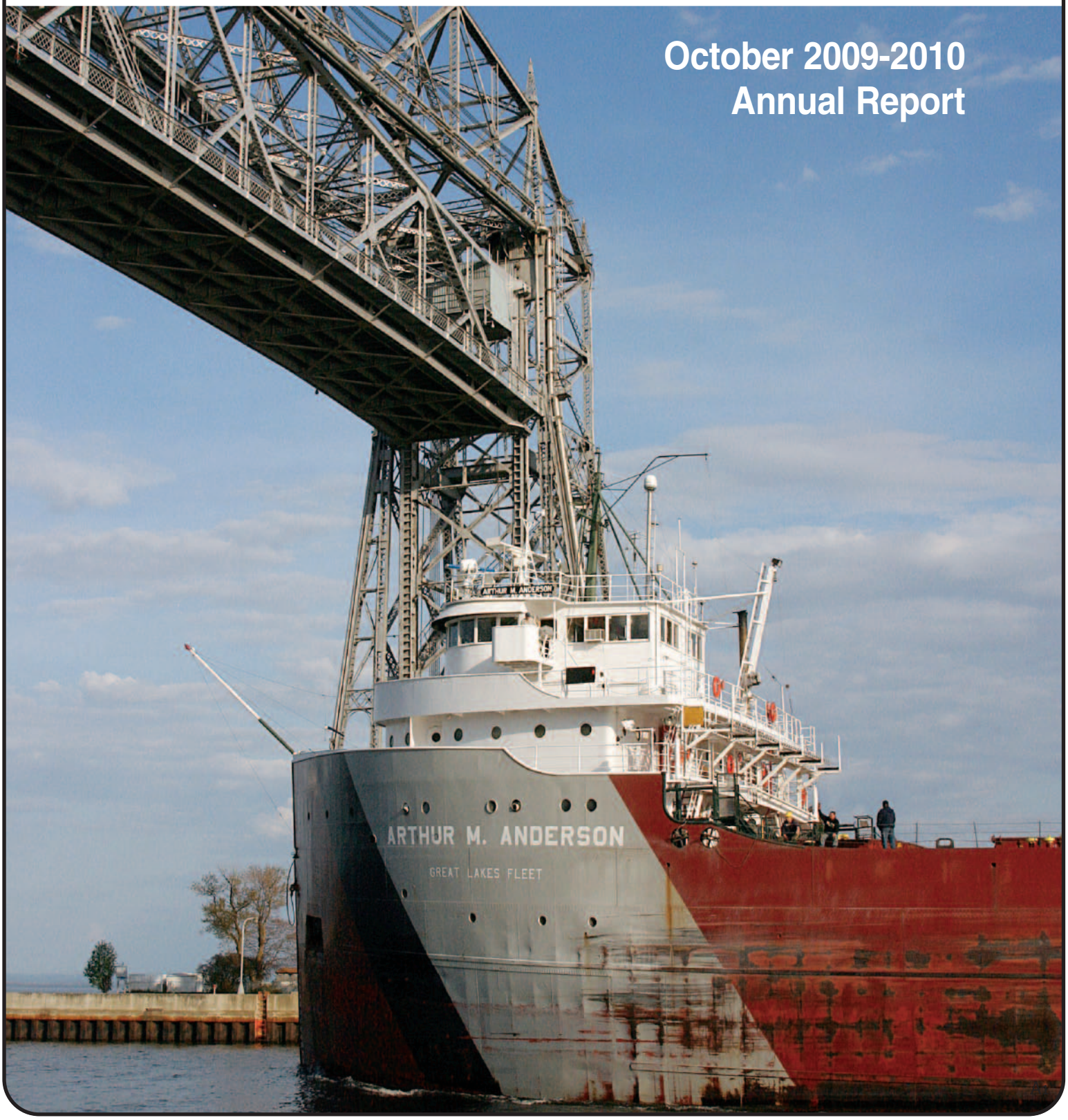
Great Lakes Maritime Research Institute

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

A NATIONAL MARITIME ENHANCEMENT INSTITUTE

October 2009-2010 Annual Report



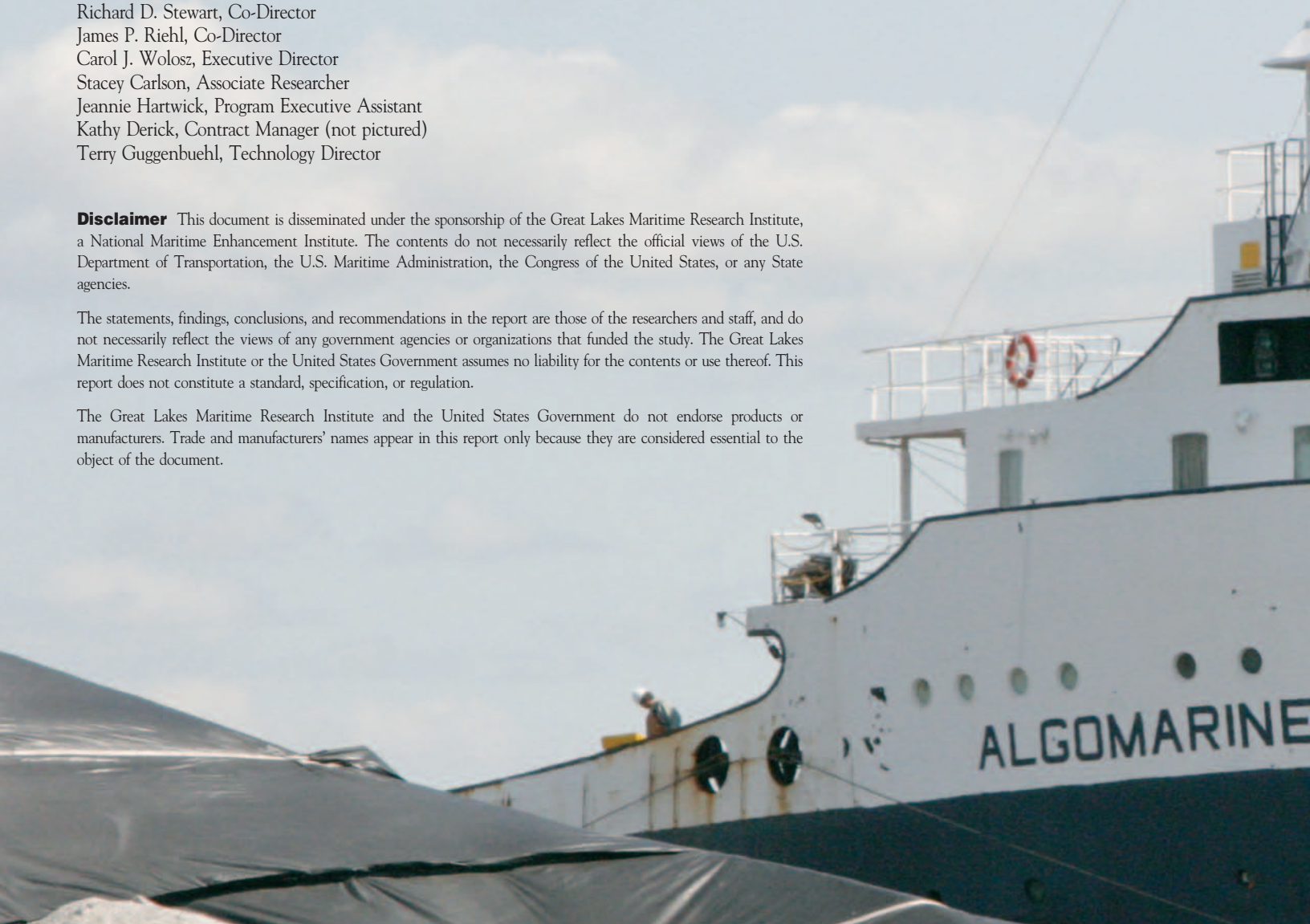
The Great Lakes Maritime Research Institute is a National Maritime Enhancement Institute designated by the U.S. Department of Transportation Maritime Administration

GLMRI Program Office
229 Voss Kovach Hall
1305 Ordean Court
Duluth, MN 55812
(218) 726-7446
www.glmri.org

This study was supported by the U.S. Department of Transportation, Office of the Secretary and the Maritime Administration.

Grant Number DTMA1G10001

Staff:
Richard D. Stewart, Co-Director
James P. Riehl, Co-Director
Carol J. Wolosz, Executive Director
Stacey Carlson, Associate Researcher
Jeannie Hartwick, Program Executive Assistant
Kathy Derick, Contract Manager (not pictured)
Terry Guggenbuehl, Technology Director



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UNIVERSITY of WISCONSIN Superior
Wisconsin's Leading Public Liberal Arts College

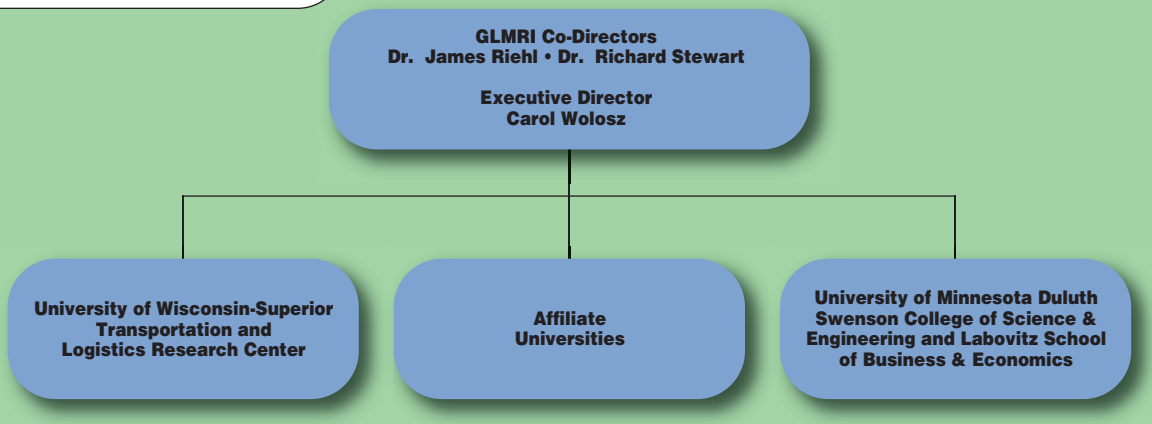
UMD DULUTH

Great Lakes Maritime Research Institute

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

PROJECT REPORTS 2009-2010

Overview



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.

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.

The Great Lakes Maritime Research Institute (GLMRI) was established in 2004 to pursue research efforts in marine transportation, logistics, economics, engineering, environmental planning and port management. The U.S. Maritime Administration designated GLMRI as a National Maritime Enhancement Institute on June 1, 2005. Federal funding to support GLMRI was first received in May 2005. Since that first appropriation of $750,000, GLMRI has received $1,980,000 in 2006, $990,000 in 2008, $950,000 in 2009 and $450,000 in 2010.

This report summarizes the progress on the research initiated under the 2009 funding from the *Transportation, Housing and Urban Development, and Related Agencies Appropriations Act, 2009*. Due to the late receipt of funding to the universities, the projects did not commence until the Spring 2010. Completion reports for these projects will be included in the 2011-2012 annual report. Previous annual reports are available on the GLMRI web page (www.glmri.org).

In March 2004, the University of Minnesota Duluth and the University of Wisconsin-Superior formed the GLMRI consortium to 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 are serviced by four Class I railroads, is the terminus of the longest pipeline in North America, and home to more than 30 trucking companies in the area. The cities are serviced by an international airport and are the corporate headquarters for the largest single engine airplane manufacturer in the U.S. The Twin Ports has a U.S. Coast Guard (USCG) Marine Safety Unit, is the home port for the USCG Cutter *Alder* and a Port of Entry with the U.S. Customs Office and the Immigration and Naturalization Service.

GLMRI represents a consortium of the University of Wisconsin-Superior Transportation and Logistics Research Center and the University of Minnesota Duluth Swenson College of Science and Engineering and Labovitz School of Business and Economics, combining the strengths of their academic and research expertise. Additionally, universities in the Great Lakes region with expertise in the research focus areas may be offered affiliation. This dynamic model provides a program with tremendous breadth as a National Maritime Enhancement Institute. There are currently seven institutions throughout the U.S. designated as National Maritime Enhancement Institutes (NMEIs) by the Maritime Administration under Public Law 101-115. The purpose of the NMEIs is to create a research-oriented atmosphere that lends itself to providing effective input for addressing maritime issues. The institutes selected as NMEIs are capable of researching interdisciplinary, intermodal issues and have access to a broad spectrum of resources enabling them to address national problems within the individual program areas.

GLMRI seeks input from experts in maritime shipping and commerce and ports and governmental agencies. The consortium is committed to improving the maritime system of the Great Lakes and the United States.

Co-Directors' Statement

We would like to recognize the support that GLMRI has received from Congressman David Obey, Congressman James L. Oberstar and the Great Lakes congressional delegation. Without their backing, we would not have had the resources for GLMRI. Thanks to all of you for your trust in GLMRI and your interest in shipping and maritime commerce. We sincerely appreciate it.

This report summarizes the fifth year of research projects, along with the education and outreach initiatives that our members have been engaged in. We are continuing to progress toward our goal of a permanent funding solution for maritime research, however, we do not have that milestone accomplished yet. We are continuing our efforts to secure funding for permanence through the U.S. Department of Transportation. Our Advisory Board members have been a great resource as we seek solutions for a long-term resource stream that focuses on economical- and environmentally-focused projects and studies for maritime transportation and commerce.

In 2010, John Carroll University was endorsed by GLMRI to become an affiliate program. The Ohio-based school joined the group in May. However, with the retirement of Dr. Lynn Corson, The Clean Manufacturing Technology Institute at Purdue University is no longer active and participating in maritime research. We remain at 12 universities with a focus on maritime research.

A key success of this year has been our engagement with our Advisory Board members and agencies. We have worked closely with the Lake Carriers' Association and its members to tie in critical topics for the GLMRI research agenda. The U.S. Army Corps of Engineers is continuing to fund GLMRI for special projects, such as the University of Toledo's data center for updating the master dock information for the Great Lakes. The Corps is providing in-kind support to GLMRI and the University of Minnesota Duluth's project in identifying the associated bacteria that is tied to the corrosion of the steel infrastructure in the Twin Ports and the region. GLMRI is working with a multi-agency steering group on the project to develop an annual economic impact analysis for the region. The steering group is actively involved with the principal investigator in providing direction and support for the project's focus. The Lake Carriers' Association has also provided funding to support the K-12 Teachers' workshops.

In September, GLMRI announced the selections for the sixth year of projects. Although the direct congressional funding we received was cut in half, the Institute was able to select a slate of projects to move the research forward. We appreciate the affiliate universities working with us to help maximize the funding, by pursuing matching funding and agency and commercial funding to support the projects.

We continue to engage in events and associations to extend the research and outreach of the Institute. We believe we need to maintain a presence in maritime venues to ensure that we are current on the issues impacting shipping in the Great Lakes. Also, in national maritime discussions, the issues on the Lakes are often excluded and diminished. We strongly feel we need to be aggressive in advocating the need to extend maritime research in the Great Lakes.

Again, we thank you for your support over another successful year, and we look forward to addressing the needs of governmental agencies and industry in the future.

Sincerely,

Richard D. Stewart, Co-Director
James P. Riehl, Co-Director

Advisory Board

Advisory Board

The 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.

University of Minnesota Duluth Large Lakes Observatory Research Vessel Blue Heron.

Saint Lawrence Seaway Development Corporation
MR. CRAIG MIDDLEBROOK
Deputy Administrator
Washington, D.C.

American Great Lakes Ports Association
MR. ADOLPH OJARD
Chairman
Duluth, MN

U.S. DOT Maritime Administration
MR. FLOYD MIRAS
Acting Director
Great Lakes Gateway
Schaumberg, IL

U.S. Coast Guard
CAPTAIN TIM CUMMINS
Ninth District
Cleveland, OH

Lake Carriers' Association
MR. JAMES H. I. WEAKLEY
President
Rocky River, OH

Great Lakes Commission
MR. DAVID KNIGHT
Special Events Manager
Ann Arbor, MI

U.S. Army Corps of Engineers
LIEUTENANT COLONEL MICHAEL DEROSIER
Detroit District
Detroit, MI

The Society of Naval Architects and Marine Engineers
MR. JAMES SHARROW
Great Lakes & Rivers Section
Duluth, MN

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's co-directors for affiliate status in GLMRI. University affiliates are renewed 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.

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229 Voss Kovach Hall
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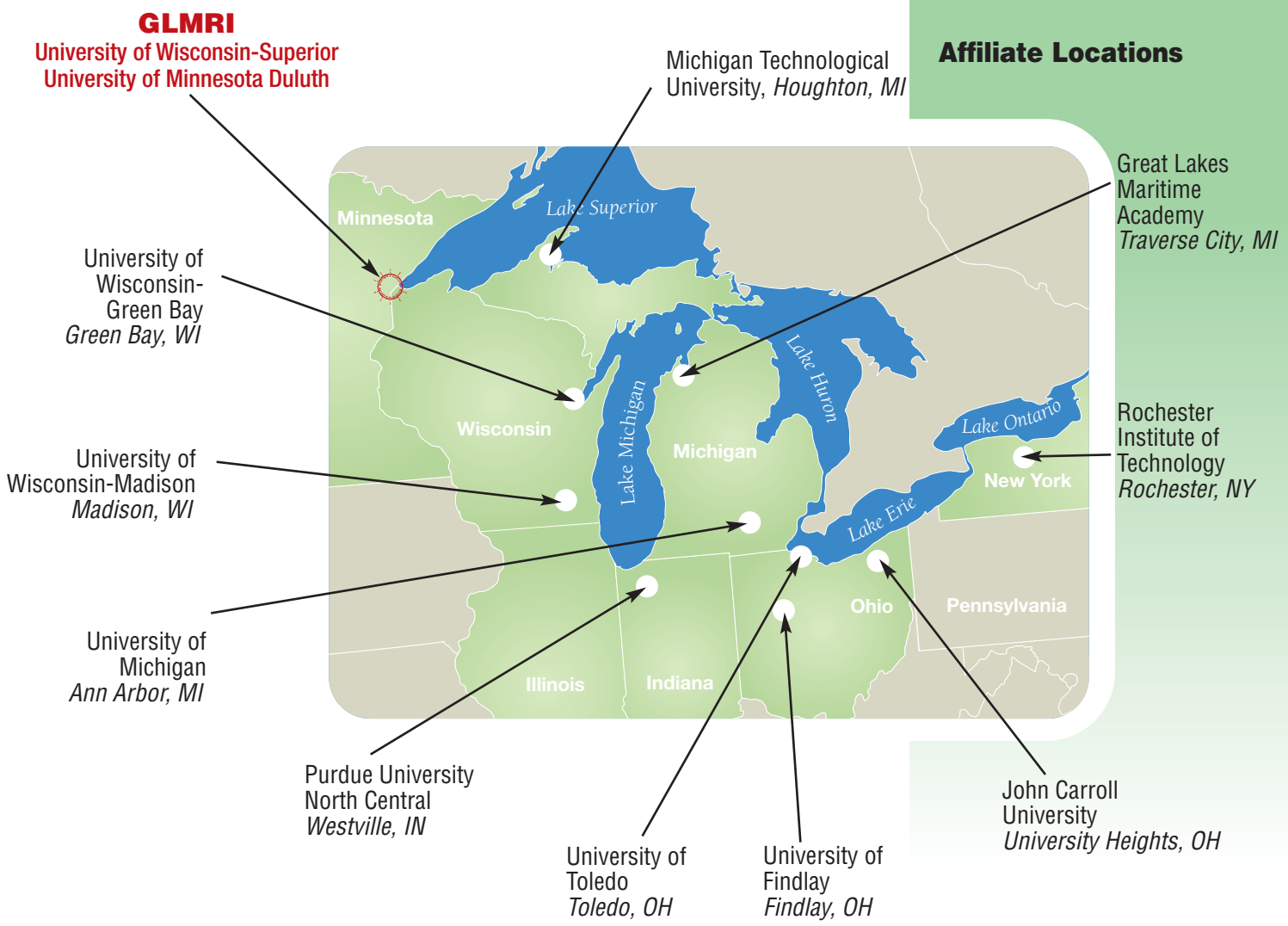
Affiliate Locations



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.

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 a collaboration with Finnish universities, we have initiated discussions with Canadian universities and academics.

Affiliate universities meet annually with the GLMRI Directors and the Advisory Board to provide input on future research topics and to discuss current research results and process. GLMRI maintains an open and continuous dialogue with 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. 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.

Top: K-12 Educators Summer Workshop.

Right: Duluth Slip Bridge and SS William A. Irvin.

Research Affiliates

Duluth's intermodal waterfront.

Great Lakes Maritime Academy
1701 East Front Street, Traverse City, MI 49686
RADM Jerry Achenbach, USMS, Superintendent

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).

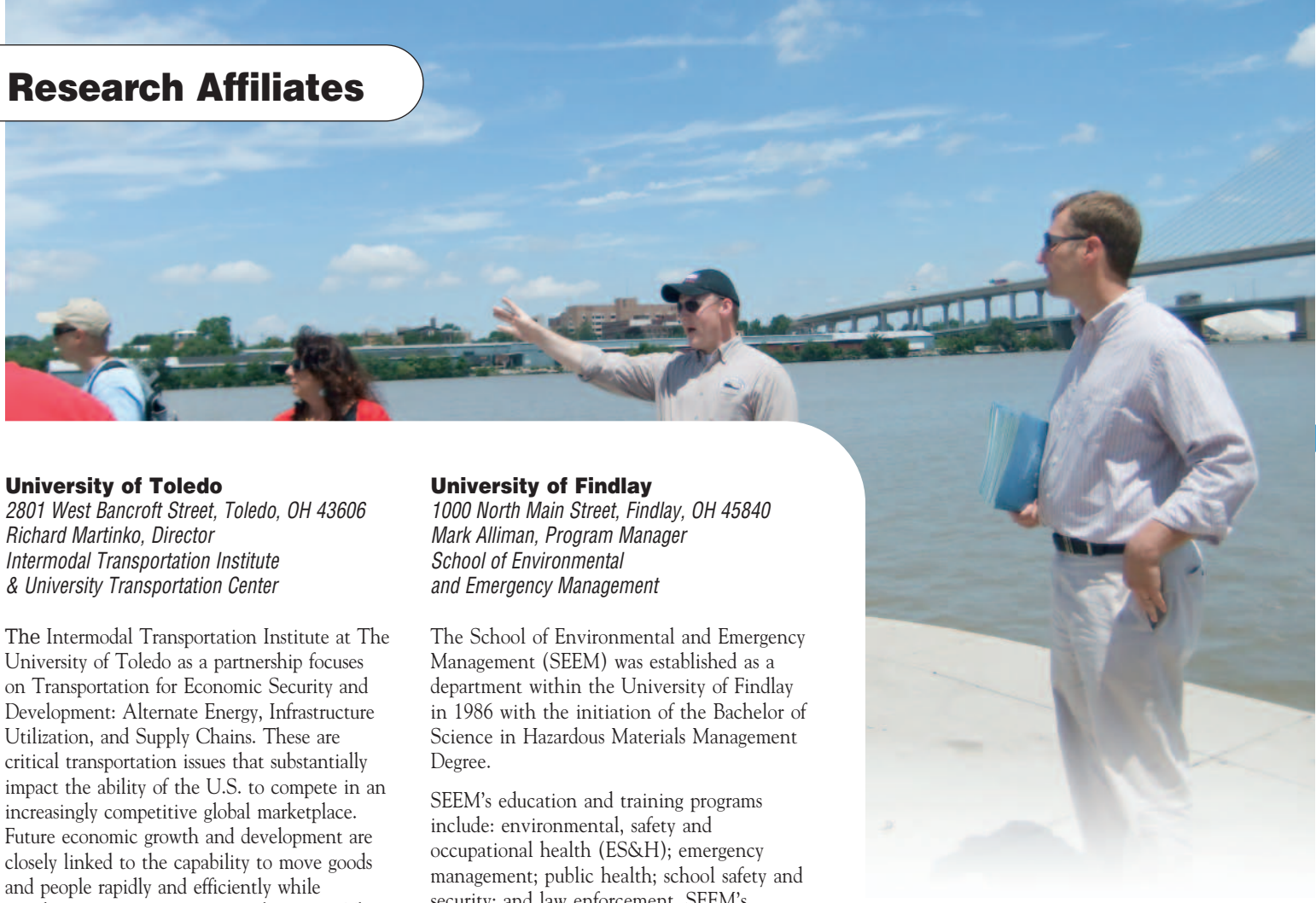
University of Michigan
2600 Draper Drive, Ann Arbor, MI 48109
Dr. Armin Troesch, Chair
Department of Naval Architecture and Marine Engineering

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 and other maritime agencies.

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

Michigan Technological University conducts an educational outreach program on Great Lakes Maritime Transportation for K-12 students, teachers and communities. From 2006-08, program activities have included conducting five-day summer teacher institutes in Duluth and in the eastern Upper Peninsula, developing new classroom lessons on Great Lakes shipping, assembling and disseminating 24 Great Lakes Maritime Transportation education trunks and training workshops to maritime museums and K-12 education centers throughout the Great Lakes basin, developing a web module on Great Lakes shipping (http://techalive.mtu.edu/series.htm), presenting posters and presentations at conferences and developing a Great Lakes Maritime Transportation education website. Partners have included: Minnesota Sea Grant, Duluth Seaway Port Authority, Great Lakes Shipwreck Historical Society & Whitefish Lighthouse and Lake Carriers' Association.

Research Affiliates



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

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.

John Carroll University
20700 North Park Boulevard
University Heights, OH 44118
Dr. Bradley Hull, Associate Professor
and Ried Chair, Department of
Management, Marketing and Logistics

Army Transportation Corps, the program is now domiciled in the Department of Management, Marketing and Logistics. The Department is dedicated to educating and serving its students, the University, and the community through quality teaching, significant research and the appropriate community involvement with shippers and carriers. The primary goals of the logistics faculty are to achieve national recognition, and to provide students, the University and the business community with comprehensive, up-to-date information about business logistics theory and practice. Methods of achieving these goals include, but are not limited to, excellent teaching, quality research (both academic and practitioner), student internships, and faculty/student involvement in logistics-related organizations.

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

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.

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

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.

Research Affiliates

Left: Paul LaMarre Jr., Manager of Maritime Affairs for the Toledo-Lucas County Port Authority leading a tour of the port facilities at the K-12 Educators Summer Workshop.

Right: Ships staged at Fraser Shipyard facility, Superior, Wisconsin.

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

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 cyber-infrastructure. Its goal is to improve freight-related transportation decision-making by advancing and integrating environmental cyber-infrastructure 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 Wisconsin-Madison
1415 Engineering Drive, Room 2205
Madison, WI 53706
Dr. Teresa Adams, Director
National Center for Freight and Infrastructure Research and Education

The University of Wisconsin-Madison is home to the National Center for Freight and Infrastructure Research and Education (CFIRE). CFIRE is a U.S. Department of Transportation National University Transportation Center with a multimodal research, training, education and outreach focus on Sustainable Freight Transportation Infrastructure and Systems. CFIRE has an annual budget of approximately $7 million. It facilitates 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.

University of Wisconsin-Green Bay
2420 Nicolet Drive, WH303
Green Bay, WI 54311-7001
Dr. Derryl Block, Interim Dean
College of Professional and Graduate Studies

The University of Wisconsin-Green Bay (UW-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.

2010 Special Projects

Left: Members of the Economic Analysis Steering Group. Front row: Max Jeronimus, Dr. Peter Lindquist, Sarah Schafer, Jon Brown. Back row: Jim Skurla, Dr. Jean Jacobson, Dr. David Doorn, Kevin O'Malley, Jim Sharrow, Ken Gerasimos, Marie Strum, Carol Wolosz, Mike O'Bryan and Dr. David Voss.

Below: EPA Grant press conference speakers (left to right): Mr. Don Kurz, President, Keystone Shipping Company; Drs. Richard Stewart and James Riehl, GLMRI Co-Directors; and Steve Marquardt, Coordinator, U.S. EPA Region 5

Above: GLMRI Panelists at TRB Summer Meeting: Craig Middlebrook, Sandra Beaupre, Dr. Richard Stewart, Ray Johnston, and Andy McDonald.

GLMRI Advisory Board Meeting

The GLMRI Advisory Board met at the Richard I. Bong Veterans Heritage Center in Superior, Wisconsin on Wednesday, September 22, 2010. New members to the Board this year are LTC Michael Derosier, Commander of the USACE-Detroit District Office and Cmdr Tim Cummins from the US Coast Guard 9th District Office in Cleveland, Ohio. Each of the board members provided an update on their agency's concerns and focus for the coming year. An open discussion ensued throughout the meeting, with an outcome of possible topics or focuses for GLMRI research areas.

GLMRI Affiliates Meeting

The Affiliate Research meetings were held at the Barkers Island Inn Conference Center on September 23 and 24, 2010. Members from the industry and government agencies along with university researchers and administrators and non-profit associations were in attendance. Researchers from all of the current GLMRI projects provided updates and progress reports on their topics. The meeting provides an open forum for comments and feedback.

GLMRI hosted a dinner and social event to foster conversation with the researchers. This year's event was well attended in spite of a last minute change of venue. Due to gale force winds, the tour of the Duluth-Superior Harbor had to be cancelled, but a landside dinner was able to be set up for the evening event with over 50 people attending, in spite of the weather conditions.

Economic Impact Study Steering Group Meeting

The Steering Group for the Great Lakes/St. Lawrence Seaway Economic Impact Study met at the Lake Superior Maritime Visitors Center Duluth, Minnesota on September 21, 2010. The group included representatives from the St. Lawrence Seaway Development Corporation, the US Army Corps of Engineers, the Great Lakes Fleet and Lake Carriers' Association, the Port of Duluth, and the Oakridge National Research Laboratories in addition to the academic team.

It was announced that a study had been contracted for with a commercial consulting firm to provide an analysis of 32 Great Lakes ports, both Canadian and US, by next year.

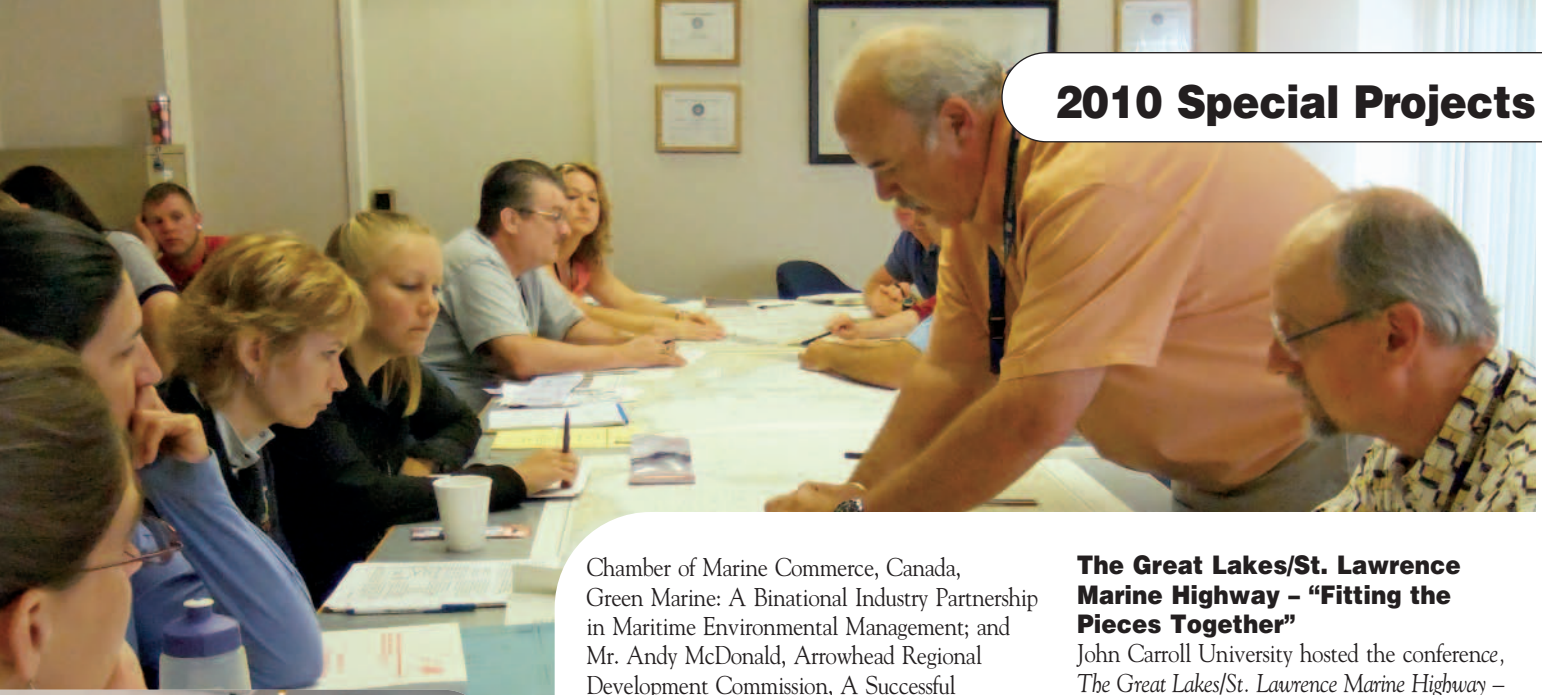
Dr. Doorn went over the progress to date and issues with the model. Doorn is working with the MARAD Port Kit that had to be purchased through Rutgers University. This process proved to take a lot longer than anticipated, and if used across the Great Lakes would have to be purchased for each of the included ports. Dr. Doorn is working his prototype for data needs and results on the ports of Duluth/Superior and Green Bay. The objective of the project remains to provide an annual analysis of Great Lakes ports and provide an annual economic index consistent across the Great Lakes ports. A progress summary is included in the following section of this report.

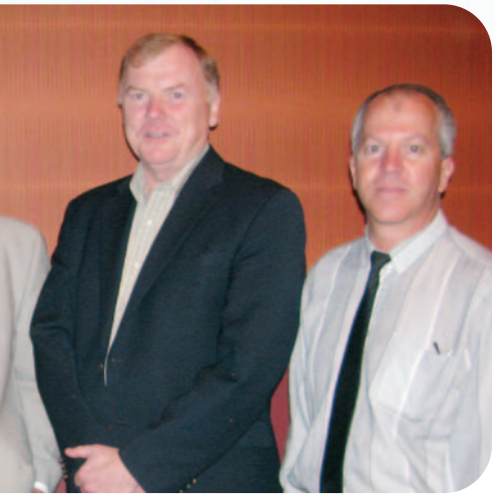
Industry Partnership for EPA Grant

GLMRI has been awarded a $750,000 US EPA Region 5 Midwest Clean Diesel Initiative grant to help reduce air emission from a 1,000-foot Great Lakes ore carrier. GLMRI partnered with Key Lakes I, Inc., a major Great Lakes vessel operator, on the project that will enable Key Lakes to repower the M/V Edwin H. Gott during the year-long project. A press conference to announce the award was held in Superior, Wisconsin on Friday, July 30, 2010.

GLMRI Panel at TRB Summer Meeting

Dr. Stewart chaired a panel titled The Future of Great Lakes Transportation at the Transportation Research Board (TRB) Joint Summer Meeting held July 11-14, 2010, in Minneapolis, Minnesota. Panelists included Mr. Craig Middlebrook, Deputy Administrator, St. Lawrence Seaway Development Corporation, An Effective Ballast Water Management Program for the Great Lakes-St. Lawrence Seaway; Ms. Sandra Beaupre, Wisconsin Department of Transportation, Connections 2030: Wisconsin's Long Range Transportation Plan-Integrating Waterways; Mr. Ray Johnston, President,





Page 11 Top: Captain Rick Brown, maritime instructor at The Maritime Academy of Toledo, provides lesson to K-12 Educators on navigation and map reading.

Chamber of Marine Commerce, Canada, Green Marine: A Binational Industry Partnership in Maritime Environmental Management; and Mr. Andy McDonald, Arrowhead Regional Development Commission, A Successful Collaborative Waterfront Planning Model.

Mid-Continent Transportation Research Forum

Carol Wolosz and Dr. Lindquist and his research team (University of Toledo) presented at the 2010 Mid-Continent Transportation Research Forum hosted by the Wisconsin Transportation Center at the University of Wisconsin, held in Madison, Wisconsin on August 19th and 20th. Carol provided an update of the on-going GLMRI research projects and a summary of the summer educational initiatives. This year, the University of Wisconsin-Madison, as an affiliate university of GLMRI, co-funded the K-12 Maritime Education Program with GLMRI. Dr. Lindquist's team presented updates on the work that they are doing in conjunction with the U.S. Army Corps of Engineers and their on-going data clearinghouse project.

Wisconsin Commercial Ports Association

Dr. David Doorn, University of Minnesota Duluth, presented an update on the Great Lakes/St. Lawrence Seaway Economic Impact Study at the Wisconsin Commercial Ports Association (WCPA) meeting held in Superior, Wisconsin on August 19, 2010. Dr. Doorn is currently working with the ports of Duluth/Superior and Green Bay to develop the initial analysis and validate the model for the full study.

The WPCA is a trade association representing 14 commercial ports, their terminal operators and associated marine transportation businesses located on Lake Superior, Lake Michigan and the Mississippi River.

The Great Lakes/St. Lawrence Marine Highway – "Fitting the Pieces Together"

John Carroll University hosted the conference, *The Great Lakes/St. Lawrence Marine Highway – "Fitting the Pieces Together"* with Administrator Terry Johnson from the St. Lawrence Seaway Development Corporation as the keynote speaker. GLMRI provided sponsorship for this event that was held in Cleveland, OH on August 30, 2010. The goal of the conference was to define and take action on the issues that need to be surmounted to increase commerce on the Great Lakes St Lawrence Seaway System. Speakers included Ger van Langen (Wagenborg), Mark Locker (ODOT), William Friedman (Port of Cleveland), John Baker (ILA), and Adm. Michael Parks (USCG). The afternoon consisted of two panels. The first panel, moderated by Arnie de la Porte (Consul of the Netherlands) addressed opportunities for cross lake ferries. It included Tom McKenna (Penske), Stuart Theis (Consultant), Ray Schreckengost (Port of Erie), and Ger van Langen. The second panel addressed opportunities for short sea movements into the Lakes. It was moderated by Roy Knapp (Consultech), and included Gord McNeil (McKeil Marine), Stan Shumway (GLFL), Bill Yankow (Cleveland Freight Association), and Ger van Langen. Approximately 200 people participated in the conference, from as far away as the Netherlands, Halifax, Montreal, Washington, Columbus, and Toledo. The size and breadth of the audience attests the strong interest in such projects. The conference was a success and received attention in the media.

Ohio Conference on Freight

Dr. Stewart (University of Wisconsin-Superior) presented a session on educating transportation and logistics professionals at the Ohio Conference on Freight, titled, "*A Holistic Transportation and Logistics Education System*." Hosted by the Ohio Department of Transportation, the National Association of Regional Councils, and the Toledo Metropolitan Area Council of Governments, this conference focuses on freight transportation and

2010 Special Projects

Left: Ryan Oster and Dr. Randall Hicks on tour of the Duluth Superior Harbor reviewing corrosion study samples.

logistics in Ohio and the Great Lakes region and the growing effect this industry has on the wider economy. This was the fourth year for the conference.

Great Lakes Maritime Academy Visits the Port of Duluth-Superior

On Sunday, June 13, 2010, the *T/S State of Michigan* arrived in the port of Duluth-Superior as part of their annual cadet training voyage. On Monday, the cadets were given a tour of local shipping operations and business entities. The tour included a stop at the CN Docks with an overview by Mr. Mark Erickson, the Canadian National port manager and Captain Ken Gerasimos of Key Lakes Shipping. Mr. Tom Nicodemus hosted the cadets for a tour of the Midwest Energy Resources Corporation's Coal operations. Dr. Mary Balcer, Biology Professor and Director of the Lake Superior Research Laboratory at the University of Wisconsin-Superior provided a classroom lesson on invasive species and their ecological impact, followed by a tour of the Great Ships Initiative's Ballast Water Treatment Testing Facility. Mr. Ron Johnson, the Trade Director for the Duluth Seaway Port Authority briefed the cadets on the Port Authority's business operations.

After lunch, Mr. Herb James at the Burlington Northern and Santa Fe rail yard jumped on the bus with the group, and gave the cadets a full tour of their taconite facility and conveyor system. He also included a brief summary on the history of the last loading of the *Edmund Fitzgerald*.

Mr. Tom Correlli, the facility naval architect at Fraser Shipyard, provided an overview of their upcoming projects, and gave the cadets a tour of the company's dry dock. Mr. Joe Cuseo, the terminal manager for the Murphy Oil Terminal concluded the agenda with the site tour of their maritime fueling facility, emphasizing their environmental safety measures and procedures.

A reception was held on the vessel on Monday evening, with cadets providing tours of the ship for the local guests. This was Admiral John Tanner's last visit to the Twin Ports as the Academy's superintendent after a long and distinguished career. We wish him the best in his retirement. Admiral Tanner with GLMA was the first institute to become an affiliate with GLMRI in 2005.

Commencement Speaker at GLMA 2010 Graduation

Dr. Richard Stewart, Co-Director of GLMRI was the commencement speaker for the Academy's graduation on May 1, 2010 in Traverse City. The 2010 class included 28 cadets with the split of 17 deck officers and 11 engineers.

Ship Operators Cooperative Program

Carol Wolosz attended the Ship Operators Cooperative Program meeting in Houston, Texas, on April 20-21, 2010 and was recognized as a new member agency. Also, Carol provided an update on the GLMRI upcoming summer workshops at the Maritime Primary and Secondary Education Coalition break-out session.

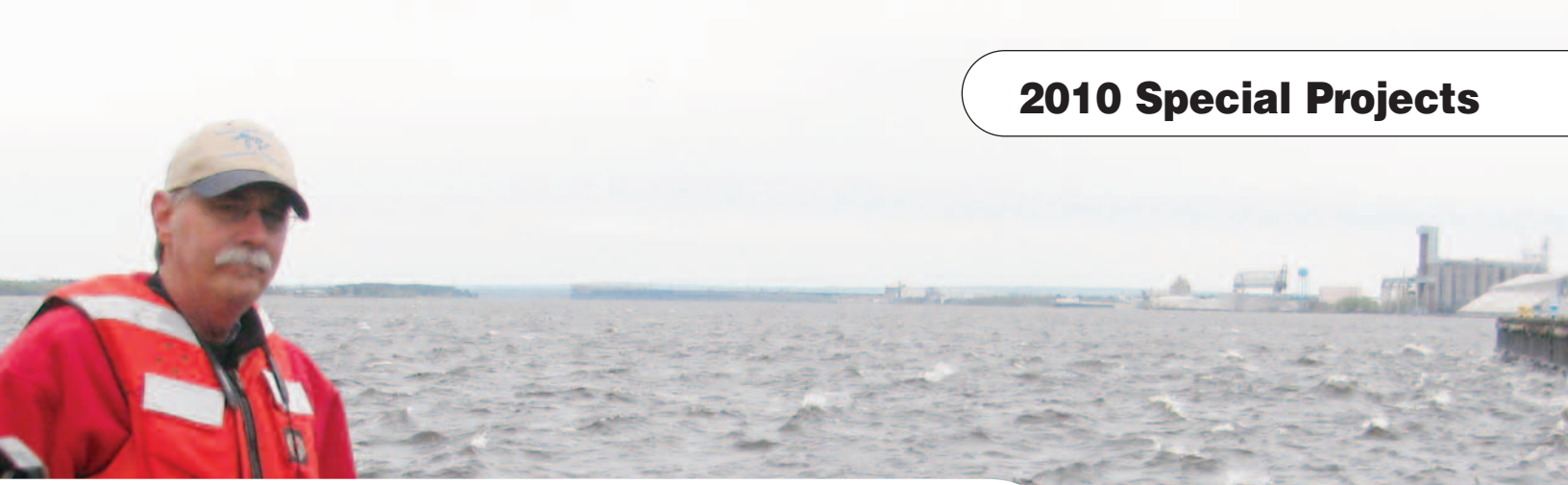
USACE Commander Meeting

Major General John Peabody, the Commander for the USACE Great Lakes and Ohio River Division, and Lt. Col Jim Davis, Commander for USACE's Detroit District and GLMRI Advisory Board member, along with USACE staff members met with Carol Wolosz to discuss GLMRI and USACE project collaboration. During General Peabody's visit on June 16th to Duluth, Minnesota he also met with the port directors from both Duluth and Superior.

TRB-CMTS Transforming the Marine Transportation System Conference

Dr. Stewart attended the Transportation Research Board and Committee on the Marine Transportation sponsored conference titled *Transforming the Marine Transportation System*. Dr. Stewart presented a paper titled "Dedicated Funding for University Maritime Research: Issues and Opportunities" and sat on an academic panel, chaired by Dr. Sandra Knight with fellow panelists Dr. Thomas H. Wakeman, Mr. Carl James Kruse, and Dr. William H. McAnally. The conference was held in Irvine, CA on June 29-July 1, 2010.

Above: Dr. Mary Balcer from University of Wisconsin-Superior's Lake Superior Research Institute provides tour of the Ballast Water Treatment Testing facility to the Great Lakes Maritime Academy cadets.



Marine Community Day

In conjunction with MARAD, GLMRI provided a slate of researchers at the Marine Community Day event on February 11, 2010 in Cleveland, Ohio. Mr. Floyd Miras, the Acting Director of the MARAD Great Lakes Gateway Office in Schaumburg, IL provided an introduction of the panel on the afternoon's agenda. Carol Wolosz provided a brief overview of the Institute and current happenings. Dr. David Singer from the University of Michigan discussed his plans for looking at electric power plant options for the Great Lakes Self-Unloaders. Dr. David Doorn from the University of Minnesota Duluth gave an update on the Great Lakes Economic Study. Dr. Scott Hawker from Rochester Institute of Technology presented the current progress for the Great Lakes-Geospatial Intermodal Freight Transportation Model since their team's workshop in August. Dr. Peter Lindquist from the University of Toledo also attended the workshop as the Principal Investigator for the Great Lakes Maritime Information Delivery System, and Co-PI of the Economic Study.

Society of Naval Architects and Marine Engineers

Dr. Richard Stewart, GLMRI Co-Director presented a report to the Society of Naval Architects and Marine Engineers at their Great Lakes and Rivers Section meeting on February 13, 2010 on the impact and effects of erroneous data for shipping and commerce.

Transportation Research Board Involvement

Dr. Stewart, a member of the Ports and Channels Committee and the Marine Environmental Committee, and Carol Wolosz participated in the Annual Transportation Research Board research presentations and committee meetings, along with Dr. James Winebrake (Rochester Institute of Technology), Dr. Peter Lindquist and Sarah Schaefer (U/Toledo), Jason Bittner and Greg Waidley from UW-Madison CFIRE and numerous students from UW-Superior and affiliate universities. The annual conference was held in Washington, DC, from January 10-14, 2010.

Ballast-Free Ship Design focus for IMO Forum

Dr. Michael Parsons was the keynote speaker at the International Maritime Organization's (IMO) GloBallast Program Research and Development Forum on Emerging Ballast Water Management Systems at the World Maritime University in Malmo, Sweden on January 27-29, 2010. His presentation included the results of the GLMRI Ballast-Free Ship research.

8th Annual Northeastern Wisconsin Global Trade Conference

Ms. Libby Ogard, Prime Focus LLC, participated in the 8th Annual Northeastern Wisconsin Global Trade Conference on March 30, 2010 in Oshkosh, Wisconsin where she included GLMRI informational material at the booth promoting the development of a freight advisory group in North Central Wisconsin. Over 300 attended the event with keynote presentations by Congressmen Tom Petri (R-WI 6th) and Steve Kagen (D-WI 8th).

Port Corrosion Study Group

The Corrosion Study Group met twice over the past year to discuss the latest findings on the sheet piling samples. The two meetings were held on December 1, 2009 and May 12, 2010 at the Lake Superior Marine Museum in Duluth. Dr. Randall Hicks and graduate research assistant Jon Bostrom from the University of Minnesota Duluth's Biology Department provided updates to the group. Dr. Brenda Little from the Naval Research Laboratory had recently published her findings on the corrosion tubercles. Dr. Little also presented her findings at the HTAC meeting held on December 2, 2009.

Above: Mr. Gene Clark, Wisconsin Sea Grant, on corrosion study tour of the Duluth/Superior Harbor.

2010 Special Projects

Graduate Thesis Seminar

Masters Degree candidate Jonathan Bostrom provided a public presentation of this thesis, *Microbiological and Chemical Aspects of Corrosion of Sheet Steel in the Duluth Superior Harbor* on November 3, 2010 at the University of Minnesota Duluth. Jon is a student in the Integrated Biosciences Graduate Program in UMD's Biology Department. His advisor is Dr. Randall Hicks. GLMRI provided funding support for this study.

River Quest

Associate Researcher Stacey Carlson partnered with the Duluth Seaway Port Authority (DSPA) for the 18th Annual St. Louis River Quest on May 10-13, 2010. River Quest is an educational program for local sixth graders that focuses lessons on the Duluth-Superior harbor and the St. Louis River. The students are taught through hands-on learning stations about making good environmental decisions, being safe on the water, and understanding industrial, commercial and recreational activities. This year, over 1,000 6th graders from the Duluth-Superior area participated in the event.

The GLMRI/DSPA learning station focused on many topics that highlighted the Duluth-Superior harbor and its position as the westernmost port in the Great Lakes St. Lawrence Seaway system. The students were asked to identify the types of cargoes that are handled in the port, where the commodities go, either in the Lakes or around the world, and in which end products they can be found. In addition, the students were asked how far Duluth-Superior is located from the ocean, how long it takes an oceangoing ship to reach the port and how the ship navigates the system of locks. Lastly, in order to show the importance of proper trim of a vessel during transits and cargo operations, the students "loaded" iron ore pellets on a laker model and were tasked with loading the pellets safely to keep the vessel in trim. www.seagrant.umn.edu/riverquest.

ASTM Seminar

Matt TenEyck, from the University of Minnesota Duluth, University of Wisconsin-Superior and Great Ships Initiative joint project supporting the biological research on the propagule pressure and colonization of invasive species, participated in the seminar on environmental requirements for commercial and Navy ships at the ASTM (formerly known as American Society for Testing and Materials) meeting in Atlanta, GA on December 9, 2009.

Shipowners International Joint Conference

Dr. Stewart presented a paper titled "The Critical Need for Accurate Marine Transportation Data and Analysis" at the International Joint Conference. The International Joint Conference was the summer business meeting of the Canadian Shipowners Association and the Lake Carriers' Association held in Niagara-on-the-Lake, Ontario on June 21, 2010.

Above: Mr. Chad Scott and AMI Consulting Engineers extracting sampling coupons from the tour of the Duluth Superior Harbor for the corrosion study.

Projects for 2010

Right: K-12 Educators Summer Workshop touring the Toledo drydock.

Research Projects commencing in 2010

With a reduced amount of funding provided in the FY10 Federal Appropriation, GLMRI released a limited request for proposals in April 2010. Eleven proposals were received within the submission period. In order to maximize the funding allocation, reduced offers were made on many of the proposals. Seven projects were awarded in September 2010 for research effort through August 2011:

- The Economics of a Bi-State Truck Ferry, Purdue North Central University, Dr. Thomas Brady
- Air Lubrication Drag Reduction on Great Lakes Ship, University of Michigan, Dr. Steven Ceccio
- Great Lakes Maritime Education Program for K-12 Teachers, Students and Communities, Michigan Technological University, Ms. Joan Chadde
- Economic Impact of the Great Lakes and St. Lawrence Seaway System (GLSLS), Oct 2010-Oct 2011, University of Minnesota Duluth, Dr. David Doorn
- Phase II-Developing a Risk Assessment Tool to Predict the Accelerated Corrosive Loss of Port Transportation Infrastructure: Model Validation and Regional Application, University of Minnesota Duluth, Dr. Randall Hicks
- Combining Fine Dredged Materials and Biosolids for Sustainable, Beneficial Reuse, University of Minnesota Duluth, Dr. Nathan Johnson
- Expanding Regional Freight Information Resources for the Upper Midwest Phase VI: The Great Lakes Maritime Information Delivery System: A Resource for the Regional Analysis of Intermodal Freight Flows in the Great Lakes Region, University of Toledo, Dr. Peter Lindquist

This report provides progress updates on the research efforts selected in 2009. The Request for Proposals for these projects was released in March 2009. The program office received a total of 15 proposals from eight of the 12 universities, requesting more than $1 million. External reviewers were selected based on the content/topic of the proposal. Each proposal was reviewed by multiple reviewers from academia, the maritime industry and governmental agencies.

As in the past, proposals were prioritized and a funding plan developed within the constraints of the available resources. Many of the proposers were offered a lesser amount than their requests and were asked to provide an updated work plan and budget to allow for the reduced funding.

Although the selections were announced in August 2009, the research contracts were delayed until the spring of 2010, due to the late receipt of funding to GLMRI. With the late start on the projects, the research has been delayed. Therefore, the following reports provide a summary of the progress through September 2010, with the research period extended to March 2011. Full reports will be posted on the GLMRI web page upon completion.

GLMRI Research Focus Areas

- 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
- 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 and develop tools for economic and environmental modeling and analysis.
- Identify market opportunities for, and impediments to, the use of United States-flag vessels in trade with Canada on the Great Lakes.

Evaluation of Integrated Electric Plants for Great Lakes Self-Unloaders

Full research reports are available at www.glmri.org

MV American Mariner – A prototype vessel for 730' MacArthur Lock/Welland/Seaway max self-unloader.

PRINCIPAL INVESTIGATOR
David J. Singer
Assistant Professor
Naval Architecture and Marine Engineering
University of Michigan

Co-Principal Investigator:
Michael G. Parsons
Professor Emeritus
Naval Architecture and Marine Engineering
University of Michigan

Dr. Singer earned his PhD in Naval Architecture and Marine Engineering from the University of Michigan in 2003. His B.S.E degree is also in Naval Architecture and Marine Engineering, with Masters Degrees in Concurrent Marine Design and Industrial and Operations Engineering, all from the University of Michigan. He is the Director of the NAVSEA Ship Production Science Program and the Advanced Naval Design Laboratory at the University of Michigan.

The feasibility and potential benefits of using Integrated Electric Plants in future Great Lakes self-unloading bulk carriers is being evaluated in this project. Integrated Electric Plants, all-electric ships, utilize electrical propulsion motors and central station power generation that would power all propulsion, thruster, self-unloading equipment and other ship service needs. Integrated Electric Plants have been used in recent naval vessels, cruise ships, high technology cargo vessels and many special purpose vessels, such as offshore supply and service vessels and icebreakers. This study is considering the arrangements, effects on cargo capacity at constant draft, fuel usage and environmental emissions in all operating modes, maintenance requirements, manning, and overall ship life-cycle economics of IEP Great Lakes self-unloaders. This comparison is being made for two notional self-unloading bulk carriers covering the length range from about 660 to 1000 feet.

Integrated Electric Plants (IEPs) have the potential advantages of reducing the number of prime movers required on a ship with more flexible arrangements since the design is not tied to a rigid linear prime mover, gearing, shaft line, propeller configuration. It can eliminate the need for reduction gears and the less efficient and more expensive Controllable Reversible Pitch (CRP) propellers. With correct design, there is also the potential to reduce fuel usage and emissions since the engines operating in any mode can be operated closer to their optimum design point. Maintenance requirements can also be reduced. The disadvantages that must be overcome are greater capital cost, loss of transmission efficiency, greater weight, and usually a greater machinery volume requirement. IEPs can prove advantageous in applications where the ship must spend much of its time at slower speeds, when high ship service (non-propulsion) power is required, or where special mission power requirements exist. Great Lakes self-unloading bulk carriers are particularly suited for the possible use of IEPs due to their relatively modest propulsion requirement due to their low speed and their varying speed profiles due to the short distances and many restricted waterways, locks, and connecting channels of the Great Lakes system. They also have large lateral thruster loads due to their relatively severe maneuvering requirements, large ballast system pumping loads due to their rapid loading and unloading, and large self-unloader conveyor loads needed to achieve their rapid unloading rates.

The initial focus in the first six months of this project has been on establishing the prototype Great Lakes self-unloaders to redesign with Integrated Electric Plants and evaluating the expected fuel use in all operating modes.

After a review of existing 1000' vessels designs, it was decided to use American Steamship's MV *Walter J. McCarthy, Jr.* (originally the MV *Belle* River Bay Shipbuilding hull 716) as the prototype for the 1000' Poe Lock maximum size self-unloading vessel for the study. After a review of smaller Great Lakes self-unloaders, it was decided to use American Steamship's MV *American Mariner* as the prototype for the 730' MacArthur Lock, Welland Canal, St. Lawrence Seaway maximum size vessel for the study. Data on these vessels was made available by American Steamship of Buffalo, New York, a subsidiary of GATX, through their Acting President Noel L. Bassett. The principal characteristics of the two study vessels are summarized in Table 1. (right)

MV Walter J. McCarthy, Jr. – A prototype vessel for 1000' Poe Lock max self-unloader.

A typical operating profile and Integrated Electric Plant (IEP) loadings for these two vessels in the various operating modes: open lake, reduced speed, maneuvering, locking/docking, loading, and unloading were established. The 1000' vessel was assumed to be in the taconite pellet trade. The 730' vessel was assumed to be in a more versatile limestone, coal, grain, etc. trade. This provided the basis for the development of the IEP's. For the fuel usage investigation, the original vessels with mechanically-driven, Controllable Pitch Propellers were updated to use current EPA Tier 2 versions of their engines to provide a comparison basis. For each vessel, IEP's were developed using fixed-pitch propellers and either EPA Tier 2 Caterpillar generators or EPA Tier 2 Wärtsilä generators. The latter designs use dual fuel engines (burning 99 percent Liquid Natural Gas with a 1 percent diesel ignition pilot) for the smaller generators to further reduce emissions while in port.

On a typical round-trip voyage, the vessels were assumed to spend six hours loading with their ballast pumps in use, six hours maneuvering at 30 percent propulsion power, eight hours at reduced speed at 50 percent propulsion power, 103 hours in the open lakes at 85 percent propulsion power, two hours locking and docking with the lateral thrusters in use while at ten percent propulsion power, and ten hours unloading with the ballast pumps and self-unloading system in use. Operation was assumed to be in winter conditions requiring ship heating. On the updated, current design vessels the reduction gearing transmission efficiency is about 97 percent, but the CRP propellers are about 1.5 percent less efficient. On the IEP vessels, the overall transmission efficiency from the prime movers to propeller shafting is about 90 percent. The roughly 7 percent overall transmission and propeller disadvantage for the IEP can, however, be overcome by the proper selection of the generator number and sizing so that all of the operating engines can be operated near their optimum point (between 80 and 100 percent of rated power) where their specific fuel rate (g/kWh) is best.

For the 1000' self-unloader comparison, the fuel usage per round trip voyage was found to be 7.1 percent less with the IEP design with Caterpillar generators compared to that required by the updated original vessels. More than half of this is due to the Caterpillar engines having a 4.1 percent better specific fuel rate at their design point than the updated EPA Tier 2 versions of the engines used on the current vessels. The fuel usage per round trip voyage was found to be 11.9 percent less with the IEP design with Wärtsilä generators than required by the updated original vessels. Over half of this is due to the Wärtsilä engines having a 7.9 percent better specific fuel rate at their design point than the updated EPA Tier 2 versions of the engines used on the current vessels. Thus, with proper IEP design the apparent 7 percent propulsion efficiency disadvantage can be overcome and a significant fuel use advantage of as much as 11.9 percent can be created by the proper selection and design of the IEP generator configuration.

For the 730' self-unloader comparison, the fuel usage per round trip voyage was found to be 4.9 percent less with the IEP design with Caterpillar generators compared to that required by the updated original vessels. Most of this is due to the Caterpillar engines having a 4.1 percent better specific fuel rate at their design point than the updated EPA Tier 2 versions of the engines used on the current vessels. The fuel usage per round trip voyage was found to be 9.8 percent less with the IEP design with Wärtsilä generators than required by the updated original vessels. Again most of this is due to the Wärtsilä engines having a 7.9 percent better specific fuel rate at their design point than the updated EPA Tier 2 versions of the engines used on the current vessels. Similar advantages are expected to be found in the emissions from these plants.

Work is continuing to study the arrangements and weight impacts and address the emissions and life-cycle economics comparisons between these plants. The IEP designs will consider the uses of modular generators installed on the main deck so that they can be easily removed and replaced in case of damage or so that major maintenance can be performed ashore during the Great Lakes winter layup period. The possibility of the generators remaining the property of the generator supplier with the ship owner just purchasing the electricity on a kWh basis is also being investigated. This is now existing practice in some land-based applications and would have the advantage of reducing the capital required for new Great Lakes self-unloading bulk carrier construction, in exchange for increased annual operating cost. This may be advantageous to some ship owners and enable earlier Great Lakes fleet modernization. ●

Table 1: Principal Characteristics of Two Study Vessels

	1000 FT (POE-MAX) SELF-UNLOADER	730 FT (MACARTHUR-MAX) SELF-UNLOADER
LOA	1000 ft	730 ft
B	105 ft	78 ft
D	56 ft	45 ft
Design T	27.5 ft	27.5 ft
Service Speed	14.0 kts	14.0 kts
Cargo capacity	80,900 gross tons	37,300 gross tons
Current propulsion power	14,000 hp = 10,440 kW	7,000 hp = 5,220 kW
Number shafts	twin screw	single screw
Propellers	17.5 ft. dia., 120 rpm FPP	17.5 ft dia., 120 rpm FPP
Bow thruster	1200 kW	800 kW
Stern thruster	1200 kW	800 kW
Hold-loop belt drive	2 @ 750 kW = 1500 kW	conveyor system total
Boom belt drive	2 @ 430 kW = 860 kW	1300 kW
Ballast pumps	4 @ 120 kW = 480 kW	2 @ 120 kW = 240 kW
Ship service power	467 kW, max during docking	510 kW, max. during docking
Design prototype	MV Walter J. McCarthy	MV American Mariner

Project Report

Refinement of the Ballast-Free Ship Concept

Full research reports are available at www.glmri.org

PRINCIPAL INVESTIGATOR
Michael G. Parsons
Professor Emeritus
Naval Architecture and Marine Engineering
University of Michigan

Co-Principal Investigator:
Militiadis Kotinis
Assistant Professor
Mechanical and Aerospace Engineering
Old Dominion University

Dr. Parsons earned his BSE in naval architecture and marine engineering from the University of Michigan. Following six years of active duty in the U.S. Navy, he earned his Ph.D. in applied mechanics from Stanford University. He joined the Department of Naval Architecture and Marine Engineering of Michigan in 1972. He 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.

In this project, the Ballast-Free Ship Concept is being further analyzed and refined to resolve outstanding issues related to its effectiveness, operational practicality and economics. Recent GLMRI sponsored testing has shown that the optimum use of the Ballast-Free Ship Concept could result in a significant improvement in propulsion power requirement. This savings needed to be better understood, to ensure that this advantage could actually be realized. The remaining confounding issue was that in all previous laboratory experiments stock propellers were used from the hydrodynamics laboratory library. It was suspected that part of the indicated required power reduction might have been due to the stock propellers simply being more optimal for the Ballast-Free trunk flow case. An optimum propeller has been designed for the vessel and a model has been manufactured using rapid prototyping. This propeller has been used in recent towing tank experiments to clarify this issue. Various draft and trim control operational scenarios are also being investigated to establish the capability and limitations of the Ballast-Free Concept ballast control in ship operations. Finally, the detailed design of the incorporation of bulkhead isolation valves and their effect on the internal trunk flow is also being investigated.

A critical aspect regarding the viability of the Ballast-Free Ship (BFS) Concept is the impact of the concept on the hydrodynamic performance of the vessel. Investigations have been performed both in the towing tank and numerically using Computational Fluid Dynamics (CFD), in order to understand the interaction between the water suction/discharge and the flow around a bulk carrier vessel, including the inflow to the propeller. The investigations performed prior to this project showed that discharging water at the stern at low speed, relative to the ship speed, did not have a negative effect on the propulsion requirements of the vessel and might result in a fuel savings of about 1.6 percent in the no load (ballast) condition. These investigations were all performed in model scale using analysis procedures that are widely-accepted for experimental ship hydrodynamic investigations. These procedures are not physically able to scale the viscous flow in an accurate manner, thus, they cannot fully account for flow interactions that occur within the boundary layer region. For this reason, it was decided to follow a different course of action in order to quantify the effect of the BFS concept on the flow around the vessel. The first step was to analyze the wake of the un-appended vessel using CFD. This was done for both the bulk carrier model and full scale vessel operating in both full load and ballast drafts. The initial results of the CFD analysis were reported in the GLMRI 2008 Annual Report. As expected, these results revealed considerable differences in the wake distribution in the propeller plane between model and full scale hulls. This numerical investigation has been carried over to the current project.

The next task in the refinement of the hydrodynamic investigation of the BFS required the design of an optimal wake-adapted propeller. The model scale vessel operating at the full load draft was used as the design basis. The corresponding wake distribution in the propeller plane, which was previously computed using CFD, was utilized as input to the propeller design procedure. The resistance of the vessel in this condition was measured during towing tank experiments. The co-PI performed a preliminary analysis using data from the Wageningen B-Series five-bladed propellers in order to find the combination of rotational speed and expanded area ratio that provides high efficiency with minimal blade cavitation. This optimal value of the expanded area ratio (A_e/A_o = 0.75) was used in order to compute the chord lengths of the blade sections at different radii based on the Wageningen B-Series data. The blade sections were modeled using a parameter a = 0.8 camber distribution combined with a modified NACA 66 thickness distribution. The optimal circulation and pitch distributions were then obtained utilizing the open source propeller design and analysis program OpenProp. OpenProp's propeller design algorithm is based on a vortex lattice lifting line analysis with panels distributed along the propeller blade span. A helical wake model aligned with the flow at the lifting line is incorporated, enabling the design of moderately loaded propellers. The optimization algorithm is

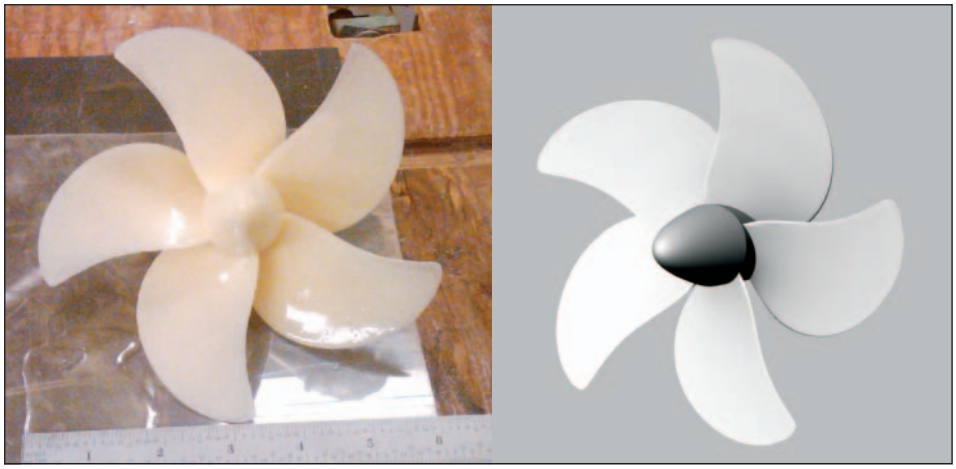
based on Lerbs' criterion, which allows for a radially varying circumferential mean inflow. The propeller has a 15˚ rake and a moderate 25˚ (34.7 percent) quadratic skew distribution. A 3-D image of the resulting optimal propeller design is depicted above in Figure 1. The corresponding open water performance diagrams are displayed in Figure 2.

The optimal wake-adapted propeller was then manufactured using Fused Deposition Modeling (FDM); a rapid prototyping procedure. Acrylonitrile butadiene styrene (ABS) was used as the propeller material since it provides high mechanical strength and rigidity, but is also easy to process. The manufactured propeller is shown on the right in Figure 1.

The model-scale propulsion tests were then performed in the towing tank of the Marine Hydrodynamics Laboratories (MHL) at the University of Michigan. The results revealed that, as suspected, the utilization of an optimal propeller does diminish the gain in propulsive efficiency obtained with the non-optimal stock propellers. These gains in propulsive efficiency, however, are still capable of offsetting the 4.5 percent increase in resistance observed with the discharge of the trunk flow at the stern of the vessel. A comparison between the no-trunk-flow case and the case with a 90-minute exchange time discharge at Station 17 (near the forward engine room bulkhead) is shown in Table 1. This confirms that the Ballast-Free Ship concept can be used in Seaway-sized bulk carriers without incurring a fuel use penalty.

At the time of this writing, at the midpoint of this project, effort has shifted to studying the draft and trim control of vessels designed using the Ballast-Free Ship (BFS) concept. The control of the vessel's trim and draft when adopting the BFS concept has a more 'discrete' nature compared to a conventional bulk carrier. This needs to be evaluated further to ensure that these vessels will have adequate control of their draft and trim. The initial BFS design concept omitted fill/empty lines to each isolatable section of the outboard trunks that extend beneath the cargo region of the ship and included no subdivision capability within the two longitudinal trunks next to the keel. An investigation of the trim and draft control capability of a conventional bulk carrier and a Ballast-Free concept bulk carrier is now being undertaken using Hydromax® assuming that the vessel carries no load and two-thirds of fuel and fresh water. The results of this control capability comparison and any required modifications to the segregation and piping concepts will be reported in the final report for this project. When this is completed, the bulkhead isolation valve study will be undertaken and the BFS concept economics comparison will be updated to reflect these refinements. ●

Figure 1: Optimum Propeller Design (left) Rapid Prototyping Realization of Model Propeller (right).



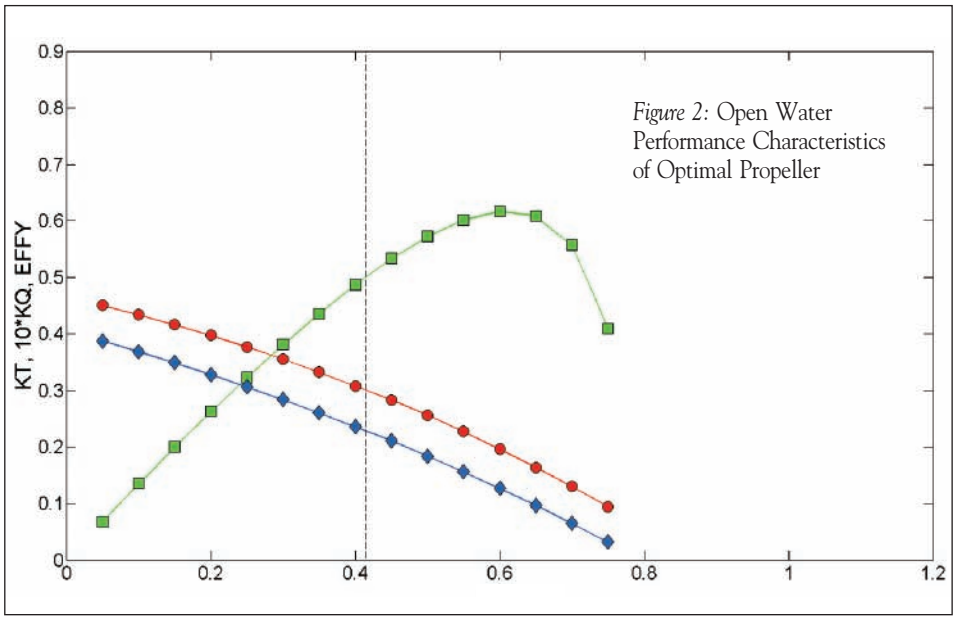


Figure 2: Open Water Performance Characteristics of Optimal Propeller

Table 1: Propulsion Test Results - Ballast Condition at 15.5 knots

	Baseline - No Trunk Flow	Discharge at Station 17 - 90-min Exchange Time
Open water efficiency η_O	0.437	0.423
Effective wake fraction w	0.458	0.468
Thrust deduction t	0.343	0.366
Hull efficiency $\eta_H = (1-t)/(1-w)$	1.211	1.193
Relative rotative efficiency η_R	1.078	1.183
Behind propeller efficiency $\eta_P = \eta_O\ \eta_R$	0.471	0.500
Advance coefficient $J = V(1-w)/(nD)$	0.399	0.383
Propulsive efficiency $\eta_D = \eta_O\ \eta_H\ \eta_R$	0.571	0.597
Change in propulsive efficiency	base	+4.55%
Delivered power P_D (hp)	12,336 ± 64	12,343 ± 107

WebGIFT-GL: Expanding Access to the Great Lakes Geospatial Intermodal Freight Transportation (GL-GIFT) Model

Full research reports are available at www.glmri.org

PRINCIPAL INVESTIGATOR
J. Scott Hawker, Ph.D.
Associate Professor of Software Engineering
Rochester Institute of Technology

Dr. Hawker is an Associate Professor of Software Engineering and Co-Director of the Laboratory for Environmental Computing and Decision Making at RIT. He has more than 15 years of industry experience developing large-scale, multi-agent information and control systems for diverse applications including manufacturing, combat pilot decision support and mission management, robotics and surveillance. In these areas, he developed and applied technologies including distributed, component-based software architectures, software and systems engineering process models, intelligent control, the semantic web and real-time artificial intelligence. Since 1999, Dr. Hawker has been in academia, first at the University of Alabama then at RIT, where he teaches undergraduate and graduate courses in Software Engineering.

In prior Great Lakes Maritime Research Institute (GLMRI) projects, we developed and demonstrated the value of the Great Lakes Geospatial Intermodal Freight Transport (GL-GIFT) model—an innovative, dynamic, network optimization model for analyzing: (1) the economic, energy and environmental impacts associated with Great Lakes freight movement, including the ability to make tradeoffs among different freight modes operating in the Great Lakes; (2) decisions related to various highway and intermodal facility infrastructure development; and (3) decisions and policies aimed at improving maritime transport efficiency in the Great Lakes. GL-GIFT allows users to conduct route analyses based on various network attributes, including: cost, time-of-delivery, distance, energy use and emissions. Our case studies have shown that Great Lakes marine shipping demonstrates certain advantages when compared to landside modes such as trucks and rail.

This new project is moving GL-GIFT from a desktop computing environment to a web-based platform so that it will be available to many users via the internet. We will also develop user-friendly interactions to support case study definitions, data management and sharing, and analysis. We will make this new tool, called WebGIFT-GL, available to GLMRI affiliates and other selected users for a trial operation period of two to four months, including an evaluation/training workshop and user support.

Project Objective. Availability and Ease of Use. GL-GIFT has proven valuable in understanding the environmental, economic and energy trade-offs across freight transportation modes in the Great Lakes region. Our prior years' projects used the desktop based tool to perform case studies of (1) containerized freight movement between Montreal, Quebec and Cleveland, Ohio and (2) high-volume bulk (in this case, coal) movement. In the first study GL-GIFT helped us understand, for example, that the type of vessel used impacts the selection of marine over rail transport for the least CO_2 impact and how these vessel choices compared against rail and truck transport on environmental and time-of-travel factors. In the second study we found that intermodal routes that combine rail transport for land-side segments with transfer to marine routes for segments that can cover significant distances (such as the Great Lakes or coastal short-sea routes) could lead to significant operating cost savings and reduced CO_2 emissions.

Unfortunately, performing these case studies is time consuming, sometimes confusing and requires detailed freight transportation policy expertise to properly set up the cases and interpret the results. Further, the policy analyst would need GL-GIFT installed and configured on their local computer, requiring significant software license costs and installation and continuous update and maintenance of large data sets that model the water/rail/road transportation network, intermodal transfer facilities and variety of vessels, trains and trucks available. Our goal in the current project, WebGIFT-GL, is to make GL-GIFT functionality available to a broad range of users via Web-based access and intuitive user guidance. We want to enable policy analysts, regional planning organizations, non-government organizations, and others to do basic trade-off case studies specific to their needs. Through a limited initial roll-out and trial use, we will also gather data to evaluate the costs and feasibility of

Figure 1

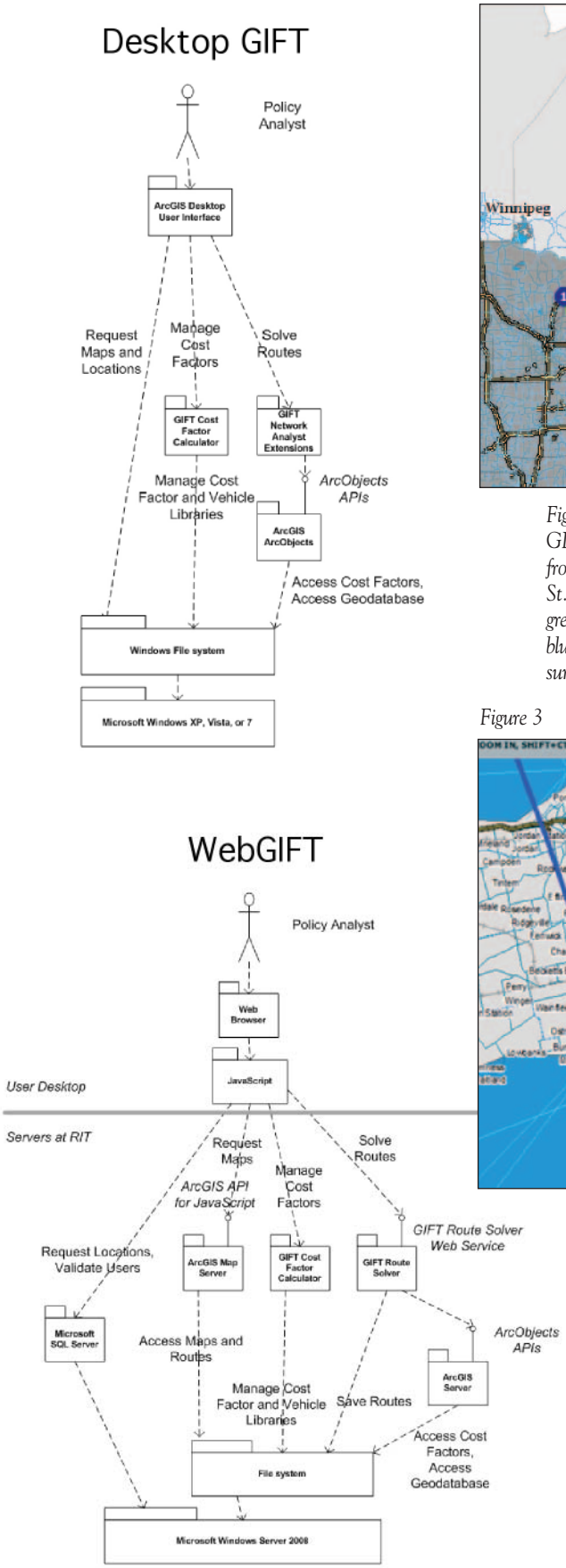


Figure 1. Moving Desktop GIFT functionality to run on the Web requires significantly more technology and computing infrastructure, but it eases the technology needs of the end user—they only need a standard Web browser.

Figure 2

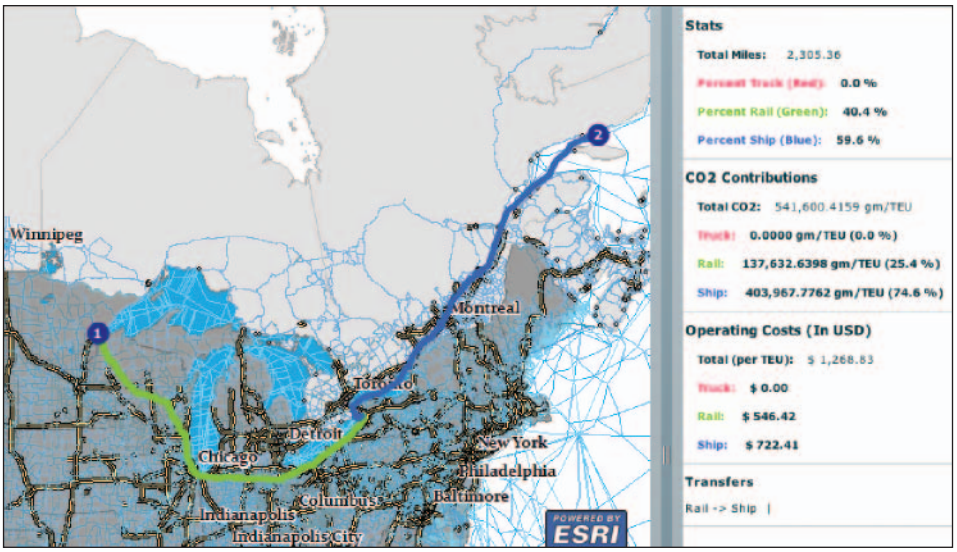


Figure 2. A screen snapshot of a WebGIFT-GL prototype showing an intermodal route from Duluth, Minnesota to the inlet of the St. Lawrence Seaway. The first segment (in green) is on rail, and the second segment (in blue) is on a marine route. To the right are summary statistics for the route.

Figure 3

Figure 3. Zooming into the map allows the analyst to visualize the freight being transferred from rail to water at the Port of Buffalo, New York, then traversing through the Welland Canal from Lake Erie to Lake Ontario.

providing WebGIFT-GL as a service to government, non-government and non-profit organizations.

Progress. Our initial work evaluated the technical feasibility of moving the desktop-based GIFT to a web-based platform. As Figure 1 illustrates, moving the desktop-based implementation of GIFT to the Web requires significantly more technology and computing infrastructure, but it eases the technology needs of the end user. The end user needs only a standard Web browser with JavaScript enabled (JavaScript is built in to virtually all browsers since 1995—no plug-ins or downloads are required). Most of the "hard" computing functionality is moved to RIT-hosted server hardware running Windows Internet Information Server, SQL Server relational database management system, and other server platform technology. On this server hardware, ArcGIS Server (instead of ArcGIS Desktop) and a number of components to make functionality available as Web services are necessary. Before the JavaScript web-side approach, we originally selected Adobe Flash plug-ins and a commercial server-side technology called WebORB to allow Flash ActionScript programs to access web services. We chose this for ease of development, but found that the dependencies on Flash and WebORB would be hard to manage in the long-run, and some users may not be able to use Flash.

We succeeded in getting the "stack" of new technologies to play together and provide a useful visualization of the route and associated environmental and economic data. Figure 2 is a screen snapshot of our WebGIFT-GL prototype showing an intermodal route where the first segment is on rail and the second segment is on a water route. Summary statistics of the route are

Continued

WebGIFT-GL: Expanding Access to the Great Lakes Geospatial Intermodal Freight Transportation (GL-GIFT) Model

available in the panel to the right. Zooming in, as in Figure 3, the user can visualize the transfer of freight from rail to water at the Port of Buffalo, then traversing through the Welland Canal from Lake Erie to Lake Ontario. Figure 4 shows that detailed, segment by segment information is available for the route, providing the raw data for detailed analytics to support the environmental, economic, and other characteristics of a given route. Figure 5 illustrates our new JavaScript-based user interface implementing a comparison of the mode shift occurring between least cost, least time and least CO2 routing choices.

Figures 2 through 4 show some of the interaction available to a user to understand specific routes. We are also working to ease the effort in creating routes and selecting from a library of vessels, trains and trucks. We have created a database of pre-defined locations based the US Department of Transportation Bureau of Transportation Statistics Commodity Flow Survey (CFS) data. This enables the user to easily select route origins and destinations that provide intermodal service, and it allows the user to integrate with the commodity type, volume and value information available from CFS for case studies needing that data. The user can also enter origin/destination information using street addresses, latitude and longitude, or by point-and-click on the map. To ease selecting vehicles, we are integrating WebGIFT with a vehicle emissions calculator and library to allow users to select vessels, train configurations and trucks appropriate for their case study

On-going work. We have not yet completed software development and testing. We need to re-implement the user interaction functionality using JavaScript instead of Adobe Flash and ActionScript, we need to make improvements to our Web service interface to our route solver software that extends the ArcGIS Network Analyst route solver functionality, we need to integrate with our vehicle emissions model and library, we need to improve the overall user task flow for improved usability, and we need to integrate our user login and user account management functionality.

There are a number of other functional and user interaction improvements we seek to make. Our plan is to deliver a "pre-beta" WebGIFT-GL prototype to internal and selected external users to obtain early feedback on functionality, usability and other necessary improvements. We will continue development during this initial testing, and then we will release a more general-release version that incorporates more functionality and improvements based on the pre-beta test results and on-going development. Our intent is to have two-to-four months of limited deployment and trial operation before the end of the current project phase.

Outreach. We had a number of good opportunities to share and discuss our GIFT work, including presentations and a paper.

- Presented previous Great Lakes GIFT work as part of a GLMRI panel at the Marine Community Day event in Cleveland, Ohio, on February 11, 2010.
- A paper titled "An Integrated Model to Study Environmental, Economic, and Energy Tradeoffs in Intermodal Freight Transportation" was presented at the International Environmental Modeling and Software Symposium in Ottawa, Ontario, in July, 2010.
- Presented GIFT at an Innovation Showcase in Washington, D.C. on August 4, 2010. This was sponsored by Senator Kirsten Gillibrand from New York. ●

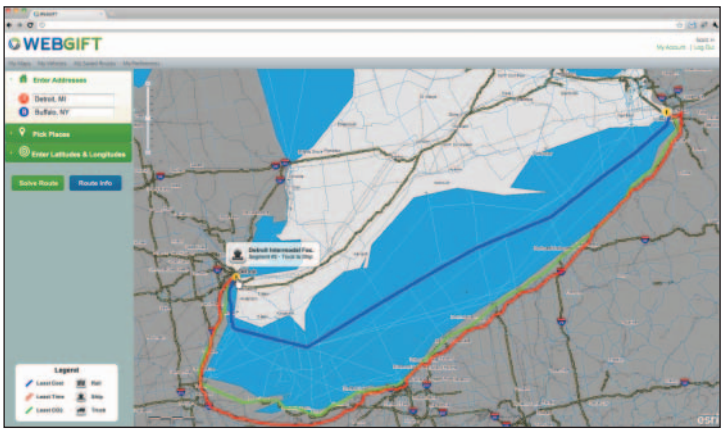


Figure 4. Detailed, segment by segment information of a route is available, allowing detailed analytics for energy, environmental, and economic trade-off case studies.

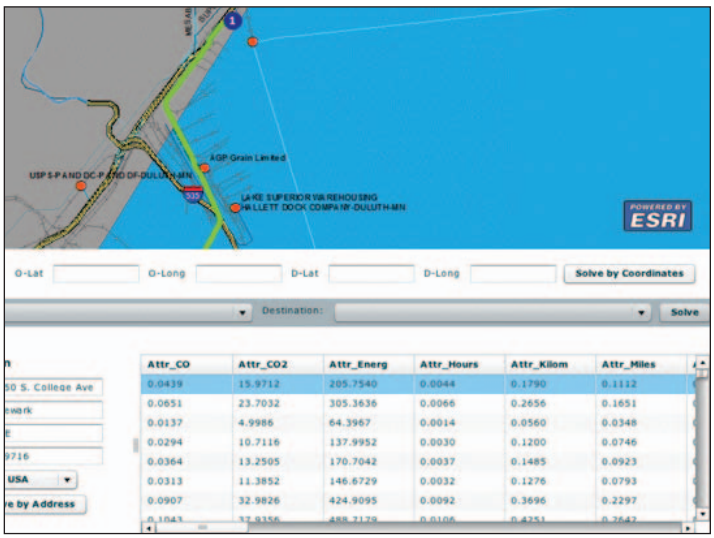


Figure 5. A visual comparison of the different routes and modes taken, comparing least cost (blue color - marine), least time (red color - truck), and least CO_2 (green color – rail).

Expanding Regional Freight Information Resources for the Upper Midwest: Phase V The Great Lakes Maritime Information Delivery System: A Resource for the Regional Analysis of Intermodal Freight Flows in the Great Lakes Region

Full research reports are available at www.glmri.org

This is the fifth phase of a long-term effort to develop and manage the Great Lakes Maritime Information Delivery System (GLMIDS). This web-based data repository, information clearinghouse and online geographic information system (GIS) is designed to serve as a comprehensive data resource linking maritime freight transportation in the Great Lakes to the wider regional economy (see *http://www.maritime.utoledo.edu)*. Users can take advantage of the GIS location-based query and selection capabilities as well as mapping functions to report data concerning transportation networks, ports, economic activities and commodity flows in the region. This project collectively contains the following functions and data sets in its current state:

- An information clearinghouse and centralized data facility furnishing links to other sites, private vendors furnishing commercial products, and government agencies, etc.;
- A data delivery system that includes detailed regional economic data, weather and climatic data, dock and terminal facilities, commodity movements, intermodal connectivity, lock data and navigation facilities, movements, intermodal transportation networks (including rail, highway and air);
- Access to AIS data for tracking vessel movements in the Great Lakes;
- An interconnected intermodal network (water, rail, highway) that will enable analysts to incorporate transshipment costs and characteristics at terminals;
- An online *Atlas of Great Lakes Maritime Commerce* that includes maps for download in PDF format;
- A data delivery function in the form of a secured FTP site at the project web page for approved users;
- A customized GIS data viewer in the form of *Midwest FreightView (MWFV)*;

The current phase of this project has been devoted in large part to continued data collection and management, with an emphasis toward automated data collection and toward the collection of new sources of data. In addition, the project team has continued efforts in collaboration with researchers in GLMRI partner institutions through data sharing and providing access to the online GIS. The project team has also stepped up efforts to provide more detailed information on commodity flows and the preparation of maps, graphics and data displays in the *Atlas of Great Lakes Maritime Commerce*. The final stages of this phase of the project are concentrated on phasing out the current version of MWFV in favor of a newer, more user-friendly online GIS data viewer that will feature the same data viewing features of the old system, but with improved data download capabilities and a new set of analytical tools. The project team has programmed modules for seamless incorporation into the new MWFV for the routing of cargoes, definition of market and port catchment areas, site selection and intermodal connectivity on this data delivery site. As these features are incorporated in the new system, the project team will devote its attention to technology transfer functions, including workshops, online documentation and publications.

Data collection with an emphasis on automation. Data collection will always remain an ongoing central process if the repository is to remain current and relevant to the maritime

PRINCIPAL INVESTIGATOR
Dr. Peter Lindquist
Associate Professor
Geography and Planning
University of Toledo

Dr. Peter S. Lindquist is Associate Professor of Geography in the Department of Geography and Planning at The University of Toledo. He is the Director of the Spatially Integrated Social Science Ph.D. Program and the Director of the Center for Geographic Information Science and Applied Geographics (GISAG). Dr. Lindquist received his Ph.D. degree from The University of Wisconsin-Milwaukee. His research interests focus on geographic information systems applications in operations research, freight planning and location analysis.

Expanding Regional Freight Information Resources for the Upper Midwest: Phase V The Great Lakes Maritime Information Delivery System: A Resource for the Regional Analysis of Intermodal Freight Flows in the Great Lakes Region

Figure 1: AIS Vessel Tracking on Secure Web Page.

community in the region. However, many of our data collection efforts to date have been labor intensive and reliant on existing sources of data either through download or purchase. An alternative to this approach is to identify and implement new ways to collect data through automated methods. As a result, the project team has implemented new procedures for data collection through web-based data entry by dock owners and operators, as well as through the acquisition of AIS (Automated Identification System) data in partnership with the Great Lakes and Seaway Shipping Online, Inc. (GLSS, *aka* BoatNerd). GLSS has placed several AIS receivers at key points throughout the Great Lakes region and is currently planning to install additional sites.

The Toledo project team has purchased three additional AIS receivers for GLSS to install at key points. In return, GLSS streams vessel positions to the Toledo server, where vessels are tracked at one-half hour intervals and posted into the MWFV GIS on their closest link in the U.S. Army Corps of Engineers (USACE) National Waterway Network. These data, however, are not available for public viewing through an agreement with GLSS. As these data are processed, reduced and summarized, the repository will maintain an inventory of aggregate monthly vessel movements. The project team will also use this technology to track arrivals to and departures from specific docks and terminals when used in conjunction with the USACE *Master Docks Plus* data residing in the repository. This capability is an outcome of a related project undertaken by the Toledo project team in partnership with the USACE, U.S. Customs, the IRS and the U.S. Coast Guard through the Federal Initiative for Navigation Data Enhancement (FINDE) program. This information could be applied in a number of ways in addition to monitoring vessel traffic in the lakes, such as in promoting and marketing port functions or in providing accurate and timely data for dredging requests, *etc*. To date the dock data collection and AIS data collection methods have been successfully integrated into the repository (see Figures 1 and 2). As mentioned above, the streamlined AIS data are secured with encryptions and password protections and are not available to the general public.

Data collection using more traditional methods has also continued in this phase through the acquisition of information relating to the regional economy, transportation networks, port and terminal facilities, and cargo movements. As these efforts continue, the project team will also continue to maintain and improve the web site and our online GIS MWFV platform for data delivery purposes. In terms of continued data acquisition, preprocessing and incorporation into MWFV, the following tasks (as outlined in the project proposal) are completed or currently in process:

- ORNL CTA North American Rail Interlining Network
- Integrated Network—Great Lakes Waterway, Highway, Rail linked to Commercial Docks, Locks (USACE)
- Updated U.S. Highway Network Speed/ Estimated Travel Times with ATRI Travel Time Data (by time of day, day of week)
- Add ESRI Traffic Counts to integrated highway network
- Link BEA Regions/BEA GDP Data to Public Rail Waybill Data
- Encode enhanced EPA eGRID Power Plant Database into MWFV and link to Rail and Waterway Network
- Link USACE Foreign Traffic Vessel Entrances and Clearances to Ports
- Add legends, labels and text to "Last Mile" Connections on Satellite Imagery—connect these images to the new MWFV Viewer Site
- Input County-to-County Mileage and Impedance Tables into MWFV for analytical procedures (Useful for Analytical Tools—Accessibility, Location Analysis, etc.). The primary modes for these tables include: Highway, Rail, Water.

Cooperative work and data sharing with GLMRI partner institutions. If the data products and online data delivery tools are to be useful to the maritime community, it is essential that the members of the project team find ways to put them to work in the hands of analysts with the skills to optimize their use. As data collection continues, so will the project team's involvement in disseminating and sharing data with our GLMRI partners and a wider community of partners. Selected cooperative ventures are summarized as follows:

- Economic Impact of the Great Lakes and St. Lawrence Seaway System (GLSLS) (see Doorn, D: http://www.glmri.org/research, 2009).
- Great Lakes Marine Container Service Feasibility Study: Connecting Green Bay to Global Container Service providers serving ports on the St. Lawrence Seaway (see Hutchinson, E.R.: http://www.glmri.org/research, 2009).
- Multimodal Freight Transportation within the Great Lakes-Saint Lawrence Basin
- TRB National Cooperative Freight Research Program-35 (Joint project between CPCS Transcom Limited, GLMRI, University of

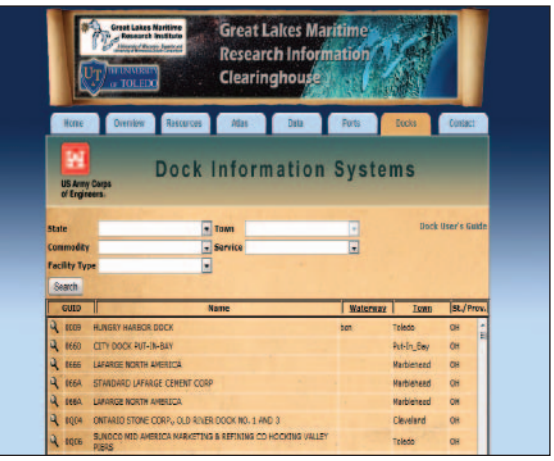


Figure 2: Dock Information Data Site

Figure 3: Origin/Destination Ports for Coal

Figure 4: Origin/Destination Ports for Limestone

Figure 5: Iron Ore Shipments and Receipts

Figure 6: Coal Consumption for Power Plants

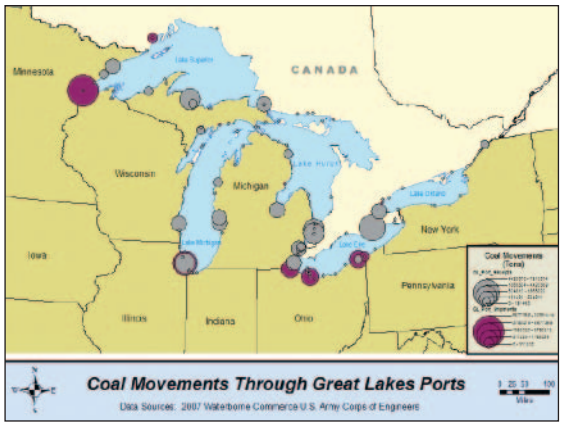
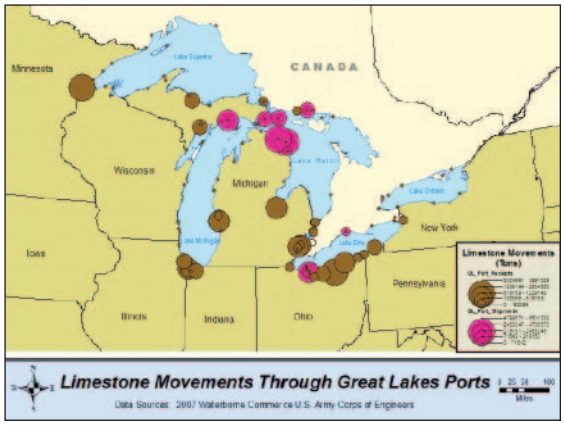


Figure 3



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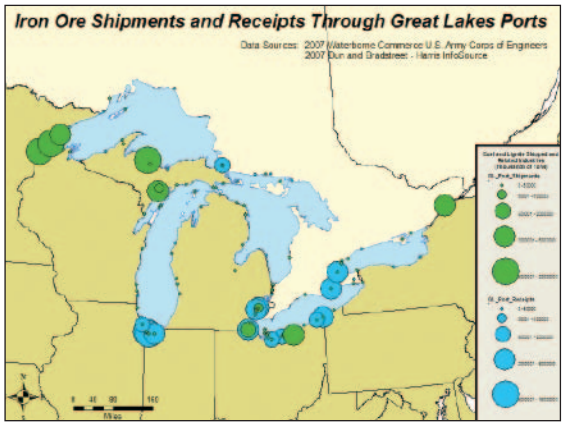

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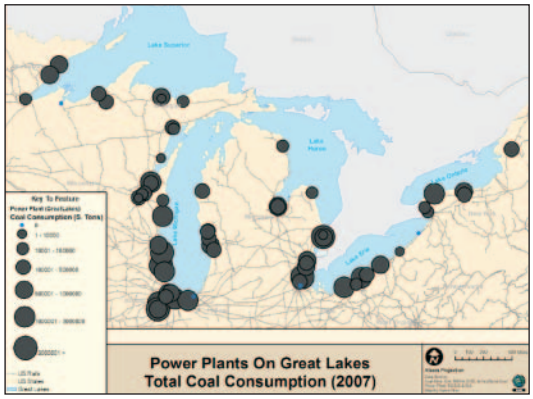


Figure 6

Toledo GISAG Center, Economic Development Research Group, Prime Focus LLC, and Sustainable Ports)

- *Ohio Statewide Freight Plan* (Joint project between the University of Toledo GISAG Center and Wilbur Smith Associates)
- FINDE: Federal integrated Navigation Data Enhancement (*Joint automated data acquisition project between University of Toledo GISAG Center, USACE, IRS, US Customs, Coast Guard)*

In addition to these projects, the project team is also involved with a number of other joint projects with researchers at UW-Madison, UW-Milwaukee and The University of Illinois-Chicago. The project team will continue to solicit opportunities for joint work with our affiliate universities and outside contractors. Data and analysis results from these efforts will be documented and published on the data delivery site where appropriate.

Commodity flow analysis and the *Atlas of Great Lakes Maritime Commerce*. A detailed analysis of select major commodities flowing through the Great Lakes is currently being assembled by the project team. Comprehensive coal supply chain mapping is currently underway from the mine, through the lakes, and finally to the end power plants. An economic assessment, by mode through the region, will accompany this analysis. In addition, limestone, iron ore and petroleum are being investigated on a broader spectrum by relating flows between origin and destination ports. Sample maps for inclusion in the *Atlas of Great Lakes Maritime Commerce* are in Figures 3-5. The final product will be in the form of an interactive PDF that can be downloaded or printed from the site and feature comprehensive commodity flows through the region.

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 wide 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 a 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.

During phase five, the project team has expanded its efforts to include automated data collection programs linked to AIS acquisition and web-based entry of dock and port facilities, as well as in collecting new sources of data. Another focus has been the cooperative work and data sharing with GLMRI partner institutions and other partners. Finally, the project team has stepped up efforts to compile detailed commodity flows in the Great Lakes for incorporation into the *Atlas of Great Lakes Maritime Commerce*. ●

Project Report

Year 4, Building Sustainable Solutions to the Issue of Ballast Water Treatment: Testing Relationships Between Propagule Pressure and Colonization Success of Invasive Species

Full research reports are available at www.glmri.org

PRINCIPAL INVESTIGATOR
Donn K. Branstrator
Department of Biology
University of Minnesota Duluth

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

Donn received the B.A. in Biology from Lawrence University, Wisconsin, and the Ph.D. in Biology from the University of Michigan. He teaches courses in general ecology, lake ecology, and plankton biology, and leads a team of undergraduate and graduate students that study the ecology of freshwater zooplankton at the University of Minnesota Duluth.

This multi-year project addresses the issue of ballast water treatment by examining the efficacy of the standard 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 the International Maritime Organization (IMO) standard for zooplankton greater than 50 microns in length in minimum dimension.

In years one and two of this project, we characterized the density and diversity of crustacean zooplankton in the Duluth-Superior Harbor and St. Louis River Estuary. This was a necessary first step in developing the experimental context. In particular, the data on natural harbor and estuary densities of zooplankton species that taxonomically resemble our experimental surrogate invader provided a means to identify anticipated densities that the invader would have to achieve to be considered successfully established in our mesocosm experiments. The results of years one and two have been conveyed in previous annual reports.

Our analysis here of three experimental trials indicates that growth trajectories were trial and treatment specific. Densities of *D. magna*, our surrogate invader, were the highest in Trial 1 and the lowest in Trial 3. It is believed that the differences in growth trajectories and establishment success are influenced by the background communities specific to each trial. The results from Trials 1-3 and future trials may be used to 1) help evaluate the efficacy of the current IMO standard at preventing future invasions and 2) determine whether there are particular times and locations in the Duluth-Superior Harbor where the natural zooplankton community may reduce the probability of establishment for organisms similar to the surrogate invader tested in these trials.

Freshwater ecosystems are highly vulnerable to invasions by non-native species because of their close association with human activity, including uses for municipal and industrial water supplies, natural resource development and commercial navigation and recreation (Ricciardi and MacIsaac 2000, Colautti et al. 2003). Many non-native species are causing environmental changes to food web structure and water quality, and are imposing high economic costs in a variety of ways (Colautti et al. 2003, Leung and Mandrak 2007, Bailey et al. 2009). It has been estimated that the damages and additional maintenance caused by non-native species in the U.S. has cost $120 billion, or $100 per household annually (Pimentel et al. 2005).

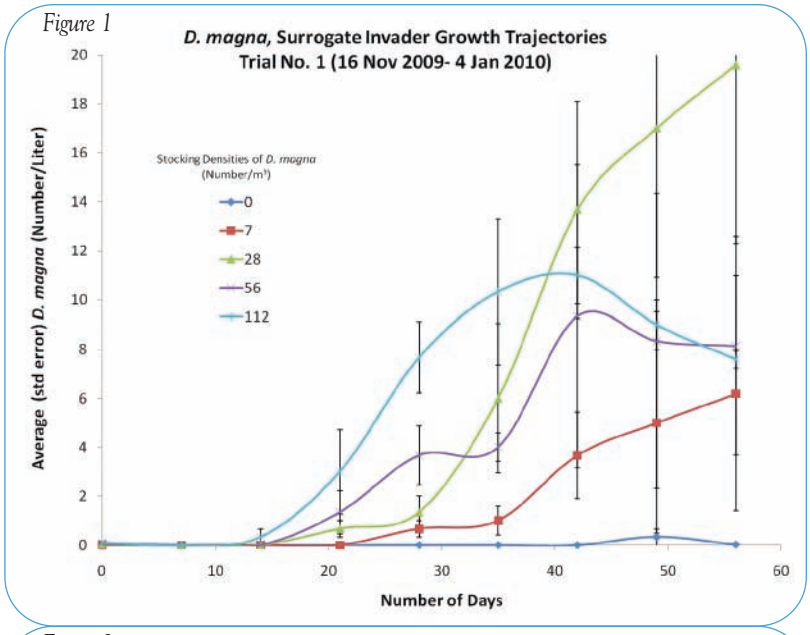
During the past century, the North American Laurentian Great Lakes have received an increasing number of non-native species (Ricciardi and MacIsaac 2000). Ballast water ferried by ships and used to correct imbalance in cargo is believed to be the leading dispersal agent of coastal non-native aquatic biota 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.

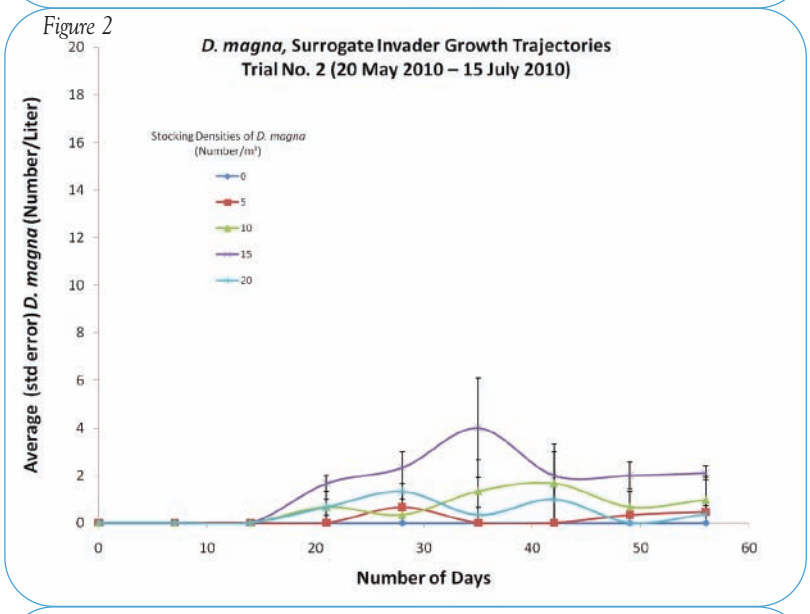
In an effort to prevent additional species introductions via this vector, the U.S. Congress passed and reauthorized legislation in the 1990s that requires vessels to manage their ballast water in one of two ways. Ships are required either to

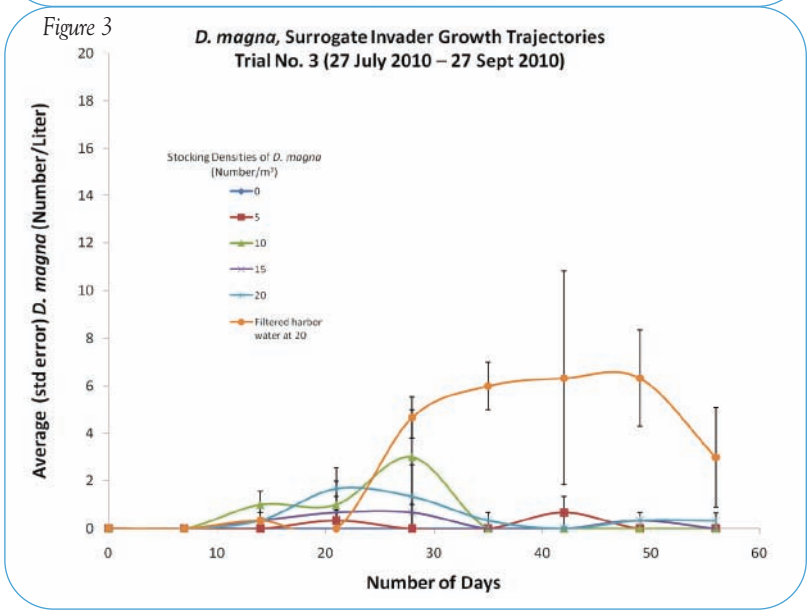
Figure 1: Trial 1 estimated densities (number per liter) of the surrogate invader, D. magna, as a function of time (days) and initial stocking density (color). Experiments were conducted in 200-L mesocosms in the laboratory and began with unfiltered water drawn from the Duluth-Superior Harbor.

Figure 2: Trial 2 estimated densities (number per liter) of the surrogate invader, D. magna, as a function of time (days) and initial stocking density (color). Experiments were conducted in 200-L mesocosms in the laboratory and began with unfiltered water drawn from the Duluth-Superior Harbor.

Figure 3: Trial 3 estimated densities (number per liter) of the surrogate invader, D. magna, as a function of time (days) and initial stocking density (color). Experiments were conducted in 200-L mesocosms in the laboratory and began with unfiltered water drawn from the Duluth-Superior Harbor except for one of the treatments in which water was passed through a 20-μm net prior to stocking with D. magna.







carryout Ballast Water Exchange (BWE) by flushing ballast tanks in the open ocean or to perform Ballast Water Treatment (BWT) by proactive decontamination. Although BWE may be effective at reducing total population densities of non-native freshwater biota (Gray et al. 2007), the 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. As a result, researchers are currently developing and testing ballast water treatment technologies that will kill organisms upon entrance or exit from ballast holding tanks.

Because it is widely recognized that no BWT technology can be expected to perform with 100 percent effectiveness all of the time, accepted standards will 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 International Maritime Organization (IMO). The IMO has currently recognized discharge standards that future technologies will have to meet. These standards state that no more than ten viable organisms per m^3, each greater than 50 μm length in minimum dimension, may be discharged (International Maritime Organization 2004).

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, Colautti and MacIssac 2004, Colautti et al. 2006). There are several reasons for this including that larger populations succumb less often to dramatic changes in abiotic conditions or density-dependent effects associated with predation and competition. Although propagule pressure is a key element in explaining why some populations invade and others do not (Coulatti et al. 2006, Britton-Simons and Abbott 2008), it has rarely been tested experimentally across variation in the density of the recipient community (Elton 1958, Bohonak and Jenkins 2003, Drake et al. 2005, Lockwood et al. 2005, Verling et al. 2005, Von Holle and Simberloff 2005, Colautti et al. 2006, Britton-Simons and Abbott 2008). Our project begins to fill this gap and should provide valuable

Continued

Year 4, Building Sustainable Solutions to the Issue of Ballast Water Treatment: Testing Relationships Between Propagule Pressure and Colonization Success of Invasive Species.

experimental-based information that can guide the IMO regarding post-treatment standards for BWT technologies.

We selected a common crustacean zooplankton, Daphnia magna, as our surrogate invader. D. magna is found throughout the Northern Hemisphere in freshwater lakes and ponds, ditches and small eutrophic reservoirs (Hanski and Ranta 1983), but is not native to northern Wisconsin, Minnesota and Lake Superior and is not currently found there. D. magna serves as a "worst-case" scenario surrogate invader because this organism is capable of rapid population growth by asexual reproduction (parthenogenesis) following the introduction of a few individuals. In a study by Korpelainen (1986) the range of mean generation times for D. magna was from 28-37 days at 14˚C and 12-15 days at 24˚C. In the same study, the life span of female D. magna ranged from 74-93 days at 14˚C and from 27-52 days at 29˚C. In general, the number of young produced increases from 10˚ to 20˚C and then decreases to 30˚C (Goss and Bunting 1983).

Propagule pressure experiments were conducted in mesocosms in a dose-gradient design that bracketed the IMO permissible post-treatment ballast water discharge standard. Square polyethylene mesocosm tanks (61 cm L x 46 cm W x 91 cm H) that hold approximately 230 L of water were equipped with an air stone to promote gentle mixing and gas exchange with the atmosphere. Mesocosms were housed in a climate controlled laboratory equipped to handle aquatic invasive species. A 16:8 hour light:dark cycle created by overhead fluorescent lights was applied.

On the day before each experiment began, tanks were filled with water and its ambient concentrations of biota, drawn directly from the Duluth-Superior Harbor by submersible pumps. Water was transported in 20-L carboys approximately 10 minutes. to the test facility at the University of Wisconsin-Superior. For each experiment, a total of 15 (Trial 1 and 2) or 18 (Trial 3) tanks were filled to a total volume of 200 L each. Triplicate tanks were randomly assigned to a stocking density. Tanks were stocked with D. magna on the first day of the experiment.

To identify appropriate stocking densities of the surrogate invader, we considered dilution factors that would occur as ship ballast water is emptied into a harbor slip. The discharge volumes of ballast water from several classes of ships can range from 1,500 to 100,000 m^3 per event (Minton et al. 2005). The geometric mean of the reported range is approximately 52,000 m^3. An example of a 'real-world' slip or receiving body of water is 309 m length, 32 m width and 10 m depth, for a total of 98,900 m^3 of water. This volume is based on a slip that can accommodate a Great Lakes vessel 304 m in length. Based on the current IMO standard of ten viable organisms m^3 (see above), allowable discharge densities in 52,000 m^3 of water would equal 520,000 organisms. This number of organisms discharged into a surrounding volume of 98,900 m^3 of harbor water equals approximately five animals m^3. Hence, we chose stocking densities to bracket 5 animals m^3.

Each of the three experiments we report here ran for eight weeks. During this time, densities of D. magna and other zooplankton in the mesocosms were monitored weekly. We also monitored the physiochemical conditions of the tanks on a weekly basis which included measurements of temperature, dissolved oxygen, pH, specific conductivity, Chl-a fluorescence, and turbidity with a calibrated hand-held Yellow Springs Instrument (YSI) data sonde. On the final day of each experiment, the contents from each 200-L tank were passed through a 20-μm mesh net and preserved.

The trials were initiated in November 2009, May 2010, and July 2010 (Figs. 1-3). In most instances, no D. magna were detected among controls (but see trial 1) indicating that there was little to no cross-contamination among tanks. In most treatments there was large variation, shown as standard errors, between replicates. This is not surprising because these are densities that are being averaged between replicate populations at single points in time. When growing and declining populations are even slightly out of phase, large differences in average densities among them can occur.

There were similarities and differences in population growth trajectories among the trials. In all trials, D. magna generally increased in density by day 20. Thereafter, growth trajectories were trial and treatment specific. Population densities of D. magna in Trial 1 reached much higher concentrations than in Trials 2 or 3. In Trials 1 and 2, D. magna appeared to be increasing or stable in density by the end of the experiment (day 56). By contrast, in trial 3, D. magna densities were generally declining in most treatments near the end of the experiment, and in some mesocosms D. magna were undetectable by day 56. We hypothesize that these differences in growth performance of D. magna among trials will be explainable by differences in the background communities of organisms that were used to start the experiments. In Trial 3, for example, complete pre-removal of the recipient community had a big effect on D. magna growth performance. This hypothesis will be tested in the coming year as more samples are analyzed and more trials are conducted.

It is too early to determine whether there is a relationship between starting densities of D. magna (propagule pressure) and establishment success in our experiments. Within each trial, there were general positive trends between starting density (propagule pressure) and early densities (day 20-30) achieved in the mesocosms. However, interpretation of the data with respect to establishment success will require the identification of threshold densities that we can expect D. magna to achieve under different ambient conditions. This will be determined in the coming year of research on this project. ●

Project Report

Phase II, Developing a Risk Assessment Tool to Predict the Accelerated Corrosive Loss of Port Infrastructure

Full research reports are available at www.glmri.org

Coastal communities around the Great Lakes have historically been dependent upon maritime transportation. Even in this challenging economy, planned expansions in the mining and steel industries and growing tourism indicate an even greater future need for adequate port infrastructure. Yet, Lake Superior ports face a severe problem—accelerated corrosive loss of their docks and piers.

Although no one has yet proven what causes the accelerated corrosion of steel structures in the Duluth-Superior Harbor (DSH), results from previous research indicate an approach that can be used to predict the risk of similar corrosion at other ports within the Great Lakes. We are developing a model that predicts the severity (i.e. risk) of accelerated corrosion of steel structures in the DSH. We are measuring sulfate, chloride, alkalinity, dissolved oxygen and dissolved organic carbon (DOC) concentrations, abundances of iron-oxidizing and sulfate-reducing bacteria, and estimates of accumulated steel corrosion (corrosion pit depths, corrosion tubercle abundance) to parameterize this model. Our ultimate goal is to create a tool that can assist economic forecast companies and governments to decide when to repair or replace their docks, bulkheads and piers.

Preliminary data suggests that water quality alone may not be responsible for accelerating this corrosion problem. The Larson-Skold Index (LSI) of corrosivity was calculated at three sites in different parts of the DSH. It may be a useful tool because it predicts the risk of corrosion based on water chemistry alone from sulfate and chloride concentrations and alkalinity. Sulfate and chloride are known accelerators of corrosion, and alkalinity in the form of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) is known to inhibit corrosion (Larson and Skold, 1958). An index value in the range of 0-0.8 indicates a low risk corrosion risk, a ratio of 0.8-1.2 intermediate risk and > 1.2 high corrosion risk.

Water quality data obtained from the Western Lake Superior Sanitary District (WLSSD) was used to analyze historical trends of water quality in the DSH, including dissolved oxygen, chloride, sulfate, alkalinity, temperature and pH, and calculate the Larson-Skold Index. The Larson-Skold index remained constant from 1972 to 1997 in the inner part of the DSH where corrosion is often most severe (Fig. 1 and 2) and actually decreased during this period at the Oliver Bridge in the upper reaches of this harbor (Fig. 3). Dissolved oxygen increased at both the Oliver and Burlington Northern Railroad Bridge sites from about 5 mg/L to 15 mg/L from 1972 to 1997, but remained constant at 10 mg/L from 1987-1996 at the old Bascule Bridge in the inner part of the DSH. In 2006, the LSI usually indicated a low risk of corrosion when this index was calculated for different sites within the DSH (Fig. 4). However, sites that are known to have the most severe corrosion (e.g., Duluth Superior Port Authority berths, Midwest Energy Resources Corporation and Hallett Dock 5) had higher LSI values than other sites in the harbor. These data indicate that water chemistry may not be solely responsible for accelerated corrosion in the DSH. So, our investigation will also include the collection and analysis of microbiological data at different sites in the DSH.

Ryan Oster (graduate student) sampled 10 sites in the DSH with AMI Consulting Engineers August 9 and 10, 2010. Two sites were in low corrosion areas (Duluth Entry and Superior Entry), four sites were in moderately corroded areas of the

PRINCIPAL INVESTIGATOR
Randall E. Hicks
University of Minnesota Duluth

Co-Investigator
Ryan J. Oster
University of Minnesota Duluth

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. Current research efforts in his lab focus on great lakes of the world and watersheds in northern Minnesota.

Phase II, Developing a Risk Assessment Tool to Predict the Accelerated Corrosive Loss of Port Infrastructure

harbor (U.S. Army Corps of Engineers, Cargill Dock, Cutler Magner and Oliver Bridge) and four sites were in highly corroded areas (Cenex Harvest States, DSPA berth 4, Midwest Energy and Hallett Dock 5). Bulk water was collected for water quality analyses, corrosion tubercles were sampled for microbiological analyses and corrosion pit depths were measured. Water alkalinity, oxygen, chloride, sulfate, dissolved organic carbon and dissolved copper concentrations were measured in the water from all sites.

DNA has been extracted from corrosion tubercles material from each site and will be used to estimate the abundances of sulfate-reducing bacteria (by qPCR of the *dsr*A gene; Schipper et al. 2006, Kondo et al. 2004) and iron-oxidizing bacteria using qPCR assays we are developing using primers sets developed by Heinzel et al. (2009) Wang et al. (2009) that target *Gallionella* and *Sideroxydans* species.

After the microbiological measurements are completed, we will parameterize a logistic regression model with the data collected from the DSH and subsequently test it in a second year (with new GLRMI funding) using data collected from other harbors in the western part of Lake Superior.

The predicted severity of corrosion from the models will be compared with accumulated corrosion measurements (e.g., corrosion pit depths) made in these harbors to validate this model (the risk assessment tool). Our risk assessment tool is not being developed to predict if corrosion is present or occurring (these things can be measured directly) but instead to predict the risk of accelerated corrosion similar to that observed in the DSH. ●

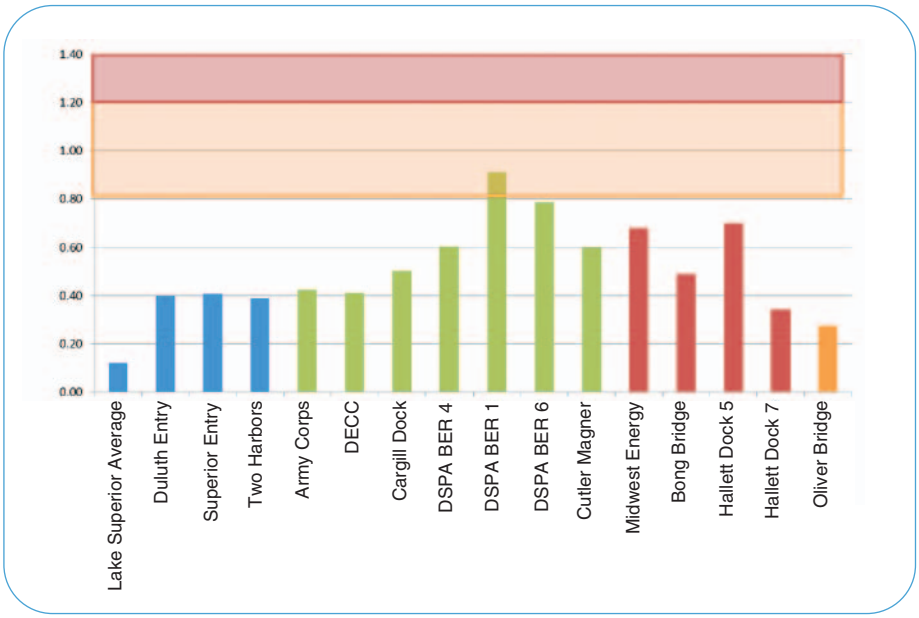


Figure 2: Larson-Skold Index comparison between sample sites in 2006 characterized as low, intermediate and high corrosion risk. Blue: Lake Superior water; Green: Outer Harbor; Red: Inner Harbor; Orange: St. Louis River.

DATA COURTESY OF CHAD SCOTT, AMI CONSULTING ENGINEERS.

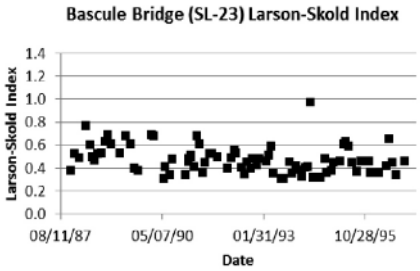


Figure 1: Analysis of Bascule Bridge Fishing Pier Larson-Skold Index from 1987-1996.

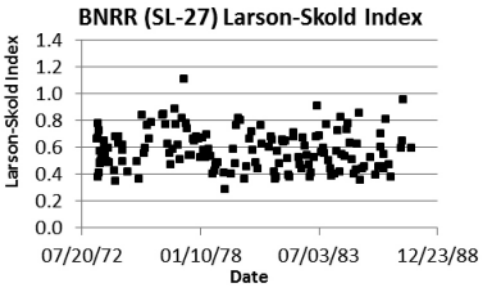


Figure 2: Analysis of Burlington Northern Railroad Bridge Larson-Skold Index from 1972-1987.

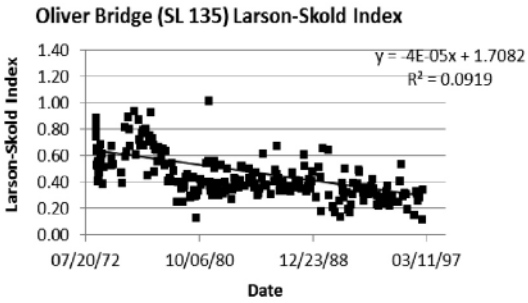
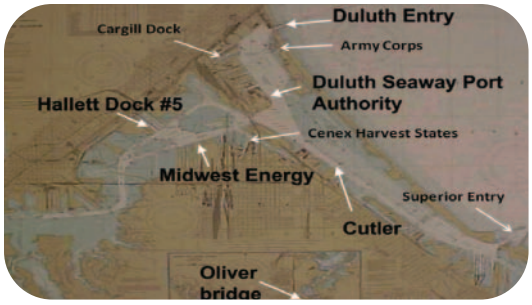


Figure 3: Analysis of Oliver Bridge Larson-Skold Index from 1972-1997.



Sample site locations in the Duluth-Superior Harbor.

MAP COURTESY OF CHAD SCOTT, AMI CONSULTING ENGINEERS.

Modal Comparisons of Marine Freight Diversions: The Case of Coal Movements from a Soo Lock Closure

Full research reports are available at www.glmri.org

Loading coal at Midwest Energy Terminal, Superior, Wisconsin.

PRINCIPAL INVESTIGATOR
Christopher McIntosh
Assistant Professor
Economics
University of Minnesota Duluth

This project, now in review, analyzes the external costs of shifting a cargo from the marine to the rail mode as the result of a hypothetical closure of the 1,000 foot lock at Sault St. Marie, Michigan. The study begins with the assumption that coal originating in the western United States that is currently railed to Superior, Wisconsin and then transshipped onto vessels will instead be moved on all rail routes to customers near the lower lake ports. The case study will examine the projected external costs of a modal shift on this coal supply chain from an intermodal (marine/rail) operation to an all rail operation. Rail capacity in terms of locomotives and rail cars to transport the additional coal cargo is evaluated. External costs are examined in the following categories: rail congestion, energy efficiency, air emissions from power units, safety incidents accidents and rail infrastructure. ●

Professor McIntosh is an applied microeconomist with field specializations in Industrial Organization, Regulation, Environmental, and Natural Resource Economics. He has been a faculty member at the University of Minnesota Duluth since receiving a Ph.D. in Economics from the University of Wyoming in 2006.

Project Report

Economic Impact of the Great Lakes and St. Lawrence Seaway System (GLSLS): Phase II

Full research reports are available at www.glmri.org

PRINCIPAL INVESTIGATOR
David Doorn
Assistant Professor
Economics Department
University of Minnesota Duluth

Co-Investigator:
Peter Lindquist
Department of Geography and Planning, Associate Professor and Department Chair

David Doorn is an Assistant Professor of Economics at the University of Minnesota Duluth. He joined UMD after working for two years at the Bureau of Labor Statistics in Kansas City. David received his Ph.D. from North Carolina State University in 2003 with a specialization in econometrics. His teaching interests are in the areas of macroeconomics and econometrics. Dr. Doorn's research activities focus on macroeconomics, applied time series econometrics, and economic impact analysis.

Project goals include plans to make use of economic impact analysis to estimate the economic value of the Great Lakes and St. Lawrence Seaway (GLSLS) system for different regions of interest. These study areas include individual port communities, the eight states bordering the Great Lakes, the Great Lakes and St. Lawrence Seaway System (GLSLS) region and the nation. A second project goal is to report impact results in terms useful to a range of stakeholders, including port authorities, government agencies, policy makers, and the general public, industry contributions to employment, incomes, value added (contribution to GDP or GSP) and tax revenues. It is also a project goal to enable updated economic impact(s) on a regular basis. The economic variables of interest in such analysis include measures of employment, industrial output, incomes, value added (contribution to GDP or GSP) and tax revenues.

This project uses input-output (IO) modeling, which depends on inter-sectoral linkages across a region's economy. Summing over the direct, indirect and induced effects gives the total impact on a region's economy. Typical IO models use links between hundreds of industrial sectors (517 in MARAD model). However, IO models require underlying data to be representative of the region of analysis. These models also require direct effects as inputs to the model to determine total economic impact. After careful consideration, the project team chose the MARAD Port Kit model over the IMPLAN model for the initial pilot study. However, problems have become apparent and the choice was made to also include IMPLAN. The MARAD Port Kit seemed the best option because it provides a port-specific interface that generates direct effects from data on shipments and inland movements. It also has minimal survey requirements. The major problem with this model is that even the version customizable by region is outdated. This model came out in 2000 and is based on 1992/1998 RIMSII multipliers. It is also based on SIC codes instead of more recent NAICS codes.

An updated version based on NAICS is recently available, but unfortunately the MARAD funded version is only offered on a national basis, and is therefore not appropriate for analysis of the GLSLS. Also, to pursue the Great Lakes impact, it would be necessary to order regionally customized versions from the Rutgers University source, which would be very expensive if not beyond the funding scope of this project. The strength of this model remains its underlying industry linkages based on national averages for port-related costs.

The MARAD Port Kit requires input data such as cargo and transportation mode information as well as itemized costs for services, fees and other charges. Specifically, these data include

Left: Unloading windmill parts.

Right: Edgar B. Speer at dock.

shipments by cargo type, including containerized cargo; breakbulk—cargo in individual pieces or on pallets, such as forest products, paper and steel; liquid bulk—such as petroleum and petrochemicals; dry bulk—such as grain or coal; autos and other vehicles; and project cargo—such as wind turbine components. Required port kit data also includes specifying inland modes of transportation. The MARAD model can be adjusted to reflect local conditions by accounting for the following costs in relation to each cargo type: costs of waterside services including tugs, pilots, line hauling and launch fees, dockage fees; government requirements; customs, entrance/clearance fees, immigration, quarantine; loading/discharging; stevedoring, clerking, security, cleaning/fitting and equipment rental. Costs related to the following can also be adjusted in the model: suppliers. including chandlers/provisions, laundry, medical, waste handling charges; bunkers; oil, water; in-transit storage; wharfage fees, yard handling, demurrage, warehousing and other storage; cargo packing; export packing, container stuffing/stripping, cargo movement and adjustment. Again, inland movement needs to be tracked, as well as long- and short-distance trucking, barge, rail and pipeline. Our survey is gathering the required data. The initial survey went out to 24 Twin Ports' dock/terminal operators and shipping agents on August 12. Surveys also went out to 14 Green Bay terminals.

Given the difficulties discovered for the MARAD model, the project team determined that IMPLAN must be considered a viable alternative. IMPLAN uses up-to-date underlying data and the model is updated annually. Also, the model is NAICS based and relatively inexpensive. However, there are potential difficulties. We find that the port-related sectors of interest are overly aggregated and to model port activity researchers will need to input employment or output data from all port-related industries as direct effects. To collect these input data will require extensive surveying. We expanded the initial survey to collect employment data for input into IMPLAN. However, it is important to note that for the IMPLAN model, we need to collect as close to 100 percent of the data as possible to generate good impact analyses.

The selected initial pilot study region is the Twin Ports of Duluth/Superior (to which Green Bay has been added). This pilot will be expanded to include 16 ports in eight states. These study regions will include the definition of separate port regions by the counties in which they lie. Potential further expansion of the study region will include additional ports and docks.

Conclusions to date are as follows: the updated MARAD model is not a good tool for meeting the objectives of this research. Problems include mounting difficulties with ordering, the presence of too many bugs in the software, and evidence that the model builders are still using the old version's national average cost data. It is expected that further project impact models will use IMPLAN as we move forward. However, the survey process in either case is more involved than expected. Given the necessity of collecting more data for the IMPLAN model than anticipated for the MARAD model, a limited survey response becomes a particular problem for use of IMPLAN. Data collection is underway but is proving to require much follow-up.

The next steps will continue current data collection in order to complete the pilot study, acquire a revised updated version of the MARAD model for the Twin Ports and complete the IMPLAN analysis of the Twin Ports. The project team will compare results from these two models and present recommendations for how to move forward with surveys of additional ports and to assess 2010 economic impact for the GLSLS. ●

Great Lakes Marine Container Service Feasibility Study

Full research reports are available at www.glmri.org

PRINCIPAL INVESTIGATOR
Dr. Ray Hutchison
Urban and Regional Studies
University of Wisconsin-Green Bay

Co-Investigator:
Dr. John Stoll, Co-Investigator
Environmental Management and Business Institute, University of Wisconsin-Green Bay

Ray Hutchison is Professor of Sociology and Chair of Urban and Regional Studies at the University of Wisconsin-Green Bay. He received his MA and Ph.D. from the University of Chicago and taught at the University of California-San Diego and the University of Nevada-Las Vegas before coming to UW-Green Bay.

The Great Lakes Marine Container Service Feasibility Study is a continuation of work from the 2008-2009 funding cycle, also supported by the Great Lakes Maritime Research Institute, into the feasibility of connecting the Port of Green Bay and its primary catchment area extending to the North Central region to ocean carriers providing global container service accessing the Great Lakes via the St. Lawrence Seaway. The Northeast Wisconsin region has historically been a transportation hub for basic industries for the state of Wisconsin, Northern Minnesota, and the Upper Peninsula of Michigan. Before World War II, a number of marine services transported a broad variety of consumer and packaged goods on the Great Lakes. After World War II rail traffic expanded dramatically and took much of the market share from the former vessel operators. The upper Midwest region has been significantly impacted by the changing ownership of the railroads, and the state of Wisconsin's rail profile changed dramatically with the sale of Wisconsin Central to Canadian National. Rail carriers have rationalized terminal locations and service networks, resulting in reduced service levels for rural shippers. In Wisconsin, Canadian National closed intermodal terminals in Steven's Point, Neenah and Green Bay, leaving the Great Lakes shipping community with reduced access to national and to expanding international markets.

Our project examines the commodity flows and infrastructure development needed to support marine containerization networks on the Great Lakes—in this case, the introduction of containerized freight at the Port of Green Bay. During the first year of the study, we analyzed potential freight flows, user transportation requirements, and container networks operated by Great Lakes vessels. Information about the first year of the Great Lakes Marine Container Service Feasibility Study appeared in the summer issue of Great Lakes/Seaway Review. For 2009-2010 we have sought to expand the reach of our freight flow analysis, develop a business case to identify necessary features and facility requirements, and examine organizational structures and local and regional governance support requirements. In the final project report we will identify strengths, weaknesses, opportunities and threats for potential infrastructure developments to connect the Port of Green Bay to global container service providers.

Figure1

The original freight flow analysis, using PIERS and other data sources to capture truck, rail and water freight movements, focused on commodities produced within a 200-mile catchment area surrounding the Port of Green Bay. As we examined information from this analysis, and from our survey of manufacturers and shippers in the northeast Wisconsin region, it became clear the original research design was too conservative. With existing transportation links and harbor facilities, there is a much larger potential freight flow from the north-central region that could be captured by the port. Our revised strategy has been to expand the earlier survey to include manufacturers and shippers in a multi-state area, and to identify specific commodities originating from the north-central region that must be shipped to coastal ports that might better be directed through the Port of Green Bay. We have been working with other GLMRI affiliates to refine the freight flow analysis and to present state-of-the-art mappings of the case study information from our panel group interviews, and with a consultant to expand our case studies to include other supply chains that can be directed through the Port of Green Bay. Case studies of potential supply chains will be used to identify potential terminal size, location, requirements, productivity and other features needed to sustain an intermodal containerized freight facility.

Figure 2

Figure 3

Redevelopment of the Green Bay waterfront is a major initiative of the current mayoral administration. New residential construction (including condominiums and up-scale apartments), revitalization of the Broadway District, and development of the Fox River Boardwalk have transformed the downtown area. Recent reports from the Lower Fox River and Green Bay Shoreline Waterfront Redevelopment Committee and the Brown County Economic Development Agency have highlighted riverfront development and public access to the Fox River and Green Bay shoreline as important and continuing initiatives. There is considerable discussion of how best to combine the public goals of waterfront redevelopment, emphasizing residential development in the downtown area, with the economic priorities of a working riverfront. (See Figure 1) The Port of Green Bay, located on the Lower Fox River, includes 14 terminal operators, including bulk cargo, freight, and oil companies. It is accessed by a 500' wide channel maintained at 26' below low water datum, with a navigation channel 300' wide maintained at 24' below low water datum to the first operating bride. We have focused on terminal locations in this area—before the first operating bridge—because the area is not included in existing city plans for residential development, and because it will not require additional lifts of the Ray Nitschke Memorial Bridge. The riverfront has seen extensive industrial development since the late 1800s, including a power plant, paper mills, fuel tanks, and warehouses. The original rail yards of the Green Bay and Western Railroad are located on the west side of the river, and an interstate highway runs on the Tower Drive / Leo Frigo Memorial Bridge above the industrial area, with highway interchanges on both sides of the bridge.

In our discussions with public authorities, two locations have been mentioned for the potential development of the intermodal containerized freight facility. The first location includes an existing reinforced dock wall and vacant land located adjacent several manufacturing plants on the east side of the river (shown in Figure Two). The industrial plants are served by a rail spur that can be extended to the riverfront, and there is considerable space available for extensive loading operations. Rail traffic will require switching operations and movement across a railroad bridge to reach the Canadian National rail yard. Access to Interstate 43 is less than one mile distant, through an industrial area that has little through traffic. The major cost for development of this location is land acquisition.

The second location, on the west side of the river, involves new landfill and construction of a reinforced dock wall, as shown in the Port Opportunity Study for the Port of Green Bay. The landfill and adjacent land just south of the Tower Drive / Leo Frigo Memorial Bridge will be sufficient for loading operations, and the main yards of the Canadian National railroad are located one-quarter mile from this location (shown in Figure Three). Access to Interstate 43 is approximately one mile distant, with access on roads that serve a variety of industries along the riverfront. The major costs for development of this area will involve construction of the reinforced dock wall and landfill. (See Figure 3) Both locations share important characteristics: they are separated from planned residential development along the riverfront, they are located in industrial zones, and they can be connected to the existing rail network serving other industries in the area. Both have access to Interstate 43 with little or no travel through residential areas. There are other terminals along the riverfront that could be used for intermodal operations, and final decisions as to location will be addressed by public authorities.

Our final report will address costs and benefits as well as opportunities and potential problems for intermodal containerized freight operations at the Port of Green Bay.

There are public benefits from intermodal operations as well as regional economic benefits for the carriers and shippers in the Great Lakes region. An intermodal terminal can serve as an engine of growth for the regional economy, reduce transportation costs, and improve global access to new markets. Improved transportation increases the competitive advantage of existing businesses and provides opportunities for new economic innovations. Enhanced transportation logistics resulting from the introduction of containerized freight through the Port of Green Bay could help draw new business to an area and provide stimulus for existing enterprises.

Success of the larger project will require partnerships among public authorities, local stakeholders, Canadian National, and other groups to establish the balanced and efficient network support services, equipment supply and service delivery to realize global operations. The Principal Investigator has participated in meetings of the Green Bay Harbor Commission and the Lower Fox River and Green Bay Shoreline Waterfront Redevelopment Steering Committee. He also has met with Dean Haen, Director of the Port of Green Bay, Aaron Schuette, Senior Planner for the Brown County Planning Commission, and Derek Lord, Director of Economic Development, City of Green Bay. Development of an intermodal containerized freight facility at the Port of Green Bay has been voted the number one priority of the Greater Green Bay Executive Leadership Committee, a group established by the Green Bay Area Chamber of Commerce to enhance cooperation of municipalities in the region. With the cooperation and support of these groups, we look forward to expansion of the working riverfront, with containerized freight arriving at the Port of Green Bay connected by class one rail service and by truck to regional markets throughout the north central region, providing an important economic stimulus to enhanced import and export markets for business and manufacturing firms in Green Bay and beyond. ●

Project Report

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

Full research reports are available at www.glmri.org

PRINCIPAL INVESTIGATOR
Joan Chadde
Education Program Coordinator
Center for Science & Environmental Outreach
Michigan Technological University

Joan Chadde is the education program coordinator for the Center for Science and Environmental Outreach at Michigan Technological University in Houghton, Michigan since 1995. Ms. Chadde has more than 25 years of experience in science/natural resources education, water resource management, and program development. She has designed and implemented numerous K-12 science programs and over sixty teacher professional development workshops and summer teacher institutes. She earned an M.S. in Water Resources from the University of Wyoming, BS in Natural Resources from the University of Michigan, and secondary science teaching certification from Michigan Technological University.

Michigan Technological University has led an educational/outreach effort for the Great Lake Maritime Research Institute since 2006. Despite Michigan Tech's relative isolation and long distance from most locations in the Great Lakes Basin, every state in the Basin has been touched with some aspect of the outreach program. For the 2010 program, The National Center for Freight and Infrastructure Research and Education (C-FIRE) at the University of Wisconsin-Madison teamed with the Great Lakes Maritime Research Institute to fund the program. This year's program consisted of two week-long institutes and two weekend workshops, along with support to develop and deploy educational teaching chests that provide outreach resources to communities and schools. The target audience for the education/outreach program is K-12 and community educators. K-12 teachers have the option to earn graduate credits from Michigan Tech along with maritime education materials and lessons to take back to their classrooms.

Summer Teacher Institutes

In June 2010, the Great Lakes Maritime Transportation summer teacher institute was conducted at The Maritime Academy of Toledo. Eighteen educators participated—10 from Michigan, six from Ohio and one each from Ontario and Wisconsin. Teachers toured the *S.S. Boyer* with Paul LaMarre Jr., Manager of Maritime Affairs for the Toledo-Lucas County Port Authority and the Executive Director of the *S.S. Willis B. Boyer* Museum Ship. LaMarre also led a tour of port facilities, highlighting the variety of cargo that moves through the City of Toledo.

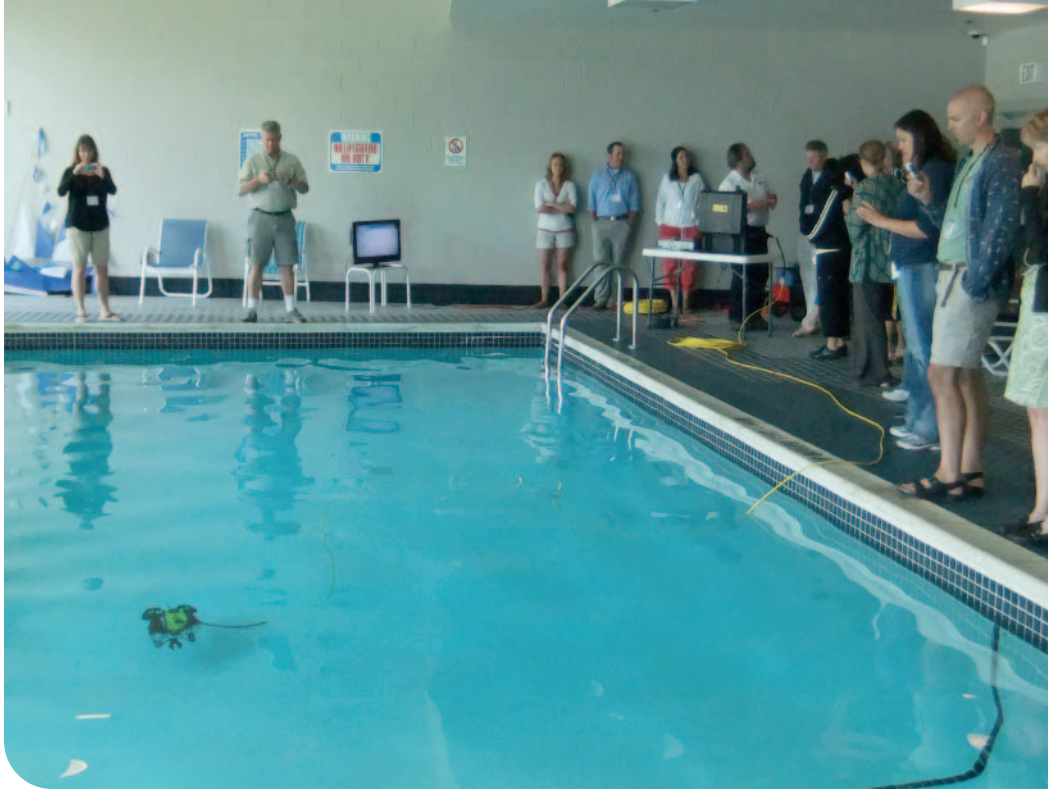
Summer institute participants toured the Maumee River and Harbor aboard the Sandpiper and explored maritime history and mapping shipwrecks with Carrie Sowden, underwater archaeologist, and executive director, Christopher Gillcrist, at the Inland Seas Maritime Museum in Vermillion, Ohio. This summers institute's location at The Maritime Academy of Toledo afforded several unique opportunities, including model boat building, radar simulator demonstrations, navigation and mapping instructions, and using an underwater remotely operated vehicle (ROV) in maritime academy's pool.

The second 2010 summer teacher institute was held at Michigan Technological University (MTU) on Mathematics & Navigation, taught by mathematics professor and boat captain, Dr. Stephen Roblee. This institute focused on the theory and practice of marine navigation as used in the marine industry. The participants spent one-half of each day on MTU's Research Vessel (R/V) *Agassiz* and had hands-on lessons in using the magnetic compass, nautical charts and electronic navigation equipment to tie mathematics into maritime applications.

The teacher institutes were well received by participants. In their post-institute evaluations, participants gave the field trips and hands-on activities high marks. When asked what they liked best about the institute, one participant stated, "well organized, variety of programs, awesome fellow students, field trips." Lessons

Left: K-12 Educators Summer Workshop at the Maritime Academy of Toledo boat building lesson.

Right: K-12 Educators Summer Workshop at The Toledo Maritime Academy testing a remotely operated vehicle (ROV).



were submitted by participants of the 2010 Institutes and are now posted on MTU's Great Lakes Maritime Transportation website and are also linked to the GLMRI web page: *http://wupcenter.mtu.edu/education/great_lakes_maritime/institute2010.htm*. They are also linked to the GLMRI website *www.glmri.org/resources*.

School Year Teacher Workshops

School-year workshops (one-to-two days in length) are also being conducted. A two-day Great Lakes maritime lesson-writing workshop was conducted in partnership with the Great Lakes Shipwreck Historical Society (GLSHS) on November 5-6, 2010 at the Great Lakes Shipwreck Museum and Whitefish Point Lighthouse. Ten educators from Wisconsin and Michigan attended. Renown shipwreck and maritime historian and author, Fred Stonehouse, presented on Lake Superior shipwrecks and also on the Life-Saving Service on the Great Lakes, the precursor to the U.S. Coast Guard. Tom Farnquist, GLSHS founder, described various shipwreck investigations. Participants toured the lighthouse, lighthouse keepers' quarters, museum and grounds. The Great Lakes Shipwreck Historical Society provided two nights lodging for participants, two presenters, an onsite assistant and waived admission to the museum and lighthouse.

One of the workshop participants, a fifth-grade teacher for Detroit, wrote two days after the workshop, "Thank you so much for informing me about this workshop. This was the best workshop I have ever attended! Everything was great—the presenters, the participants, the location and the food. I started teaching one of the lessons from the workshop to my students today and they are really enthusiastic. They loved the Lake Superior rocks!"

Another teacher workshop was held December 4 at Whitefish Dunes State Park in Wisconsin that focused on using the Great Lakes Maritime Teaching Chest.

Great Lakes Maritime Transportation Treasure Chests: This year's program also funds the assembling and dissemination of eight Maritime Teaching Chests. The chest contains children's literature, teacher activity guides, posters, maps, DVDs, sample cargo and a 12'x15' floor map of the Great Lakes basin, all related to maritime history and transportation. To date this year, two chests have been purchased for $150 each (the grant provides a $350 subsidy) by:

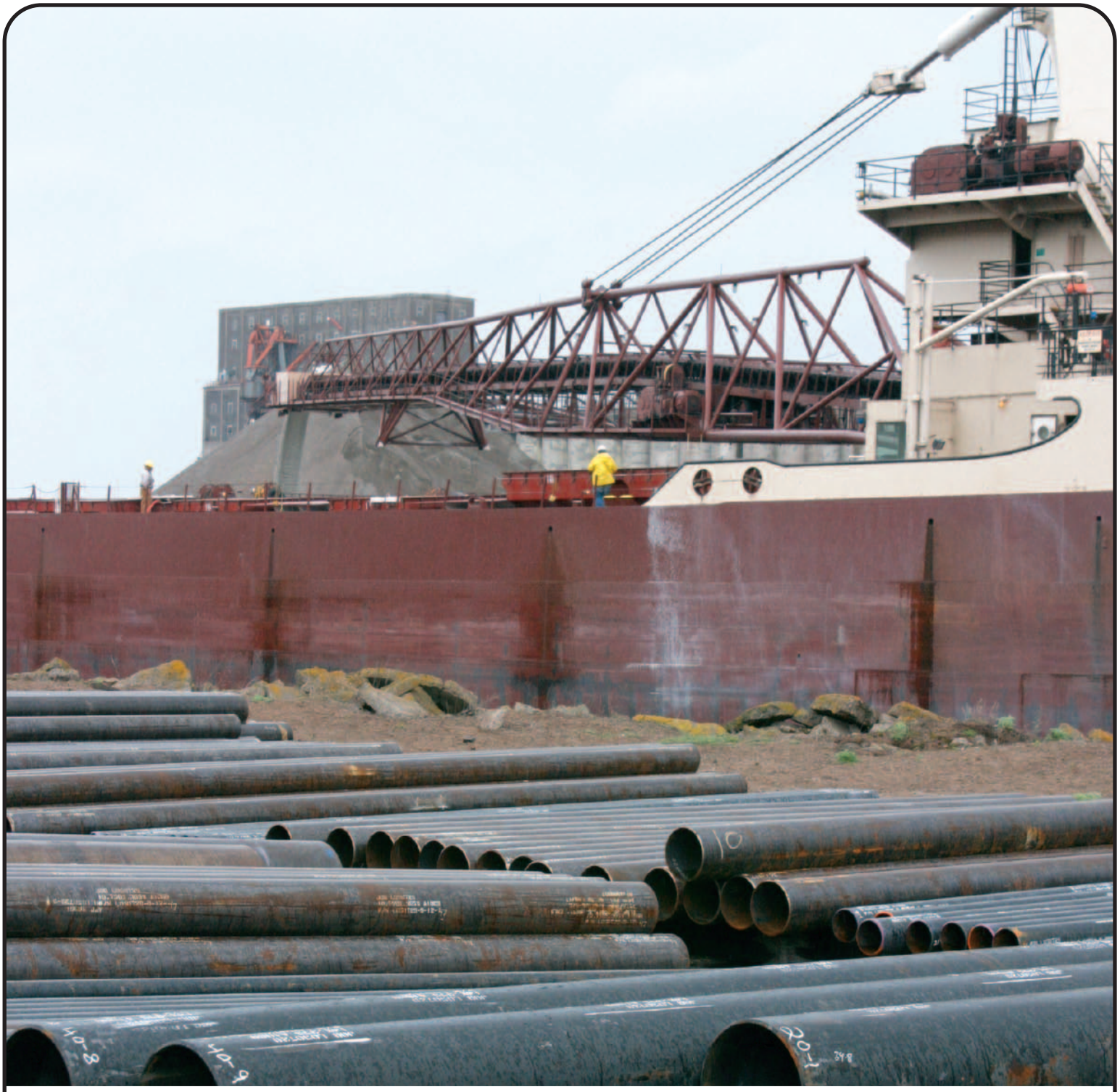
1) Community Education Services Agency (CESA 6) in Oshkosh, WI
2) Wisconsin DNR Wild Rose Fish Hatchery in Wild Rose, WI

Since 2007, 33 maritime teaching chests have been distributed to the following states: 15 in Michigan, 2 in Pennsylvania, 7 in Wisconsin, 1 in Indiana, 5 in Ohio, and 3 in Minnesota. The chests, by lake, are in the following Great Lakes watersheds: 6 in Superior, 11 in Michigan, 6 in Huron, 9 in Erie, and 2 in Ontario. The 33 recipients of these teaching chests were surveyed to find out how they are using the chest and to gather suggestions for improvements and other potential recipients.

Thirty percent of the recipients responded to the survey, ranking the Great Lakes floor map, a 12'x15' canvas drop cloth with the five Great Lakes painted on it, along with labels for all states/countries, port cities and rivers in the Great Lakes watershed, as the most useful item. Six more locations were suggested for potential dissemination of the chest. It was suggested that information on maritime careers be added, a timeline for Great Lakes development and more on ship loading and unloading. The chest is on loan to teachers for classroom use approximately once per month. One survey respondent wrote, "I think you have done a great job of including a wide variety of materials in the chest."

Since 2006, six week-long summer teacher institutes have been conducted: three in Duluth, Minnesota/Superior, Wisconsin, one in Toledo, Ohio and two in Upper Peninsula of Michigan reaching a total of 90 educators, including two from the Saint Lawrence Seaway Development Corporation. Plans for conducting the 2011 summer institute in Door County, Wisconsin are already underway. Carolyn Rock, educator at Whitefish Point Sand Dunes State Park and a 2007 institute participant, and Wendy Lutzke, educator at Manitowoc Maritime Museum and the recipient of a Great Lakes Maritime Shipping Chest, are helping to plan the institute.

To find out more about the education/outreach program, please visit the website: *http://wupcenter.mtu.edu/education/great_lakes_maritime/*.●



Great Lakes Maritime Research Institute

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GLMRI Program Office
229 Voss Kovach Hall, 1305 Ordean Court
Duluth, MN 55812
(218) 726-7446 www.glmri.org