

OCTOBER
2013

Annual Report



Great Lakes Maritime Research Institute

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

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

A National Maritime Enhancement Institute

UNIVERSITY OF MINNESOTA DULUTH



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James P. Riehl, *Co-Director*

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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

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ABOUT THE COVER: Andrie's integrated tug-barge *Endeavour*.

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Great Lakes Maritime Research Institute

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

UNIVERSITY OF MINNESOTA DULUTH

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CO-DIRECTORS' STATEMENT

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.



In 2014, GLMRI will celebrate its 10th anniversary. We are proud of the successes GLMRI has accomplished while building a reputation as a leader in the Great Lakes in maritime research and education.

In reviewing the past year, GLMRI has been able to maintain an aggressive plan on research and outreach to develop the supply chain for Liquefied Natural Gas (LNG) for the Great Lakes region. In the meetings we have hosted or participated in, momentum has developed to focus not only on the maritime industry but also other transportation modes and other industries that may pursue a fuel conversion to natural gas. The industry and communities have taken notice of the pending changes, and are now looking to embrace the potential economic and environmental benefits associated with LNG, or other forms of natural gas. The initial research effort has continued to gain support, as the use of natural gas as transportation fuel is being expanded in countries around the world and by other domestic transportation modes and industries. During 2013, Interlake Steamship Company (ISC) announced that they are moving forward with plans to convert the *M/V Mesabi Miner* to dual fuel. This announcement was tied to Shell announcing it will be building a liquefaction plant in Sarnia, Ontario to supply the maritime industry. Once the supply of gas is available throughout the region, we anticipate that the industry will move quickly to follow the lead of ISC.

GLMRI will continue to focus on educating the industry, governmental agencies and the public on natural gas and the reduced emissions that would benefit from the conversions. While the U.S. Coast Guard is actively pursuing regulations to support the use of LNG, many communities are not familiar with and do not understand the product and processes, along with the risks and safety procedures. The LNG industry has a long track record of safety, but that safety culture needs to be ingrained as LNG becomes more and more accessible. A future goal for the GLMRI education program is providing

factual information to users and the general public so that natural gas becomes an accepted and safe marine fuel and can be transported by marine vessels as a cargo on the Great Lakes.

GLMRI researchers and staff are continuing to prepare reports, publish articles, and provide presentations on natural gas. In the successful model GLMRI was built upon, we continue to partner with professional societies, government agencies, environmental groups and universities, along with gas and shipping industry experts to keep abreast of the movement to LNG and provide updated information at various venues.

The Lake Carriers' Association funded the second phase of ballast sediment testing in 2013, and the findings were presented in conjunction with the Society of Naval Architects Section meeting in September. This is a key example of the synergistic benefits of GLMRI, its advisory board agencies and university affiliations to provide meaningful outcomes to support improvements to the Great Lakes shipping industry.

We continue to seek permanent funding for the Institute through the federal executive departments and legislative personnel when given the opportunity and greatly appreciate the support from our advisory board agencies in this pursuit. Again in 2013, the Great Lakes Maritime Task Force endorsed GLMRI and has been helpful in gaining support with legislators and federal agencies in pursuing funding not only for GLMRI, but national maritime research.

We credit GLMRI's success to our unique arrangement, with the two host universities and support and expertise from ten affiliate universities. GLMRI continues to provide regional-focused, multi-discipline teams to address a variety of topics in support of maritime research and education. We look to continue to serve the region for the next 10 years while continuing to build the pool of expertise in shipping and maritime commerce to affect positive changes for the economy and the environment, while working closely with industry and governmental agencies. ■

Sincerely,

Richard D. Stewart, Co-Director

James P. Riehl, Co-Director

2013 Overview

RESEARCH FOCUS

Initial broad research focus areas for GLMRI were mandated by Congress and have been refined with input from the Maritime Administration and the GLMRI Advisory Board agencies. Each year at the GLMRI annual meetings, discussion is held with the Advisory Board and other stakeholders on current issues and opportunities for potential maritime research topics with impact for the Great Lakes.

This report highlights the research and education accomplishments that GLMRI has been able to achieve over the past year with limited resources. In the spring of 2013 GLMRI finalized the remaining projects and effort funded against the Congressionally appropriated funding included in the *Transportation, Housing and Urban Development, and Related Agencies Appropriations Act, 2009*. GLMRI was able to maximize the work under this funding, in working with the Wisconsin Commercial Ports Association, to develop a best practices report based on plans already developed in other states and Canada.

Lake Carriers' Association provided funds at the end of 2012 to support the second phase of the ballast sediment biological study. Dr. Branstrator and his research team completed the second phase of the study, due in great part by the cooperation and assistance from the shipping companies and the crews of the *M/V Mesabi Miner*, *M/V American Century*, and *M/V Edwin Gott*.

The U.S. Maritime Administration (MARAD) Office of Environment had supported a continuation of the LNG research at the end of fiscal year 2012. This became the greater focus for GLMRI projects and studies in 2013. Captain Helland extended the regulatory analysis to the Ohio River tug and barge industry.

GLMRI was involved in hosting meetings

and conferences, providing materials and presentations, and assisting with developmental agencies in educating LNG suppliers and potential users on the viability of natural gas conversions. The supply chain study for LNG continued with a focus on establishing a network of liquefaction plants to meet the future demand. Studies were also performed on the existing marine fuel terminal in the Duluth/Superior area and the possible demand and impacts on the infrastructure of a fuel conversion to natural gas.

With the federal government shut down and budget sequestration, no additional funding was provided from federal sources in 2013. The supporting universities have provided some additional support to minimally continue the research and education initiatives, but the future of GLMRI is unclear. The Great Lakes Maritime Task Force stepped up efforts to obtain permanent funding for GLMRI by contacting federal executive departments and Great Lakes federal legislators.

A cooperative agreement is in place with MARAD to support environmental research related to maritime commerce in the Great Lakes region. The five-year cooperative agreement can provide up to \$1 million a year in project-based funding, although it's dependent on MARAD's budget and performance in carrying out projects. MARAD and GLMRI are working cooperatively with the maritime industry,

the GLMRI Advisory Board and government agencies to establish a research agenda.

GLMRI was established in 2004 to pursue research efforts in marine transportation, logistics, economics, engineering, environmental planning, and port management. MARAD designated GLMRI as a National Maritime Enhancement Institute on June 1, 2005. Since its inception, GLMRI has been supported by an advisory board representing industry, government agencies, non-governmental agencies, and professional societies. GLMRI also seeks input from experts in maritime shipping and commerce, along with the ports and governmental agencies. The consortium is committed to improving the maritime system of the Great Lakes and the United States. This dynamic model provides a program with tremendous breadth as a National Maritime Enhancement Institute.

The Institute proves to be effective because of the unique arrangement with the two host universities and having ten affiliate universities that bring their research expertise and assets to support maritime research and education. GLMRI is able to address requested topics by reaching out to our affiliates and experts to draw in their strengths and provide regional multi-discipline teams.

Previous annual reports are available on the GLMRI webpage (www.glmri.org). ■



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.

2013 Advisory Board



SAINT LAWRENCE SEAWAY DEVELOPMENT CORPORATION
Washington, D.C.
Ms. Betty Sutton
Administrator

U.S. DOT MARITIME ADMINISTRATION
Chicago, IL
Mr. Floyd Miras
Director, Great Lakes Gateway

LAKE CARRIERS' ASSOCIATION
Rocky River, OH
Mr. James H. I. Weakley
President

U.S. ARMY CORPS OF ENGINEERS, DETROIT DISTRICT
Detroit, MI
Lieutenant Colonel Rob Ells
Commander

AMERICAN GREAT LAKES PORTS ASSOCIATION
Cleveland, OH
Mr. William Friedman
Chairman

U.S. COAST GUARD, NINTH DISTRICT
Cleveland, OH
Commander Scott Anderson

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
Great Lakes & Great Rivers Section
Mr. Stephen Kemp
Section President

GREAT LAKES COMMISSION
Ann Arbor, MI
Mr. Tim Eder
Executive Director





2013 Research Affiliates

About 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 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 progress. 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.

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.

GLMRI PROGRAM OFFICE

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

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). The Academy trains men and women for service as licensed Officers in the U. S. Merchant Marine. GLMA's program is unique among the state maritime academies as it is the nation's only freshwater academy. Upon successful completion of the program graduates are qualified to sail as an Officer onboard a U. S. Merchant vessel sailing on either the oceans or the Great Lakes. All cadets will also earn a Bachelor's Of Science in Maritime Technology. The education provided at GLMA ensures employers have a steady supply of the finest maritime personnel who are fully compliant with both U.S. regulations and the Standards for Training, Certification, and Watchkeeping Code (STCW).

As a condition of graduation all deck



cadets are required to sit for their unlimited tonnage Third Mate (ocean) license as well as Great Lakes Pilotage. All engineering cadets are required to sit for Third Assistant Engineer, Steam and Motor Vessels of any Horsepower.

University of Michigan

2600 Draper Drive, Ann Arbor, MI 48109
Prof. Steve Ceccio, 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 laboratories, peer academic institutions and other maritime agencies.

Michigan Technological University

1400 Townsend Drive
Houghton, MI 49931
William J. Sproule, Ph.D., P.E.
Professor, Department of Civil and Environmental Engineering

Michigan Technological University was founded in 1885 in Houghton, Michigan as the Michigan Mining School to train mining engineers to work in Michigan's Upper Peninsula copper and iron ore mines. Since that time, the university has expanded to over 120 degree programs in arts, humanities, social science; business and economics; computing; engineering; forestry and environmental science; biological and physical sciences; and technology. The university has grown into a leading public research university and a key educational partner within Michigan, the nation and beyond.

In 2012, Michigan Tech opened a new Great Lakes Research Center (<http://greatlakes.mtu.edu>) that provides state-of-the-art laboratories to support research on a broad array of topics. Faculty from many departments across campus collaborate to conduct interdisciplinary maritime research relating to air-water interactions, biochemistry, hydrodynamics and sediment transport, fisheries, invasive species and food web relationships, low impact development and storm water management. The Research Center contains a boathouse and convenient docking facility to provide a year round home for Michigan Tech's research vessel, the Agassiz. The Center for Science and Environmental Outreach is also housed in the new Research Center building and provides numerous programs for K-12 students and teachers and community education and has led the development of GLMRI education/outreach programs and activities on Great Lakes maritime transportation.

University of Toledo

2801 West Bancroft Street
Toledo, OH 43606
Richard Martinko, Director
Intermodal Transportation Institute

The Intermodal Transportation Institute at The University of Toledo was organized by public and private stakeholders to encourage the development of technology-enabled intermodal transportation systems and supply chains that promote economic development and quality of life. The Goals and Objectives of the UT-ITI are to create an internationally recognized center of excellence; advance technology and expertise in the many disciplines comprising transportation; educate a multi-disciplinary workforce; attract students, faculty and staff in undergraduate, graduate and professional programs; and to enhance diversity in the various fields related to transportation. The ITI was named a Center of Excellence in Logistics and Transportation by the Ohio Board of Regents.

Purdue University North Central

1401 South U.S. Hwy 421
Westville, IN 46391
Thomas F. Brady, Ph.D.
Dean, College of Engineering and 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.

John Carroll University

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

John Carroll University has offered a logistics major since 1950. Established shortly after WWII by the U.S. 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 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, excellent

many other customized programs. AHTC's Maritime Security program includes three courses approved by the U.S. Maritime Administration: Facility Security Officers (UNFIND-560); Maritime Security Awareness (UNFIND-561); and Maritime Security for Facility Personnel with Specific Security Duties (UNFIND-565). Additionally, AHTC has two Maritime Security courses developed for and approved by U.S. Department of Homeland Security (DHS): one is titled Port and Vessel Security for Public Safety Officials; the second is titled Small Vessel Security. To-date, AHTC has awarded Bachelor and Master degrees to more than 1,350 people through the Academic Degree Programs and through the practice-based training center, more than 170,000 people have been trained.

Rochester Institute of Technology

92 Lomb Memorial Drive
Rochester, NY 14623
Dr. James Winebrake
Dean, College of Liberal Arts
Co-Director, Laboratory for Environmental
Computing and Decision Making

University of Wisconsin-Green Bay

2420 Nicolet Drive, RH 305
Green Bay, WI 54311
Dr. Sue J Mattison, Dean
College of Professional 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.



teaching, quality research (both academic and practitioner), student internships and faculty/student involvement in logistics-related organizations.

The University of Findlay

1000 North Main Street
Findlay, OH 45840
Jeff McGuire, Director of Operations
All Hazards Training Center

The All Hazards Training Center (AHTC) 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 program. A practice-based and regulatory compliance/competency-based training center was added in 1989. Today AHTC's educational and training programs include: environmental, safety and occupational health (ES&H); emergency response; emergency management; OSHA safety; public health; homeland security; maritime security; school safety and security; and

Our Great Lakes Research Program is housed in the RIT Laboratory for Environmental Computing and Decision Making (LECDM). The LECDM has as a central focus the study of freight movement, transportation logistics, environment and cyberinfrastructure. Our goal is to improve freight-related transportation decision-making by advancing and integrating environmental cyberinfrastructure tools and modeling techniques into supply chain logistics analyses. Our 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, Executive 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 Making Multimodal Freight Systems Work for Economic Recovery and Quality of Life. CFIRE has an annual budget of approximately \$7 million. It facilitates the Mid-America Freight Coalition, a 10-state regional organization to cooperate in the planning, operation, preservation and improvement of multimodal freight transportation infrastructure systems, operations and networks.

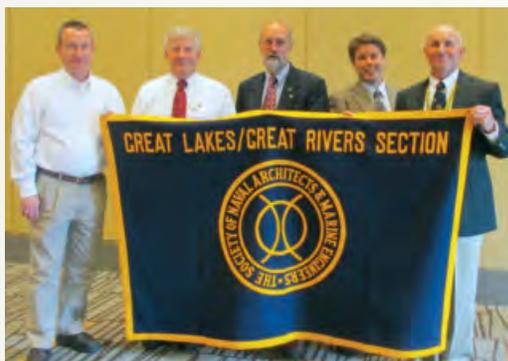
2013 Special Projects and Outreach

Partnership with Society of Naval Architects and Marine Engineers (SNAME)

GLMRI has continued to partner with SNAME on education and outreach venues for GLMRI research areas.

At the Fall SNAME Section meeting held in Ann Arbor, Michigan on October 4-5, 2012, Ms. Carol Wolosz presented an overview of the GLMRI project on Liquefied Natural Gas for maritime use. Ms. Ziyang Zhang, from Bay Engineering Incorporated in Sturgeon Bay, Wisconsin followed with a presentation on Bay Engineering's designs for converting the S.S. *Badger* from a coal-fired ferry to a natural gas burning ferry, using both liquefied natural gas (LNG) and compressed natural gas (CNG). The *Badger* is the last coal-fired steamship on the Great Lakes. Mr. Rick Harkins, Mr. Randy Helland and Ms. Wolosz discussed their 2012 trip to Norway, where they observed how Norway is utilizing both LNG and CNG in the marine transportation system. The presentation covered regulatory issues, government support for various projects, and both single fuel and dual-fuel engines. Dr. Steve Ceccio, Chair of the Department of Naval Architecture and Marine Engineering at the University of Michigan's College of Engineering, presented on current research at the department and plans for new buildings on the north campus. University of Michigan is an affiliate university to GLMRI. After the meeting, Dr. Ceccio arranged for Mr. Steve Kemp, Section President, Mr. Jim Sharrow, from the Duluth Seaway Port Authority, and Ms. Wolosz to receive a tour of the department's Marine Hydrodynamics Laboratories and the testing tanks by Dr. Simo Makuharju.

At the SNAME winter meeting in Cleveland, Ohio on February 13-14, 2013, a venue of LNG speakers was themed. On Wednesday afternoon, a gas tutorial was presented by Dr. Jerry Hutton



Top left to right: Speakers at the September 2013 meeting; Fuel pump at LNG Station, Seville, Ohio; SNAME tour group, Seville, Ohio.

from Clean Fuels Ohio. A reception was held that evening to allow the attendees to network and discuss the afternoon session. Students from the University of Michigan's Naval Architecture and Marine Engineering program were in attendance. On Thursday, the session opened with a detailed presentation by Dr. Michael Parsons on his final report on the GLMRI study to convert the Great Lakes steamships to LNG. Other sessions included Mr. Michael McLean, Director of New Business Development for Trans-Canada Pipeline Company, Mr. Mesgina Risat, from GE Oil and Gas Turbo Machinery Division and Mr. Holt Bradshaw, from Pace Global Energy Management. In the afternoon, the attendees toured the Pilot Station in Seville, Ohio. The participants were able to see the LNG platform and observe two trucks fueling, and personally witness the controls and safety procedures in place

when the drivers fuel their trucks. Dr. Hutton and Mr. Paul Chadcort, the facility manager from Clean Energy Fuel, provided the tour and discussed information on pumping and the storage facility, along with the safety and controls that are built into the operation.

The fall meeting was held in September at the Hyatt Regency-McCormick Place in Chicago. GLMRI speakers were included as part of the agenda. Dr. Donn Branstrator, Biology Professor from the University of Minnesota Duluth, provided a report on the ballast tank sediment study that was funded by Lake Carriers' Association. Dr. Richard Stewart, GLMRI Co-Director, presented an update of GLMRI projects and the GLMRI LNG study. Other speakers included Mr. Al Horsmon, presenting on composite materials for boat designs and the marine industry, and Mr. Jerry West and Mr. Rich Kulaga, from EMD, discussed their two-

cycle engine conversions to dual fuel diesel/LNG. Since the meeting was held in conjunction with the High Horsepower (HHP) Summit, several participants from HHP extended their stay to attend the SNAME meeting. Mr. Kevin Markey, from General Physics Corporation, provided comments and clarifications on LNG use. Mr. Alexander Harsema-Mensonides, from Marine Service GMBH, in Hamburg, Germany, provided comments on maritime conversions and Mr. Leif Gross, Caterpillar Marine Power Systems Manager, spoke on new natural gas engine technologies being developed by Caterpillar. A tour of the EMD locomotive engine plant in LaGrange, Illinois was a highlight. At the plant, the company is developing its production line for LNG powered locomotive engines. Students from the University of Michigan also attended the tour.

Great Lakes Waterways Conference

Dr. Richard Stewart, GLMRI Co-Director, was part of the MARAD Panel at the Great Lakes Waterways Conference, held in Cleveland, Ohio February 12-13, 2013. Dr. Stewart provided an overview of LNG along with an update on the GLMRI project. Mr. Michael Carter, the MARAD Director for Environmental Programs, moderated the session. Mr. Mark Barker, President, Interlake Steamship Co., provided an industry perspective on shifting to LNG as a marine fuel. GLMRI was a sponsor of this annual event and used this venue to release the GLMRI Annual Report.

Meeting Held to Discuss Siting a Natural Gas Liquefaction Plant in Twin Ports Region



Mr. Joel Hirschboeck, Superintendent of Alternative Fuels, Kwik Trip, presenting at GLMRI meeting.

On Tuesday, May 21, GLMRI, along with support from the Duluth Seaway Port Authority, hosted a meeting at the

University of Wisconsin-Superior for members from the natural gas industry, along with current users of natural gas, to meet with community and industry leaders regarding building a liquefaction plant in the Duluth/Superior area. About 100 people gathered from the gas industry, governmental agencies and potential users to participate in the discussions. The Duluth/Superior region would provide a key location for another gas liquefaction facility that could reach a 250 mile radius at the western end of the Lakes. In addition to the maritime industry, Duluth/Superior is a hub for rail and trucking, with mining and agricultural industries located in the service area. The speakers at the meeting supported this concept and discussed several ongoing projects and some of the equipment needs to support a fuel transition to natural gas. A detailed summary of the meeting and the presentations are available at www.glmri.org/research/.



Participants at the May 2013 GLMRI meeting at University of Wisconsin-Superior.

Since this meeting, a local working group has been established. Dr. Stewart, GLMRI Co-Director, Ms. Carol Wolosz, Dr. Mokashi and Ms. Roemhildt have been involved to assist with education and outreach initiatives for local officials and the public to better understand the environmental and economic benefits of converting to natural gas.

Annual Advisory Board Meeting



Participants at the May 2013 LNG meeting: Mr. Steve Kemp, Mr. Alex Quintero and Mr. Gary Van Tassel.

The GLMRI 2013 Annual Advisory Board meeting was held on September

19 in conjunction with the High Horsepower Summit and the SNAME Great Lakes and Rivers Section Fall meeting in Chicago, Illinois. Mr. Richard Paris and Mr. Leo MacKeller participated from Andrie Shipping, representing Lake Carriers' Association. Major Booth, with Mr. Mike O'Bryan and Ms. Marie Strum from the U.S. Army Corps of Engineers Detroit District, provided updates on several district projects. Mr. Michael Carter, Mr. Dan Yuska and Mr. Floyd Miras participated from MARAD. Mr. Steve Kemp, President of the Great Lakes and Rivers Section of SNAME, discussed the HHP Summit and the pending SNAME meeting for Friday. Dr. Richard Stewart provided an update on the GLMRI projects and events that we have taken place over the past year. With his membership on the EPA's Advisory Board for the Great Lakes Restoration Initiative (GLRI), he also took away several ideas for GLRI consideration.

High Horsepower Summit



Marine panel speakers.

GLMRI was involved in the High Horsepower (HHP) Summit from September 17-19, 2013 in Chicago, Illinois. GLMRI was included as an endorsing organization. On Wednesday morning, Capt. Randolph Helland, U.S. Coast Guard retired and GLMRI Regulatory Consultant, presented his findings on regulatory issues impacting the use of LNG as a maritime fuel based on his initial work on the Great Lakes and subsequent analysis for the Ohio River.

On Thursday morning, Ms. Carol Wolosz moderated the marine panel of speakers discussing case studies on recent marine projects. Speakers included Mr. Roy Bleiberg, Director of Engineering for ABS Americas, Mr. John Hatley, Americas Vice President of Ship Power for Wartsila North America, Mr. Jan Hagen Andersen, Principal Engineer

for Det Norske Veritas, and Dr. Paul Blomerus, Senior Director of High Horsepower for Westport. Ms. Wolosz provided an overview of GLMRI and a brief summary of the LNG project progress and outcomes. On Tuesday, Mr. Steve Kemp, GLMRI Advisory Board member representing SNAME, moderated a panel addressing natural gas engine technologies.

LNG Education and Outreach

Over the past year, Dr. Richard Stewart and Ms. Carol Wolosz provided numerous presentations on LNG and the fuel conversion for the maritime industry to many groups, agencies and during meetings. In October 2012, Dr. Stewart was the keynote speaker at the 3rd Annual Yangtze-Mississippi River Conference in Wuhan, China. Later that month, he presented at the Wisconsin Freight Rail Day in Eau Claire, Wisconsin. In December 2012, he presented at the University of Minnesota's Center for Transportation Studies 16th Annual Freight and Logistics Symposium in Minneapolis, Minnesota. Dr. Stewart was a speaker at the LNG Fuel Forum North America in Miami, Florida in February 2013. In June, he presented on Maritime LNG use at the American Association of Port Authorities summer meeting in Chicago, Illinois. Ms. Wolosz presented an overview of GLMRI and the LNG Study at the Superior Wisconsin Rotary Club meeting in April 2013.



Dr. Richard Stewart, GLMRI Co-Director, media interview.

OTHER PROJECTS AND PRESENTATIONS

GLMRI Co-Hosts 2013 James L. Oberstar Forum "21st Century Transportation Systems: Challenges and Opportunities for Academia"

GLMRI Co-Director and Dean of the Swenson College of Science and Engineering, Dr. James Riehl, moderated the forum at the University of Minnesota Duluth on Wednesday, March 13, 2013. Mr. James Sharrow, the Facilities Manager from the Duluth Seaway Port Authority, provided the maritime perspective on the panel of speakers. Mr. Sharrow tied in the research projects GLMRI has been working on with the Port. Former Congressman and Chair of the House Transportation and Infrastructure Committee, Jim Oberstar, provided his extensive views on the need for critical investment in the American transportation infrastructure.

Ship Operations Cooperative Program (SOCP) and Maritime Education Initiatives



Attendees at the Maritime Education Symposium, Toledo, Ohio.

GLMRI continues to be an active member of Ship Operations Cooperative Program (SOCP). Ms. Carol Wolosz was re-elected to the Operations Committee and also serves as Co-chair to the maritime education sub-committee.

SOCP funded a project to develop curriculum for maritime schools. Dr. Arthur Sulzer, SOCP Committee Chair, is leading this effort to build teaching modules that include the latest industry content while cross referencing the lesson plans to the Department of Education's Common Core Standards. GLMRI is assisting to facilitate this education initiative. The Maritime Academy of Toledo held the first "K-12 Maritime Education Great Lakes and Inland Waterways Symposium" on Friday, April 26, 2013. Keynote speaker, Mr. Mark Barker, President of Interlake Steamship Company, Cleveland, Ohio,

addressed "Why Maritime Education Matters to Our Community, Industry and Country." Three panel discussions focusing on K-12 maritime education programs in practice, industry support for these programs, maritime training, research and post-graduate studies were also part of the symposium's agenda. The symposium highlighted successful K-12 maritime-focused schools and initiatives, including program and curriculum designs, funding, the state approval process, and state teacher licensing considerations. Maritime industry leaders from companies, port authorities, shipyards, and unions attended to discuss how their organizations support K-12 maritime education. A panel of experts discussed adult maritime training programs, current K-12 maritime education research and doctoral studies, maritime college and university programs and courses of study. The symposium concluded with table talk discussions related to "K-12 Maritime Education: Where Are We Now, Where Do We Want to go in the Future?"



Mr. Mark Barker, President, Interlake Steamship Company, keynote speaker at the Maritime Education Symposium.

In July, the Maritime Institute of Training and Advanced Graduate Studies (MITAGS) in Linthicum, Maryland hosted the "National Maritime Curriculum Development Workshop 2013" to bring together a team of experts to update the maritime course. As a side trip, the participants toured the Marine Engineers' Beneficial Association (MEBA) Calhoun School of Marine Engineering in Easton, receiving informative presentations on the school's history, background and current programs along with tours of the campus facilities—diesel engines, machining, welding, and refrigeration laboratories.

At the fall SOCP meeting held at MITAGS in November 2013, Dr. Sulzer provided an update on the project and expects to have the maritime curriculum completed by the spring of 2014.

Great Lakes Maritime Academy Board of Visitors



T/S State of Michigan.

Ms. Carol Wolosz and members of the Duluth Seaway Port Authority met and boarded the *T/S State of Michigan* while it was docked in Duluth Harbor during its summer training voyage on June 11, 2013. In October, Ms. Wolosz attended the annual Board of Visitors meeting and met with cadets and staff members from the Academy. GLMRI is pleased to be included in the GLMA Board of Visitors and appreciates their input and collaboration on research and education initiatives in support of the Great Lakes shipping industry.

Capitol Hill Oceans Week 2013



Dr. Richard Stewart, GLMRI Co-Director, speaking at Capitol Hill Oceans Week.

GLMRI Co-Director, Dr. Richard Stewart, moderated the panel on ports, trade, and supply chains at the Capitol Hill Oceans Week 2013 conference held June 4-6 in Washington, D.C. Capitol Hill Ocean Week 2013 is hosted by the National Marine Sanctuary Foundation (NMSF) to bring together hundreds of policymakers, industry leaders, scientists, and conservationists to shape marine policy and provoke conversation about critical ocean and coastal issues.

The conference covered sessions on a broad array of topics, including coastal resilience and the role of national marine sanctuaries in supporting coastal economies, and the future of U.S. fisheries.

2013 Transportation Research Board

GLMRI staff and researchers participated in the 2013 Transportation Research Board meetings held in Washington, D.C. Dr. Richard Stewart presented GLMRI updates at the Marine Environmental and the Ports & Channels Committees. Dr. Zamira Simkins, from the University of Wisconsin-Superior, presented "Measuring a Port's Performance Using the Economic Value of Commodities." Ms. Carol Wolosz was selected to serve on a three-year appointment to the Ports & Channels Committee. Dr. Stewart rotated off the Ports and Channels Committee after nine years of continuous service. He remains on the Marine Environmental Committee and a member of the Disaster Relief Task Force.

Hwy H₂O Education Advisory Council

The Hwy H₂O Advisory Council is comprised of professors and professional educators from scholastic institutions around the Great Lakes St. Lawrence Seaway System (GLSLSS). The council is a mutually beneficial partnership with Hwy H₂O Port Partners and Members. The goal is to utilize the expertise from each party in efforts to promote business, growth and learning within the GLSLSS. Dr. Stewart and Ms. Wolosz, along with Dr. Peter Lindquist from GLMRI affiliate University of Toledo, are members of the council. In November 2012, Ms. Wolosz and Dr. Lindquist attended the annual conference in Toronto and met with the education council. Dr. Stewart presented at the November 2013 annual conference. The group also has quarterly teleconferences to pursue education initiatives that support bi-national shipping and commerce throughout the GLSLSS.

Council of Great Lakes Governors

Dr. Richard Stewart was part of a team of maritime experts briefing staff members from the Council of Great Lakes Governors. Dr. Stewart represented the academic research community in the panel of experts. Topics discussed included: current shipping operations, environmental issues, expanding domestic maritime shipments, export opportunities for marine vessels, growing the Great Lakes cruise market and the use of alternative fuels to make marine transportation economically and environmentally sustainable.

Other Educational Venues and Maritime Outreach Involvement

GLMRI staff members, researchers, board members, and affiliates continue to be involved in committees and meetings around the Great Lakes region. Dr. Bradley Hull, from John Carroll University in Cleveland, has been actively supporting and advocating the container traffic between Cleveland, Ohio and Holland, which will commence in Spring 2014. Ms. Libby Ogard, consultant to GLMRI, participated in the Green Bay Port Symposium in March 2013. Dr. Stewart is active in the American Society of Transportation and Logistics and the National Association of Purchasing Management. Both Dr. Stewart and Ms. Wolosz are members of the Duluth-Superior Transportation Association. GLMRI is involved in the Duluth-Superior Harbor Technical Advisory Committee providing updates on GLMRI projects and events. Dr. Stewart also participated in the Marine Club meetings in Toronto, Canada, partially hosted by the American Great Lakes Ports Association in January 2012.

Time on the Lakes



Breaking ice in the Duluth Harbor on the Mackinaw.

Dr. Stewart sailed aboard the *M/V Roger Blough* from Duluth, Minnesota to Conneaut, Ohio, during August 2013.

The U.S. Coast Guard Cutter *Mackinaw* visited the Port of Duluth/ Superior on March 16-17 to open shipping lanes for the 2013 season. Ms. Carol Wolosz was invited to join a group for the Sunday morning icebreaking. The commander and crew provided an operational tour for industry and media guests while in the harbor. In addition to icebreaking, the *Mackinaw* services buoys, provides search and rescue, law enforcement, and the ability to deploy an oil skimming system to respond to oil spill situations.

PRESENTATIONS AND PUBLICATIONS

Natural Gas Feasibility and Design Study

The MARAD Great Lakes Natural Gas Feasibility and Design Study prepared by GLMRI was finalized and released in the spring of 2013. The report along, with detailed summary reports, is available on the GLMRI web page: www.glmri.org/research/.

Dr. Simo Makiharju's Paper Selected for Publication



Dr. Simo Makiharju's (University of Michigan) journal article on his research and testing on Air Lubrication Drag Reduction was published in the

International Journal of Naval Architecture and Ocean Engineering (December 2012). He worked with Dr. Steve Ceccio on this project that received funding from GLMRI in 2010. His research report on the application for Great Lakes Ships is posted on the GLMRI web page. Congratulations to Dr. Makiharju.

GLMRI Project Receives International Recognition by SNAME



Drs. Michael Parsons and **David Singer's** paper "Integrated Electric Plants in Future Great Lakes Self-Unloaders" received Honorable

Mention for the Vice Admiral E.L.



Cochrane, USN Award. The Cochrane Award is awarded to the best peer reviewed presentation published by SNAME based on originality and technical

quality. Dr. Parsons also received this award in 1985. Drs. Parsons and Singer are professors in the GLMRI affiliate University of Michigan, Naval Architecture and Marine Engineering Department. The paper was originally published in the Journal of Ship Production and Design, Vol. 27 No. 4, Nov. 2011 and is available on the GLMRI web page. (www.glmri.org/research/completed0910)

Study Published in Great Lakes/Seaway Review



Drs. Zamira Simkins and **Richard Stewart**, University of Wisconsin-Superior authored an article "Economic Gateways" in the *Great Lakes/Seaway Review* (Vol. 41, No. 3, January-March, 2013). The article summarized their work in the 2012 GLMRI project on measuring a port's

performance using the economic value of the commodities as compared to tonnage shipped. Their research paper, "Measuring a Port's Performance Using the Economic Value of Commodities," was also peer reviewed and selected for presentation at the 2013 Transportation Research Board.

PEOPLE UPDATES

GLMRI Co-Director Selected for EPA Advisory Board

The U.S. Environmental Protection Agency (EPA) formed the first advisory board in March 2013 to support the implementations of the Great Lakes Restoration Initiative. Dr. Richard Stewart was selected for a two-year appointment to the Great Lakes Advisory Board (GLAB). The GLAB provides advice and recommendations to the EPA Administrator, who chairs the Federal Interagency Task Force. Since the announcement, the GLAB has had monthly meetings/teleconferences to pursue their agenda.

GLMRI Advisory Board Member Retires

Mr. Adolph Ojard, President of the American Great Lakes Ports Association and Executive Director of the Duluth Seaway Port Authority, retired at the end of September 2013. Mr. Ojard was intricately involved in the establishment of GLMRI in 2004 and a supportive member of the Institute and its projects. Congratulations Adolph, and enjoy the next chapter of your life. Thank you for your many years of support.

White House Administration Leadership Recognition

Ms. Carol Wolosz was invited to participate in the White House Office of Engagement and Department of Transportation's Forum on Women in Transportation in April 2013. Approximately 60 national transportation leaders were invited to discuss their organization's best practices relative to the education, recruitment, retention, and leadership development of women, and to help evolve strategies for overcoming barriers.

2013 Project Reports

Summary Reports

This report provides summary reports on the GLMRI research projects that have taken place over the past year. Full reports are available on the GLMRI web page.

Liquefied Natural Gas As Maritime Fuel On The Ohio River: A Case Study and Regulatory Evaluation

PRINCIPAL INVESTIGATOR: Randolph C. Helland, Regulatory Consultant

Ballast Tank Sediment Study: An Analysis of Invertebrate Resting Eggs and Other Biota of Domestic Great Lakes Cargo Ships

PRINCIPAL INVESTIGATOR: Donn K. Branstrator, Ph.D.
Department of Biology, University of Minnesota Duluth

Strategic Port Development: Is Centralized Planning Essential to Optimize a Marine Multi-Modal Transportation System?

PRINCIPAL INVESTIGATORS: Elizabeth Ogard and Dr. Richard Stewart

A Study on the Conversion of Great Lakes Bulk Vessels to LNG: Evaluation of a Potential Fuel Terminal

Hiroko Tada, Julia Haeder and Dr. Richard Stewart

Liquefied Natural Gas as Maritime Fuel on the Ohio River:

A Case Study and Regulatory Evaluation

PRINCIPAL INVESTIGATOR

Captain Randolph Helland, USCG (ret)
R.C. Helland Consulting
Regulatory Consultant for the Great Lakes
Maritime Research Institute

Under the cooperative agreement between the Great Lakes Maritime Research Institute (GLMRI) and the U.S. Maritime Administration, in 2013 GLMRI continued work to analyze the feasibility of implementing LNG as fuel on commercial vessels and developed a case study to look at the barges that operate on the Ohio River. This report builds on the previous study that analyzed the use of LNG as fuel on commercial vessels operating on the Great Lakes and addresses current federal, state and local regulations regarding LNG propulsion on commercial vessels and LNG fueling facilities and operations. Further, it analyzes mid-stream fueling as a bunkering option.

There are many federal, state and local government agencies in the U.S. that have jurisdiction over some aspect of LNG. Some agencies that have jurisdiction over the vessel (ship) and others have jurisdiction over the facility that stores and/or transfers LNG to the vessel. Facility types are further broken down into fixed facilities (storage tanks or liquefaction plant) and mobile facilities (LNG tank truck).

The International Maritime Organization (IMO) has continued work to develop international standards to address the safety and security of LNG bunkering operations, and the training and qualifications of personnel involved in those operations. International standards that address LNG fueled engines on ships are found in IMO Resolution MSC 285(86), Interim Guidelines For Gas-Fuelled Engine on Ships. Most of the classification societies around the world have adopted these standards. In 2011, Working Group 10 (WG 10) within the Technical Committee 67 (TC 67) of the International Organization for Standardization (ISO) drafted international guidelines for bunkering of gas-fueled vessels focusing on requirements for the LNG transfer system, the personnel involved and the related risk of the entire LNG bunkering process. A draft technical report was released in June 2013. The goal of the working group is to have standards finalized in 2014.

There are a myriad of federal, state and local government regulations that address LNG safety and security requirements at

facilities. (These are detailed in the full report, accessible at www.glmri.org.) However, there are no regulations that address LNG bunkering. Until regulations are developed and in order to address the increased interest and demand for using LNG as fuel, the U.S. Coast Guard drafted several policy letters in 2013. The first addresses Vessels and Waterfront Facilities conducting Liquefied Natural Gas (LNG) Marine Fuel Transfer (Bunkering) Operations and the other one addresses Liquefied Natural Gas fuel Transfer Operations and Training of Personnel using Natural Gas as Fuel.

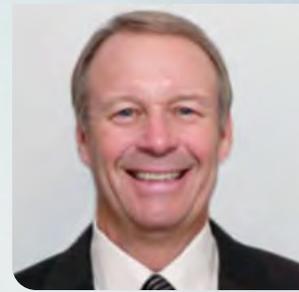
The Coast Guard has the statutory responsibility to administer vessel inspection laws which ensure that both U.S. flag and foreign flag vessels are safe and well equipped for their intended service. Inspections of vessel safety systems include the following: hull inspections, main/auxiliary power inspections, electrical systems inspections, lifesaving system inspections, firefighting systems inspections, navigation equipment inspections and pollution prevention inspections.

The Coast Guard delegates this responsibility to the Officer in Charge, Marine Inspection. There are four basic categories of vessels subject to inspection. They are passenger vessels, tank vessels, cargo vessels and special use vessels such as offshore drilling units (MODU), offshore supply vessels, oceanographic research vessels, oil spill response vessels, nautical school vessels and sailing school vessels. Towing vessels are not currently included in the list of inspected vessels.

Ohio River Case Study

As discussed above, the international community and U.S. government are making strides in developing standards and regulations for LNG bunkering. Further, there is increased interest in the maritime industry for this technology. The study also analyzes the feasibility of implementing LNG as maritime fuel on vessels that operate on the Ohio River, and it addresses potential land-based and midstream refueling options.

The inland waters of the United States contain nearly 12,000



CAPTAIN RANDOLPH HELLAND, USCG (ret)

Captain Helland held senior executive positions over a 32 year U.S. Coast Guard career at the national, regional and local levels in the areas of marine/port safety, security, environmental protection and waterways management. After his Coast Guard career, he has consulted for several companies conducting Port Vulnerability Assessments, Trade Resumption/ Business Continuity plans and marine navigation projects around the country.



Towboat W. Scott Noble provided by B.B. Riverboats

miles of water and approximately 192 locks. Every year, nearly 624 million tons of waterborne cargos transit the inland waterways. Waterways transport more than 60% of the nation's grain exports, approximately 22% of domestic petroleum and petroleum products and 20% of the coal used in electricity generation.

The Ohio River system contains 19 locks and dams that span the area from Pittsburgh, Pennsylvania to Cairo, Illinois. The commercial industry that plies these waters include towboats with barges and small passenger vessels. The towboats vary in size and horsepower based on their location in the river and the size limitations of the locks.

Towboats that operate on the Ohio River generally range in size from 100 to 200 feet long, 26 to 35 feet wide and 1,000 to 9,000 horsepower. These tend to be much smaller than those operating on the lower Mississippi River because there are no locks below St. Louis on the Mississippi River that serve as a limiting factor.

Since towboats that operate on the Ohio River are not Coast Guard inspected, they do not need to comply with the regulations governing inspected vessels. However, the Coast Guard has published a Notice of Proposed Rulemaking on August 11, 2011 which proposes safety regulations governing the inspection, standards and safety management systems of towing vessels. The date the new rules will be published is unknown. Until that time, towboat owners desiring to either convert existing engines or build new vessels with LNG fueled engines must obtain Commandant, U.S. Coast Guard approval. The design criteria listed in Coast Guard CG- 521 Policy letter number 01-12 dated April 19, 2012 would have to be followed for uninspected vessels.

While towboats would be a natural fit for the application of LNG propulsion technology, there are several significant hurdles to overcome. Below is a list of some of those challenges.

- Small towboats bring space challenges for LNG engines and fuel tanks. An engineering study needs to be conducted on all

towboat sizes that operate on the Ohio River to determine the feasibility of adopting this technology. The study needs to include, but is not limited to, the engineering requirements of an engine retrofit, determining the size and location of the LNG fuel tank, stability requirement and any operational requirements that may be placed on the vessel.

- The location of the LNG fuel tank on the boat may be a limiting factor. The current Coast Guard policy prohibits the placement of LNG fuel tanks above or below accommodation spaces. Working closely with the Coast Guard and applicable classification society early on in the process is critical to success.

Refueling Options

Establishing a supply system along the Ohio River that can provide LNG to towboats is critical to the success of this effort. It can be accomplished by tank truck, fixed facility (LNG storage tank or liquefaction plant) or by tank barge. There are a number of options for refueling:

- Tank truck fueling at the dock.
- Construction of designated facilities (either LNG storage tanks or liquefaction plants) along the Ohio River where the towboat can refuel. This option would most likely require the tow boat to disconnect from their tow, conduct bunker operations then reconnect. This would cause an operational delay that would have to be assessed by the company.
- Refueling by an LNG tank barge at a dock, anchorage area, fleeting area or while underway in the river. If approved, there will most likely be operational restrictions required by the Coast Guard.

Key to the successful implementation of LNG as fuel along the Ohio River is the supply chain. There is a significant supply of nature shale gas plays in the United States. The Marcellus play in the Pennsylvania area provides a huge supply that can be tapped for future use. An examination of the current supply chain on the Ohio River reveals no current infrastructure in place. There are a number of existing peak shaving plants, satellite peak

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shaving plants and import terminals around the U.S. The closest peak shaving plants to the Ohio River are located in the middle of Indiana (three locations), Illinois (one location) and one location in the eastern portion of Pennsylvania. There are no LNG facilities in West Virginia and Kentucky.

Future Supply Chain: In the Gulf Coast Corridor, Shell Oil Company plans to install a small-scale liquefaction unit at its Shell Geismar Chemicals facility in Geismar, Louisiana. Once operational, this unit will supply LNG along the Mississippi River, the Intra-Coastal Waterway and to the offshore Gulf of Mexico and the onshore oil and gas exploration areas of Texas and Louisiana. In the Great Lakes Corridor, Shell plans to install a small-scale liquefaction unit at its Shell Sarnia Manufacturing Centre in Sarnia, Ontario, Canada along the St. Clair River. Once operational, this project will supply LNG fuel to all five Great Lakes, their bordering U.S. states and Canadian provinces and the St. Lawrence Seaway.

Midstream Refueling by LNG tank barge: Internationally, the first LNG bunker barge in the world services LNG-fueled vessels in Stockholm, Sweden. The Seagas will provide liquefied natural gas fuel to Viking Line's *Viking Grace*, a dual fuel passenger ferry, and possibly other vessels in the Stockholm harbor. The benefit of transporting LNG by barge on the Ohio River is that it allows the product to be moved and delivered more efficiently on a small-scale basis to locations where large LNG infrastructure is not existent and is too costly and time consuming to construct. The barge can also serve as a floating storage facility, positioned to provide LNG fuel to towboats.

While there are many benefits to midstream refueling, there are operational and regulatory issues that need to be addressed. In concert with the Coast Guard Captain of the Port, the location(s) of the midstream refueling area will need to be determined. A Waterways Suitability Assessment, while required for transportation of large quantities of LNG (as cargo), may be required by the Coast Guard Captain of the Port. A variety of waterway restrictions could be imposed from safety or security zones, exclusion zones and operational restrictions including day time operations, escort vessels and security requirements.

This study has identified some potential roadblocks that could hinder the development of LNG fueled vessel technology and supply chain along the Ohio River. The roadblocks listed below are not limited to regulatory challenges, but also include a broader context including stakeholder involvement and buy-in, the cost to implement this new technology and the current lack of LNG supply chain. The roadblocks include: stakeholder concern over LNG, cost to implement, delays in completing Federal, State and Local regulatory requirements, lack of LNG supply chain infrastructure, and tow boat design for LNG engines and fuel tanks. To overcome the potential roadblocks, industry representatives need to conduct outreach addressing facilities, mobile facilities and vessel construction.

The full research reports are available at www.glmri.org. ■



DR. DONN BRANSTRATOR

Donn received the B.A. in Biology from Lawrence

University and the Ph.D. in

Biology from the University of Michigan. He was a postdoctoral fellow at McGill University and at the University of Chicago before coming to the University of Minnesota Duluth in 2000. He teaches graduate and undergraduate courses in general ecology, lake ecology, and plankton biology. He is the Associate Director of the Integrated Biosciences Graduate Program and leads a team of students that study the ecology of zooplankton. His research focuses on Lake Victoria (East Africa), Lake Superior, and small inland lakes in North America.

Carol Wolosz and Donn Branstrator gathering sediment samples



Ballast Tank Sediment Study: An Analysis of Invertebrate Resting Eggs and Other Biota of Domestic Great Lakes Cargo Ships

PRINCIPAL INVESTIGATOR
Donn K. Branstrator, Ph.D.
*Department of Biology,
University of Minnesota Duluth*

The Lake Carriers' Association provided funding to perform a two-year study to examine sediment in ships' ballast tanks. We extend our appreciation for their support in both funding and providing access to their ships and tanks while during their critical operations and schedules.

For over a century, species native to other continents have been steadily invading the Laurentian Great Lakes of North America. From 1840 to 2003, more than 180 non-native species became established in the Great Lakes, representing an invasion rate of > 1 species year, with the rate increasing in recent decades. While most non-native species in the Great Lakes appear to have had little measurable impact on the ecosystem, some have become invasive as a result of excessive population growth and novel interactions with the environment. Noteworthy examples of non-native, invasive species in the Great Lakes include round goby (*Neogobius melanostomus*), zebra mussel (*Dreissena polymorpha*), and spiny water flea (*Bythotrephes longimanus*). As a group, invasive species have caused enormous changes to the structure and function of the Great Lakes ecosystem with economic and environmental costs now estimated at \$138 million annually for the sub-set of non-native species originally introduced by ocean-going ships.

Ballast sediments of three Great Lakes bulk freighters (*M/V Edwin H. Gott*, *M/V American Century*, and *M/V Mesabi Miner*) were sampled during 2011 and 2012 at Lake Superior shipping ports. While the ships were still sailing for the season, and during winter lay-up, Dr. Branstrator (PI) and Carol Wolosz worked with the carriers to schedule access for tank sampling by the research team.

All three ships are 1000-foot, bulk freighters constructed in the United States during the 1970s to 1980s. They operate exclusively within the upper Great Lakes (Superior, Michigan, Huron, and Erie). This study of ballast tank sediments was conducted in two phases. Phase I objectives were to assess invertebrate diversity and density in ballast tank sediments. Phase II objectives were to assess invertebrate resting egg

density, viability (hatching percentage), taxonomy, and size.

Sediments contained evidence of a diversity of pelagic and benthic invertebrate groups including Bivalvia, Cladocera, Copepoda, Ostracoda, Gastropoda, Hydracarina, Nematoda, Oligochaeta, as well as zooplankton resting eggs. The mean density of invertebrate resting eggs among the three ships ranged from 0.2-2.7 eggs g⁻¹ wet sediment (phase I samples) and from 16.0-24.6 eggs g⁻¹ wet sediment (phase II samples). The mean viability (percentage hatched in laboratory assays) of resting eggs among the three ships ranged from 31.2-75.8% (phase II samples) for batches of eggs that were separated from sediment (after 7-11 weeks incubation) with sugar floatation. Hatched eggs were identified as species of Cladocera, Copepoda, Ostracoda, and Rotifera, and included two species that are non-native to the Laurentian Great Lakes (*Bosmina coregoni* and *Bythotrephes longimanus*). Species of Bosminidae (Cladocera) were the most common group that hatched, comprising 550 of the 817 hatchlings (or 67.3%) across the study. Length-frequency distributions of resting eggs were consistently bimodal with a primary peak centered at 80-110 μm length and a secondary peak of lower frequency centered at 150-180 μm length.

The results of this study indicate that ballast tank sediments of these three domestic cargo ships are suitable sites for survival of freshwater invertebrates, including the resting egg stages of native and non-native species. Although the results imply that non-native, viable biota as resting eggs could be spread by ship ballast sediment, it was not our objective to test this or whether ships are affecting the range distributions of non-native biota in the Great Lakes through sediment transport and exchange.

(References and supporting material are available in the full report at www.glmri.org.) ■

Strategic Port Development:

Is Centralized Planning Essential to Optimize a Marine Multi-Modal Transportation System?

PRINCIPAL INVESTIGATOR

Elizabeth Ogard
Prime Focus, LLC

CO-PRINCIPAL INVESTIGATOR

Dr. Richard Stewart
Co-Director, GLMRI
Chair, Department of Business and Economics
University of Wisconsin-Superior

GLMRI initiated a project to evaluate port planning and its benefits to a multi-modal transportation system. In an effort to inform Wisconsin port leaders, a study team benchmarked certain states and Canadian ports to identify how others approach port planning. Three U.S. states and one Canadian Province were selected for analysis. The selection criteria included: 1) Inland Waterway or Intercostal Waterway and deepwater access, 2) Diversity of cargo types including alternative energy terminals, and 3) States which have been identified as leaders with unique organizational structure. Pennsylvania, Florida, Texas and Hamilton, Ontario were selected for further review.

The project work plan included three tasks: 1) To compile and review a list of Wisconsin marine development plans, sources of funding, programs and promotional activities sponsored or under the authority of the Wisconsin Department of Transportation (WisDOT), the Wisconsin Economic Development Corporation, Coastal Zone Management and Metropolitan Planning Organizations (MPOs), 2) Benchmarking of three states, and 3) Benchmarking Ontario, Canada.

Literature has been compiled and state Departments of Transportation (DOTs), Regional Planning Commissions (RPCs), MPOs and ports have been surveyed.

Benchmarked states report that the office or individual within their organization responsible for port planning is at the senior management level. Port strategic planning is done with a combination of senior, mid-level management and public input and involvement. Data gathering varies between benchmarked states. When asked about how marine transportation as a mode is represented by the state/provincial government in strategic planning, responses varied based on departmental organization. In Pennsylvania, marine strategic planning has not received the same level of involvement as air, rail, highway or pipeline efforts due to the fact marine planning has been part of the state's economic development organization, however, this is changing and ports will be brought back under the Department of Transportation in the

near future. In Texas, air, rail and intermodal efforts receive about equal attention. Funding and programs varied across benchmarked states, some provide loans, grants and data, while others provide none. Respondents reported that marine transportation receives less financial support than other modes.

When benchmarking Ontario, Canada, in contrast, there is no provincial-wide port planning effort, each port is independent. Ontario notes that a Marine Caucus and the Chamber of Marine Commerce have been marine advocates at the provincial and national level. The Hamilton Port Authority in Ontario has a five-year planning horizon and adopted a land use policy in 2002. Hamilton Port Authority is fiscally independent and there are no government subsidies for development, security or dredging. One of the innovations Hamilton Port Authority has implemented includes a portal for cargo movement, available to facility users and port related interfaces.

Eighteen Wisconsin MPOs, RPCs and state offices were also contacted to identify their level of involvement in strategic port planning and promotional efforts at the state level. Seven responses at the time of this review were received: some contacts indicated they were not in districts with marine resources. Three respondents identified familiarity with marine development plans within their area. Only one reported direct involvement with marine transportation plans, and another reported indirect involvement. Only one respondent indicated participation in Wisconsin Commercial Ports Association, GLMRI or MARAD activities. When asked about the importance of marine development compared to other activities they are responsible for, responses varied substantially which, in part, reflect the port activities of the regions surveyed and the diverse marine network in the state of Wisconsin encompassing Great Lakes ports and Mississippi watersheds. Only two survey respondents reported that marine planning was not important. The majority of respondents reported inadequate information to undertake marine planning and development. Eight resources were examined:



LIBBY OGARD

Prime Focus LLC was established in 2001 as a freight transportation planning firm. Ms. Ogard has co-authored eight National Academies transportation research studies and has been involved in intermodal terminal assessments, mode conversion opportunities, port assessments, and trucking studies. Prior to 2001, she spent 18 years in the railroad industry at Burlington Northern and Conrail. Ms. Ogard joined Schneider National and spent seven years in the TruckRail division. As General Manager, Ms. Ogard managed private fleet operations, brokerage and intermodal services for Target, Walgreens, Family Dollar, and Home Depot. She holds an MBA from University of St. Thomas, St. Paul, Minnesota.



DR. RICHARD STEWART

Dr. Richard Dow Stewart is a Chair of the Business Department at the University of Wisconsin-Superior, the Director (Professional) of the Transportation and Logistics Research Center and Co-Director of the Great Lakes Maritime Research Institute. He earned his Ph.D. at Rensselaer Polytechnic Institute's Lalley School of Management, his Master's degree at the University of Wisconsin-Green Bay and his Bachelor's at the U.S. Mercant Marine Academy. He has commanded ocean-going ships and was manager of a \$300 million fleet of tankers and bulk vessels trading worldwide. He was a Captain in the U.S. Naval Reserve and holds a current Unlimited Ocean Master's License and STCW-95 certification.



Freight Data – Planners noted that data was very important especially for performance measures. However other factors were identified as more important.

Funding Programs – Planners ranked funding as the most important, with only one agency reporting a funding program available to them.

Stakeholder Involvement – Involvement of stakeholders was highly ranked yet it was identified as difficult to engage individuals who are not necessarily located in the region, but have responsibility for local assets and facilities. It was noted that it is difficult to engage stakeholders if no funding or program exists for future development.

Marine Project Management Expertise – ranked lower in importance, yet there was interest in project development

support and marine planning expertise especially by agencies with small staff numbers.

State Agency Support – Reported especially important for the City and County related aspects of marine planning.

Project Development Resources – This resource ranked last in the survey, planners note that there is a need for more resources for harbor projects.

Land Use and Port Preservation – Planners identified that more resources were available for land use planning and few if any resources were available for port preservation work. Responses to this question were mixed based on location. Coastal planners ranked this resource higher than inland agencies.

Intermodal Connectors – Connectors were identified as very important, however not many have been identified within the regions which replied to the survey. It was noted that there is a need to update the 2003 inventory given changes in business levels and wind energy tax incentives.

While the sample size is small, the anecdotal responses provide some initial insights into the perceived need for port planning and the available resources. In general planning activities increase if there is a funded program for project development. Stakeholder interest and participation is heightened if project funds are available in marine development programs. Wisconsin benefits from experts and agencies such as GLMRI, Wisconsin DOT and engaged leaders in the Wisconsin Commercial Ports Association, however, in a constrained financial environment, planning is difficult. MAP 21 performance requirements will result in a greater level of interest in data and levels of activity.

More information and findings will be available in the final report that is expected to be completed in 2014. ■

A Study on the Conversion of Great Lakes Bulk Vessels to LNG:

Evaluation of a Potential Fuel Terminal

Hiroko Tada, Julia Haeder and
Dr. Richard Stewart
University of Wisconsin-Superior

*Calumet Superior, LLC. Duluth Marine
Terminal Storage Tanks*

SOURCE: DR. RICHARD STEWART



In order to support the GLMRI study on establishing a Liquefied Natural Gas (LNG) supply chain to serve ships in the Great Lakes, Hiroko Tada and Julia Haeder, student researchers under the direction of Dr. Richard Stewart, examined the Calumet marine fueling terminal in Duluth, Minnesota. The information gathered will assist in determining supply chain options and the potential market for marine fuels in this region. The market data will, to an extent, impact the size of a liquefaction plant that would be built in this region to supply LNG for transportation systems. There are currently no USCG approved terminals to fuel vessels with LNG but the Calumet terminal was examined for the potential delivery, storage and fueling of vessels with LNG.

Most current marine fuels are residual fuels, which is the low-grade oil product that remains after the distillation of crude oil. After the petroleum crisis of 1973, the quality of the residual oil declined because oil companies improved their refining technologies to extract the maximum quantity of refined products. At the same time the contaminants, such as sulfur, in residual fuels that causes negative health effects and environmental threats has increased. To improve on air quality and protect public health from the toxic emission, the United States and Canada became signatories to the Treaty that designated Emission Control Areas (ECA). The ships sailing within the ECAs, which include all of the Great Lakes, have to reduce their emission of sulfur oxide (SO_x), nitrogen oxide (NO_x), and fine particulate matter (PM). To meet the ECA standard, the ships will have to reduce their emissions by either installing, scrubbers to remove exhaust contaminants when burning residual fuel, using a very low sulfur content fuel, or converting to an alternative (not oil based) cleaner fuel. Natural gas has emerged as a viable option as an alternative fuel.

If the ship continues to use a residual fuel with scrubbers, the company will have to deal with several issues. First: is the ability to fit a scrubber into existing vessels where space is at a premium. Second: is the fact that it will cost millions of dollars to purchase and install a scrubber and that cost will have to be recovered. Third: The effluent that results from scrubbing the

exhaust gasses has to be stored aboard the vessel and will require shore side disposal. Fourth: shore side disposal facilities have to be certified as the effluent may be a hazardous waste material and there will be a limited number and this may impact voyage planning and or winter lay-up.

Initial GLMRI research indicated that LNG would be the most likely type of natural gas fuel used by Great Lakes vessels. In order to use LNG as a marine fuel, it is essential to develop a supply chain for LNG in the Great Lakes region. Without a stable availability of LNG, it is difficult for ship owners to convert to LNG. GLMRI has cataloged the current fueling locations used by Great Lakes vessels and as part of the research process is evaluating the potential to modify the existing fuel terminals to provide LNG.

Duluth, Minnesota/Superior, Wisconsin (the Twin Ports) is the largest port on the Great Lakes and in the top 20 ports for tonnage shipped in the United States. With over 1200 vessel calls each year at the port, it has been a fuel hub for over 100 years. There are sufficient natural gas supply pipelines coming to the region that could supply a gas liquefaction plant. Within 250 miles of the port there are multiple markets for LNG including trucking, rail, mining, transit and agriculture as well as shipping. The research team prepared a survey for the major fuel suppliers to obtain fuel consumption data.

The research team prepared a survey for the major fuel suppliers to obtain fuel consumption data. The student team was able to tour the Calumet Marine Fuel Terminal in Duluth, MN. They met with the manager, prepared a survey for the major fuel

HIROKO TADA and JULIA HAEDER

Hiroko Tada and Julia Haeder were students at the University of Wisconsin-Superior, Transportation and Logistics Program. Ms. Tada completed an internship in the summer of 2012 with Japan Marine Science, Inc. located in Tokyo, Japan. During her three months at Japan Marine Science she assisted in a variety of research projects with a focus on alternative fuels.

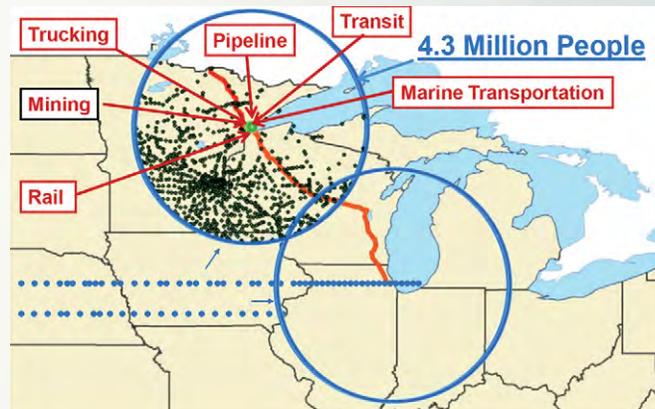
Ms. Julia Haeder was an exchange student at UW-S for one semester in the Transportation and Logistics Program. She was enrolled in a cooperative bachelor's degree program in Aviation Management at the University of Applied Sciences, Frankfurt am Main, Germany.



Additional Potential Storage Tank Location



Twin Ports LNG Terminal Marketing Region



suppliers to obtain fuel consumption data and learned about the facility, its operations and resources. While at the terminal they observed the bunkering operation for *M/V Paul R. Tregurtha*, a Great Lakes bulk carrier that is 1,013 feet (309m) long. The vessel's Chief Engineer said that the ship burns an average 9,700 U.S. gallons (36,718.49 liters) of Intermediate Fuel Oil (IFO) a day when they are underway. He also mentioned that in the winter the ship loads fuel in Duluth every trip in case the vessel would not be able to stop at a fueling dock because of ice. In the summer, they load fuel less frequently than in the winter.

The Calumet fueling terminal has four different pumps. Three of them are located inside their facility: for heavy fuel, diesel fuel, and for blending the diesel fuel into heavy fuel. The fourth pump is for pumping fuel for the ships' bow thruster and is located at the far end of the facility. Diesel fuel is pumped by this remote pumping station.

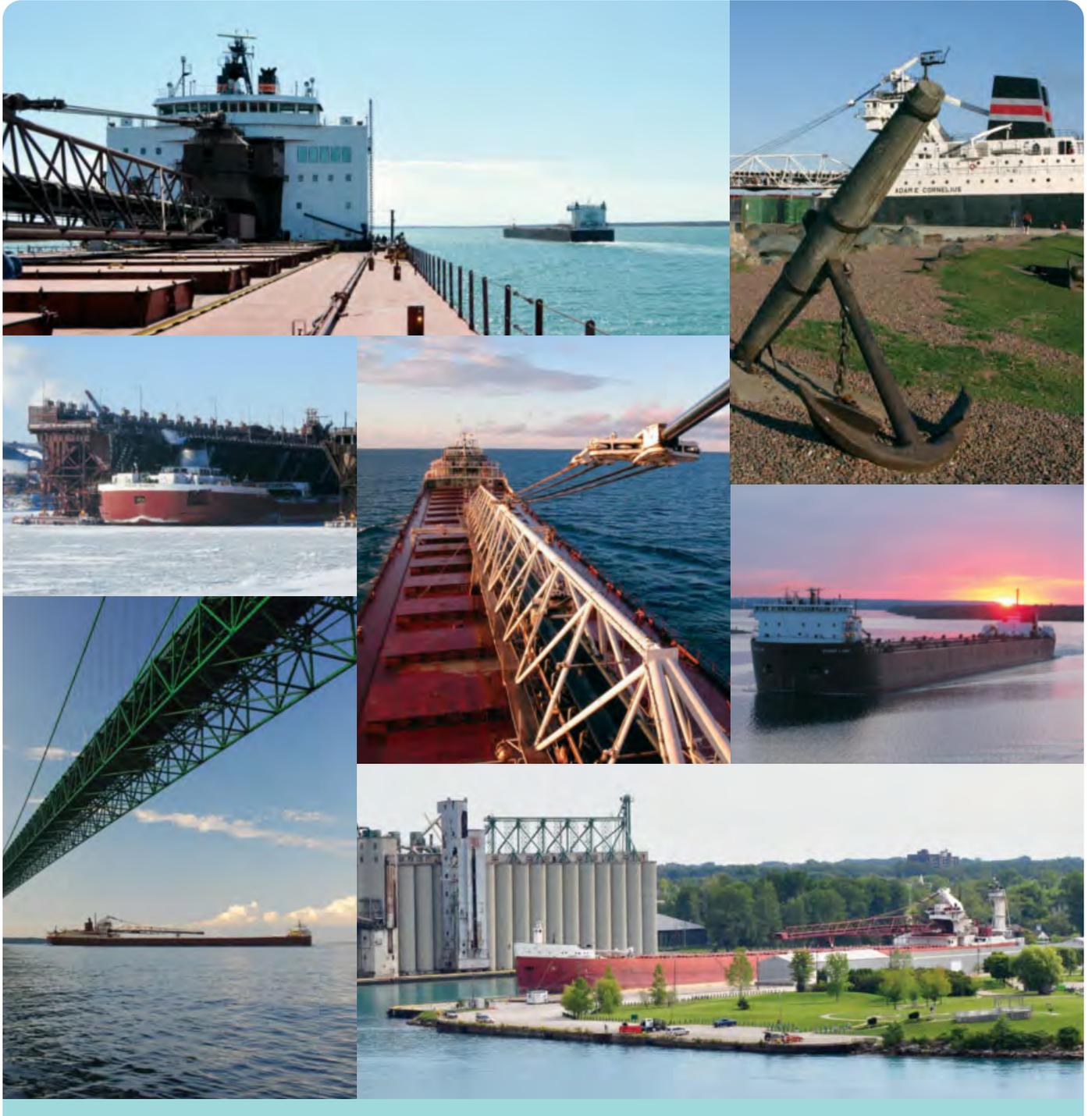
The Calumet Marine Terminal obtains its fuel from the Calumet Refinery located in Superior, Wisconsin. The refinery obtains its crude oil from Canadian wells that arrives at the refinery by pipelines. The Calumet terminal does not have a pipeline to transport their fuel at their terminal. The refined products are shipped to the Calumet fuel terminal by truck and placed in storage tanks. The Jeff Foster Trucking Company delivers most of the fuel to Calumet fueling terminal from Calumet's refinery in Superior, WI. A diesel delivery truck and a heavy fuel delivery truck can unload their fuel at the same time since Calumet expanded their truck terminal two years ago.

One of the advantages to Calumet Marine Terminal is having a

refinery close to fueling terminal. It is approximately 8 miles between the refinery and the fueling terminal. In the tank storage area, there is space to build additional tanks that could possibly be used to store LNG. The facility is already approved by the U.S. Coast Guard (USCG) for bunkering operations. However, specific regulations on bunkering LNG are still in development with USCG. Since Calumet leases the site from the Duluth Seaway Port Authority, there is additional land that could be accessed if requirements dictate a separation zone greater than the current one.

There are multiple potential users for LNG in the Twin Ports market. The Calumet terminal moves an average of over 17 million gallons of fuels a year. There are four class one railroads operating in the Twin Ports and one of the railroads uses about 18 million gallons of diesel per year. Establishing a liquefaction plant in the Twin Ports would not only provide fuel to regional users but LNG can be drayed to other nearby markets. Within a 250 miles circumference of the Twin ports there is a population base of 4.3 million people that includes the Minneapolis/St. Paul statistical Metropolitan Area (The Twin Cities along with the Twin Ports). Both the Twin Ports and Twin Cities are major transportation hubs that include multiple rail lines, trucking, and mining, transit and agriculture as well as Great Lakes and Mississippi river shipping. The Calumet terminal has potential to serve as an LNG fueling station for marine vessels. The success of the terminal will be dependent on regulatory compliance, availability of LNG and profitability.

(The full report of this study is available at: www.glmri.org) ■



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