singer for their capstone design project. The results of this design were then presented at the September 2008 Great Lakes Maritime Research Institute Affiliate University meeting in Duluth, MN. A brief background of the initial problem statement and summary of the design project as presented:

The Duluth Seaway Port Authority is undergoing an upgrade of their port transshipment facilities in order to better accommodate projected steel slab shipment in 2009. To further explore steel slab shipment options, the University of Michigan design team was asked to design a vessel that will carry steel slabs from Duluth, MN to downbound ports along the Great Lakes. These ports would include Sault Ste. Marie, ON, Detroit, MI, Hamilton, ON and possibly other ports as the trade develops. Some opportunities for the shipment of miscellaneous cargo upbound on the return trip may exist, including project and/or containerized cargo.

For each Phase 2 (full steel output) trip, approximately 22,102 metric tons of steel slabs, each approximately 40 ft x 8 ft and 25 metric tons in weight, would be loaded in Duluth. Approximately one third of the steel cargo would be unloaded at each destination, proceeding in the order given above. A fleet of four of the selected design vessels would be required to meet the total expected annual steel throughput out of Duluth.

The designed vessels are articulated tug

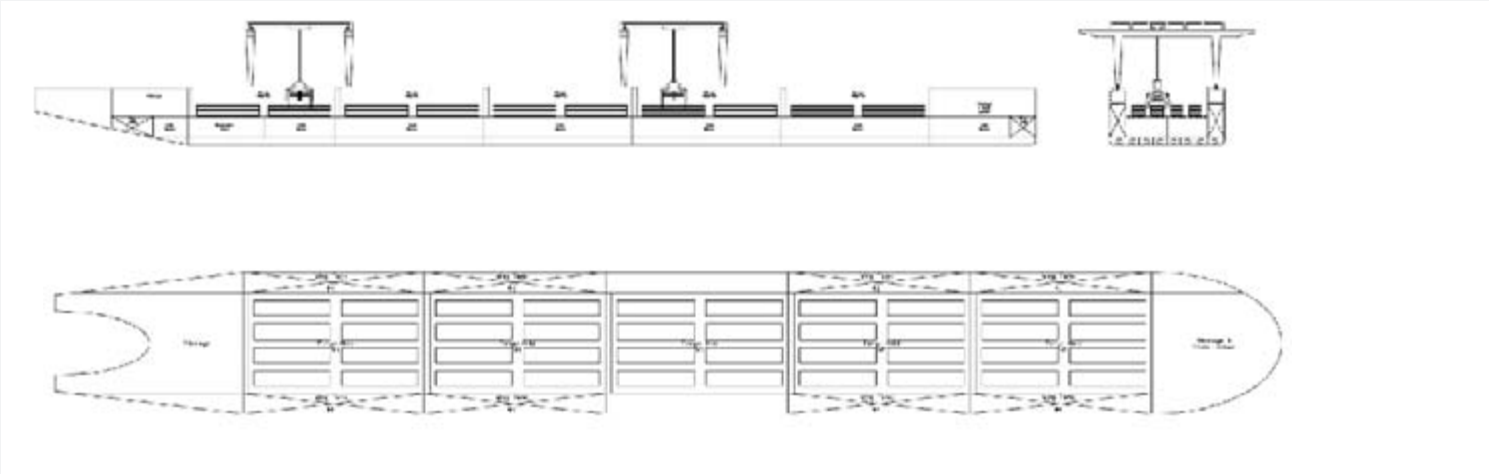

Figure 1. Plan and profile views of barge general arrangements.

Anders Hammersborg is a Lieutenant in the U.S. Coast Guard, currently pursuing Master's degrees in Concurrent Marine Design and Industrial and Operations Engineering at the University of Michigan. He is a 2003 graduate of the U.S. Coast Guard Academy and served tours of duty aboard the Coast Guard Cutter Chase in San Diego as a shipboard engineer and the Office of Naval Engineering at Coast Guard Headquarters in Washington, D.C. before returning to graduate school.

and barges (ATBs) with a design speed of 11 knots and geared with loading/unloading equipment that is primarily suited to handling steel slabs while also being able to accommodate some specialized/project cargo and containerized cargo. The primary focus of the analysis was design of the barge. Though a parametric design of the tug was completed, the intention was that an "off-the-shelf" tug could be selected based on the specifications outlined.

A general cargo ATB with five cargo holds and outfitted with two gantry cranes (as pictured) was selected as the best solution based on an Analytical Hierarchy Process (AHP) trade-off analysis and simulation of loading and unloading scenarios using ProModel simulation software. The AHP analysis quantitatively compared the different attributes of lead time, total cost, fuel economy, maintainability, crewing, seakeeping, ice operation, and survivability, for different potential designs and propulsion configurations. This analysis was based on feedback from surveys sent to contacts within industry and the GLMRI. The loading simulations, run using various combinations of fork-trucks and gantry cranes for different hold configurations, were helpful both in the selection of the final design in conjunction with the AHP analysis and specifically with respect to cargo hold configuration and general layout. These simulations lead to selection of two 80-ton overhead gantry cranes in order to be self-sufficient in loading operations and to provide the most flexibility in scheduling.

The sizing of these ATBs was primarily bounded by the seaway dimensions for transit within the St. Lawrence Seaway and the annual number of steel slabs to be shipped. Selected principal characteristics are length 197.5 meters, beam 22.5 meters, and draft 7.5 meters. This design is fairly typical of an ATB, though slightly narrower and shallower in order to transit the Seaway and locks. A basic level of analysis was then completed on the design of the vessels. The analysis included resistance and powering, seakeeping, stability, weights, and structures. The barges were designed to the Finnish-Swedish Ice Class Rules (FSICAR) 1B classification in order to allow for continued operation to Sault Ste. Marie in brash ice during the beginning and end of the winter season (when locks are closed) if desired.

While the design group understands that other, less expensive options may exist to meet the given design objective, such as the conversion of a bulk carrier or the purchase of traditional tugs with deck-barges, the vessel designed in the report is a purpose-built ship that is ideal for the steel slab trade. Features such as the two overhead gantry cranes and the five open hatch holds would make loading, unloading and transportation of steel slabs for this application fast and efficient. Certainly, as the nature and specifics of the potential for steel slab shipment via the Great Lakes is developed and becomes clearer, this design for shipment could be a useful starting-point for parties interested in participating in the endeavor. ❍

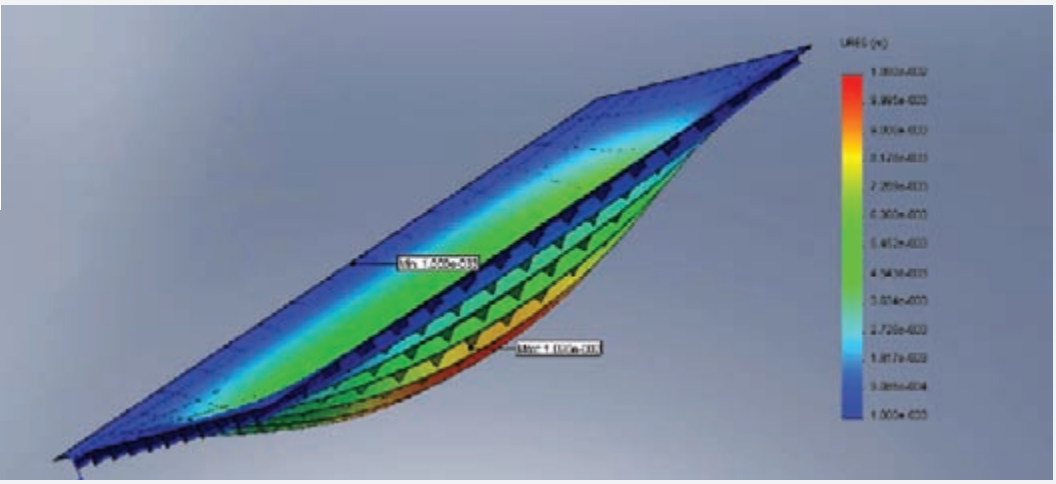

Figure 2. Finite Element Analysis (FEA) of cargo deck loading (exaggerated) from SolidWorks.

Full research reports are available at www.glmri.org

Great Lakes Maritime Transportation K-12 Education Program for Teachers, Students & Communities

Principal Investigator:
Joan Schumaker Chadde
Education Program Coordinator
Michigan Technological University

BELOW LEFT: Dr. Richard Stewart and Captain Ken Gerasimos, Key Lakes/Great Lakes Fleet touring the engine room on the EDWIN H. GOTT.

BELOW MIDDLE: Joan Chadde, Michigan Tech program coordinator, Katie Ferguson, Sales, Marketing, and Traffic Analyst for the Great Lakes Fleet, Inc. and Carol Wolosz, GLMRI at the Two Harbors, Minnesota taconite docks.

BELOW RIGHT: Jim Skurla from UMD's Bureau of Business and Economic Research and Jim Sharrow the Duluth Seaway Port Authority's facility manager on the T/S State of Michigan.

While many Great Lakes residents enjoy ship-watching, few know what is being shipped, or the economics of shipping. Why is Great Lakes shipping preferable to alternate modes of transportation? How does the Seaway system of locks at the Soo, Welland Canal and St. Lawrence Seaway allow ships to safely navigate? How can the shipping industry help slow the spread of invasive species, improve air quality, and help promote biofuels? How does weather affect the speed, route, and amount of cargo ships can carry? How is technology used in navigation? What is the legacy and what is the future of Great Lakes shipping? Few adults and still fewer students can answer these questions. However, the future of the Great Lakes shipping industry depends, in part, on having an informed citizenry.

To address the need for an informed citizenry, this project addressed the GLMRI Focus Area of K-12 public education and outreach programs and provided several venues to address this area through Michigan Technological University's Western U.P. Center for Science, Mathematics & Environmental Education:

- conducted a 2-day lesson-writing workshop for pre/post-visit use by classroom teachers at Whitefish Point Lighthouse in Paradise, MI, in partnership with the Great Lakes Shipwreck Historical Society;
- conducted three teacher workshops in Hancock, Sault Ste. Marie, and Alpena, Michigan in partnership with two intermediate school districts and the Thunder Bay Marine Sanctuary;
- conducted a 6-day summer teacher institute in Duluth, Minnesota;
- assembled and disseminated 12 Great Lakes Maritime Transportation Education Treasure Chests to museums and education centers in PA, MI, WI, MN with financial support from Lake Carriers' Association;
- made four conference presentations at the Michigan Science Teachers Association, Michigan Council of Social Studies Teachers, National Science Teachers Association, and the Ship Operators Cooperative Program;

Joan Chadde is the education program coordinator for the Center for Science and Environmental Outreach at Michigan Technological University. Chadde has more than 25 years of experience in science/natural resources education, water resources management, and program development. She earned an M.S. in Water Resources from the University of Wyoming, B.S. in Natural Resources from the University of Michigan, and secondary science teaching certification from Michigan Technological University.

- provided incentives for program participants to conduct conference presentations and submit articles related to Great Lakes shipping;
- completed the text and graphic design for "F is for Freighter: An Introduction to Great Lakes Shipping," maintained the Great Lakes Maritime Transportation Education website;
- and completed the text and graphic design for "K-8 Great Lakes Maritime Transportation Lessons."

As a project highlight, the summer teacher institute took place July 20-25, 2008 in Duluth, Superior, and Minnesota's north shore, and had ten participants. The institute addressed maritime history, Great Lakes shipping challenges, careers, ports, and cargoes; and required teachers to develop one maritime transportation lesson that could be implemented in their math, social studies, language arts, and/or science classes.

Thousands of students and teachers in the Great Lakes basin and nationwide have been and will continue to be reached by the wide variety of educational tools that have been developed between 2006-2008. The project was coordinated by Joan Chadde, K-12 program coordinator for the Western Upper Peninsula Center for Science, Mathematics and Environmental Education at Michigan Technological University. ❍

ABOVE: Participants in the Summer 2008 Great Lakes Maritime K-12 Teachers Institute.

Great Lakes Maritime Research Institute

A University of Wisconsin - Superior and University of Minnesota Duluth Consortium

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