Great Lakes Maritime Research Institute

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

Grant Completion Report May 2005 — November 2006

Provided to the United States Congress through the U.S. Department of Transportation

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Grant Completion Report

The Great Lakes Maritime Research Institute (GLMRI)

A U.S. Department of Transportation, Maritime Administration
National Maritime Enhancement Institute

November 2006

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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.

A U.S. Department of Transportation, Maritime Administration

National Maritime Enhancement Institute

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Technical Report Documentation

1. Report No. **GLMRI-2006-0001**	**2. Government Accession No.**	**3. Recipient's Catalog No:** **Catalog of Federal Domestic Assistance #20.000**
4. Title and Subtitle The Great Lakes Maritime Research Institute		**5. Report Date: November 2006** **6. Performing Organization Code**
7. Author/s Richard D. Stewart, Ph.D James P. Riehl, Ph.D Carol J. Wolosz Dale Bergeron Tab 1: Michael D. Parsons, Ph.D Tab 2: Peter Lindquist, Ph.D Tab 3: Randall K. Skalberg Tab 4: Abu R. Hasan, Ph.D , Daniel Pope, Ph.D, and James Skurla Tab 5: Steven M. Colman, Ph.D, and R. Douglas Ricketts, Ph.D Tab 6: Joan Schumaker Chadde		**8. Performing Organization Report No.**
9. Performing Organization Name and Address The Great Lakes Maritime Research Institute 291 Marshall W. Alworth Hall 1023 University Drive Duluth, MN 55812		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** **DTOS59-05-G-00019**
12. Sponsoring Organization Name and Address The United State Department of Transportation Office of the Secretary		**13. Type of Report and Period Covered** End of Grant Period Report **14. Sponsoring Agency Code** **US DOT**
15. Supplementary Notes		

16. Abstract

The Great Lakes Maritime Research Institute (GLMRI) was established to pursue research efforts in marine transportation, logistics, economics, engineering, environmental planning and port management. The consortium also draws on expertise in a wide range of other areas through affiliations with other "Great Lakes" universities. In this initial year of funded support, the Institute established formal affiliations with seven other Great Lakes universities, set up an external advisory board, engaged in extensive outreach to stakeholders and developed a prioritized research focus. This publication provides reports on the progress against the initial research agenda.

17. Key Words: Great Lakes, Maritime, Data, Harbor Maintenance Tax, Fuel Alternatives, MARAD, NMEI, US DOT	**18. Distribution Statement: US Congress, US DOT, state DOTs, US Coast Guard, US Army Corps of Engineers, GL Port Authorities**		
19. Security Classification (of this report) Unclassified	**20. Security Classification (of this page)** Unclassified	**21. No. Of Pages**	**22. Price** -0-

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Overview and Background:

During March 2004, The University of Minnesota Duluth and University of Wisconsin-Superior formed the consortium, The Great Lakes Maritime Research Institute (GLMRI). Federal funding to support the GLMRI was received in May of 2005. The US Maritime Administration (MARAD) designated the GLMRI as a National Maritime Enhancement Institute (NMEI) on June 1, 2005.

$750,000 was federally appropriated through the Transportation Act of 2005, specifically for Great Lakes Research by a NMEI. This appropriation provided partial funding to support of the research objectives in the Coast Guard and Maritime Transportation Act of 2004 authorizing a U.S. designated Great Lakes NMEI.

This report is the summary of research and effort accomplished through this grant, from the commencement of the program through the first year of funded research.

Consortium Partners:

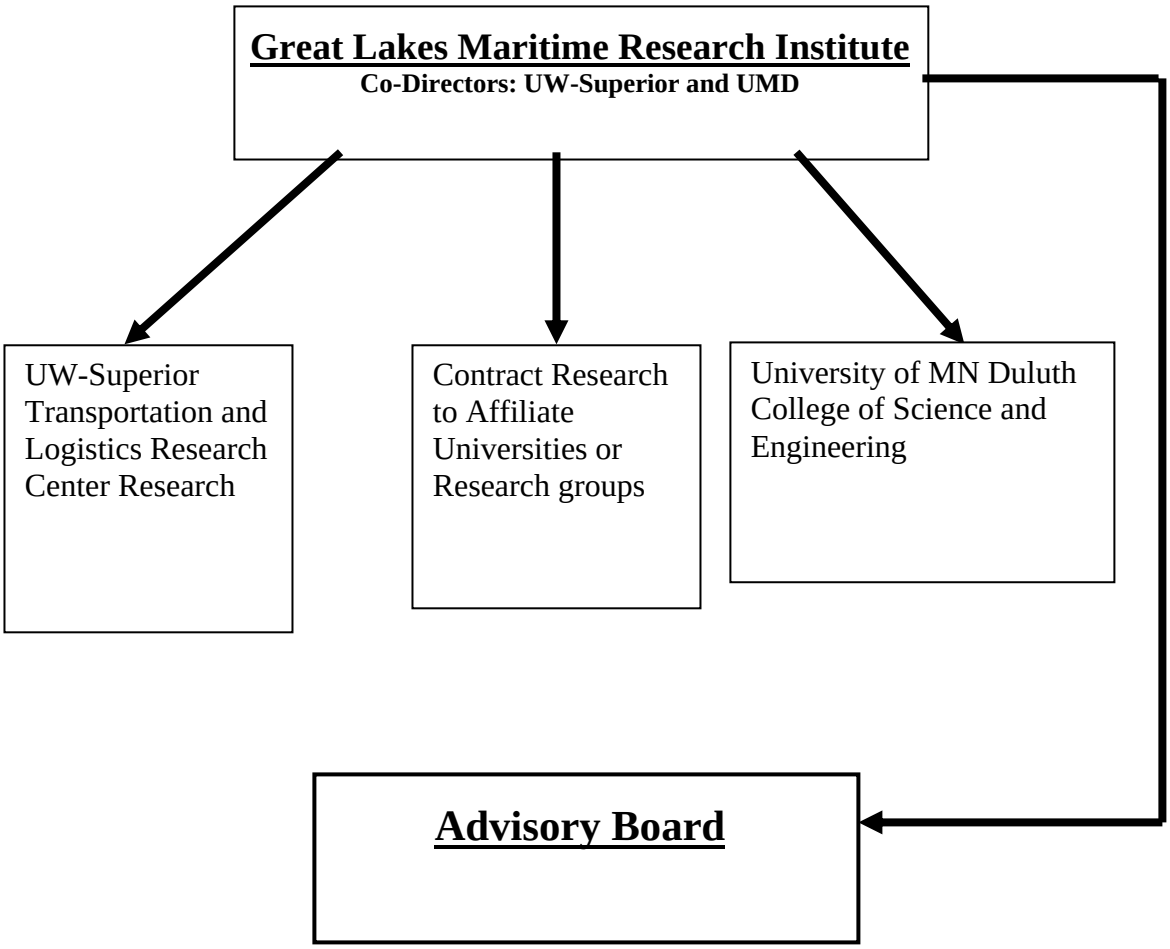
The transportation research centers of the **University of Wisconsin-Superior** and the **University of Minnesota Duluth** have for several years jointly pursued transportation and logistics research, public forums and funding. In March of 2004 these universities formally agreed to form a research institute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

The two Universities are located in the largest port on the Great Lakes. The communities have been a transportation hub for over 150 years. In addition to the maritime industry, the Twin Ports have service by four class 1 railroads, the terminus of the longest pipeline in North America, headquarters to over thirty trucking companies, an international airport and the largest single engine airplane manufacturer in the US. The Twin Ports have a US Coast Guard Office of Marine Inspection and is the home port for the new USCG Cutter *Alder*. The Twin Ports are also a Port of Entry with the U.S. Customs Office and The Immigration and Naturalization Service.

The Great Lakes Maritime Research Institute combines the strengths of two universities and their respective Transportation Research Centers. This dynamic combination provides a program area with tremendous breadth as a National Maritime Enhancement Institute serving the Great Lakes Region. The University of Wisconsin-Superior and the University of Minnesota Duluth have formally joined together to pool the considerable resources available to the two institutions to continue and expand Great Lakes maritime research. The universities have a history of supporting each other in the area of transportation research.

The consortia that forms the GLMRI draws staff from two universities with experts in marine transportation, logistics, economics, engineering, technology, computer management, management, marine environmental, planning, geography and port management. The consortium can also draw on expertise in a wide range of other areas including among others, air and rail transportation management, operations research, mathematics and social sciences. Both universities are members of federally nominated University Transportation Research Centers.

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



Advisory Board:

One of the first tasks of the Institute was to establish an advisory board. With input from the US DOT and the Maritime Administration, the Co-Directors of the Institute came up with a list of representatives who have expertise in maritime commerce, marine environmental issues or other segments of the Great Lakes Marine transportation system. The membership of the board was designed to bring together industry, academia and government leaders to advise the co-directors on the research agenda and to provide input on topical priorities. The Advisory Board can be expanded to include additional relevant stakeholders that agree to participate. The list of advisory organizations/board members is listed below:

- The Chairman of the Great Lakes Commission
- The Administrator of the St. Lawrence Seaway Development Corporation
- The US DOT Maritime Administration, Director of the Great Lakes Region
- The Chairman of the Society of Naval Architects and Marine Engineers, Great Lakes Section
- The Chairman of the American Great Lakes Ports Association
- The Commander of the Ninth Coast Guard
- The President of the Lake Carriers' Association
- The Army Corps of Engineers, Detroit District Engineer

Several of the organizations have delegated their membership to a specific person in their organization. The current membership of the Advisory Board is listed below:

Ms. Doris J. Bautch
Director, MARAD, Great Lakes Region
Schaumberg, IL 60173

Commander Gary Croot
U.S. Coast Guard, Marine Safety Office
Duluth, MN 55802

Dr. Thomas Huntley
Chairman, Great Lakes Commission
Duluth, MN 55812

Mr. Craig Middlebrook
Deputy Administrator, St. Lawrence Seaway Development Corporation
Washington, DC 20590

Mr. Al Horsmon
Chairman, Society of Naval Architects and Marine Engineers (SNAME)
Three Rivers, MI 49093

Lieutenant Colonel William Leady
US Army Corps of Engineers
District Engineer, Detroit District
Detroit, MI 48266

Mr. Adolph Ojard
Chairman, American Great Lakes Ports Association (AGLPA)
Duluth, MN 55802

Mr. James H.I. Weakly
President, Lake Carriers' Association
Cleveland, OH 44113

On October 7, 2005, the first meeting of the GLMRI Advisory Board was held in Duluth, MN. The Board members recommended that the research agenda include a solid communication strategy along with a balance of the research agenda topics. The Co-Directors agreed to keep the board members updated on the progress of the research areas.

The second meeting of the Advisory Board was held on October 6, 2006 in Duluth, MN. The Board members reviewed the progress that the Institute had made over the first year, and reviewed the research agenda for the future. The members were pleased with the progress that was made, and recommended that the Board continue to meet annually. Also, the members discussed the current make up of the Board, and agreed that the current membership was appropriate, but would consider/review other potential members at the annual meetings.

University Research Affiliations:

One of the tasks identified in the 2005 Statement of Work was to build the base of affiliate research universities to broaden the expertise. Universities in the Great Lakes region with expertise in the research focus areas were offered affiliations to partner in applicable areas. Researchers and other relevant affiliate assets from the affiliated universities are included as part of the research portfolio of the GLMRI, and the affiliate may serve as project researchers based on submitted proposals in response to an annual Request for Proposals. Research affiliates are encouraged to leverage GLMRI resources in efforts to secure independent and joint funding opportunities for Great Lakes maritime research. As of the end of this grant period, there are seven affiliate universities:

Great Lakes Maritime Academy
Admiral John Tanner
1701 East Front Street
Traverse City, MI 49686

Michigan Technological University
Dr. William Sproule
Dept. of Civil and Environmental Engineering
1400 Townsend Drive
Houghton, MI 49931

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

Purdue University
Mr. Rick Evans
Assistant Director, Industrial/Foundation Administration
Young Hall
302 Wood Street
West Lafayette, IN 47907-2108

Purdue University North Central
Dr. Keith Schwingendorf
Dean, College of Science
1401 S. US Hwy 421
Westville, IN 46391

University of Toledo
Dr. Mark Vonderembse
Director, Intermodal Transportation Institute
2801 W. Bancroft St.
Toledo, OH 43606

University of Wisconsin-Madison
Dr. Teresa Adams
Midwest Regional University Transportation Center
1415 Engineering Drive, Rm. 2250
Madison, WI 53706

On October 8, 2005, the first meeting for affiliate universities was held in Duluth, MN to review possible collaborations and discuss opportunities for synergistic partnerships. With this information, combined with the feedback from the GLMRI Advisory Board meeting, a research agenda was finalized for this grant. A long-term communication and marketing strategy was also considered to develop an outreach program.

The second meeting of the affiliate universities was held on October 7, 2006 in Duluth, MN. The principle investigators from the GLMRI research projects presented reports on the accomplishments made throughout this initial period.

Initial Research Focus: After the initial meeting of the Advisory Board in October 2005, the consortium co-directors finalized the research agenda for the initial research pursued under the Institute. A call for proposals was released to affiliate universities, and proposals were submitted for consideration within the time and fiscal constraints of the initial grant. The Call for Proposals highlighted the following areas for research focus:

- **Economics and development of the Great Lakes (GL) marine transportation system (MTS)**
  - New Markets
  - Concepts to expand GL ship repair and ship building
  - Removing or streamlining regulatory barriers to maritime commerce
  - The use of smaller (handy size vessels)
  - GL Passenger trade market studies

- **Economic Issues concerning Great Lakes port development**
  - Impacts of gentrification of the waterfronts
  - Impact of lock closure on the Soo

- **Security issues relative to the Great Lakes marine transportation system**
  - The use of Intelligent Transportation Systems to track cargo and ships
  - The establishment of a cost-effective Great Lakes MTS security training program

- **Inter-modal transportation opportunities for Great Lakes transportation systems**
  - Hub and spoke MTS system
  - MTS Routes to relieve road congestion
  - Intelligent transportation systems for seamless intermodal movements
  - Freight Corridors roads to facilitate overweight, oversize trucks linked to the MTS
  - Distribution centers linked to the GL MTS

- **Marine transportation and port environmental issues**
  - Addressing the future impact of the clean air bill on GL vessels
  - Issues in shipboard management of proposed ballast water treatment systems
  - Ballast water free ship designs for GL and foreign trade
  - Establishing a Green Ship programs on the Great Lakes

- **Marine transportation and port education**
  - K-12 GL MTS education programs
  - Maritime Commerce public education and outreach

Other topics under consideration: Port Security Training and Research, Tourism, Intelligent Marine Transportation Systems, International Oceans Commission, Winter Shipping and Port Access/Winter Navigation

Specific Project Awards to University Researchers and Other Cooperative Efforts:

After review of the proposals received through the two consortium universities and the Call for Proposals to the Affiliate Universities, the following projects were selected for award. In addition to the direct funded research, GLMRI provided support to several other projects as cooperative arrangements to on-going research projects from other centers and institutes. The research proposals submitted exceeded the available funds and a grant review process was used to select the proposals. Research reports are provided as tabs to this publication on each of the completed efforts. Reports still pending will be available on the GLMRI website upon their completion. www.glmri.org

1) Evaluate new vessel designs: Seaway-Sized Bulk Carrier Model for Hydrodynamic Optimization of Ballast-Free Ship Design. Led by University of Michigan. (Tab 1)

2) Expanding Regional Freight Information Resources for the Upper Midwest through the development of a maritime information data delivery system. Led by University of Toledo. (Tab 2)

3) Review of the tax systems and other economic barriers to maritime commerce impacting the Great Lakes. Led by University of Minnesota Duluth. (Tab 3)

4) Research of Bio-Diesel Fuel Alternatives for Maritime Applications. Led by University of Minnesota Duluth. (Tab 4)

5) Perform lake level and/or sediment studies. Led by University of Minnesota Duluth's Large Lakes Observatory, utilizing the Research Vessel, *R/V Blue Heron*. (Tab 5)

6) Providing a marine transportation and port education program for K-12 teachers. Led by Michigan Technological University. (Tab 6)

7) Evaluation of a Great Lakes Short Sea Shipping Routes: Thunder Bay, Ontario to the Twin Ports Freight/passenger Ferry (Led by University of University of Wisconsin-Superior) (Report pending)

8) Review Ballast Water Commercial Operations – Cooperative program with UW-S Lake Superior Research Institute and the Great Ships Initiative, Northeast Midwest Institute

9) Study the potential for capacity expansion of the Detroit-Windsor Truck Ferry: Participants University of Toledo, Detroit Windsor Truck Ferry, Global Insights, and Transport Canada (Report pending)

10) Review and examine policy issues and barriers related to making rail and maritime modes more competitive for short haul freight in the upper Midwest as part of the Upper Midwest Freight Corridor Study (Cooperative effort led by the MRUTC, UW-Madison)

Outreach Events, Presentations and Participation

- GLMRI Co-Directors and staff participated on behalf of GLMRI and/or have made presentations on the benefits of short-sea shipping and other research projects to various Great Lakes audiences

- March 2, 2005	The Co-Directors presented an orientation of the Institute to The Lake Superior Harbor Technical Advisory Committee. Duluth MN
- April 11&12, 2005	Dr. Stewart presented an update on GLMRI to the Journal of Commerce Domestic Maritime Conference. Hilton Head Island, SC
- April 17&18, 2005	Dr. Riehl and Carol Wolosz participated in the The James L. Oberstar Transportation Forum. Minneapolis, MN
- April 20, 2005	Carol Wolosz presented a program overview at the MN Sea Grant Advisory Board. Duluth, MN
- June 4, 2005	Ms. Doris Bautch, Director of the Great Lakes Region for the US Maritime Administration, formally presented the letter to the co-directors designating GLMRI as a National Maritime Enhancement Institute (NMEI) at a public ceremony. Duluth, MN
- July 9&12, 2005	Dr. Stewart presents at Ports and Waterways section of the Transportation Research Board Semi-Annual Meeting. Boston, MA
- July 7, 2005	Drs. Stewart and Riehl and Ms. Wolosz attended the The Great Lakes Regional Collaboration Summit I. Duluth, MN
- August 1, 2005	Congressman David Obey's Visit and Briefings, University of Wisconsin-Superior. Superior, WI
- August 5, 2005	Drs. Stewart and Riehl presented an overview of GLMRI to Center for Freshwater Research and Policy. Duluth, MN
- September 1, 2005	Dr. Stewart presents at the St. Lawrence Seaway Development Corporation H_20 Wood Products meeting. Duluth, MN
- September 8, 2005	Dr. Stewart at the Northern Networks Trade Conference. Duluth, MN
- September 15, 2005	Dr. Stewart presented at the Wisconsin Commercial Ports Annual Meeting. Bayfield, WI.
- September 20, 2005	Dr. Riehl met with the University of Minnesota, Center for Transportation Studies, director. Minneapolis, MN
- September 26, 2005	Dr. Stewart at the Midwest Regional University Transportation Center Meeting. Chicago, IL
- October 7, 2005	GLMRI Advisory Board meeting, Duluth, MN

- October 8, 2005	GLMRI Affiliate Universities Meeting and R/V Blue Heron Tour. Duluth, MN
- November 2, 2005	Marine Industry Sustainability Initiative Group
- November 14-15, 2005	Midwest Transportation Coalition – Freight Corridor Study Dr. Stewart presented. Milwaukee, WI
- November 17-18, 2005	Great Lakes Regional Waterways Management Forum. Dr. Stewart presented. Point Edward, Ontario
- December 16, 2005	Meeting with the Port Authority for Intermodal Plan for the Twin Ports. Dr. Stewart and Mr. Skurla attended. Duluth, MN
- December 29, 2005	Dr. Richard Stewart and Adolph Ojard, the Duluth Seaway Port Authority Director, did an interview with "Almanac North" on Great Lakes Shipping. "Almanac North" is a local television show run through the Public Broadcasting System (PBS). Duluth, MN
- January, 11, 2006	Dr. Stewart presented at he Wood Products Conference hosted by the University of Minnesota Duluth. Duluth, MN
- January 20, 2006	Dr. Stewart presented an update of GLMRI research projects at the American Great Lakes Ports Association annual meeting. Toronto, Canada
- January 22-25, 2006	Transportation Research Board. Dr. Stewart presented on at the Short Sea Shipping in the United States and Canada Session. Dr. Riehl and Carol Wolosz also attended the conference. Washington, D.C.
- January 27, 2006	Carol Wolosz participated in the Society for Naval Architects and Marine Engineers (SNAME) Winter Meeting, Perrysburg, OH
- March 8&9, 2006	Dr. Stewart gave a presentation on "What Great Lakes Maritime Environmental Course Should We Steer?" at Maritime Day. Cleveland, OH
- March 27&28, 2006	Dr. Stewart and Carol Wolosz participated in the Northeast Midwest Institute's planning meeting for the Great Ships Initiative demonstration project. Duluth, MN
- April 9&10, 2006	Dr. Stewart and Carol Wolosz attended The James L. Oberstar Forum on Transportation Policy and Technology. Minneapolis, MN
- April 25&26, 2006	Carol Wolosz participated in the Upper Midwest Freight Workshop. Columbus, OH
- May 17& 18, 2006	GLMRI co-sponsored The Great Lakes Maritime Academy's T/S State of Michigan for local education and outreach tours in the Twin Ports harbor. A reception and harbor tour were provided to local dignitaries on May 17th. The ship was open for community tours on both days of the visit. Duluth, MN

- May 19, 2006	Dr. Stewart was keynote speaker at Duluth-Superior Maritime Day Community Ceremony, "The Future of Great Lakes Maritime Commerce". Duluth, MN
- May 22, 2006	Dr. Stewart presented ideas and direction to the Taconite Aggregate Transportation Meeting Group at the Natural Resources Research Institute. Duluth, MN
- June 7, 2006	Dr. Stewart presented an update on the research projects at the Harbor Technical Advisory Committee. Superior, WI
- June 9, 2006	Drs. Stewart and Wang and Ms. Wolosz participated in the meeting of the Great Lakes Maritime Information Delivery System, a sponsored GLMRI research project. Detroit, MI
- June 27, 2006	Dr. Stewart presented on "Great Lakes Environmental Issues" at the Green Marine Conference. St. Catherines, Ontario
- June 28, 2006	Drs. Stewart and Riehl provided program updates to Congressman James L. Oberstar and staff members for Congressman David Obey. Washington, D.C.
- June 29, 2006	Drs. Stewart and Kwon and Ms. Wolosz provided program updates to members of US DOT, The Maritime Administration and the St. Lawrence Seaway Development Corporation. Washington, D.C.
- July 13, 2006	Dr. Stewart moderated a panel on Short Sea Shipping at Thor Fest. Duluth MN
- July 26&27, 2006	Dr. Kwon attended the Marine Transportation System National Advisory Council meeting. Norfolk, VA
- August 17&18	Ms. Wolosz participated in the Midcontinent Transportation Research Forum, hosted by the University of Wisconsin-Madison, with sponsorship from GLMRI. Madison, WI
- August 29, 2006	Dr. Stewart presented on Great Lakes Maritime Commerce to the TRB Committee on the St. Lawrence Seaway: Options to Eliminate Introduction of Non-indigenous Species into the Great Lakes, Phase II. Toronto, Canada
- October 3, 2006	Dr. Stewart provided an update on the GLMRI research projects to the Council of Great Lakes Research Centers. Duluth, MN
- October 4, 2006	Dr. Stewart provided an update on the GLMRI research projects to the Great Lakes Commission at their annual meeting. Duluth, MN
- October 6, 2006	The 2nd GLMRI Advisory Board meeting. Duluth, MN

- October 7, 2006 The 2nd GLMRI Affiliate Universities Meeting. Duluth, MN

- October 13, 2006 Dr. Stewart provided an update on the GLMRI research projects to the University Transportation Center meeting at the University of Wisconsin-Madison. Madison, WI

Extension Education and Outreach Support

GLMRI is developing an education and outreach program, tied with MN and WI Sea Grant. Mr. Dale Bergeron was hired in cooperation with MN Sea Grant to perform marketing and develop presentations to regional and governmental agencies. Ultimately, the goal of our outreach and educational efforts is to make sure information generated within the research community makes its way into the hands of those who need it, whether those individuals are industry experts, policy makers, or the citizens of the Great Lakes basin and beyond.

In its continuous effort to develop and improve economically and environmentally sustainable maritime commerce on the Great Lakes, GLMRI is not only supporting creative applied research, but is also working with existing organizations, like MN Sea Grant, to build new partnerships to promote constituent driven programs, and conduct educational activities that can effect both behavioral and economic change through local and regional, stakeholder focused programs. The primary goals are to continue to build and maintain significant relationships with constituent groups. A dedicated effort has been made to reach out for input, and to provide a neutral science-based resource for information.

Our outreach efforts are focused on providing constituents with access to university-based research and technologies to address specific technical and economic issues in relation to the optimization of maritime commerce in the Great Lakes. We will continue to use linkages to raise visibility, conduct conferences and workshops, present talks, design and produce educational and informational materials, raise awareness and work to change behaviors and improve creative public and private collaborations.

One of the key outreach methods is to present the research in academic and professional forums and journals. GLMRI funded research outcomes are being presented in 2007 at peer reviewed conferences and in journals.

Future Plan for GLMRI – Beyond this Grant:

In fiscal year 2006, $2,000,000 was appropriated in the U.S. Transportation Bill to support maritime research through GLMRI. In accordance with the intent of the Authorizing legislation, the 2006 US DOT Appropriations have been routed through MARAD to support the Great Lakes NMEI. The FY 07 amount has been initially spread over two years, providing $1 million per year with approximately $400,000 designated for affiliate university research projects

A call for proposals was released in April 2006 for the first year of projects, against this 2-year funding (Oct 2006 – Oct 2008). Eighteen proposals from the affiliated universities and the 2 host-universities were received requesting over $1.4 million. A review process that included outside reviewers from MARAD made the final selection. As of the final writing of this report the following projects have been awarded in support of the current research agenda:

- Testing Relationships between Propagule Pressure and Colonization Success of Invasive Species (University of Minnesota Duluth and the University of Wisconsin-Superior's Lake Superior Research Institute in cooperation with the Northeast Midwest Institute's Great Ships Initiative)

- Evaluating the impact of long term storage at low temperatures of Biodiesel fuel blends for consideration of use in marine vessels on the Great Lakes (University of Minnesota Duluth)

- Part II: Hydrodynamic optimization testing of the model built under the first grant for the ballast-free ship design (University of Michigan)

- Phase II of implementing the Great Lakes Maritime Information Delivery System (University of Toledo)

- A review of the Great Lakes shipbuilding and repair capability – Past, present and future (University of Michigan)

- Structure of Bacterial Communities Associated with Accelerated Corrosive Loss of Port Transportation Infrastructure (University of Minnesota Duluth)

- A multibeam bathymetry and sidescan-sonar survey of the Duluth-Superior Harbor and nearshore (University of Minnesota Duluth)

- Continued support from Minnesota Sea Grant for extension education and outreach projects

- Year 2 of a marine transportation and port education program for K-12 teachers (Michigan Technological University)

The Institute is becoming recognized in the area for leadership and its research capabilities. In its short existence, GLMRI has become an independent source for business studies as an "honest broker". The Institute is evolving a permanent relationship with DOT and the Maritime Administration to maximize continued funding in support of maritime research on the Great Lakes through the National Maritime Enhancement Institute. During the next two years GLMRI will continue: outreach to stakeholders, hold advisory and affiliate university meetings, and collaborate with MARAD and other relevant government agencies and stakeholder in supporting GLMRI's mission.

Seaway-Sized Bulk Carrier Model for Hydrodynamic Optimization of Ballast-Free Ship Design

Prof. Michael G. Parsons Department of Naval Architecture and Marine Engineering
2600 Draper Road
University of Michigan
Ann Arbor, MI 48109

Prof. Miltiadis Kotinis Engineering Department, Office 2-39
SUNY Maritime College
6 Pennyfield Avenue
Throggs Neck, NY 10465

October 2, 2006

Department of Naval Architecture and Marine Engineering
University of Michigan
Ann Arbor, MI 48109-2145

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Research funded in part by the Great Lakes Maritime Research Institute

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1. Introduction

The Ballast-Free Ship Concept has been recently invented [US Patent #6694908 2004] and investigated [Kotinis et al. 2004, Kotinis 2005, *Ballast Water News* 2004] at the University of Michigan. Even though the feasibility of the concept was demonstrated, the aforementioned analysis was limited by its required comprehensive research scope and associated budget. Thus, it was only feasible to support model testing that utilized an existing model. Although the vessel type of greatest interest for the Great Lakes nonindigenous aquatic species introduction problem is the Seaway-sized bulk carrier, the best available model was of a relatively finer, higher-speed barge-carrying Lighter Aboard Ship (LASH) vessel. This existing model was modified to utilize a more conventional stern, but the model test results were not directly applicable to the Seaway-sized bulk carriers studied in detail in the rest of the research effort.

The current research focuses on the design of a typical Seaway-sized bulk carrier and the construction of a scaled model to be utilized in subsequent towing tank experiments. This model has already been procured and is expected to be delivered to the University of Michigan at the end of October, 2006.

A major part of the initial hydrodynamic analysis that was performed on the modified LASH vessel was based on the ship-specific Computational Fluid Dynamics (CFD) code SHIPFLOW® [Flowtech Int. 1998], which has been shown to have significant limitations regarding the prediction of the important viscous flow near the stern.

In the current research, the external flow around the Ballast-Free bulk carrier has been investigated numerically using FLUENT® [Fluent 2005]. These external flow results have been utilized to obtain the necessary boundary conditions for numerical simulation (also in FLUENT®) of the water flow in the longitudinal ballast trunks. The internal flow was simulated in order to estimate the flow rate scaling factor needed in preparation for the subsequent towing tank experiments.

In the next stage of this research, the model will be utilized for towing tank experiments in order to study, in more detail, the hydrodynamic impact of the Ballast-Free Ship Concept. The experimental and numerical hydrodynamic investigation, combined with an optimization procedure, is expected to lead to a design solution that could offer a net savings in Required Freight Rate (RFR) relative to alternate ballast water treatment methods and approaches. The numerical solution will be refined and validated through the scale model testing.

2. Background

The initial Sea Grant supported development of the Ballast-Free Ship Concept was reported in a paper before the Annual Meeting of the Society of Naval Architects and Marine Engineers in Washington, DC, on October 2004 [Kotinis et al. 2004]. Overall, the investigation of the Ballast-Free Ship Concept has shown that it provides a viable alternative to the addition of costly ballast water treatment systems in order to meet the evolving performance requirements for ballast water treatment. The concept essentially eliminates the transport of foreign ballast water. This should be more effective than current treatment methods in reducing the potential for the further introduction of nonindigenous aquatic species into the Great Lakes and coastal waters. Furthermore, it should be equally effective as international requirements extend below the 50 micron range [IMO 2004].

The traditional approach to ballast operations, since the introduction of steam machinery, has been the use of water ballast to increase the weight of the vessel in the light cargo condition. A paradigm shift in thinking would be to view the ballast condition as a change of buoyancy rather than an addition of weight in order to get the vessel to its safe ballast drafts. Such a shift in thinking led to the invention of the Ballast-Free Ship Concept [US Patent #6694908 2004].

In this concept, the traditional ballast tanks are replaced by longitudinal, structural ballast trunks that extend beneath the cargo region of the ship below the ballast draft. The arrangement of an equal capacity conventional Seaway-size bulk carrier is shown on the left in Fig. 2.1; the arrangement of a Ballast-Free Ship Concept Seaway-size bulk carrier is shown for comparison on the right. In this example, the three ballast trunks per side are connected to the sea through a plenum at the bow and a second plenum at the stern. Typical trunk and plenum arrangements at the bow and stern of the vessel are illustrated in Fig. 2.2 and 2.3, respectively. These trunks are flooded with seawater to reduce the buoyancy of the vessel in the ballast condition in order to get the vessel down to its ballast drafts. Since there is a natural hydrodynamic pressure differential created between the bow region and the stern region of a ship due to its motion through the water, a slow flow is induced in these open ballast trunks. This ensures that the ballast trunks are always filled with slowly-moving "local seawater." This will essentially ensure that there is no transport nonindigenous aquatic species across the globe. Therefore, the vessel becomes foreign "ballast-free" from the traditional viewpoint.

When the ballast voyage is completed, the ballast trunks can be isolated from the sea by valves and then pumped dry using conventional ballast pumps. The need for costly ballast water treatment equipment or ballast water treatment chemicals would, thus, be eliminated. This approach would also be equally effective for biota smaller than 50 microns. During the full load condition or any condition where ballast is not necessary, the double bottom ballast trunks can be segregated utilizing sluice gate valves. This is needed to provide the vessel adequate damage survivability.

In order to provide adequate intact stability, equivalent damage survivability, equivalent cargo capacity, etc., the entire vessel design needs to be developed to support this concept of ballast operations as illustrated in Fig. 2.1. The ship requires a higher tank top in order to locate enough ballast trunk volume below the ballast draft and requires a greater hull depth in order to

maintain the vessel's capacity to carry light cargos, such as grain. The Ballast-Free Ship Concept also includes features to minimize the buildup of sediment within the ballast trunks and facilitate their required cleaning; i.e., easier to clean 2.4 m high ballast trunks, elimination of the lower part of the floors next to the shell, etc.

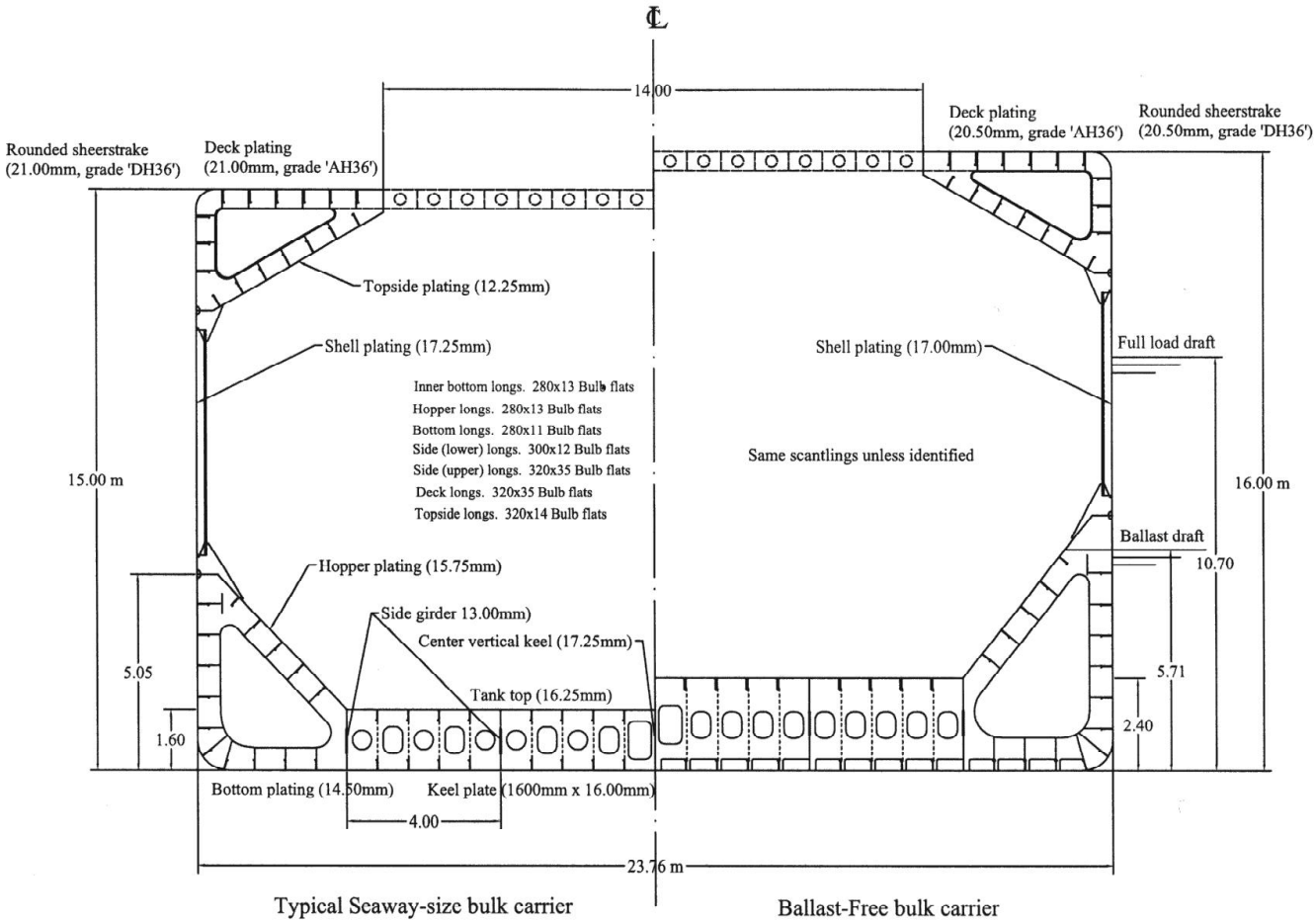

Figure 2.1: Typical Seaway-size Bulk Carrier (left) and Ballast-Free Concept Bulk Carrier (right)

As noted, the recent Sea Grant sponsored research on the development of the Ballast-Free Ship Concept was limited by its required comprehensive research scope and associated budget. For budgetary reasons, it was only feasible to support model testing that utilized an existing model. Although the vessel type of greatest interest for the Great Lakes nonindigenous aquatic species introduction problem is the Seaway-size bulk carrier, the best available model was of a relatively finer, higher-speed barge-carrying Lighter Aboard Ship (LASH) vessel. This existing model was modified to utilize a more conventional stern, but the model test results were not directly applicable to the Seaway-size bulk carriers studied in detail in the rest of the research effort.

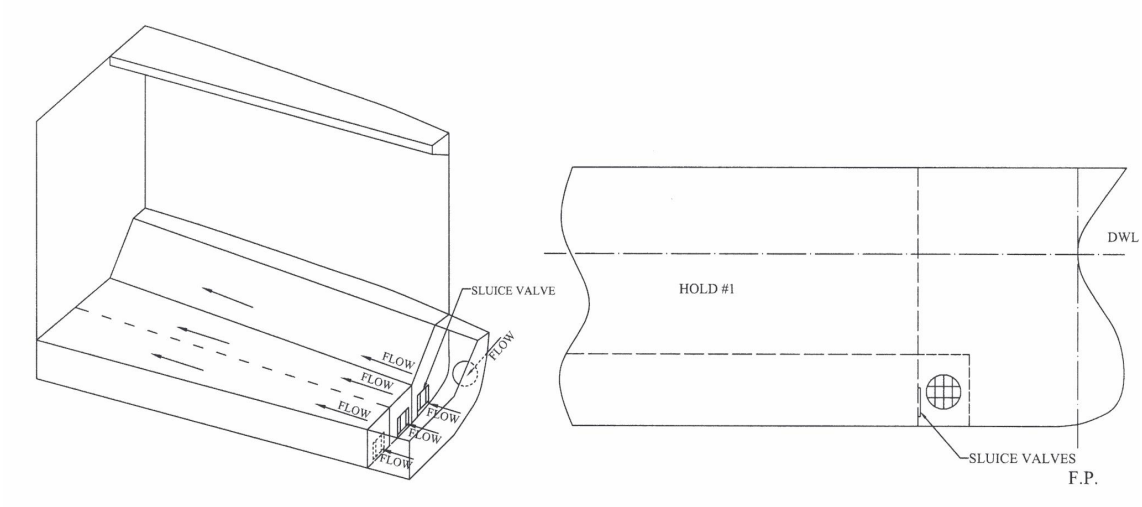

Figure 2.2: Typical Forward Plenum and Collision Bulkhead Arrangement

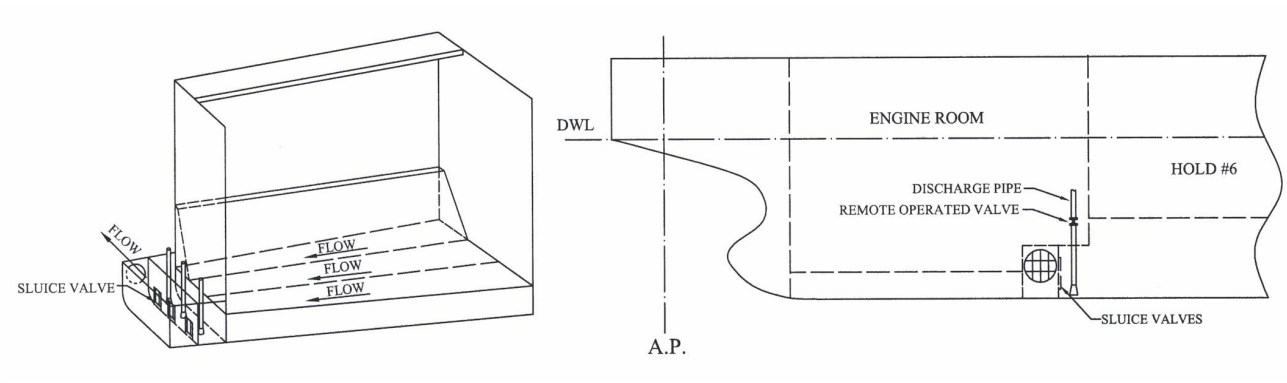

Figure 2.3: Typical Aft Plenum Arrangement

Budget restrictions in the initial investigation phase also required that the model tests be limited to a <u>single system design</u> for a single existing model. There was no opportunity to optimize the hydrodynamic design of the system to minimize the economic impact of the Ballast-Free Ship Concept design. Model tests and CFD simulations using a modified LASH vessel hull showed that the specific ballast intake and discharge locations and method tested in the initial investigation resulted in a modest 2.2% increase in resistance but a more significant 7.4% increase in the required propulsion power. This specific result assumed a change in the ballast water within the ballast trunks once every two hours, which would meet the environmental intent of the Ballast-Free Ship Concept. The large power increase could result in an undesirable engine size increase and would result in fuel cost penalties. In that investigation, it was concluded that further hydrodynamic optimization could eliminate most, if not all, of this significant added power requirement.

3. General Description of Design Procedure

A typical Seaway-sized bulk carrier was designed using data from similar vessels. The prototype vessels were the *Isa* bulk carrier owned by the Polish Steamship Company (PZM Polsteam) as shown in Figure 3.1 and a recent bulk carrier class designed by the Jiangnan shipyard in China.

Figure 3.1: Polsteam Seaway-sized Bulk Carrier *Isa*

The vessel hydrostatic data match the data of typical bulk carriers of the same size. The service speed was assumed to be 14.5 knots, which results in a Froude number of 0.175. The speed of the vessel when in ballast draft was assumed to be 15.5 knots, which results in a Froude number of 0.185. The stern region was designed to accommodate specific propeller-hull clearances. For this purpose, the Det Nordske Veritas (DNV) requirements were utilized. The main particulars of the Ballast-Free Bulk Carrier are presented in Table 3.1.

The model testing of interest will be performed with the vessel at the ballast draft. A conservative heavy weather ballast draft corresponds to a value of 40% of the summer load line at the forward perpendicular and 70% at the aft perpendicular. These values were utilized in the current study. The vessel particulars at this ballast condition are listed in Table 3.2.

Table 3.1: Ballast-Free Bulk Carrier Main Particulars

Waterline length (m)	195.5
Length between perpendiculars (m)	192.0
Maximum beam (m)	23.76
Depth to main deck (m)	16.0
Full-load draft (m)	10.70
Block coefficient	0.835
Prismatic coefficient	0.837
Waterplane area coefficient	0.909
Midship section coefficient	0.998
Full-load displacement (metric tons)	42,546
Wetted surface area (m^2)	7673

Table 3.2: Ballast-Free Bulk Carrier Ballast Condition

Waterline length (m)	189.5
Maximum beam (m)	23.76
Draft at F.P. (m)	4.28
Draft at A.P. (m)	7.49
Speed (knots)	15.5
Reynolds number (fresh water)	$1.35*10^9$

The hull of the Ballast-Free Bulk Carrier has been designed in Maxsurf [Formation Design Systems 2003]. The vessel lines are illustrated in Figures 3.2 through 3.4.

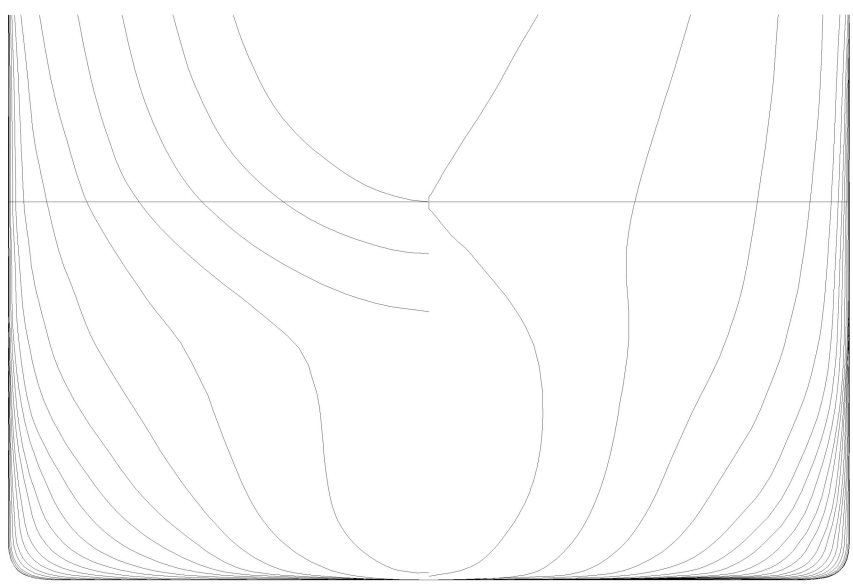

Figure 3.2: Ballast-Free Bulk Carrier Body Plan

Figure 3.3: Ballast-Free Bulk Carrier Profile View

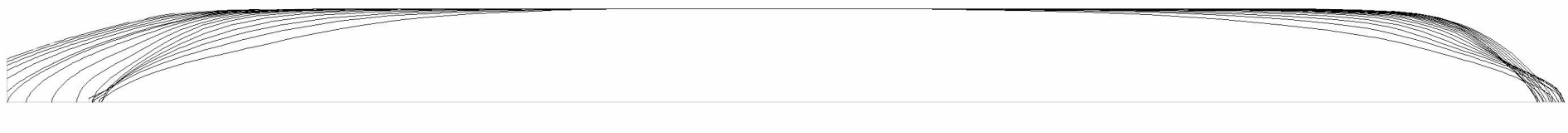

Figure 3.4: Ballast-Free Bulk Carrier Plan View

4. Model Construction Constraints

The construction of a ship model to be tested in a towing tank needs to comply with certain requirements that stem from the experimental procedure and the available testing equipment. The models tests will be performed at the towing tank of the University of Michigan Marine Hydrodynamic Laboratory (MHL). The towing tank dimensions are shown in Table 4.1.

Table 4.1: MHL Towing Tank Dimensions

Length (m)	109.7
Width (m)	6.70
Depth (m)	3.20
Tank cross-sectional area (m^2)	21.44

A significant constraint in the experimental procedure is the interference between the side walls and bottom of the tank and the pressure field and wave system generated by the motion of the model. This is usually termed "blockage effect" and results in total resistance measurement errors (artificial increase). A general guideline is that the model cross-sectional area be at most 1/200 of the tank cross-sectional area (in terms of the tank beam and water depth). Nevertheless, if the operating Froude number is relatively low (less than 0.20), the wave resistance is not a large proportion of the total resistance, and thus correction factors can be introduced in the calculation procedure when large models are utilized.

If the vessel under investigation normally operates in deep water, a similar situation needs to be simulated in the towing tank experiments. Operation in shallow water is generally considered to increase the resistance. A general guideline is that the ratio of the square root of the model cross-sectional area over the tank water depth should not exceed a value of 0.25.

5. Model Propeller Selection and Geometric Scale Factor

A very significant parameter in determining the geometric scale factor of the model is the size of the available stock propellers. Two propellers from the MHL stock (No.10 and No.23) were investigated during the propulsion analysis. The thrust requirements were based on Holtrop's resistance and propulsive coefficients estimates [Holtrop 1984]. The total resistance of the Ballast-Free bulk carrier at the full-load condition was estimated at 573 kN. The propulsive coefficients were also estimated using Holtrop's empirical formulas. These were utilized as input to the propeller analysis.

The corresponding non-dimensional thrust and torque versus coefficient of advance (Kt, Kq – J) charts of the propellers were utilized for the analysis. The results showed that the model propeller No.23 provides a higher propulsive efficiency (0.55) assuming a full-scale propeller diameter of 6.0 m. The corresponding value of the geometric scale ratio is $\lambda = 37.92$, which is within the acceptable range, based on the design constraints. This will result in a model waterline length of approximately 5 m. The amount of back cavitation is expected to be well below the upper limit for merchant ships. A summary of the stock propeller No. 23 characteristics is presented in Table 5.1. The model characteristics are demonstrated in Table 5.2.

Table 5.1: MHL No. 23 Stock Propeller Characteristics

Diameter (in.)	6.229
Pitch/Diameter (P/D) ratio	1.08
Number of blades	4
Expanded area ratio (A_E/A_O)	0.55
Hub diameter (in.)	1.226
Hub length (in.)	1.355
Material	Brass

Table 5.2: Ballast-Free Bulk Carrier Model Characteristics

Geometric scale factor λ	37.92
Waterline length (m)	5.00
Maximum beam (m)	0.627
Average draft (m)	0.155
F.P. draft (40% F.L.)	0.113
A.P. draft (70% F.L.)	0.198
Wetted surface area (m^2)	5.34
Speed (m/s)	1.295
Reynolds number (fresh water)	$5.78*10^6$

The extent of laminar flow along the model length that corresponds to the aforementioned scale factor value and model speed is 9% (of the model length). The attachment of trip-wires or sand-strips to the model bow will be used to stimulate turbulence at a point closer to the forward stagnation point as expected at full scale.

6. Computational Fluid Dynamics (CFD) Analysis of the External Flow

The commercial CFD code FLUENT® was utilized to study the external flow around the model of the Ballast-Free Bulk Carrier in the ballast condition. The model scale speed is 1.295 m/s, which is calculated assuming Froude scaling. The obtained solution has been demonstrated to be grid–independent. The Realizable κ-ε turbulence model was utilized in the calculations. The flow close to the hull was approximated with wall functions. The computational grid consists of a hybrid mesh with 1,507,546 cells. The investigated flow corresponds to a double-model solution; the free-surface is ignored and the waterplane is considered to be a plane of symmetry.

The converged CFD solution can be utilized to obtain the hull resistance, which consists of the friction drag and the pressure (form) drag for this configuration. The friction drag around a ship hull is usually estimated through a semi-empirical formula adopted by the International Towing Tank Conference (ITTC). The computed value is extremely close to the semi-empirical one. The form drag corresponds to only a small fraction of the total drag. The utilization of a double-model flow allows for the computation of the form factor, which is calculated as the ratio of the total drag (excluding the wave drag) to the ITTC friction drag estimate. The computed value is reasonable for the ship in the ballast condition. A summary of the results is presented in Table 6.1.

Table 6.1: Ballast-Free Bulk Carrier Model Resistance Calculations

Friction drag coefficient (FLUENT)	$3.32*10^{-3}$
Friction drag coefficient (ITTC)	$3.31*10^{-3}$
Pressure (form) drag coefficient (FLUENT)	$0.45*10^{-3}$
Total drag coefficient (FLUENT)	$3.77*10^{-3}$
Form factor k	0.139

An important aspect of the Ballast-Free Ship Concept is the location of the water inlet and discharge plena. The steady pressure differential between the two locations will generate a slow water flow in the longitudinal ballast trunks. The volume flow rate is proportional to the square root of the pressure differential. It was demonstrated [Kotinis 2005] that the higher the flow rate the more effective (less time required) the flushing of the trunks. The computed pressure contours in the bow and stern region of the Ballast-Free Bulk Carrier are shown in Figs. 6.1 and 6.2, respectively.

The pressure contours in the bow region reveal that the pressure is high in a small region near the bulbous bow. However, starting at the forward perpendicular, the flow is relatively smooth with low pressure and pressure gradient values. This is also observed in Fig. 6.3, where the velocity vectors in the bow region are plotted. The downward flow direction reduces the height of the bow wave. The only significant drawback is with respect to the location of the bow plenum, as the positive pressure is limited to a small area starting at the stagnation point and extending aft to about 6% of the waterline length.

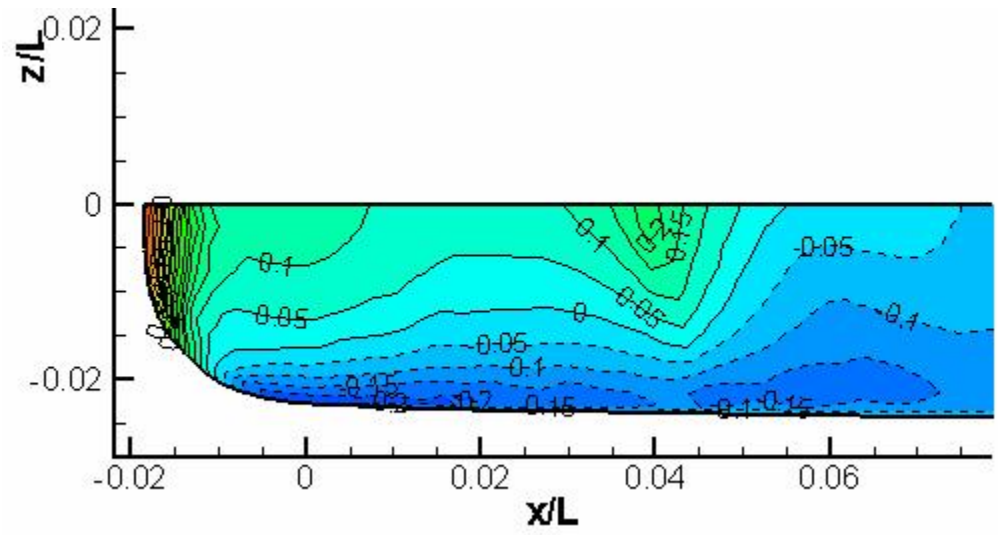

Figure 6.1: Pressure Contours Velocity Vectors at the Bow of the Ballast-Free Bulk Carrier Model

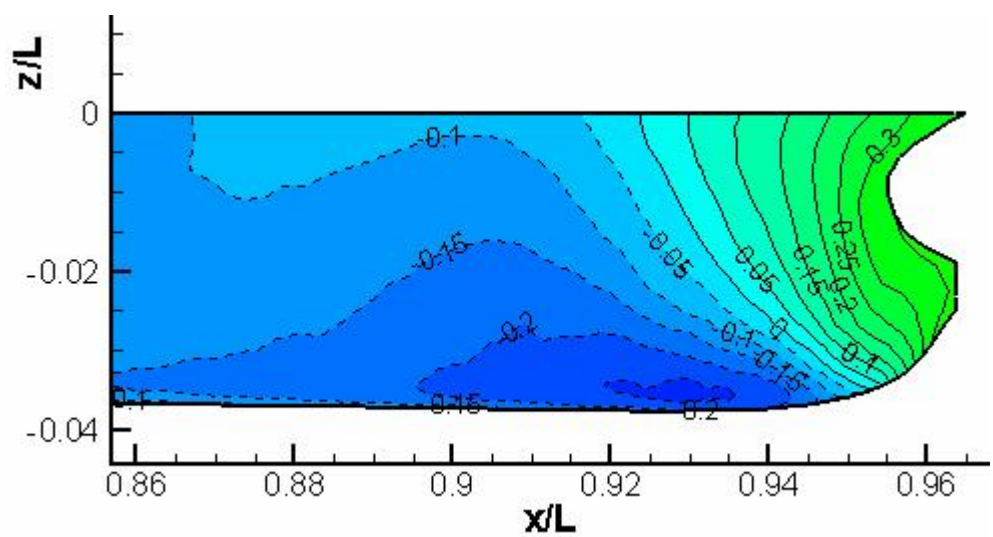

Figure 6.2: Pressure Contours at the Stern of the Ballast-Free Bulk Carrier Model

The stern region is governed by suction pressure, which has a peak near the bilge just ahead of the stern bulb. A significant positive pressure region exists above the stern bulb. No separation is observed in the velocity vector plot in Fig. 6.4. The location of the stern plenum will be close to the aft end of the engine room (around x/L = 0.92) and above the inner bottom (2.4 m from the keel).

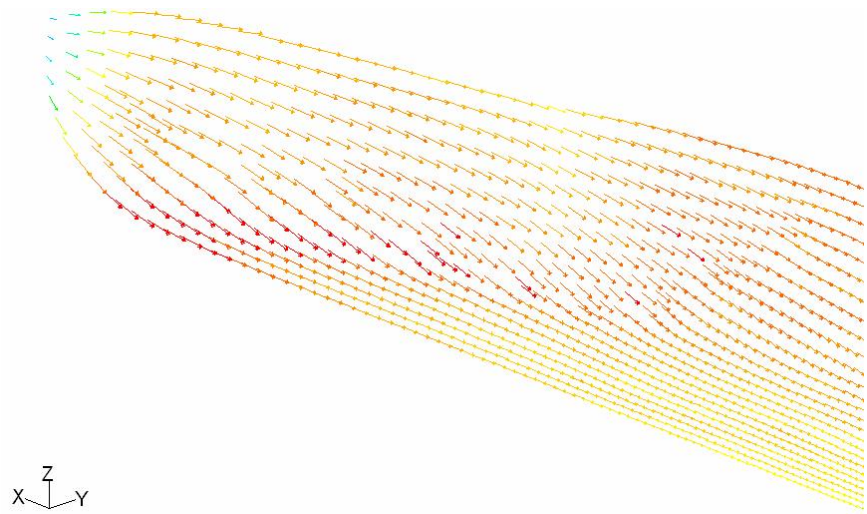

Figure 6.3: Velocity Vectors at the Bow of the Ballast-Free Bulk Carrier Model

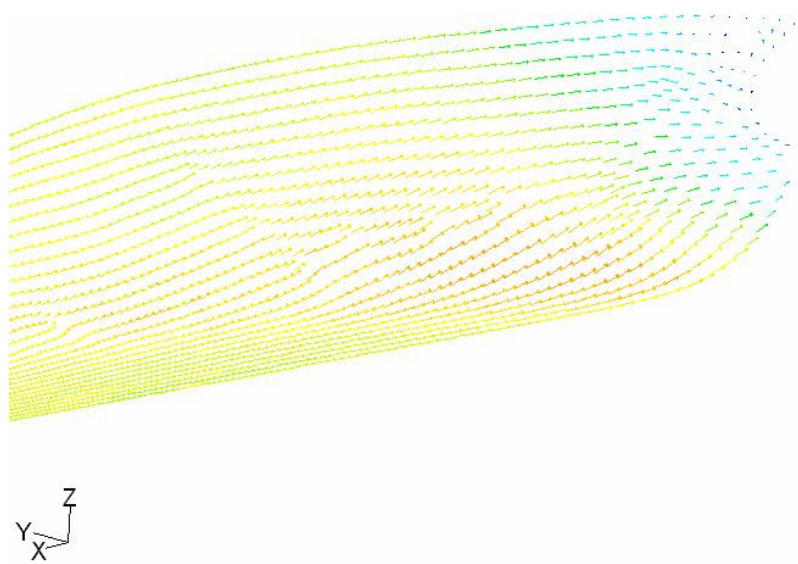

Figure 6.4: Velocity Vectors at the Stern of the Ballast-Free Bulk Carrier Model

7. Computational Fluid Dynamics (CFD) Analysis of the Internal Ballast Trunk Flow

The internal trunk flow was investigated in both full and model scale. A typical trunk configuration [Kotinis 2005] was generated and the corresponding pressure boundary conditions, as calculated from the external flow simulations, were imposed on the inlet/outlet plena. The forward plenum was located at a point about x/L = 0.04 between the 0.2 and 0.35 design waterlines. The aft plenum was located at a point near x/L = 0.925 between the 0.3 and 0.45 design waterlines.

The pressure distribution was assumed to be the same in both full and model scale. This assumption is justified by the fact that the Reynolds number is relatively high in both cases and the body at ballast draft is relatively streamlined (low form drag). The computational grid consists of a hybrid mesh with 705,915 cells. The trunks were assumed to be filled with ballast water and the natural trunk flushing was initiated by new ballast water entering the system through the inlet plenum. The volume flow rate at the inlet and outlet plena was monitored until convergence to a constant value was observed. The unsteady flow solver in FLUENT was utilized with a time step size of one second (1s). The solution at each time step was considered to have converged when the residuals dropped by four orders of magnitude. The computational model geometry of the double bottom structure is shown in Fig. 7.1.

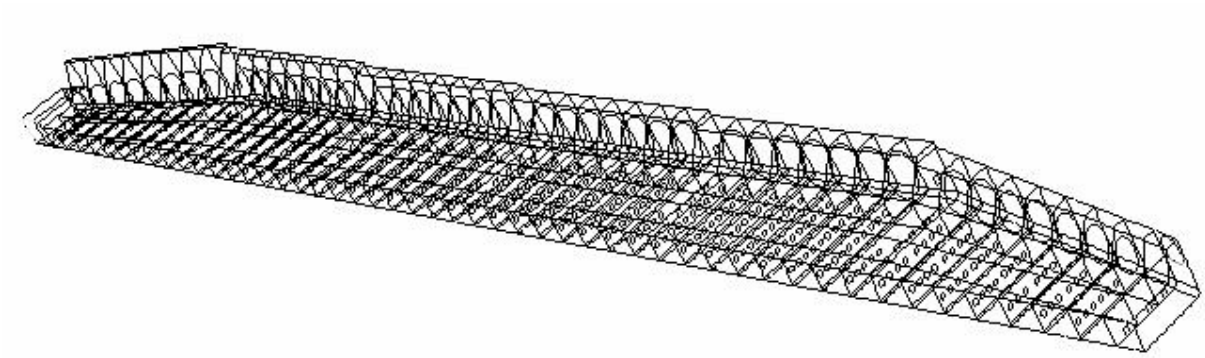

Figure 7.1: Computational Model Geometry of Double Bottom Structure

The average volume flow rate at full scale is 0.969 m^3/s. The model scale solution has an average flow rate of $1.02*10^{-4}$ m^3/s. The corresponding ratio is approximately 9,500. This result is in agreement with the scaling factor between the ship scale flow rate and the model scale flow rate, $Q_s = Q_m \lambda^{5/2}$, theoretically derived in the initial investigation of the Ballast-Free Ship Concept based on Froude scaling. This scaling assumed that the flow rate scaling should be proportional to the scale factor λ raised to the 2.5 power. The corresponding exponent of the geometric scaling factor based on the numerical CFD results was approximately 2.52.

8. Model Construction

The model of the Seaway-Sized Bulk Carrier for use in subsequent hydrodynamic optimization testing has been contracted for construction by F.M. Pattern Works of North Vancouver, BC. This is the primary deliverable of the project and its procurement represents approximately half of the project funding. The model is under construction at the time of this writing and delivery of the completed 5 m scale model is expected near the end of October 2006. Progress photographs of the glue up of the aft portion of the hull are shown in Figs. 8.1 and 8.2.

Figure 8.1: Aft Portion of the Scale Model Seaway-Sized Bulk Carrier – Inverted Stern Quarter View

Figure 8.2: Aft Portion of the Scale Model Seaway-sized Bulk Carrier – Inverted Side View

9. Potential Economic Impacts of the Research Results

The hydrodynamic optimization of the Ballast-Free Ship Concept is expected to demonstrate that there is only a small, if any; propulsion power penalty associated with the concept. In that case, it should result in a net Required Freight Rate savings relative to alternate ballast water treatment methods such as filtration and UV treatment of about 0.20 $/ton of cargo. The concept should also provide superior protection from the further introduction of nonindigenous aquatic species into the Great Lakes and coastal waters.

10. References

Ballast Water News (2004) "The Ballast-Free Ship - Fact or Fancy?" *Ballast Water News*, Global Ballast Water Management Program, IMO, **17**, April-June.

Flowtech International AB (1998) "SHIPFLOW 2.4 User's Manual."

Fluent (2005) "FLUENT 6.2 User's Manual," Fluent Inc., Lebanon, NH.

Formation Design Systems Pty (2003) "MAXSURF Windows Version 9.6 User's Manual."

Holtrop, J. (1984) "A Statistical Re-Analysis of Resistance and Propulsion Data," *International Shipbuilding Progress*, **31**-363, November.

IMO (2004) "International Convention for the Control and Management of Ships' Ballast Water & Sediments," Diplomatic Conference, February, London.

Kotinis, M., Parsons, M. G., Lamb, T. and Sirviente, A. (2004) "Development and Investigation of the Ballast-Free Ship Concept" *Transactions* SNAME, **112**, pp. 206-240.

Kotinis, M. (2005) "Development and Investigation of the Ballast-Free Ship Concept" Ph.D. Dissertation, University of Michigan, Department of Naval Architecture and Marine Engineering.

U. S. Patent #6694908 (2004) "Ballast Free Ship System," U. S. Patent and Trademark Office, Washington, DC.

Expanding Regional Freight Information Resources for the Upper Midwest: The Great Lakes Maritime Information Delivery System

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September 29, 2006

Great Lakes Maritime Research Institute
A University of Wisconsin - Superior and University of Minnesota Duluth Consortium

Research funded in part by the Great Lakes Maritime Research Institute

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Expanding Regional Freight Information Resources for the Upper Midwest: The Great Lakes Maritime Information Delivery System

Executive Summary

This project marked the beginning of a long-term endeavor to develop and manage a comprehensive data repository and information clearinghouse for the maritime industry in the Great Lakes. The system is envisioned to facilitate the acquisition, storage, management, analysis and exchange of data between analysts and decisionmakers within the industry. This system will thus serve as a resource for public policy decisions and for drawing the necessary link between maritime freight movements, economic viability, and environmental quality throughout the Great Lakes and St. Lawrence Seaway. As such, the system will serve as a central focus for diverse interests within the industry to support the promotion of sustainable maritime transportation in the region.

This project was originally proposed to focus on expanding an existing detailed GIS-based multimodal regional freight data reporting system named ***Midwest FreightView*** (MWFV). However, this approach was modified significantly over the course of the project based on interactions with representatives of the maritime industry in the Great Lakes Region. Stakeholders in the region attending the June 9 Great Lakes Data Workshop in Detroit rejected MWFV as the only component of the information delivery system in favor of a more diversified approach that incorporated web-based dissemination of prepared information in the form of maps, reports, tables and graphics. While the core of the data repository would still reside in the comprehensive MWFV GIS, the main user interface and information delivery system would be located on a more "user friendly" web page. The project team thus responded by amending the design of the system to meet the needs of our partners in the industry and will be unveiling the new web page for the system in November, 2006.

The main objective originally envisioned for MWFV was to generate and maintain a long-term database and data distribution system that would be available for state transportation agencies, regional planning agencies, port authorities and economic development organizations, as well as other interested decisionmakers and stakeholders within the region. This objective still remains as an important component of the work completed in the first phase of this project. Much of the data acquired in the first phase of this project came from existing sources—both commercial and government. The data are currently being stored on designated server space in the central repository at the GISAG Center at The University of Toledo and are undergoing incorporation into MWFV. Specific data assembled into this centralized data repository currently include the following:

1. Intrastate Employment patterns for each commodity type by SIC, NAICS, (Demographics Plus, Inc. *Business Counts Database*);
2. Population and Socioeconomic data representing Market Demand within the region
3. Port Locations—U.S. (BTS National Transportation Atlas);
4. Dock Locations (Army Corps of Engineers) and attributes:
5. Waterway Network—Great Lakes and Inland Waterways (Army Corps of Engineers)

6. Port Operations Data such as Tonnages, Commodities transshipped (Lake Carriers Assn.), Vessels Serviced, Equipment, *etc*.
7. Baseline 2002 commodity flows through the Saint Lawrence Seaway and Great Lakes System obtained from the FHWA Freight Analysis Framework estimated from 2002 Commodity Flow Survey Data. This data set provided the research team with a skeleton framework upon which to add subsequent flow data.

Other data dealing with dock locations and related operational attributes were manually entered into the database. This process was the most labor intensive and time consuming of the data assembly tasks. Most of this information has been compiled for docks on the American side of the Great Lakes. The corresponding information for the Canadian side of the Great Lakes is in its final stages of compilation. Dock identification codes were standardized within the database and documented.

The data listed above will reside in the data reporting system built on a ***Citrix Metraframe*** installation. Currently a specialized ***ArcView GIS*** application provides the user interface. Users can access MWFV with a web browser and Internet connection; all operations are carried out on the Toledo Server—the user's computers simply act as a terminal. The site is thus able to accommodate a wide range of users that extends between casual browsers and "basic mappers" to more experience GIS and database users.

The most recent activities undertaken have been to start compiling information on the various types of commodities transported on the Great Lakes, with an emphasis on observing the origins and destinations of these commodities, flow routes, tonnages, *etc*. In addition, the project team will investigate the acquisition of AIS data to track vessel movements. Implementation of this technology will be actively pursued in the next phase of the project.

In addition to the data assembly operations, the project team set about to design a more generalized information delivery system following our discussions with industry representatives at the June 9 Great Lakes Maritime Data Workshop in Detroit. Workshop participants readily agreed that the data delivery system must serve as an accurate, current, comprehensive and user-driven data resource that will be used to inform public policy decisionmakers as to the value and utility of the Great Lakes Maritime Transportation System (GL MTS). Of particular importance in reporting to public officials are:

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

Workshop participants discussed additional data needs for regional stakeholders that require data to facilitate projections and forecasts for freight movements under alternative scenarios involving alternative modes or intermodal movements. Regulatory impacts were also emphasized in the discussion along with improved coordination of public investments over the entire system to benefit all stakeholders within the region despite their location or jurisdiction.

Workshop participants also effectively argued that any system that requires a significant amount of training and practice would not be used as heavily as a more "user friendly" system consisting of prepared graphs, maps, bullet points, tables, and other features such as prepackaged reports in basic standard formats such as Annual Reports, Executive Summaries, and reports of studies completed by analysts who used data from the repository. The project team responded to this point by proposing to develop a system that offers a variety of products and functions among varying degrees of expertise required by users. These include:

- A detailed data repository for vessel movements, port functions, commodity flows, economic activities and environmental impacts, etc.
- A GIS data viewer for advanced users to view and analyze a variety of data
- An information delivery site for maps, tables, graphics, text and other features
- A data exchange to support user inquiries and furnish information on demand.
- Assemble data and report information among different Geographic areas of impacts and jurisdictions (*e.g.*, states and provinces, congressional districts, cities, counties, ports, *etc.*)
- Establish a communication link within the system (*e.g.*, email access) for regional stakeholders to request specific information to be posted on the site. This function was agreed upon as essential if the information delivery was to be successful
- Establish a system for data exchange to analysts in maritime industry agencies and organizations; also develop a site in the system for analysts within the region to publish the results of their analysis—particularly with regard to public policy issues of interest to the Great Lakes Maritime Industry
- Begin to develop a library function in the form of a data clearinghouse that reviews and summarizes data from diverse sources--both public and commercial--and provide links for users to branch to from the site. The result of which is to provide the Great Lakes Maritime Industry with a comprehensive centralized resource for data and information. An example of such a link would be for taxes, fees, and other costs; however, this component would not represent a core function of the data resource. It was further suggested that the site become a gateway to maritime agencies (*e.g.*, Coast Guard, USACE, *etc.*)

All of these functions have been adopted into the design of the prototype information delivery site to be opened in November, 2006.

One of the objectives of this project that was discussed at the June 9 meeting concerns the long-term viability of this information delivery resource. Eventually this data repository and delivery system must be able to sustain itself financially as other members of the maritime industry in this region. To this end, the project team has begun to explore the establishment of a ***Great Lakes Maritime Exchange*** (GLMX) in the form of a non-profit ***501(c)(6)*** organization that would be financed through subscription fees by its partners in the industry. This exchange could partner with MISNA (Maritime Information Services of North America), an umbrella organization of maritime exchanges in the United States and British Columbia. The principal investigator on the project team was invited to the MISNA National Meeting in Portland, Oregon in September, 2006 to gather more information on maritime exchange activities in North America. This approach shows significant promise.

The vision for the Great Lakes Maritime Information Delivery System Project evolved over the course of the project to produce a multidimensional system that will support a wider array of functions that include data storage, delivery of prepared documents, GIS functionality, and a clearinghouse for information over the entire industry. The project team will solicit feedback and suggestions for continuous improvement of the information delivery system; communication with the industry will be a major objective as this resource evolves in the coming years.

Expanding Regional Freight Information Resources for the Upper Midwest: The Great Lakes Maritime Information Delivery System

Introduction

This project marked the beginning of a long-term endeavor to develop and manage a comprehensive data repository and information clearinghouse for the maritime industry in the Great Lakes. The system is envisioned to facilitate the acquisition, storage, management, analysis and exchange of data between analysts and decision makers within the industry. This system will thus serve as a resource for public policy decisions and for drawing the necessary linkages between maritime freight movements, economic viability, and environmental quality throughout the Great Lakes and St. Lawrence Seaway. As such, the system will serve as a central focus for diverse interests within the industry to support the promotion of sustainable maritime transportation in the region.

This project was originally proposed to focus on expanding an existing detailed multimodal regional freight data reporting system named ***Midwest FreightView*** (MWFV) by incorporating maritime transportation data. It was argued that significant increases in highway freight traffic volumes have produced increasing pressures on this system, resulting in the necessity to examine every transportation alternative to relieve this pressure--especially by maritime transportation. This system would also serve as an effective tool for evaluating intermodal transportation opportunities in the Great Lakes Region; it can be used to model flows between modes to improve the flow of commodities within the region and to minimize environmental impacts. Finally, it was envisioned that expanding MWFV would enable stakeholders in the region to relate maritime traffic flows to the regional economy of the Midwest and adjacent Canadian provinces.

While the original objective of this project to develop a detailed maritime database that would be added to the existing MWFV system, the project team began to see the necessity for an expanded effort in the delivery of information from this resource. The scope of this project thus evolved over time as the project team interacted with stakeholders in the region. The watershed event in this change of focus took place at the June 9 Great Lakes Data Workshop in Detroit. A significant number of the participants at the Workshop expressed greater interest in having access to a wider array of prepared maps, reports, tables and graphics on the project web site than a comprehensive GIS as the core of the information delivery system. The project team responded by revising the design of the system to meet the needs of our partners in the industry. This resulted in fewer deliverables in terms of raw data in the database, but a clearer picture of what an effective information delivery system will be for this industry. This revised vision for the regional information delivery system therefore forms the basis for a significant portion of this report.

While the project team will not abandon our development of the GIS database as the core element of the database management portion of the project, our emphasis in the delivery of data will shift to the development of a user interface that distributes the wider a variety of resources requested by users.

The project team gathered additional insight as work progressed in this effort. In particular, it became clear that the data currently stored and managed in the database needed to be enhanced through real-time acquisition of vessel locations using AIS technology, compilation of detailed regional employment data by sector, and collection of detailed commodity flows by vessel. Data from these sources will be essential if stakeholders desire an up-to-date, reliable and effective resource that truly reflects the level of activity currently working in the lakes. Our stakeholders emphasized the importance of accurate and current

information to share with government officials in the area of public policy. It can also be argued that such data would facilitate intermodal connectivity at ports if short sea shipping is to be a viable alternative in diverting freight off of congested highways. Such data would also be useful in our expanded efforts with the Upper Midwest Freight Coalition to draw the link between transportation and the regional economy and in gaining a clearer understanding of patterns of freight flows within the region.

Finally, this project report ends with a proposal for the establishment of a Great Lakes Maritime Exchange using the model developed by MISNA (Maritime Information Services of North America). Such an exchange would provide the foundation for continued data collection, management and exchange in the Great Lakes to support long-term sustainable maritime transportation.

Project Background. As stated above, the original intent of this project was to expand MWFV to include maritime transportation. This System was well positioned to carry out the task of assembling, storing and managing maritime data for the Great Lakes system. A major effort had already been undertaken in the development of MWFV. At present, MWFV is a distributed GIS developed to track patterns of intermodal freight movements within a seven state area of the upper Midwest and two provinces of Canada. The principal objectives of MWFV were threefold: 1) to provide a means to spatially relate existing and projected freight flows to the regulatory environment and the physical capacity of the infrastructure, 2) to track trends in freight movement over time and space, and 3) to link freight movement to population characteristics and economic activity within the region. Users can take advantage of the GIS location-based query and selection capabilities as well as mapping functions to illustrate these relationships. In addition, the system was designed to expand into providing advanced analysis capabilities such as vehicle routing and travel time computations to evaluate the effectiveness of the network to support freight movement. As a result, the system has begun to develop into an effective tool for economic development planning as a means to measure accessibility to markets, identify bottlenecks in the network that hinder freight flows, and for identifying feasible locations for warehousing, manufacturing, retail and intermodal connection facilities. The system displays data on highways, railroads, intermodal connections, and air transportation. However, little data are currently assembled for maritime transportation. The structure of the MWFV database is presented in Appendix A.

The system was developed as part of the ***Upper Midwest Freight Corridor Study***, a cooperative venture between seven Midwestern state departments of transportation and the Midwest Region University Transportation Center (MRUTC) at the University of Wisconsin, The University of Illinois-Chicago, and The University of Toledo. The data reside entirely in The GISAG Center at The University of Toledo and are accessed as part of a distributed GIS.

One of the main objectives originally envisioned for MWFV was to generate and maintain a long-term database and data distribution system that would be available for state transportation agencies, regional planning agencies, port authorities and economic development organizations, as well as other interested decisionmakers and stakeholders within the region. This requires ongoing efforts to furnish the most up-to-date data available *from all modes* in the transportation system. These data collection efforts are discussed in detail in the next chapter.

Data Acquisition

Much of the data acquired in the first phase of this project came from existing sources—both commercial and government. The data are currently being stored on designated server space at the GISAG Center at The University of Toledo. These data will be added to MWFV in the Fall of 2006 when the project web page is posted. The challenge to the project team at this stage was to organize the data in such a way that all elements of the database were spatially compatible with respect to data structure format, geo-referencing, scale, segmentation, and compatibility with widely-used GIS software. Specific data assembled into the centralized data repository currently include the following:

1. Intrastate Employment patterns for each commodity type by SIC, NAICS, (Demographics Plus, Inc. *Business Counts Database*);
2. Population and Socioeconomic data representing market demand within the region
3. Port locations—U.S. (BTS National Transportation Atlas);
4. Dock locations (Army Corps of Engineers) and attributes:
5. Waterway Nenwork—Great Lakes and inland waterways (Army Corps of Engineers)
6. Port operations data such as tonnages, commodities transshipped (Lake Carriers Assn.), vessels serviced, equipment, *etc*.
7. Baseline 2002 commodity flows through the Saint Lawrence Seaway and Great Lakes System obtained from the FHWA Freight Analysis Framework estimated from 2002 Commodity Flow Survey Data. This data set provided the research team with a skeleton framework upon which to add subsequent flow data as we obtain it.

Please refer to Appendix B for a set of maps prepared on MWFV that display a sample of the data listed above. Appendix B also provides an illustration of the user interface for MWFV and some of its analytical capabilities.

While most of the data listed above have been obtained from existing digital data sources, other data dealing with dock locations and related operational attributes were manually entered into the database. This process was the most labor intensive and time consuming of the data assembly tasks. These efforts however, yielded a data layer that displays the location of commercial docks with their associated dock data available to be viewed. No such database exists to our knowledge. We are currently seeking permissions to display the following characteristics for each of the docks:

1. I.D. code number (please see Appendix C)
2. Name
3. Location
4. Address
5. Phone number
6. County
7. State/Province
8. Waterway
9. Port
10. Mile (if located on a river)
11. Latitude
12. Longitude
13. Operator
14. Owner
15. Purpose
16. Slip length
17. Slip width
18. Slip depth
19. Vessel loading equipment
20. Vessel loading speed
21. Vessel unloading equipment
22. Vessel unloading speed
23. Railway connections
24. Notes of interest

Most of this information has been compiled for docks on the United States side of the Great Lakes. The corresponding information for the Canadian side of the Great Lakes is still in the final stages of compilation. An identification code system has been developed by the project team to uniquely identify the commercial docks in this database. This code was developed because of a lack of standardization in identification codes among agencies and firms. As this project is looking at the Great Lakes system as a whole, our ID code was designed to work for all docks on both the Canadian and US sides of the Lakes. The code is an eight-digit number system where each digit, or set of digits, represents a specific category (please see Appendix C for a detailed explanation of code numbers). The advantage of this ID system is that each number represents something real, it is not a mere arbitrary number used for administrative functions. Users who understand this code system will be able to easily locate a dock and know what types of commodities it handles.

- **X**0000000 First Digit – Country Code
- 0**XX**00000 Second & Third Digits – State/Province Code
- 000**XX**000 Fourth & Fifth Digits – Port Code
- 00000**X**00 Sixth Digit – Commodity Code
- 000000**XX** Seventh & Eight Digits – Specific Dock Code

The data listed above are in the final stages of being merged into the MWFV data reporting site for viewing. The reporting site is best described as a file sharing data library consisting of geospatial data and non-spatial data in a usable format. Users of the site will have secured access to this repository. Technical System Specifications for the data repository are described as follows. The repository is situated on aa ***Apple® G4 Xserve®*** file server with ***ATAboy2® RAID*** (Redundant Array of Inexpensive Disks) system connected to the World Wide Web (WWW) in the GISAG (Geographic Information Science and Applied Geography Lab) at The University of Toledo. RAID LEVEL 5 is implemented for maximizing "High data reliability and Highest Transfer capacity" along with frequent data backups.

The user interface for this data reporting system is built on a ***Citrix Metraframe*** installation of a specialized ***ArcView GIS*** application. Users can access MWFV with a web browser and Internet connection; all operations are carried out on the Toledo Server—the users' computers simply act as a terminal. The site is thus able to accommodate a wide range of users that extends between casual browsers and "basic mappers" to more experienced GIS and database users.

The original proposal submitted for this project asserted the following: "It is expected that the initial assembly, storage and delivery of the maritime component of MWFV will be completed by August 2006. However, it should be emphasized here that the long-term objective of this system is to provide a *long-term* regional freight observatory for the Upper Midwest. This project represents only the beginning of this venture." It was expected that the assembly of the data would be an ongoing process and that the initial stages of the project would involve the design and structuring of the database. These tasks are completed. We are now in the process of gathering a wider array of data. The data assembled listed in this report represents the progress *so far* in this project.

The most recent activities undertaken have been to start compiling information on the various types of commodities transported on the Great Lakes, with an emphasis on observing the origins and destinations of these commodities, flow routes, tonnages, *etc*. This segment of the project is in its very preliminary stage and will include an emphasis on acquiring the following data:

1. Commodity type (SIC, NAICS) of existing freight shipped through the Great Lakes (by weight and declared value)—1999-2005;
2. Ports of origin and destination for each commodity type—1999-2004;
3. Establishment locations and employment by sector associated with each commodity type shipped on the Great Lakes, (ES-202 Database, Bureau of Labor Statistics (BLS), US Department of Labor).

The major limitation in the acquisition of the data listed above is confidentiality. For example, the BLS requires a signed waiver of any right to disclose ES-202 data in disaggregate form; all data must be reported in aggregate or in derived form to avoid disclosing employment figures for any individual firm or establishment. The same problems are going to occur when we propose to track commodity flows within vessel movements—or even tracking individual vessels. If we are to acquire, store and manage these data, we must do so under confidentiality agreements with carriers, ports and shipping companies. We intend to pursue this in the coming months. These agreements can greatly assist in the acquisition of AIS data to track vessel movements. Implementation of this technology will be accompanied by discussions with members of the industry in the next phase of the project (Additional discussion of the incorporation of AIS data is included in later sections of this report).

So far, the discussion in this report has been devoted to the assembly of data into a central data repository within MWFV. However, the project team was also charged with the task of developing a more generalized information delivery system that requires very little technical training and GIS expertise on the part of users. Representatives of the Great Lakes Maritime Industry emphasized the importance of providing useful information in a more generalized format that could be taken directly off of the web-based delivery system. In addition, industry representatives acknowledged the importance of storing and managing data that could be accessed and exchanged with other analysts in the industry. The results of studies conducted with data from the data repository could then be posted on this centralized delivery site. To date, the prototype delivery site is still in the final stages of development and will be unveiled in November 2006. These recommendations marked a significant departure from the approach originally adopted by the project team. The details of this new approach are outlined in the following chapter.

A New Perspective on Information Delivery

As stated above, the emphasis on a purely GIS-based information resource changed significantly after discussions with stakeholders within the region pertaining to their data and information needs. The objectives for this initiative thus changed midway through the project. On June 9, 2006, The Great Lakes Maritime Research Institute hosted the Great Lakes Maritime Data Workshop in Detroit. This meeting marked the beginning of an initiative to assemble an internet-based data resource for Great Lakes Carriers, Ports and regional economic development organizations. Participants included:

- US Army Corps of Engineers
- American Great Lakes Ports Association
- Canadian Chamber of Maritime Commerce
- US Maritime Administration
- NOAA
- University of Wisconsin-Superior (GLMRI)
- University of Minnesota Duluth (GLMRI)
- Lake Carriers Association
- Transport Canada
- Great Lakes Commission
- St. Lawrence Seaway
- Port of Duluth
- Detroit Port Authority
- University of Toledo

A detailed list of attendees is provided in Appendix D. This meeting was the first of several meetings in a multiyear project sponsored by The Great Lakes Maritime Research Institute. Workshop participants discussed in detail the purpose, goals and content of the data delivery system. This served to define the scope of the remainder of the first phase of this project and provided a clear direction for long-term efforts in this initiative. The recommendations are discussed in detail below.

Purpose and Goals of the Information Delivery System. Workshop participants readily agreed that the data delivery system must serve as an accurate, current, comprehensive and user-driven data resource. In terms of its purpose, a critical objective of the system must be to provide data and information to inform public policy decisionmakers as to the value and utility of the Great Lakes Maritime Transportation System (GL MTS). Of particular importance in reporting to public officials are:

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

Workshop participants discussed additional data needs for regional stakeholders that require data to facilitate projections and forecasts for freight movements under alternative scenarios involving alternative modes or intermodal movements. Regulatory impacts were also emphasized in the discussion along with improved coordination of public investments over the entire system to benefit all stakeholders within the region despite their location or jurisdiction.

One additional concern dealing with the purpose of the data delivery system dealt with the question of "Where does the reach of the Marine Industry begin or end"? Does it begin and end at the ports or should it extend all the way from the origin to the destination? Participants argued for the scope of the database to

"follow the cargo" to consider ripple effects, regional impacts and locational patterns in the supply chain (*e.g.*, steelworkers and farmers in the region both depend on the maritime industry). This perspective certainly coincides with one of the original objectives of this project in linking marine freight movements to the regional economy. These questions however, require detailed data that are not readily available without the acquisition of ES-202, vessel commodity flows, and vessel movements.

Information Delivery Priorities for System Users. The most important outcome of the meeting dealt with the form that the information delivery should take. The original design of the data delivery system was for a GIS format where users would query the database, perform simple analysis functions and prepare graphics, tables, text and maps as output. The challenge in implementing such a system however, concerns the extent to which the system should support the query, manipulation and analysis of data (*e.g.*, vehicle routing, OD flow modeling, intermodal transfer simulation, *etc.*). In turn, developers of the system are further challenged by the need for users to gain the necessary expertise to operate the system.

In response, meeting participants effectively argued that any system that requires a significant amount of training and practice would not be used as heavily as a more "user friendly" system consisting of prepared graphs, maps, bullet points, tables, and other features such as prepackaged reports in basic standard formats such as Annual Reports, Executive Summaries, and reports of studies completed by analysts who used data from the repository. The project team responded to this point by proposing to develop a system that offers a variety of products and functions among varying degrees of expertise required by users. These include:

- Basic prepared maps for viewing and download,
- Prepared tables and graphs for viewing and download,
- Simple mapping functions in the data viewer,
- Query functions for more advanced users, and
- Analysis functions and specialized functions in the database for advanced users.

In addition, the project team noted that help functions could be furnished to assist users such as:

- **Technical manuals** available in *.pdf* format in downloadable form for detailed directions on use
- **Web-based documentation / tutorials for instruction** on the Toledo web site for specific functions such as basic mapping, query functions, and more advanced analysis functions. Additional tutorials can be posted documenting the contents of the database.
- **On-line help functions** to solve routine problems that are encountered as users operate the system.
- **Technical support via telephone and email** using staff at the Toledo site at specified times to help users with more complex problems not available at the on-line help functions.

The discussion concluded with the following recommended tasks for the project team in the next phase of the project:

- Assemble, store, and manage raw data in the data set
- Begin to develop data reporting standards with regard to data reconciliation among diverse sources, standardization of reported units, "currentness" of reported statistics, establishment of data acquisition protocols, quality control and accuracy checking, and to develop mechanisms to check for redundancy and duplication of efforts among contributors to the database. It was strongly recommended that this system "level the playing field" in data reporting by using the same units as other modes and regions—this resource must reflect the metrics used in the industry. Data reporting standards should be discussed and reviewed on an ongoing basis (revisited every three years)

- Assemble data and report information among different geographic areas of impacts and jurisdictions:
  - States and Provinces
  - Congressional districts
  - Cities
  - Counties
  - Ports
- Begin to prepare information in the form of maps, tables, text and graphics for stakeholders pertaining to public policy interests
- Establish a communication link within the system (*e.g.*, email access) for regional stakeholders to request specific information to be posted on the site. This function was agreed upon as essential if the information delivery was to be successful
- Establish a system for data exchange to analysts in maritime industry agencies and organizations
- Develop a site in the system for analysts within the region to publish the results of their analysis—particularly with regard to public policy issues of interest to the Great Lakes Maritime Industry
- Begin to develop a library function in the form of a data clearinghouse that reviews and summarizes data from diverse sources--both public and commercial--and provide links for users to branch to from the site. The result of which is to provide the Great Lakes Maritime Industry with a comprehensive centralized resource for data and information. An example of such a link would be for taxes, fees, and other costs; however, this component would not represent a core function of the data resource. It was further suggested that the site become a gateway to maritime agencies (*e.g.*, Coast Guard, USACE, *etc.*)

One final charge to the project team resulting from the discussion was to begin thinking about how to implement expedited data collection through technological innovations (*e.g.*, AIS, informatics, electronic forms, *etc.*). It was suggested that a pilot project for automated data acquisition would be extremely useful in later phases of the project. This recommendation in particular is to be actively pursued in the next phase of the project.

Recommendations for Data Acquisition. One final topic covered in the June 9 meeting dealt with data requests for the site. It was recognized early in the discussion that data acquisition efforts must be prioritized given constraints in time, staffing and budget. Data priorities were highest for the following in the initial phase of the project:

- **Cargo flows**—vessel types, vessel size, types of commodities, origins, destinations
- **Facilities** including docks, terminals, locks, equipment, and navigation facilities
- **Linking Great Lakes maritime freight movements and the economy of the Great Lakes Region** (*e.g.*, evaluating impacts of GL MTS freight movements on regional employment)
- **Environmental Data** dealing with air and water emissions from Great Lakes vessels, including a baseline inventory of emissions data from great lakes vessels and a baseline ballast inventory
- **Data to support air and water pollution reductions based on diverting traffic** from highway and rail modes to marine transport modes
- **Data to support comparative analysis of Great Lakes Fleet vs. Railroads and Trucks** in terms of fuel consumption per ton-mile along with effects of fuel costs on transport economics of great lakes vessels vs. rail vs. truck over time
- **Compiled lists of current sources of data** as part of the data library and clearinghouse function of the site.

Meeting participants contributed a number of additional recommendations related to long-term issues associated with the assembly, storage and management of the database. Of great importance was the establishment of both baseline information and projected trends among a wide range of factors in the industry. Specific recommendations included:

- Consider the utility of data for projections into the future and tracking trends.
- Data pertaining to investments in the infrastructure are critical. The system should account for current costs, projected costs, investments (over different planning horizons) and the benefits of investments; include the costs of making no investments
- Include data that have been developed jointly between government and private interests—these data have considerable utility and credibility
- Seek permissions in acquiring, storing and disseminating data. Acquire MOUs before including data in the system
- Check for gaps in the data and additional needs for data that may not yet be available
- Document caveats in working with the data—prepare a metadata reference page.

The data collection efforts and recommendations for the project site obtained from the June 9 Meeting thus set the direction for the remainder of Phase I of this project and formed the basis for the approach to be followed in subsequent phases of the project. Given the continuing nature of this project, the contents of this report should not only contain the progress of the project and work completed to date, but also a serious discussion of the direction of our data management and delivery efforts in the upcoming months and years. The following section covers the direction that the project team plans to take in our next steps.

Looking Ahead: Next Steps

The main objective of this resource is to maintain a long-term database and data distribution system built on a strong relationship with the political jurisdictions and stakeholders listed above. This data resource will serve as a central focus for these various interests to come together to focus on optimizing freight movements within the region. With the addition of other interests such as firms, shippers, carriers, regional planning agencies, port authorities and economic development organizations, this resource can have a direct positive impact on the regional economy. Furthermore, this system was originally developed as part of the ***Upper Midwest Freight Corridor Study*** conducted as a cooperative venture between seven Midwestern state departments of transportation and the Midwest Region University Transportation Center (MRUTC) at the University of Wisconsin, The University of Illinois-Chicago, and The University of Toledo. The added input of the regional maritime industry stakeholders within the region during the June 9 meeting further reinforces the relevance and utility of this resource for the region.

Specific Tasks. It was made clear that the next phase of the project must carry out parallel tasks of providing a generalized information delivery system while still expanding data collection efforts in the direction of acquiring flow data in greater detail with respect to commodities, origins and destinations, and vessel characteristics (including fuel consumption and emissions). The project team must link the maritime transportation "network" to the highway and rail networks, which in turn can be linked to the regional economy. These efforts also include detailed data library system and information clearinghouse functions. As a result, the next steps to be completed by the project team will involve the following distinct tasks:

- Continue to assemble data in the centralized repository to include the following:
  - **Cargo flows**—vessel types, vessel size, types of commodities, origins, destinations
  - **Baseline data for vessel movements** including size, horsepower, emissions, fuel consumption, ballast inventories, *etc*.
  - **Port Facilities** including docks, terminals, etc. and relevant attributes dealing with capacity, tonnages, *etc*.
  - **Linking Great Lakes maritime freight movements between origins, routes, ports and destinations** as a means to link maritime freight flows to the regional economy
  - **Acquisition of additional economic data** dealing with employment by sector, establishments, *etc*.
  - **Lock data** including relevant attributes dealing with size, capacity, tolls, *etc*.
  - **Navigation facilities**.
- Documentation of data standards derived from data sources in the region (including consultation with data source agencies, Maritime Exchanges, Ports and other related organizations) and reporting data in units consistent with the maritime industry and related transportation modes
- Begin a dialog with regional stakeholders with respect to their information needs in order to prepare maps, graphics, tables and text in a user friendly format
- The development of an internet-based data reporting site for data resources and organizations within the region including links to related sites
- Documentation of the data resources on the site.

Given the inherent spatial nature of the transportation infrastructure, the organization of the data in this study has been assembled within a geographic information system and will be stored in that format. However, the data will be made available outside of that format as well in tabular and other database management formats.

Partnerships. This proposed project represents a partnership between the Great Lakes Maritime Research Institute, the Intermodal Transportation Institute at The University of Toledo, and The Geographic Information Science and Applied Geographics (GISAG) Center at the University of Toledo. The GISAG Center will provide all server space and data management services for this project. Access to the Toledo Site will be linked from the GLMRI Web Page. The Toledo Project team will work closely with Dr. Xiubin Wang of GLMRI to identify data for the system and to design the database and data dissemination system. Additional partnerships will be maintained with participants from the June 9 meeting:

- US Army Corps of Engineers
- American Great Lakes Ports Association
- Canadian Chamber of Maritime Commerce
- US Maritime Administration
- NOAA
- University of Wisconsin-Superior (GLMRI)
- University of Minnesota Duluth (GLMRI)
- Lake Carriers Association
- Transport Canada
- Great Lakes Commission
- St. Lawrence Seaway
- Port of Duluth
- Detroit Port Authority
- University of Toledo

The meeting participants suggested participation from additional industry stakeholders including Canadian Shipowners, the St. Lawrence Seaway Development Corporation, Green Marine, AIS System, and interested private shippers. One additional partnership that would yield long-term sustained viability for this information delivery endeavor is with MISNA (Maritime Information Services of North America). The following section represents a proposal to join MISNA as their maritime exchange in the Great Lakes.

A Great Lakes Maritime Exchange. One of the objectives of this project is to develop a long-term sustained information delivery resource for the Great Lakes Region. Eventually this data repository and delivery system must be able to sustain itself financially as a member of the maritime industry in this region. To this end, it is proposed here that GLMRI and its partners in the industry consider the establishment of a ***Great Lakes Maritime Exchange*** (GLMX) in the form of a non-profit organization that would be financed through subscription fees by its partners in the industry. There are a number of such exchanges in the coastal regions of the United States and in British Columbia. These exchanges partner with one another through MISNA, an umbrella organization of non-profit *501(c)(6)* maritime exchanges in the United States and British Columbia. According to MISNA:

> [these maritime exchanges] represent a broad cross section of maritime interests in their respective regions -- vessel owners and agents, ports, pilots, towboat companies, stevedores and terminal operators, admiralty lawyers, customs brokers and freight forwarders, ship repair firms, employer associations, insurance agencies, marine surveyors, maritime unions and oil spill response organizations, just to name a few. [1].

Again, according to MISNA, the marine exchanges comprising this organization carry out a range of tasks that include:

- Advance Vessel Schedule Information, including ETAs and ETDs
- Advance and real-time vessel movement monitoring (AIS)
- Actual Arrival and Departure Data
- Vessel Traffic Analysis
- Historical Vessel Movement
- Port and Terminal Utilization Studies
- Promote Maritime Interests [1].

The principal investigator on the project team was contacted by MISNA in June, 2006 with the proposal to begin a maritime exchange in the Great Lakes. To date, none exist in this region. Subsequently the principal investigator was invited to a MISNA National Meeting in Portland, Oregon in September, 2006. MISNA has established standards and protocols for data reporting that could be adopted in the Great Lakes without developing a new set independently. A sample of data obtained from vessel tracking includes the following fields:

- Ship Name
- Lloyd's Number
- Ship Flag
- Ship Type
- Local Agent
- Estimated Date of Arrival
- Estimated Time of Arrival
- Actual Date of Arrival
- Actual Time of Arrival
- Arrival Port
- Arrival Berth
- Actual Date of Departure
- Actual Time of Departure
- Last Port of Call
- Next Port of Call

One of the main functions for many of the maritime exchanges is real-time vessel tracking using the AIS System as implemented in the Great Lakes/St. Lawrence Seaway system [2]. Continuous tracking enhances safety, optimizes transit times through better traffic management, optimizes scheduling of lock passages, improves fleet management for ship owners and assists in navigation through the system, provides faster response times following accidents/incidents, provides data to support homeland security efforts, and assists in tracking hazardous cargoes [2].

It is further argued here that continuous tracking of vessels can provide a means for effective coordination of intermodal connections in short sea shipping. The system can also provide input functions for long-term vessel tracking such as with the Automated Secure Vessel Tracking System [3]. Long-term vessel tracking can provide useful data to track total vessel traffic over the entire system—including specific channels where dredging is needed or other navigation improvements are required. Continuous vessel tracking can also provide needed data to track vessel emissions and to demonstrate savings in overall emissions by diverting freight traffic from rail and highway to the lakes.

It should be emphasized that maritime exchanges maintain strict confidentiality with their client organizations and do not disclose data among organizations without authorization. As discussed previously in this report, the same approach would be adopted in the Great Lakes. Thus a great lakes maritime exchange could serve as another partner with GLMRI and the maritime industry as a commercial resource and merits consideration.

Conclusion

The initial phase of the Great Lakes Maritime Information Delivery System Project began with an initial assumption that it would simply serve as an extension to the ***Midwest FreightView*** system developed for the Upper Midwest Freight Corridor Study. The end of the first phase of the project yielded significantly different results from what was originally envisioned. The new product will be a multidimensional system that will support the following functions:

- A detailed data repository for vessel movements, port functions, commodity flows, economic activities and environmental impacts, etc.
- A GIS data viewer for advanced users to view and analyze a variety of data
- An information delivery site for maps, tables, graphics, text and other features
- An information clearinghouse and centralized data facility to furnish links to other information resources, private vendors furnishing commercial products, and government agencies
- A data exchange to support user inquiries and furnish information on demand.

The project team anticipates that the initial prototype of the web-based information delivery resource will be introduced to the Great Lakes maritime community in November, 2006. The project team will solicit feedback and suggestions for improvements at that time. Continuous improvement of the information delivery system will also be a major objective as this resource evolves in the coming years. We will strive to maintain an open dialog with the members of the industry to assure our success in this endeavor.

References Cited

[1] Maritime Information Service of North America (MISNA), (2004) (Internet), *History of MISNA*, (cited September, 2006), http://www.misnadata.org/content/history.php?m=15.

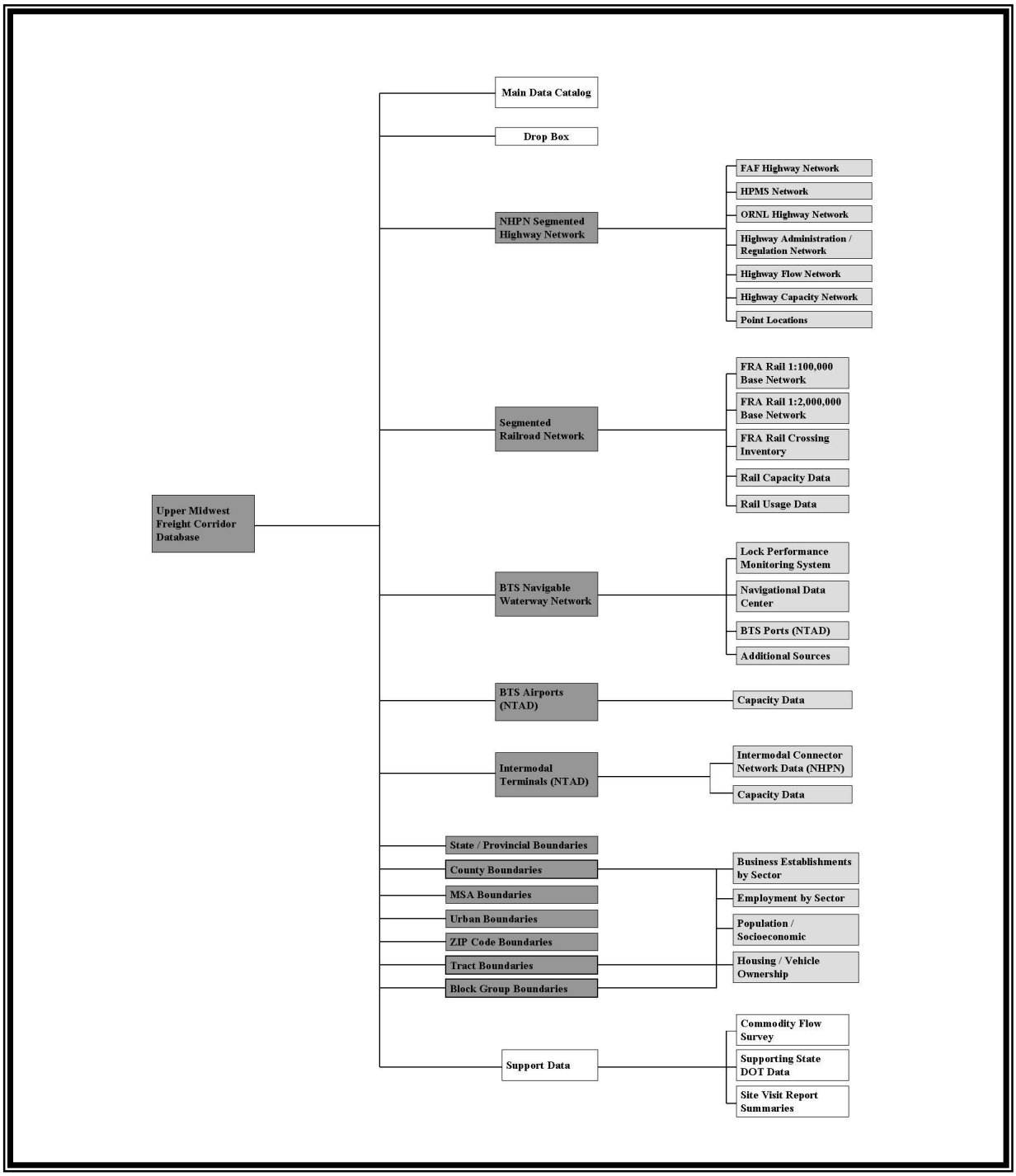
[2] Great Lakes/St. Lawrence Seaway System (SLSDC and SLSMC), (2006) (Internet), *AIS Project* (cited September, 2006), http://www.greatlakes-seaway.com/en/navigation/ais_project.html.

[3] Maritime Information Service of North America (MISNA), (2006) (Internet), *Automated Secure Vessel Tracking System (ASVTS)*, (cited September, 2006), http://www.asvts.org

APPENDIX A

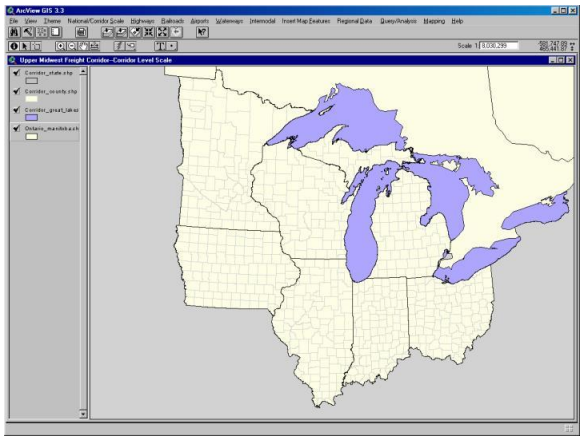
Schematic Diagram of the Structure of the Current *Midwest FreightView* Database

Schematic Diagram of the Structure of the Current MWFV Database



APPENDIX B

Sample of Map Output from *Midwest FreightView* Great Lakes Maritime Database



Example 1: Basic Mapping Functions

Figure B.1
Initial display for the user Interface
in ***Midwest FreightView***

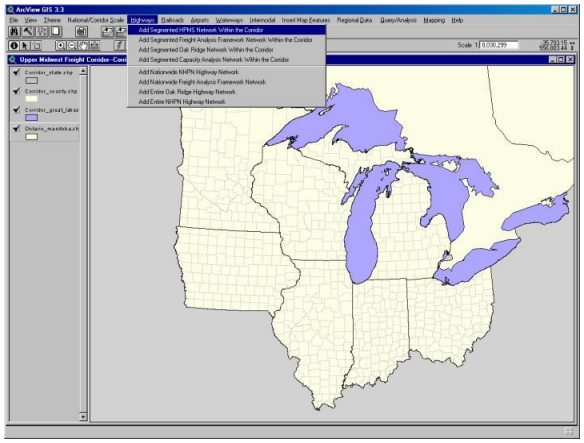


Figure B.2
User activates pull down menu to open the highway network in the Great Lakes Region.

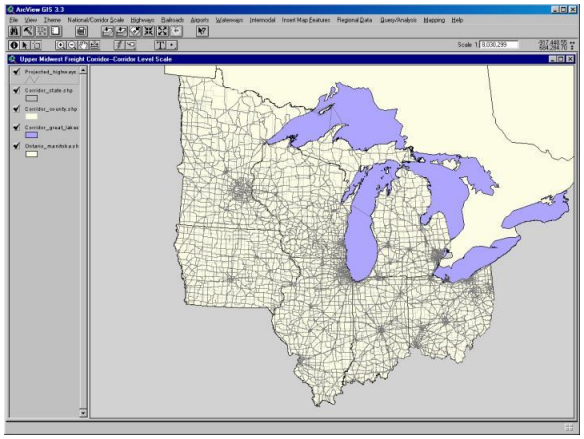


Figure B.3
MWFV displays highway network in the view window.

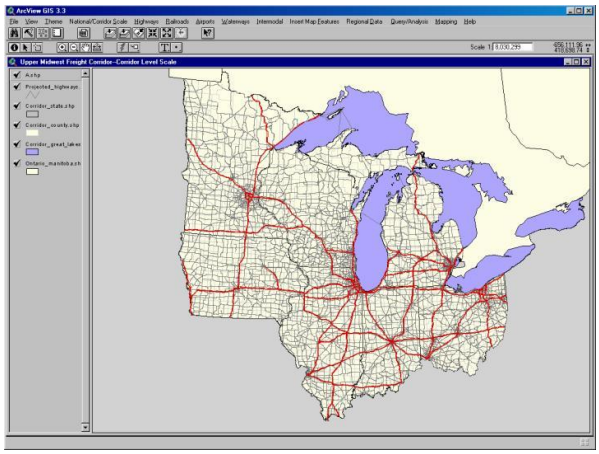


Figure B.4
MWFV provides users with the ability to highlight specific features in the display. In this case, major highways are highlighted.

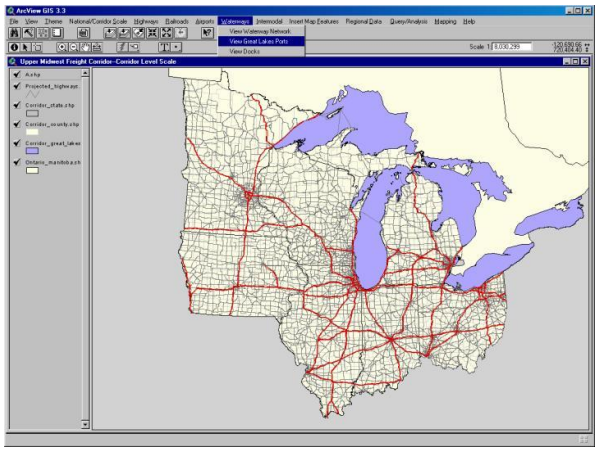


Figure B.5
User activates pull down menu to display the Great Lakes Port locations in the system.

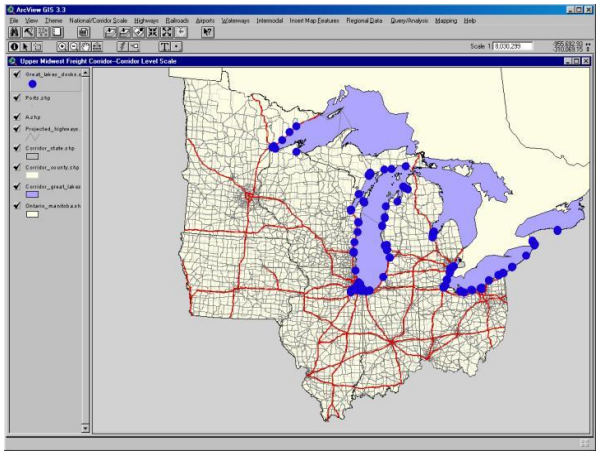


Figure B.6
MWFV displays port locations in the view window.

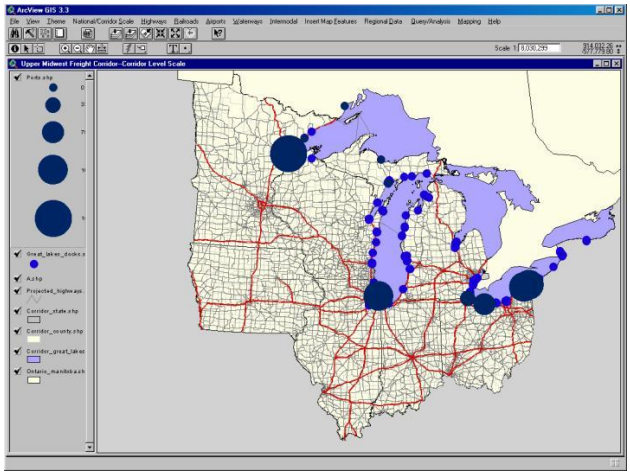
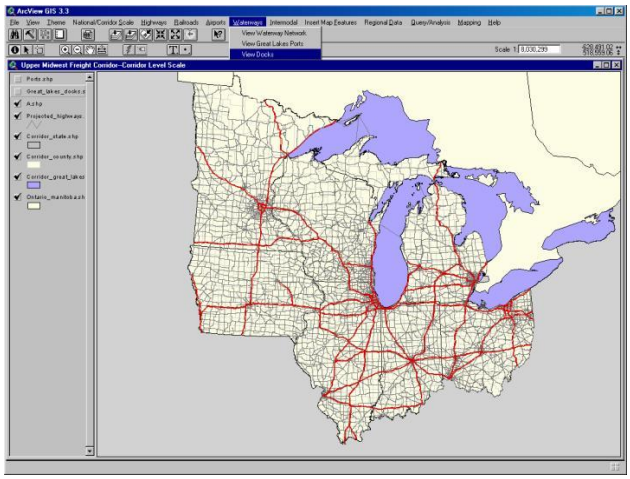


Figure B.7
User now queries the port data points for map display. In this case, the user opened the database to query ports for coal tonnages. The graduated symbols in the map thus provide a graphic comparison among Great Lakes Ports for coal tonnage in 1995 (provided by Lake Carriers Association).



Example 2: Display of Attributes for Features in the System

Figure B.8
User activates pull down menu to display the Great Lakes dock locations in the system.

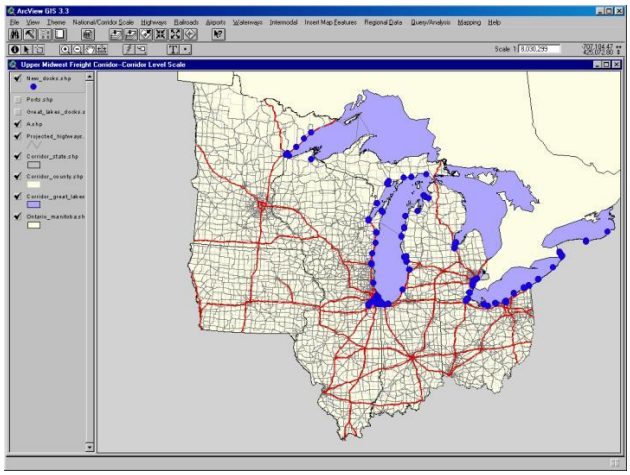


Figure B.9
MWFV displays dock locations in the view window. Note that at this scale, dock locations are distributed in the same locations as ports; however there are more points in this map than in the map in Figure II.6.

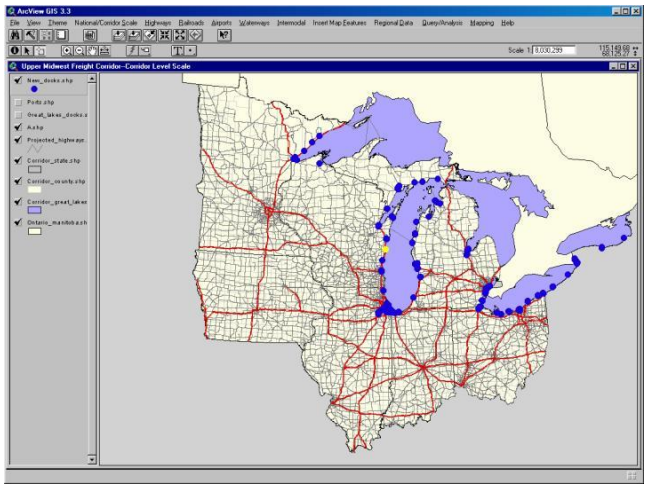


Figure B.10
User points to a single dock and highlights it with the cursor. (See yellow dot located at Sheboygan, Wisconsin)

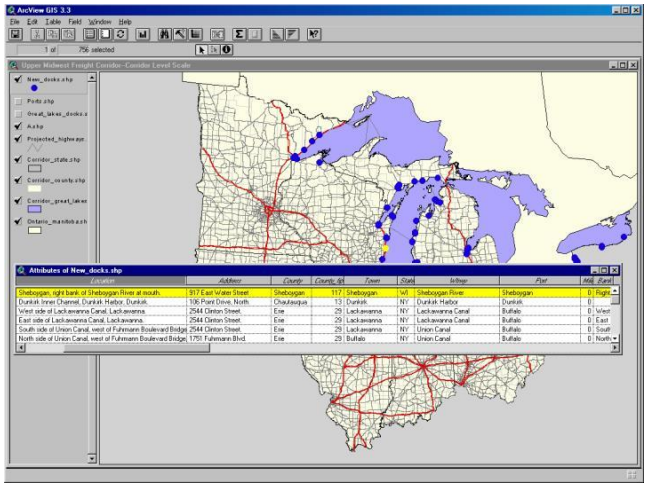
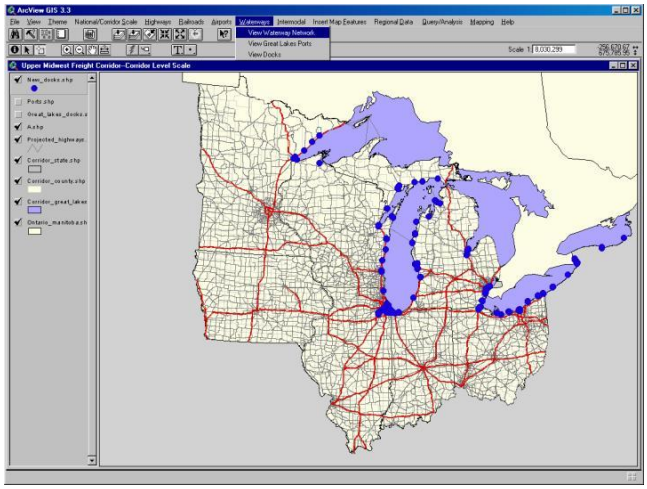


Figure B.11
User opens attribute table and examines highlighted record in the table corresponding to the dock location (note only a portion of the table is shown in the display).



Example 3: Mapping the Network

Figure B.12
User activates pull down menu to open the waterway network.

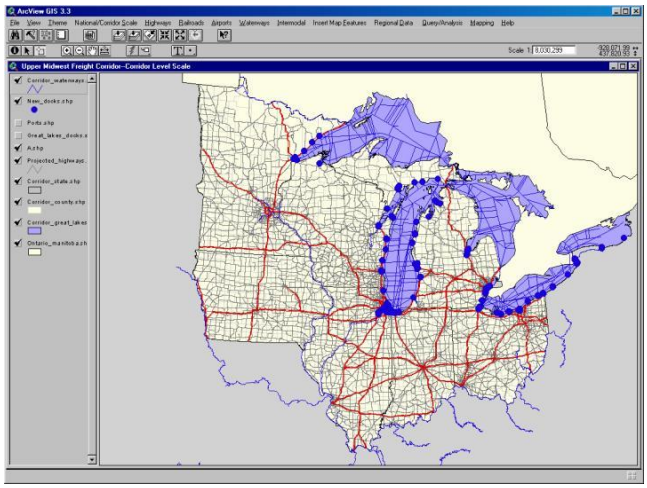


Figure B.13
MWFV displays USACE waterway network for both the Great Lakes and the Inland Waterway system. Given that MWFV was developed as an intermodal transportation display system for the Upper Midwest Freight Corridor Study, more than one waterway system is displayed.

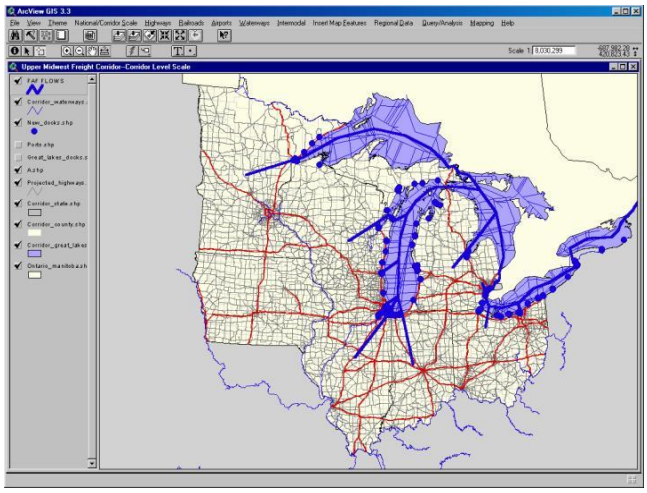
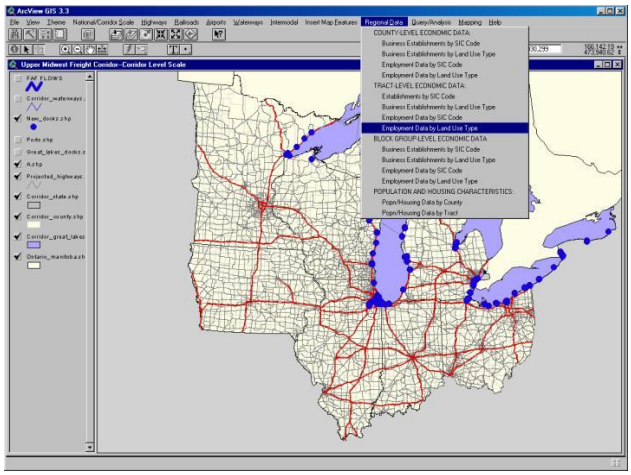


Figure B.14
User highlights shortest path links on the Great Lakes/St. Lawrence Seaway Network that were developed to contain baseline commodity flows from the 2002 Freight Analysis Framework. Flow data were based on 2002 Commodity Flow Survey. Note that additional links are inserted to state centroids as a means to capture state-based flows that originate or terminate away from the major ports in the region.



Example 4: Linking the Great Lakes Maritime Transportation System to the Regional Economy.

Figure B.15
User activates pull down menu to open the regional employment database. In this case, the user is opening employment data by census tract.

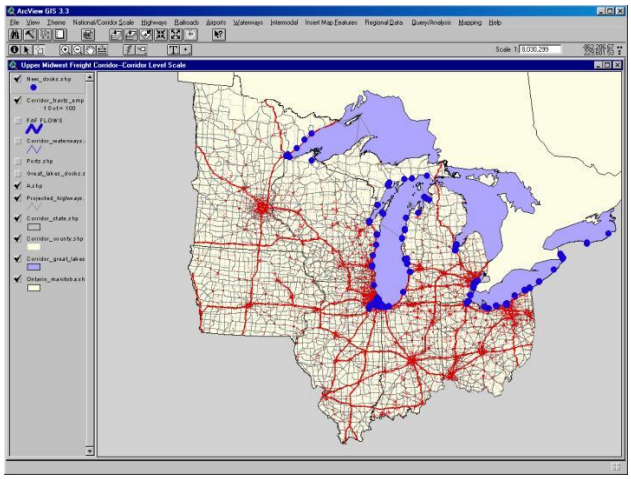


Figure II.16
MWFV displays a dot distribution map of manufacturing employment alongside Great Lakes dock locations. MWFV was developed as an intermodal transportation display system for the Upper Midwest Freight Corridor Study, more than one waterway system is displayed. The map appears cluttered, prompting the user to "turn off" some of the map elements in the display to produce the map in Figure B.17.

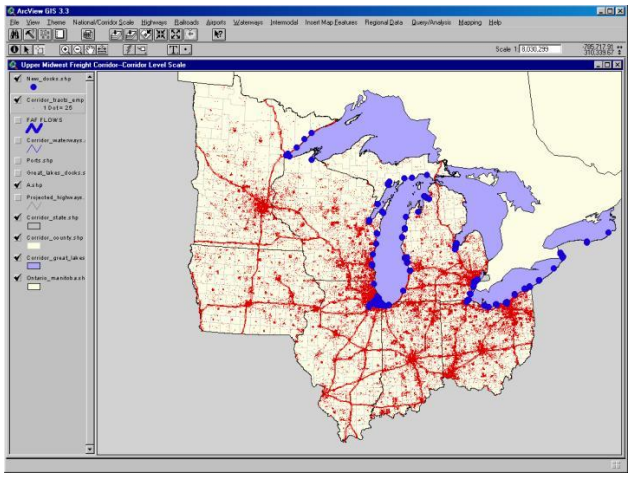


Figure B.17
MWFV displays an uncluttered dot distribution map of manufacturing employment superimposed over Great Lakes dock locations. Not only will users be able to cartographically display these relationships, but the data are also stored in a convenient format for a wide variety of statistical and spatial analyses.

APPENDIX C

Code Specifications for Great Lakes Commercial Docks

Code Specifications for Great Lakes Commercial Docks

An identification code system has been developed by the project team to uniquely identify the commercial docks in this database. This code was developed because of a lack of standardization in identification codes among agencies and firms. As this project is looking at the Great Lakes system as a whole, our ID code was designed to work for all docks on both the Canadian and American sides of the Lakes. The code is an eight-digit number system where each digit, or set of digits, represents a specific category. The advantage of this I.D. system is that each number represents something real, it is not a mere arbitrary number used for administrative functions. This code system enables individuals to easily identify and locate a dock and determine the types of commodities it handles.

Code Key

- **X**0000000 First Digit – Country Code
- 0**XX**00000 Second & Third Digits – State/Province Code
- 000**XX**000 Fourth & Fifth Digits – Port Code
- 00000**X**00 Sixth Digit – Commodity Code
- 000000**XX** Seventh & Eight Digits – Specific Dock Code

The advantage of this I.D. system is that each number represents an actual characteristic of the dock; it is not an arbitrary number used for administrative functions.

Identification System Code Index

- **X**0000000 First Digit – Country Code
  - 1 Canada
  - 2 United States

- 0**XX**00000 Second & Third Digits – State/Province Code
  - 01 Illinois
  - 02 Indiana
  - 03 Michigan
  - 04 Minnesota
  - 05 New York
  - 06 Ohio
  - 07 Ontario
  - 08 Pennsylvania
  - 09 Quebec
  - 10 Wisconsin

- 000**XX**000 Fourth & Fifth Digits – Port Code

  Illinois:
  - 01 Chicago
  - 02 Waukegan

  Indiana:
  - 01 Buffington
  - 02 Burns International Harbor
  - 03 Gary
  - 04 Indiana Harbor

Michigan:

- 01	Alpena	-19	Marine City
- 02	Brevort	-20	Menominee-Marinette
- 03	Calcite	-21	Marquette
- 04	Charlevoix	-22	Marysville
- 05	Cheboygan	-23	Monroe
- 06	Detroit	-24	Munising
- 07	Escanaba	-25	Muskegon
- 08	Filer City	-26	Ontanagon
- 09	Frankfort Harbor	-27	Port Dolomite
- 10	Gladstone	-28	Port Gypsum
- 11	Grand Haven	-29	Port Huron
- 12	Gulliver	-30	Port Inland
- 13	Harbor Beach	-31	Portage Canal
- 14	Holland	-32	Saginaw River
- 15	Ludington	-33	Sault Ste. Marie
- 16	Macinac Island	-34	St. Joseph
- 17	Manistee Harbor	-35	Stoneport
- 18	Manistique	-36	Traverse City

Minnesota:

- 01 Duluth – Superior
- 02 Silver Bay
- 03 Taconite Harbor
- 04 Two Harbors

New York:

- 01 Buffalo
- 02 Dunkirk
- 03 Ogdensburg
- 04 Oswego
- 05 Rochester

Ohio:

- 01 Ashtabula
- 02 Cleveland
- 03 Conneaut
- 04 Fairport Harbor
- 05 Huron
- 06 Kelly's Island
- 07 Lorain
- 08 Marblehead
- 09 Sandusky
- 10 Toledo

Ontario:

- 01	Amherstburg	-13	Morrisburg
- 02	Bath	-14	Nanticoke
- 03	Bowmanville	-15	Oshawa
- 04	Britt	-16	Owen Sound
- 05	Bruce Mines	-17	Pelee Island
- 06	Cornwall	-18	Port Colborne
- 07	Goderich	-19	Port Stanley
- 08	Hamilton	-20	Sarnia
- 09	Little Current	-21	Thunder Bay
- 10	Marathon	-22	Toronto
- 11	Millhaven	-23	Windsor
- 12	Mississauga		

Pennsylvania:

- 01 Erie

Quebec:

- 01	Baie Comeau	-11	Port Alfred
- 02	Becancour	-12	Port Cartier
- 03	Contrecoeur	-13	Quebec City
- 04	Cote Ste. Catherine	-14	Rimouski
- 05	Gros-Cacouna	-15	Sept Iles
- 06	La Baie	-16	Sorel
- 07	Lauzon Levis	-17	St. Romuald
- 08	Mataine	-18	Tracy
- 09	Montreal	-19	Trois Riveres
- 10	Pointe Naire	-20	Valleyfield

Wisconsin:

- 01 Ashland
- 02 Duluth – Superior
- 03 Green Bay
- 04 Manitowoc
- 05 Menominee – Marinette
- 06 Milwaukee
- 07 Sheboygan
- 08 Sturgeon Bay
- 09 Washburn

- 00000**X**00 Sixth Digit – Commodity Code

- 1 Aggregate
- 2 Coal
- 3 General Cargo
- 4 Government
- 5 Grain
- 6 Iron Ore
- 7 Liquid
- 8 Passenger
- 9 Shipyard / Lay-Up

- 000000**XX** Seventh & Eight Digits – Specific Dock Code

The Specific Dock Code is a two-digit number used to differentiate between docks in a particular port that handle the same type of commodity. It is possible that there will be multiple docks with identical code numbers up until these last two digits, which will always show the difference between specific docks in a port.

APPENDIX D

Meeting Participants in the Great Lakes Data Workshop
Detroit, Michigan
June 9, 2006

ATTENDEES

Name	Organization	Title
Jeff Ahlgren	Coast Guard Sector Detroit	Chief
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Jonathan Brown	Army Corps of Engineers	Regional Economist
Steve Fisher	American Great Lakes Ports Assn.	Director
David Grier	Army Corps of Engineers	Navigation Analyst
Tonya Harrington	Army Corps of Engineers	Regional Economist
Ray Johnston	Chamber of Maritime Commerce	President
Dave Knight	Great Lakes Commission	Program Manager
Jatinder (Paul) Kochhar	Transport Canada	Economist
Patrick Lawrence	University of Toledo	Professor
Peter Lindquist	University of Toledo	Professor
Brian Link	USCOC, NOAA, OCS	G.L. Nav. Advisor
Douglas McDonald	Army Corps of Engineers	Washington Liaison
Glen Nekvasil	Lakes Carriers Association	Vice President
Adolph Ojard	Duluth Seaway Port Authority	Executive Director
Steven Olinek	Detroit/Wayne County Port Authority	Deputy Director
Richard Stewart	University of Wisconsin-Superior	Co-Director
Kevin Tunks	Maritime Administration	Enterprise Architect
Mark Vonderembse	University of Toledo	Director
Xiubin Wang	University of Wisconsin-Superior	Professor
Carol Wolosz	University of Minnesota Duluth	Program Coordinator

Tax Systems and Barriers to Great Lakes Maritime Commerce

Final Report

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October 2006

Great Lakes Maritime Research Institute

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

Research funded in part by the Great Lakes Maritime Research Institute

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Adolph Ojard, Executive Director, Duluth Seaway Port
Ray Skelton, Duluth Seaway Port Authority Security Director and Environmental and Government Affairs Director
Andy McDonald, Senior Planner, Metropolitan Interstate Committee (MIC), Metropolitan Planning Organization (MPO) for the Duluth-Superior
Mark Ross, United States Department of Treasury, Bureau of the Public Debt, Office of Public Debt Accounting, Trust Fund Management Branch.
University of New Orleans, NPWI, and SCOOP
Rodriguez, O'Donnell, Ross & Fuerst
Great Lakes & Ohio River Division, Army Corps of Engineers Dredging Districts

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List of Figures

Executive Summary

This project inventories the tax impact on the Great Lakes marine transportation system imposed by federal regulations. This project also identifies the unique tax burdens placed on the commercial maritime regulatory process in the Great Lakes, and presents an analysis of the Great Lakes maritime tax structure focusing on its most significant tax, the Harbor Maintenance Tax (HMT). Finally this project discusses possible changes to the current tax structure to improve the efficiency of port maintenance tax collection and expenditure, and to improve intermodal transportation fuel efficiency. This study was funded by a grant from the Great Lakes Maritime Research Institute.

The primary public policy intent of this study is to advance understanding of the tax structure of commercial maritime on the Great Lakes. The primary purpose of this study for the research team at the Labovitz School of Business and Economics is to accomplish the contract's goals and objectives, and to suggest methods for increasing efficiency in the relationship between tax policy and commercial maritime operations.

The inventory database includes individual assessments currently levied on the commercial maritime industry by federal agencies (119 assessments) derived from data published by the United State General Accounting Office.

Each data record is made up of variables which include: assessment name; description of the assessment; agency that levies the assessment; type of service provided; tax, or duty associated with assessment; type of vessel the assessment is levied on; commerce type of vessel the assessment is levied on; flag type of vessel the assessment is levied on; payor of the assessment; entity that collects the assessment; type of fund that receives the collections; entity that uses the collections; formula and frequency of assessment; collection amounts for FY 1989 through FY 1991, FY 1996 through FY 1998, and estimated collections for FY 1999; collection limitations; and laws and regulations. Most variables have footnotes. The database is presented in Appendix A to this report (without notes) and the full data is available in digital format from the Great Lakes Maritime Research Institute.

Detailed views of these data presented in this report include tables for 1) Federal Commercial Maritime Assessments Other than Great Lakes and Federal Commercial Maritime Assessments Great Lakes Only; 2) Top Collections Assessments; 3) Tables of Assessments by Stakeholder; 4) Kinds of Assessments Levied on Great Lakes Commerce; and 5) Harbor Maintenance Tax Tables.

Tables also present U.S. Army Corps of Engineers' (USACE) port maintenance activity data by district within the Great Lakes & Ohio River Division. District data is also presented in detail by port, including ports in the districts of Buffalo, Chicago, Detroit, Huntington, Louisville, Nashville, and Pittsburgh.

As has been discussed in Stewart's 2003 Twin Ports Intermodal Freight Terminal Study[1] and Fruin and Fortowsky's 2004 Modal Shifts from the Mississippi River and Duluth/Superior to Land Transportation Study [2], beneficiaries of USACE dredging activity do not necessarily correspond with payors of the HMT. For instance, the HMT

paid by the now terminated Incan Superior railcar ferry (estimated at $200,000 in 1991) delivered no benefit to this vessel requiring a loaded draft of about 17 feet in a navigation channel of 27 feet [3]. The report includes an overview of beneficiaries of the HMT, with detailed Great Lakes port by port totals for 2000 to 2004 amounts spent for port maintenance supported by the collections of the HMT.

Following the presentation of the tax inventory, the U.S. Harbor Maintenance Tax is reviewed under the inquiry: "The U.S. Harbor Maintenance Tax, a Bad Idea Whose Time has Passed?"

The history of the Harbor Maintenance Tax is shown including legal challenges to the HMT's validity and problems with the harbor maintenance tax today. Implications of this history are discussed including the HMT's application to imports but not exports and how the HMT discourages the most fuel efficient means of transportation. Also presented are arguments showing the HMT unfairly taxes high value cargo when compared to low value cargo, that the HMT has prevented some types of waterborne transport from flourishing in the Great Lakes, and that as currently enacted the HMT is difficult to properly enforce. These findings suggest that the HMT is a barrier to international trade and may result in a shift in container-borne cargo to Canadian ports.

The report presents data from the U.S. Treasury Department of Public Debt which shows revenues and transfers of the Harbor Maintenance Trust Fund through 2005 and part of 2006. Tables for these data show that the HMTF generates substantially more revenue than the U.S. currently expends for harbor maintenance. Comparisons with the USACE activity by port suggest that income from the HMT is not fairly allocated to the commercial ports which generate HMT revenues; for instance, that the HMT does not allocate its tax burden to either ports which require the largest dredging expenditures, or vessels which require the deepest drafts, and that the income from the HMT is used for work at some ports but not others. The report also notes that HMT revenue is a small portion of total transportation tax revenue and a small portion of transportation spending.

Strategies and attempts to "fix" the HMT's flaws are also discussed, including the 1992 attempt to reduce the HMT; the trust fund excess/HMT rate reduction bill; the Harbor Services Fund; the Support for Harbor Investment Program Act of 1999; the container port exemption bill of 2002; the $100,000,000 import value port limit bill of 2003; the ferry borne trailer cargo exemption bill of 2004; the Short Sea Shipping Tax Exemption Act of 2005; and the Great Lakes Short Sea Shipping Enhancement Act of 2006.

Three proposals are presented in the HMT review: 1)Abolish the HMT and Fund Harbor Maintenance Using General Government Revenue; or 2) Abolish the HMT and Fund Harbor Maintenance Using an Increase in the Diesel Fuel Excise Tax; or 3) Institute a Short Sea Shipping Tax Credit. Each proposal shares the possible outcome of increased shipping activity on the Great Lakes. A conference call among port and shipping stakeholders confirmed the likelihood of some increase in shipping activity following the incentive provided by removing the tax.

The input-output modeling tool IMPLAN® provides a general estimate of the economic impact of possible increase in shipping activity. For purposes of estimation, the impact of an assumption of $1 million in increased shipping output for the economy of the State

of Minnesota is reported in 2005 dollars. Value Added, Employment and Output measures are modeled here with three effects, sometimes referred to as "rounds of spending": the direct effect (the initial new spending), the indirect effect (additional inter-industry spending), and an induced effect (additional household expenditure from the direct and indirect impact). The modeling shows that for every million dollars in increased maritime shipping activity, the economy of Minnesota could see an additional total Value Added impact of $581,519, an additional $500,000 in Output, and almost eight new jobs added to the economy.

The report concludes by noting: Analysis of the federal assessment structure for current Great Lakes maritime commerce shows an array of 119 various fees, duties, taxes and other assessments. Among these the Harbor Maintenance Tax deserves special and immediate attention for reform as a failed taxation system that arose out of the "user fee fever" of the 1980s.

A substantial portion of the HMT's tax base was found to be unconstitutional by the U.S. Supreme Court, leaving an unbalanced, unfair and excessive tax in effect. The Harbor Maintenance Trust Fund continues to grow well beyond the amounts expended for harbor maintenance. At least nine attempts have been made to reform this failed system in the past ten years, none of which were successful. It's time for Congress to abolish this failed method of taxation and replace the revenue stream with funds from either the Treasury's general fund or funds generated by an increase in the diesel fuel excise tax.

Chapter 1: Introduction

1.1 Research issue.

This project inventories the tax impact on the Great Lakes marine transportation system imposed by federal regulations. This project also identifies the unique tax burdens placed on the commercial maritime regulatory process in the Great Lakes, and presents an analysis of the Great Lakes maritime tax structure focusing on its most significant tax, the Harbor Maintenance Tax (HMT). Finally this project discusses possible changes to the current tax structure to improve the efficiency of port maintenance tax collection and expenditure; as well as to improve intermodal transportation fuel efficiency.

This study was funded by a grant from the Great Lakes Maritime Research Institute.

The contract for this study has the following project description:

> *This topic addresses the tax impact on the Great Lakes (GL) marine transportation system (MTS) imposed by federal tax codes and regulations.*
>
> *This project will attempt to identify the unique tax burdens placed on the commercial maritime regulatory process in the Great Lakes.*
>
> *This project proposes to recommend methods for decreasing the tax impact on Great Lakes shipping from both a tax burden and a compliance standpoint and to offer a viable option for government to help ease the tax complexities that shipping companies face.*

The primary public policy intent of this study is to advance understanding of the tax structure of commercial maritime transportation on the Great Lakes.

The primary purpose of this study for the research team at the Labovitz School of Business and Economics is to accomplish the contract's goals and objectives, and to further the discussion of the possibilities for increasing efficiency in the relationship between tax policy and commercial maritime operations.

1.2 Background.

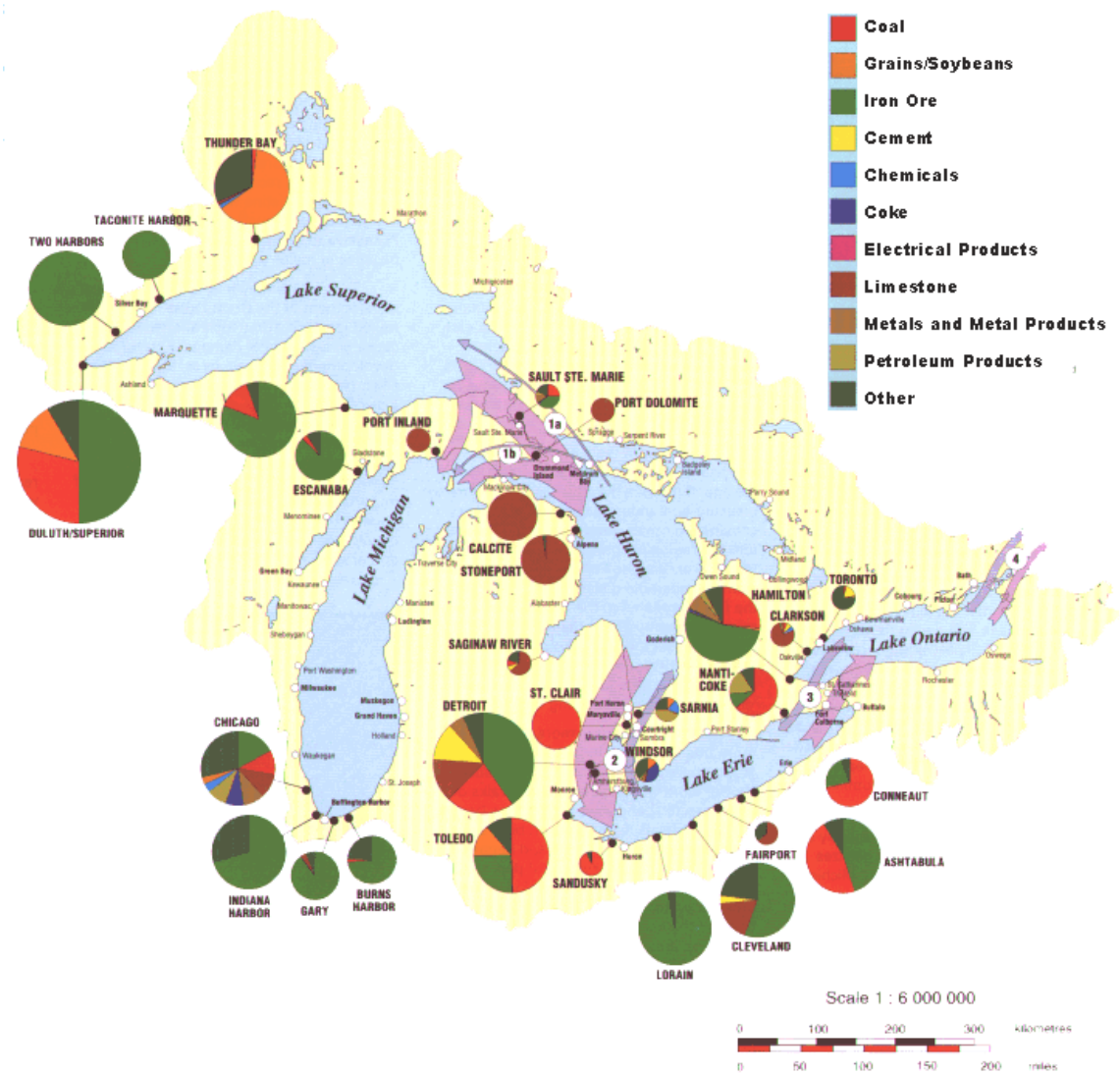

Figure 1: Overview of Ports on the Great Lakes: Waterborne Commerce, Cargo Volume by Port in Tonnes, 1990. *Source:* Great Lakes: An Environmental Atlas and Resource Book, EPA.

The Center for Naval Analysis notes that responsibility for managing U.S. ports and its waterways system is spread among various federal agencies and stakeholders. Management is fragmented and there is no mechanism for coordination [4]. The Center further indicates that unless all entities work together in unison, it will not be possible to ensure that all ships and cargoes can move efficiently into and out of U.S. ports, global prices will rise, and U. S. global competitiveness will drop.

Support for such a reformed tax system can be found with Great Lakes United, an organization devoted to sustainable development on the Great Lakes. In their

presentation, “A Transportation Infrastructure to Sustain Our Economy” at the Moving Towards a Sustainable Great Lakes Conference held in 2003, the organization notes,

> “One way to sustainabl[y] develop the commercial navigation industry that should be given serious consideration is through tax reform. While this is a discussion unto itself, tax reform holds the potential to increasingly support the most fuel-efficient means of moving bulk goods as water levels change because of, largely, fossil fuel consumption itself. In other words, with tax reform, the role of commercial navigation could become more and more important…” [5].

The Great Lakes Commission’s Strategic Plan notes that in order to promote “[s]trong and growing commercial navigation on the Great Lakes and St. Lawrence Seaway” one important objective is to “promote the efficient and cost-effective movement of goods and people at the domestic and U.S./Canadian levels by eliminating infrastructure and policy barriers” [6]. One of these policy barriers is the myriad of taxes imposed on Great Lakes shipping.

Unfortunately, the importance of minimizing policy barriers on Great Lakes shipping has not been universally accepted. The Bush Administration’s fiscal year 2006 Budget contained a provision which would have imposed tolls on the U.S. portion of the St. Lawrence Seaway. As Minnesota Congressman Mark Kennedy noted,

> We believe this new fee will negatively impact agricultural exports from our states. Affordable commercial navigation is important to midwest farmers. Millions of tons of agricultural products such as wheat, corn, soybeans, oats, barley, peas and beans are exported through the Seaway each year. The Great Lakes shipping industry estimates that the toll proposal will add 30 cents to the cost of each ton of export grain. International grain sales are often won or lost by pennies per ton.
>
> Cost effective shipping is important to other economic sectors as well. The region's steel industry is heavily dependent upon the Seaway. In turn, the North American automotive industry relies upon cost effective steel products. At Great Lakes ports, thousands of Americans are employed on the docks as longshoremen, crane operators, warehousemen, truckers, cargo inspectors, tug operators, vessel agents, marine pilots, etc.
>
> The toll proposal discriminates against the Great Lakes navigation system and the shippers that rely upon it. In fact, it is the only new maritime user fee in the Administration's budget. Great Lakes ports compete with those on the East Coast and Gulf of Mexico for the handling of import and export cargoes. A new tax imposed exclusively on Great Lakes shipping will disadvantage products from our region, and possibly result in a diversion of cargo to other ports with a resulting loss of jobs on our docks.
>
> It is important to note that Great Lakes navigation system users are already paying

a user fee to support the operation and maintenance of the St. Lawrence Seaway (and other navigation infrastructure). The Harbor Maintenance Tax (HMT) was enacted in 1986 for that specific purpose. It is currently assessed at all Great Lakes and coastal ports. Revenue from the tax is deposited to the Harbor Maintenance Trust Fund, which today carries a surplus balance of $459 million. New Seaway tolls would represent double taxation of navigation system users for the same purpose [7].

Such a proposal takes a step away from strategic regulation of Great Lakes shipping, and instead looks at this enterprise as a revenue source to be utilized elsewhere within the government's budget. The proposed new toll on Great Lakes shipping, which in addition to dramatically increasing the tax cost to ship products through the lakes, would also include yet another layer of compliance for shipping companies. Rather than imposing such a new toll in an ad hoc manner, our research would propose a streamlined, simplified method for taxing shipped product. Chapter 3 of this report continues this discussion of possible changes to the tax structure.

1.3 Relevant literature

Data

Data sources for background to the tax structure presented in this report were derived from the following:

- United States. Maritime Administration. Dept of Transportation. Industry Survey Series: Great Lakes Operators 2005. Nov. 2005. 18 May 2006 http://www.marad.dot.gov/marad_statistics/ [8].

  This reports findings of a survey (conducted by the MARAD) of the U.S.-flag carriers who account for 93 percent of the 2004 domestic (lake) Great Lakes traffic, and includes data on annual cargo, industries supplied to, carriers' investment preferences. This work supplies data on annual cargo transported on the GL, and industries served.

- United States General Accounting Office. Maritime Industry: Federal Assessments Levied on Commercial Vessels (GAO/RCED-93-65FS, Mar. 5, 1993, and especially the supplement to this report, Commercial Maritime Industry: Supplemental Information on Federal Assessments (GAO/RCED-99-260S) [9].

  This key resource, and conversations with the U.S. Department of the Treasury, supplied the information from which data transcription for the assessment inventory was made.

- United States General Accounting Office. Commercial Maritime Industry: Updated Information on Federal Assessments, 09/16/1999, GAO/RCED-99-260) [10].

- United States General Accounting Office. Marine Transportation: Federal Financing and a Framework for Infrastructure Investments (GAO-02-1033 September 2002) [11].

- Great Lakes Waterborne Commerce. United States. Institute for Water Resources. Department of the Army Corps of Engineers. Waterborne Commerce of the US. 2004. 23 May 2006 [12].

  This source supplied tables about commerce on the Great Lakes, and includes definitions, details on freight traffic, and in specific data on ton-mileage/freight-tons of foreign and domestic freight carried on the Great Lakes.

Research Contributions

Researchers whose discussions furthered our understanding of the specifics of stakeholders' positions, such as the port authorities, vessel operators/carriers, terminal operators, trucking companies, warehouse or container freight station operators, railroads, importers and exporters, freight forwarders, cruise line operators, contract security forces, labor groups and dock workers, and trade associations include the following:

For background on Great Lakes Marine Transportation Systems:

- Stewart, Richard D. Great Lakes Marine Transportation System. Great Lakes Maritime Research Institute. 10 Mar. 2006 [13].

  This white paper was prepared for the Midwest Freight Corridor Study and reports current operations, strategies for optimizing the GLMTS and GL challenges (physical and non-physical, regulations).

- The Cleveland Trans-Erie Ferry Feasibility Study May 20, 2004 [14].

  The Cleveland-Cuyahoga County Port Authority authorized a feasibility study concerning the commencement of a ferry service on Lake Erie. An analysis of US and Canadian laws was done, and included helpful discussions such as Part 1: US laws and regulations, HMT, Dept. of Homeland Security and marine safety; Part 2: Canadian laws; Part 3: Index of US and Canadian laws most applicable to implementation of ferry service; Part 4: Three legal memoranda and special focus on HMT, truck cabotage and the Canadian Coasting Trade Act.

For St. Lawrence Seaway Traffic Report:

- St. Lawrence Seaway Management, Transport Canada and St. Lawrence Seaway Devel . US Dept of Transportation. St. Lawrence Seaway Traffic Report 2005 Navigation Season. 2005. 17 May 2006 www.greatlakes-seaway.com [15].

  Including St. Lawrence Seaway combined data tables on toll traffic, cargo, and ports.

For Environment Advantages of Waterborne Transportation:

- United States. Maritime Administration. Dept of Transportation. Environmental Advantages of Inland Barge Transportation. 1994 [16].

  Including discussion of energy efficiency of barge transportation results in environmental benefits and fuel savings.

- United States. Maritime Administration. Dept of Transportation. Transportation Mode Comparison Energy Environment Efficiency. 7 Jan. 2002. 6 June 2006 http://www.mvr.usace.army.mil/navdata/tr-comp.htm [17].

  Including discussion of relative energy efficiencies.

For status of HMTF:

- United States. Institute for Water Resources. Army Corps of Engineers. Status of the Harbor Maintenance Trust Fund Fiscal Years 2000, 2001, 2002. 12 June 2006 [18].

- And also conversation and data from the U.S. Department of Treasury for updated HMT revenues and transfers

For Bureau of Transportation Financials:

- United States. Bureau of Transportation Statistics. Dept of Transportation. Government Transportation Financial Statistics 2003. 2004. 9 June 2006 [19].

For articles on HMT:

- United States. Congressional Budget Office. Impose a New Harbor-Maintenance Fee. 12 June 2006 http://www.cbo.gov/bo2005/bo2005_showhit1.cfm?index=300-03 [20].

- The U.S Harbor Maintenance Tax Controversy: Is there a solution?
  Kumar, Shashi N. " The U.S Harbor Maintenance Tax Controversy: Is There a Solution?" International Journal of Maritime Economics 4 (2002): 149-163. 12 June 2006 [21].

- Short Sea Vessel Service and Harbor Maintenance Tax
  National Ports & Waterways Institute. Short Sea Vessel Service and Harbor Maintenance Tax. Oct. 2005. Short Sea Shipping Cooperative Program, SCOOP; University of New Orleans. 9 June 2006 [22].

For dredging information:

- Duluth Superior Dredging Report from United States. Detroit District. Army Corps of Engineers. Annual Report/Contract Dredging Report. 10 Feb. 2006. 26 July 2006 [23].

- The National Dredging Needs Study of Ports and Harbors
  Planning and Management Consultants, Ltd Illionis. The National Dredging Needs Study of Ports and Harbors. 12 June 2006 [24].

1.4 Methodology, basic approach

This project presents an inventory of taxes, fees, duties and assessments on Great Lakes maritime commerce. An analysis of the current scenario variables presents assessments in relative significance. The project then recommends methods for decreasing the tax impact on Great Lakes shipping from both a tax burden and a compliance standpoint and offers a viable option for government to help ease the tax complexities that shipping companies face.

The project conducts a review of current tax regulations as applied to Great Lakes shipping and provides proposals for an improved tax system for Great Lakes shipping.

1.5 Report organization

This report is divided into the following Chapters:

Chapter 1: Introduction
Chapter 2: Great Lakes Maritime Tax Inventory
Chapter 3: Harbor Maintenance Tax Review
Chapter 4: Potential Economic Impacts of the Research Results
Chapter 5: Conclusion

The report includes a reference section which includes citations for all sources mentioned in the body of the report. This report also includes four appendices.

Tables and figures are listed separately in the Contents pages as List of Tables and List of Figures and follow chapter numbers plus sequential table or figure number.

Chapter 2: Great Lakes Maritime Tax Inventory

2.1 Tax data

Data include individual assessments currently levied on the commercial maritime industry by federal agencies (119 assessments).

Note: Most variables have footnotes. The database is presented in Appendix A to this report (without notes) and the full data is available in digital format from the Great Lakes Maritime Research Institute.

Each data record is made up of the following variables:

- Assessment name
- Description of the assessment
- Agency that levies the assessment
- Type of service provided, tax, or duty associated with assessment
- Type of vessel the assessment is levied on
- Commerce type of vessel the assessment is levied on
- Flag type of vessel the assessment is levied on
- Payor of the assessment
- Entity that collects the assessment
- Type of fund that receives the collections
- Entity that uses the collections
- Formula and frequency of assessment
- Collection amounts for FY 1989 through FY 1991, FY 1996 through FY 1998, and estimated collections for FY 1999
- Collection limitations
- Laws and regulations

2.2 Analysis of Tax Data

An overview of federal agencies represented in this inventory shows the following rank order by number of assessments:

2.1 Overview of Federal Agencies Ranked by Number of Assessment on Maritime Commerce

Coast Guard, U.S. Dept. of Transportation	25
National Marine Fisheries Services, National Oceanic and Atmospheric Administration	23
Federal Maritime Commission	17
Panama Canal Commission	17
Customs Service, U.S. Treasury	13
Maritime Administration, U.S. Dept. of Transportation	8
Federal Communications Commission	8
Internal Revenue Service, U.S. Treasury	3
Animal, Plant, and Health Inspection Service, U.S. Dept. of Agriculture	3
National Marine Fisheries Services, National Oceanic and Atmospheric Administration	1
Grain Inspection, Packers, and Stockyards Administration, U.S. Dept. of Agriculture	1
Centers for Disease Control and Prevention, U.S. Dept. Health and Human Services	1

Detailed views of these data presented in this report include the following breakouts:

1) Federal Commercial Maritime Assessments Other than Great Lakes
   Federal Commercial Maritime Assessments Great Lakes Only
2) Top Collections Assessments
3) Tables of Assessments by Stakeholder
4) Kinds of Assessments Levied on Great Lakes Commerce
5) HMT Tables

1) Federal Commercial Maritime Assessments Other than Great Lakes

Table 2.2: Federal Commercial Maritime Assessments Other than Great Lakes

Panama Canal Commission (PCC)			
Name of Assessment:	**Description of Assessment:**	**Collected by:**	**Payor:**
Docking /Undocking Tug Service Fee	For providing tug services for vessels docking, undocking, or shifting at berth (a)	PCC	Owner or operator
Extraordinary Transit Tug Service Fee	For providing tug services for vessels with physical or operating deficiencies at the time of transit and for vessels that request tug service (a)	PCC	Owner or operator
General Tug Service Fee	For towing through the Canal and other transit tug services not covered by a fixed fee (a)	PCC	Owner or operator
Handling Lines for Docking After Transit Service Fee	For PCC deckhands to assist the vessel crew in handling the cables that guide the vessel while docking after transit of the Canal (a)	PCC	Owner or operator
Handling Tug Line Service Fee	For PCC deckhands placed on board the vessel to receive and secure the ropes from the tugboats to the vessel (a)	PCC	Owner or operator
Handling Vessel Lines Service Fee	For PCC deckhands to connect cables attached to locomotives located on the side walls of Panama Canal locks to vessels transiting the locks (a)	PCC	Owner or operator
Launch Service Fee-Dredging Division	For Dredging Division launches used to transport officers of the National Port Authority of Panama or other Canal users as per agreement with the National Port Authority to assist small vessels in lieu of a tug and to visit vessels for inspection purposes as authorized by PCC (a)	PCC	Owner or operator
Launch Service Fee-Marine Bureau	For Marine Bureau launches used to transport officers of the National Port Authority of Panama or other canal users as per agreement with the National Port Authority to assist small vessels in lieu of a tug and to visit vessels for inspection purposes as authorized by PCC (a)	PCC	Owner or operator
Offshore Pilotage Fee	For requiring or requesting a PCC pilot to board or debark a vessel outside the Atlantic breakwater (a)	PCC	Owner or operator
Pilotage Fee at the Gamboa Mooring	For providing a PCC pilot at the PCC mooring facility at Gamboa (a)	PCC	Owner or operator
Pilotage Fee During Dock Trial	For providing a PCC pilot for vessels undergoing a dock trial (a) Note: Testing a vessel's engine while it is securely docked at a pier to see if repairs will hold is an example of a dock trial.	PCC	Owner or operator
Port Pilotage Fee	For providing a PCC pilot to dock, moor, or anchor a vessel after	PCC	Owner or

	transiting the Canal or to pilot the vessel beyond Canal waters (a)		operator
Sea Tug Service	For providing tug services involving a trip to sea (a)	PCC	Owner or operator
Special Ad-measurement Service Fee	For determining a vessel's Panama Canal tonnage and issuing a Panama Canal tonnage certificate when the vessel arrives without proper documentation (a)	PCC	Owner or operator
Standard Tug Service	For providing tug services to vessels coming into and out of each set of locks and through Gaillard Cut (a)	PCC	Owner or operator
Tolls For Transit	For utilizing the Panama Canal Waterway (a)	PCC	Owner or operator
Transit Booking Fee	For reserving a time for vessels to transit the Panama Canal (a)	PCC	Owner or operator

2) Federal Commercial Maritime Assessments Great Lakes Only:

For the list of assessments that apply to the Great Lakes Only, please see the material in Appendix A to this report. For a version of these data that includes all variables, including footnotes, in digital or paper form, please see the Great Lakes Maritime Institute or the University of Minnesota Duluth Labovitz School Bureau of Business and Economic Research.

3) Top Collections Assessments

Table 2.3: Top Ten Revenue Producing Commercial Maritime Federal Assessments

Name of Assessment:	Description of Assessment:	Collections in Thousands 1999 (est.)
Customs Duties	Total duties are calculated by summing the total dollars collected for consumption entries, warehouse withdrawals, mail entries, passenger baggage entries, crew member baggage entries, military baggage entries, informal entries, vessel repair entries, and other duties. Note: The "other duties" consist of duties in which payments of supplemental duties are recorded posted as cash receipts.	$18,030,233
Merchandise Processing Fee	For processing documentation for imported cargo that is brought into the United States	$924,250
Harbor Maintenance Fee	For the loading or unloading of imported commercial cargo from commercial vessels at a U.S. port for which federal funds have been used since 1977 for construction, maintenance, or operation (Note: This assessment does not apply to ports de-authorized by federal law before 1985.)	$598,231
Tolls For Transit	For utilizing the Panama Canal Waterway	$567,239
Air/Sea Passenger fee	This fee is levied for inspection and processing services that are provided for all passengers aboard commercial vessels or aircraft arriving in the U.S. Customs territory from a place outside the United States.	$246,385
Inland Waterways Fuel Tax	A tax imposed on any liquid used as a fuel on certain U.S. inland and intercoastal waterways Note: Collected taxes are used for construction and rehabilitation of the inland waterways.	$120,000

Guarantee Fee for MARAD's Title XI Program	For covering a portion of the principal and interest on guaranteed financing in the event of a default and administrative, custodial, and insurance costs associated with defaulted equipment Note: Collections specifically reimburse the agency for the potential expenses incurred in the event of a default.	$100,000
Vessel Tonnage Tax	A tax on vessels entering the United States from any foreign port or place (Note: Tax is based on the net tonnage of the vessel, as well as the origin of the vessel's voyage).	$67,989
Docking /Undocking Tug Service Fee	For providing tug services for vessels docking, undocking, or shifting at berth	$53,300
Handling Lines for Docking After Transit Service Fee	For PCC deckhands to assist the vessel crew in handling the cables that guide the vessel while docking after transit of the Canal	$40,400

4) Tables of Assessments by Stakeholder

Table 2.4: Great Lakes Assessments Paid by Passenger and Non-Passenger Vessel Operators			
Name of Assessment:	**Type of Service:**	**Collected by:**	**1999 (est.)**
Harbor Maintenance Fee	Miscellaneous	Customs Service	598,231
Inland Waterways Fuel Tax	Taxes	IRS	120,000
Vessel Tonnage Tax	Taxes	Customs Service	67,989
Ship Passengers International Departure Tax	Taxes	IRS	18,543
Collection of Fees for Sanitation Inspection of Cruise Ships	Physical Services	HHS: USPHS (CDC)	1,300
Stowage Examination Fee	Physical Services	USDA: GIPSA	1,175
Reimbursement of Travel and Subsistence Costs for Overseas Vessel Inspections	Physical Services	DOT: Coast Guard	1,000
Ship Radio Station License Regulatory Fee	Admin. Proc. & Assoc. Services	FCC	508
International Telecommunications Settlements	Physical services	FCC	435
Ship Radio Station License Application Fee	Admin. Proc. & Assoc. Services	FCC	427
Certification Fee for Payment of Vessel Tonnage Tax and Certify Admeasurment by Foreign Vessels	Admin. Proc. & Assoc. Services	Customs Service	88
Entry of Vessel from Foreign Port Fee	Admin. Proc. & Assoc. Services	Customs Service	72
Clearance of Vessel to Foreign Port Fee	Admin. Proc. & Assoc. Services	Customs Service	56
New Agreement Filings Requiring Commission Review	Admin. Proc. & Assoc. Services	FMC	48
FMC: Special Permission Application Fee	Admin. Proc. & Assoc. Services	FMC	43
Agreement Filing for Terminal and Carrier Exempt Agreements Application Fee	Admin. Proc. & Assoc. Services	FMC	25
Ageement Filing Under Delegated Authority Application Fee	Admin. Proc. & Assoc. Services	FMC	24
Agreement Amendment Filing Requiring Commission Action	Admin. Proc. & Assoc. Services	FMC	17
Radio Communications Equipment Carriage Exemption Processing Fee	Admin. Proc. & Assoc. Services	FCC	10
FMC: Special Docket Application Fee	Admin. Proc. & Assoc. Services	FMC	9
Filing fee for service contracts and amendments	Admin. Proc. & Assoc. Services	FMC	8
Receiving Post Entry	Admin. Proc. & Assoc. Services	Customs Service	6
Receiving Manifest and Granting Permit to Unlade (s)	Admin. Proc. & Assoc. Services	Customs Service	5

Table 2.4: Great Lakes Assessments Paid by Passenger and Non-Passenger Vessel Operators			
Issuance Fee for a Permit to Proceed (p)	Admin. Proc. & Assoc. Services	Customs Service	4
Petition for Rulemaking Fee	Admin. Proc. & Assoc. Services	FMC	1
Formal Complaint Filing Fee	Admin. Proc. & Assoc. Services	FMC	1
Additions and changes to filer registration	Admin. Proc. & Assoc. Services	FMC	1
Name of Assessment:	Type of Service:	Collected by:	1999 (est.)
Harbor Maintenance Fee	Miscellaneous	Customs Service	598,231
Inland Waterways Fuel Tax	Taxes	IRS	120,000
Vessel Tonnage Tax	Taxes	Customs Service	67,989
Ship Passengers International Departure Tax	Taxes	IRS	18,543
Collection of Fees for Sanitation Inspection of Cruise Ships	Physical Services	HHS: USPHS (CDC)	1,300
Stowage Examination Fee	Physical Services	USDA: GIPSA	1,175
Reimbursement of Travel and Subsistence Costs for Overseas Vessel Inspections	Physical Services	DOT: Coast Guard	1,000
Ship Radio Station License Regulatory Fee	Admin. Proc. & Assoc. Services	FCC	508
International Telecommunications Settlements	Physical services	FCC	435
Ship Radio Station License Application Fee	Admin. Proc. & Assoc. Services	FCC	427
Certification Fee for Payment of Vessel Tonnage Tax and Certify Admeasurment by Foreign Vessels	Admin. Proc. & Assoc. Services	Customs Service	88
Entry of Vessel from Foreign Port Fee	Admin. Proc. & Assoc. Services	Customs Service	72
Clearance of Vessel to Foreign Port Fee	Admin. Proc. & Assoc. Services	Customs Service	56
New Agreement Filings Requiring Commission Review	Admin. Proc. & Assoc. Services	FMC	48
FMC: Special Permission Application Fee	Admin. Proc. & Assoc. Services	FMC	43
Agreement Filing for Terminal and Carrier Exempt Agreements Application Fee	Admin. Proc. & Assoc. Services	FMC	25
Ageement Filing Under Delegated Authority Application Fee	Admin. Proc. & Assoc. Services	FMC	24
Agreement Amendment Filing Requiring Commission Action	Admin. Proc. & Assoc. Services	FMC	17
Radio Communications Equipment Carriage Exemption Processing Fee	Admin. Proc. & Assoc. Services	FCC	10
FMC: Special Docket Application Fee	Admin. Proc. & Assoc. Services	FMC	9
Filing fee for service contracts and amendments	Admin. Proc. & Assoc. Services	FMC	8
Receiving Post Entry	Admin. Proc. & Assoc. Services	Customs Service	6
Receiving Manifest and Granting Permit to Unlade (s)	Admin. Proc. & Assoc. Services	Customs Service	5

Table 2.4: Great Lakes Assessments Paid by Passenger and Non-Passenger Vessel Operators			
Issuance Fee for a Permit to Proceed (p)	Admin. Proc. & Assoc. Services	Customs Service	4
Petition for Rulemaking Fee	Admin. Proc. & Assoc. Services	FMC	1
Formal Complaint Filing Fee	Admin. Proc. & Assoc. Services	FMC	1
Additions and changes to filer registration	Admin. Proc. & Assoc. Services	FMC	1

Table 2.5: Great Lakes Assessments Paid by Passenger and Non-Passenger Owners			
Name of Assessment:	**Type of Service:**	**Collected by:**	**1999 (est.) U.S. Totals in thousands**
Guarantee Fee for MARAD's Title XI Program	Miscellaneous	DOT: MARAD	$100,000
Agricultural Quarantine and Inspection User Fee (for commercial vessels over 100 net tons)	Physical Services	Customs Service	$23,386
Commercial Vessel Fee	Physical services	Customs Service	$18,973
Direct User Fees for Inspection and Examination of U.S. or Foreign Commercial Vessels	Physical Services	DOT: Coast Guard	$10,700
Approval of Exchange of Certificate of Documentation Requiring Mortgage Consent	Admin. Proc. & Assoc. Services	DOT: Coast Guard	$2,500
Fisheries Obligation Guarantee Program Guarantee Fee	Miscellaneous	NOAA: NMFS	$1,735
Collection of Fees for Sanitation Inspection of Cruise Ships	Physical Services	HHS: USPHS (CDC)	$1,300
Reimbursement of Travel and Subsistence Costs for Overseas Vessel Inspections	Physical Services	DOT: Coast Guard	$1,000
Title XII War Risk Interim Binder Fees	Miscellaneous	American War Risk Agency	$800
Barge /Bulk Carrier Fee	Physical services	Customs Service	$791
Evidence of Financial Responsibility for Water Pollution Certificate Fee	Admin. Proc. & Assoc. Services	DOT: Coast Guard	$772
Ship Radio Station License Regulatory Fee	Admin. Proc. & Assoc. Services	FCC	$508
International Telecommunications Settlements	Physical services	FCC	$435
Ship Radio Station License Application Fee	Admin. Proc. & Assoc. Services	FCC	$427
New Agreement Filings Requiring Commission Review	Admin. Proc. & Assoc. Services	FMC	$48
FMC: Special Permission Application Fee	Admin. Proc. & Assoc. Services	FMC	$43
Agreement Filing for Terminal and Carrier Exempt Agreements Application Fee	Admin. Proc. & Assoc. Services	FMC	$25

Agreement Filing Under Delegated Authority Application Fee	Admin. Proc. & Assoc. Services	FMC	$24
Agreement Amendment Filing Requiring Commission Action	Admin. Proc. & Assoc. Services	FMC	$17
COFR for Indemnification of Passengers for Nonperformance of Transportation Application Fee	Admin. Proc. & Assoc. Services	FMC	$15
Radio Communications Equipment Carriage Exemption Processing Fee	Admin. Proc. & Assoc. Services	FCC	$10
FMC: Special Docket Application Fee	Admin. Proc. & Assoc. Services	FMC	$9
COFR to Meet Liability Incurred for Death or Injury to Passengers or Other Persons on Voyages Application Fee	Admin. Proc. & Assoc. Services	FMC	$8
Foreign Transfer of Ownership or Registry Application Fee	Admin. Proc. & Assoc. Services	DOT: MARAD	$7
Foreign Transfer of Ownership Pursuant to MARAD Contracts	Admin. Proc. & Assoc. Services	DOT: MARAD	$7
Foreign Fishing Permit Application Fee	Admin. Proc. & Assoc. Services	NOAA: NMFS	$4
Formal Complaint Filing Fee	Admin. Proc. & Assoc. Services	FMC	$1
Petition for Rulemaking Fee	Admin. Proc. & Assoc. Services	FMC	$1
Aquaculture Permit	Admin. Proc. & Assoc. Services	NOAA: NMFS	$1

Table 2.6: Great Lakes Assessments Paid by Passenger and Non-Passenger Exporters

Name of Assessment:	Type of Service:	Collected by:	1999 (est.) U.S. Totals in thousands
Customs Duties	Miscellaneous	Customs Service	$18,030,233
Merchandise Processing Fee	Admin. Proc. & Assoc. Services	Customs Service	$924,250
Phytosanitary Certificate Fee for Plants and Plant Products	Physical Services	USDA: APHIS	$4,791
Export Health Certificate Endorsement Fees for Animals	Physical Services	USDA: APHIS	$3,823
Stowage Examination Fee	Physical Services	USDA: GIPSA	$1,175

Table 2.7: Great Lakes Assessments Paid by Passenger and Non-Passenger Importers			
Name of Assessment:	**Type of Service:**	**Collected by:**	**1999 (est.) U.S. Totals in thousands**
Customs Duties	Miscellaneous	Customs Service	$18,030,233
Merchandise Processing Fee	Admin. Proc. & Assoc. Services	Customs Service	$924,250
Harbor Maintenance Fee	Miscellaneous	Customs Service	$598,231
Stowage Examination Fee	Physical Services	USDA: GIPSA	$1,175

Table 2.8: Great Lakes Assessments Paid by Passenger and Non-Passenger Other Stakeholders				
Name of Assessment:	**Payor:**	**Type of Service:**	**Collected by:**	**1999 (est.) U.S. Totals in thousands**
Harbor Maintenance Fee	foreign trade zone user, domestic shipper, or operator of commercial passenger vessel	Miscellaneous	Customs Service	$598,231
Air/Sea Passenger fee	Individual passenger	Physical services	Customs Service	$246,385
Export Health Certificate Endorsement Fees for Animals	broker	Physical Services	USDA: APHIS	$3,823
International Telecommunications Settlements	U.S. ship owners utilizing telecommunication services off foreign coasts	Physical services	FCC	$435
New Agreement Filings Requiring Commission Review	marine terminal operator	Admin. Proc. & Assoc. Services	FMC	$48
FMC: Special Permission Application Fee	NVOCC	Admin. Proc. & Assoc. Services	FMC	$43
Agreement Filing for Terminal and Carrier Exempt Agreements Application Fee	marine terminal operator	Admin. Proc. & Assoc. Services	FMC	$25
Agreement Filing Under Delegated Authority Application Fee	marine terminal operator	Admin. Proc. & Assoc. Services	FMC	$24

Agreement Amendment Filing Requiring Commission Action	marine terminal operator	Admin. Proc. & Assoc. Services	FMC	$17
COFR for Indemnification of Passengers for Nonperformance of Transportation Application Fee	charterer	Admin. Proc. & Assoc. Services	FMC	$15
FMC: Special Docket Application Fee	NVOCC	Admin. Proc. & Assoc. Services	FMC	$9
COFR to Meet Liability Incurred for Death or Injury to Passengers or Other Persons on Voyages Application Fee	charterer	Admin. Proc. & Assoc. Services	FMC	$8
Foreign Fishing Permit Application Fee	representative of the foreign fishing nation	Admin. Proc. & Assoc. Services	NOAA: NMFS	$4
Formal Complaint Filing Fee	shipper, or other interested party	Admin. Proc. & Assoc. Services	FMC	$1
Petition for Rulemaking Fee	shipper, or other interested party	Admin. Proc. & Assoc. Services	FMC	$1

5) Kinds of Assessments Levied on Great Lakes Commerce

Table 2.9: Tax Assessments on Great Lakes Maritime Commerce

Assessment Name	Type of Service	1999 U.S. Totals Est. in Thousands
Harbor Maintenance "Fee" [declared a tax by U.S. Supreme Court, 1998]	Miscellaneous	$598,231
For the loading or unloading of imported commercial cargo from commercial vessels at a U.S. port for which federal funds have been used since 1977 for construction, maintenance, or operation (Note: This assessment does not apply to ports de-authorized by federal law before 1985.)		
Inland Waterways Fuel Tax (Not applied to Great Lakes per se but applied to inland and intercoastal waterways)	Taxes	$120,000
A tax imposed on any liquid used as a fuel on certain U.S. inland and intercoastal waterways Note: Collected taxes are used for construction and rehabilitation of the inland waterways.		
Vessel Tonnage Tax	Taxes	$67,989
A tax on vessels entering the United States from any foreign port or place (Note: Tax is based on the net tonnage of the vessel, as well as the origin of the vessel's voyage).		
Ship Passengers International Departure Tax	Taxes	$18,543
A tax imposed on each passenger who embarks from or disembarks in a U.S. port and whose voyage extends over 1 or more nights (more than 24 hours)		

Table 2.10: Duty Assessments on Great Lakes Maritime Commerce

Assessment Name	Type of Service	1999 U.S. Totals Est. in Thousands
Customs Duties	Miscellaneous	$18,030,233

Total duties are calculated by summing the total dollars collected for consumption entries, warehouse withdrawals, mail entries, passenger baggage entries, crew member baggage entries, military baggage entries, informal entries, vessel repair entries, and other duties. Note: The "other duties" consist of duties in which payments of supplemental duties are recorded posted as cash receipts.

Table 2.11: Fee Assessments on Great Lakes Maritime Commerce (descriptions available in the appendix matter to this report)

assessment name	type of service	1999 U.S. totals est. in thousands
Merchandise Processing Fee	Admin. Proc. & Assoc. Services	$924,250
Tolls For Transit	Physical services	$567,239
Air/Sea Passenger fee	Physical services	$246,385
Guarantee Fee for MARAD's Title XI Program	Miscellaneous	$100,000
Docking /Undocking Tug Service Fee	Physical services	$53,300
Handling Lines for Docking After Transit Service Fee	Physical services	$40,400
Transit Booking Fee	Admin. Proc. & Assoc. Services	$35,200
Agricultural Quarantine and Inspection User Fee	Physical Services	$23,386
Commercial Vessel Fee	Physical services	$18,973
Direct User Fees for Inspection and Examination of U.S. or Foreign Commercial Vessels	Physical Services	$10,700
Offshore Pilotage Fee	Physical services	$5,300
High Seas Fishing Compliance Act Permit Application	Admin. Proc. & Assoc. Services	$5,000
Phytosanitary Certificate Fee for Plants and Plant Products	Physical Services	$4,791
Export Health Certificate Endorsement Fees for Animals	Physical Services	$3,823
Approval of Exchange of Certificate of Documentation Requiring Mortgage Consent	Admin. Proc. & Assoc. Services	$2,500
Fisheries Finance Program Application Fee	Admin. Proc. & Assoc. Services	$1,735
Fisheries Obligation Guarantee Program Guarantee Fee	Miscellaneous	$1,735
Collection of Fees for Sanitation Inspection of Cruise Ships	Physical Services	$1,300
Stowage Examination Fee	Physical Services	$1,175
Launch Service Fee-Dredging Division	Physical services	$1,087
Reimbursement of Travel and Subsistence Costs for Overseas Vessel Inspections	Physical Services	$1,000
Title XII War Risk Interim Binder Fees	Miscellaneous	$800
Barge /Bulk Carrier Fee	Physical services	$791
Evidence of Financial Responsibility for Water Pollution Certificate Fee	Admin. Proc. & Assoc. Services	$772
Ship Radio Station License Regulatory Fee	Admin. Proc. & Assoc. Services	$508
Ship Radio Station License Application Fee	Admin. Proc. & Assoc. Services	$427
Bluefin Tuna Permit Application Fee	Admin. Proc. & Assoc. Services	$414
Special Ad-measurement Service Fee	Physical services	$240
Coastal Migratory Pelagic Fish Permit Application Fee	Admin. Proc. & Assoc. Services	$97

Certification Fee for Payment of Vessel Tonnage Tax and Certify Ad-measurement by Foreign Vessels	Admin. Proc. & Assoc. Services	$88
Entry of Vessel from Foreign Port Fee	Admin. Proc. & Assoc. Services	$72
Atlantic Swordfish Permit Application Fee	Admin. Proc. & Assoc. Services	$63
Clearance of Vessel to Foreign Port Fee	Admin. Proc. & Assoc. Services	$56
Reef Fish Permit Application Fee	Admin. Proc. & Assoc. Services	$44
FMC: Special Permission Application Fee	Admin. Proc. & Assoc. Services	$43
Snapper-Grouper Permit Application Fee	Admin. Proc. & Assoc. Services	$36
Shark Permit (fee)	Admin. Proc. & Assoc. Services	$29
Agreement Filing for Terminal and Carrier Exempt Agreements Application Fee	Admin. Proc. & Assoc. Services	$25
Agreement Filing Under Delegated Authority Application Fee	Admin. Proc. & Assoc. Services	$24
Groundfish Endorsements Permit	Admin. Proc. & Assoc. Services	$23
Marine Mammal Authorization Program Registration Fee	Admin. Proc. & Assoc. Services	$22
Spiny Lobster Permit Application Fee	Admin. Proc. & Assoc. Services	$15
COFR for Indemnification of Passengers for Nonperformance of Transportation Application Fee	Admin. Proc. & Assoc. Services	$15
Radio Communications Equipment Carriage Exemption Processing Fee	Admin. Proc. & Assoc. Services	$10
FMC: Special Docket Application Fee	Admin. Proc. & Assoc. Services	$9
COFR to Meet Liability Incurred for Death or Injury to Passengers or Other Persons on Voyages Application Fee	Admin. Proc. & Assoc. Services	$8
Foreign Transfer of Ownership or Registry Application Fee	Admin. Proc. & Assoc. Services	$7
Foreign Transfer of Ownership Pursuant to MARAD Contracts	Admin. Proc. & Assoc. Services	$7
South Atlantic Rock Shrimp Permit	Admin. Proc. & Assoc. Services	$7
Receiving Manifest and Granting Permit to Unlade (s)	Admin. Proc. & Assoc. Services	$5
Commercial Spiny Lobster Permit	Admin. Proc. & Assoc. Services	$5
Issuance Fee for a Permit to Proceed (p)	Admin. Proc. & Assoc. Services	$4
Foreign Fishing Permit Application Fee	Admin. Proc. & Assoc. Services	$4
Pelagics Permit	Admin. Proc. & Assoc. Services	$2
Formal Complaint Filing Fee	Admin. Proc. & Assoc. Services	$1
Petition for Rulemaking Fee	Admin. Proc. & Assoc. Services	$1
Vessel Certificate of Inclusion Application Fee	Admin. Proc. & Assoc. Services	$1
Aquaculture Permit	Admin. Proc. & Assoc. Services	$1
Bottomfish /Seamount Groundfish Permit	Admin. Proc. & Assoc. Services	$1
Conciliation Service Application Fee	Admin. Proc. & Assoc. Services	$0
Declaratory Order Application Fee	Admin. Proc. & Assoc. Services	$0
Informal Procedures Application Fee	Admin. Proc. & Assoc. Services	$0

Petition for Investigation to Determine Existence of Adverse Conditions Affecting U.S.-flag Carriers	Admin. Proc. & Assoc. Services	$0
Petition for Relief for U.S.-flag Vessels Operating in Foreign-to-Foreign Trades	Admin. Proc. & Assoc. Services	$0
Petition for Section 19 Relief	Admin. Proc. & Assoc. Services	$0
Authority to Transfer Ownership of Ships Built With Construction Subsidies Application Fee	Admin. Proc. & Assoc. Services	$0
Foreign Fishing Observer Fee	Physical Services	$0
Foreign Fishing Poundage Fee	Miscellaneous	$0
Golden Crab Permit	Admin. Proc. & Assoc. Services	$0
Wreckfish Permit Application Fee	Admin. Proc. & Assoc. Services	$0

Table 2.12: Other Assessments, including Permits, Administrative Charges, and Other User Fees on Great Lakes Maritime Commerce

Assessment name	Type of Service	1999 U.S. Totals Est. in Thousands
International Telecommunications Settlements	Physical services	$435
Payment of line charges for U.S. ships communicating via foreign coast earth stations		
New Agreement Filings Requiring Commission Review	Admin. Proc. & Assoc. Services	$48
For processing new agreements that require review by the Commission		
Agreement Amendment Filing Requiring Commission Action	Admin. Proc. & Assoc. Services	$17
For processing agreement amendments that require review by the Commission		
Receiving Post Entry	Admin. Proc. & Assoc. Services	$6
For processing a report of merchandise found but not manifested for vessels entering into the U.S. Customs territory (Note: Name change only).		
Permission to Correct Clerical Errors on Service Contracts Application	Admin. Proc. & Assoc. Services	$0
For processing requests to correct clerical or administrative errors in the essential terms of a serivce contract		

6) HMT Tables

As noted above and in the references, Harbor Maintenance Trust Fund data is available only through the U.S. Treasury Bureau of Public Debt. The data from the source does not make available the answer to some interesting questions about compliance levels for the HMT, the details of how much refund activity has followed the Supreme Court decision to grant exclusion for exporters, and HMT collections by port.

Table 2.13: Harbor Trust Fund Transfers and Revenues 1988-2006

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Beginning Balance	$15,199	$9,715	$12,312	$30,254	$72,795	$120,931	$303,277	$451,385	$621,194	$866,063
Revenues:										
Harbor Maint. Tax	$144,001	$166,000	$180,493	$374,420	505,827	$628,462	$622,253	$670,532	$698,267	$735,534
Toll Receipts	$10,448	$9,806	$8,849	$9,267	$8,733	$8,739	$11,112	$173	$0	$0
Interest*	$6,528	$7,343	$8,281	$11,814	$16,502	$13,521	$12,826	$30,186	$40,870	$53,632
Net Revenue	$160,977	$183,149	$197,623	$395,501	$531,062	$650,722	$646,191	$700,891	$739,137	$789,166
Net Available	$176,176	$192,864	$209,935	$425,755	$603,571	$771,653	$949,468	$1,152,276	$1,360,331	$1,655,230
Transfers:										
Corps of Engineers	$148,000	$159,026	$159,074	$333,401	$462,229	$446,434	$476,620	$519,196	$482,126	$535,987
St. Lawrence Seaway	$9,424	$10,382	$11,397	$9,075	$10,950	$13,584	$10,765	$10,193	$9,539	$10,322
SLS Toll Rebates	$8,895	$10,977	$9,041	$10,298	$9,565	$8,074	$9,546	$1,512	$0	$0
Dept. of Transportation	$0	$0	$0	$0	$16	$160	$175	$181	$169	$193
Administrative Costs	$142	$167	$169	$186	$184	$124	$0	$0	$3,000	$3,000
Transfer to Customs										
Net Expenditures	$166,461	$180,552	$179,681	$352,960	$482,944	$468,376	$497,106	$531,082	$494,834	$549,502
Surplus/(Deficit)	$9,715	$12,312	$30,254	$72,795	$120,627	$303,277	$452,362	$621,194	$865,497	$1,105,728
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	
Beginning Balance	$1,112,241	1,289,018	$1,608,957	$1,667,642	$1,818,841	$1,873,417	$2,092,080	$2,366,263	$2,782,936	
Revenues:										
Harbor Maint. Tax	$621,500	552,835	$677,588	$721,612	$652,856	$757,994	$869,699	$1,047,862	$993,300	
Toll Receipts	$0	$0								
Interest*	$66,370	$62,766	$82,965	$89,156	$57,933	$46,524	$52,684	$74,768	$91,885	
Net Revenue	$687,870	$615,601	$760,553	$810,769	$710,789	$804,518	$922,383	$1,122,630	$1,085,185	
Net Available	$1,800,111	$1,904,619	$2,369,510	$2,478,411	$2,529,630	$2,677,935	$3,014,463	$3,488,893	$3,868,121	
Transfers:										
Corps of Engineers	$496,900	$281,202	$686,897	$643,601	$639,909	$568,900	$630,944	$687,249	$674,000	
St. Lawrence Seaway	$11,000	$11,260	$11,971	$12,975	$13,305	$13,974	$14,273	$15,707	$16,284	
SLS Toll Rebates	$0	$0								
Dept. of Transportation	$193	$200								
Administrative Costs	$3,000	$3,000								
Transfer to Customs			$3,000	$2,993	$3,000	$2,981	$2,982	$3,000	$3,000	
Net Expenditures	$511,093	$295,662	$701,869	$659,570	$656,214	$585,855	$648,200	$705,956	$693,284	
Surplus/(Deficit)	$1,289,018	$1,608,957	$1,667,641	$1,818,841	$1,873,416	$2,092,080	$2,366,263	$2,782,937	$3,174,837	

Source: Funds Accounting Branch, Financial Management Services, Department of the Treasury

* Does not include Interest Income which is not available for obligation ($229,200 in FY 1999).

**Interest" represents the total interest accrued on interest bearing securities during the fiscal year, including interest from securities that matured in FY 1998 and an estimate of interest earnings on longer-term investments. For FY 1999 the interest actually deposited in the fund was $ 53.6 million.

2.3 Challenges of Great Lakes Maritime Infrastructure: Army Corps of Engineers Dredging on the Great Lakes Ports

Table 2.15 presents comparative ACE activity data by district within the Great Lakes & Ohio River Division. District data is also presented in detail by port. Figure 2 shows the geographic distribution of districts within the division.

Figure 2: Great Lakes & Ohio River Division, Army Corps of Engineers Dredging Districts.
Source: ***http://www.lrd.usace.army.mil/***

As has been discussed in Stewart's 2003 Twin Ports Intermodal Freight Terminal Study and Fruin and Fortowsky's 2004 Modal Shifts from the Mississippi River and Duluth/Superior to Land Transportation study, beneficiaries of ACE dredging activity do not necessarily correspond with payors of the HMT. For instance, the HMT paid by the now terminated Incan Superior railcar ferry (estimated at $200,000 in 1991) delivered no benefit to this vessel requiring a loaded draft of about 17 feet in a navigation channel of 27 feet [25]. An overview of beneficiaries of the HMT follows, with detailed Great Lakes port by port totals for 2000 to 2004 amounts spent for port maintenance supported by the collections of the HMT.

Table 2.14: Total Bid Dollars by Corps of Engineers, by District in the Great Lakes & Ohio River Division, 2000-2005						
District	2000	2001	2002	2003	2004	2005
DETROIT	$10,444,958	$10,966,793	$8,475,339	$6,493,502	$5,485,298	$10,172,216
BUFFALO	$5,533,946	$5,892,469	$4,942,435	$3,157,400	$6,497,900	$4,025,160
HUNTINGTON	$141,800	$1,392,221	$1,012,881	$1,544,632	$1,922,831	$1,232,033
CHICAGO	$4,548,503	$2,784,000	-	-	-	-
LOUISVILLE	$3,463,784	$3,577,197	$3,650,087	$3,843,153	$4,053,216	-
PITTSBURGH	$334,095	$1	$2	$112,846	$1	$32,000
Total Dollars (Bid)	$587,819,249	$790,126,695	$1,013,629,099	$600,260,707	$666,377,838	$466,963,933
Source: BBER. http://www.usace.army.mil/						

Table 2.15: Buffalo District Detail, ACE Activity by Port, 2000-2004		
Year	Port	Actual $ Spent
2000	Fairport Harbor	$798,645
2000	Lorain Harbor	$361,095
2000	Huron	$334,149
2000	Dunkirk	$231,185
2000	Irondequoit Harbor	$146,899
2000	Wilson Harbor	$116,522
2000	Oak Orchard Harbor	$96,959
2000	Cleveland(Cuy.R.)	-
2000	Sandusky	-
2000	Toledo Harbor	-
2000	Toledo(River)	-
2000	TOTALS	$2,085,454
2001	Maumee River/Bay	$1,725,000
2001	Ashtabula	$660,800
2001	Fairport	$651,289
2001	Sandusky	$472,463
2001	Rochester	$464,735
2001	Toussaint	$382,724
2001	Vermilion	$204,617
2001	Cuyahoga	
2001	TOTALS	$4,561,627
2002	Toledo Maumee River	$947,867
2002	Huron	$468,111
2002	Toledo Maumee River	$385,000
2002	Dunkirk	$273,158
2002	Cuyahoga River	-
2002	Fairport	-
2002	TOTALS	$2,074,136
2003	Buffalo River & Black Rock C	$2,003
2003	Cleveland	$2,003
2003	Huron Harbor	$2,003
2003	Lorain Harbor	$2,003
2003	TOTALS	$8,012
2004	Maumee Bay	$1,542,100
2004	Cleveland Harbor	$1,376,708
2004	Maumee River	$830,600
2004	Rocky River/Vermilion Harbor	$414,958
2004	Cooley Canal/West Harbor	$410,250
2004	Conneaut Harbor	$390,724
2004	Toussaint Harbor	$218,870
2004	Buffalo River	-
2004	G. Sodus/Oak Orchard/Oswego	-
2004	Rochester Harbor	-
2004	TOTALS	$5,184,211

Chicago District		
2000	Calumet Harbor & River, Il	$2,762,289
2000	Burns Small Boat Hbr, In	$1,350,081
2000	Michigan City Hbr, In	$839,800
2000	Waukegan Harbor, Il	$434,684
2000	TOTALS	$5,386,854
2001	Calumet Harbor & River, Il	-
2001	Waukegan Harbor, Il	-
2001	TOTALS	-

Detroit District		
2000	St Clair River, Mi	$1,861,896
2000	Green Bay Harbor, Wi	$1,825,400
2000	Saginaw River, Mi	$1,471,901
2000	Holland Harbor, Mi (Inner)	$1,033,070
2000	Clinton River, Mi	$764,404
2000	Detroit River, Mi (Eo&Ll)	$754,311
2000	Duluth-Superior Hbr Mn&Wi	$705,986
2000	Two Rivers Harbor, Wi	$310,716
2000	St Joseph Harbor, Mi (8a)	$252,249
2000	Caseville Harbor, Mi (8a)	$212,156
2000	Ontonagon Harbor, Mi	$197,091
2000	Lexington Harbor, Mi (8a)	$165,275
2000	Grand Haven Hbr, Mi (Outer)	$157,885
2000	Saugatuck Harbor, Mi	$140,330
2000	Menominee Harbor, Wi	$138,365
2000	Manitowoc Harbor, Wi	$128,428
2000	Harrisville Harbor, Mi (8a)	$113,409
2000	Whitefish Point, Mi	$95,680
2000	Leland Harbor, Mi	$85,270
2000	Big Bay Harbor, Mi	$82,185
2000	Holland Harbor, Mi (Outer)	$75,589
2000	Pentwater Harbor, Mi	$73,787
2000	South Haven Harbor, Mi	$48,057
2000	Arcadia Harbor, Mi	$41,804
2000	TOTALS	$10,735,244
2001	Green Bay Harbor, Wi	$2,451,379
2001	Milwaukee County Port, Mi	$633,986
2001	Duluth-Superior Hbr Mn&Wi	$546,536
2001	Saginaw River, Mi	$427,927
2001	Ludington Harbor, Mi	$417,894
2001	Point Lookout Hbr, Mi (8a)	$409,975
2001	Manitowoc Harbor, Wi	$382,860
2001	Monroe Harbor, Mi	$341,394
2001	Little Lake Harbor, Mi	$338,023
2001	Ontonagon Harbor, Mi	$319,810
2001	Manistee Harbor, Mi	$277,328
2001	St Joseph Harbor, Mi (O)	$262,709
2001	Saugatuck Harbor, Mi	$259,141
2001	Bolles Harbor, Mi	$193,123
2001	Au Sable Harbor, Mi	$189,729
2001	St Joseph Hbr, Mi (I)	$168,614
2001	Port Sanilac Harbor, Mi	$159,562
2001	Grand Haven Harbor, Mi(O)	$148,565
2001	Saxon Harbor, Mi (8a)	$133,167
2001	North Manitou Is Hbr, Mi	$121,950

2001	Duluth Superior Hbr Mn&Wi	$118,276
2001	Cornucopia Harbor, Wi	$98,920
2001	Holland Harbor, Mi (O)	$84,888
2001	Pentwater Harbor, Mi	$82,744
2001	Leland Harbor, Mi	$80,072
2001	Black River(Up), Mi	$70,384
2001	White Lake Harbor, Mi	$59,133
2001	New Buffalo Harbor, Mi	$45,532
2001	Arcadia Harbor, Mi	$37,392
2001	Milwaukee Harbor, Wi	$21,597
2001	St Marys River, Mi	-
2001	TOTALS	$8,882,611
2002	Detroit River, Mi	$1,876,110
2002	Green Bay Harbor, Wi	$1,758,999
2002	Saginaw River, Mi	$1,636,722
2002	Duluth-Superior Hbr Mn&Wi	$813,550
2002	Rouge River, Mi	$609,248
2002	Ontonagon Harbor, Mi	$537,705
2002	Big Suamico Harbor, Wi	$303,982
2002	Muskegon Harbor., Mi	$283,216
2002	South Haven Harbor, Mi	$198,591
2002	St Joseph Harbor, Mi(O)	$193,587
2002	Portage Lake Harbor, Mi	$190,506
2002	Grand Haven, Harbor Mi (O)	$170,824
2002	Port Wing Harbor, Wi	$160,424
2002	Holland Harbor, Mi (O)	$126,548
2002	Leland Harbor, Mi	$79,296
2002	Pentwater Harbor, Mi	$65,245
2002	Arcadia Harbor, Mi	$62,644
2002	TOTALS	$9,067,197
2003	St Marys River, Mi	$1,825,092
2003	Green Bay Harbor, Wi	$1,804,455
2003	Black River (Ph), Mi	$617,878
2003	Ontonagon Harbor, Mi	$435,860
2003	Monroe Harbor, Mi	$329,947
2003	Little Lake Harbor, Mi	$238,573
2003	Port Washington Harbor, Wi	$185,595
2003	St Joseph Harbor, Mi	$126,885
2003	Holland Harbor, Mi	$126,500
2003	Grand Haven Harbor, Mi	$103,601
2003	Leland Harbor, Mi	$80,546
2003	New Buffalo Harbor, Mi	$67,124
2003	Lexington Harbor, Mi	$60,443
2003	Port Sanilac Harbor, Mi	$57,407
2003	Pentwater Harbor, Mi	$37,389

2003	Arcadia Harbor, Mi	$33,246
2003	Grand Traverse Bay Hbr, Mi	
2003	TOTALS	$6,130,541
2004	Manistee Harbor, Mi	$402,408
2004	St Joseph Harbor, Mi	$286,336
2004	Holland Harbor, Mi	$217,749
2004	Grand Haven Harbor, Mi	$177,710
2004	Port Austin Harbor, Mi	$172,896
2004	Saugatuck Harbor, Mi	$159,056
2004	Bolles Harbor, Mi	$135,238
2004	Little Lake Harbor, Mi	$104,602
2004	Frankfort Harbor, ,Mi	$90,905
2004	Leland Harbor, Mi	$83,010
2004	Pentwater Harbor, Mi	$78,169
2004	Arcadia Harbor, Mi	$39,424
2004	Ontonagon Harbor, Mi	$0
2004	Detroit River, Mi	-
2004	Duluth-Superior Mn&Wi	-
2004	Muskegon Harbor, Mi	-
2004	Saginaw River, Mi	-
2004	St Clair River, Mi	$1,947,501
2004	TOTALS	$3,895,004

Huntington		
2000	Portsmouth Harbor	$140,387
2000	TOTALS	$140,387
2001	Elk River Harbor	$439,729
2001	Big Sandy Harbor	$418,721
2001	Kanawha River	$143,050
2001	TOTALS	$1,001,500
2003	Big Sandy River - Opt Yr 1	$811,990
2003	Elk River	$236,029
2003	Portsmouth Harbor	$88,475
2003	TOTALS	$1,136,494

Louisville		
2000	Ohio Riv Open (4 Yr Opt)	$2,410,190
2000	TOTALS	$2,410,190
2001	Ohio Riv Open(1of4yr Opt)	$1,998,481
2001	TOTALS	$1,998,481
2002	Ohio Riv Open 2nd Of 4yr Opt	$1,665,872
2002	TOTALS	$1,665,872
2003	Ohio Riv Open 3rd Of 4yr Opt	$1,963,541
2003	TOTALS	$1,963,541
2004	Ohio Riv Open 4yr Of 4yr Opt	$1,945,350
2004	TOTALS	$1,945,350

2.4 Highlighting the Harbor Maintenance Tax

From the foregoing tables we find the Harbor Maintenance Tax to be very significant to the overall burdens placed on Great Lakes maritime commerce. Noting especially the ranking of assessments for the top revenue producing assessments, we note from Table 2.3 HMT is third in assessments paid by importers, behind Customs Duties, and Merchandise Processing Fee.

The HMT is unique to commerce assessments in that the revenue is dedicated to maintenance of maritime transportation infrastructure. The following chapter in this report discusses the HMT and possible changes to the current tax structure to improve the efficiency of port maintenance tax collection and expenditure, and to improve intermodal transportation fuel efficiency.

Chapter 3: The U.S. Harbor Maintenance Tax, a Bad Idea Whose Time has Passed?

It's a sunny mid-summer afternoon at South Bass Island on Lake Erie north of Sandusky, Ohio. The harbor on South Bass Island is filled with hundreds of recreational boaters enjoying the beautiful summer weather, touring the island's historic sites and stopping for lunch and cold beverage at many of the island's bars and restaurants. If you travel to the south end of the island, you might see an ore carrier traveling through the Great Lakes. The ore carrier will not, however, stop at South Bass Island since its shallow water harbor is not suitable for deep water commercial vessels.

The Edward L. Ryerson leaves Duluth Harbor bound for Cleveland with a cargo of 25,000 tons of taconite a few tons below its maximum capacity. In an unusual attempt to utilize this excess capacity, the Ryerson agrees to accept a small container from St. Jude Medical in Minneapolis. The container (which weighs only a few pounds) holds 500 new heart valves bound for the Cleveland Clinic. The Ryerson can handle the extra weight, and its merchant mariners barely notice the additional cargo. Upon arrival in Cleveland, the two cargo items (taconite and heart valves) are unloaded and forwarded to US Steel and the Cleveland Clinic for further processing. Both products are subject to a tax that few U.S. taxpayers are familiar with, the U.S. Harbor Maintenance Tax or HMT. Here is where the similarity in transport of these two items ends. The HMT is an ad valorem (value based) tax, so the heart valves draw $4,165 in tax while the taconite draws $1,836 in tax. It's an anomaly in our tax system that a tax intended to recover the government's cost of canal and port dredging would impose a lower amount of tax on 25,000 tons of unprocessed steel raw materials, than it does on a few pounds of heart valves, but that is how the HMT is structured.

Figure 3: ***Edward L. Ryerson***

It's also an anomaly that the recreational boaters at South Bass Island received $132,310 dollars in dredging services in 1999. An amount paid entirely by the HMT, a tax that is not assessed to them at all, but rather is borne by the ore carrier and all other forms of commercial maritime transportation. As shown in the foregoing Great Lakes tax inventory section of this report, the HMT is one of the most significant contributors to Great Lakes maritime infrastructure. This section of the report will address the problems noted above, and explain why the HMT should be abolished.

History of the Harbor Maintenance Tax

As shown in the HMT timeline in the previous report section, and as detailed in Appendix C, the U.S. has a long history of taxing products transported onboard ship;

some of the first taxes imposed by the southern colonies were import taxes [26]. In 1789, Congress authorized the first improvement projects for navigable channels. The Army Corps of Engineers was established in 1824 as the agency charged with maintaining the nation's water navigation [27].

The HMT was enacted as part of the Water Resources Development Act of 1986 [28]. Prior to the HMT's enactment, general funds from the U.S. Treasury were used to cover the federal government's share of costs to maintain and deepen both inland ports and coastal ports. The HMT was intended to recover a portion of the federal government's cost of maintaining the nation's deep draft navigation channels [29]. The Act created both the HMT and the Harbor Maintenance Trust Fund (HMTF). The HMTF is the trust fund which holds HMT revenues from the time they are collected, until they are disbursed by Congressional appropriation [30].

Originally, the HMT was intended to recover only 40% of port maintenance costs. However, in 1990 the HMT was more than tripled by Congress to its current rate equal to 0.125 percent of the value of the commercial cargo involved [31]. This dramatic increase in the HMT was intended to recover 100 percent of maintenance dredging expenses. The HMT currently is imposed at the time of unloading [32] on importers and domestic shippers, but the term domestic shipper would include foreign flag vessels traveling between U.S. ports [33]. The HMT was created as an ad valorem tax in an attempt to minimize its impact on U.S. exports, especially price sensitive bulk commodities [34]. The impact on U.S. exports was eliminated by a U.S. Supreme Court decision in March of 1998, where the court held that the HMT was unconstitutional as applied to exports [35]. One might have expected that this dramatic change in application of the HMT would have resulted in a major drop in HMT revenues. However, the decrease in HMT revenue from 1997 to its low-water mark in 1999 was only 21.99% [36]. By 2001, HMT revenues had once again exceeded their pre-1998 levels [37].

Legal Challenges to the HMT's Validity

The principal legal challenge to the HMT began with a constitutional challenge based on the export clause of the U.S. Constitution. The U.S. Shoe Corporation brought an action on November 3, 1994 against the U.S. Government in the Court of International Trade (CIT). U.S. Shoe sought a refund of the HMT it had paid on exports arguing that the HMT was an unconstitutional tax as applied to exports [38]. Both the CIT and the Court of Appeals for the Federal Circuit held that the HMT was a tax, not a user fee, and that as a tax, it violated the Export Clause. The U.S. Supreme Court agreed to hear the case after the decision by the Federal Circuit.

The first step in the Supreme Court's analysis of the HMT was to determine whether the CIT had proper jurisdiction over the case as filed by U.S. Shoe. The scope of the CIT's jurisdiction is established by 28 U.S.C. §1581. The HMT's own jurisdictional provision states that for jurisdiction purposes, the HMT, "shall be treated as if such tax were a customs duty" [39]. The CIT's jurisdictional statute states that the CIT has jurisdiction over civil actions against the U.S. that, "…arises out of any law of the United States

providing for – (1) revenue from imports or tonnage; (4) administration and enforcement with respect to the matters referred to in paragraphs (1) – (3) of this subsection…." [40]. The Supreme Court found HMT claims to be within the jurisdiction of the CIT because at that time, the HMT applied to both imports and exports and its specific jurisdictional provision references revenue from imports. Even though the lawsuit involved the HMT's applicability to exports, it was possible for the CIT to rely on jurisdiction created over imports [41].

The Supreme Court then turned to the issue of whether the HMT was a "tax" which would potentially be impermissible under the Export Clause, or whether it qualified as a "user fee" which might survive Export Clause scrutiny. The Court found that the HMT is a tax, basing its decision on the Congressional description of the HMT as a "tax on any port use" [42]. The Court went on to analyze the HMT and determined that it is not a user fee. It distinguished prior cases involving user fees such as the civil aircraft registration fee, [43] and other valid user charges that involved either the Dormant Commerce Clause or the Takings Clause, finding that the Export clause contained a "simple direct and unqualified prohibition on any taxes or duties…on exports" [44]. The Court then analogized the HMT to the excise tax on tobacco that was the subject of the Court's 1876 decision in *Pace v. Burgess* [45]. In *Pace*, the stamps required to sell tobacco in the export market, "'bore no proportion whatever to the quantity or value of the package on which [the stamp] was affixed' and the fee was not excessive" [46]. Since the amount of HMT paid by an exporter, "does not correlate reliably with the federal harbor services used or useable exporter" [47] it imposes a tax, not a user fee, and as such was invalid as applied to exports. The Court invalidated the HMT as it applied to exports, but since the Export Clause does not prohibit taxing imports or domestic transportation, the HMT continues to apply to both imported items and domestic transportation.

Litigation Subsequent to U.S. Shoe

Since the Court's decision in U.S. Shoe, the Harbor Maintenance Tax has continued to be controversial. On February 28, 2000, the Court of Appeals for the Federal Circuit ruled that there was no statute of limitations for exporters asserting claims for refund of the HMT. This effectively required the U.S. Customs Service to refund all HMT paid on exports back to April 1, 1987, the original effective date of the HMT [48]. Exporters, whether they were involved in the U.S. Shoe litigation or not, immediately began to file claims for refund of the HMT paid on exports.

The second post-U.S. Shoe suit involved interest on refunds of HMT. Here the exporters did not fare as well. The Court of Appeals for the Federal Circuit ruled that the U.S. government was not required to pay interest along with refunds of the unconstitutionally collected HMT [49]. The court's decision was based on the principal that, "interest may only be recovered in a suit against the government if there has been a clear and express waiver of sovereign immunity by contract or statute, or if interest is part of compensation required by the Constitution" [50]. The court found that nothing in the HMT statute, the Constitution, or other equitable principals required payment of interest on HMT refunds.

Problems with the Harbor Maintenance Tax Today

Application to Imports but not Exports. As a result of the U.S. Supreme Court's decision in U.S. Shoe, described in the litigation section above, as it exists today, the Harbor Maintenance Tax applies to imported products and products transported domestically, but it does not apply to exported products. Undoubtedly, exported products put as much burden on U.S. harbors and shipping channels as do imports, but they are exempt from this ad valorem tax. To resolve this imbalance, either of two steps could be taken. The U.S. Constitution could be amended to allow taxation of exports (a very difficult and likely unsuccessful approach) or, the HMT could be replaced with another system of taxation that passes constitutional muster.

The HMT Discourages the Most Fuel Efficient Means of Transportation. Water transportation is the most fuel efficient method of transportation currently available in the United States. Ships can transport a ton of cargo 514 miles using one gallon of diesel fuel, whereas trucks can transport that same ton of cargo only 59 miles on the same gallon of fuel. As an ad valorem tax, the HMT serves to encourage the use of truck transport for higher value lower weight cargo, leaving waterborne transport as a viable option only for lower-value high-weight cargo. In an era where the U.S. is increasingly dependent of foreign oil, we simply cannot afford to have a tax policy that discourages fuel efficiency in transportation. A recent example of U.S. efforts to make tax policy consistent with fuel efficiency can be found in the modification of §179. This provision reduced the small business write-off for sport utility vehicles, (SUVs) from $100,000 to a maximum of $24,000) [51]. Eliminating the HMT would allow companies to use waterborne transit for items which are currently transported using less fuel efficient means. This not only reduces America's dependence on foreign oil, but could reduce highway traffic and reduce the number of accidents that occur on our highways [52].

The HMT Violates GATT. After the decision in U.S. Shoe, the HMT applies to imports but not to exports. On February 6, 1998 the European Communities brought a Request for Consultations (RC) against the United States in the World Trade Organization's Dispute Settlement Body. Canada, [53] Japan, [54] and Norway [55] also joined in the RC. The RC alleged that the HMT violated Articles I, II, II, VIII and X of GATT, as well as the Understanding on the Interpretation of Article II: 1(B) of GATT [56]. The European Community's RC was introduced a few weeks before the Supreme Court's decision in U.S. Shoe, but the U.S. Shoe decision at least arguably makes the EC's claim against the HMT even stronger. By dropping the HMT on exports, but maintaining it on imports, the U.S. has unintentionally violated the national treatment obligation under GATT [57]. This in effect allows tax free port use to products originating in the U.S. but imposes a tax on imported products, a direct violation of the national treatment clause of GATT Article III [58]. One important exception to this rule applies to user fees which are imposed for services actually rendered. However, as the Supreme Court noted in U.S. Shoe, the HMT is not a valid user fee because it has little or no direct relationship to services provided to importers [59]. The WTO has not acted on the European

Community's RC. No panel has been established to act on the Request for Consultations [60]. Abolishing the HMT would clearly be viewed favorably by our European and other trading partners.

The HMT Unfairly Taxes High Value Cargo When Compared to Low Value Cargo. As noted in the preceding section, one effect of the HMT is to impose a large tax burden on high value cargo. While the intent of the HMT is to provide a revenue source for dredging and harbor maintenance, its effect is to strongly discourage manufacturers of high value non-bulk items from using waterborne transportation. While this would appear to suggest that a tonnage tax would be a fairer means of generating harbor maintenance revenue, fuel efficiency and other issues and opportunities indicate that generating this revenue elsewhere actually represents better national tax policy.

The HMT has Prevented Some Types of Waterborne Transport from Flourishing in the Great Lakes. Both Roll-On/Roll-Off (RORO) and various truck ferry services have been very difficult to establish on the Great Lakes due in large part to the existence of the HMT. It effectively transfers goods and products that could be shipped on the Great Lakes to both truck and rail-based transportation systems. The HMT creates a disincentive for maritime shipping of both ferry cargo and containerized cargo. As an ad valorem tax, the HMT imposes a requirement that containerized cargo be valued for the purpose of assessing HMT. The burden of the HMT is two-fold: First, the HMT represents an added cost of 0.125 percent for the product shipped. But also, compliance with the HMT requires valuation of items within any container or vehicle transported onboard a ship, requiring a substantial volume of paperwork [61]. There is currently one operating truck-only ferry on the Great Lakes, the Detroit/Windsor Truck Ferry, ferry service exists to various islands such as the Erie Islands and the Apostle Islands, and a RO-Pax (Roll-On/Roll-Off with Passenger Service), the Michigan Car Ferry Service on Lake Michigan [62]. The opportunities for additional truck ferry and RO/RO service on the Great Lakes are substantially limited by the imposition of the HMT. Previous research has indicated that the HMT (applied to both imports and exports at the time) was an important factor and perhaps even the primary factor in the termination of RO/RO service between Duluth, Minnesota and Thunder Bay, Canada [63].

As Currently Enacted the HMT is Difficult to Properly Enforce. The HMT currently applies to imports and to domestic transportation. With respect to imports, it is collected by the U.S. Customs Service when the goods arrive in a U.S. port and clear customs. Payment is voluntary with respect to domestic shipping. Since the Customs Service doesn't monitor domestic shipping there is no clear enforcement tool for domestically shipped items. While potential compliance problems alone are usually not sufficient to militate elimination of a tax system, when the system is as flawed as the current HMT, it may be better to eliminate the tax altogether than to try to create a new and expensive system to ensure taxpayer compliance.

The HMT is a Barrier to International Trade. Our trading partners in Europe particularly those who are members of the European Community have routinely expressed strong opposition to the HMT. Its imposition on imports (many of which come

from Europe) but not on exports is perceived as a tariff on imported goods. While this was clearly not the intention of the Supreme Court's U.S. Shoe decision [64], the decision's effect is unavoidable. Eliminating the HMT would eliminate this inadvertent "tariff".

The HMT Results in a Shift in Container-Borne Cargo to Canadian Ports. Port-related jobs currently employ about five million U.S. workers. These workers earn roughly $44 billion in annual personal income. With respect to containerized cargo, the Port of Seattle estimates that each container of goods that arrives in port adds about $1,000 to the local economy [65]. Containerized cargo (and bulk cargo as well) entering the U.S. through U.S. ports is subject to the HMT. If the cargo is containerized and enters a Canadian port where the container is moved to a truck or train, it avoids the HMT altogether. The HMT puts ports near the Canadian border at a competitive disadvantage. This disadvantage results in job losses at U.S. ports, some of the highest paid union jobs in the U.S. [66].

The HMT Generates Substantially More Revenue than the U.S. Currently Needs for Harbor Maintenance. The HMT has been a very effective (perhaps too effective) vehicle for generating revenue for the Army Corps of Engineers dredging and harbor maintenance activities. There is currently a $3.1 billion surplus in the Harbor Maintenance Trust Fund, an amount sufficient to support the Army Corps of Engineer's dredging and harbor maintenance at the current rate for 3 ½ years. The HMT could be abolished currently, and a replacement revenue stream could be deferred or phased in over a period as long as three years without risking any of the Corps' ability to complete important dredging and harbor repairs.

Table 3.1: Harbor Maintenance Trust Fund Balances (figures rounded to nearest thousand)

	Beg. Balance	Revenue	Total Balance	Expenditures	Ending Balance	Net Change
FY 97	$866,063	$789,166	$1,655,230	$549,502	$1,105,728	$239,665
FY 98	$1,112,241	$687,870	$1,800,111	$511,093	$1,289,018	$176,777
FY 99	$1,289,018	$615,601*	$1,904,619	$295,662	$1,608,957	$319,939
FY 00	$1,608,957	$760,554	$2,369,511	$701,869	$1,667,642	$58,685
FY 01	$1,667,642	$810,769	$2,478,411	$659,570	$1,818,841	$151,199
FY 02	$1,818,841	$710,789	$2,529,630	$656,214	$1,873,417	$54,576
FY 03	$1,873,417	$804,518	$2,677,935	$585,855	$2,092,080	$218,663
FY 04	$2,092,080	$922,383	$3,014,463	$648,200	$2,366,263	$274,183
FY 05	$2,366,263	$1,122,630	$3,488,892	$705,956	$2,782,936	$416,674

*See estimated collections for 1999 (Table 2.3)

Data source: Bureau of the Public Debt, Office of Public Debt Accounting, Trust Fund Management Branch

The Income from the HMT is not Fairly Allocated to the Commercial Ports Which Generate HMT Revenues. As previously noted, the HMT was enacted to fund dredging and maintenance of commercial ports. Unfortunately, the HMT is used for a variety of waterway projects that are completely unrelated to dredging and maintenance of commercial ports. Even if the HMT were lowered so that it produced only enough

revenue to fund current and future harbor maintenance and dredging expenses, the allocation of funds is currently unfair.

In some cases HMT revenues have been spent on maintenance of harbors which provide little or no commercial trade, and hence contribute virtually nothing to the HMTF. In other cases HMT revenues are collected at ports which do not require or fund maintenance through HMTF expenditures. The Great Lakes Boating Federation, in making a case for federal support for recreational boating notes that recreational boaters benefit from large breakwaters protecting cities like Cleveland and Chicago, built and maintained by the Army Corps of Engineers. [http://www.greatlakesboatingfederation.org/action/infrastructure.html] On the other hand, commercial interests, as represented by the AAPA note in testimony before a House subcommittee "Ports like Seattle and Tacoma, which need little or no maintenance dredging, have long suffered the inequity of competing for cargos that must pay significant fees for essentially no service" [67].

Calculation and direct comparison of collections and expenditures is currently compromised by lack of data; as noted in the arguments for reform of the HMT and for increased intermodal support by the National Ports and Waterways Institute (NPWI) at the University of New Orleans, since all domestic shipment databases are weight-based almost no information is available on the value of shipments. The NPWI study makes estimates from ACE lake-wise waterborne commerce data for average value per ton, and shows lake-wise commodity tonnage shipped. See appendix D for these data and estimates [68].

The HMT does not Allocate its Tax Burden to Either 1) Ports which Require the Largest Dredging Expenditures, or 2) Vessels which Require the Deepest Drafts. While the U.S. Supreme Court made it clear that the HMT is to be classed as a tax [69], not a user fee, a tax that is enacted to recover the government's cost for providing a specific service should be fairly applied to the users of those services, to be perceived by the public and the stakeholders as an equitable tax. Dredging expenses (but not necessarily other port maintenance) are largely a function of draft depth of ships traveling through the Great Lakes and St. Lawrence Seaway and the amount of sediment deposited in various locations on the system from rivers and other runoff. The HMT does not attempt to account for these differences in its imposition of an ad valorem tax.

The Income from the HMT is Used for Work at Some Ports but not Others. The Port of Seattle incurred $792,500 in HMT funded expenses for the years 1999-2004. International imports to Seattle incurred $27,966,250 in HMT for 2004 alone. Seattle is a naturally deep water port containing at least 15 berths that are at least 50 feet deep. The Port of Seattle handled 20,564,860 metric tons of cargo in 2005 with this minimal amount of HMT [70]. By comparison, the Port of Wilmington, North Carolina incurred $95,015,705 in HMT funded expenses during the same five year period while international imports shipped through Wilmington incurred only $1,790,000 in HMT for 2004. HMT collections were estimated using USACE value of cargo.

HMT Revenue is a Small Portion of Total Transportation Tax Revenue and a Small Portion of Transportation Spending. The HMT represents only three percent of the U.S. government's revenue from transportation sources. While government spending on water transport is 6% of the total transportation budget, this apparent "imbalance" is more than justified by the importance of water transport as both a strategic military tool, and the fuel efficiency of waterborne transport as identified previously. The significance of these funding levels is that while the HMT stands as a meaningful barrier to specific types of water transport, it actually provides a very small percentage of the federal government's transportation budget.

Attempts to Fix the HMT's Flaws

The argument in this report is far from the first indictment of the HMT. Carriers, port authorities, shippers, manufacturers and legal scholars have provided almost constant opposition to the HMT [71]. For most of these stakeholders, the most significant opposition resulted in the U.S. Shoe litigation which ended in the elimination of the HMT on exports. Since the end of the U.S. Shoe litigation, several attempts have been made to reform the HMT.

The 1992 Attempt to Reduce the HMT. In August of 1992, H.R. 5896 was introduced to reduce the HMT from 0.125 percent to 0.04 percent, its pre-increase level. The bill also attempted to broaden the types of expenses which could be funded by the HMT and to enhance enforcement by turning 10 percent of all HMT revenue over to the IRS to cover costs of IRS enforcement of the HMT. The bill was not reported out of the House Ways and Means Committee's Subcommittee on Water Resources, and enforcement remains an activity of the U.S. Customs Service [72].

The Trust Fund Excess/HMT Rate Reduction Bill. A bill was introduced by Congressman McDermott (D-WA) to reduce the HMT rate to .0105 for 1996, 0.085 for 1997, and 0.065 percent for 1998. It would then have reduced the post- 1998 HMT rate by 0.01 percent for each calendar year in which the HMTF remained funded in excess of $100,000,000. The bill was introduced on March 6, 1995 with an effective date of January 1, 1996. It did not pass a vote in the House Ways and Means Committee [73].

The Harbor Services Fund. In April 1999, the Clinton Administration proposed a new Harbor Services Fund Tax (HSF) as part of the Harbor Services Fund Act of 1999, H.R. 1947. The Harbor Services Fund Tax was proposed to replace the revenue lost as a result of the Supreme Court's U.S. Shoe decision. This additional tax would have produced roughly $850 million in additional annual revenue [74]. The HSF met with strong opposition from a wide variety of shipping industry stakeholders. In describing the HSF, Kurt Nagle, President of the American Association of Port Authorities (AAPA) stated, "the Federal Government continues to suggest that it completely abdicate its financial responsibility for federal navigation channel maintenance" [75]. The Harbor Services Fund proposal failed in 1999 and was reintroduced by the Bush Administration as part of its fiscal year 2001 budget request, where it once again failed.

The Support for Harbor Investment Program Act of 1999. On March 24, 1999 Representatives Borski (D-PA) and Oberstar (D-MN) introduced a bill to repeal the HMT, use the funds in the HMTF to fund dredging activities, and once those funds were expended, to fund the Army Corps of Engineers' dredging out of the general fund of the U.S. Treasury [76]. The bill was referred to the House Ways and Means Committee and the Committee on Transportation and Infrastructure. The Committee on Transportation and Infrastructure referred it to its Subcommittee on Water Resources and Environment on March 26, 1999. The bill was not reported out of the Subcommittee and died there [77].

The Container Port Exemption Bill of 2002. A bill was introduced in the House, in July of 2002, to provide an exemption to the HMT for any port that is within 200 miles of a container port in a foreign country and which does not use harbor maintenance funds from the Treasury. The bill, offered by several members of Washington State's congressional delegation, essentially would have provided an HMT exemption for the Port of Seattle/Tacoma Washington. The bill was not reported out of the House Ways and Means Committee [78].

The $100,000,000 Import Value Port Limit Bill of 2003. A 2003 bill attempted to change the definition of exempt port under IRC §4462(a)(2). This section provides that the HMT does not apply to ports which have not received federal funds for construction, maintenance or operation at any time after 1977. The bill, which was introduced in the Senate by Senator John Kerry (D-Mass.), attempted to remove this exemption for any port which was used to transport more than $100,000,000 of commercial cargo in any year after 2001. The bill was not reported out of the Senate Finance Committee.

The Ferry Borne Trailer Cargo Exemption Bill of 2004. In March of 2004 a bill was introduced in the House which would have provided an exemption from the HMT for "qualified container cargo." Qualified container cargo included cargo, "in or on a truck trailer or semi-trailer parked on a ferry operating between two ports for the sole purpose of transporting such trailers and trucks between such ports due to traffic congestion on the nearest international bridge serving the area in which such ports are located" [79]. This bill, introduced by Congressman Phil English (R-PA) was an attempt to exempt the Detroit-Windsor Truck ferry and other similar ferries from HMT. The bill was not reported out of the House Ways and Means Committee.[80]

The Short Sea Shipping Tax Exemption Act of 2005. Congressman Dave Weldon, M.D. (R-FL) introduced a bill on July 18, 2005 which would provide an exemption from the HMT for domestic container-based cargo unloaded in U.S. ports transported between U.S. ports via coastal routes or river systems [81]. This would have effectively eliminated the HMT on products shipped in containers within the U.S. and left the HMT in place for imports and bulk cargo only. The bill has not been reported out of the House Ways and Means Committee.

The Great Lakes Short Sea Shipping Enhancement Act of 2006. On July 26, 2006 a bill was introduced in the House to exempt from the HMT commercial non-bulk cargo

loaded at a port in the Great Lakes or St. Lawrence Seaway System and unloaded at any other port in the Great Lakes or St. Lawrence Seaway System [82]. The bill was referred to the House Ways and Means Committee, but has yet to be reported out of that committee.

Proposed Solutions to the HMT Problem

After at least nine failed reform attempts in a ten-year period, it's time for a major change to the HMT. We suggest three possible proposals for change: The first two reform proposals would provide a permanent solution to the HMT problem and retain the ability to fund Army Corps of Engineers' important dredging and harbor work. The third proposal, while not solving the HMT problem, at least provides a tax incentive for companies engaged in short sea shipping.

Proposal 1: Abolish the HMT and Fund Harbor Maintenance Using General Government Revenue. This proposal calls for a renewal of the Support for Harbor Investment Program Act of 1999. It provides a clear set of appropriations for the Army Corps of Engineers by requiring funding only in years after the funds in the HMTF are fully expended.

Proposal 2: Abolish the HMT and Fund Harbor Maintenance Using an Increase in the Diesel Fuel Excise Tax. This proposal requires abolishing the HMT and replacing its revenue stream with funds generated from an increase in the federal excise tax on diesel fuel sold for over-the-road use. This excise tax is currently $0.245 cents per gallon. In order to fund the Army Corps of Engineers' dredging and maintenance activities, the required increase in the excise tax would be $0.0112 cents per gallon [83]. While this tax increase is borne by the over-the-road transportation industry as opposed to the marine transport industry, it's fair to propose this burden in order to increase over-all fuel efficiency, which favors water transport. As suggested, a tax structure of this type would divert traffic to water transportation and thereby reduce our nation's dependence on foreign oil. This modal shift would potentially reduce congestion on America's highways as well. (See for instance Fruin's calculations and conclusions of cost increase incurred by a proposed shift from waterway to land transportation in the Mississippi Metro area, or the recent modal shift from water to truck for New York trash disposal New York is trying reverse) [84]. This approach has been used successfully in Europe, with the support of the trucking industry.

Table 3.2: U.S. Fuel Consumption and Demand

	(millions of barrels per day)		
Demand	2005	2006	2007
Motor Gasoline	9.13	9.19	9.28
Jet Fuel	1.63	1.66	1.70
Distillate Fuel Oil	4.11	4.20	4.31
Residual Fuel Oil	**0.91**	**0.76**	**0.81**
Other Oils	4.88	4.93	5.08
Total Demand	20.66	20.74	21.18

Source: Energy Information Administration\Short-Term Energy Outlook - July 2006, Table 5a

Table 3.3: Percent Change in U.S. Fuel Consumption*			
	Millions of barrels per day		
Demand	**2005-2006 change**	**2006-2007 change**	**2005-2007 change**
Motor Gasoline	0.66%	0.98%	1.64%
Jet Fuel	1.84%	2.41%	4.29%
Distillate Fuel Oil	2.19%	2.62%	4.87%
Residual Fuel Oil	-16.48%	6.58%	-10.99%
Other Oils	1.02%	3.04%	4.10%
Total Demand	0.39%	2.12%	2.52%
*Diesel fuel is projected to have the greatest change from 2005-2007.			
Source: Energy Information Administration\Short-Term Energy Outlook - July 2006, Table 5a; Bureau of Business and Economic Research			

Table 3.4: 2005 U.S. Diesel Excise Tax and Daily, Yearly Demand	
	Federal tax: 24.4 cents per gallon
	State tax: 21.6 cents per gallon
Daily Demand	= 4.11 Million Barrels (Barrel = 42 U.S. Gallons) = 172.62 Million Gallons
Yearly Demand	= 63,006.3 million gallons
2005 Excise Tax collection total	= $630,063,000
Sources: Diesel Demand from: Energy Information Administration\Short-Term Energy Outlook - July 2006, Table 5a; Excise Tax Totals from: Energy Information Administration, Petroleum Marketing Monthly, February 2006, Explanatory Notes, Table EN1	

Table 3.5: U.S. Tax Collections and Revenue, Diesel Excise Tax Compared to HMT				
Scenario 1	Increase excise tax to cover expenditures		Amount needed to cover:	$705,956,074*
Scenario 2	Increase excise tax to cover total revenue		Amount needed to cover:	$1,122,629,667*
			HMT Collections	
Rise in Excise Tax (cents)		2005	2006**	2007**
Scenario 1	1.12	$705,670,560	$721,123,200	$740,009,760
Scenario 2	1.78	$1,121,512,140	$1,146,070,800	$1,176,086,940
* Based on 2005 HMT Collections ** Projection based on stable excise tax using the projected distillated demand provided by the Energy Information Administration				
Source: UMD Bureau of Business and Economic Research;				

Proposal 3: The Short Sea Shipping Tax Credit. While abolishing the HMT would be ideal from a tax policy standpoint, should Congress choose to leave the HMT in place, a tax credit should be created to provide a tax incentive for Great Lakes and other U.S. short sea shipping. This non-refundable credit, the "Short Sea Shipping Tax Credit," would operate as follows:

- The credit would be offered to companies engaged in transporting either products or people between any two U.S. ports, or originating in a port in either Canada or Mexico, and ending in a U.S. port.
- The credit would be incremental, meaning that companies would claim the credit on their corporate tax return, but it would be based on the increase in products or people shipped in the current tax year over a base period of the preceding three tax years.
- The credit would be the greater of: 10 percent of the increase in value of items shipped for the tax year, or an amount based on the increase in tonnage of items shipped. This tonnage portion of the credit would provide different credit amounts per ton for grain, coal, sand, salt, iron ore, or other bulk cargo.
- The credit would be nonrefundable, meaning that it would only offset positive current tax liability of the carrier. If the carrier has a tax loss for the year, the credit could be carried back two years and forward for five years.

Harbor Maintenance Tax Time Line

1987	TITLE XIV WATER RESOURCES DEVELOPMENT ACT OF 1986	***HMT and HMTF ad valorem tax established at 0.04% value of cargo.***
1990	SECTION 11214 OMNIBUS BUDGET RECONCILIATION ACT OF 1990	***HMT rate increased to 0.125%***
1996	WATER RESOSURCES DEVELOPMENT ACT OF 1996	***Water Resources Development Act of 1996 allows the ACE to recover the Federal share***
1997	APPELLATE COURT RULES HMT ON EXPORTS UNCONSTITUTIONAL	***Appellate court confirms the lower court decision that the HMT on exports is unconstitutional.***
1998	SUPREME COURT FOUND HMT UNCONSTITUTIONAL	***U.S. Supreme Court has declares the harbor maintenance fee (HMF) an unconstitutional tax on exports by a vote of 9 - 0 .***
1998	HMF REFUND STATUS	***When exporters can expect their Harbor Maintenance Fee (HMF) refunds remains open.***
1998	HMF REPLACEMENT PROPOSED	***Clinton Administration rolls out proposal to replace the Harbor Maintenance Fee (HMF).***
1999	HMT UPDATE	***Although ruled unconstitutional on exports, challenges by IBM and etc.)***
2000	CHALLENGING CUSTOMS	***Supreme Court Hears Arguments in two import-export cases.***
2000	COURT RULES ALL EXPORT HMT SUBJECT TO REFUND	***Court of Appeals for the Federal Circuit ruled that all harbor maintenance tax (HMT) payments made since 1986 (when the law was enacted) are subject to refund.***
2000	HMT INTEREST OVERTURNED	***The Court of Appeals for the Federal Circuit finds the U.S. immune from interest payment.***
2000	RECOVER INTEREST APPEAL	***I.B.M. has filed an appeal to the U.S. Supreme Court over the question of whether exporters are entitled to recover interest on HMT refunds. The Court of Appeals rules no.***
2000	HARBOR MAINTENANCE TAX UPDATE	***Swisher International, Inc. v. United States confirms that there is no statute of limitations which applies to harbor maintenance tax refunds.***
2000	HMT REFUNDS	***Effective March 28, 2001, Customs issued interim rules for those seeking refunds of harbor maintenance taxes.***
2006	HMT INTEREST	***Re question of interest, importers counseled to file complaints at the CIT to claim two years of HMT payments at time of filing.***
2006	NO INTEREST ON EXPORT HMT	***CIT held there was no statute which authorized the payment of interest and no obligation on the part of the government to pay it.***
2006	HMT RULED LEGAL ON IMPORTS	***CIT rejects attempts to extend the illegality of the HMT. Possible appeals pending.***

Challenges and Appeals

Figure 4: HMT Timeline. *Source:* See expanded detail of this chronology in Appendix C, courtesy of Rodriguez O'Donnell Ross & Fuerst.

Chapter 4: Potential Economic Impacts of the Research Results

The three proposals presented in Chapter 3 (Abolish the HMT and Fund Harbor Maintenance Using General Government Revenue; or Abolish the HMT and Fund Harbor Maintenance Using an Increase in the Diesel Fuel Excise Tax; or institute a Short Sea Shipping Tax Credit) share the possible outcome of increased shipping activity on the Great Lakes. A conference call among port and shipping stakeholders confirmed the likelihood of some increase in shipping activity following the incentive provided by removing the tax.

The input-output modeling tool IMPLAN® can provide a general estimate of the possible economic impact of increased shipping activity associated with the proposed hypothetical tax relief [85]. For purposes of estimation, we use a hypothetical assumption of $1 million in increased shipping output for the economy of the State of Minnesota, reported in 2005 dollars. The following table shows estimated impacts for the economic measures and effects that might be associated with a change in the HMT.

IMPLAN modeling here includes the impact 2002 NAICS Definitions 483 Water Transportation (or IMPLAN sector 393 Water Transportation). NAICS sector 483 Water Transportation industries provide water transportation of passengers and cargo using water craft, such as ships, barges, and boats.

The subsector is composed of two industry groups: (1) one for deep sea, coastal, and Great Lakes; and (2) one for inland water transportation. This split typically reflects the difference in equipment used.

Table 4: Estimated Economic Impact per $Million Increase in Shipping

Table 4.1: Value Added Impact

Industry	Direct	Indirect	Induced	Total
Water transportation	$252,114	$95	$119	$252,328
Scenic and sightseeing transportation and support	$0	$53,190	$134	$53,324
Insurance carriers	$0	$27,050	$3,002	$30,052
Owner-occupied dwellings	$0	$0	$21,209	$21,209
Wholesale trade	$0	$12,562	$7,307	$19,869
Total	$252,114	$212,101	$117,303	$581,519

Table 4.2: Employment Impact

Industry	Direct	Indirect	Induced	Total
Water transportation	2.0	0.0	0.0	2.0
Scenic and sightseeing transportation and support	0.0	0.6	0.0	0.6
Food services and drinking places	0.0	0.2	0.3	0.5
Insurance carriers	0.0	0.2	0.0	0.2
Wholesale trade	0.0	0.1	0.1	0.2
Other State and local government enterprises	0.0	0.2	0.0	0.2
Accounting and bookkeeping services	0.0	0.2	0.0	0.2
Travel arrangement and reservation services	0.0	0.2	0.0	0.2
Architectural and engineering services	0.0	0.2	0.0	0.2
Total Employment	2.0	3.3	2.4	7.7

Table 4.3: Output Impact

Industry	Direct	Indirect	Induced	Total
Water transportation	$1,000,000	$377	$471	$1,000,848
Scenic and sightseeing transportation and support	$0	$62,791	$158	$62,949
Insurance carriers	$0	$53,587	$5,946	$59,533
Other State and local government enterprises	$0	$35,983	$3,572	$39,554
Petroleum refineries	$0	$27,294	$4,274	$31,568
Total	$1,000,000	$404,378	$194,930	$1,599,308

Table 4.4: Total Impact

	Direct	Indirect	Induced	Total
Total Value Added Impact	$252,114	$212,101	$117,303	$581,519
Employment Impact	2.0	3.3	2.4	7.7
Output Impact	$1,000,000	$404,378	$194,930	$1,599,308

Source: IMPLAN. UMD BBER. Estimates are reported in 2003 dollars, the most recent year of IMPLAN data available.

Scenic and sightseeing water transportation services are not included in 483 Water Transportation but are included in Subsector 487, Scenic and sightseeing transportation. Although these activities use water craft, they are different from the activities included in water transportation. Water sightseeing does not usually involve place-to-place transportation; the passenger's trip starts and ends at the same location. The IMPLAN model shows the impact on both Water transportation and Scenic and sightseeing transportation and support as quantified in the tables above.

The three measures modeled here include Gross Output (the value of local production or maritime activity in Minnesota); Value Added (the maritime industries' contribution to the State of MN, in wages, rents, interest and profits); and Employment (in terms of jobs, which include part time or short term jobs).

Value Added, Employment and Output measures are modeled here with three effects, sometimes referred to as "rounds of spending": the direct effect (the initial new spending), the indirect effect (additional inter-industry spending), and an induced effect (additional household expenditure from the direct and indirect impact).

For every million dollars in increased maritime shipping activity, the economy of Minnesota could see an additional total Value Added impact of $581,519, an additional $500,000 in Output, and almost eight new jobs added to the economy.

Chapter 5. Conclusion

Analysis of the federal assessment structure for current Great Lakes maritime commerce shows an array of 119 various fees, duties, taxes and other assessments. Among these the Harbor Maintenance Tax deserves special and immediate attention for reform as a failed taxation system that arose out of the "user fee fever" of the 1980s.

A substantial portion of the HMT's tax base was found to be unconstitutional by the U.S. Supreme Court, leaving an unbalanced, unfair and excessive tax in effect. The Harbor Maintenance Trust Fund continues to grow well beyond the amounts needed for harbor maintenance. At least nine attempts have been made to reform this failed system in the past ten years, none of which were successful. It's time for Congress to abolish this failed method of taxation and replace the revenue stream with funds from either the Treasury's general fund or funds generated by an increase in the diesel fuel excise tax.

References

Chapter 1

[1] Stewart, Richard D. Twin Ports Intermodal Terminal Freight Study. University of Wisonsin-Superior. Madison: Midwest Regional University Transportation Center, 2003. 20 Sept. 2006 <www.mrutc.org/research/0206/02-06_Summary.pdf>.

[2] Fruin, Jerry, and Fortowsky, K. Modal Shifts From the Mississippi River and Duluth/Superior to Land Transportation. University of Minnesota: Center for Transportation Studies. Minneapolis: Minnesota Department of Transportation, 2004. 20 Sept. 2006 <http://www.cts.umn.edu/publications/reports/reportdetail.pl?id=704>.

[3] The National Dredging Needs Study of Ports and Harbors Planning and Management Consultants, Ltd Illinois. The National Dredging Needs Study of Ports and Harbors. 12 June 2006.

[4] Center for Naval Analysis. Carus, W. Seth, and Thomas J. Hirschfeld. Coast Guard Future Direction Study: Capstone Support Analysis. Center for Naval Analysis. 1997. 11 Sept. 2006. < http://cna.org/>

[5] Great Lakes United. "Great Lakes Navigation and Sustainable Development." Great Lakes United. 26 June 2003. Army Corps of Engineers. 11 Sept. 2006 <www.glu.org>.

[6] The Great Lakes Commission's Strategic Plan. A Strategic Plan for the Great Lakes Commission." Great Lakes Commission. 2005. 11 Sept. 2006 <www.glc.org>.

[7] Kennedy, Mark. Congressman Kennedy: No Tolls on St. Lawrenece Seaway. 2005. 13 Sept. 2006 <http://markkennedy.house.gov/cgi-data/press/files/389.shtml>.

[8] United States. Maritime Administration. Dept of Transportation. Industry Survey Series: Great Lakes Operators 2005. Nov. 2005. 18 May 2006 <http://www.marad.dot.gov/marad_statistics/>.

[9] United States General Accounting Office. Maritime Industry: Federal Assessments Levied on Commercial Vessels (GAO/RCED-93-65FS, Mar. 5, 1993, and especially the supplement to this report, Commercial Maritime Industry: Supplemental Information on Federal Assessments (GAO/RCED-99-260S).

[10] United States General Accounting Office. Commercial Maritime Industry: Updated Information on Federal Assessments, 09/16/1999, GAO/RCED-99-260).

[11] United States General Accounting Office. Marine Transportation: Federal Financing and a Framework for Infrastructure Investments (GAO-02-1033 September 2002)

[12] Great Lakes Waterborne Commerce. United States. Institute for Water Resources. Department of the Army Corps of Engineers. Waterborne Commerce of the US. 2004. 23 May 2006.

[13] Stewart, Richard D. Great Lakes Marine Transportation System. Great Lakes Maritime Research Institute. 10 Mar. 2006.

[14] The Cleveland Trans-Erie Ferry Feasibility Study. TranSystems, 2004. 13 Sept. 2006 <www.portofcleveland.com/pdf/Ferry Study 06.04.pdf>.

[15] St. Lawrence Seaway Management, Transport Canada and St. Lawrence Seaway Devel . US Dept of Transportation. St. Lawrence Seaway Traffic Report 2005 Navigation Season. 2005. 17 May 2006 <www.greatlakes-seaway.com>.

[16] United States. Maritime Administration. Dept of Transportation. Environmental Advantages of Inland Barge Transportation. 1994.

[17] United States. Maritime Administration. Dept of Transportation. Transportation Mode Comparison Energy Environment Efficiency. 7 Jan. 2002. 6 June 2006 <http://www.mvr.usace.army.mil/navdata/tr-comp.htm>.

[18] United States. Institute for Water Resources. Army Corps of Engineers. Status of the Harbor Maintenance Trust Fund Fiscal Years 2000, 2001, 2002. 12 June 2006.

[19] United States. Bureau of Transportation Statistics. Dept of Transportation. Government Transportation Financial Statistics 2003. 2004. 9 June 2006.

[20] United States. Congressional Budget Office. Impose a New Harbor-Maintenance Fee. 12 June 2006 <http://www.cbo.gov/bo2005/bo2005_showhit1.cfm?index=300-03>.

[21] The U.S Harbor Maintenance Tax Controversy: Is there a solution? Kumar, Shashi N. " The U.S Harbor Maintenance Tax Controversy: Is There a Solution?" International Journal of Maritime Economics 4 (2002): 149-163. 12 June 2006.

[22] National Ports & Waterways Institute. Short Sea Vessel Service and Harbor Maintenance Tax. Oct. 2005. Short Sea Shipping Cooperative Program, SCOOP; University of New Orleans. 9 June 2006.

[23] Duluth Superior Dredging Report from United States. Detroit District. Army Corps of Engineers. Annual Report/Contract Dredging Report. 10 Feb. 2006. 26 July 2006.

[24] The National Dredging Needs Study of Ports and Harbors Planning and Management Consultants, Ltd Illinois. The National Dredging Needs Study of Ports and Harbors. 12 June 2006.

[25] The National Dredging Needs Study of Ports and Harbors Planning and Management Consultants, Ltd Illinois. The National Dredging Needs Study of Ports and Harbors. 12 June 2006.

Chapter 3

[26] Treasury Education Office. "History of the U.S. Tax System." United States Department of the Treasury. 2002. 13 Sept. 2006 <www.treasury.gov/education/fact-sheets/taxes/ustax.shtml>.

[27] American Association of Port Authorities (AAPA). "The History of the Harbor Maintenance Tax." AAPA. 2006. 13 Sept. 2006 <www.aapa-ports.org/govrelations/historyhmt.htm>.

[28] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[29] American Association of Port Authorities (AAPA). "The History of the Harbor Maintenance Tax." AAPA. 2006. 13 Sept. 2006 <www.aapa-ports.org/govrelations/historyhmt.htm>.

[30] Kumar, Shashi. "User Charges for Port Cost Recovery: the US Harbour Maintenance Tax Controversy." International Journal of Maritime Economics 4 (2002): 149-163. 13 Sept. 2006 <http://www.palgrave-journals.com/ijme/journal/v4/n2/abs/9100040a.html;jsessionid=F703E4885C66995196500F5EA7C4794E>
.

[31] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[32] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[33] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[34] American Association of Port Authorities (AAPA). "The History of the Harbor Maintenance Tax." AAPA. 2006. 13 Sept. 2006 <www.aapa-ports.org/govrelations/historyhmt.htm>.

[35] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[36] Kumar, Shashi. "User Charges for Port Cost Recovery: the US Harbour Maintenance Tax Controversy." International Journal of Maritime Economics 4 (2002): 149-163. 13 Sept. 2006 <http://www.palgrave-journals.com/ijme/journal/v4/n2/abs/ 9100040a.html;jsessionid=F703E4885C66995196500F5EA7C4794E>.

[37] Kumar, Shashi. "User Charges for Port Cost Recovery: the US Harbour Maintenance Tax Controversy." International Journal of Maritime Economics 4 (2002): 149-163. 13 Sept. 2006 <http://www.palgrave-journals.com/ijme/journal/v4/n2/abs/9100040a.html; jsessionid=F703E4885C66995196500F5EA7C4794E>.

[38] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[39] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[40] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[41] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.
.
[42] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[43] Evansville Airport v. Delta Airlines. No. 405 U.S. 707. United States Supreme Court. 19 Apr. 1972. 13 Sept. 2006 <http://caselaw.lp.findlaw.com/scripts/getcase.pl?court=US&vol=405&invol=707>.

[44] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[45] Pace v. Burgess. No. 92 U.S. 372. United States Supreme Court. Oct. 1875. 13 Sept. 2006 <http://caselaw.lp.findlaw.com/cgi-bin/getcase.pl?friend=nytimes&court=us&vol=92&invol=372>.

[46] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[47] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[48] Swisher International v. United States. No. 99-1277. United States Court of Appeals for the Federal Circuit. 28 Feb. 2000. 13 Sept. 2006 <http://www.ll.georgetown.edu/Federal/judicial/fed/opinions/99opinions/99-1277.html>.

[49] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[50] Library of Congress v. Shaw. No. 85-54. United States Supreme Court. 01 July 1986. 13 Sept. 2006<http://caselaw.lp.findlaw.com/scripts/getcase.pl?friend=nytimes&navby=case&court=us&vol=478&invol=310>.

[51] Online Taxes (olt). "I.R.C. 179 Expense." OLT. 2006. 13 Sept. 2006 <http://www.online-taxes.com/main/tc/AZ/751.asp>.

[52] Stewart, Richard D., Great Lakes Marine Transportation System White Paper Prepared for the Midwest Freight Corridor Study

[53] Request for Consultations: Communication from Canada: United States – Harbor Maintenance Tax, March 3, 1998.

[54] Request for Consultations: Communication from Japan: United States – Harbor Maintenance Tax, March 3, 1998.

[55] Request for Consultations: Communication from Norway: United States – Harbor Maintenance Tax, March 5, 1998.

[56] World Trade Organization. "Dispute Settlement: United States-Harbor Maintenance Tax." WTO. 06 Feb. 1998. 20 Sept. 2006 <http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds118_e.htm>.

[57] Request for Consultations by the European Communities: United States – Harbor Maintenance Tax, Feb 16, 1998.

[58] Lundell, S., Princess Cruises, Inc. v. United States: Will the Love Boat Finally Sink the Harbor Maintenance Tax, 8 Minn. J. Global Trade 325 Summer, 1999.

[59] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[60] World Trade Organization. "Dispute Settlement: United States-Harbor Maintenance Tax." WTO. 06 Feb. 1998. 20 Sept. 2006 <http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds118_e.htm>.

[61] Stewart, Richard D., Great Lakes Marine Transportation System White Paper Prepared for the Midwest Freight Corridor Study

[62] Price, William, and Vickerman, J. Great Lakes Cargo and Passenger Ferry Systems, American Society of Civil Engineers, June 3, 2004

[63] Stewart, Lavoie, Shutes, Parameters for a Roll-On Roll-Off Marine Intermodal Service on Lake Superior, 2003

[64] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[65] American Association of Port Authorities (AAPA). "America's Ports Today." AAPA. Feb. 2006. 13 Sept. 2006 <www.aapa-ports.org/pdf/8-pg_Americas_Ports_Today.pdf>.

[66] American Association of Port Authorities (AAPA). "Repeal the Harbor Maintenance Tax Now!" AAPA. 2006. 13 Sept. 2006 <www.aapaports.org/govrelations/hmt_repeal_paper.htm>.

[67] Nagle, Kurt J. Address. United States Capital Building, Washington, DC. 26 May 1999. 20 Sept. 2006 <http://www.house.gov/transportation/water/hearing/05-26-99/nagle.html>.

[68] Short-Sea Vessel Service and Harbor Maintaince Tax. University of New Orleans. New Orleans: National Ports and Waterway Institute, 2005. 20 Sept. 2006 <http://www.shortsea.us/scoop_hmt_report.pdf#search=%22short%20sea%20vessel%20service%20and%20Harbor%22>.

[69] United States V. United States Shoe Corporation. No. 97-372. Supreme Court of the United States. 31 Mar. 1998. 13 Sept. 2006 <www.law.cornell.edu/supct/html/97-372.ZO.html>.

[70] Port of Seattle. "Container Terminals." Port of Seattle Seaport Cargo. 2006. 13 Sept. 2006 <http://www.portseattle.org/seaport/cargo/container.shtml>.

[71] Messer, David M., The Harbor Maintenance Tax: All Dredged Up and No Place to Go, 6 Tulsa J. Comp. & Int'l L. 99, Fall 1998.

[72] Representative Studds, and Representative Moakley . United States. Cong. House. Reduce the Harbor Maintenance Tax, Amend Its Applicability and Enhance Its Enforcement. 102nd Cong., 2nd sess. HR 5896. 12 Aug. 1992. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c102:1:./temp/~c102srTeC3::>

[73] Representative McDermott. United States. Cong. House. Amend the Internal Revenue Code of 1986 to Reduce the Harbor Maintenance Tax If the Harbor Maintenance Trust Fund is Overfunded. 104th Cong., 1st sess. HR 1138. 06 Mar. 1995. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c104:1:./temp/~c104CQCj7q:>

[74] American Association of Port Authorities (AAPA) . "Organizations Opposed to Harbor Services Fund Proposal." AAPA. 07 Feb. 2000. 13 Sept. 2006 <http://www.aapa-ports.org/pressroom/feb072000.htm>.

[75] American Association of Port Authorities (AAPA) . "Organizations Opposed to Harbor Services Fund Proposal." AAPA. 07 Feb. 2000. 13 Sept. 2006 <http://www.aapa-ports.org/pressroom/feb072000.htm>.

[76] Representative Borski, and Representative Oberstar . United States. Cong. House. Support for Harbor Investment Program Act. 106th Cong., 1st sess. HR 1260. 24 Mar. 1999. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c106:1:./temp/~c106Aiq7p1::>.

[77] Representative Borski, and Representative Oberstar . United States. Cong. House. Support for Harbor Investment Program Act. 106th Cong., 1st sess. HR 1260. 24 Mar. 1999. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c106:1:./temp/~c106Aiq7p1::>.

[78] Representative Dunn. United States. Cong. House. United States Port Opportunity and Revitalizing Trade Act of 2002. 107th Cong., 2nd sess. HR 5199. 24 July 2004. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c107:1:./temp/~c1079c7jZw::>.

[79] Representative English. United States. Amend the Internal Revenue Code of 1986 to Exempt From the Harbor Maintenance Tax Certain Truck Cargo on a Ferry Operating Between Two Ports for the Sole Purpose of Bypassing Traffic Congestion on the Nearest International Bridge Serving the Area in Which. 108th Cong., 2nd sess. HR 3882. 03 Mar. 2004. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c108:1:./temp/~mdbs1xx4Za::>.

[80] Representative English. United States. Amend the Internal Revenue Code of 1986 to Exempt From the Harbor Maintenance Tax Certain Truck Cargo on a Ferry Operating Between Two Ports for the Sole Purpose of Bypassing Traffic Congestion on the Nearest International Bridge Serving the Area in Which. 108th Cong., 2nd sess. HR 3882. 03 Mar. 2004. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c108:1:./temp/~mdbs1xx4Za::>.

[81] Representative Weldon. United States. Cong. House. Short Sea Shipping Tax Exemption Act of 2005. 109th Cong., 1st sess. HR 3319. 18 May 2005. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c109:1:./temp/~c109YvC4Vm::>.

[82] Representative Jones. United States. Cong. House. Great Lakes Short Sea Shipping Enhancement Act of 2006. 109th Cong., 2nd sess. HR 5589. 26 July 2006. 11 Sept. 2006 <http://thomas.loc.gov/cgi-bin/query/D?c109:1:./temp/~c109wyOCos::>.

[83] 2005 diesel excise tax taken from National Energy Information Center, Energy Information Administration, Petroleum Marketing Monthly, February 2006, Explanatory Notes, Table EN1.

[84] Eric Lipton (2003). City Seeks Ideas as Trash Costs Dwarf Estimate. New York Times; 2 Dec.

Chapter 4

[85] IMPLAN Data and software: Minnesota IMPLAN Group, Inc., IMPLAN System (data and software), 1725 Tower Drive West, Suite 140, Stillwater, MN 55082 www.implan.com.

Bibliography

20060728 Duluth News Tribune, "Port Authority Pushes for Tax Change," Passi, Peter. Duluth News Tribune 28 July 2006. 14 Sept. 2006 <www.duluthsuperior.com>.

Retail On-Highway Diesel Prices (for last 53 weeks) United States. Energy Information Administration. Retail on-Highway Diesel Prices. 14 Sept. 2006 <http://tonto.eia.doe.gov/oog/info/wohdp/diesel_detail_report.asp>.

State Motor-Fuel Tax Rates , United States. Federal Highway Administration. Department of Transportaion. State Motor Fuel Taxes. 14 Sept. 2006 <www.fhwa.dot.gov/policy/ohim/hs03/pdf/mf205.pdf>.

United States Department of Treasury, Bureau of the Public Debt, Office of Public Debt Accounting, Trust Fund Management Branch. Details about principal holdings and investment transaction data can be viewed at http://www.federalinvestments.gov/dfi/ dfifederalinvestreports.htm. See also: ftp://ftp.publicdebt.treas.gov/.

Appendix A: Tax Inventory Data

Source: United States General Accounting Office. Maritime Industry: Federal Assessments Levied on Commercial Vessels (GAO/RCED-93-65FS, Mar. 5, 1993; and United States General Accounting Office. Commercial Maritime Industry: Updated Information on Federal Assessments, 09/16/1999, GAO/RCED-99-260)

Note: Other variables in this inventory, as used elsewhere in this report, include data for GAO source page; Name of Assessment; Update; Description of Assessment; Type of Service; Collected by; Fund that receives collections; Used by; Commerce Type; Payor; Vessel Type; Flag Type; Specific to Maritime Industry?; Formula and Frequency of Assessment; Collection Limitations; Laws and Regulations; Collections for 1989, 1990, 1991, 1996, 1997, 1998, and 1999 (est.) ; and Description of Exemption. See the Great Lakes Maritime Research Institute for a digital copy of these data.

Overview of Maritime Tax Inventory by Federal Assessment Name, Collector, and Payor

Name of Assessment:	Collected by:	Payor:
Abstract of Title	DOT: Coast Guard	Requestor
Agricultural Quarantine and Inspection User Fee (for commercial vessels over 100 net tons)	Customs Service	Owner (a)
Export Health Certificate Endorsement Fees for Animals	USDA: APHIS	Exporter or broker
Phytosanitary Certificate Fee for Plants and Plant Products	USDA: APHIS	Exporter
Collection of Fees for Sanitation Inspection of Cruise Ships	HHS: USPHS (CDC)	Owner or operator
Approval of Exchange of Certificate of Documentation Requiring Mortgage Consent	DOT: Coast Guard	Owner
Certificate of Compliance	DOT: Coast Guard	Owner
Certificate of Ownership	DOT: Coast Guard	Requester
Direct User Fees for Inspection and Examination of U.S. or Foreign Commercial Vessels	DOT: Coast Guard	Owner
Evidence of Deletion from Documentation	DOT: Coast Guard	Requester
Evidence of Financial Responsibility for Water Pollution Certificate Fee	DOT: Coast Guard	Owner or operator
Exchange of Certificate of Documentation	DOT: Coast Guard	Owner
Filing and Recording: Bills of sales and Instruments in Nature of Bills of Sale	DOT: Coast Guard	Owner

Overview of Maritime Tax Inventory by Federal Assessment Name, Collector, and Payor

Name of Assessment:	Collected by:	Payor:
Filing and Recording: Mortgages and Related Information	DOT: Coast Guard	Owner or mortgagee
Filing and Recording: Notice of Claim of Lien and Related Instruments	DOT: Coast Guard	Lien claimant
Initial Certificate of Documentation	DOT: Coast Guard	Owner
Late Renewal Fee	DOT: Coast Guard	Owner
Miscellaneous Applications: Rebuild Determination--Preliminary or Final	DOT: Coast Guard	Owner
Miscellaneous: Copy of Each Instrument or Document	DOT: Coast Guard	Requester
New Vessel Determination	DOT: Coast Guard	Owner
Reimbursement of Travel and Subsistence Costs for Overseas Vessel Inspections	DOT: Coast Guard	Owner or operator
Replacement of Lost or Mutilated Certificate of Documentation	DOT: Coast Guard	Owner
Return of Vessel to Documentation	DOT: Coast Guard	Owner
Trade Endorsement: Coastwise Bowaters Endorsement	DOT: Coast Guard	Owner
Trade Endorsement: Coastwise Endorsement	DOT: Coast Guard	Owner
Trade Endorsement: Fishery Endorsement	DOT: Coast Guard	Owner
Waiver: Bill of Sale Eligile for Filing and Recording	DOT: Coast Guard	Owner
Waiver: Original Build Evidence	DOT: Coast Guard	Owner
Wrecked Vessel Determination	DOT: Coast Guard	Owner
Air/Sea Passenger fee	Customs Service	Individual passenger
Barge /Bulk Carrier Fee	Customs Service	Owner (d)
Certification Fee for Payment of Vessel Tonnage Tax and Certify Admeasurment by Foreign Vessels	Customs Service	Operator
Clearance of Vessel to Foreign Port Fee	Customs Service	Operator
Commercial Vessel Fee	Customs Service	Owner (d)
Customs Duties	Customs Service	Importer
Entry of Vessel from Foreign Port Fee	Customs Service	Operator
Harbor Maintenance Fee	Customs Service	Importer, foreign trade zone user,

Overview of Maritime Tax Inventory by Federal Assessment Name, Collector, and Payor

Name of Assessment:	Collected by:	Payor:
		domestic shipper, or operator of commercial passenger vessel
Issuance Fee for a Permit to Proceed (p)	Customs Service	Operator
Merchandise Processing Fee	Customs Service	Importer
Receiving Manifest and Granting Permit to Unlade (s)	Customs Service	Operator
Receiving Post Entry	Customs Service	Operator
Vessel Tonnage Tax	Customs Service	Operator
Great Lakes Radio Agreement Inspection Fee	FCC-Licensed Technicians	Owner or operator
International Telecommunications Settlements	FCC	U.S. shipowners/telecommunicationoff foreign coasts
Oceangoing Vessel Radio Inspection Fee	FCC-Licensed Technicians	Owner or operator
Radio Communications Equipment Carriage Exemption Processing Fee	FCC	Owner or operator
Safety Convention Radio Inspection Fee	FCC-Licensed Technicians	Owner or operator
Ship Radio Station License Application Fee	FCC	Owner or operator
Ship Radio Station License Regulatory Fee	FCC	Owner or operator
Small Passenger Vessel Radio Inspection Fee	FCC-Licensed Technicians	Owner or operator
Ageement Filing Under Delegated Authority Application Fee	FMC	Owner, operator, or marine terminal operator
Agreement Amendment Filing Requiring Commission Action	FMC	Owner, operator, or

Overview of Maritime Tax Inventory by Federal Assessment Name, Collector, and Payor

Name of Assessment:	Collected by:	Payor:
		marine terminal operator
Agreement Filing for Terminal and Carrier Exempt Agreements Application Fee	FMC	Owner, operator, or marine terminal operator
COFR for Indemnification of Passengers for Nonperformance of Transportation Application Fee	FMC	Owner or charterer
COFR to Meet Liability Incurred for Death or Injury to Passengers or Other Persons on Voyages Application Fee	FMC	Owner or charterer
Conciliation Service Application Fee	FMC	Owner, operator, shipper, or other interested party
Declaratory Order Application Fee	FMC	Owner, operator, shipper, or other interested party
FMC: Special Docket Application Fee	FMC	Owner, operator, or NVOCC (e)
FMC: Special Permission Application Fee	FMC	Owner, operator, or NVOCC (e)
Formal Complaint Filing Fee	FMC	Owner, operator, shipper, or other interested party
Informal Procedures Application Fee	FMC	Owner, operator, shipper, or other interested party
New Agreement Filings Requiring Commission Review	FMC	Owner, operator, or marine terminal operator

Overview of Maritime Tax Inventory by Federal Assessment Name, Collector, and Payor

Name of Assessment:	Collected by:	Payor:
Permission to Correct Clerical Errors on Service Contracts Application	FMC	Owner, operator, shipper, or other interested party
Petition for Investigation to Determine Existence of Adverse Conditions Affecting U.S.-flag Carriers	FMC	Owner, Operator, NVOCC, importer, exporter, freight forwarder, shipper or other interested party
Petition for Relief for U.S.-flag Vessels Operating in Foreign-to-Foreign Trades	FMC	Owner or operator
Petition for Rulemaking Fee	FMC	Owner, operator, shipper, or other interested party
Petition for Section 19 Relief	FMC	Owner, operator, NVOCC, importer, exporter, or other interested party
Stowage Examination Fee	USDA: GIPSA	Importer or exporter
Inland Waterways Fuel Tax	IRS	Operator
Leaking Underground Storage Tank (LUST) Tax	IRS	Operator
Ship Passengers International Departure Tax	IRS	Operator
Authority to Transfer Ownership of Ships Built With Construction Subsidies Application Fee	DOT: MARAD	Owner
Foreign Transfer of Ownership or Registry Application Fee	DOT: MARAD	Owner
Foreign Transfer of Ownership Pursuant to MARAD Contracts	DOT: MARAD	Owner
Guarantee Fee for MARAD's Title XI Program	DOT: MARAD	Owner
Investigation Fee	DOT: MARAD	Owner
Substitution of Participants for Title XI Assistance Application Fee	DOT: MARAD	Owner or mortgagee

Overview of Maritime Tax Inventory by Federal Assessment Name, Collector, and Payor

Name of Assessment:	Collected by:	Payor:
Title XI Application Filing Fee	DOT: MARAD	Owner
Title XII War Risk Interim Binder Fees	American War Risk Agency	Owner
Aquaculture Permit	NOAA: NMFS	Owner
Atlantic Swordfish Permit Application Fee	NOAA: NMFS	Owner
Bluefin Tuna Permit Application Fee	NOAA: NMFS	Owner
Bottomfish /Seamount Groundfish Permit	NOAA: NMFS	Owner
Coastal Migratory Pelagic Fish Permit Application Fee	NOAA: NMFS	Owner or operator
Commercial Spiny Lobster Permit	NOAA: NMFS	Owner
Fisheries Finance Program Application Fee	NOAA: NMFS	Borrower
Fisheries Obligation Guarantee Program Guarantee Fee	NOAA: NMFS	Owner
Foreign Fishing Observer Fee	NOAA: NMFS	Owner or representative of the foreign fishing nation
Foreign Fishing Permit Application Fee	NOAA: NMFS	Owner or representative of the foreign fishing nation
Foreign Fishing Poundage Fee	NOAA: NMFS	Owner or representative of the foreign fishing nation
Golden Crab Permit	NOAA: NMFS	Owner
Groundfish Endorsements Permit	NOAA: NMFS	Owner
High Seas Fishing Compliance Act Permit Application	NOAA: NMFS	Owner
Marine Mammal Authorization Program Registration Fee	NOAA: NMFS	Owner or operator
Pelagics Permit	NOAA: NMFS	Owner
Reef Fish Permit Application Fee	NOAA: NMFS	Owner
Shark Permit	NOAA: NMFS	Owner
Snapper-Grouper Permit Application Fee	NOAA: NMFS	Owner

Overview of Maritime Tax Inventory by Federal Assessment Name, Collector, and Payor

Name of Assessment:	Collected by:	Payor:
South Atlantic Rock Shrimp Permit	NOAA: NMFS	Owner
Spiny Lobster Permit Application Fee	NOAA: NMFS	Owner or operator
Vessel Certificate of Inclusion Application Fee	NOAA: NMFS	Owner or operator
Wreckfish Permit Application Fee	NOAA: NMFS	Owner
Docking /Undocking Tug Service Fee	PCC	Owner or operator
Extraordinary Transit Tug Service Fee	PCC	Owner or operator
General Tug Service Fee	PCC	Owner or operator
Handling Lines for Docking After Transit Service Fee	PCC	Owner or operator
Handling Tug Line Service Fee	PCC	Owner or operator
Handling Vessel Lines Service Fee	PCC	Owner or operator
Launch Service Fee-Dredging Division	PCC	Owner or operator
Launch Service Fee-Marine Bureau	PCC	Owner or operator
Offshore Pilotage Fee	PCC	Owner or operator
Pilotage Fee at the Gamboa Mooring	PCC	Owner or operator
Pilotage Fee During Dock Trial	PCC	Owner or operator
Port Pilotage Fee	PCC	Owner or operator
Sea Tug Service	PCC	Owner or operator
Special Admeasurement Service Fee	PCC	Owner or operator
Standard Tug Service	PCC	Owner or operator
Tolls For Transit	PCC	Owner or operator
Transit Booking Fee	PCC	Owner or operator

Appendix B: Commercial Maritime Assessments Tax Code Inventory

Tax Code Inventory of Assessments as Legislated for U.S. Commercial Maritime

Source: GAO

31 U.S.C. § 9701; 46 C.F.R. § 67.509, 58 Fed. Reg. 60256, November 15, 1993.
31 U.S.C. § 9701; 46 C.F.R. § 67.533, 58 Fed. Reg. 60256, November 15, 1993.
31 U.S.C. 9701; 46 C.F.R § 68.05(requirement); 46 C.F.R. § 67.511(c) (fee).
31 U.S.C. 9701; 46 C.F.R. § 67.101 (requirement); 46 C.F.R. § 67.550 (fee).
31 U.S.C. 9701; 46 C.F.R. § 67.133 (requirement); 46 C.F.R. § 67.523 (fee).
31 U.S.C. 9701; 46 C.F.R. § 67.141(requirement); 46 C.F.R. § 67.501(fee); 58 Fed. Reg. 60226, November 15, 1993.
31 U.S.C. 9701; 46 C.F.R. § 67.141(requirement); 46 C.F.R. § 67.507 (fee).
31 U.S.C. 9701; 46 C.F.R. § 67.171 (requirement); 46 C.F.R. § 67.550 (fee); 58 Fed. Reg. 60266, November 15, 1993.
31 U.S.C. 9701; 46 C.F.R. § 67.175 (requirement); 46 C.F.R. § 67.521 (fee).
31 U.S.C. 9701; 46 C.F.R. § 67.177 (requirement); 46 C.F.R. § 67.525 (fee)
31 U.S.C. 9701; 46 C.F.R. § 67.220(requirement); 46 C.F.R. § 67.527 (fee).
31 U.S.C. 9701; 46 C.F.R. § 67.303 (requirement); 46 C.F.R. § 67.537 (fee) (Note: Previously, a statute authorized this assessment; currently, a regulation authorizes this assessment.)
31 U.S.C. 9701; 46 C.F.R. § 67.503; 58 Fed. Reg. 60266, November 15, 1993.
31 U.S.C. 9701; 46 C.F.R. § 67.507
31 U.S.C. 9701; 46 C.F.R. § 67.517(fee); 58 Fed. Reg. 60226, November 15, 1993.
31 U.S.C. 9701; 46 C.F.R. § 67.527; 58 Fed. Reg. 60226, November 15, 1993.
31 U.S.C. 9701; 46 C.F.R. § 67.529; 58 Fed. Reg. 60226, November 15, 1993.
31 U.S.C. 9701; 46 C.F.R. § 67.531; 58 Fed. Reg. 60226, November 15, 1993.
31 U.S.C. 9701; 46 C.F.R. § 67.539; 59 Fed.reg. 49847, September 30. 1994.
31 U.S.C. 9701; 46 C.F.R. § 68.05(requirement); 46 C.F.R. § 67.511(a) (fee).
31 U.S.C. 9701; 46 C.F.R. § 68.05(requirement); 46 C.F.R. § 67.511(b) (fee).

31 U.S.C. 9701; P.L. 100-710, 46 C.F.R. §. 67.301 (requirement); 46 C.F.R. §. 67.535 (fee).

33 U.S.C. § 2716; 42 U.S.C. § 9608; 33 C.F.R. §138.130.

46 C.F.R. § 2.10.
46 C.F.R. § 502.51.
46 C.F.R. §502.404(a).
46 C.F.R. §502.68(a)(3).

46 U.S.C. §121; 19 C.F.R. §4.20.
46 U.S.C. §3317(b); 46 C.F.R. § 2.10.
46 U.S.C. App. §1281; 46 C.F.R. § 308.102
47 U.S.C. § 158(g); 47 C.F.R. §1.1103 and §1.1119
47 U.S.C. § 159; 47 C.F.R. § 1.152.

Communications Act of 1934 ch. 652, §351, as amended by the Omnibus Budget Reconciliation Act of 1993, P.L.103-66, §6003; 47 U.S.C. §158 (g); 47 C.F.R. §1.1104.
Communications Act of 1934, as amended by the Omnibus Budget Reconciliation Act of 1989, P.L. 101-239, §3001 (a), 103 Stat. 2124; 47 U.S.C. §381, 382, and 385; 47 C.F.R. §1.1103; and §80.901.
Communications Act of 1934, as amended by the Omnibus Budget Reconciliation Act of 1989, P.L. 101-239, §3001 (a); 47 U.S.C. §351 and 352; 47 C.F.R. §1.1103, Safety of Life At Sea Convention, ch. 4, regulation 3, 16 U.S.T. 185, T.I.A.S. No. 9700.
Communications Act of 1934, as amended by the Omnibus Budget Reconciliation Act of 1989, P.L.101-239, §3001 (a), 103 Stat. 2124; 47 U.S.C. §351, 352 and 381; 47 C.F.R. §1.1103, §80.801: and §80.851.
Communications Act of 1934, as amended by the Omnibus Budget Reconciliation Act of 1989, P.L.101-239, §3001 (a), 103 Stat. 2124; 47 U.S.C. §351, 352 and 381; 47 C.F.R. §1.1103, §80.951.
Communications Act of 1934, as amended by the Omnibus Budget Reconciliation Act of 1993, P. L. 103-66, §6003; 47 U.S.C. §158; 47 C.F.R. §80.951 (e); Safety of Life at Sea Convention, ch. 4, regulation 5 (b), 16 U.S.T. 185, T.I.A.S. No. 9700.

Consolidated Omnibus Budget Reconciliation Act of 1985, P. L. 99-272, §13031, 100 Stat. 308; 19 U.S.C. §58c(a)(1); 19 C.F.R. §24.22(b).

Consolidated Omnibus Budget Reconciliation Act of 1985, P. L. 99-272, §13031, 100 Stat. 308; 19 U.S.C. §58c(a)(5); 19 C.F.R. §24.22(g).

Customs Procedural Reform and Simplification Act of 1978, P. L. 95- 410, §214, 92 Stat. 904; 50 Fed. Reg. 15271, April 17, 1985; 19 C.F.R. §4.98 (a).

Food, Agriculture, Conservation, and Trade Act of 1990, P. L. 101-624,§2509, 104 Stat. 4071; 21 U.S.C. §136-136a; 9 C.F.R. §130 as revised in 57 Fed. Reg. 755, January 9, 1992.

Food, Agriculture, Conservation, and Trade Act of 1990, P.L. 101-624,§ 2508-2509, 104 Stat. 4071 as amended by Omnibus Budget Reconciliation Act of 1990, P.L. 101-508, §1203(a); 21 U.S.C. §136-136a; 7 C.F.R. § 354.3(g) as revised in 57 Fed. Reg. 755, January 9, 1992.

Food, Agriculture, Conservation, and Trade Act of 1990, P.L. 101-624,§2508-2509, 104 Stat. 4071 as amended by Omnibus Budget Reconciliation Act of 1990, P. L. 101-508, §1203(a); 21 U.S.C. §136-136a; 7 C.F.R. §354, as amended by §504 of the Federal Agriculture Improvement and Reform Act of 1996, P. L. 104-127, 110 Stat.890.

Internal Revenue Code of 1986, §4042; 26 U.S.C. §4042.

Magnuson-Stevens Fishery Conservation and Management Act, P.L. 94-265, §104, 90 Stat. 342; 16 U.S.C. §1824(b) (1); 50 C.F.R. §600.518 (b) (1).

Magnuson-Stevens Fishery Conservation and Management Act, P.L. 94-265, §204, 90 Stat. 342; 16 U.S.C. §1824(b) (1); 16 U.S.C. §1827(l); 50 C.F.R. §600.518 (d).

Magnuson-Stevens Fishery Conservation and Management Act, P.L. 94-265, §204, 90 Stat. 351; 16 U.S.C. §1824(b) (1); 50 C.F.R. §600.518 (a).

Magnuson-Stevens Fishery Conservation and Management Act, P.L. 94-265, 90 Stat. 351; 50 C.F.R. §622.4.

Merchant Marine Act of 1920, §19, 46 U.S.C. App. § 876; 46 C.F.R. § 585.402.

Merchant Marine Act of 1936 as amended, § 501, (46 App. U.S.C. 1151); 46 C.F.R. § 251.31 (b).
Merchant Marine Act of 1936, as amended, § 1104 A(e) (46 App. U.S.C. 1274 (e)); 46 C.F.R. §298.36.
Merchant Marine Act of 1936, as amended, § 204 (b) and 1101 et seq.; 46 App. U.S.C. 1114 (b) and 1274 (et seq.); 46 C.F.R. §298.16.
Merchant Marine Act of 1936, as amended, § 204 (b); § 1103 as added June 23, 1938 and § 1104 (e) and (f), ch. 600, §46, 52 Stat. 969; 46 App. U.S.C. 1114 (b) §1273(a), 1274 (e) and (f); 46 C.F.R. §298.3 (c).
Merchant Marine Act of 1936, as amended, §1104 A (f); 46 App. U.S.C. 1274(f); 46 C.F.R. §298.15.
Merchant Marine Act of 1936, c.858, §1103 as added June 23, 1938, ch. 600, §46, 52 Stat. 969, as amended by American Fisheries Promotion Act, P L. 96-561, §220, 94 Stat. 3291; 46 U.S.C. §1271; 50 C.F.R. §253.16 (b) 15 C.F.R. 902, 61 Fed. Reg. 19171, May 1, 1996.
Merchant Marine Act of 1936, c.858, §1103 as added June 23, 1938, ch. 600, §46, 52 Stat. 969, as amended by American Fisheries Promotion Act, P. L. 96-561, §220, 94 Stat. 3291; 46 U.S.C. App. §1271(a); 50 C.F.R. §253.16.

Omnibus Budget Reconciliation Act of 1986, P.L. 99-509, §8101; 19 U.S.C. §58c(a) (9) (A); 19 C.F.R. §24.23; 56 Fed. Reg. 15036, April 15, 1991.
Omnibus Budget Reconciliation Act of 1989, P.L. 101-239, §7504(a), 103 Stat. 2362; 26 U.S.C. §4471-4472; 26 C.F.R. §43.

P. L. 89-777, §2 (a), 80 Stat. 1356, 46 U.S.C. §817d; 46 C.F.R. §540.20, 540.23.
P. L. 89-777, §3 (a), 80 Stat. 1357, 46 U.S.C. §817e; 46 C.F.R. §540.1, 540.4.

Public Health Service Act, c. 373, § 361-369, 58 Stat. 704, 42 U.S.C. § 264-272, 42 C.F.R. 71; P. L. 99-591, § 101(i), Department of Labor, HHS and Education and Related Agencies Appropriations Act 1987, 52 Fed. Reg. 27060, July 17, 1987 and 54 Fed. Reg. 48942, November 28, 1989.

Tariff Act of 1930, c 497, 46 Stat. 590; 19 U.S.C. §1202; Omnibus Trade and Competitiveness Act of 1988, P. L. 100- 418, §1204, 102 Stat. 1148; 19 C.F.R. §148.33-39.

Tax Reform Act of 1986, P. L. 99-514, §1893(a), 100 Stat. 2927; 19 U.S.C. §58c(a)(8).

Foreign Shipping Practices Act of 1988, P.L. 100-418, Title X, 102 Stat. 1570; 46 U.S.C. app. 1710a; 46 C.F.R. § 588.4. On May 1, 1999, the authority for the Shipping Act of 1984, is amended by the Ocean Shipping Reform Act of 1998, P.L. 105-258, 112 Stat. 1902 and is located at 46 C.F.R. § 555.4(a).

Shipping Act Amendments of 1979, P. L. 96-25, §5, 93 Stat. 72; 46 U.S.C. App. §821; Shipping Act of 1984, P. L. 98-237, §11(a), 98 Stat. 80; 46 U.S.C. App. §1710(a); 46 C.F.R. §502.62 (f); 46 C.F.R. §502.301(a). Effective May 1, 1999, the statutory authority for this assessment, the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P. L. 105 - 258, 112 Stat. 1902.

Shipping Act of 1916, as amended, § 2, § 3, § 9, § 37, and § 41; 46 App. U.S.C. §802, §803, §808 (c), §835 and the Merchant Marine Act, 1936, as amended, § 204 (b); 46 C.F.R. § 221.7 (b) and § 221.15.

Shipping Act of 1916, as amended, § 2, §3, §9, §37, and §41; 46 App. U.S.C. §802, §803, §808 (c), §835 and the Merchant Marine Act, 1936, as amended, § 204 (b); 46 C.F.R. § 221.7 (b) and § 221.15.

Shipping Act of 1984, P. L. 98-237, §11(a), 98 Stat. 8046 U.S.C. App § 1710 (a) ; 46 C.F.R. §502.182; §502.301(c); and §502.182; §502.304(b). Effective May 1, 1999, the statutory authroity for this assessment, the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P.L. 105-258, 112 Stat. 1902.

Shipping Act of 1984, P. L. 98-237, §8 (d) and 9 (c), 98 Stat. 74; 46 U.S.C. App. §1707(d); 46 C.F.R. §514.21 (f). Effective May 1, 1999, part 514 of 46 C.F.R. is deleted, and this assessment was located at 46 C.F.R. § 520.14 (c) (1).

Shipping Act of 1984, P. L. 98-237, §8, 98 Stat. 74; 46 U.S.C. App. §1707; 46 C.F.R. §502.92 (a) (3) (ii). Effective May 1, 1999, the statutory authority for this assessment, the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P. L. 105 - 258, 112 Stat. 1902.

Shipping Act of 1984, P. L. 98-237, § 8 (c), 46 U.S.C. app. 1707 (c), as amended by the Ocean Shipping

Reform Act of 1998, P. L. 105-258, 112 Stat. 1902; 46 C.F.R. § 530.11 (c) (1).

Shipping Act of 1984, P. L. 98-237, § 8 (c), 46 U.S.C. app. 1707 (c), as amended by the Ocean Shipping Reform Act of 1998, P. L. 105-258, 112 Stat. 1902; 46 C.F.R. § 530.11 (c) (2).

Shipping Act of 1984, P. L. 98-237, § 8 (c), 46 U.S.C. app. 1707 (c), as amended by the Ocean Shipping Reform Act of 1998, P. L. 105-258, 112 Stat. 1902; 46 C.F.R. § 530.11 (c) (3).

Shipping Act of 1984, P. L. 98-237, § 8 (c), 46 U.S.C. app. 1707 (c), as amended by the Ocean Shipping Reform Act of 1998, P. L. 105-258, 112 Stat. 1902; 46 C.F.R. § 530.11 (c) (5).

Shipping Act of 1984, P. L. 98-237, §4, 5 and 6; 46 U.S.C. app. 1703-1705; 46 C.F.R. § 572.401(f); 63 Fed. Reg. 50534, September 22,1998. On May 1, 1999, the authortiy for this assessment, the amendments to the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P.L. 105-258, 112 Stat. 1902 and is located at 46 C.F.R. § 535.401 (f).

Shipping Act of 1984, P. L. 98-237, §8, 46 U.S.C. app. 1707; 46 C.F.R. § 514.21(k) (2). On May 1, 1999, the authority for this assessment, the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P.L. 105-258, 112 Stat. 1902 and is located at 46 C.F.R. § 530.11 (c)(4).

Shipping Act of 1984, P.L. 98-237, § 13(b)(5), 46 U.S.C. app. 1712; 46 C.F.R. § 587.3. On May 1, 1999, the authority for this assessment, the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P.L. 105-258, 112 Stat. 1902 and is located at 46 C.F.R. § 560.3 (a)(2).

Shipping Act of 1984, P.L. 98-237, §4, 5 and 6; 46 U.S.C. app. 1703-1705; 46 C.F.R. § 572.401(f). On May 1, 1999, the authority for this assessment, the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P.L. 105-258, 112 Stat. 1902 and is located at 46 C.F.R. § 535.401 (f).

Shipping Act of 1984, P.L. 98-237, §4, 5 and 6; 46 U.S.C. app. 1703-1705; 46 C.F.R. § 572.401(f); 63 Fed. Reg. 50534, September 22,1998. On May 1, 1999, the authority for this assessment, the amendments to the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P.L. 105-258, 112 Stat. 1902 and is located at 46 C.F.R. § 535.401 (f).

Shipping Act of 1984, P.L. 98-237, §4, 5, and 6; 46 U.S.C. app. 1703- 1705; 46 C.F.R. § 572.401 (f); 63 Fed. Reg. 50534, September 22,1998. On May 1, 1999, the authority for this assessment, the amendments to the Shipping Act of 1984, was amended by the Ocean Shipping Reform Act of 1998, P.L. 105-258, 112 Stat. 1902 and is located at 46 C.F.R. §535.401(f) .

U.S. Grains Standards Act, c.313, Pt. B, §5, 39 Stat. 483; 7 U.S.C. §77; Agricultural Marketing Act, c.966, §203, 60 Stat. 1087; 7 U.S.C. §1622; 7 C.F.R. §800.71, §800.75 and §800.76.

Water Resources Development Act of 1986, P.L. 99-662, §1402(a), 100 Stat. 4266; Omnibus Budget Reconciliation Act of 1990, P. L. 101-508, §11214(a), 104 Stat. 1388-436; 26 U.S.C. §4461-4462; 19 C.F.R. §24.24

Appendix C: Detailed HMT Timeline

HARBOR MAINTENANCE TAX

By permission, Rodriguez O'Donnell Ross & Fuerst

See also: http://rorfgw.com/TOPIC_ARCHIVE/Harbor_Maintenance_Fee/harbor_ maintenance_fee.html

HMT Ruled Legal on Imports
09/02

In a closely watched case which attempted to extend the illegality of the HMT, the position of Thomson Multimedia was rejected by the Court of International Trade. The bases for Thomson's claims were technical in nature relying on interpretations of several provisions in the U.S. Constitution. The court rejected all of Thompson' arguments. Could this be an indicator of the outcome if the currently mentioned security user fees are enacted and challenged?

The HMT on exports was found unconstitutional as a tax of exports. That same principal does not apply to imports and so Thomson's position was soundly defeated. It remains to be seen whether the case will be appealed.

No Interest on Export HMT
06/02

One of the few questions remaining regarding the harbor maintenance tax on exports was whether the government had to pay interest on the monies refunded to exporters. Under the doctrine of sovereign immunity, a government is immune from suit unless it agrees to allow itself to be sued. In the case of the HMT, there are statutory provisions which allow the collection of duties and user fees to be challenged in court. The Court of International Trade in Swisher resoundingly answered the question about payment of interest by saying - no! A variety of arguments were made, including Constitutional ones, all of which failed to persuade the court. In the end, Judge Restani held there was no statute which authorized the payment of interest in the circumstances presented and so there was no obligation on the part of the government to pay it.

HMT UPDATE
6/01

Wondering what all the fuss is about the HMT and imports? Check our web site for a recent posting which provides the latest information regarding both imports and exports.

HARBOR MAINTENANCE TAX UPDATE
5/01

There is much in the trade press these days regarding an issue many thought resolved - refunds of the harbor maintenance tax (HMT) on exports. We provide in this memorandum an update regarding the refunds for exports plus information in the newly developing area of the potential for refunds on imports.

Exports:

Between the U.S. Shoe and Swisher cases, it is now clear that the HMT on exports was unconstitutional and could be challenged in a number of ways which were successful. Swisher challenged the HMT relying on the standard method of challenge - protests. U.S. Shoe challenged the HMT relying on the inherent jurisdiction of the court. Both were successful and, in many instances, the refunds have already been issued.

Subsequent cases addressed interest, saying none would be paid if refunds were obtained relying on U.S. Shoe. Whether interest will be paid if protests were filed remains unclear.

The latest development in the export context is a new Customs regulation which, in effect, cuts off all refund claims not already filed. In reliance on a comment by one of the judge's, Customs changed its regulations to provide a one year statute of limitation for all export refund claims. Since no one has paid HMT for several years, such action effectively cuts off all claims not already filed. The new regulation is not retroactive so any pending claims are unaffected.

Customs is currently focused on the claims arising out of the Swisher decision and is obligated to process those refunds by June 18, 2001. Customs has approximately 2,700 administrative refund claims on which it will start the refund processing thereafter. One open question is exactly how much supporting documentation exporters will be required to provide so that their claims are deemed

complete and refunds are issued.

Imports:

One area where there has been recent movement has to do with the possibility of HMT refunds on imports. On April 18, 2001, the Court of Appeals for the Federal Circuit (CAFC) overturned the decision of the Court of International Trade (CIT) dismissing the lawsuit brought by Thomson Consumer Electronics (Thomson). Thomson filed its claim relying on the inherent jurisdiction of the courts (called 1581(i) or residual jurisdiction). Thomson claimed the HMT violated the U.S. Constitution regarding the Port Preference and Uniformity clauses. Thomson also asserted that since the HMT on exports was invalid, the HMT on exports and the HMT on imports could not be severed and so if one was invalid, so was the other. Rather than deciding the case, the CIT dismissed saying it lacked jurisdiction because the proper basis to challenge the HMT assessment on imports was said to be by way of a protest (1581(a) or the traditional method of challenging assessments on imports).

The CAFC held that Customs had no authority to decide whether or not the HMT was constitutional and so the filing of a protest would be a futile act. The court went on to state that Thomson is not required to undertake a futile act and so the CIT decision was reversed. The CAFC also made a point of stating it has not made any determination as to whether or not the HMT on imports is unconstitutional (which many think unlikely) as the merits of that claim must first be decided by the lower court.

While it may well be several years before the HMT litigation regarding imports is finalized, importers may wish to take advantage of the Thomson decision by filing complaints at the CIT to preserve the issue. They can claim two (2) years of HMT payments at time of filing. Importers might also keep in mind that a future court could determine that the filing of protests is required and so undertaking both steps in tandem may be the safest way to proceed.

HMT REFUNDS
4/01

Effective March 28, 2001, Customs issued interim rules for those seeking refunds of harbor maintenance taxes, see T.D. 0125.

INTEREST ON HMT - IS IT DEAD?

01/01

With the holding in IBM v. US, the courts made clear that HMT refunds could be obtained but no interest would be paid. Then the court issued its decision in Swisher v U.S. relying on standard protest jurisdiction - 1581(a). The IBM case relied on 1581(i) or residual jurisdiction. The granting of a protest allows the award of interest pre-judgment. 21 plaintiffs who received their refunds relying on the IBM case, recently sought to amend those judgments to include an award relying on the Swisher case. The court denied their motions saying the cases have to come to finality. If the plaintiffs wanted to keep open the option of recovering interest, they should not have signed the judgments and accepted the benefits. While Swisher allows for an award of interest back to date of filing, HMT payments date all the way back to 1987. Interest back to date of HMT payment is not likely to be allowed absent further litigation.

MORE HMT LITIGATION
12/00

I.B.M. has file an appeal to the U.S. Supreme Court over the question of whether exporters are entitled to recover interest on HMT refunds. The Court of Appeals for the Federal Circuit said no.

HARBOR MAINTENANCE TAX UPDATE
12/00

In Swisher International, Inc. v. United States, No. 99-1227 (February 28, 2000), the Court of Appeals for the Federal Circuit confirmed that there is no statute of limitations which applies to harbor maintenance tax refunds. The case was appealed to the U.S. Supreme Court which refused to hear it.

In an attempt to deal with the lack of a time limit, the Customs Service has now proposed a one year limitations period which would start to run from the date of the quarterly payment to Customs. The proposed change has no effect on HMT payments made on imports. Exporters are, therefore, advised to file their refund claims as quickly as possible.

HMT UPDATE
03/00

There was unexpected good news for exporters in late February when the Court of Appeals for the Federal Circuit ruled that all harbor maintenance tax (HMT) payments made since 1986 (when the law was enacted) are subject to refund, even those outside the two (2) year statute of limitations generally governing the jurisdiction of the Court of International Trade (C.I.T.). The court reached its decision because there is no time limit governing when an HMT refund request has to be filed. The case has been returned to the C.I.T. to calculate the amounts due the exporter. Once that judgment is entered, it is expected the case will again be appealed.

If finally upheld on appeal, an administrative procedure is likely to be established (possibly through Customs) allowing claims for additional HMT refunds. Whether it will literally extend to all HMT payments not previously refunded remains to be seen.

Now we hear that the question of replacing the HMT monies with some other funding source is turning to earmarking certain monies collected by Customs, a decidedly unpleasant turn of events given the inability to find the $1.4 billion needed to fund Customs' new computer system.

HMT INTEREST OVERTURNED
3/00

The Court of Appeals for the Federal Circuit has overturned a CIT decision finding that exporters are entitled to be paid interest for any harbor maintenance taxes refunded, instead finding the U.S. was immune from interest payment because there was no law authorizing it.

CHALLENGING CUSTOMS
1/00

By Su Ross, ©1999 Los Angeles Daily Journal

Supreme Court Hears Arguments in Two Import-Export Cases The 1999 U.S. Supreme Court session was quite surprising for practitioners in the import-export arena. At the beginning of the year, the first import-export case was argued before the Supreme Court since the early 1970s. The case involved the harbor maintenance tax. See United States Shoe Corporation vs. United States, 523 U.S. 360, 118 S.Ct. 1290 (1998).

The HMT was assessed as a percentage of value on imports into, and exports out of, the United States and was intended to fund improvements at America's ports and waterways. See 26 U.S.C. § 4461. U.S. Shoe challenged the HMT assessment on exports only. Despite the Government's argument that the HMT was a permissible user fee, relying on the export clause of the U.S. Constitution (U.S. Const., art. I, §9, cl. 5), the Supreme Court found the HMT to be a tax on exports and declared it unconstitutional.

Still pending is the question of whether interest has to be paid on the HMT amounts being refunded. Interest was found to be due by the Court of International Trade (a specialized lower court), but that decision has been appealed to the U.S. Court of Appeals for the Federal Circuit. See International Business Machines Corp. v. United States, Court No. 94-10-00625, 1998 Ct Intl Trade LEXIS 73 (1998). The judgment in U.S. Shoe found interest was due, but that portion of the decision was stayed pending the outcome of the IBM case, an outcome that carries substantial consequence for the government in that as of early September 1999, some $732 million previously paid in HMT fees had been refunded.

Using different procedural devices, the HMT was challenged on imports in Thomson Consumer Electronics, Inc. v. United States, Court No. 95-32-00277, 1999 Ct. Intl. Trade, LEXIS 81, Slip Op. 99-84 (1999) and Amoco Oil Co. v. United States, Court No. 95-07-00971, 1999 Ct. Intl. Trade LEXIS 89, Slip Op. 99-91 (1999). In both cases, the basic argument was that the HMT on imports is not severable and so, if invalid on exports, it is equally invalid on imports. Further, assessing the HMT solely on imports violates the Uniformity and Port Preference Clauses of the Constitution (as some 20 States do not have ports). These arguments were rejected by the Court of International Trade which found the HMT to be validly assessed on imports.

Later in the same Supreme Court session, the second trade-related case was argued before the Supreme Court, United States vs. Haggar Apparel Company, 143 L.Ed. 2d 480, 119 S.Ct. 1392 (1999). The basic dispute was over whether the operations Haggar performed on the jeans it processed in Mexico qualified as assembly or manufacturing. The difference was important in determining the value on which duty would be calculated. If the process was a manufacturing operation, duty would be assessed on the full value of the finished jeans. However, if the operation was qualified as an assembly process, duty would be due only on the value added in Mexico.

The trial and appellate court both dealt with the issues and found in favor of Haggar. The result turned on how the courts interpreted the "permapressing" performed in Mexico was interpreted.

Permapressing became the focal point of the case because of the way in which the tariff provision relied upon by Haggar was worded. Harmonized Tariff Schedule provision 9802.00.80 and 19 U.S.C. § 1202 provide a duty exemption for:

Articles... assembled abroad in whole or in part of fabricated components, the product of the Unites States, which ... (c) have not been advanced in value or improved in condition abroad except by being assembled and except by operations incidental to the assembly process such as cleaning, lubricating and painting.

Subheading 9802.00.80 HTSUS, 19 U.S.C. § 1202.

The relevant regulation described processes that did not qualify for partial duty exemption under HTSUS 9802.00.80:

Any significant process, operation, or treatment other than assembly...shall not be regarded as incidental to the assembly and shall preclude the application of the exemption to such articles...Chemical treatment of components or assembled articles to impart new characteristics, such as showerproofing, permapressing, sanforizing, dying or bleaching of textiles.

19 C.F.R. § 1016(c) (1998).

The U.S. Customs Service contended that permapressing took the jeans out of the assembly provision because permapressing is specifically named as a disqualifying operation and so that the resulting garments were manufactured in Mexico not assembled. Haggar argued the exact opposite and won before the Court of International Trade, Haggar Apparel Co. vs. United States, 938 F. Supp. 868 (1996), relying on arguments explaining that permapressing as done today is no longer the harsh chemical treatment it was once thought to be and so Customs' regulatory determination was no longer accurate.

The question of the deference to be given to Customs' interpretation of HTSUS 9802 was raised again by Customs before the appellate court, which nonetheless affirmed the decision. United States v. Haggar, 127 F.3d 1460 (1997). Customs then appealed to the Supreme Court, which granted Certiorari.

What makes Haggar notable, beyond its being the second trade case in one term argued before the Supreme Court, was the deference question. The question posed to the Supreme Court was whether Customs had undertaken sufficient rule-making in enacting the relevant regulations so that judicial deference should be given to its interpretation, an issue raised for the first time by this case. This type of deference is known as Chevron deference (Chevron U.S.A. Inc. vs. Natural Resources Defense Council, Inc., 467 U.S. 837 (1984),

Relying on the holding in Chevron, courts generally give the regulations promulgated by an agency judicial deference, provided those regulations are the result of proper rule-making and reasonable interpret and implement an otherwise ambiguous statutory provision.

The Supreme Court in Haggar found that if Congress speaks directly regarding a question, the court must give deference to Congress' specific intent pursuant to Chevron. However, if an agency's statutory interpretation fills a gap or defines a term, that interpretation is to be given judicial deference, provided the Administrative Procedures Act (5 U.S.C. Section 553) has been complied with.

In the case of the regulations in question, Customs had indeed published them in proposed form, accepted comment, and then issued final regulations. In those regulations, permapressing was specifically named as a chemical treatment, which qualified the resulting garments as having been manufactured, rather than assembled. As a result, the Supreme Court remanded the case to the Federal Circuit for further consideration, as the appellate court had only dealt with the question of Chevron deference and rejected it. On remand, the Federal Circuit was directed to consider whether the regulations themselves actually warrant deference.

The question of Chevron deference was raised again by Customs in Mead Corp. vs. United States, 1999 U.S. App. LEXIS 17831 (Fed. Cir. July 28, 1999). Customs issued a ruling to Mead regarding the tariff provision and rate that would apply to its day-planners. Mead took issue with Customs' decision. By complying with the requisite procedures, Mead was eventually able to bring the matter before the Court of International Trade, which granted Customs' motion for summary judgment affirming the original classification decision.

The Federal Circuit took note of the Haggar case and held that a ruling by the Customs Service is an interpretation of a tariff provision. It does not involve input from any party except the importer to whom the ruling is issued. A ruling is issued only when requested by an interested party. It involves no public debate prior to issuance (although it is subject to public comment after the fact if an appropriate petition to overturn the results is filed - a rare but not unheard of event). A ruling is confined to the specific facts presented. It does not clarify the law or the rights of an importer.

Conversely a regulation undergoes notice and comment and provides a mechanism for input from the interested public. It may be amended or changed later in response to subsequent public input. Therefore, the appellate court found that rulings are not entitled to Chevron deference. Customs has not yet decided whether it will appeal this decision to the Supreme Court.

Many practitioners think the holding in Haggar will force them to carefully monitor each regulation as it is proposed by Customs to ensure it is a reasonable interpretation of congressional intent so as to preserve the issue for trial. Many others think it does not mean

that each and every regulation is subject to challenge because it wrongly interprets congressional intent. In the end, what both Haggar and Mead do is provide practitioners with yet one more tool to use in challenging Customs' decisions.

HMT UPDATE
10/99

Even after the finding that the harbor maintenance tax (HMT) an unconstitutional tax on exports, a number of outstanding issues remained. IBM is prosecuting a case questioning the government's liability to pay interest and how it is to be calculated. Stone Container deals with the question of the applicable statute of limitations. Is it two years under the law's general provisions or is the HMT void from inception?

Thomson and Amoco challenged the HMT on imports. Thomson just argued the law's general two (2) year statutory provision. Amoco made the same argument but raised it via a protest. In both cases, the basic argument was the HMT on imports is not severable and so, if invalid on exports, is equally invalid on imports. Further, assessing the HMT solely on imports violates the Uniformity and Port Preference Clauses of the Constitution.

The focus of the non-severability argument is that Congress would not have enacted the HMT on imports alone. An additional argument is that assessing the HMT on only imports violates international treaty obligations. Also, the argument was made that not all ports are water ports thereby excluding cargo loaded in 20 states. The tax is also not assessed on domestic movements. As a result, because it is not geographically uniform, the HMT violates the Uniformity and Port Preference Clauses.

As of late August/early September 1999, Customs had refunded about $732 million to about 3,4000 exporters. Both the Thomson and Amoco claims were recently dismissed. Thomson's on the technical ground that no protest was first filed. In the Amoco case, the court rejected all the arguments mentioned above. At the same time, the European Union is threatening a WTO complaint about the continuing imposition of the HMT strictly on imports.

Additionally, the Court of International Trade has now decided the BMW case. BMW sought a finding the HMT was not applicable to shipments entered into a foreign trade zone (FTZ). The CIT found the HMT applied because there was no exception in the law. The court also found the HMT is not a duty so the provisions of the FTZ law did not bar its application.

HMF REPLACEMENT PROPOSED
8/98

The Clinton Administration finally rolled out its proposal to replace the Harbor Maintenance Fee (HMF). (Challenge of the fee against imports is being considered at the WTO.) The HMF was previously assessed against importers and exporters based on the value of their goods. The fee against exporters was overturned by the courts. The Harbor Services User Fee will be assessed against carriers, who are expected to pass the cost on to their customers. It will be calculated based on a ship's net tonnage with an adjustment for cargo space not otherwise included. Bulk ships and tankers will be taxed per port of call, while container and cruise ships will be taxed per voyage.

As announced, it appears container ships will be taxed at twice the rate for tankers, five times the rate for dry bulk ships and seven times the rate for cruise ships. Justification for the disparity is given as a response certain ships operating across the largest number of ports with time-sensitive movements. Assuming some form of this new tax is adopted, its validity remains in doubt because the largest amount of money would be raised from West Coast ports which have the least need for dredging. As a result, the new fee does not closely match where the expenditures are being made. Will it withstand a court's scrutiny?

HMF REFUND STATUS
7/98

The question of when exporters can expect their Harbor Maintenance Fee (HMF) refunds remains open. The government contends it should not be required to calculate and pay any refunds until all the legal issues are decided. The government also arbitrarily selected a handful of HMF claims in order to determine whether its own records could be used to confirm those claims. It was successful only 50% of the time. Therefore, it is expected the government's proposed claim form will soon be approved for distribution to litigants.

The major issues under review are interest and whether there is a time bar to claims' filing. The government contends interest is not due but lost before the trial court. It also claims that a two year statute of limitations applies. Exporters argue because the HMF is an illegal tax, it is void from its date of enactment, so exporters should be able to obtain refunds regardless of when their HMF was paid. The lower court has yet to rule about the statute of limitations. Appeals are expected on both issues.

Another challenge to the HMF as applied to imports is being mounted on the grounds it is illegal as 1) not severable from the import tax, 2) a violation of the equal protection and port preference clause of the U.S. Constitution, and 3) a violation of U.S. WTO obligations. In the meantime, Customs has announced it will not accept HMF protests for domestic movements, commercial vessel passengers and admission into foreign trade zones.

HMF FOUND UNCONSTITUTIONAL
4/98

In a decision amazing for its speed and its unanimity, the U.S. Supreme Court has declared the harbor maintenance fee (HMF) an unconstitutional tax on exports by a vote of 9 - 0 . As a result, any exporter who filed a claim with the Court of International Trade (CIT) under the two year jurisdictional statute can expect refunds - maybe!

The CIT has issued an order stating the government is to develop a claim form. The refunds will be issued with interest. The claim form is to be completed within thirty (30) days and the bulk of the refund claims are to be processed within 18 months. The claims will be processed even if there are issues on appeal regarding the statute of limitations, interest or any other issue.

It is expected the claim form the government develops may also be applied to those who have protests pending. When the claim form is finalized and the requirements to prove a claim are issued, those details will be published in the Customs Bulletin.

SUPREME COURT TO HEAR HMF CASE
11/97

The U.S. Supreme Court has agreed to hear the government's appeal of the harbor maintenance tax case. A decision is expected by early next summer. In the meantime, exporters should continue to pay the tax, seek refunds from Customs and file court action. Up to now the courts have uniformly held any exporter has two years from date of payment in which to file an action seeking refund of all sums paid. However, until the decision is final (and it is not yet), all options should be kept open by seeking refunds from Customs, too.

HMF REFUNDS
8/97

Depending on the source, Customs either has already filed or is about to file a Notice of Appeal with the U.S. Supreme Court seeking a hearing on the case involving the harbor maintenance fee (HMF) on exports. Exporters have won before both lower courts which have held the HMF is an illegal tax on exports. A similar case was filed regarding imports: Sarne Corp. vs. U.S.. It was dismissed with a finding that Sarne could point to no specific harm caused to it by the way in which the Harbor Maintenance Trust Fund is administered. It is not clear whether the import case will be appealed. On the export side, it is not clear the Supreme Court will agree to hear the case because it recently decided U.S. vs. Int'l Business Machines Corp. and found a non-discriminatory federal tax on exports to be unconstitutional.

HMF LOSES AGAIN
6/97

Late last week the appellate court issued its ruling confirming the lower court decision that the harbor maintenance fee (HMF) is an unconstitutional tax on exports. The court also found there is no discretion for Customs to exercise, so exporters wishing to receive HMF refunds need not protest first. All exporters need do is file complaints at the Court of International Trade (CIT) within two (2) years of having made their payments.

It is expected the government will appeal the decision, although it is not clear whether the Supreme Court will agree to hear the case, having recently ruled regarding unconstitutional taxes on exports in another matter. In the meantime, exporters should continue to file both protests with Customs and complaints at the CIT.

The HMF challenge to imports failed with the judge finding that relief from the HMF on imports must come from Congress and not the court.

HARBOR MAINTENANCE FEE UPDATE

It was originally thought that oral argument on the harbor maintenance fee (HMF) case (U.S. Shoe) would take place before the end of 1996. Then it seemed likely the time frame would be February 1997. Even once argued, it was unclear how long the Court of Appeals for the Federal Circuit would take to reach the decision whether or not it agreed with the lower court that the HMF on exports is unconstitutional. Individual exporters were advised to continue to file their protests at time of payment while also seeking relief directly from the Court of International Trade for these same payments.

Appendix D: Estimating Harbor Maintenance Tax Revenues

Problems surrounding the data for HMT collections, and strategies for calculating the estimated tax collected are presented in "Short-Sea Vessel Service and Harbor Maintenance Tax," Prepared for The Short Sea Shipping Cooperative Program – SCOOP, by National Ports and Waterways Institute University of New Orleans, October 2005. (By permission.) See http://www.shortsea.us/scoop_hmt_report.pdf (This report provides a comparison between the amount of HMT collected with private and external benefits attained by short-sea intermodal operations.)

We note below from this report a statement summarizing data problems, as well as relevant tables for calculating the HMT in a specific import situatation. Pursuing these data and making up to date calculations for the lake-wise variables and the Great Lakes region would constitute an appropriate area for further research:

> "The enforcement of 0.125% *ad-valorem* tax, HMT, on domestic cargo movements is complicated by many factors. First, vessel operators carrying domestic cargo are used to reporting the weight of shipments and not the value, and secondly, as most of the cargo involved are bulk shipments, the calculation of weights is relatively easy. In contrast, break-bulk cargo and space consuming light material, etc. are reported in terms of measurement tons and the overall tonnage is often estimated as revenue tonnage. Because of these data constraints, it is not possible to compare actual revenue collections against the value of domestic cargo or to determine the degree of compliance in paying the levy." III-6

Figure I-1: Comparison of Tax Revenues to Benefits in a Sample of Short-Sea Services

Item	Boston-NYC Loop	NYC-Miami Loop	Total
Annual TEU Estimate			
Number of Truck-Loads per Day	360	180	540
TEU Equivalent per Day @ 2.5 TEU/truck	900	450	1,350
Total TEU Handled per Year	315,000	157,500	472,500
Cargo Value Estimate			
Value/ton of Imports on Liner Vessels in 2004 ($)	3,636	3,636	
Value per TEU @ 6.5 tons/TEU ($)*	23,894	23,894	
Value of Cargo Handled ($millions)	**7,527**	**3,763**	**11,290**
Total HMT Estimates for 2004			
HMT Gross Revenue in 2004($ millions)			880.0
Tax on Imports ($ millions)			737.0
Tax on Domestics ($ millions)			56.6
Short-Sea Collection of HMT ($ millions)	**9.4**	**4.7**	**14.1**
Short-Sea Operation Benefits			
Financial Cost Savings per Trailer ($)	51.0	335.0	
Annual Financial Cost Savings ($ millions)	**6.4**	**21.1**	**27.5**
Social Cost Savings			
Infrastructure Costs ($ millions)	0.2	0.5	0.7
Air Pollution Costs ($ millions)	1.6	3.1	4.7
Congestion Costs ($ millions)	9.6	11.0	20.6
Noise costs ($ millions)	0.7	1.4	2.1
Accident Costs ($ millions)	1.9	4.3	6.2
Annual Social Cost Savings ($ millions)	**14.0**	**20.3**	**34.3**
Total Cost Savings ($ millions)	**20.4**	**41.4**	**61.8**
Cost Savings to HMT Ratios	**2.2**	**8.8**	**4.4**
Short Sea Share of Total HMT (%)	**1.0**	**0.5**	**1.5**

Source: Figure II-1 and Figure III-7 of this report.

* As applies to trailers; average payload per TEU is based on conversion from average payload per truck-semi trailer combination at 36,000 lbs. as reported in "Freight Analysis Framework Highway Capacity Analysis – Methodology Report," Office of Freight Management and Operations, DOT, April 2002.

Figure III-2: Cargo Value by Vessel Service and HMT Collections

Vessel Service	2001	2002	2003	2004	2001-2004 Change (%)
Liner Vessels					
Value ($ millions)	345,458	353,861	358,322	376,679	9.0%
Weight (1000 metric tons)	84,493	94,424	93,934	102,479	21.3%
Value/metric ton ($)	4,089	3,748	3,815	3,676	-10.1%
Annual Change (%)		-8.3%	1.8%	-3.6%	
Tanker Vessels					
Value ($ millions)	98,914	95,507	123,765	165,047	66.9%
Weight (1000 metric tons)	572,794	550,150	604,520	630,089	10.0%
Value/metric ton ($)	173	174	205	262	51.7%
Annual Change (%)		0.5%	17.9%	27.9%	
Tramp Vessels					
Value ($ millions)	78,714	89,082	122,544	177,042	124.9%
Weight (1000 metric tons)	172,673	168,997	182,960	223,679	29.5%
Value/metric ton ($)	456	527	670	792	73.6%
Annual Change (%)		15.6%	27.1%	18.2%	
Total					
Value ($ millions)	523,086	583,450	604,631	718,765	37.4%
Weight (1000 metric tons)	829,959	813,571	881,414	956,247	15.2%
Value/metric ton ($)	630	717	686	752	19.3%
Annual Change (%)		13.8%	-4.3%	9.6%	
HMT Revenue by Source*					
Imports ($ Millions)	583.2	544.7	620.0	737.0	26.4%
Exports ($ Millions)	2.5	1.7	n/a	n/a	n/a
Domestic ($ Millions)	39.4	27.8	40.6	56.6	43.7%
Domestic Containers ($ Millions)	n/a	n/a	1.9	1.7	n/a
Other ($ Millions)	96.6	78.7	n/a	n/a	n/a
HMT Total	721.7	652.9	827.0	880.0	21.9%
HMT Total-Annual Change (%)		-9.5%	26.7%	6.4%	
HMT for Containers (%)**			0.2%	0.2%	

Source: Army Corps of Engineers Report to the U.S. Congress and U.S Bureau of Census.
* HMT Revenues for 2003 and 2004 are estimates based on 2002 HMT Annual Report to Congress, and the U.S Imports value trends.
** Share of domestic containers is provided by " Preliminary Estimate of CY 2003 and 2004 Domestic Coastwise Tonnage", USACE.

Figure III-4: HMT Domestic Collection Trends and Coastwise / Lake-wise Tonnage Trends, 1998-2002

Fiscal Year	HMT Revenue Domestic ($1,000)	Change (%)	Total Coastwise & Lakewise Tonnage (1,000)	Change (%)	Total Value of shipments ($ millions)	Value/ton ($)
1998	39,158	19.3%	371,789	-3.7%	31,326	84
1999	48,801	24.6%	342,689	-7.8%	39,041	114
2000	44,502	-8.8%	341,290	-0.4%	35,602	104
2001	39,365	-11.5%	323,608	-5.2%	31,492	97
2002	27,786	-29.4%	317,862	-1.8%	22,229	70
1998-2002 Change	-11,372	-29%	-53,927	-15%	-9,098	-17%

Sources: HMT Annual Report to Congress, Fiscal Years 2000, 2001 and 2002, and Annual publications of the Waterborne Commerce of the United States.

Lake-wise cargo movements for 2002 and 2003 are analyzed
by commodity types and in terms of relative shares in Figure III-6.

Figure III-6: Summary of Coastwise and Lake-wise Waterborne Commerce by Commodity - 2003

SITC Code	Commodity Description	Coastwise Commodity Shares & Tonnage			Lakewise Commodity Shares & Tonnage			Total
		Tonnage (1,000)	Major Group	Minor Group	Tonnage (1,000)	Major Group	Minor Group	Major Group
	Total all commodities	223,458	100%	--	89,776	100%	--	--
10	Total Coal	10,607	5%	--	17,959	20%	--	9%
20	Total Petroleum and Products	161,361	72%	--	1,531	2%	--	52%
21	Crude Petroleum	50,953	--	32%	0	--	0%	--
2-29	Petroleum Products	110,409	--	68%	1,531	--	100%	--
30	Total Chemicals & Products	13,014	6%		198	0%	--	4%
31	Fertilizers	1,454	--	11%	0	--	--	--
32	Other Chemicals & Products	11,561	--	89%	198	--	100%	--
40	Total Crude Materials, Inedible	13,868	6%	--	65,793	73%	--	25%
41	Forest Products, w ood & Chips	1,989	--	14%	0	--	0%	--
43	Soil, Sand, Gravel, Rock & Stone	10,551	--	76%	25,549	--	39%	--
44	Iron Ore & Scrap	400	--	3%	39,095	--	59%	--
46	Non Ferrous Ores & Scrap	662	--	5%	26	--	0%	--
47	Sulphur, Clay & Salt	15	--	0%	38	--	0%	--
50	Total Primary Manfactured Goods	8,826	4%	--	3,933	4%	--	4%
51	Paper Products	179	--	2%	0	--	0%	--
52	Lime Cement & Glass	2,650	--	30%	3,781	--	96%	--
53	Non Ferrous Metal Products	5,647	--	64%	1	--	0%	--
60	Total Food & Farm Products	6,101	3%	--	316	0%	--	2%
2-65	Grain & Oilseeds	322	--	5%	299	--	95%	--
66	Processed Grain & Animal Feed	842	--	14%	9	--	3%	--
68	Other Agr. Products	4,849	--	79%	0	--	0%	--
70	Total All Man. Equipment, Machinery & Pr.	9,619	4%	--	0	--	--	3%
	Total Commodity Shares		100%	--	--	100%	--	100%

Source: Waterborne Commerce of the United States, Calendar Year 2003.

Although the SCOOP report estimates Coastwise Tonnage Estimates Subject to HMT Levy, 2003 Lake-wise levies are not estimated.

Alternatives to Petroleum Based Fuel for Marine Vessels

Final Report

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November 2006

Great Lakes Maritime Research Institute

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

Research funded in part by the Great Lakes Maritime Research Institute

Acknowledgements

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Also thanks to:
Murphy Oil USA Inc., Joe Cuseo
Duluth Seaway Port Authority:
Capt. Ray Skelton, Security, and Environmental and Government Affairs Director
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Executive Summary

Biodiesel: An Alternative Fuel for Great Lakes Marine Vessels, Process Enhancement; Engine Test Data

We investigated use of transesterified vegetable oils – biodiesel – as an alternative fuel for marine vessels. The project goals were to determine technical and economic viability of using biodiesel, investigate cheaper ways to produce it, and study engine performance using biodiesel. In addition, we studied the possibility of using fuel cells to enhance the energy efficiency of biodiesel and to reduce the adverse impact of ships to the marine environment.

Our investigation has led to the following findings:

1. Technically, biodiesel production has become routine. A continuous, economically efficient, production process is used by all the large volume producers. Smaller producers use batch reactors that allow flexibility in operation and use of raw materials.

   Unfortunately, like any other agri-based energy source, biodiesel requires some form of federal or state subsidy to be competitive with petroleum based fuel. Minnesota State Statute 239.77, which was adopted on March 15th, 2002, mandates 2% biodiesel fuel by volume in all diesel fuel sold or offered in Minnesota. The mandate officially took effect on September 30th, 2005, when sufficient biodiesel production within the state of Minnesota was available to support the mandate.

2. An enzyme – lipase – can be used as a catalyst in the production process instead of the usual catalyst, sodium hydroxide. Although more expensive, lipase holds the promise of faster reaction rate and more economical biodiesel production. Further investigation into the enzymatic production of biodiesel is recommended.

3. The use of biodiesel blends in diesel engines lowers overall engine emissions when compared to petroleum-based diesel. In addition, biodiesel is a renewable energy source, has better lubricity than diesel fuel, is nontoxic and biodegrades faster than diesel fuel, and can be used in current diesel engines with little or no modification. Environmental concerns, legislative measures, and continued research into improved methods of producing biodiesel are among the many factors contributing to the increased use of biodiesel. Both legislative and industrial efforts point to the use of up to 20% biodiesel blends (B20) in the near future.

4. The tendency of biodiesel to act as a solvent and its higher cold flow properties can lead to problems during operation. Individual ship systems should be reviewed to identify potential cold weather and material compatibility problems prior to the adoption of high biodiesel content blends as a fuel. There is a potential for fuel gelling problems in Great Lakes vessels over the winter lay up period due to long-term (2 month) storage of biodiesel blends at low temperatures. The development

of a long-term low-temperature storage test to verify that separation of the blend and preferential gelling of the biodiesel component does not occur is recommended.

5. Our study also indicates that although ship-board use of fuel cells using biodiesel is energy efficient and environment friendly, is very capital intensive and highly unlikely to be economical.

Biodiesel: An Alternative Fuel for Great Lakes Marine Vessels; Economic Analysis; Supply and Demand; Economic Impact Model

Volatile production and pricing associated with dynamic changes make modeling the biodiesel industry challenging. For instance, for business planning, a break-even analysis usually calculates a break-even point based on fixed costs, variable costs per unit of sales, and revenue per unit of sales. Business planning at the level of individual enterprise is suggested as further research, and assumptions of per-unit revenue and per-unit cost as well as assumption of other fixed costs would be estimated through a detailed sales forecast as well as profit and loss data from the industry. Given the aforementioned volatility of this market, as seen in the supply and demand trends in the foregoing data tables, average sales and costs may not be representative. Analysts predict, however, that costs will come down and prices will rise, making the break-even point a moving target. The variation in feedstock producers, type of feedstock, the possibility of increased demand from Great Lakes maritime fleets, "fixed" costs such as legislated incentives and regulations which can be amended or removed, and the technological advances in chemical processing and operations and end-use engineering can introduce new variables at any stage of the business model.

For the industry sector, it can be assumed that eventually the low cost producers will able to force the independent producers out of the industry and capture market share. Changes in the industry sector will have impacts for the regional economy.

An estimate of economic impacts to the Great Lakes region from the introduction of more biodiesel production is provided. The use of biodiesel fuel by Great Lakes commercial fleets is expected to increase in the future. By the end of the decade, the demand for biodiesel could be over 30 million gallons. Although over 23 million gallons of diesel sales were disclosed by two Great Lakes suppliers for this report, other Great Lakes producers would not reveal sales volume. Therefore total Great Lakes sales or production could not be reported. However, it is possible to assume that a new 30 million gallons biodiesel facility could be supported as the Great Lakes fleets convert to biodiesel usage. Data show that there was total domestic demand for 2.1 billion gallons of distillate fuel oil for vessel bunkering in 2004. Great Lakes states maritime commerce consumes about 170 million gallons of diesel fuel. Based on soybean production in 2005 it would only take about 9% of the states' soybean production to satisfy demand for converted biodiesel maritime use. How quickly vessels will convert to biodiesel is unknowable, but some of this demand could be supplied by increased biodiesel production. To meet this increased demand a new Great Lakes Biodiesel Plant, of typical production capacity of 30 million

gallons per year, should be feasible. Our assumptions as inputs to these models are constrained to projections for commercial maritime diesel consumption.

With the completion of the construction phase it is estimated that the biodisel plant project will have spent a total of approximately $33.9 million on construction, and that the Biodiesel Plant Project will have generated $64.5 million in spending across the Great Lakes Region over two years. The Value Added economic impact of the $14.3 million in expenditures for construction are expected to produce an impact of a total of $33.9 million for region. In Year 1 of construction, the Great Lakes Biodiesel Plant is expected to directly employ 172 workers for construction projects, which will result in the creation of 365 jobs in the Region. In Year 2 the plant is expected to directly employ 86 workers for construction projects, which will result in the creation of 182 jobs in the region.

When operations for the biodiesel plant reach typical year capacity, it is estimated to generate $48.4 million in direct spending across the Great Lake states. The indirect spending adds $22.5 million and $8.1 million (in induced spending). The total $79 million in expenditures occurs annually for the life of the facility.

During a typical year of operations, Great Lakes Biodiesel Plant will create over 194 full-time, part-time, and temporary jobs in the region by directly employing nearly 37 people.

■

Chapter 1: Overview

1.1 Introduction

This project was proposed in two parts: The first part presents engineering aspects of biodiesel fuel use for maritime commerce. This alternative fuel can be used as renewable energy in current diesel engines. The literature suggests that biodiesel fuel has similar energy content to diesel and little impact on performance; the fuel has better lubricity than petro-diesel and it compensates for Ultra Low Sulfur Diesel (ULSD); and that biodiesel can use the current distribution infrastructure, with some modifications for cold weather. It is also noted that biodiesel biodegrades faster than petro-diesel, and produces reduced emissions. Part two follows this chapter and offers an economic impact analysis.

1.2 Research Questions

Given these justifications for using biodiesel fuel in maritime operations, this project proposed to study the fuel production process and engine test data, and specifically, the operational issues associated with using biodiesel fuel and blends for Great Lakes maritime commerce. Researchers pursued the questions: What are the process enhancements issues for biodiesel fuel in the maritime setting? What are the cold weather recommendations? What are the engine conversion issues?

In a second part of this project, this report presents a review of supply and demand market data for the biodiesel industry, a review of legal mandates and incentives, as well as economic impact modeling for increased production of biodiesel fuel for maritime use. The larger question of costs and benefits for a maritime fuel conversion is outlined and suggested for further research in the recommendations of Chapter 5 of this report.

1.3 Report Organization

Chapter 1: Overview. A general overview of the project and a description of the organization of the report, including:

- Introduction
- Research questions

Chapter 2: Alternatives to Petroleum Based Fuels for Marine Vessels. Chapter 2 is divided into the following sections:

- Introduction
- Background, including B100 and blends; production of B100
- Process improvement, including potential improvements, including identified enzymatic catalyst (lipase), potential problems; and next step/s to be taken.
- Review of available engine test data: performance; emissions; power/torque/fuel economy including general issues with usage; potential issues for maritime applications; next step/s to be taken.

Chapter 3: Economic Impacts, Supply and Demand. Chapter 3 is divided into the following sections:

- Introduction, including the definition of the research issue, background, relevant literature, methodology, and report organization.
- Economics of the suggested conversion, including supply and demand (national picture, Great Lakes specifics); Duluth-Superior Fleet/Murphy Oil, inputs; status quo picture, petro-diesel, bio-diesel (b2); pricing, production data, storage, transportation; incentive programs; by-products; risk analysis.

Chapter 4: Potential Economic Impacts of a Biodiesel Fuel Plant for Great Lakes Maritime Fuel. This chapter contains our focus on impact modeling including the introduction of a biodiesel production plant to a Great Lakes state economy, including:

- The I/O model assumptions.
- Estimations of industry output, employment (all measures, all effects).
- Economic projections.

Chapter 5: Conclusions and Recommendations

- Engineering conclusions and recommendations, including a discussion of likely use of up to B20; legislative/economic environment promotes usage; potential to improve production process; summary of next step/s.
- Economic conclusions, a summary of the economic impact of the research findings, recommendations regarding cost benefit analysis and analysis of carbon credit trading, among other strategies.

The report includes a reference section which includes citations for all sources mentioned in the body of the report. The report includes one appendix of demand and supply supporting data. Tables and figures are listed separately in the contents pages as List of Tables and List of Figures and follow chapter numbers.

Chapter 2: Biodiesel: An Alternative Fuel for Great Lakes Marine Vessels

2.1 *Introduction*

Biodiesel is a renewable fuel that can be used in current diesel engines with little or no modification, and is therefore an attractive alternative to the significant volume of #2 diesel fuel used by vessels that operate on the Great Lakes. The following discussion presents some background on biodiesel, its definition, its properties, a description of the production process, and the current mandates and incentives for its use. The production process is investigated in detail and recommendations for potentially reducing biodiesel costs through process improvements are presented. Finally, engine performance and operational issues are explored and a new test for cold weather operation is proposed.

2.2 *Background*

The increased use of biodiesel and blends of biodiesel and petroleum-based diesel fuel has been motivated by several factors including; higher fuel prices, concern over emissions, and the uncertainty associated with foreign sources of oil. The production of biodiesel is unlikely to ever reach a level where it would completely replace petroleum-based diesel in the commercial fuel supply. However, the use of higher percentage biodiesel blends to extend limited oil supplies appears to be a foregone conclusion given the current political environment. Whether it is used as the primary fuel, or as part of a blend, biodiesel offers several attractive advantages:

- It is a renewable energy source.
- It can be used in current diesel engines.
- It has similar properties to diesel fuel.
- It has better lubricity than diesel fuel.
- The combustion of biodiesel produces fewer harmful emissions.
- It requires no major changes in the current distribution infrastructure.
- It is nontoxic and biodegrades faster than diesel fuel.

In addition to the above advantages, there are several legal mandates and incentives at both the state and federal level that encourage the use of biodiesel.

2.2.1 *Definition of Biodiesel and Blends*

Biodiesel is defined as "a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100" [1]. Biodiesel in its pure form is designated as B100 to indicate that the mixture consists of 100% (by volume) biodiesel. Blends of biodiesel and distillate fuel (e.g. #2 diesel) are designated by the letter "B" followed by the volume percentage of biodiesel contained in the mixture; for example, B20 refers to a blend of 20% biodiesel and 80% distillate fuel. The "distillate fuel" used in the blend can consist of a single distillate (e.g. #1 diesel, #2 diesel, fuel oil, etc.) or a mixture of more than one distillate, with the use of #1 and #2 diesel being the most common.

Biodiesel, as discussed in this report, should not be confused with straight vegetable oil (SVO) or the "home-brew" product described by authors such as Tickell [2]. In general, homemade versions of "biodiesel" often utilize different stock and catalysts than commercially produced biodiesel and have considerable variability in methanol and glycerin content in the final product. This variability is undesirable in the fuel supply as a standard fuel specification is desired for both predicting performance and designing engines to run efficiently on B100 and its blends. The variability in biodiesel supply has led to problems with the use of biodiesel and contributed to skepticism within certain communities (for example the trucking industry) about the incorporation of biodiesel blends in the commercial fuel supply.

The international standard that delineates the properties and testing procedures for B100 is ASTM D6751 [1]. Table provides a summary of the ASTM D6751 standard for grade S15 (sulfur content of less than 15 ppm) biodiesel. There is a separate standard for diesel fuel (ASTM D975 [3]) which includes testing procedures for both oxidation (long term) (ASTM D2274 [4] and ASTM D4625 [5]) and thermal (ASTM D6468 [6]) stability. Thermal and oxidation stability tests are accurate when used with diesel fuels and ASTM D6468 [6] testing indicates that B100 has good thermal stability. However, as the literature review provided by Waynick [7] shows, the oxidation tests are not reliable for predicting the oxidation stability of B100 and biodiesel blends. Westbrook [8] discussed combining a modified ASTM D2274 test with kinematic viscosity and acid number tests. The results show promise for characterizing B100 oxidation stability, but the limited amount of data is insufficient to specify stability limits. The problem of defining oxidation stability for biodiesel blends is further complicated by a lack of any standard for biodiesel blend properties. A standard for B20 is currently being defined by ASTM [9] in coordination with OEM engine manufacturers.

Property	Test Method	Grade S15 Limits
Flash point	D 93	130°C min
Water and sediment	D 2709	0.05 % volume max
Kinematic viscosity	D 445	1.9-6.0 mm^2/s
Sulfated ash	D 874	0.02 % mass max
Sulfur	D 5453	0.0015 % mass (ppm) max
Copper strip corrosion	D 130	No. 3 max
Cetane number	D 613	47 min
Cloud point	D 2500	Report
Carbon residue	D 4530	0.05 % mass max
Acid number	D 664	0.80 mg KOH/g max
Free glycerin	D 6584	0.02 % mass
Total glycerin	D 6584	0.24 % mass
Phosphorous content	D 4951	0.001 % mass max
Distillation temperature	D 1160	360°C max

Table 2.1: Biodiesel (B100) requirements from ASTM D6751 [1].

2.2.2 *Properties of Biodiesel*

The properties of biodiesel vary slightly based on the vegetable oil used as the feedstock. In general, the properties of biodiesel are similar to #2 diesel fuel which allows it to be used directly in diesel-powered vehicles. The kinematic viscosity and density of biodiesel are close to that of #2 diesel, resulting in only minor changes in fuel delivery characteristics. The energy content of B100 is only slightly lower than that for #2 diesel and has little impact on engine power, torque, and fuel economy. As previously discussed, the use of biodiesel has several advantages over #2 diesel. Biodiesel is nontoxic and biodegradable, reducing fuel handling requirements. It has better lubricity than diesel fuel which reduces wear on fuel system parts such as injectors and pump bearings. Biodiesel could be used as an additive to ultra low sulfur diesel which suffers from low lubricity. The combustion of biodiesel produces fewer harmful emissions overall. Unburned hydrocarbon (HC), carbon monoxide (CO), and particulate matter (PM) emissions from combustion of biodiesel are significantly lower than those from burning #2 diesel.

Biodiesel also exhibits some less desirable properties that can cause operational problems. It acts as a solvent and will remove paint from surfaces and degrade some elastomers and rubber parts (e.g. fuel pump seals). Biodiesel has a tendency to gel at higher temperatures than #2 diesel. The increase in cold flow properties (tendency to gel) associated with biodiesel is quantified using cold filter plugging point, cloud point, and pour point tests. The cloud point, which is the temperature at which solid crystal first appear, has an average value of 3 deg. F for #2 diesel and 32 to 40 deg F for B100. Thus, B100 is not suited for use in cold climates if fuel system components are exposed to the environment. However, tests have shown that the cloud point for a B20 blend with #2 diesel is approximately 7 deg F. Solutions for the problems associated with the use of biodiesel will be addressed later in this report.

2.2.3 *Production of B100*

There are three general methods for producing biodiesel; base catalyzed transesterification of oil with alcohol, direct acid catalyzed esterification of oil with methanol, and conversion of oil to fatty acids, and then to alkyl esters with acid catalysis. The first of these methods has several advantages and is the most widely used; it is a low temperature and pressure process, it has high conversion efficiency, it has a short reaction time, and it does not require exotic construction materials.

The transesterification process involves the mixing of vegetable oil with an alcohol and a catalyst as shown in Figure 2. The vegetable oil is usually soybean or canola oil and the most commonly used alcohol is methanol. The catalyst for the reaction can be sodium hydroxide (NaOH), potassium hydroxide (KOH), or sodium methylate ($NaOCH_3$). Initial mixture fractions by volume are approximately 87%, 12%, and 1% for the vegetable oil, methanol, and catalyst respectively. The reaction takes place in either a batch or continuously stirred reactor and has a 98% conversion efficiency resulting in 86% methyl ester (biodiesel), 9% glycerin, 4% alcohol (unreacted), and 1% fertilizer by

volume. The by-product glycerin has a higher density than biodiesel and may be removed via settling tank or centrifugal separator. The unreacted methanol may also be recovered for reuse.

The increased demand for biodiesel has led to the construction of several plants across the nation. According to the National Biodiesel Board (NBB), there are currently 86 biodiesel plants in the U.S. with annual capacities ranging from 50,000 to 30,000,000 gallons [10]. The three states with the largest biodiesel production capacity are Iowa, Texas, and Minnesota. Biodiesel is produced at three main plants within Minnesota: the Minnesota Soybean Processors (MNSP) plant in Brewster [11], the SoyMor plant in Albert Lea [12], and the Farmers Union Marketing and Processing Association (FUMPA) plant in Redwood Falls [13]. Biodiesel producers ship the B100 to refineries, such as the Flint Hills Resources' Pine Bend refinery in Rosemount, MN [14] or the Murphy Oil refinery in Superior, WI [15], where it is blended with diesel fuel.

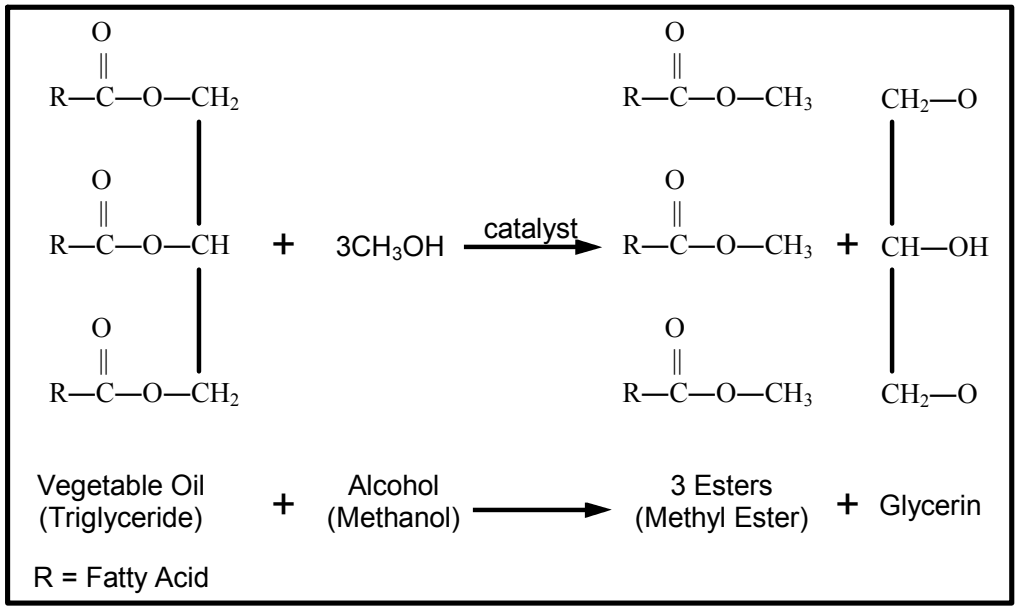

Figure 2: Transesterification process.

2.2.4 *Legal Mandates and Incentives*

Several pieces of biodiesel legislation have been enacted over the past five years at both the state and federal levels. For example, Minnesota State Statute 239.77, adopted on March 15th, 2002, mandates 2% biodiesel content in all diesel fuel sold in Minnesota. This mandate, which officially took effect on September 30th, 2005, has supported the development of three biodiesel plants in the state of Minnesota. There are currently 38 states that have legal incentives and/or usage mandates for biodiesel. On the federal level, B20, which is a mixture of 20% biodiesel and 80% petroleum diesel, was approved as an alternative fuel for use by federal, state, county and utility company vehicles under the Energy Policy Act of 1992 (EPACT). More recently, in response to the 2005 EPACT, the EPA has specified that a minimum of 2.78% of all fuel used nationwide will

be renewable fuels (e.g. ethanol and biodiesel) [16]. The EPA also recognizes the use of biodiesel in emissions reduction strategies as part of their Clean Diesel [17] and Clean Ports USA [18] Programs.

2.3 *Process Improvement*

In general, the biodiesel production process can be described as esterification of vegetable oils by the process of alcoholysis [19,20]. For either batch (low production) or continuous (production rate > 1 million gal/year) production, a vegetable oil is reacted with methanol and a solvent (to promote mixing) in the presence of sodium catalyst (to reduce reaction activation energy). The reaction may be represented by,

$$\begin{aligned} &CH_5O_2RO_2R'O_2R'' + 3CH_3OH \longleftrightarrow \\ &\quad CH_5(OH)_3 + CH_3OOR + CH_3OOR' + CH_3OOR'' \end{aligned}$$

where R , R' and R'' are primarily 16, 17, and 18 carbon chains. The triglycerides from vegetable oil in this process are converted to three separate methyl esters.

2.3.1 *Biodiesel Production Economics*

A preliminary technical and economic feasibility study of biodiesel production using soybean oil and the method described above was studied for this project. The recent findings of Haley et al. [21] are adapted for this purpose. For a 10 million gallon/year production facility, the total capital investment required is about $9.5 million dollars and the production cost is about $2.50/gal. Considering inflation, the production cost for biodiesel for 2006 would be about $2.75/gal. Thus, biodiesel is not competitive with petroleum-based diesel unless indirect (mandated use) or direct incentives are provided by the federal, state, or local government.

Our efforts to improve the economics of biodiesel production led us to thoroughly investigate an enzymatic catalyst that has the promise of increasing the esterification rate and decreasing effective production cost.

2.3.2 *Enzymatic Catalyst*

Our investigation into more efficient production of biodiesel from soybean oil led us to lipase, an enzymatic catalyst, to replace sodium hydroxide (NaOH) in the esterification reaction of soybean or other vegetable oils. Lipase is much more expensive than NaOH. In spite of its cost, lipase could potentially reduce production cost because it is recyclable and because it eliminates a separation step in the traditional base catalyzed process. P.flouroscens is a widely used variety of lipase. Other varieties include T. langinosa, R.miehei, and Candida Antarctica (Novozym 435). Candida Antarctica has a number of interesting properties that make it a candidate for further investigation.

Esterification using lipase as a catalyst generally requires it to be immobilized on some type of carrier particle allowing collection of the catalyst after the reaction is completed.

A few simple "cleansing" steps are required for the catalyst to be reused. The reaction is essentially similar to the traditional process in that the raw feed (vegetable oil) is reacted with a primary alcohol (usually methanol) to produce methyl esters and a by-product glycerol.

2.3.3 *Potential Problems and Solutions*

Using the more expensive enzymatic catalyst in place of NaOH poses a few potential problems. These problems are briefly described below.

- Methanol (used for esterification) is known to deactivate the lipase, greatly hindering its catalytic capabilities.
- Lipases are expensive, and must be reusable to be cost effective.
- Glycerol, the by-product of esterification reaction, seems to reduce the conversion of methyl esters, possibly due to unwanted side reactions.
- No reliable continuous process of esterification using lipase has been developed yet. A continuous process for biodiesel production is highly desirable to keep production costs low.

To improve the economics of biodiesel production using a lipase as the catalyst we are looking into the following process improvements:

- A step-wise addition of methanol to reduce the deactivation of the lipase by the alcohol. This may be done in a three part process; one molar equivalent being added every few hours a total of three times, resulting in the required 3:1 methanol to oil ratio. While this is effective, catalyst deactivation tends to be inevitable at some point. A good process seems to run about 10 batches before noticeable deactivation occurs.
- Different "carriers" of the lipase have been investigated to maximize conversion. One common carrier is polypropylene 100EP for P.flouroscens.
- Glycerol adsorbing compounds have been investigated to consume the glycerol and allow for a higher conversion. This incurs the loss of a valuable by-product and may require additional steps to deal with the additives.
- Alternate alcohols have been used to improve miscibility and/or lower the deactivation rate of the lipase caused by methanol.

2.3.4 *A Novel Biodiesel Production Method*

We believe that a new biodiesel production process, based on the work of Xu et al. [22] that addresses the above-mentioned problem areas, could significantly increase the fuel's competitiveness. In this process, methyl acetate is used as the reacting alcohol with soybean oil, and immobilized Candida Antarctica as the lipase catalyst. Methyl acetate has negligible effect on the catalyst. The main by-product, triacetylglycerol (instead of glycerol), is not absorbed on the catalyst surface, alleviating the catalyst deactivation problem. In addition, the recent work of Cortright [23] shows the promise of low cost hydrogen production from triacetylglycerol [24].

2.4 *Engine Test Data*

Summaries of the available literature for engine tests using biodiesel can be found on the NBB [25] and EPA [26] websites. The majority of engine test data for on-road diesel engines. While these engines are not precisely the same as those used on maritime vessels, most of the results can be generalized to any diesel engine. The available literature provides useful guidance for incorporating biodiesel in the fuel supply. Of particular interest are the effects of biodiesel on both direct performance measurements, such as power, torque and fuel economy, and the environmental impact via emissions.

2.4.1 *Power/Torque/Fuel Economy*

Biodiesel has slightly lower energy content per unit volume (average of approximately 33 MJ/L) than #2 diesel (36 MJ/L) which tends to cause a corresponding reduction in maximum power, maximum torque, and fuel economy. The reduction in performance decreases with the percentage of biodiesel in a blend. The engine testing results of Rakopoulos et al. [27] show that, within the range of experimental uncertainty, B10 and B20 blends exhibit similar performance to #2 diesel fuel. However, performance results using biodiesel blends are affected by the specific engine used, the percentage load at which the engine is operated, and the vegetable oil used in producing the biodiesel [27].

2.4.2 *Emissions*

Table 2 shows a summary of "average" biodiesel energy content and emissions results [28] obtained from reference [29]. The table shows that the use of biodiesel and biodiesel blends results in reductions in most regulated emissions. Total unburned hydrocarbons (THC), carbon monoxide (CO), and particulate matter (PM) emissions decrease significantly with biodiesel usage, while oxides of nitrogen (NOx) emissions increase moderately. It should be stressed that these are "average" emission results, and may not reflect actual conditions obtained using a specific engine and "type" of biodiesel used in the blend. However, the large reductions in THC, CO, and PM indicate that a reduction can be expected in these emissions regardless of the engine or "type" of biodiesel used. The slight increase in NOx emissions shown in Table 2 may or may not be present for a specific engine and/or "type" of biodiesel. For example, the test results of Rakopoulos et al. [27] show a slight reduction in NOx emissions when comparing results using #2 diesel to results using B20 blends produced from five different "types" (cottonseed oil, soybean oil, sunflower oil, rapeseed oil, and palm oil methyl ester) of biodiesel.

Table 2 also shows the "average" emissions results for some non-regulated pollutants. Emissions of sulfates, polycyclic aromatic hydrocarbons (PAH's), nitrated PAH's (nPAH), and hydrocarbon species that can react to form smog, are greatly reduced with the use of biodiesel. Since B100 is derived from vegetable oil, it contains no sulfur compounds, and thus sulfate emissions are reduced in proportion to the percent volume of biodiesel in the blend. The primary concern over sulfur emissions is the potential to produce acid rain. The reduction of sulfur emissions is currently being addressed via the

introduction of ultra low sulfur diesel (ULSD) in the fuel supply. Polycyclic aromatic hydrocarbons and nPAH's have been identified as potential cancer causing compounds [28] and are precursors to soot (particulate matter) formation. Smog is a form of air pollution in which certain emissions react to produce several irritating and oxidizing compounds, the most prominent of which is ozone. Nitrogen oxides, hydrocarbons, and sunlight are required to form smog. The reaction of certain hydrocarbons with nitrogen oxide (NO) contributes to the formation of ozone. The tendency of hydrocarbon emissions to contribute to ozone formation is described as the ozone potential of speciated hydrocarbons. Even though the last four pollutants in Table 2 are currently unregulated, the reduction in these pollutants is clearly desired.

Biodiesel Content	**B100**	**B20**
Energy Content/Gal	-8%	<-2%
Emission		
Regulated		
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
NOx	+10%	+2%
Non-Regulated		
Sulfates	-100%	-20%
PAH (Polycyclic Aromatic Hydrocarbons)	-80%	-13%
nPAH (nitrated PAH's)	-90%	-50%
Ozone potential of speciated HC	-50%	-10%

Table 2.2: Energy content and emissions for B100 and B20 [28,29].

2.4.3 *Issues with Usage*

The advantageous and potentially problematic properties of biodiesel were introduced in an earlier section (**2.2.2 *Properties of Biodiesel***). The issues associated with biodiesel usage stem primarily from two properties; biodiesel acts as a solvent, and biodiesel has higher cold flow properties than #2 diesel. Several solutions to the issues associated with biodiesel usage are presented in the U.S. Department of Energy's "2004 Biodiesel Handling and Use Guidelines" [30]. These issues and solutions are discussed below.

The fact that biodiesel acts as a solvent leads to both fuel handling and operational issues. The least critical of these issues is that biodiesel spills on painted surfaces should be cleaned up immediately to prevent paint removal. A larger concern is B100's tendency to soften and degrade certain rubber and elastomer compounds. These compounds are often used in fuel hoses and fuel pump seals, particularly on older engines. Prior to using B100 in an engine, the OEM engine manufacturer should be consulted to determine if the fuel system components are compatible with B100. Compatibility issues can be resolved by replacing fuel system components with synthetic hoses and seals that are resistant to oxygenated fuels. For example, parts made with Viton® are compatible with B100. Newer engines that are manufactured to operate using ULSD will, in general, have parts that are compatible with B100. Even if a newer ULSD compatible engine is used, the

OEM manufacturer should be consulted to verify compatibility and ensure engine warrantees will be honored. Biodiesel blends up to B20 have been used in older engines without any observed fuel system component degradation. However, a prudent course of action would be to upgrade fuel system components if B20 is to be used. Because it is a solvent, B100 will remove deposits left in the fuel system by petroleum diesel, which can lead to clogged fuel filters. When switching directly from petroleum diesel to B100, fuel filters should be checked and cleaned frequently until the fuel system deposits are removed. Blends as high as B20 have not shown the same tendency to remove fuel system deposits, however, more frequent checking and cleaning of the fuel filters should still initially be performed.

Engine operation in cold weather can be problematic due to the higher cold flow properties associated with B100. As a precaution, B100 should not be used without heated fuel tanks and fuel lines if the temperature is below 40°F. This is a conservative estimate since the "average" cloud point of B100 is 32°F as compared to 3°F for #2 diesel. Blends up to B20 can be used in environments with temperatures approaching the operational temperature for the distillate used in the blend. For example, the cloud point of #2 diesel is 3°F, and when B20 is produced with #2 diesel, the cloud point is approximately 7°F. The solutions for avoiding fuel gelling when using B100 or a biodiesel blend (such as B20) are the same as those for #2 diesel. Namely, blend with #1 diesel, use a fuel line heater, keep the engine and fuel lines in an environmentally controlled space, and use cold flow enhancing fuel additives.

2.4.4 *Maritime Usage*

Biodiesel blends up to approximately B20 can be used as direct replacements for diesel powered equipment on maritime vessels that utilizes #2 diesel with little or no modification to current systems. The use of a B20 blend will allow for measurable reductions in emissions with no noticeable decrease in fuel economy. Many OEM engine manufacturers currently certify the use of up to B5 in their engines as long as both the biodiesel and the distillate portion of the blend meet ASTM specifications. ASTM International is currently working with OEM engine manufacturers to create a B20 standard for engine certification tests. Main engines that operate on heavy fuel oils or Bunker C are not candidates for the use of B20.

Examples of ship board systems that currently use #2 diesel include, the main engines on ships with EMD diesels, diesel-generator sets, emergency generators, and deck crane power packs. The specific engines that power these systems, as well as the makeup of the systems themselves, vary from ship to ship. Some components, such as the deck crane power packs, have fuel systems exposed to ambient weather conditions, while other components, such as the diesel-generator sets, have fuel system components in environmentally controlled spaces. As a result, no single set of rules for converting to B20 usage can be delineated, and the general rules for dealing with the issues discussed in the preceding section should be applied to each system on each ship.

A potential problem with maritime operation that has not been addressed in the literature is that of the long-term stability of biodiesel blends in cold weather. As discussed earlier in this report, stability tests address both the thermal [6] and oxidation [4,5] stability. These tests use a slightly elevated temperature to simulate long-term storage (greater than 4 to 6 months). This is unlikely to be a problem with vessels on the Great Lakes, which refuel often. The exception to frequent refueling occurs during the winter lay up period (2 months), when the portions of the main fuel tank below the waterline are at approximately 0°C (32°C) and portions above the waterline may be at temperatures slightly below freezing. Auxiliary systems may have components exposed to below freezing temperatures. The available stability tests do not address this potential cold weather problem. The 2004 Biodiesel Handling and Use Guidelines [30] recommends that blends should be stored at 5 to 10°F above the cloud point of the blended fuel, which suggests that distillate portion of a B20 blend should consist of "winter diesel" (a mix of #1 and #2 diesel). Given that this is done, it is still unclear if prolonged exposure of a B20 (or lower) blend to low temperatures causes any separation and preferential gelling of the biodiesel component.

2.4.5 *Cold Weather Storage Test*

There is currently no test specification for extended storage of biodiesel blends at low temperatures. However, the 2004 Biodiesel Handling and Use Guidelines [30] present a test to check for stratification of biodiesel blends. We plan to modify this test to visually check for biodiesel crystallization and determine if any stratification occurs under low temperatures for extended periods. Such a test would provide useful information to potential biodiesel users on the Great Lakes.

2.5 *Conclusions and Recommendations*

The preceding discussion suggests that biodiesel is an attractive alternative to petroleum-based diesel. The shift to increased biodiesel usage is being driven by, among other factors, environmental concerns, legislative measures, and continued research into improved methods of producing biodiesel. Based on both legislative trends and the efforts of OEM engine manufacturers, it appears likely that B20 will become the standard blend in the diesel fuel supply sometime in the foreseeable future, much as E10 has become a standard fuel in the Midwestern states gasoline fuel supply.

Investigations into possible improvements in the biodiesel production process led to the potential use of a lipase as a replacement for the currently used catalyst sodium hydroxide. The commercial development of a lipase-based process could lower fuel costs and would represent a novel approach to biodiesel production. Hydrogen gas could be extracted from the primary by-product (triacetylglycerol) of the new process to produce energy via either direct combustion or a fuel cell. Investigation into the development of a commercially viable lipase-based production process should be continued.

A review of the literature addressing engine performance and operational issues shows that, while biodiesel has several advantages, such as reduced emissions, the use of biodiesel and its blends in cold weather conditions presents some problems. The guidelines for conversion from petroleum-based diesel to the use of biodiesel blends like B20 suggest that a review of current individual ship systems to identify potential cold weather and material compatibility problems should be performed. This can be accomplished proactively since mandated biodiesel content will likely increase in a step-wise manner over time, for example, from B2 to B5 to B10, and finally to B20. A particular concern for marine vessels on the Great Lakes is potential fuel problems due to storage of biodiesel blends at the low temperatures present during the winter lay up period. It is recommended that a long-term low-temperature test be developed to verify that separation of the blend and preferential gelling of the biodiesel component does not occur.

Chapter 3: Biodiesel: An Alternative Fuel for Great Lakes Marine Vessels; Economic Analysis, Demand and Supply

3.1 Introduction

In the past application of biodiesel for merchant ship propulsion on a large scale has not been seen as an option because of the unavailability of fuel. Background literature has shown a 2% blend of biodiesel is estimated to increase the cost of diesel by 2 or 3 cents per gallon, which includes the fuel, transportation, storage, and blending costs. The following tables quantify demand and supply for biodiesel fuel, review incentives and risk including by-products as market risk.

Research issue. The Labovitz School proposes to quantify the economic impact of fuel conversion from current petroleum based fuel to biodiesel fuel as presented in the research findings for the Great Lakes Maritime Research Institute project by the UMD Departments of Chemical and Industrial Engineering.

Financial and economic scenarios for conversion will be modeled.

This study was contracted for by the Great Lakes Maritime Research Institute.

The contract for this study has the following project description:

> *The economic analysis will include modeling of supply and demand for biodiesel fuel.*
>
> *Great Lakes shipping requirements will be highlighted; an overview of federal and Great Lake states regulations and biofuel subsidies will be completed.*
>
> *Comparisons between the U.S. and Great Lakes Region for the modeling, regulations, and subsidies will be reported.*

Background. The advantages of using biodiesel include supporting domestically produced fuel that helps the agriculture sector and drastically decreases in the amount of polluting emissions. Biodiesel is the only alternative fuel to have fully completed the health effects testing requirements of the Clean Air Act. The use of biodiesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide, and particulate matter compared to emissions from diesel fuel. In addition, the exhaust emissions of sulfur oxides and sulfates (major components of acid rain) from biodiesel are essentially eliminated compared to diesel. Soybean oil is currently the leading source of virgin vegetable oil used for biodiesel feedstock in the United States.[31]

Biodiesel tax credits are available so it will make it competitive with petroleum. [32] General business credit requires certification and eligibility for selling or using biodiesel (not in a mixture) as a fuel. The biodiesel fuel credit consists of a straight biodiesel fuel

credit and a biodiesel mixture credit. Certification must identify the product produced and the percentage of biodiesel and agric-biodiesel in the product. [Currently, the credit is not allowed for biodiesel (or agric-biodiesel) used as a fuel in a trade or business if that biodiesel (or agric-biodiesel) was sold in a retail sale for circumstances described by the IRS.]

The U.S. Department of Agriculture announced in January 2001 the implementation of the first program providing cost incentives for the production of 36 million gallons of biodiesel. Bills supporting the use of biodiesel and ethanol were also introduced to the U.S. Congress in 2003, including one that would set a renewable standard for fuel in the U.S. and one that would give biodiesel a partial fuel excise tax exemption. More than a dozen states have passed favorable biodiesel legislation. [See: 2005 Federal Energy Bill Provisions; and MN State Energy Legislation 2005.] [33]

Biodiesel is known to have a solvent effect that may release deposits accumulated on tank walls and pipes from previous diesel fuel storage. This affect is much more dramatic with B100 than with biodiesel blends like B20.

Relevant sources and literature. Secondary data sources include, but are not limited to, the U.S. Department of Energy, Energy Information Administration, for oil pricing trends; the MN Soybean Processors for producer data; Farmers Union Marketing and Processing Association (FUMPA) for producer data; U.S. Department of Transportation and the Census; the Bureau of Economic Analysis for commodity and industry tables; the National Biodiesel Board for trade association and industry data; and the Renewable Fuels Association for industry statistics. One of the fastest moving statistical sources for biodiesel data to date remains the National Biodiesel Board (nbdb.org).

Methodology. This economic analysis does not include assumptions from the wide ranging national discussion of biodiesel processes and its use as a fuel, nor does it develop arguments or contribute to many of the environmental and economic topics currently being pursued by interest groups.

This economic analysis looks briefly at the national picture, for perspective and comparisons but focuses on the regional industry impacts for the Great Lakes. The analysis presents for comparison measures of the petro-diesel supply chain, and compares the hypothetical B2 supply chain including financial considerations such as pricing, production data. Also presented on a local and regional basis are incentive programs, regulations, and subsidies from the federal government, the State of MN, and other Great Lakes regional agencies.

A larger economic perspective includes strategies such as carbon credits trading, as a business asset, which are one choice among many for fuel consumers to consider when planning for regulation compliance. Carbon credit trading is part of a larger incentive approach. The market gives consumers the opportunity to choose the most efficient means for reducing their carbon emissions. Benefit cost analysis presents a range of other compliance strategies, in some cases choices more efficient (less expensive, more

productive) than mandating change to biodiesel fuel. This research includes: review of the economics of emissions regulation strategies (of which carbon credit trading is one); study of appropriate caps on emissions levels; quantifying the variety of incentives that encourage consumer compliance with regulatory caps; and comparing economic benefit and cost to various stakeholders. These strategies are taken up in Chapter 5: Recommendations to this report.

3.2 Demand and Supply for Great Lakes Maritime Biodiesel Fuel

The fuel tested for this study was specifically derived from soybean feedstock and blended as B2 fuel. Therefore the following discussion will present supply chain information based on these two attributes and generally constrained to the study area for Great Lakes maritime commerce.

The supply chain for biodiesel demand and supply production and delivery is made complicated by vertical integration of processes at various points in the supply chain. For instance, producers and distributors are often the same entity, as are distributors and retailers. This industry started with small independent entrepreneurs, with demand as a grass roots movement at large, however large and global scale production is growing, for instance the aggressive Brazilian project, so that the small players are destined to be subsumed into conglomerate structures. For our analysis, the changing nature of these structures, and the volatile production and pricing associated with these dynamic changes make modeling the industry in its infancy beyond the scope of this project. An analogy can be drawn with the computer industry, when the industry was first beginning there were many independent producers trying to meet growing demand. Eventually the low cost producers were able to force the independent producers out of the industry and capture more and more market share. Thus, the moving target of capturing data to show trends and industry structure, as we attempt to do below, is challenging.

3.2.1 Demand

Demand will be presented first from the larger national perspective, then from the Great Lakes and maritime perspectives. The national overview of transportation energy crude oil consumption is shown in the graphic below. Data from the Transportation Energy Data Book 2005 shows that U.S. marine petroleum demand was approximately 0.43 million barrels per day, or 157 million barrels per year in 2002, or 8.6 billion gallons of crude oil demand for the total domestic U.S. marine sector.

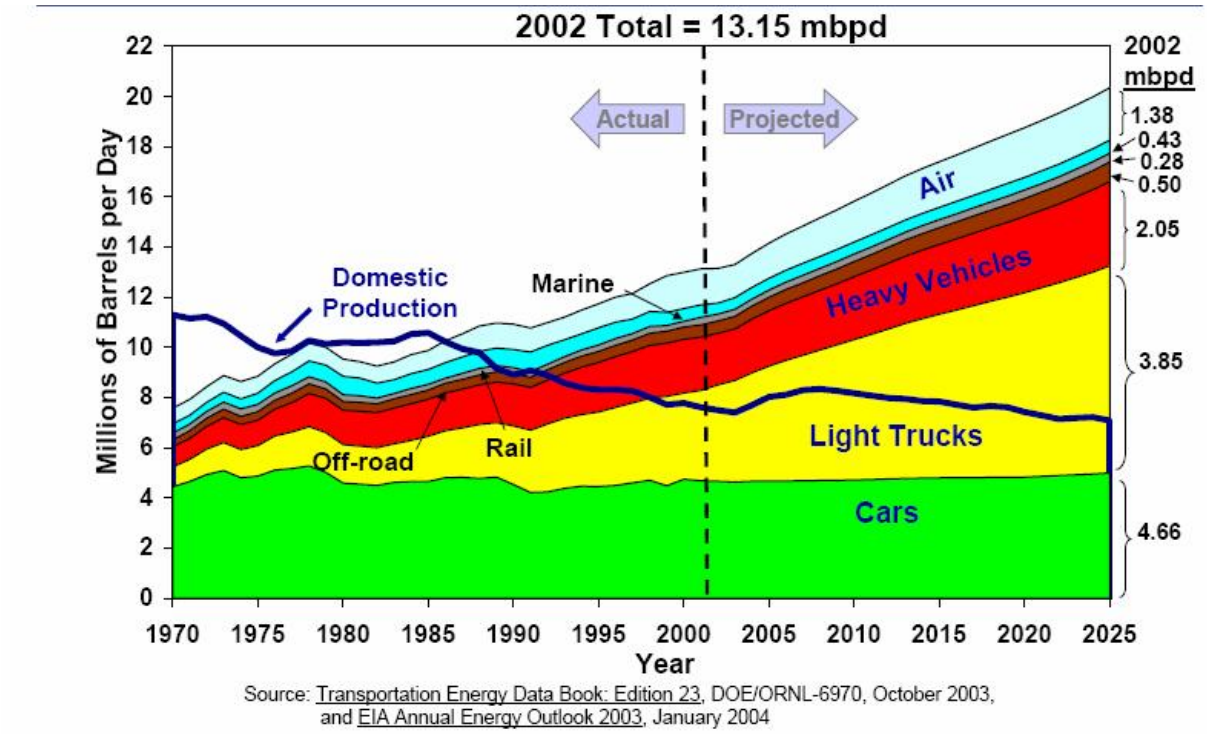

Figure 2: U.S. Diesel Demand

Moving again from the national demand to the U.S. domestic marine detail, vessel bunkering data from the US DOE, show that demand was 2.1 billion gallons in 2004. Note: Vessel bunkering includes sales for the fueling of commercial or private boats, inclusive to oil company vessels but excluding military vessels.

Table 3.1: Diesel Consumption: Vessel Bunkering, Sales of Distillate Fuel Oil by Energy Use in the United States: 2000-2004 (in thousands of gallons)

	Distillate Fuel Oil				
Energy Use	*2000*	*2001*	*2002*	*2003*	*2004*
U.S. Total	59,601,230	59,911,345	59,342,633	63,854,776	62,257,934
Vessel Bunkering	2,261,422	2,044,049	2,078,921	2,216,921	2,139,643

Source: DOE EIA http://www.eia.doe.gov/pub/oil_gas/petroleum/data publications/fuel_oil_and_kerosene_sales/historical/2004/foks_2004.html

From the U.S. domestic marine sector to the Great Lakes detail, we see vessel bunkering data by Great Lakes use as almost 170 million gallons in 2004.

Table 3.2: Diesel Consumption: Vessel Bunkering, Sales of Distillate Fuel Oil by Energy Use in the Great Lakes States: 2004 (in thousands of gallons)

Destination	*Vessel Bunkering 2004*	*% of Great Lakes*
New York	13,296	8%
Pennsylvania	22,964	14%
Illinois	107,110	63%
Indiana	7,289	4%
Michigan	8,792	5%
Minnesota	5,367	3%
Ohio	3,104	2%
Wisconsin	1,949	1%
Great Lakes Total	169,871	
U.S. Total	2,139,643	100%

Source: DOE EIA
http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/fuel_oil_and_kerosene_sales/historical/2004/foks_2004.html

*Note: these data are used in the impact modeling for Chapter 4.

Biodiesel B20 prices increased from $1.23 in July in 2002 to a peak of $2.84 in September 2005. The price came back somewhat in February 2006.

Table 3.3: U.S. Biodiesel Prices October 2000 to February 2006

Date	*Petroleum Diesel ($/gal)*	*Biodiesel B20 ($/gal)*
10-Oct-00	1.44	
3-Jul-01	1.56	
22-Oct-01	1.33	1.47
11-Feb-02	1.13	1.27
15-Apr-02	1.31	1.25
22-Jul-02	1.30	1.23
28-Oct-02	1.46	1.60
10-Feb-03	1.65	1.48
8-Dec-03	1.45	1.55
8-Mar-04	1.59	1.65
14-Jun-04	1.66	1.73
15-Nov-04	2.10	2.09
21-Mar-05	2.20	2.18
15-Sep-05	2.77	2.84
09-Feb-06	2.56	2.64

Source: Biodiesel prices, DOE.gov

Demand Forecast. Table 3.4 below shows 2005 to 2015 projected consumption of highway diesel and B100 from soybeans and other feedstock. B100 demand is expected to increase almost nine-fold, rising from 75 million gallons in 2005 to 648 million gallons by 2015. It is unlikely that the Great Lakes maritime industry will experience these explosive growth rates, but this is an indication of the expected acceptance of biodiesel fuels.

Table 3.4: U.S. Diesel Fuel and Biodiesel Forecast

	Highway Diesel Use /1 (Bil gal)	***B100 Volume (Mil gal)***	***Biodiesel From Soybeans (Pct)***	*Biodiesel From Soybeans (Mil gal)*	*Biodiesel From other Feedstocks (Mil gal)*	*Soybean Oil Equiv /2 (Mil lb)*	*Soybean Equiv /3 (Mil Bu)*
2005	43.2	**75.0**	**91.5%**	68.6	6.4	51	46
2006	44.4	**150.0**	**90.8%**	136.1	13.9	1,021	92
2007	45.5	**172.5**	**90.0%**	15.3	17.3	1,164	105
2008	46.4	**215.6**	**89.3%**	192.4	23.2	1,443	130
2009	47.4	**269.5**	**88.5%**	238.5	31.0	1,789	161
2010	48.4	**323.4**	**87.8%**	283.8	39.6	2,129	191
2011	49.4	**388.1**	**87.0%**	337.7	50.5	2,533	227
2012	50.2	**465.8**	**86.3%**	401.7	64.0	3,013	270
2013	51.0	**535.6**	**85.5%**	457.9	77.7	3,435	308
2014	51.6	**589.2**	**84.8%**	499.3	89.8	3,745	336
2015	52.3	**648.1**	**84.0%**	544.4	103.7	4,083	367

Source: Forecast prepared by LECG, LLC
1. Annual Energy Outlook 2006. High Oil Price Case. Table 2. Converted from btu at 138,690 btu/gal
2. Converted using 7.5 lb soybean oil = 1 gal biodiesel
3. Assumes 11.1 lbs sbo/bu soybeans

3.2.2 Supply

Following the data for soybean feedstock supply, we compare the Great Lakes states' ability to supply feedstock for biodiesel production of fuel for maritime commerce. The 1996-2006 production level trend for soybean production and prices for the U.S. is shown below. In 2006 production topped 3 billion bushels.

Table 3.5: U.S. Soybean Production and Price Trends 1996-2006

Year	*Area*	*Production (thousands of bushels)*	*Price($ per bushel)*
1996	U.S.	2,380,274	$7.35
1997	U.S.	2,688,750	$6.47
1998	U.S	2,741,014	$4.93
1999	U.S	2,653,758	$4.63
2000	U.S	2,757,810	$4.54
2001	U.S	2,890,682	$4.38
2002	U.S	2,756,147	$5.53
2003	U.S	2,453,665	$7.34
2004	U.S	3,123,686	$5.74
2005	U.S	3,086,432	$5.50
2006	U.S	3,092,970	

Source: USDA - National Agricultural Statistics Service

The detail in the U.S. trend for the Great Lakes states for 2005 shows the percent of U.S. The eight Great Lakes states produced 45% of the total U.S. soybean production.

Table 3.6: Great Lakes States Soybean Production and Price Trends 2005

Year	Area	Production *(thousands of bushels)*	Per Cent of US Total	Price *($ per bushel)*
2005	Illinois	439,425	14%	$5.50
2005	Indiana	263,620	9%	$5.50
2005	Michigan	76,615	2%	$5.55
2005	Minnesota	306,000	10%	$5.45
2005	New York	7,896	0%	$5.20
2005	Ohio	201,600	7%	$5.55
2005	Pennsylvania	17,220	1%	$5.55
2005	Wisconsin	69,520	2%	$5.50
2005	Totals	1,381,896	45%	$5.48

Source: USDA - National Agricultural Statistics Service; NASS - Data and Statistics - Quick Stats.
See: www.nass.usda.gov/Data_and_Statistics/Quick_Stats/

Great Lakes states' maritime commerce consumes about 170 million gallons of diesel fuel. Based on soybean production in 2005 it would take about 9% of the eight states' soybean production to satisfy total demand for converted biodiesel maritime use.

Table 3.7: Great Lakes States Soybean Production and Price Trends 2005 for Maritime

Year	Area	Production *(thousands of bushels)*	Possible total gallons from 2005 soybean production (thousands of gallons)*	Gallons forecast to achieve states' contribution to meet 2005 Great Lakes maritime demand
2005	Illinois	439,425	615,195	54,058
2005	Indiana	263,620	369,068	32,430
2005	Michigan	76,615	107,261	9,425
2005	Minnesota	306,000	428,400	37,644
2005	New York	7,896	11,054	971
2005	Ohio	201,600	282,240	24,801
2005	Pennsylvania	17,220	24,108	2,118
2005	Wisconsin	69,520	97,328	8,552
				170,000
2005	Totals	1,381,896	1,934,654	

*According to the US Department of Agriculture's (USDA) Farm Service Agency, one bushel of soybeans yields approximately 1.4 gallons of biodiesel.
Source: USDA - National Agricultural Statistics Service; NASS - Data and Statistics - Quick Stats. See: www.nass.usda.gov/Data_and_Statistics/Quick_Stats/; UMD BBER

3.2.3 Incentives

Federal Incentives. "The main drivers for increased biodiesel demand will be projected high energy prices and incentives provided by the EPACT05 and individual States. As indicated earlier, EPACT05 mandates that a minimum of 7.5 billion gallons of renewable

fuels (ethanol and biodiesel) be used in the nation's motor fuel by 2012. The legislation provides other significant incentives, specifically: Extension of the biodiesel tax credit through 2008 at one cent per gallon for agri-biodiesel and ½ cent per gallon for biodiesel from other sources such as recycled fats and oils" [34]

Table 3.8: U.S. Biodiesel Tax Incentives

Biodiesel Tax Credit	Current rules: Excise tax credit of $1/gal agri-biodiesel & $0.50/gal waste-biodiesel owed on federal road taxes. Changes 1/1/06: 1¢/% biodiesel through December 31, 2008. IRS rules on changes have not been issued yet.
Biodiesel Station Tax Credit	Up to 30% of the total costs up to $30,000 of B20 (20% biodiesel) or greater fueling equipment installed as of January 1, 2006 through December 31, 2007. IRS rules have not been issued yet.

Source: www.biodiesel.org/news/taxincentive/

Table 3.9: U.S. Incentive Program Payments

Fuel	*Gallons Reported*	*Payments*
Q1 2006 Payment Information		
Ethanol Increase	178,906,818	$4,257,670
Biodiesel Increase	25,909,877	$4,252,737
Biodiesel Base	10,206,299	$0
Total Biodiesel	36,116,176	$4,252,737
Program Total	215,022,994	$8,510,407
Second Quarter, Fiscal Year (FY) 2006 Payment Information		
Ethanol Increase	202,515,048	$4,676,529
Biodiesel Increase	29,078,589	$3,834,885
Biodiesel Base	6,905,720	$0
Total Biodiesel	35,984,309	$3,834,885
Program Total	238,499,357	$8,511,414
Q3 2006 Payment Information		
Ethanol Increase	203,970,911	$5,029,630
Biodiesel Increase	50,273,774	$4,385,807
Biodiesel Base	14,380,439	$0
Total Biodiesel	64,654,213	$4,385,807
Program Total	268,625,124	$9,415,437
Cumulative 2006 Payment Information		
Ethanol Increase	580,996,189	$13,860,613
Biodiesel Increase	103,321,587	$12,165,625
Biodiesel Base	32,192,229	$0
Total Biodiesel	135,513,816	$12,165,625
Program Total	716,510,005	$9,415,437

Cumulative 2005 Payment Information		
Ethanol Increase	543,546,642	$65,947,726
Biodiesel Increase	50,922,590	$32,022,011
Biodiesel Base	15,263,152	$1,630,945
Total Biodiesel	66,185,742	$33,652,956
Program Total	609,732,383	$99,600,682

US Incentive Bioenergy Program Payments 2005-06
Source: http://www.fsa.usda.gov/FSA/webapp?area=home&subject=coop&topic=pai-be-05. See Programs and Initiatives; Bioenergy Program

Table 3.10: Great Lakes States Biodiesel Incentives

	MN	*WI*	*IL*	*IN*	*MI*	*OH*	*PA*	NY
Biodiesel Use Incentive		Yes						
AFV Acquisition Requirements	Yes	Yes	Yes			Yes	Yes	Yes
Blend Mandate	2%		2%					
Alternative Fuel Tax	Yes		Yes			Yes	Yes	
AFV Tax Deduction		Yes	Yes					Yes
Emissions Reduction Requirement	Yes						Yes	
LEV Acquisition Requirement		Yes						
Alternative Fuel Production Incentive				Yes	Yes			
Biodiesel Blending Credit				Yes				
Biodiesel Retailer Credit				Yes		Yes		Yes
Consumption Mandate								Yes

AFV = Alternative Fuel Vehicle LEV = Low Emission Vehicle

Source: U.S. DOE Energy Efficiency and Renewable Energy.
See: http://www.eere.energy.gov/afdc/laws/incen_laws.html

Minnesota incentives

Table 3.11: Minnesota Biodiesel Mandate

Biodiesel Blend Mandate	*Issue Date*	*Effect Date*	*Exemptions*	*Conditions to be met for the mandate*
Two Bills: H.F. 362 and S.F. 326. All diesel fuel sold or offered for sale in the state for use in internal combustion engines must contain at least 2% biodiesel fuel by volume.	2001	30-Jun-05	Jet fuel and aviation fuel	The state is able to produce more than eight million gallons of biodiesel fuel annually, or a federal action creates a $0.02 per gallon or greater reduction in the price of taxable fuel containing at least 2% biodiesel fuel sold in the state.

Source: U.S. DOE Energy Efficiency and Renewable Energy.
See: http://www.eere.energy.gov/afdc/laws/incen_laws.html

3.4.2 Risk

The following two tables highlight a simple SWOT analysis (strengths, weaknesses, opportunities and threats). The tables show both the producers (or suppliers) and the consumers (end-users). The SWOT analysis is typically used in the development of a feasibility study or business plan, and for marketing plans.

Producers:

Table 3.12: Producers' Risk Analysis

Strengths:	*Weaknesses:*	*Opportunities:*	*Threats:*
Less dependence on foreign oil	By-products from process of producing Biodiesel Glycerin	Many new opportunities will arrive for alternative fuel producers in the next couple of years with raising gas prices	Threat of higher up companies coming by and stealing business
High energy multiplier	Chemical and engineering skills are required	Rapidly emerging fuel	
Tax incentives			

Source: UMD BBER

Consumers:

Table 3.13: Consumers' Risk Analysis

Strengths:	*Weaknesses:*	*Opportunities:*	*Threats:*
Better lubricity	More expensive then petro-diesel	Alternative fuel choices	Better lubricity
Consumer incentives	Poor performance in cold temperatures (gelling)	Environmentally friendly	Higher prices

Source: UMD BBER

For the general economy of the U.S. (and the Great Lakes states) the strengths include reduction of dependence on foreign oil supplies, the benefits from reinvesting money in the U.S. and regional economy, stronger energy yield, and the advantage of net energy gain for biodiesel fuel compared to other fuels.

Table 3.14: Net Energy Gain (or loss) by Fuel

Fuel	Energy Yield	Net Energy (loss) or gain
Gasoline	0.805	(19.5 percent)
Diesel	0.843	(15.7 percent)
Ethanol	1.34	34 percent
Biodiesel	3.2	220 percent

Source: Energy Balance/Energy Life Cycle Inventory

By-products as market risk

Glycerol is a by-product from the transesterification process used in the formation of biodiesel. The glycerol produced during the transesterification process is about 50% pure. You can raise the purity level to 80%-90% by adding hydrochloric acid until the crude glycerol reaches a pH level that is acidic (around 4.5).

Market: Glycerol is a very common industrial product. Primary uses for glycerol include: food products, cosmetics, toiletries, toothpaste, explosives, drugs, animal feed, plasticizers, tobacco, and emulsifiers. There are color and odor standards for glycerol. Market pricing is based on glycerol that is 99.7% pure

The glycerol market will most likely become oversaturated in the next two years unless new uses for glycerol are discovered.

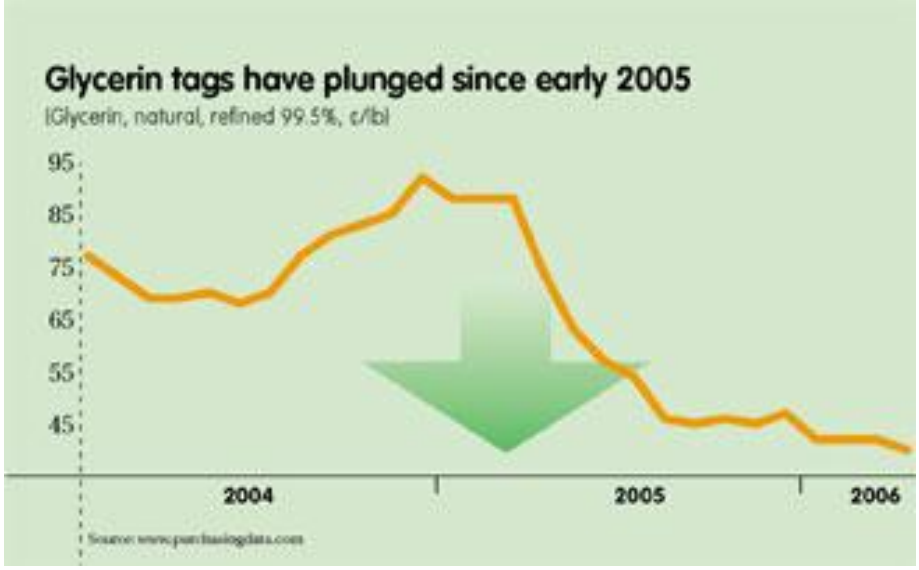

Figure 3: Glycerin as Market Risk
Source: "Glycerin Glut Sends Prices Plummeting," Gordon Graff. See www.purchasing.com/article/CA6341035.html

Summary. Volatile production and pricing associated with dynamic changes make modeling the biodiesel industry challenging. For instance, for business planning, a break-even analysis usually calculates a break-even point based on fixed costs, variable costs per unit of sales, and revenue per unit of sales. Business planning at the level of individual enterprise is suggested as further research, and assumptions of per-unit revenue and per-unit cost as well as assumption of other fixed costs would be estimated through a detailed sales forecast as well as profit and loss data from the industry. Given the aforementioned volatility of this market, as seen in the supply and demand trends in the foregoing data tables, average sales and costs may not be representative. Analysts predict, however, that costs will come down and prices will rise, making the break-even point a moving target. The variation in feedstock producers, type of feedstock, the possibility of increased demand from Great Lakes maritime fleets, "fixed" costs such as legislated incentives and regulations which can be amended or removed, and the technological advances in chemical processing and operations and end-use engineering can introduce new variables at any stage of the business model.

For the industry sector, it can be assumed that eventually the low cost producers will able to force the independent producers out of the industry and capture market share. Changes in the industry sector will have impacts for the regional economy. An estimate of economic impacts to the Great Lakes region from the introduction of more biodiesel production follows in Chapter 4.

Chapter 4: Potential Economic Impacts

Economic Impact Modeling: Great Lakes Biodiesel Plant

4.1 Biodiesel Plant Impact

The use of biodiesel fuel by Great Lakes commercial fleets is expected to increase in the future. By the end of the decade, the demand for biodiesel could be over 30 million gallons. Although over 23 million gallons of diesel sales were disclosed by two Great Lakes suppliers for this report, other Great Lakes producers would not reveal sales volume. Therefore total Great Lakes sales or production could not be reported. However it is possible to assume that a new 30 million gallons biodiesel facility could be supported as the Great Lakes fleets convert to biodiesel usage. We note from the previous chapter, data show that there was domestic demand for 2.1 billion gallons of distillate fuel oil for vessel bunkering in 2004. How quickly vessels will convert to biodiesel is unknown, but some of this demand could be supplied by increased biodiesel production. To meet this increased demand, a new Great Lakes Biodiesel Plant, of typical production capacity of 30 million gallons per year, should be feasible. Our assumptions as inputs to these models are constrained to projections for commercial maritime diesel consumption.

The following Great Lakes Biodiesel Plant is modeled to be a 30 million gallon production facility with a construction cost of $30.98 million. This study is not site-specific in that the findings are for a facility that can be located anywhere in the eight-state Great Lakes Region. There would be 37 workers employed at full capacity operations. These economic model specifications were selected to be conservative and well under estimated market demand. In reality, sales should be able to support additional Great Lakes plants to feed the expanding maritime demand. The economic impacts presented in this report are for a single plant.

The UMD Labovitz School research bureau (Bureau of Business and Economic Research) worked with biodiesel industry contacts in determining key assumptions in the development of the economic impact model. Regional and state data for the impact model for Value Added, Employment, and Output is supplied by IMPLAN. [35] From these data, Social Accounts, Production, Absorption, and By-products information are generated from the national level data and incorporated into the model.

The Study Area. This report measured the economic impact of a Great Lakes Biodiesel Plant on the eight-state Great Lakes region. The study area includes the states of Minnesota, Wisconsin, Michigan, Ohio, Illinois, Indiana, Pennsylvania and New York.

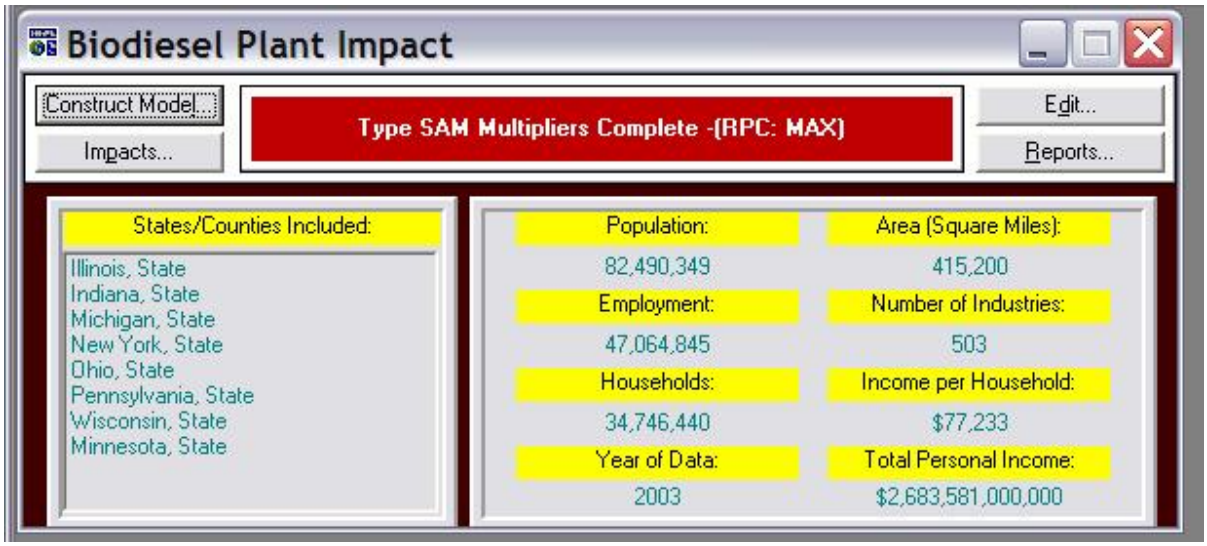

Figure 4: Great Lakes Region IMPLAN model information
Note: The most recent data available for modeling is year 2003. IMPLAN model deflators were used to report 2005 impacts.

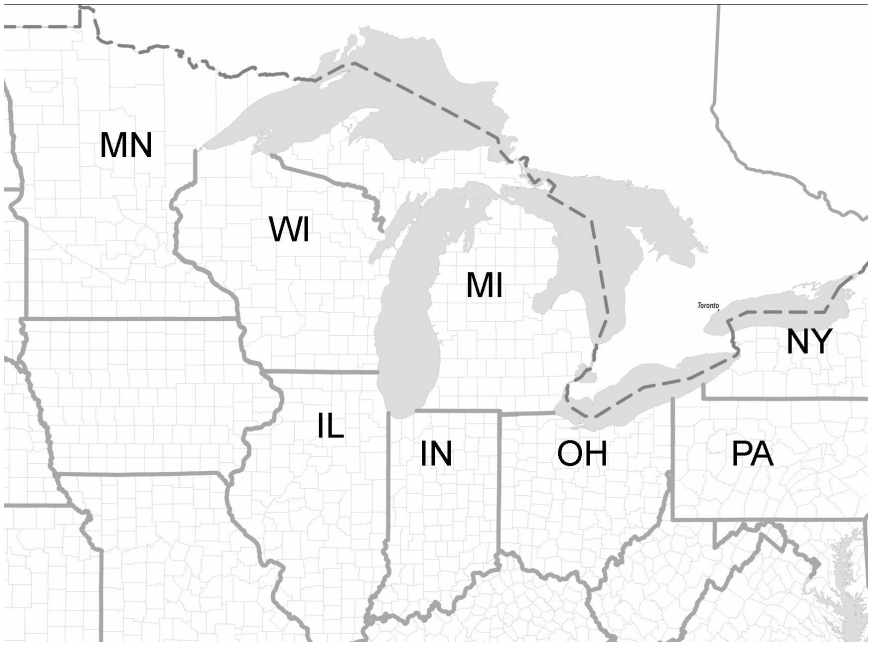

Figure 5: Great Lakes Study area including Illinois, Indiana, Michigan, New York, Ohio, Pennsylvania, Wisconsin, and Minnesota.
*Source:**www.amaps.com/,** by permission.*

Impact Procedures and Input Assumptions. There are two components to the IMPLAN system, the software and databases. The databases provide all information to create regional IMPLAN models. The software performs the calculations and provides an interface for the user to make final demand changes.

Comprehensive and detailed data coverage of the IMPLAN study areas by county, and the ability to incorporate user-supplied data at each stage of the model building process, provides a high degree of flexibility both in terms of geographic coverage and model formulation, in this case definition of the State of Minnesota and the eight-state Great Lakes Region study areas, and the definition of specific models for construction and operations. Using the IMPLAN software and data, BBER identified Great Lakes Biodiesel Plant's expenditures in terms of the sectoring scheme for the model, in producer prices, in historical dollars based on the year of the model, and applied those dollars spent within the two study area definitions given for the impact analysis.

Data:

IMPLAN data files use federal government data sources including:

- US Bureau of Economic Analysis Benchmark I/O Accounts of the US
- US Bureau of Economic Analysis Output Estimates
- US Bureau of Economic Analysis REIS Program
- US Bureau of Labor Statistics County Employment and Wages (CEW) Program
- US Bureau of Labor Statistics Consumer Expenditure Survey
- US Census Bureau County Business Patterns
- US Census Bureau Decennial Census and Population Surveys
- US Census Bureau Economic Censuses and Surveys
- US Department of Agriculture Crop and Livestock Statistics

IMPLAN data files consist of the following components: employment, industry output, value added, institutional demands, national structural matrices and inter-institutional transfers.

Impacts for these models use the most recent IMPLAN data available which is for the year 2003. The impact is reported in 2005 dollars, calculated with the built-in deflators of the modeling software.

Economic impacts are made up of direct, indirect, and induced impacts. The following cautions are suggested assumptions for accepting the impact model:

- IMPLAN input-output is a production based model
- Local or export based purchases that represent transfers from other potential local purchases are not counted.
- The numbers (from U.S. Department of Commerce secondary data) treat both full and part time individuals as being employed.
- Assumptions need to be made concerning the nature of the local economy before impacts can be interpreted.
- The IMPLAN model was constructed for the year 2003 (most recent data available). 2005 dollars are estimated by the model.

Definitions used in this report:

Measures

- **Gross Output** represents the value of local production required to sustain activities.
- **Value Added** is a measure of the impacting industry's contribution to the local community; it includes wages, rents, interest and profits.
- **Employment** estimates are in terms of jobs, not in terms of full-time equivalent employees. Hence, these may be temporary, part time or short term jobs.

Effects

- **Direct** – Initial new spending in the study area resulting from the project
- **Indirect** – The additional inter-industry spending from the direct impact
- **Induced** – The impact of additional household expenditure resulting from the direct and indirect impact.

Inputs provided for modeling the impact of the Great Lakes Biodiesel Plant

BBER modeled key assumptions to estimated expenditures for the proposed plant.

Construction

Materials: For the construction impact, BBER estimates the construction period is 18 months. Construction costs are estimated to be $20,654,014 for Year 1 and $10,327,007 in Year 2. For these dollars, percent of the total cost for materials, and the percent the eight-state region could supply of products and services for the project.

Labor: Costs for the 18 month timeline. IMPLAN model's estimates of wage rates and output per workers are used for labor costs.

Operations

For the operations impact, BBER provided estimates for such components as staffing and labor cost per year. BBER also projected the annual total output of the plant.

Industry sector adjustments

NAICS industry sector 311225 Fats and Oils Refining and Blending (IMPLAN sector 54) was used to model the potential Great Lakes Biodiesel Plant.

Production functions addressed in the gross absorption tables for the industrial sectors of the input-output modeling were adjusted to reflect estimates for the Great Lakes Biodiesel Plant construction and operations demand changes.

Benchmark (economic base) and impact (additional plant) models were constructed for the regional eight-state economy.

Employment

IMPLAN measures of direct, indirect, and induced employment follow from assumptions in the model concerning the estimation of permanent, temporary, and part-time employment.

Inflation

The most recent IMPLAN data available for modeling these impacts are for industry sectors in the year 2003. To more accurately represent costs and impacts 2003 impacts were then inflated to show 2005 dollars in the tables of this report, using the industry specific deflators from the IMPLAN model.

4.2 Findings: Construction Impacts and Operations Impacts

The following tables use the estimated values of Great Lakes Biodiesel Plant's direct expenditures on the Great Lakes Region as the original input for the model. Direct expenditures are listed in the column labeled, "Direct Effect." "Indirect Effect" measures the amount of increased spending between commercial, government and service industries, and "Induced Effect" measures the amount of increased spending by residential households. "Total Effect" is the sum of Direct, Indirect, and Induced Effects.

None of the tables that show Great Lakes Biodiesel Plant's yearly employment impacts add the total number of jobs-created across all 18 months of construction. Although IMPLAN required that each calendar year of construction be modeled as a separate event, each job created by construction activity may carry through all calendar years as the same job, and could thus be counted more than once. (For instance, the engineers, project managers, and installers that Great Lakes Biodiesel Plant will employ for Year 1 might still be employed by Great Lakes Biodiesel Plant in Year 2.)

Table 4.1: Summary
Great Lakes Biodiesel Plant Construction Impacts *Year 1 and 2*
(2005 Dollars)

Years	Value Added Totals $	Employment Totals	Output Totals $
Year 1	$22,606,772	365	$43,003,008
Year 2	$11,303,386	182	$21,501,504
Total	$33.910.158	N/A	$64.504.513

Construction. Table 4.1 summarizes the total effects of Great Lakes Biodiesel Plant's direct construction expenditures. The column on the right (labeled "Output Totals") shows that Great Lakes Biodiesel Plant's overall construction expenditure of $30.98 million (direct effect) is calculated to create an additional $34.5 million (indirect and induced effects) in further spending—resulting in economic activity totaling $64.5 million. The column on the left (labeled "Value Added Totals") measures the economic impact of the $14.3 million that the Great Lakes Biodiesel Plant is expected to use to pay for wages, rents, interest, and profits, and is estimated to result in an additional $19.7 million in commercial, government, services and consumer spending for a total of $33.9 million. The column in the center (labeled "Employment Totals") shows the total number of jobs that Great Lakes Biodiesel Plant will create in the Great Lakes Region by directly employing construction workers. The

column shows that in Year 1 of construction, the Great Lakes Biodiesel Plant, which is expected to directly employ nearly 172 workers for construction projects, will result in the creation a total of nearly 365 jobs in the Region. In Year 2 the plant is expected to directly employ almost 86 workers for construction projects, which will result in the creation of more than 182 jobs in the region.

Table 4.2 shows the detailed impact of Great Lakes Biodiesel Plant's construction expenditures on the eight-state Great Lakes Region, over the 18 months of construction required to build Great Lakes Biodiesel Plant. As Table 4.2 illustrates, Great Lakes Biodiesel Plant expects to directly spend a total of $14.3 million on wages, rents, interest, and profits, which in turn will generate an additional $19.6 million in further spending (for a total of $33.9 million). Dividing total value added impact ($33.9 million) by direct -expenditures ($14.3 million) results in a value-added multiplier of 2.37. This means that for each dollar that Great Lakes Biodiesel Plant expends on wages, rents, interest, and profits related to construction, the economy will spend another $1.37.

Table 4.2: Value Added Impact from Construction, Great Lakes Region (2005 dollars)

Year	*Direct Effect*	*Indirect Effect*	*Induced Effect*	*Total Effect*
1	$9,515,959	$5,646,003	$7,444,810	$22,606,772
2	4,757,980	2,823,002	3,722,405	11,303,386
Total	$14,273,939	$8,469,005	$11,167,215	$33,910,158

Table 4.3 shows the economic impact of Great Lakes Biodiesel Plant's total output expenditures over two years of construction. Based on direct-expenditures of $30.9 million, Great Lakes Biodiesel Plant is expected to create $33.5 million in further spending activity in the region. The ratio of Total Effect to Direct Effect ($64.5 million to $30.9 million) gives us an output multiplier of 2.08 for the region.

Table 4.3: Output, Impact from Construction, Great Lakes Region (2005 dollars)

Year	*Direct Effect*	*Indirect Effect*	*Induced Effect*	*Total Effect*
1	$20,654,014	$9,989,732	$12,359,263	$43,003,008
2	10,327,007	4,994,866	6,179,631	21,501,504
Total	$30,981,021	$14,984,598	$18,538,894	$64,504,513

Table 4.4 shows the Great Lakes Biodiesel Plant's impact on employment in the eight-state Great Lakes Region, over the 18 months of plant construction. This table shows that every job that Great Lakes Biodiesel Plant creates during the construction period will result in the creation of additional jobs. Table 4.4 shows that the plant will create roughly 172 full-time, part-time, and temporary jobs during Year 1, which in turn will cause the creation of 193 jobs throughout other sectors. In Year 2 the Great Lakes Biodiesel Plant will create 86 new direct jobs and another 96 jobs will be created in the other sectors of the regional economy.

Table 4.4: Employment, Impact from Construction, Great Lakes Region, Year 1, Year 2

Year	*Direct Effect*	*Indirect Effect*	*Induced Effect*	*Total Effect*
1	172	80	113	365
2	86	40	56	182

Note: Employment impacts from construction cannot be summed for a total over the two year construction period.

(Note: Although each year of construction must be modeled as a separate event, each job created by construction activity can carry through all years, as the same job. For instance, engineers, project managers, and installers for year 1 can be in the same job in year 2.)

The following table, Table 4.5shows the employment impacts from construction for the Great Lakes Region comparing the two years of the construction period. Jobs are ranked by industry sector.

Table 4.5:, Employment Impacts from the Great Lakes Biodiesel Plant Construction, Great Lakes Region, Construction Year 1 and Year 2, by Industry Sector

Source: IMPLAN

YEAR 1	*Jobs*	*YEAR 2*	*Jobs*
Other new construction	171.6	Other new construction	85.8
Architectural and engineering services	19.5	Architectural and engineering services	9.8
Food services and drinking places	14.3	Food services and drinking places	7.2
Employment services	10.8	Employment services	5.4
Wholesale trade	9.4	Wholesale trade	4.7
Hospitals	5.7	Hospitals	2.8
Offices of physicians- dentists- and other health	5.5	Offices of physicians- dentists- and other health	2.7
Food and beverage stores	5.4	Food and beverage stores	2.7
General merchandise stores	5.0	General merchandise stores	2.5
Automotive repair and maintenance- except car wash	4.4	Automotive repair and maintenance- except car wash	2.2
Real estate	4.2	Real estate	2.1
Services to buildings and dwellings	3.7	Services to buildings and dwellings	1.9
Nursing and residential care facilities	3.6	Nursing and residential care facilities	1.8
Motor vehicle and parts dealers	3.4	Motor vehicle and parts dealers	1.7
Social assistance- except child day care services	3.0	Social assistance- except child day care services	1.5
Miscellaneous store retailers	2.8	Miscellaneous store retailers	1.4
Truck transportation	2.8	Truck transportation	1.4
Insurance carriers	2.6	Insurance carriers	1.3
Private households	2.6	Private households	1.3
Nonstore retailers	2.4	Nonstore retailers	1.2
Clothing and clothing accessories stores	2.4	Clothing and clothing accessories stores	1.2
Religious organizations	2.3	Religious organizations	1.2
Building material and garden supply stores	2.2	Building material and garden supply stores	1.1

Operations. Tables below show the economic effects that the Great Lakes Biodiesel Plant is expected to have on the Great Lakes Region during a typical year of operations. It is important to note that unlike the effects of Great Lakes Biodiesel Plant's construction expenditures, which are singular, this report assumes that the region will reap the benefits of the plant's typical-year operations expenditures annually for the life of the plant. The detailed operations impact findings below are reported for the study area, for the typical year, by measure, and by effect.

Table 4.6: Summary
Great Lakes Biodiesel Plant Operations Impacts
Typical Year (2005 Dollars)

Years	Value Added Totals $	Employment Totals	Output Totals $
Typical	$20,187,559	231	$79,035,226

Table 4.6 Summary shows the total economic effects of Great Lakes Biodiesel Plant's direct expenditures for operations on the Great Lakes Region. The right-most column (labeled "Output Totals") displays the economic effects that the plant's total expenditures for operations are expected to have on the region. In a typical year, the plant is expected to directly spend $48.4 million for operations, thereby generating a total of $79 million in economic activity across the region. The left-most column (labeled "Value Added Totals") shows the economic impact of the money that Great Lakes Biodiesel Plant expects to specifically use to pay for wages, rents, interest, and profits related to operations. During a typical year, it is predicted that the plant will directly expend $5.3 million to meet these costs, which should result in total spending of $20 million. The center column (labeled "Employment Totals") measures the number of jobs that Great Lakes Biodiesel Plant is likely to indirectly create by directly creating jobs in operations. Over a typical year, the plant is likely to employ 37 workers in operations, which should result in the creation of nearly 231 jobs in total across the Region.

Table 4.7 shows the detailed Value Added, Output, and Employment impacts for a typical year from operations activity related to the project. The Table shows that in a typical year, the plant is expected to directly spend around $5.3 million in value added expenditures, which should create a total of over $20 million in spending in the region.

Table 4.7: Impact from Operations, Great Lakes (2005 dollars)

	Direct Effect	*Indirect Effect*	*Induced Effect*	*Total Effect*
Value Added	$5,290,991	$9,988,629	$4,907,939	$20,187,559
Output	$48,409,100	$22,478,363	$8,147,766	$79,035,226
Employment	37	120	74	231

As illustrated by Table 4.7, the plant is expected to spend almost $48.5 million for operations in a typical year, which should result in a total of $79 million in spending region-wide. The economic multiplier is 1.63 ($79 million to $48.5 million).

Table 4.7 also shows the multiplier effect for employment, where the 37 direct employment jobs create related jobs in the larger economy totaling 194, and a total added employment in the region of 231. The following table, Table 4.8 shows Employment impacts from Operations for the Great Lakes Region broken out by industry sector. Total jobs are ranked by industry sector employment for the typical year.

Table 4.8: Employment Impacts from the Great Lakes Biodiesel Plant, Great Lakes Region Operations, Total Effect Ranked by Industry Sector

IMPLAN SECTOR	*Direct Effect*	*Indirect Effect*	*Induced*	*Total Effect*
Fats and oils refining and blending	36.9	0.3	0.0	37.2
Wholesale trade	0.0	16.8	2.2	19.0
Truck transportation	0.0	15.8	0.5	16.3
Food services and drinking places	0.0	3.4	7.1	10.5
Oilseed farming	0.0	6.1	0.0	6.1
Employment services	0.0	3.1	0.9	4.0
Real estate	0.0	1.9	1.7	3.5
Management of companies and enterprises	0.0	2.9	0.3	3.3
Automotive repair and maintenance- except car wash	0.0	1.8	1.4	3.2
Hospitals	0.0	0.0	2.9	2.9
Food and beverage stores	0.0	0.7	2.1	2.8
Offices of physicians- dentists- and other health	0.0	0.0	2.8	2.8
General merchandise stores	0.0	0.6	2.0	2.6
Monetary authorities and depository credit	0.0	1.5	0.6	2.2
Plastics plumbing fixtures and all other plastics	0.0	2.1	0.1	2.1
Nursing and residential care facilities	0.0	0.0	2.1	2.1
Rail transportation	0.0	2.0	0.0	2.1
Motor vehicle and parts dealers	0.0	0.5	1.5	2.0
Services to buildings and dwellings	0.0	1.3	0.6	1.9
Social assistance- except child day care services	0.0	0.0	1.7	1.7

4.3 Conclusions

This chapter applies an economic multiplier analysis and input/output model that was created in Minnesota by the Minnesota IMPLAN Group, Inc., and is used by other state governments and the USDA Forest Service, among others.

This economic analysis from the UMD Labovitz School's research bureau reports models for a Great Lakes Biodiesel production plant's direct effects, plus the additional spending effects that could be expected in the greater economy of the Great Lakes States.

With the completion of the construction phase it is estimated that the biodisel plant project will have spent a total of approximately $33.9 on construction, and that the Biodiesel Plant Project will have generated $64.5 million in spending across the Great Lakes Region over two years. The Value Added economic impact of the $14.3 million in expenditures for construction are expected to produce an impact of a total of $33.9 million for region. In Year 1 of construction, the Great Lakes Biodiesel Plant is expected to directly employ 172 workers for construction projects, which will result in the creation of 365 jobs in the Region. In Year 2 the plant is expected to directly employ 86 workers for construction projects, which will result in the creation of 182 jobs in the region.

When operations for the biodiesel plant reach typical year capacity, it is estimated to generate $48.4 million in direct spending across the Great Lake states. The indirect spending adds $22.5 million and $8.1 million (in induced spending). The total $79 million in new expenditures occurs annually for the life of the facility. During a typical year of operations, Great Lakes Biodiesel Plant will create over 194 full-time, part-time, and temporary jobs by directly employing nearly 37 people.

Special Considerations. Special considerations for interpreting these impact numbers: Regional indirect and induced effects are driven by assumptions in the model. One problem is that the assumptions can mask the true multiplier. This is especially true of the assumption of constant returns to scale: This assumption most affects induced effects and says that if I drink coffee, and my income increases, I will drink proportionally more than before. The amount of weight placed on the induced effects (the percentage of the total induced effect you would want to use) can be further analyzed with an in-depth impact study, involving much more specific data collection and more detailed analysis.

Construction costs may be larger due to commodity prices, banker's fees, and interest payments. Any differences would affect the estimates given here.

Readers are also encouraged to remember the BBER was asked to supply an economic impact analysis only. Any subsequent policy recommendations should be based on the "big picture" of total impact. A cost benefit analysis would be needed to assess the environmental, social, and governmental impacts.

4.4 Impact Comparisons

The comparison impacts provided in Table 4.9 show estimates for the impact of the Great Lakes Biodiesel Plant construction and operations on the U.S. as a whole, and the Great Lakes Region as discussed above.

Table 4.9: Great Lakes Biodiesel Plant Construction Totals Impact Comparisons, U.S., Great Lakes Region (2005 dollars); Year 1, Year 2

Source: IMPLAN

	Year	*1*	*2*	*Total*
United States	*Value Added Totals*	$33,169,760	$16,809,880	$49,979,640
	Employment Totals	529	265	NA
	Output Totals	$65,410,434	$32,705,217	$98,115,651
Great Lakes	*Value Added Totals*	$22,606,772	$11,303,386	$33,910,158
	Employment Totals	365	182	NA
	Output Totals	$43,003,008	$21,501,504	$64,504,513

Table 4.10: Great Lakes Biodiesel Plant Operation Totals Impact Comparisons, U.S., Great Lakes Region (2005 dollars); Typical Year

Source: IMPLAN	*Value Added*	*Employment*	*Output*
United States	$61,545,932	845	$181,918,066
Great Lakes	$20,187,559	231	$79,035,226

Chapter 5: Conclusions and Recommendations

Chemical and Mechanical Engineering conclusions

We investigated use of transesterified vegetable oils – biodiesel – as an alternative fuel for marine vessels. The project goals were to determine technical and economic viability of using biodiesel, investigate cheaper ways to produce it, and study engine performance using biodiesel. In addition, we studied the possibility of using fuel cells to enhance the energy efficiency of biodiesel and to reduce the adverse impact of ships to the marine environment.

Our investigation has led to the following findings:

1. Technically, biodiesel production has become routine. A continuous, economically efficient, production process is used by all the large volume producers. Smaller producers use batch reactors that allow flexibility in operation and use of raw materials. Unfortunately, like any other agri-based energy source, biodiesel requires some form of federal or state subsidy to be competitive with petroleum based fuel. Minnesota State Statute 239.77, which was adopted on March 15th, 2002, mandates 2% biodiesel fuel by volume in all diesel fuel sold or offered in Minnesota. The mandate officially took effect on September 30th, 2005, when sufficient biodiesel production within the state of Minnesota was available to support the mandate.
2. An enzyme – lipase – can be used as a catalyst in the production process instead of the usual catalyst, NaOH. Although more expensive, lipase holds the promise of faster reaction rate and more economic biodiesel production. An approach to further investigate this enzymatic production of biodiesel is outlined in the report body.
3. Our study also indicates that although ship-board use of fuel cells using biodiesel is energy efficient and environment friendly, but would be capital intensive and highly unlikely to be economical.
4. The use of biodiesel blends in diesel engines lowers overall engine emissions when compared to petroleum-based diesel. In addition, biodiesel is a renewable energy source, has better lubricity than diesel fuel, is nontoxic and biodegrades faster than diesel fuel, and can be used in current diesel engines with little or no modification. Environmental concerns, legislative measures, and continued research into improved methods of producing biodiesel are among the many factors contributing to the increased use of biodiesel. Both legislative and industrial efforts point to the use of up to 20% biodiesel blends (B20) in the near future.
5. The tendency of biodiesel to act as a solvent and its higher cold flow properties can lead to problems during operation. Individual ship systems should be reviewed to identify potential cold weather and material compatibility problems prior to the adoption of high biodiesel content blends as a fuel. There is a potential for fuel gelling problems in Great Lakes vessels over the winter lay up period due to long-term (2 month) storage of biodiesel blends at low temperatures. The development of a long-term low-temperature storage test to

verify that separation of the blend and preferential gelling of the biodiesel component does not occur is recommended.

Economic analysis conclusions

Volatile production and pricing associated with dynamic changes make modeling the biodiesel industry challenging. For instance, for business planning, a break-even analysis usually calculates a break-even point based on fixed costs, variable costs per unit of sales, and revenue per unit of sales. Business planning at the level of individual enterprise is suggested as further research, and assumptions of per-unit revenue and per-unit cost as well as assumption of other fixed costs would be estimated through a detailed sales forecast as well as profit and loss data from the industry. Given the aforementioned volatility of this market, as seen in the supply and demand trends in the foregoing data tables, average sales and costs may not be representative. Analysts predict, however, that costs will come down and prices will rise, making the break-even point a moving target. The variation in feedstock producers, type of feedstock, the possibility of increased demand from Great Lakes maritime fleets, "fixed" costs such as legislated incentives and regulations which can be amended or removed, and the technological advances in chemical processing and operations and end-use engineering can introduce new variables at any stage of the business model.

For the industry sector, it can be assumed that eventually the low cost producers will be able to force the independent producers out of the industry and capture market share. Changes in the industry sector will have impacts for the regional economy. An estimate of economic impacts to the Great Lakes region from the introduction of more biodiesel production follows in Chapter 4.

Economic analysis recommendations

The environmental and economic challenge driving the presentation of alternative fuels for the Great Lakes maritime fleet includes consideration of strategies not part of the scope of this analysis. Discussion of these strategies often starts with consideration of carbon credit trading for maritime biodiesel fuel alternatives and further research is recommended. Carbon credits, as a business asset, are one choice among many for fuel consumers to consider when planning for regulation compliance. Carbon credit trading is part of a larger incentive approach. The market gives consumers the opportunity to choose the most efficient means for reducing their carbon emissions. Benefit cost analysis presents a range of other compliance strategies, in some cases choices more efficient (less expensive, more productive) than mandating change to biodiesel fuel.

This research includes: review of the economics of emissions regulation strategies (of which carbon credit trading is one); study of appropriate caps on emissions levels; quantifying the variety of incentives that encourage consumer compliance with regulatory caps; and comparing economic benefit and cost to various stakeholders.

Studying incentives for fuel emissions regulation compliance can include:

1) **Biodiesel incentives:** demand and supply analysis (as in this report); feasibility or cost comparisons for implementing emerging marine designs; differences in total costs structure; incentive for adopting new technology, early adopters and newer infrastructure/vessels gain the most, aged vessels encouraged attrition.

2) **Application of "textbook" models already in the literature such as:** $S0_2$ program; successfully regulates the sulfur emissions in the power generation market; note producers choose to cut compliance cost by changing inputs – switching to low sulfur coal – rather than install costly technology i.e. "scrubbers".

Types of economic regulation currently part of this kind of benefit cost analysis: Permits (including how permits are business assets, and can be flexible); Standards; Credits; TBE standards (technology based emission).

In short, the economics of studying how carbon credits might work in the business economy of Great Lakes carriers requires an approach broader than the narrow focus on one strategy – for instance, carbon credit trading. Economics of the market make researchers cautious about dictating a change to a new technology (for instance mandating the use of biodiesel fuel in marine vessels) as this kind of strategy has been shown to be more expensive and less productive for capping emissions. It is best to let the consumer figure out what will get the greatest compliance for the least money. The biodiesel alternative is presented as one choice.

Fischer-Tropes? "Diesel is going to be very different in the future. It will be highly refined or will be a gas-to-liquid procedure like Fisher Tropes that will take the sulfur out all together," according to Dr. Roberta Nichols, retired from Ford Motor Company and Alternative Fuel Consultant, Speaking on "Gasoline Today: Which Fuels Will You Sell Tomorrow?" At The Colorado-Wyoming Petroleum Marketers Association Convention and Trade Show Jackson Hole, Wyoming August 21-24, 1999

"Fischer-Tropes technology produces synthetic diesel fuel that is almost miraculous. The problem with Fischer Tropes diesel is it has a low lubricity factor, causing wear and tear on the equipment. That is solved by blending it with biodiesel. A 5 to 7 percent of blend biodiesel solves the cetene problem," [as identified at the 23rd Annual Wyoming Forum Wyoming Business Alliance/Wyoming Heritage Foundation "Infrastructure in Wyoming: Bucking the Tide or Directing the Future?"November 17-18, 2005 – Casper's Parkway Plaza]:

> "Now, one thing that was skipped here is that there is a possibility to use coal by converting it to syngas, a mixture of C0 and H2, that is then fed to a Fischer-Tropes Catalyst. This allows the generation of, in the crudest form, of a synthetic crude oil. Fischer used this technology in World War II to help keep the Nazi war machine running. (Sadly he was a true believer and destroyed much of his research so the Allies wouldn't get it.) Back when I [was] in graduate school, it

was considered the hot topic, very much like nano-technology is today. The emphasis was to get away from making synthetic crude and design catalysts to make specific ranges of molecules. The neat thing is Fischer used coal and we have lots of that in untapped reserves that, at current efficiencies, would last centuries. Especially if the car fuels and heating energy came from other sources." http://www.technogypsy.net/May2005.htm

Possible work plan for analysis of emission control for Great Lakes vessels might include:

- Identification/quantification of total emissions of selected pollutants (CO_2,CO, PM, NO_X, HC, etc.)
- Application of Benefit-Cost Analysis to establish total emission targets for each pollutant
- Cost-effectiveness Analysis of various types of economic regulations to attain emission targets
- Establishment of TDP markets
- Impact on emissions and the shipping industry

Details of this work plan might include:

1) Estimation of total current emissions
- Emissions per source (vessel)
- Number of sources
- Future projections

2) Establishing total emission targets
- Benefits (improved environmental quality)
- Costs (abatement, compliance, enforcement)

3) Types of economic regulation of emissions:
- TBES (Technology-Based Emission Standards)
- CAC standards (Command-And-Control standards)
- Emission Charges/Taxes
- TDP (Tradable/Transferable Discharge Permits/credits)

4) Establishment of tradable discharge permit markets
- Total emission target
- Distribution of permit/credits (historical, auction, etc.)
- Trading mechanisms
- Examples of "Cap-And-Trade" Programs (CAP):
    - SO_2 emissions (1990 Clean Air Act Amendments)
    - NO_X emissions (Ozone Transport Committee)
    - VOM (Volatile Organic Material) emissions (Chicago)

5) Impacts of emission control

- Emissions reduction/improvement in environmental quality
- Cost to shipping industry
- Incentives created (new technologies including the use of biodiesel fuel/engines)

References

Chapter 1 No references

Chapter 2

[1] ASTM D 6751, *Standard Specification for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels*, ASTM International.

[2] Tickell, Joshua, *From the Fryer to the Fuel Tank: The Complete Guide to Using VegetableOil as an Alternative Fuel*, Joshua Tickell Media Productions, 2003.

[3] ASTM D 975, *Standard Specification for Diesel Fuel Oils*, ASTM International.

[4] ASTM D 2274, *Standard Test Method for Distillate Fuel Storage Stability (Accelerated Method)*, ASTM International.

[5] ASTM D 4625, *Standard Test Method for Distillate Fuel Storage Stability at 43°C (110°F)*, ASTM International.

[6] ASTM D 6468, *Standard Test Method for High Temperature Stability of Distillate Fuels*, ASTM International.

[7] *Characterization of Biodiesel Oxidation and Oxidation Products*, J. A. Waynick, National Renewable Energy Laboratory, NREL/TP-540-39096, November, 2005, http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/39096.pdf.

[8] *An Evaluation and Comparison of Test Methods to Measure the Oxidation Stability of Neat Biodiesel*, S. R. Westbrook, National Renewable Energy Laboratory subcontract report, NREL/SR-540-38983, November, 2005, http://www.nrel.gov/docs/fy06osti/38983.pdf.

[9] ASTM WK 7852, *New Standard Specification for Diesel Fuel Oil, Biodiesel Blend (B20)*, Draft Under Development, ASTM International.

[10] National Biodiesel Board (Internet), *Commercial Biodiesel Production Plants*, *September 2006* (cited September 2006), http://www.biodiesel.org/buyingbiodiesel/producers_marketers/ProducersMap-Existing.pdf

[11] Minnesota Soybean Processors (Internet), *Homepage*, *September 2006* (cited September 2006), http://www.mnsoy.com/

[12] SoyMor Cooperative (Internet), *Homepage*, *September 2006* (cited September 2006), http://www.soymor.com/

[13] Farmers Union Marketing and Processing Association (Internet), *Homepage*, *September 2006* (cited September 2006), http://www.fumpa.com/

[14] Flint Hills Resources (Internet), *Minnesota Refining Home*, *September 2006* (cited September 2006), http://www.fhr.com/minnesota/

[15] Murphy Oil Corporation (Internet), *Product Supply*, *September 2006* (cited September 2006), http://www.murphyoilcorp.com/rm/productsupply/

[16] *EPA Renewable Fuel Standard Requirements*, 40 CFR, Pt. 80, 2006 ed., pp. 120-104.

[17] U.S. Environmental Protection Agency (Internet), *National Clean Diesel Campaign*, *September 2006* (cited September 2006), http://www.epa.gov/cleandiesel/

[18] U.S. Environmental Protection Agency (Internet), *Clean Ports USA*, *September 2006* (cited September 2006), http://www.epa.gov/cleandiesel/ports/

[19] J. S. Agarwal, H. D. Chowdury, S. N. Mukerji, and L. C. Vermoh, "Indian Vegetable Oil as Fuels for Diesel Engines", *Bulletin of Indian Industrial Research*, No. 19, 1952.

[20] *Sunflower Oil Methyl Ester as a Diesel Fuel*, D. J. Hassett and A. R. Hasan, University of North Dakota Eng. Expt. Station, (Bulletin 83-05-EES-03, Grand Forks, ND, 1983).

[21] *Biodiesel: The Future of Alternative Fuels*, C. Haley, T. Kramer, M. Johnson, and H. Pardawalla, Chemical Engineering Department, University of Minnesota Duluth, (Senior Design Report, May, 2004).

[22] Yuanyuan Xu, Wei Du, Dehua Lui, and Jing Zeng. "A novel enzymatic route for biodiesel production from renewable oils in a solvent-free medium", *Biotechnology Letters*, vol. 25, (2003),1239-1242.

[23] *Hydrogen Generation from Biomass-Derived Compounds Utilizing Aqueous-Phase Reforming*, R. Cortright, Virent Energy Systems, Inc., (Virent Energy Systems, Inc., Madison WI., 2004).

[24] *2004 Virent Executive Summary*, Supplied by Mohammad Farooque, Fuel Cell Energy, November, 2005.

[25] National Biodiesel Board (Internet), *National Biodiesel Board Homepage*, *September 2006* (cited September 2006), http://www.biodiesel.org/

[26] U.S. Environmental Protection Agency, Office of Transportation and Air Quality (Internet), *Bibliography of Biodiesel Studies*, *September 2001* (cited September 2006), http://www.epa.gov/otaq/models/analysis/biodsl/bibliog.pdf

[27] C.D. Rakopoulos, K.A. Antonopoulos, D.C. Rakopoulos, D.T. Hountalas, and E.G. Giakoumis, "Comparative performance and emissions study of a direct injection Diesel engine using blends of Diesel fuel with vegetable oils or bio-diesels of various origins", *Energy Conversion and Management*, vol. 47, (2006), 3272–3287.

[28] National Biodiesel Board (Internet), *Biodiesel Emissions*, *September 2006* (cited September 2006), http://www.biodiesel.org/pdf_files/fuelfactsheets/emissions.pdf

[29] *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions*, U.S. Environmental Protection Agency, (EPA Technical Report, EPA420-P-02-001, October 2002, http://www.epa.gov/otaq/models/biodsl.htm).

[30] *2004 Biodiesel Handling and Use Guidelines*, U.S. Department of Energy, Energy Efficiency and Renewable Energy, (DOE/GO-102004-1999, October, 2004, http://www1.eere.energy.gov/biomass/pdfs/36182.pdf).

Chapter 3

[31] The New Farm-Regenerative Agriculture Worldwide, http://www.newfarm.org/features/1004/bio3/index.shtml

[32] See Internal Revenue Service, U.S. Department of the Treasury,

http://www.irs.gov/publications/p378/ch07.html.

[33] See Internal Revenue Service, U.S. Department of the Treasury, http://www.irs.gov/publications/p378/ch07.html.

[34] Contribution of the Biodiesel Industry to the Economy of the United States; LECG, LLC; June 19, 2006

Chapter 4

[35] Minnesota IMPLAN Group, Inc., IMPLAN System (data and software), 1725 Tower Drive West, Suite 140, Stillwater, MN 55082, www.implan.com, 1997.

Bibliography

Chapter 1

2005 National Biodiesel Consumer Survey Report. National Biodiesel Board. Moore Information, 2006. 31 July 2006 <http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20060203_gen-368.pdf>.

Bickel, Kenneth, and Kelly Strebig. Final Report for "Soy-Based Diesel Fuel Study" Minnesota Department of Agriculture. 2000. 31 July 2006 <http://www.mda.state.mn.us/ams/biodieselfinal.pdf>.

The Biodiesel Plant Development Handbook. Kearney: Independent Biodiesel Feasibility Group, LLC, 2002. 27 Mar. 2006 <http://www.mda.state.mn.us/biodiesel/tfm2003sep3item2.pdf>. Booz-Allen, and Hamilton. Market Potential of Biodiesel in Regulated Fleets, Marine Vessels and Underground Mining Equipment. 1998. 25 Jan. 2006 <http://www.biodiesel.org/resources/reportsdatabase/reports/gen/19981111_gen-207.pdf>.

Duncan, John. Costs of Biodiesel Production. Energy Efficiency and Conservation Authority. 2003. 25 Jan. 2006 <http://www.eeca.govt.nz/pdfs/costs_of_biodiesel_production.pdf>. Fortenbery, Randall T. Biodiesel Feasibility Study: an Evaluation of Biodiesel Feasibility in Wisconsin. Dept. of Applied Economics, University of Wisconsin-Madison. 2005. 24 Jan. 2006 <http://aae.wisc.edu/pubs/sps/pdf/stpap481.pdf>.

Frey, Christopher H., and Kim Kwangwook. Operational Evaluation of Emissions and Fuel Use of B20 Versus Diesel Fueled Dump Trucks. Dept. of Envir. Eng., North Carolina State University. 2005. 31 July 2006 <http://www.nbb.org/resources/reportsdatabase/reports/fle/20050930_fle-030.pdf>.

"Governor Pawlenty Creates Task Force to Help Kick-Start State's Biodiesel Industry." MDA Quarterly Spring 2003: 4.

Groschen, Ralph. Overview of: the Feasibility of Biodiesel From Waste/Recycled Greases and Animal Fats. Minnesota Department of Agriculture. 31 July 2006 <http://www.mda.state.mn.us/ams/wastefatsfeasability.pdf>.

Hill, Jason, Erik Nelson, David Tilman, Stephen Polasky, and Douglas Tiffany. Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels. University of

Minneosta and St. Olaf College. 2006. 20 July 2006 <http://www.pnas.org/cgi/doi/10.1073/pnas.0604600103

Introducing Biodiesel in the Great Lakes Recreational Marine Market. Great Lakes Biodiesel Market Development Program. 1999. 03 Feb. 2006 <http://www.biodiesel.org/resources/reportsdatabase/reports/mar/19990601_mar-016.pdf.

Sigmon, Mary, comp. Demonstration and Economic Analysis of Biodiesel in Fleet Vehicle and Marine Applications. City of Chicago Department of Environment. 1997. 07 July 2006 <http://www.biodiesel.org/resources/reportsdatabase/reports/fle/19980601_fle-007.pdf>.

The State of Minnesota. Letter to Petroleum Distributors. 29 Aug. 2005.

Strong, Christopher, Charlie Erickson, and Deepak Shukla. Evaluation of Biodiesel Fuel: Literature Review. Dept. of Engineering, Montana State University – Bozeman. 2004. 25 Jan. 2006 <http://www.coe.montana.edu/wti/wti/pdf/425244_Lit_Review.pdf>. A review of relevant literature regarding the performance of biodiesel in motor vehicles.

Tiffany, Douglas M. Biodiesel: a Policy Choice for Minnesota. Dept. of Applied Sciences, University of Minnesota. 2001. 24 Jan. 2006 <http://www.misa.umn.edu/programs/biodiesoy1130.pdf

Urbanchuk, John M. Contribution of the Biodiesel Industry. National Biodiesel Board. LECG, 2006. 31 July 2006 <http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20060720_gen-372.pdf>.

Ye, Su. Economic Impact of Soy Diesel in Minnesota. Minnesota Department of Agriculture. 2004. 23 June 2006 <http://www.mda.state.mn.us/biodiesel/2004ecoimpact.pdf>.

Ye, Su. Supply and Demand of Soybeans as Feedstock for Soy Diesel. Minnesota Department of Agriculture. 2000. 31 July 2006 <http://www.mda.state.mn.us/ams/soydieselreport.pdf>.

Elements of Input Output Analysis, Willam Miernyk, New York, Random House, 1966

Input-output Analysis: Foundations and Extensions by Ronald E. Miller and Peter D Blair, Englewood Cliffs, N.J. Prentice-Hall, 1985 (out of print).

Urban Regional Economics: Concepts, Tools, Applications, by Wilbur R. Maki and Richard W. Lichty. February 2000. Iowa State Press.

Appendix A: Demand and Supply Supporting Data

Appendix tables include:

Table A-1: Great Lakes States Soybean Production and Price Trends 1996-2006

Year	*Area*	*Production (thousands of bushels)*	*Price ($ per bushel)*
1996	Wisconsin	32,190	$7.24
1997	Wisconsin	44,000	$6.38
1998	Wisconsin	51,700	$4.85
1999	Wisconsin	59,800	$4.70
2000	Wisconsin	60,000	$4.45
2001	Wisconsin	58,090	$4.31
2002	Wisconsin	66,880	$5.35
2003	Wisconsin	46,760	$7.11
2004	Wisconsin	53,475	$5.70
2005	Wisconsin	69,520	$5.50
2006	Wisconsin	68,040	
1996	Illinois	398,925	$7.55
1997	Illinois	427,850	$6.56
1998	Illinois	464,200	$5.01
1999	Illinois	443,100	$4.75
2000	Illinois	459,800	$4.62
2001	Illinois	477,900	$4.55
2002	Illinois	453,650	$5.66
2003	Illinois	379,620	$7.51
2004	Illinois	495,000	$5.84
2005	Illinois	444,150	$5.50
2006	Illinois	482,400	
1996	Indiana	203,680	$7.34
1997	Indiana	230,550	$6.59
1998	Indiana	231,000	$5.05
1999	Indiana	216,450	$4.71
2000	Indiana	252,080	$4.61

Table A-1: Great Lakes States Soybean Production and Price Trends 1996-2006

Year	*Area*	*Production (thousands of bushels)*	*Price ($ per bushel)*
2001	Indiana	273,910	$4.42
2002	Indiana	239,455	$5.55
2003	Indiana	204,060	$7.67
2004	Indiana	284,280	$5.66
2005	Indiana	263,620	$5.50
2006	Indiana	284,000	
1996	Ohio	157,150	$7.42
1997	Ohio	190,960	$6.49
1998	Ohio	193,160	$4.99
1999	Ohio	162,000	$4.72
2000	Ohio	186,480	$4.63
2001	Ohio	187,780	$4.46
2002	Ohio	151,040	$5.59
2003	Ohio	164,780	$7.20
2004	Ohio	207,740	$5.74
2005	Ohio	201,600	$5.55
2006	Ohio	201,480	
1996	New York		
1997	New York		
1998	New York	3,977	$5.10
1999	New York	4,736	$4.20
2000	New York	4,356	$4.55
2001	New York	5,214	$4.55
2002	New York	4,608	$5.85
2003	New York	4,830	$7.80
2004	New York	6,708	$5.40
2005	New York	7,896	$5.20
2006	New York	7,896	
1996	Pennsylvania	11,400	6.65
1997	Pennsylvania	13,690	6.8
1998	Pennsylvania	15,800	4.95
1999	Pennsylvania	10,150	4.6
2000	Pennsylvania	16,555	4.37
2001	Pennsylvania	13,825	4.26
2002	Pennsylvania	10,140	5.9
2003	Pennsylvania	15,375	7.33
2004	Pennsylvania	19,550	5.43
2005	Pennsylvania	17,220	

Table A-2: Minnesota Soybean Production and Price Trends 1996-2006			
Year	*Area*	*Production (millions of bushels)*	*Price ($ per bushel)*
1996	MN	224.20	$5.45
1997	MN	255.45	$5.90
1998	MN	285.60	$7.26
1999	MN	289.80	$5.42
2000	MN	293.15	$4.32
2001	MN	266.40	$4.38
2002	MN	306.85	$4.42
2003	MN	238.40	$4.65
2004	MN	232.65	$6.20
2005	MN	306.00	$7.26
2006	MN	288.00	

Source: USDA - National Agricultural Statistics Service

Table A-3: Number of Biodiesel Alternative Refuel Sites by Great Lakes State, 2005

State	Biodiesel sites
Ohio	15
Michigan	12
Indiana	10
Illinois	6
Pennsylvania	3
Minnesota	2
Wisconsin	1
New York	0

Source: U.S. Department of Energy, Alternative Fuels Data Center web site, www.eere.energy/cleancities/afdc/infrastructure/station_counts.html, September 2005. See http://cta.ornl.gov/data/chapter6.shtml

Table A-4: Minnesota Producers of Biodiesel Fuel, 2006

	FUMPA	*SoyMor*	*MN Soybean Processors*
Feedstock:	80% soy, 20% poultry fat	Soybean oil	Virgin soybean oil
Catalyst:	Sodium Methoxide	Sodium Methylate	Sodium Methylate
Methanol/Ethanol:	Methanol	Methanol	Methanol
Feedstock Supplier:	Degussa, Ashland, South Dakota Soy, CBI	Confidential	Confidential
Glycerine price:	0.12	$0.092/lb	Varies
Customers:	Confidential	Confidential	Confidential
B100 $/gallon:	Average of $2.95	2.5	2.6
B99.9 $/gallon:		2.5	
Sales:	3MM gallon	30MM gallon	30MM gallon
Employment:	10 direct	28	10 FTE

Source: UMD BBER, by phone to producers

Table A-5: Great Lakes States Private and Commercial Non-Highway Use of Gasoline-2004

Oct-05	*(Thousands of gallons)*	*Table MF-24*
State	Marine	Total All Uses
Illinois	-	135,960
Indiana	12,957	91,475
Michigan	64,693	171,076
Minnesota	33,789	97,607
New York	56,399	161,640
Ohio	32,985	159,386
Pennsylvania	23,610	110,385
Wisconsin	28,980	109,577
Great Lakes States TOTAL	253,413	1,037,106
U.S. Total	1,005,029	4,626,471

Source: United States Department of Transportation - Federal Highway Administration
Private and Commercial Non-highway Use of Gasoline - 2004 1/By state including marine
http://www.fhwa.dot.gov/policy/ohim/hs04/htm/mf24.htm

Table A-6: Marine Diesel Sales, Corunna Refinery, Ontario, Canada

Year	*Fuel*	*in cubic meters*
2005		
	Marine Diesel	
	Total	55,400 m3

Source: Shell Canada Limited

Table A-7: Biodiesel Fuel, Duluth/Superior Shipping Demand, 2005

Blend	Gallons	Month/year
B2	650,000 gallons per month	10 month season
B2	6.5 million	annual consumption

Source: Murphy Oil

Table A-8: U.S. Waterborne Traffic by State in 2004

(Millions of Short Tons)

Great Lakes States	Domestic tons
Ohio	100.60
Illinois	113.10
Pennsylvania	65.80
New York	55.60
Michigan	64.40
Indiana	73.00
Minnesota	40.20
Wisconsin	31.90

The U.S.Waterway System Transportation Facts. See www.iwr.usace.army.mil/ndc/factcard/fc05/factcard.pdf

Table A-9: U.S. Biodiesel Production and Consumption Trends

Year	Production (millions of gallons)	Consumption (millions of gallons)	B20 Price
2000	2.00	2.00	1.44
2001	5.00	5.00	1.56
2002	15.00	15.00	1.30
2003	20.00	25.00	1.50
2004	25.00	30.00	0.00
2005	75.00		2.48

Feasibility study: Usefulness of modern acoustic methods to the maritime industry in relation to changes in water depth in the Great Lakes.

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Oct. 2, 2006

This report represents the results of research conducted by the authors and does not necessarily represent the views or policies of the Great Lakes Maritime Research Institute. This report does not contain a standard or specified technique.

Great Lakes Maritime Research Institute
A University of Wisconsin - Superior and University of Minnesota Duluth Consortium

Research Funded in part by the Great Lakes Maritime Research Institute

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1. Abstract

This project is a feasibility study to determine whether state-of-the-art acoustic imaging techniques, used in basic scientific research studies, can be applied in a way that is useful to the Maritime industry. It addresses Great Lakes Maritime Research Institute (GLMRI) focus area "Marine transportation and port environmental issues," and the specific research topic "Great Lakes Outflow Investigation" listed in the call for proposals.

We collected high-resolution sidescan sonar data as well as multibeam ("swath") bathymetry. The multibeam bathymetric data was used to make detailed maps of water depth and three-dimensional models of the coverage area. It can also be used to create "fly-through" animations, although this has not yet been done with the data from this project. The sidescan sonar data produces an image of the lake floor, similar to an aerial photograph, with sound instead of light. The sidescan sonar images depend on both the reflectivity and geometry of the lake floor, so that in areas of relatively high relief, acoustic shadows are cast. The sidescan sonar imagery can also be draped on the three-dimensional model of the lake floor produced from the multibeam bathymetry.

The results of our surveys show a variety of features that may be of interest to the maritime industry. These include the configuration of the harbor entrances and part of the harbor. Outside of the harbor, the former meandering channel of the Nemadji River is clearly seen, as well as structures such as the Cloquet water intake and small shipwrecks. Areas of sediment movement were clearly imaged as fields of sand waves, this despite the fact that most of the sand derived from long-shore drift from the Wisconsin shore is trapped behind the piers of the Superior entrance. We also observed glacial sediments sticking up through the lake sediments, several meters above the lake floor. This type of survey can also be used in places where water depth is critical, such as the St. Mary's River near Sault St. Marie.

2. Introduction: Background and Objectives

This project addresses the GLMRI focus area entitled "Marine transportation and port environmental issues," and the specific research topic "Great Lakes Outflow Investigation" listed in the call for proposals.

As background, changes in water depth due to lake-level rise or channel erosion are a major issue of concern to the maritime industry in the Great Lakes. Sediment transport near port facilities, which is partly related to lake-level changes, is another significant concern. Modern lake-floor imaging technologies, such as chirp side-scan sonar and multibeam bathymetric measurements, may be practical methods for addressing these concerns at a level that is useful for shipping and port-maintenance interests.

Water depth in the Great Lakes is a critical issue for the maritime industry because it directly affects the size of the cargos that can be shipped, such that there is a well documented monetary value placed on each foot of water depth in critical passages. Water depth is determined by two quantities: the elevation of the lake floor and the elevation of the water surface. The elevation of the water surface has been precisely measured by agencies such as NOAA and the Army Corps of Engineers for more than a century. On time scales of years to decades, it is affected mainly by climate changes that determine the amount of precipitation passing through the Great Lakes. To a lesser extent, it is affected by the long-term tilting of the Great Lakes basin as a response to unloading of the earth's crust following the melting of the last great ice sheets [1], which continues slowly today [2]. In special circumstances, it may also be affected by erosion and enlargement of narrow constrictions, such as that recently documented in the St. Claire River [3].

Increase in water depth caused by erosion of the lake floor has a counterpart in the opposite direction: deposition of sediment on the lake floor or channel. Deposition, in effect, raises the elevation of the lake floor and decreases the water depth. The latter process is typically a problem at harbor entrances, which must accordingly be dredged.

Our objectives for this <u>feasibility</u> study is to determine whether state-of-the-art acoustic imaging techniques can be applied in a way that is useful to the maritime industry, addressing almost all of the concerns discussed above. We conducted a survey of the approaches to Duluth and Superior harbor entrances, from a water depth of about 10 to 50 meters. We collected multibeam bathymetric and CHIRP sidescan-sonar data, continuously covering the study area. Together, these data sets allow us to document the following: (1) the detailed configuration of the lake floor: This will serve as a baseline for comparison to any future natural or man-made changes. It will also show whether we can determine lake-floor configurations with enough resolution to be applicable to problems such as erosion of the channel of the St. Claire River. (2) The configuration of nearshore sediment along the barrier-spit coastline of the western end of Lake Superior: This sediment is assumed to be transported from the eroding bluffs of the Wisconsin coast by longshore currents to the barrier spits, where it is deposited, tending to clog the harbor entrances. However, this assumption is not well documented. Our survey provides

indications about the source and the transport direction of sediment associated with the barrier spits. (3) Evidence of former shorelines of the lake now submerged: Identification of these former shorelines would help quantify the long-term rate of tilting of the basin, which is causing the western end of Lake Superior to be submerged.

Erosion and sediment erosion have been studied with acoustic methods both for general scientific purposes and for specific engineering projects for many years. Two things, however, make this project unique. First, we will be using state-of-the-art acoustic (sonar) equipment, as described in the Methods section. Secondly, we will be using this equipment to directly address the question of whether we can produce data from a relatively large area that is useful to the maritime industry.

The recent development of high-frequency multibeam systems has revolutionized the hydrographic surveying of shallow water areas [4], making it possible to conduct geomorphological studies of sub-aqueous surfaces [5]. The high-resolution maps produced by these instruments can be used to study present day sea-floor processes as well as those that occurred in the past. For example, on continental shelves, high resolution multibeam surveys have been used to map and characterize sediment erosion and deposition processes map drowned glacial landforms and sediment erosion and deposition processes. Recently multibeam surveys have been used to study geologic processes in freshwater lakes [6 & 7].

Sidescan sonar has been used for a long time to image the sea floor. However, recent technical advances have greatly improved the quality of the data. In particular, the use of digital data and swept-frequency (CHIRP) sidescan sonar systems has substantially improved resolution and image quality. Recent examples of the use of sidescan sonar in marine environments include Monterey Bay [8], and in lake environments include Bear Lake [9].

3. Methods

The LLO has a survey-grade multibeam bathymetry system mounted on the hull of the RV Blue Heron. We have also recently acquired a state-of-the-art chirp side-scan sonar system. Finally, we have extensive computer facilities, with which we processed these data and creating maps and images of the lake floor.

The Seabat 8101 multibeam[1] used in this survey is a 240 kHz multibeam that uses 101 1.5-degree beams to measure the bathymetry of the lake floor. The width of the swath illuminated on the lake floor is approximately 7.5 times water depth in water less than 70 meters deep. The system has a range resolution of 1.25 cm. Its lateral resolution (in the absence of vessel motion and positioning error) is dependant upon water depth and the number of beams retained in the processed data. The system is capable of producing data that meets the IHO standards for hydrographic surveying (International Hydrographic Organization, 1998). In order to do this, a TSS POS MV/320 motion sensing and positioning system[1] was used to measure the survey vessel's motion (roll, pitch and heading) to an accuracy of less than +/- 0.05 degrees and it's position to less than 1meter horizontally and 25 cm vertically. Differential corrections for the positioning system were sent via a radio link, from a temporary base station established on the lakeshore. Sound velocity profiles were collected periodically during the survey. These were used in post-acquisition processing to correct ray bending artifacts in the data. Post-acquisition processing of the data was preformed using CARIS HIPS/SIPS computer programs[1].

The sidescan sonar data were collected in a manner similar to that for the multibeam bathymetry, except that the instrument was towed behind the RV Blue Heron. We used a dual frequency CHIRP EdgeTech 512 system[1]. The width of the swath imaged on the lake floor was between 50 and 100 meters on either side of the ship. The data were processed with the same computer systems as the multibeam bathymetric data.

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[1] The authors and The Great Lakes Maritime Research Institute do not endorse products or manufacturers. Trade names or manufactures names appear herein solely because they are considered essential to this report.

4. Results and Discussion

We successfully collected sidescan sonar data over swaths of the lake floor off Minnesota Point. The survey grid for both the sidescan-sonar and multibeam data are shown in Figure 1. The sidescan sonar mosaic (Fig. 2, small format here; large format image at the end of the printed report) of the entire area off Minnesota Point shows a variety of features on the lake floor. Especially prominent are the drowned, meandering channel of the Nemadji River and the dark patches that represent glacial sediments that emerge from the lake sediments and rise several meters above the otherwise smooth lake floor. The glacial sediments are presumably kept free of lake sediments by currents and waves in this nearshore environment, and they are probably in the process of being eroded down to the level of the rest of the lake floor by the same processes.

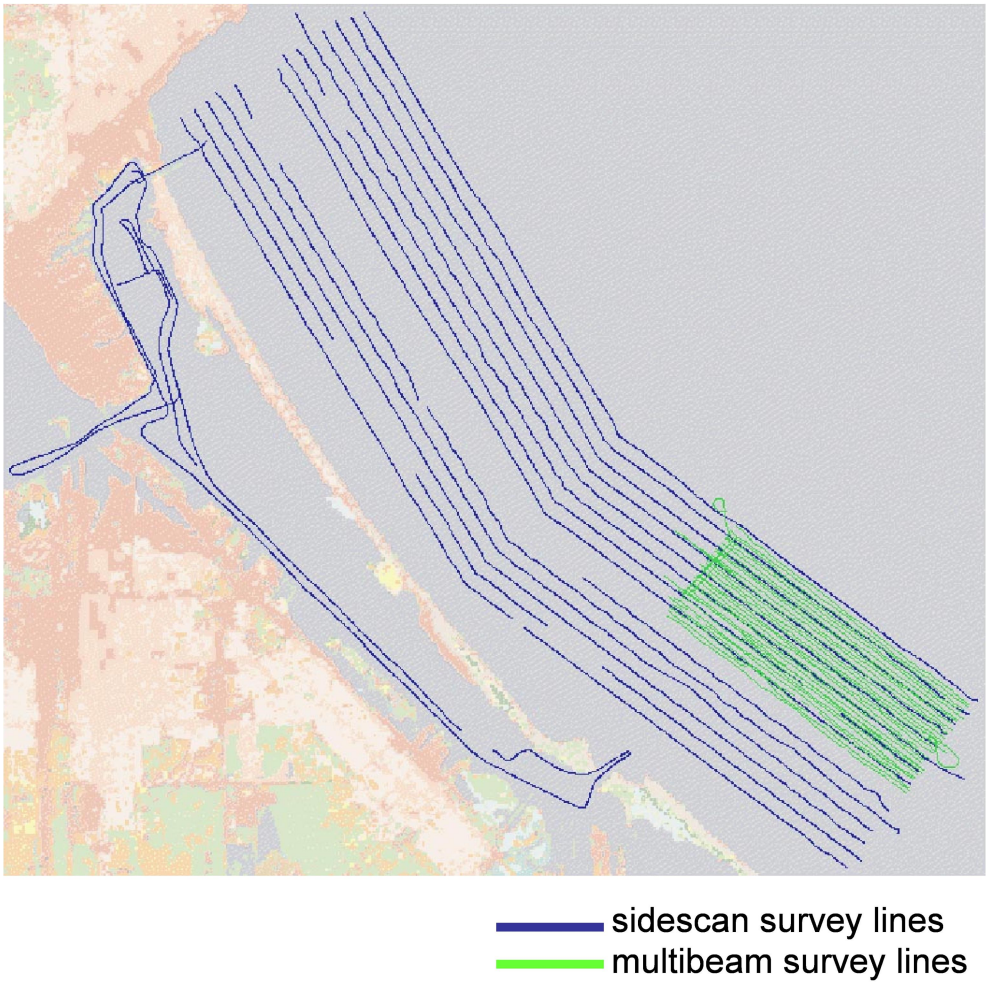


Figure 1. Distribution of ship tracklines in the study area for the sidescan sonar data and the multibeam bathymetry data.

Figure 2. Sidescan sonar mosaic of the entire area outside the harbor with the northwest portion at the top, and the southeast portion at the bottom. Inset shows the portion of the survey covered by each image.

Single track images of the sidescan data also show interesting features in greater detail. (Fig. 3). The area contains fields of sand waves, indicative of sediment transport. The sand waves occur northwest of the Superior entrance, whose piers capture most of the sand transported by longshore drift along the Wisconsin shoreline. Maps of historic changes in the shoreline [10] demonstrate the accumulation of sand on the southeast side of the Superior entry. Although these maps do not show erosion on the northwest side of the Superior entry, sand must be moving along Minnesota Point, with a source either there or from onshore movement of relict nearshore sand.

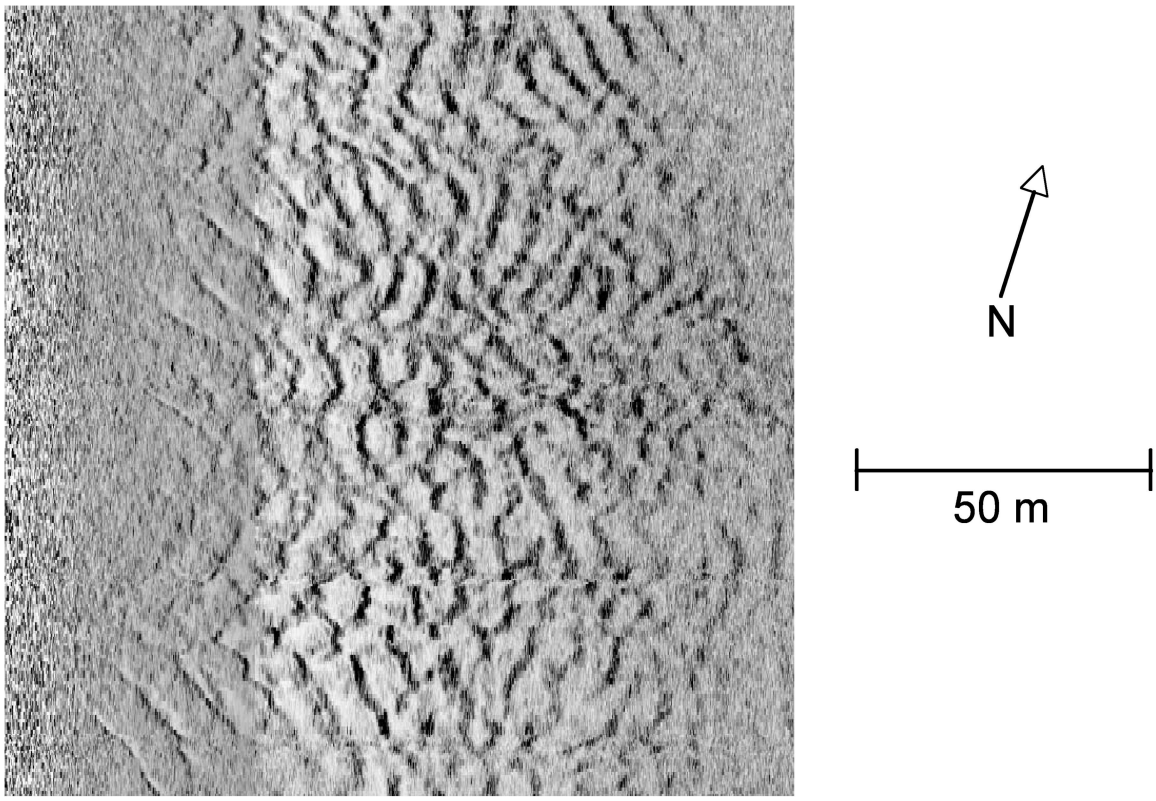


Figure 3. Single track (detailed) sidescan sonar image showing sand waves on the lake floor. Scale and north arrow at right.

Other single-track details of the sidescan sonar mosaic show a variety of man-made features, including the Cloquet water intake (Fig. 4), a small ship wreck (Fig. 5), and anchor drag marks (Fig. 6). These images show that our sidescan sonar system would be potential useful for inspecting structures or searching for man-made objects in the lake. Detailed images of structures inside the harbor reinforce this conclusion. Detailed images included here are the entrance piers for the Duluth entry (Fig. 7) and the footings for the Blatnik Bridge (Fig. 8). The sidescan sonar data would also be useful for examining the integrity of the steel sheet pilings around the harbor.

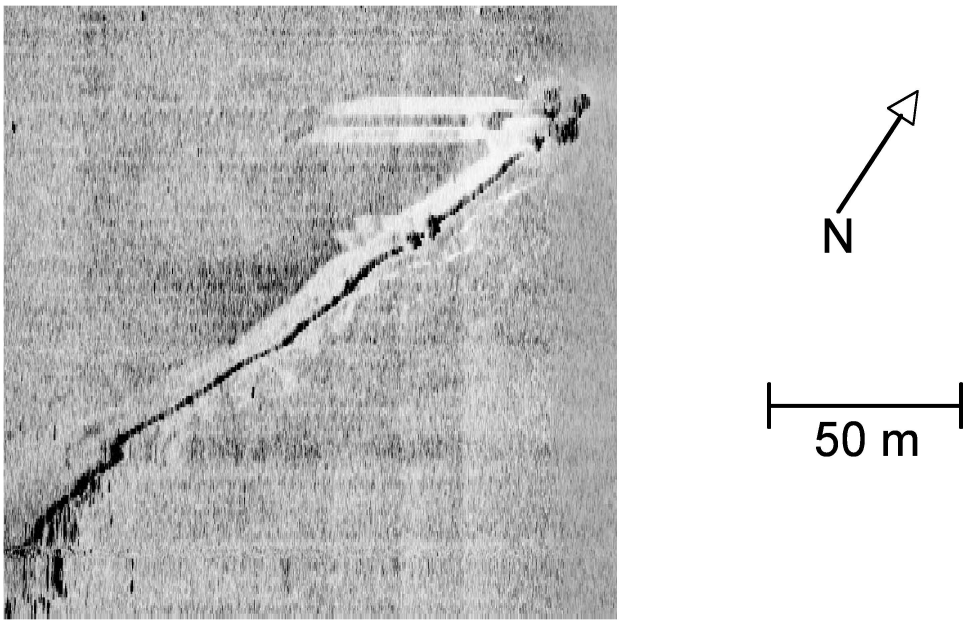


Figure 4. Single track (detailed) sidescan sonar image showing the Cloquet water intake structure. The white areas to the left of the intake and the pipe are acoustic shadows. Scale and north arrow at right.

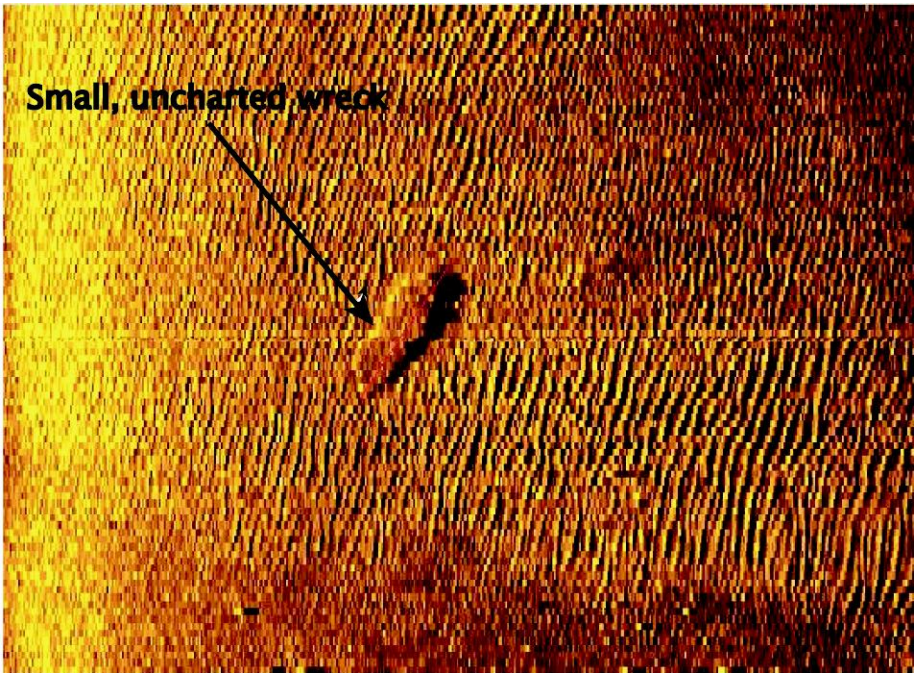


Figure 5. Single track (detailed), false color, sidescan sonar image showing a small ship wreck lying on a field of sand waves. Top-to-bottom dimension is about 100 meters.

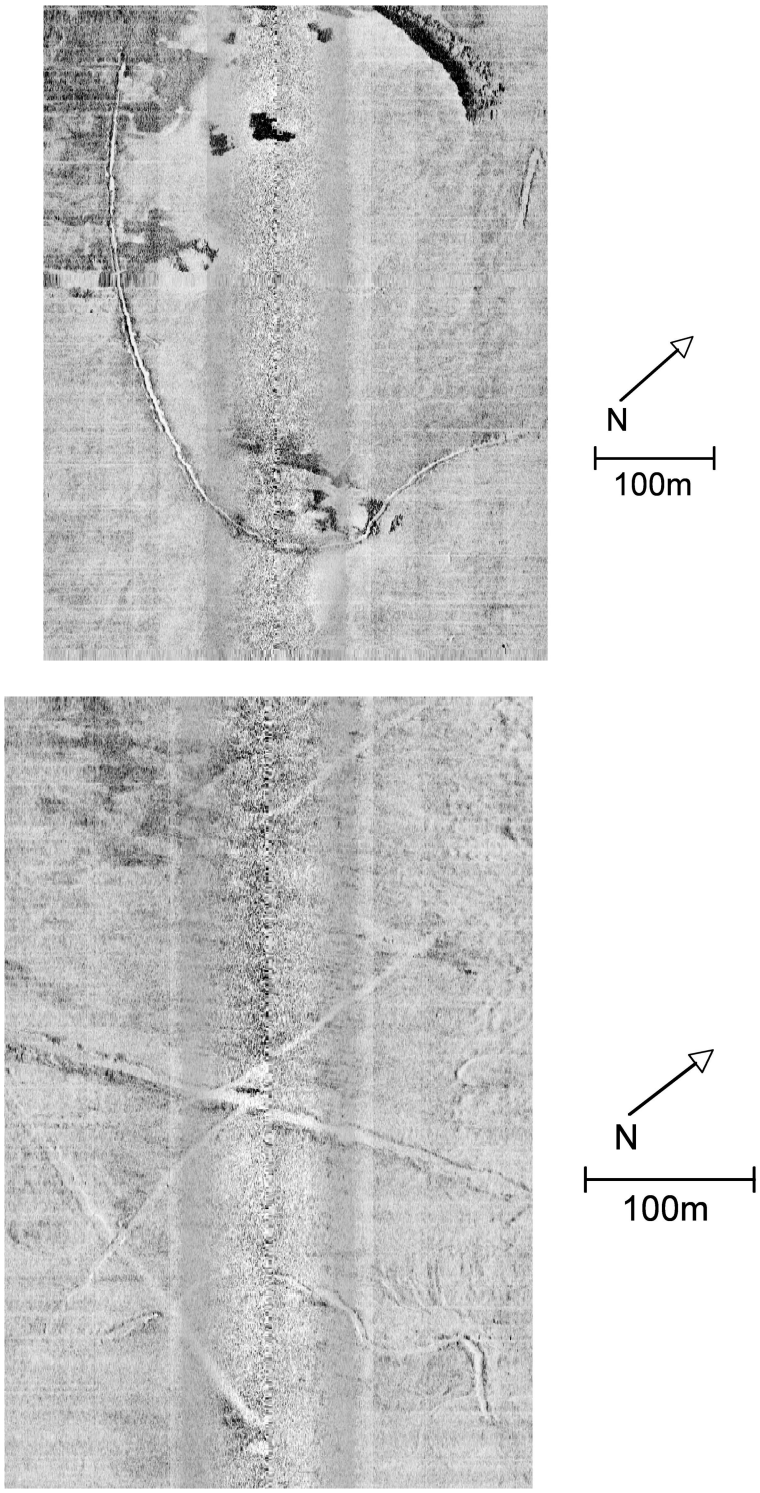


Figure 6. Single track (detailed) sidescan sonar images showing anchor drag marks off the Superior entry. Scales and north arrows at right.

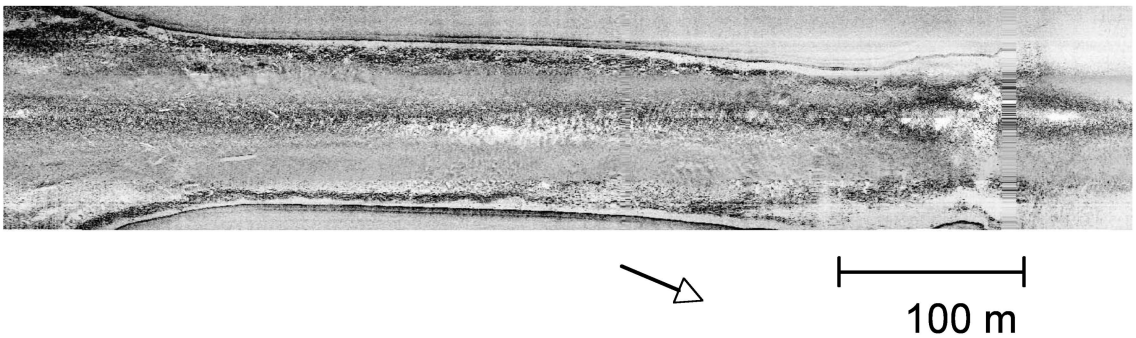


Figure 7. Single track (detailed) sidescan sonar image showing the piers of the Duluth entry. Scale and north arrow at bottom.

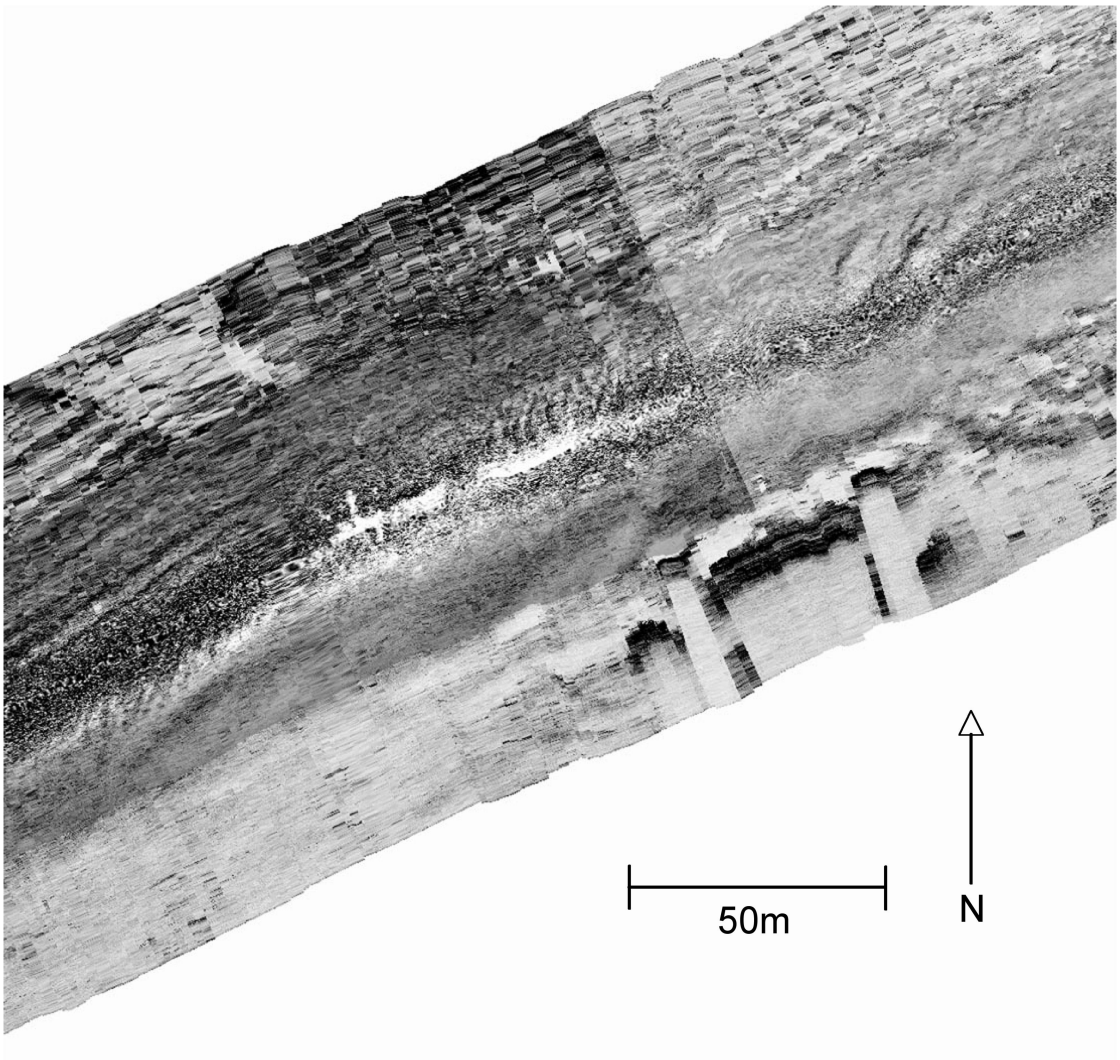


Figure 8. Single track (detailed) sidescan sonar image showing the footings for the Blatnik Bridge (lower right). Scale and north arrow at bottom.

The multibeam data provide a detailed bathymetric map of the entire survey area (Fig. 9). In close-ups of the bathymetry, smaller features, such as the drowned channel of the Nemadji River (Fig. 10) and glacial deposits that rise above the smooth surface of the lake sediments (Fig. 11) can be seen.

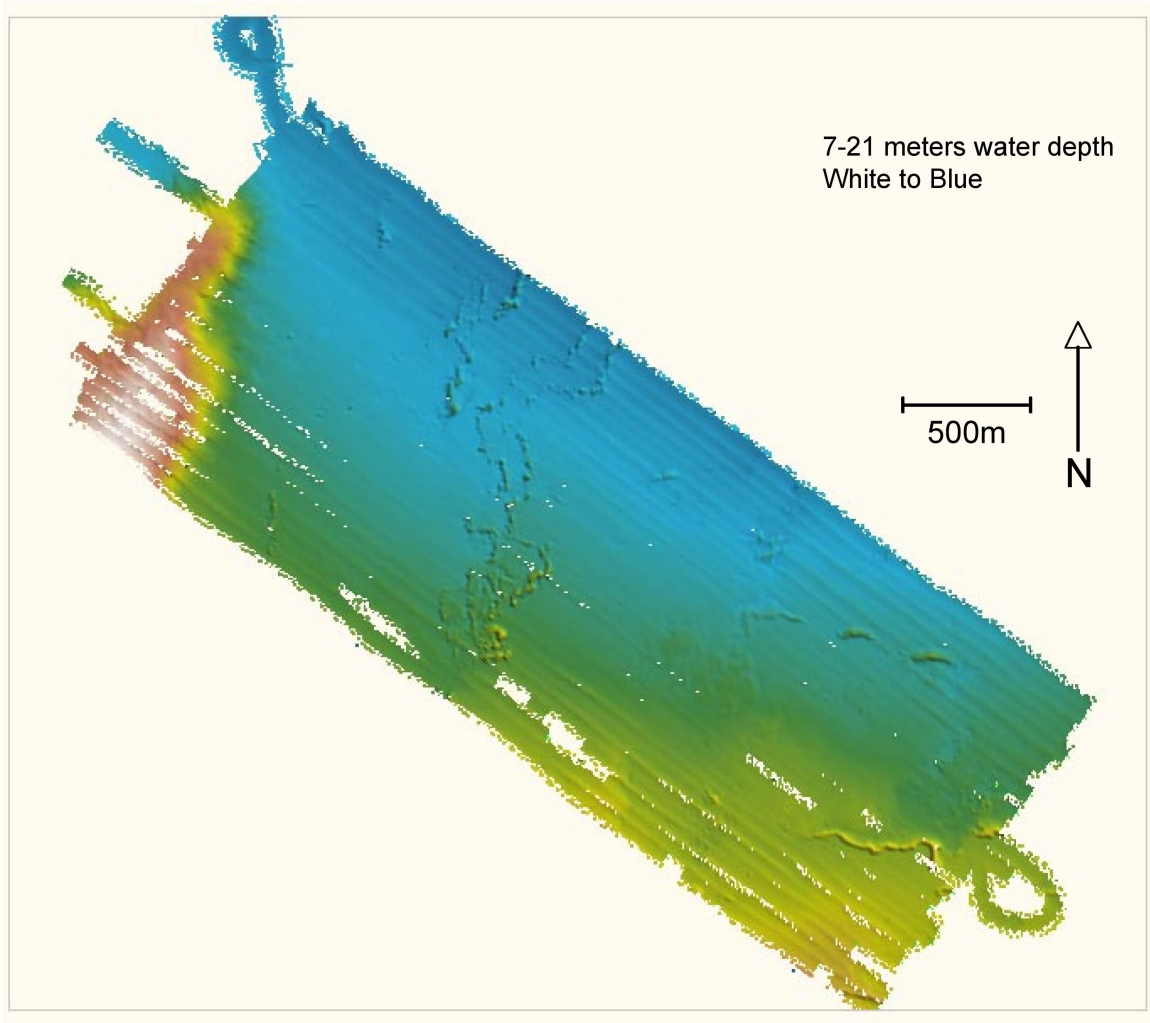


Figure 9. Detailed multibeam bathymetry map of the entire survey area outside the harbor, color coded by depth. Scale, north arrow, and color coding at upper right.

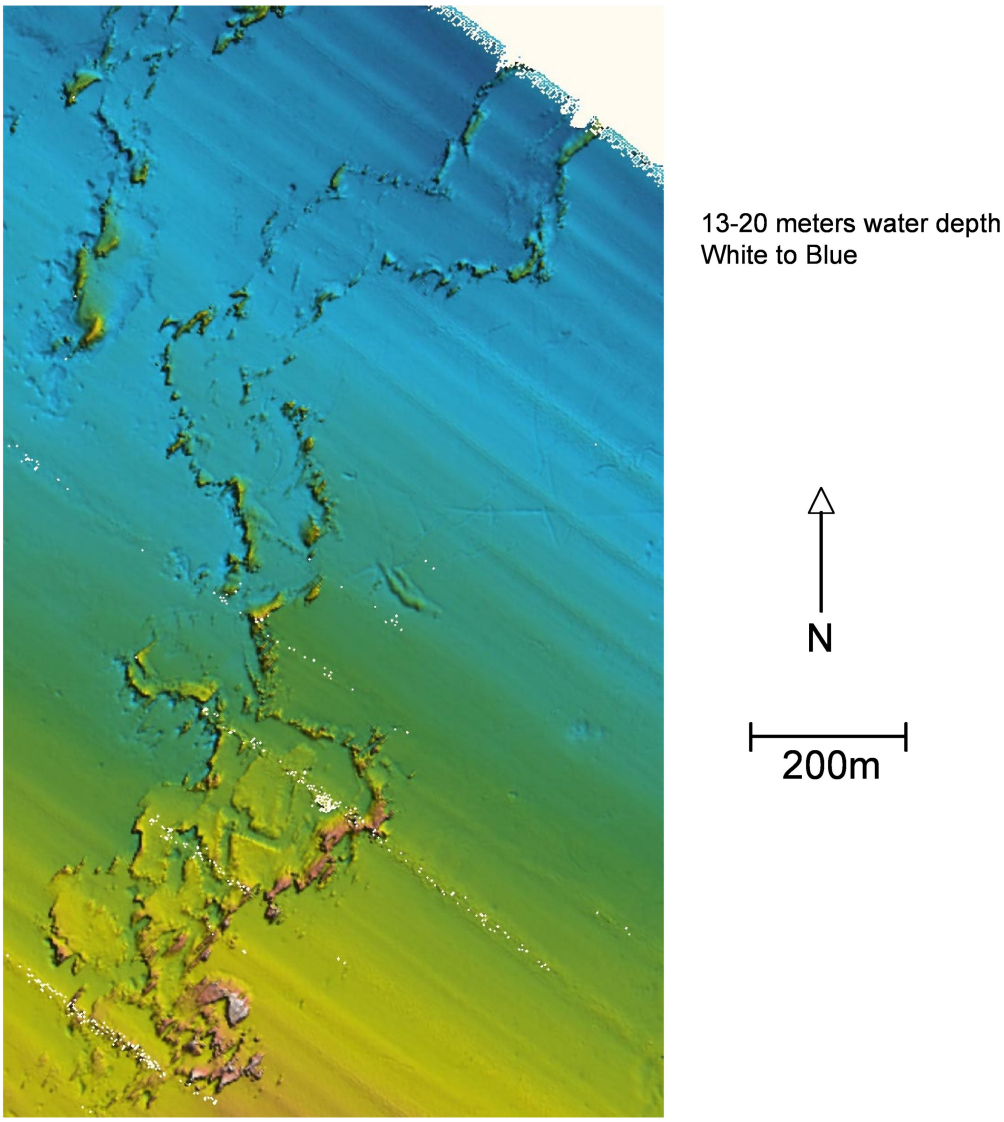
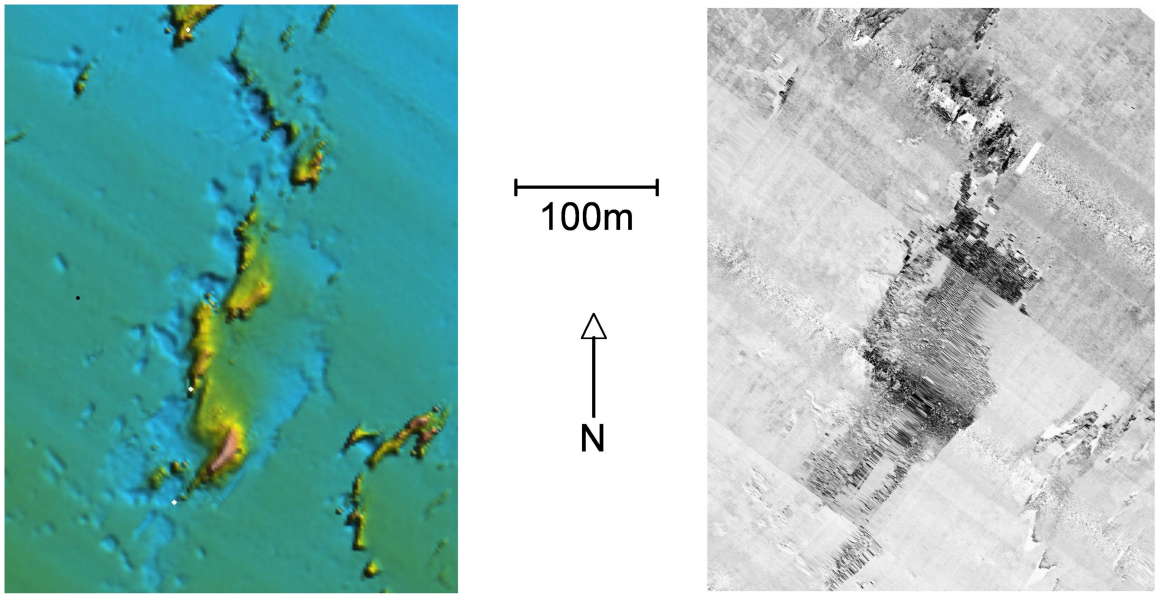


Figure 10. Detailed multibeam bathymetry map of the drowned channel of the Nemadji River, color coded by depth. Scale, north arrow, and color coding at upper right.



15-20 meters water depth
White to Blue

Figure 11. Detailed multibeam bathymetry map and sidescan sonar mosaic of an area of glacial deposits (dark in sidescan sonar image) rising above the smooth surface of lake sediments.

Although not shown here, these multibeam bathymetric maps can be viewed as three-dimensional models, from any designated perspective, and the three-dimensional perspectives can be combined to create a virtual "fly through" of the survey area.

Detailed bathymetric data is of great interest to the maritime community. Using multibeam swath systems is much more efficient and produces much more complete data than traditional single-track soundings. Also, the sidescan sonar mosaics can be "draped" over the multibeam perspectives to allow the two types of data to be viewed simultaneously. Such views are particularly useful for scientific interpretations.

In summary, we have shown that collecting high-quality data from the floor of Lake Superior is feasible, and that such data may be of interest to the maritime community. Both the sidescan sonar data and the multibeam bathymetry are state-of-the-art and are applicable in a wide variety of settings. In the near future, we will be having stakeholder meetings with the Army Corps of Engineers, the Duluth and Superior Port Authorities, the Coast Guard, and other members of the local maritime community.

5. Potential Economic Impacts of the Research Results

Because this was a feasibility study and because we achieved our goals in terms of data collection, the overall project was successful. The potential economic impacts of the project were mentioned in the introduction; specifically potential documentation of water depth changes, and sediment erosion and deposition processes. Water depth in the Great Lakes is a critical issue for the maritime industry because it directly affects the size of the cargos that can be shipped, such that there is a well documented monetary value placed on each foot of water depth in critical passages. On time scales of years to decades, water depth is affected mainly by climate changes that determine the amount of precipitation passing through the Great Lakes. To a lesser extent, it is affected by the long-term tilting of the Great Lakes basin as a response to unloading of the earth's crust following the melting of the last great ice sheets. In special circumstances, it may also be affected by erosion and enlargement of narrow constrictions, such as that recently documented in the St. Claire River. Water depth near harbors and their entrances is also caused by erosion of the lake floor and by deposition of sediment on the lake floor or channel. Deposition, in effect, raises the elevation of the lake floor and decreases the water depth. The latter process is typically a problem at harbor entrances, which must accordingly be dredged. Changes in water depth from all of the causes listed above have direct and obvious economic impacts on harbors and the maritime industry that depends on them.

Because this project was designed as a feasibility study, we intend to meet with prospective stakeholders now that the project is essentially completed. Potential local stakeholders include the Coast Guard, the Army Corps of Engineers, and the Duluth and Superior Port Authorities.

6. References

1. Farrand, W.R., and Drexler, C.W., 1985, Late Wisconsinan and Holocene history of the Lake Superior basin, *in* Karrow, P.F., and Calkin, P.E., eds., Quaternary Evolution of the Great Lakes, Geological Association of Canada Special Paper 30, p. 17-32.
2. Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, 1977, Apparent vertical movement over the Great Lakes, Detroit District, United States Army Corps of Engineers, 70 p.
3. W.F. Baird and Associates, 2005, Regime Change (Man-Made Intervention) and Ongoing Erosion in the St. Clair River and Impacts on Lakes Michigan-Huron Lake Levels, unpublished consultants' report.
4. Prior, D.B. and Hooper, J.R., 1999, Sea floor engineering geomorphology: recent achievements and future directions: Geomorphology, v. 31, p. 411-439
5. Magno, E.C.C., Torres, L.C., Jeck, I.K., Alberoni, A.A.L., and Simoes, I.C.V.P., 2000, Bathymetric swath employed in the delineation of geomorphologic features: International Geological Congress, Abstracts, v. 31, p. 31.
6. Gardner, J.V., Mayer, L.A., and Hughes Clarke, J.E., 2000, Morphology and processes in Lake Tahoe (California-Nevada): Geological Society of America Bulletin, v. 112, p. 736-746.
7. Wattrus, N.J., Rausch, D.E., 2001, A preliminary survey of relict shoreface-attached sand ridges in western Lake Superior: Marine Geology, v. 179, Issue 3-4, pp. 163-177.
8. Chavez, P.S. Jr. , Isbrecht, J., Galanis, P., Gabel, G.L., Sides, Soltesz, D.L., Ross, S.L. and Velasco, M.G., 2002, Processing, mosaicking and management of the Monterey Bay digital sidescan-sonar images, Marine Geology, v. 181, p. 305-315.
9. Colman, S.M., 2006, Acoustic stratigraphy of Bear Lake, Utah-Idaho - Late quaternary sedimentation patterns in a simple half-graben, Sedimentary Geology v. 185, p. 113-125.
10. Johnston, C., Trauger, A., Meysembourg, P., Bonde, J., Hawrot, R., Walton, G.B., 1999, Natural Resources of Minnesota Point: Maps and Data in Support of the Minnesota Point Environmental Plan: University of Minnesota, NRRI Technical Report NRRI/TR-99/11.

Final Report: Great Lakes Maritime Transportation K-12 Education Program for Teachers, Students, & Communities (Year 1: January 15-September 30, 2006)

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Table of Contents

Project Summary

This project addressed the GLMRI Focus Area of K-12 public education and outreach programs. The project conducted two one-week teacher institutes in summer 2006, developed an interactive online web module for students, a ***K-12 Maritime Transportation Education website*** and a K-12 teaching trunk. A total of 21 K-12 teachers attended the two teacher institutes. They were extremely enthused about their experience and are now excited to teach about Great Lakes shipping in their classrooms. Thousands of students and others in the Great Lakes basin and nationwide will be reached in the coming months and years via the new lessons developed by the teacher participants, or by interacting online with actual photos and real-world challenges of Great Lakes maritime transportation through an interactive web module, website, and teaching trunk. The project was coordinated by Joan Schumaker Chadde, education program coordinator for the Western Upper Peninsula Center for Science, Mathematics and Environmental Education at Michigan Technological University.

Implementation of Project Goals & Objectives

1) **Conducted two week-long *Great Lakes Maritime Transportation Summer Teacher Institutes*.**
Week I took place in western Lake Superior from July 24-28, where nine participants visited sites in Duluth, Superior, and Minnesota's north shore. Week II took place in Michigan's eastern Upper Peninsula from July 30-August 4 where 14 participants visited sites in Marquette, Munising, Whitefish Point, Sault Ste. Marie, Fayette, and Escanaba. Both institutes addressed maritime history, Great Lakes shipping routes, ports, and cargoes; and required teachers to develop two maritime transportation lessons that could be implemented in their math, social studies, language arts, and/or science classes. A summary of the 2006 teacher institute recruitment publicity, the two one-week teacher institute agendas, a list of what teachers believe K-12 students need to know about Great Lakes shipping *after* attending the two institutes, and a list of lessons developed by participating teachers is contained in Appendices A-D.

It was decided to conduct two institutes, rather than the one six-day institute originally proposed in the initial proposal, in order to comfortably visit the many interesting shipping-related sites in both Duluth-Superior and in the eastern Upper Peninsula of Michigan. Institute participants were able to visit a variety of typically inaccessible sites and interact directly with ship captains, industry personnel, port authorities, city planners, and government agencies (Duluth Seaway Port Authority, U.S. Army Corps, U.S. Coast Guard, Duluth Maritime Museum, Northern Great

Lakes Visitor Center, Marquette city planning and economic development office, Whitefish Point Lighthouse and Museum, and the Soo Locks).

Teacher participants were able to earn two graduate credits from Michigan Technological University for their work before, during, and after each Institute. They developed nearly 40 lesson plans that will be posted on the *K-12 Maritime Transportation Education website.* The best lessons will become part of the *Great Lakes Maritime Transportation Educators Guide* proposed for development in Year 2. One institute participant developed draft text for a potential children's book, *"F is for Freighter: An ABC book of Great Lakes Shipping."* Opportunities for publishing the book will be explored.

Institute participants paid a total of $250 for the 5-day institute which included all lodging and transportation expenses, 2 MTU graduate credits, most meals, and entrance fees. In addition, participants received informational packets, NOAA Great Lakes map, and a CD of the presentations made by most presenters, and photos.

Recruitment for the 2007 teacher institute has already begun and will incorporate suggestions received from 2006 participants who recommended making presentations at science and social studies conferences in Michigan, Wisconsin, and Minnesota, as well as, articles in professional organizations' newsletters, and their word of mouth contacts to colleagues.

2) **Developed *web module* on Great Lakes Maritime Transportation.** http://techalive.mtu.edu/glmri/index.htm
The development of this interactive web module was coordinated by Dr. Marty Auer, Professor of Civil & Environmental Engineering at Michigan Technological University, who cost-shared his time. The content of the module was developed by MTU graduate student, Heidi Steudel, and animations were provided by Sue Hill. Some of the topics to be included are: comparing Great Lakes shipping to alternate transportation systems, shipping routes, cargoes, lock systems, and more, etc. The web module will be beta-tested by students before being finalized. The module is hosted on the Michigan Tech Alive website (http://techalive.mtu.edu/glmri/index.htm) but will be linked from the GLMRI website.

3) **Developed new *K-12 Maritime Transportation Education website***
http://wupcenter.mtu.edu/education/great_lakes_maritime/index.htm
This new website will serve as a resource for educators. The website is hosted on the Western U.P. Center for Science, Mathematics and Environmental Education's website at Michigan Technological University and will be linked to GLMRI's website. The website will serve as a clearinghouse for teaching resources. Lessons developed by teacher participants in the summer institutes, links, photos, powerpoint presentations, a *Did You Know Quiz on Great Lakes Shipping* (see Appendix F), glossary of shipping terms (see Appendix G), and descriptions of suggested shipping-related field trip destinations are just some of the items to be included on the website that will be helpful to both formal and non-formal educators. Maritime experts and organizations are also invited to make contributions to the website.

4) **Developed *a Great Lakes Maritime Transportation teaching trunk***
The trunk is designed for upper elementary and middle school classrooms and provides a wide variety of resources for teaching about Great Lakes shipping, including sample cargo, such as iron ore (taconite) pellets, coal, salt, limestone, sand; models of "lakers;" a 12'x14' cloth floor map of the Great Lakes watershed showing major shipping ports, ten children's books, ten videos, and a half-dozen curricula on Great Lakes shipping. The trunk may be checked out for two week periods and will be shipped via UPS. Interested educators may contact Loret Roberts at the Western U.P. Center for Science, Mathematics and Environmental Education (Tel: 906-482-0331 or loret@copperisd.org) to reserve the trunk. Borrowers are responsible for returning the trunk. After piloting the trunk for one year, we will make modifications to enhance its usefulness to teachers, and funding can be sought to replicate the trunk for use throughout MI, WI, and MN. In Michigan, the trunks can be disseminated by the network of 33 math/science centers throughout the state. A list of trunk resources is included in Appendix E of this report.

Evaluation Measures and Results

To evaluate overall project success, several evaluation measures were gathered. Teacher participants completed a course evaluation following each summer institute that will be used to improve future institutes. Significant findings from the teacher institute evaluation form are listed below.

(1) The pre-course reading, *Great Lakes Marine Transportation System* white paper prepared for the Midwest Freight Corridor Study by Dr. Richard Stewart, co-director of the Great Lakes Maritime Research Institute, was considered extremely helpful by all participants.

(2) Teachers identified the best dates for scheduling summer teacher institutes:

Last 2 weeks of June - 2
July - 9
First 2 weeks of August - 5
Last 2 weeks of August - 0

(3) Teachers identified useful incentives to encourage attendance at the institute? (17 responses)

Dates were convenient - 9
Inexpensive cost - 14
Opportunity to earn credits - 12
Topic of interest - 14 (Other: MTU classes are fun.)

(4) Teachers made suggestions for teacher recruitment for next summer's institute:

Conference presentation - 3
Word of mouth recruitment - 8
Write an article for an education journal - 2
Write an article for your school newsletter - 2
Post info on your school's website - 3
Write an article for an organizational newsletter - 1

Other evaluation comments:

- Keeping the quality high and cost low.
- You supplied everything we could ask for: grad credit, room and board, and free admission to very cool sites.
- Encourage teachers to bring colleagues from the same school district to the institute so they can work together after the institute.
- Presentations at annual state social studies conferences.
- Make these institute classes part of a "planned program" for State of Michigan teacher certification. The credits aren't that useful if you don't already have your permanent teacher certification.

(5) What teachers' enjoyed most about the institutes:

Overwhelmingly, teachers enjoyed the opportunity to see and do things that would typically not be accessible to them traveling on their own, i.e. industrial port facilities, Cleveland Cliffs iron ore mine, Army Corps of Engineers, Soo locks underground tour, and access to the experts and specialists. Specific responses from each week are shown below:

Week I:

- There are too many to name! The more hands-on, the more I enjoyed it.
- I am impressed with the wide variety of site explorations that included all the facets of the shipping industry from the arrival of goods by rail and the safety processes of the port to the shipping of those goods to other GL ports and global destinations. I was able to do this with my friend and meet a new network of professional friends.

- I loved being treated like an honored and important guest. We were privileged to see so many interesting sites in a way we would never have on our own. Teachers rarely are treated so well. Everyone was so interested in our ideas and input. It was a really good and positive experience.
- Being able to go to the port terminals and other sites like the lighthouse, instead of being lectured to in a classroom!
- Becoming aware of the transportation issue. Our sessions at the Duluth Port Authority were very interesting and helpful, and the Port Authority representative did a great job narrating the harbor tour.

Week 2:

- Whitefish Point (3)
- Touring the Cleveland Cliffs Mine and learning how iron-ore gets processed and shipped. (3)
- I also was fascinated by the Soo Locks tour (by the U.S. Army Corps) behind the scenes (8)
- As a history teacher, I enjoyed the Whitefish Point museum and Fayette. (2)
- The Army Corps of Engineers was awesome.
- Visiting many places where you normally couldn't go. i.e. Soo Locks tour, Coast Guard Facility tour, (Cleveland Cliffs) iron ore mine, personal presentations at Marquette, Escanaba
- Soo Locks Boat Tour (2)
- Walking under the Poe Lock!
- I liked all of it!
- Coast Guard facility Vessel Traffic Service (2)

(6) **Ways to improve the content or schedule of the teacher institutes for next year.**

Week 1:

- Provide time to reflect with other teachers in the institute. Lots of info has been given to us throughout the week and we need time to process it all!
- Include a daily roundtable discussion at the conclusion of each day with all members participating.
- A meeting site is a necessary component in building a community of the learners and professional collegiality. The meeting site would provide a gathering place to review, discuss, answer questions, or give direction to the entire group daily.
- Be sure to have a course overview at the beginning of the institute.
- Have internet access and a resource room available at UMD.

Week 2:

- Week 2 tied in nicely with the first week. I would not recommend taking one week without the other. However, doing both weeks really wore me out physically.
- Maybe state that the class is "Shipping and Industry" or "Transportation and Industry," as we did both.
- Start at 9 and end at 5 each day with discussions at 7:30-8:30 at breakfast and 6:30-7:30 at dinners. Discussions should count as class time. Keep focus on shipping. Eliminate Sault Edison/Pictured Rocks.
- Leave out the paper mill tour and try to get a tour of a limestone quarry at Gulliver or Cedarville in U.P.
- Build in small group discussion time, do not always require whole group time, build on journal reflection time, and build in lesson planning time. End by 9:00 pm daily!
- Start class on Sunday evening for course overview.

The following additional evaluation information will be gathered over the 2006-07 school year and will be included in Year Two's report:

- Teacher feedback following implementation of newly developed lessons in their classroom and the mastery of learning objectives by their students.
- Teachers' and students' assessment of the new interactive web module on Great Lakes shipping.
- Teachers feedback on the usefulness of the Great Lakes Maritime Transportation teaching trunk, and records on the frequency of its use and teachers' comments and suggestions.

Appendix A

Summary of Publicity & Recruitment for 2006 Summer Teacher Institutes

MICHIGAN

- Michigan Science Teachers' Association (MSTA) list-serve sue@ucia2.com
- Michigan *Building A Presence for Teachers* list-serve larwad@charter.net
- Email to 1,000+ past MTU teacher workshop/institute participants (2001-2006)
- Resource agencies & organizations: conservation districts, county extension offices
- Michigan DEQ statewide Environmental Education website http://www.michigan.gov/deq/
- U.P. Environmental Educators website
- Michigan Earth Science Teachers' Association (MESTA) website http://www.mestarocks.org/
- Michigan Math & Science Centers list-serve
- Michigan Project Wild list-serve elshoff@msue.msu.edu
- Michigan Project WET list-serve vailj@gvsu.edu
- Michigan Project Learning Tree list-serve kfischer@binderparkzoo.org
- Michigan Association of Environmental & Outdoor Educators (MAEOE) list-serve and online calendar
- Michigan Teacher Network list-serve for MI educational institutions and organizations
- NMU Seaborg Center list-serve of teachers

WISCONSIN

- Wisconsin Assn of Environmental Educators (WAEE) waee@uwsp.edu and annual conference Oct. 25-27.
- Wisconsin Education Association Council (WEAC) http://www.weac.org/
- Wisconsin Center for Environmental Education - UW-Stevens Point www.uwsp.edu/cnr/leaf/sf
- Midwest Lakes Policy Center www.midwestlakes.org

MINNESOTA

- Minnesota SEEK website seek@moea.state.mn.us or mnseek.net
- University of Minnesota Duluth
- MN Association for Environmental Education maeeinfo@naaee.org
- Great Lakes Aquarium (Dave Schaeffer) education@glaquarium.org
- Minnesota Science Teachers Association (MnSTA)

REGIONAL

- Great Lakes States Seagrant coordinators: Jim Luebner, WI Seagrant; Cynthia Hagley & Marie Zhuikov, MN Seagrant, and Steve Stewart, MI Seagrant.

NATIONAL

- North American Assn for Environmental Education national conference in St. Paul, MN, Oct. 11-14, 2006

Appendix B

Great Lakes Maritime Transportation Teacher Institute
Week 1: July 24-28, 2006 (west end of Lake Superior)

Monday, July 24 – Houghton, MI to Duluth, MN

8 am (EST) – Meet at Michigan Tech University in Houghton (Wadsworth Hall)
8:30 am – Load van and depart.
10 am (CST) - **Northern Great Lakes Visitor Center** in Ashland, WI
Noon - Course overview, course requirements, and schedule
2 pm - Tour **Coast Guard facility** in Duluth
5:30 pm – Dinner
7-9 pm - **Lake Superior Maritime Visitor Center & Museum**

Tuesday, July 25 – Duluth, MN
8:30 am - Overview of Shipping on the Great Lakes by **Duluth Port Authority**
11:30-2 pm – **Duluth-Superior Harbor Tour** & lunch aboard *Vista Queen* from Barker's Island in Superior, WI
3-4:30 pm – Tour of **S.S. William A. Irvin** freighter and museum
5:30-6:30 pm Dinner
7-9 pm – visit Great Lakes Aquarium

Wed., July 26 – Duluth & Two Harbors, MN
9:00 am – **Canadian National ore docks** in Two Harbors
10:30 am - ***Edna G.* tugboat** tour
Noon – Lunch
2-5 pm - **Split Rock lighthouse** tour
6:30 pm Dinner

Thursday, July 27 – Superior, WI
9-11:30 am - **Midwest Energy Coal transition point**
Noon - Lunch
2-4 p.m. - Tour **Burlington Northern Santa Fe No. 5 Taconite Facility** (BNSF Ore Docks) in Superior, WI
4:30 – 6:00 pm – ***Balancing Social, Economic and Environmental Aspects of Shipping on the Great Lakes*** by Dr. Stewart, co-director, GLMRI
7-9 pm – Banquet

Friday, July 28 – Duluth, MN to Houghton, MI
9-11:30 am (CST) – Tour of **Lake Superior Warehousing Co.** and **Murphy Oil** in Duluth
Noon – Lunch & group discussion:
- *What are the "big ideas" regarding Great Lakes shipping that your students need to know?*
- *How can you best interest and effectively teach these "big ideas" to your students?*

12:30 pm (CST) - depart for Houghton, class ends
5 pm – arrive Houghton

Appendix B

Great Lakes Maritime Transportation Teacher Institute

Week 2: Monday-Friday, July 31-Aug. 4, 2006 (eastern U.P. Michigan)

Monday, July 31 (Houghton to Munising, MI)
8:00 am – Meet at Wadsworth Residence Hall at Michigan Tech in Houghton
8:30 am – Depart MTU
10:30 am – Tour **Cleveland Cliffs' Tilden Iron Mine & Taconite facility** with Dale Hemmila, District Mgr.
1:30 pm – Lunch in Harbor Park (Marquette)
2 pm – Overview of **City of Marquette's Harbor & Economic Development Plan** with:
Fred Stonehouse, historian, author & Chair of Marquette's Harbor Advisory Committee
Sandy Gayk, Director of Community Development for the City of Marquette
6:15 pm – **Pictured Rocks National Park Boat Tour** & group discussion
9:00 pm – Course overview, schedule, and course requirements
10:00 pm - Overnight at Sunset Motel on Munising Bay

Tuesday, August 1 (Munising to Sault Ste Marie, MI)
7:30 am – Breakfast
9 am – Depart Munising
11 am - **Whitefish Pt Shipwreck Museum**
Noon - Lunch
1 pm – Drive to Sault Ste. Marie
2:45-5 pm - **Soo Locks Boat tour**
6:00 pm – Dinner & group discussion
7:30 pm - **Soo Locks Visitor Center** (on your own)
9 pm – Overnight at (Ramada) Ojibway Hotel in Sault Ste. Marie, MI

Wednesday, August 2 (Sault Ste Marie, MI)
8:00 am – **U.S. Army Corps of Engineers tour of Soo Locks** (water levels, dredging, lock operation, homeland security) with Al Klein, Area Engineer
10:00 - **U.S. Coast Guard Vessel Traffic Service**
Noon – Lunch
1 pm – Tour **Edison Sault Electric Co. low-head hydroelectric plant & power canal**
2 pm – Tour of **Valley Camp freighter museum**
3 pm – Tour on your own: **Tower of History Lookout and River of History Museum**
7 pm – Dinner on your own
9 pm – Overnight at (Ramada) Ojibway Hotel in Sault Ste. Marie, MI

Thursday, August 3 (Sault Ste Marie, MI to Escanaba)
8:30-10:00 am - Tour of **St. Mary's Paper Mill** in Sault Ste. Marie, ON
Noon – Lunch & drive 2.5 hrs to Fayette State Park
3 pm – Tour of historic **Fayette State Park** (former iron smelting site)
6 pm – Drive to Escanaba
7 pm – Dinner & group discussion
9 pm - Overnight at House of Ludington Hotel in Escanaba

Friday, August 4 (Escanaba to Houghton, MI)
8:00 am ***Economics of Great Lakes Shipping*** **by Capt. Mark Phillips, Great Lakes Maritime Academy**
10:30 am - ***City of Escanaba Port Expansion plan & harbor tour*** by Doug Terry, Escanaba City Manager
Noon – Lunch & group discussion:
- *What are the "big ideas" regarding Great Lakes shipping that your students need to know?*
- *How can you best interest and effectively teach these "big ideas" to your students?*

2:00 pm – Course ends. Depart for Marquette & Houghton.

Appendix C

Great Lakes Maritime Transportation Teacher Institute

What students need to know about Great Lakes Maritime Transportation: A Summary of Participants' Responses following the 2006 Summer Teacher Institute

Economics

- What ships on the Great Lakes carry and why.
- How the cost, efficiency, and environmental impacts of Great Lakes shipping compares to other forms of transportation, such as rail and truck. (6)
- How natural resources are moved and used around the Great Lakes.
- How natural resources use and the regional and U.S. economy are dependent upon Great Lakes shipping. (3)
- The critical importance of the Poe lock (at the Soo locks) linking Lake Superior shipping to the lower Great Lakes.
- Connection between Great Lakes shipping and meeting global needs for goods.
- Gentrification of harbors and shipping can co-exist, i.e. Duluth
- How technological changes have affected harbor communities.
- That iron ore is shipped from northern MN and northern Michigan to Detroit, Gary, Cleveland, and other ports to make steel which we all use in our everyday lives.
- The variety of transportation systems used in the mining process.
- How technological advances in ship design, loading/unloading, navigation, and safety have helped Great Lakes shipping.
- The many and varied career opportunities related to Great Lakes shipping that are available, pay well, and require a variety of skills and post-secondary education/training.

Great Lakes Environmental Protection

- The role of ballast water management in helping to reduce invasive species entry and spread in the Great Lakes.
- How invasive species were introduced and spread throughout the Great Lakes, and control methods for reducing their impacts and their continued spread.
- That Great Lakes shipping is environmentally safe (good for the environment) and that U.S. Coast Guard and Army Corps of Engineers and shipping industry do a very good job of protecting our Great Lakes. (2)

Physical Science

- How locks work between two water bodies of different elevation, and why locks are important. (2)
- How physical principles of balance and momentum affect shipping.

History

- History of Great Lakes shipping from the fur trade, to the industrial revolution, to present-day shipping.
- How shipping has affected life in Michigan and other Great Lakes states.
- Great Lakes shipwreck stories, i.e. the Edmund Fitzgerald, so they understand the perils of the Great Lakes.

Great Lakes Geography

- Major shipping routes and ports on the Great Lakes from the St. Lawrence Seaway to Duluth.

Mathematics

- How mathematics is used in navigation.

Appendix D

Great Lakes Maritime Transportation Lessons for Gr. 3-12

(Mathematics, Language Arts/Reading, Social Studies, Science)

Developed by Participants in the 2006 Great Lakes Maritime Transportation Summer Teacher Institute sponsored by the Great Lakes Maritime Research Institute (www.glmri.org)

1. Great Lakes Shipping Calamities & The Story of the Edmund Fitzgerald (4 lessons)
   By Judi Vittito and Dan Kust, Northfield Middle School (MN)

2. How Will You Get Your Iron Ore to Market?
3. Boat Building 101: How Can a Ship Carry All That Cargo and Still Float?
4. Lighthouses: Guardians of Ships
5. Hazards of Shipping
   By Craig Croone, Northfield Middle School (MN)

6. Shipping and the Lake Erie Water Snake
7. Lake Erie Water Snake and the Round Goby
   By Lisa Bircher, East Palestine High School (OH)

8. How Is Iron Ore Mined?
9. How to Remodel a Harbor
   By Kelly Bolen, Grosse Pointe Schools (MI)

10. Pellets, Ships & Cars
11. What Happened to Fayette?
    By Susan Howey, Trombly Elementary, Grosse Pointe Schools (MI)

12. Great Lakes Geology and the Necessity of Locks
    By Margaux Parino, Assabet Valley Collaborative Alternative High School (MA)

13. Ship to Shore Communication
14. Writing a Friendly Letter to the Ship's Crew
    By Robert Palmer, Grosse Pointe Schools (MI)

15. Portage Canal Navigation
16. To Ship or Not to Ship: A Comparison of Transportation Costs in the Great Lakes Region
    By Deb Zei, Chassell High School (MI)

17. Charting A Course
18. Great Lakes Topography from the Bottom Up
19. Great Lakes Shipping Card Game
20. The Life of A Laker Board Game
    By Sarah Pregitzer, Grant Public Schools (MI)

21. Exploring Shipping Through the Ballad of the Edmund Fitzgerald
22. Comparing Costs: Maritime Shipping vs. Truck Transportation
23. Investigating Shipwreck Data
24. Exploring Great Lakes Folklore & Fables
    By Debra L. Zolynsky, Kennedy Middle School (MI)

Appendix E

Great Lakes Maritime Transportation Teaching Trunk Resources (10/22/06)

Available to Great Lakes educators from
Western U.P. Center for Science, Mathematics and Environmental Education at Michigan Technological University
105 Dillman Hall Tel: (906) 487-3341 Email: jchadde@mtu.edu

CHILDREN'S LITERATURE

Barker, Charles Ferguson. (2005). **The Day the Great Lakes Drained Away.** Grades 2-5
What would happen if the Great Lakes drained away? This unique children's book shows the interesting landscape that would be revealed if all the water in the Great Lakes was to suddenly disappear. This book educates children and adults about the geologic features under the Great Lakes, and reminds us never to take the Great Lakes for granted.

Bergel, Colin. (2000). **Mail by the Pail.** Grades K-4
This book illustrates the mail delivery system for Great Lakes freighters. The J. W. Westcott Company operates the mailboat for the U.S. Postal Service marine post office in Detroit-the only mailboat that delivers mail to freighters while they are moving.

Durbin, William. (2003). **Journal of Otto Peltonen: A Finnish Immigrant in Hibbing, MN, 1905.** Ages 12+
The story of a young Finnish boy and his family's experience working in the iron ore mines and growing up in a company town on the Minnesota Iron Range.

Gibbons, Gail. (1992). **The Great St. Lawrence Seaway.** Ages 4-8 yrs.
Explains the history of this great trade route. Early French explorers and fur traders were halted by the treacherous rapids 500 miles upstream and eventually developed a system for carrying their trade canoes and cargoes around the dangerous stretches to the river beyond, leading into what became known as the Great Lakes. Ultimately, locks were built to do the lifting. The complexities of the lock system are clearly explained in a series of animated diagrams with just enough information for young readers

Henry, Ragene. (2005). **Barefoot Boys of Fayette.** Grades 3-5
Students learn about the past in the small furnace town of Fayette in Michigan's Upper Peninsula in 1881 with a young boy and his friends.

Hertel, Captain Robert. (1999) **The Edmund Fitzgerald: Lost With All Hands.** Grades 3-6 (8 copies)
A factual account describing the fate of the Edmund Fitzgerald, including Great Lakes geography, shipping, and theories as to why the ship sank. Also contains a simple maritime glossary.

Holling, Holling Clancy. (1941). **Paddle to the Sea.** Grades 3-5
An Indian boy carves a wooden canoe and sets it into Lake Nipigon to watch it float away. The canoe spends four years on the water, being picked up by loggers, fishermen, and families before finally making it to the ocean. The canoe's adventures give children a sense of the wonders and diversity in the Great Lakes.

Walker, Niki. (2003). **Life in an Anishinabe Camp.** Grades 3-5
Crabtree Publishing Company. www.crabtreebooks.com Follow the Anishnabe as they make a living in the Lake Superior land of Hiawatha…travel, children's lives, setting up camp, hunting and fishing, clothing, games, beliefs, working, and self-government.

Wargin, Kathy Jo. (2003) **The Edmund Fitzgerald: The Song of the Bell.** Grades K-4
The giant ship leaves Superior, Wisconsin loaded with iron ore to make steel that will be used to build cars, but disaster is building as the storm clouds, known as the 'gales of November' gather… This is the story of what happened to the 29 sailors.

REFERENCES

Duluth Port Authority. 2005. **Pride of the Inland Seas** .
Describes the history of the port of Duluth. An additional 20 chapters that were not included in the book are available on Duluth Port Authority's website <http://www.duluthport.com/> .

Great Lakes Shipwreck Historical Society. 1998. **Whitefish Point Light Station 1849.**
Whitefish Point, Michigan has been known to native tribes, explorers, missionaries and mariners for centuries. Drawn by the bountiful fishing offered by Lake Superior, the Chippewa Indians used Whitefish Point as a meeting place. Early exploration of Lake Superior led to the discovery of valuable copper and iron ore deposits in the region. Their economic potential brought commercial vessel traffic that continues today. Whitefish Point marks a turning point for all shipping traffic entering or leaving Lake Superior. The Edmund Fitzgerald went down 17 miles NW of Whitefish Point on November 10, 1975.

Jauck, Autumn and Laura Pederson. 2005. **Pictured Rocks National Lakeshore: Exploring by Trail and Shoreline.**
A full-color photo book capturing the many moods of Lake Superior.

Lake Carriers Association. **U.S.-Flag Shipping on the Great Lakes .** (brochure).
Describes major cargoes and provides a useful map of shipping and receiving ports.

Marine Publishing Co. **Know Your Ships: Guide to Boat-Watching 2002.** www.knowyourships.com

Saint Lawrence Development Corporation. **The Great Lakes St. Lawrence Seaway System: Linking North America's Heartland to the World.** Describes pilotage, agents/stevedores, U.S. and Canadian port contacts, Seaway facts, cargoes and more.

Sivertson, Howard. 2001. **Schooners, Skiffs, and Steamships: Stories along Lake Superior's Water Trails**.
This book describes the many interesting watercraft used to carry people across Lake Superior. From the bark canoes and wooden schooners that transported the fur trade and the Mackinaw boats, skiffs and bateaux that worked her shores to the first side-wheel and propeller driven steamships that hauled passengers and freight, Lake Superior's early settlers relied on water transportation as a lifeline to civilization.

Soo Lock Boat Tours. 2005. **Locks & Ships.** Vol. 4.
Describes points of interest, histories of Sault Ste. Marie (Michigan & Ontario), lock and canal history in Sault Ste. Marie and St. Lawrence Seaway, historic lighthouses, charts and nautical terms, and more.

U.S. Environmental Protection Agency and Environment Canada. 1995. **Great Lakes Environmental Atlas**
Maps, history, environmental concerns, management, diagrams, fact sheets on the five Great Lakes.

VIDEOS

Aquatic Exotics (22:00 min.) Grades 4-8
Minnesota Department of Natural Resources – Exotic Species Management Program (1996)
Tel: 612-296-2835
Describes common exotic plant and animal species threatening the Great Lakes and suggests way to control their spread. For grades 4-8.

Barging into the 21st Century (1996) (8:48 min)
American Waterways Association
801 North Quincy Street, Suite 200, Arlington, VA 22203
Tel: 703-841-9300 http://www.americanwaterways.com/
Follows the tugboats, towboats, and barges which serve the waterborne commerce of the United States, enhancing the industry's ability to provide safe, efficient, and environmentally responsible transportation.

Intermodal Freight Transport http://www.marad.dot.gov/index.html.
Maritime Administration U.S. Department of Transportation
400 7th Street, SW Washington, D.C. 20590
Tel: 847-995-0122
To improve and strengthen the U.S. marine transportation system, including infrastructure, industry and labor, to meet the economic and security needs of the Nation. MARAD programs promote the development and maintenance of an adequate, well-balanced United States merchant marine sufficient to carry the Nation's domestic waterborne commerce and a substantial portion of its waterborne foreign commerce, and capable of service as a naval and military auxiliary in time of war or national emergency. MARAD also seeks to ensure that the United States maintains adequate shipbuilding and repair services, efficient ports, effective intermodal water and land transportation systems, and reserve shipping capacity for use in time of national emergency.

Living on the Edge: Great Lakes-St. Lawrence River Shoreline (25 minutes)
Army Corps of Engineers – Detroit District and the International Joint Commission

Perspective of a Vital Waterway: The Great Lakes ~ St. Lawrence Seaway System (21:38 minutes)
St. Lawrence Seaway Development Corporation
Tel: 1-800-785-2779 www.greatlakes-seaway.com
Beginning with the construction of the St. Lawrence Seaway in 1954 and the official opening in 1959, this bi-national project shared by Canada and the United States, was one of the top ten public works projects of the 20th century. This video captures the rich history, grandeur and diversification of this important waterway which includes channels, locks, rivers, and all five Great Lakes. Ocean-going freighters, bulk carriers, petroleum tankers, cruise ships, and pleasure craft all share in the convenience, efficiency and environmental benefits of one of the world's premiere inland waterways.

Rise and Fall of the Great Lakes. 1991. National Film Board of Canada (17 minutes)
Tel: 1-800-542-2164 Website: http://www.nfb.ca/.
A lesson in the geologic history of the Great Lakes. While the Great Lakes have had their ups and downs, nothing has been harder to take than present-day human impact. In the film, a lone canoeist lives through the changes over time—through Ice Age and flood—only to find himself trapped in a sea of 21st century scum.

Split Rock Light: Tribute to the Age of Steel (DVD) (22 minutes)
A story of the beacon that guided the ships along the rocky coast of Lake Superior's North Shore.

Tragedies in the Mist. 2004. Thunder Bay National Marine Sanctuary & Underwater Preserve, Alpena, MI
Thousands of vessels plied the Great Lakes for exploration, transportation, and trade. Many never reached their destinations. An area of Lake Huron known for extreme weather, treacherous waters, and dense fog has claimed over 200 ships. Today these sites are protected by the Thunder Bay National Marine Sanctuary and Underwater Preserve, allowing us to explore lost chapters of America's past.

A Vital Waterway – The Great Lakes St. Lawrence Seaway System (10:28 minutes)
St. Lawrence Seaway Development Corporation
Tel: 1-800-785-2779 www.greatlakes-seaway.com
This video captures the grandeur and economic importance of *The Great Lakes St. Lawrence Seaway System*--- its bustling ports, comprehensive marine transportation infrastructure, diverse intermodal transportation connections, and scenic vistas which all contribute to the making of North America's premier inland waterway.

Where Steel Begins (15:00 minutes) by the American Iron Ore Association (1991)
Available from Lake Carriers' Association, Suite 915, 614 W. Superior Ave., Cleveland, OH 44113-1383
Tel: 216-861-0592 Website: www.lcaships.com
Follow a hunk of iron ore, as it is mined and transformed into a taconite or a pelletized ball that is 60% iron, which then goes on to become the steel used in automobiles, rail lines, buildings, and many more of our everyday products. This video is a bit dated; may be easier to follow for younger audiences. Minnesota-based.

Steel Starts Here (12:00 minutes) by the Cleveland Cliffs, Inc. Michigan Operations (2005)
P.O. Box 2000, Ishpeming, MI 49849
Tel: 906-475-3400 Website: www.cleveland-cliffs.com
Follow a hunk of iron ore, as it is mined and transformed into a taconite or a pelletized ball that is 60% iron, which then goes on to become the steel used in automobiles, rail lines, buildings, and many more of our everyday products. This video is better for older students. Michigan-based.

HANDS-ON TEACHING SUPPLIES

Lake Superior Floor Map – this 12' x 15' cloth map which lays on the floor can be used to teach students of all ages (with shoes off!) about watersheds, Lake Superior geography, food chains, and much more. Includes laminated labels for states, countries, cities, and the Geography Concentration game found in *Lake Effects,* as well as the supplies for *Cooperative Cleanup,* an activity also described in *Lake Effects.*

Great Lakes Floor Map - this 15' x 20' cloth map which lays on the floor can be used to teach students of all ages (with shoes off!) about the Great Lakes watershed, shipping, geography, and much more. Includes laminated labels for states, countries, and the cities listed as shipping and receiving ports by the Lake Carriers' Association.

Samples of western, low-sulfur coal from the Powder River Basin of Wyoming and Montana

Samples of taconite iron pellets from Hibbing, MN

3 wooden ship models of "lakers" and a tugboat

52 playing cards of Great Lakes ships

40 Creature Cards from *Great Lakes in My World*

2" x 4" stamp of the Duluth Lift Bridge and a freighter entering the Port of Duluth

Inflatable globe

500 piece *Great Lakes Puzzle* 18" x 24"

More Legends of the Great Lakes CD (2001) by Carl Behrend. www.greatlakeslegends.com

Whatever Floats Your Boat – Designing Your Own Edmund Fitzgerald by Kathleen Sparling, Michigan Earth Science Teachers Association (MESTA). Contains a lesson, iron ore sample, and 5 cannisters of taconite pellets. In the lesson, student design an ore boat, build it, and test it using iron pellets (taconite), the cargo carried by the Edmund Fitzgerald. Student use charts of shipping routes and port cities to calculate distances and shipping time. Addresses math, social studies, and physical science curriculum benchmarks.

Weather or Not To Go by Kathleen Sparling, Michigan Earth Science Teachers Association (MESTA). In the lesson, students examine weather patterns, maps, and forecasts to determine whether it is safe to travel on the Great Lakes.

CURRICULUM MATERIALS

Exploring the Great Lakes: A Logbook of Adventures by Patricia Westfield and Nan Soper (2003)
A perfect guide for teaching about the Great Lakes. Includes information, activities, and reproducible worksheets on the Great Lakes, including geography, history, shipping and commerce, folklore, environmental issues, and a fold-out map of the lakes, along with mapping activities. A CD-ROM includes video selections of Niagara Falls, locks and

canals, ships, lighthouses, and much more. *Exploring the Great Lakes* leads young learners through the five themes of geography in a lively and relevant way, helping them link their new knowledge to their personal lives, as well as helping them understand the lakes' importance to the region and to the nation. Recommended for ages 8 and up. Spiral bound. 64 pages.

Global Change in the Great Lakes Scenarios (addresses 10 topics; Scenario #3 is on Great Lakes Shipping). (1991) by Rosanne Fortner. Ohio Sea Grant Education Program at Ohio State University. This series of short publications was designed to help people understand how global change may affect the Great Lakes region. Scenarios address: climate change models, effect on water resources, shipping, biological diversity, agriculture, air toxins, eutrophication, fish, recreation, and forests. The scenarios are written in terms the general public can understand, and their content has been reviewed by a panel of experts.

Great Lakes in My World
Alliance for the Great Lakes (Contact: Stephanie Smith <ssmith@greatlakes.org>, Alliance for the Great Lakes http://www.greatlakes.org/ Tel: 312-939-0838). A collection of lessons related to the ecology and stewardship of the Great Lakes, includes 40 creature cards of Great Lakes plants and animals, natural and exotic.

Great Lakes Shipping: Earth Systems Eduction Activites for Great Lakes Schools. (1997) Edited by Rosanne Fortner. Ohio Seagrant (http://www-ohiosg.osc.edu). Provides eleven lessons related to shipping, world connections, cultures, Great Lakes triangle and canals in Ohio.

Lake Effects: The Lake Superior Curriculum Guide for Grades K-8 (1998)
The Lake Superior Center/Great Lakes Aquarium,
353 Harbor Drive Duluth, MN 55802
A collection of lessons related to the history, geography, management and stewardship of the Great Lakes and Lake Superior. To order, call: 218 740.3474 or view: http://www.glaquarium.org/.

Lake Rhymes – Folk Songs of the Great Lakes Region CD & Book by Lee and Joann Murdock. (2004)
This 18-song CD with 71 minutes of Lee Murdock performance includes a 146-page book containing musical scores for all 18 songs, plus over 70 historic photos, maps and illustrations. In addition, the book explains the stories behind each song, plus ideas for using the songs to teach history, English, music and geography. Ideal for those who interested in the Great Lakes maritime history or traditional folk music.

Life of the Lakes: The world's greatest fishery by Shari Dann, Michigan Sea Grant Extension and Michigan State Univ. Describes the life history of lake trout, their food web, past, present and future management.

Paddle to the Sea Curriculum Activities by Marcia Seager and Rosane Fortner of Ohio State University and teacher, Timothy Taylor of Muskingum County Schools. Contains 40 classroom activities that can be taught while reading the book. Activities are on Great Lakes geography, shipping (travel math, buoys, how locks work), lake ecosystems, and stewardship which can be taught in science, social studies, language arts, and math classes. Grades 2-6.

Appendix F

Great Lakes Shipping: Did You Know Quiz

How many of the following questions can you answer correctly? Are you a:

Deck Hand = 25% correct	(5 correct answers)	*You're heading for a shipwreck!!*
First Mate = 50% correct	*(10 correct answers)*	*Get* the books out and study up!
Engineer = 75% correct	(15 correct answers)	*Good job!*
Captain = 100% correct	(20 correct answers)	*WOW!!*

1. A 1000-foot "laker" can hold enough iron pellets to make how many automobiles in the U.S.?

    a. 500
    b. 5,000
    c. 15,000
    d. 1 million

2. What percentage of the United State's iron ore used in steel production passes through the Poe lock at Sault Ste. Marie, Michigan?

    i. 10%
    ii. 25%
    iii. 90%
    iv. None

3. Which of the following make up "The Big Three" cargoes carried by U.S.–Flag lakers *in order of tonnage on the Great Lakes*?

    i. Coal
    ii. Stone
    iii. Pelletized iron ore (taconite pellets)
    iv. Salt
    v. Grain
    vi. Liquid bulk (oil and gasoline)

4. The "head of the lakes" refers to which city?
    a. Chicago
    b. Sault Ste. Marie
    c. Montreal/Quebec
    d. Duluth

5. In which year was the first lock constructed on the St. Mary's River to allow boat passage around the St. Mary's rapids?

1798 1850 1895 1959

6. What is “Operation Taconite” run by the Coast Guard at Sault Ste. Marie, Michigan?

7. What was the name of the first sailing vessel on the Great Lakes?

The Griffin *The Invincible* *Lady Elgin* *Mayflower*

8. Which President ordered the current Whitefish Point Lighthouse to be built?

9. Which of the Soo Locks is the longest and most used today?

10. Why did Mr. Carlson, the lighthouse keeper at Whitefish Point in 1918, have the assistant lighthouse keeper and his wife turned over to authorities?

11. When does a 1,000-foot laker hog, sag or list?

12. What does it mean when a large ocean-going vessel (saltie) must “swish and spit” just like you do when the dentist cleans your teeth?

a. That all the crew have to go brush their teeth right away.

b. It’s time for the crew to wash the ship by “swishing” water over the deck and polishing it to a “spit” shine.

c. The water in the ballast tanks needs to be exchanged, either saltwater for fresh, or freshwater for saltwater.

13. How many crew members does it take to load a 1000-foot laker with a full load?

1 10 20 50

14. Where is the bell from the Edmund Fitzgerald?

a. At the bottom of Lake Superior
b. At the bottom of Lake Michigan
c. In the Mariners’ Church in Detroit
d. On display at the Great Lakes Shipwreck Museum at Whitefish Point in Michigan’s Upper Peninsula.

15. What are the top 3 products *shipped through the Soo Locks each year*?

    a. Iron ore (taconite)
    b. limestone
    c. wheat
    d. coal
    e. salt

16. How many 1000-foot lakers does it take to transport the cargo carried by six 100-car trains or 2,308 trucks?

    a. One
    b. Two
    c. Three
    d. Four

17. What is the total drop in elevation from Lake Superior to the Atlantic Ocean?

18. What is the drop in elevation between each of the Great Lakes?

    Lake Superior to Lake Huron _____
    Lake Huron to Lake Erie _____
    Lake Erie to Lake Ontario _____
    Lake Ontario to Montreal (St. Lawrence Seaway) _____

19. During which month has there been the greatest number of shipwrecks?

20. What is the total number of lives lost on the Great Lakes in shipping-related casualties in recorded history?

    500 2,000 10,000 30,000 50,000

(Questions 1-10 and 16-20 by Joan Chadde; questions 11-13 by Katherine Roll; questions 14-16 by Lisa Bircher)

Great Lakes Shipping: Did You Know Quiz - ANSWERS

How many of the following questions can you answer correctly? Find out if you are a:

Deck Hand = 25% correct (5 correct answers) *You're heading for a shipwreck!!*

First Mate = 50% correct (10 correct answers) Get the books out and study up!

Engineer = 75% correct (15 correct answers) *Good job!*

Captain = 100% correct (20 correct answers) *WOW!!*

1. A 1000-foot "laker" can hold enough iron taconite pellets to make how many automobiles in the U.S.?
   a. 15,000

2. What percentage of the United State's iron ore used in steel production passes through the Poe lock at Sault Ste. Marie, Michigan?
   a. 90%

3. Which of the following make up "The Big Three" cargoes carried by U.S.–Flag *lakers in order of tonnage* on the Great Lakes?
   i. Coal = #3
   ii. Stone = #2
   iii. Pelletized iron ore (taconite pellets) = #1

4. The "head of the lakes" refers to which city?
   Duluth

5. In which year was the first lock constructed on the St. Mary's River to allow boat passage around the St. Mary's rapids? **1798 (can now be seen outside the St. Mary's Paper Company in Sault Ste Marie, ON)**

6. What is "Operation Taconite" run by the Coast Guard at Sault Ste. Marie, Michigan?
   i. The largest ice-breaking operation in the United States.

7. What was the name of the first sailing vessel on the Great Lakes? ***The Griffin (1679)***

8. Which President ordered the current Whitefish Point Lighthouse to be built? **President Lincoln**

9. Which of the Soo Lock is the longest and most used today? **Poe lock**

10. Why did Mr. Carlson, the lighthouse keeper at Whitefish Point in 1918, have the assistant lighthouse keeper and his wife (both German) turned over to authorities? ***He overheard their plan to disable the Whitefish Point light in order to stop iron ore shipments through the Soo Locks that were aiding the United States' efforts in WW I !!***

11. When does a 1,000-foot "laker" hog, sag or list?

Answer: ***When it is improperly loaded.*** A 1,000 foot laker is much like a tippy canoe. It is essential that it be properly loaded with cargo to distribute the weight. It can "list" dangerously to one side and tip over, in much the same way a canoe would. Improper loading can also cause a vessel to "hog" creating a convex curve in the hull, or "sag" creating a concave curve in the hull.

Properly Loaded Ship **Listing Ship**

HOGGING **SAGGING**

Load Load Load

12. What does it mean when a large ocean-going vessel (saltie) must "swish and spit" just like you do when the dentist cleans your teeth?

c. **The water in the ballast tanks needs to be exchanged, either saltwater for fresh, or freshwater for saltwater.** By exchanging fresh ballast water for saltwater in the ocean, an ocean-going vessel can almost completely avoid bringing non-native, invasive species from ocean ports to the Great Lakes.

13. How many crew members does it take to load a 1000-foot laker with a full load?

Answer: Just one! Due to advances in technology a large ship can be loaded by one crew member using remote control (self-loader and self-unloader).

14. Where is the bell from the Edmund Fitzgerald?

d. On display at the Great Lakes Shipwreck Museum at Whitefish Point in Michigan's Upper Peninsula.

15. What are the top 3 products shipped through the Soo Locks each year?

a. Iron ore (taconite) = 74%
c. wheat = 11%
d. coal = 6%

16. How many 1000-foot lakers does it take to carry the cargo carried by six 100-car trains (10,000-ton capacity each) or 2,308 (26-ton capacity) trucks?

a. One (a 1000-foot laker carries 60,000 tons)

17. What is the total drop in elevation from Lake Superior to the Atlantic Ocean?

Lake Superior is 640 feet above the Atlantic Ocean.

18. What is the drop in elevation between each of the Great Lakes?

Lake Superior to Lake Huron	**21 feet**
Lake Huron to Lake Erie	**12 feet**
Lake Erie to Lake Ontario	**326 feet**
Lake Ontario to Montreal	**224 feet**

(Totals 583 feet)

19. During which month has there been the greatest number of shipwrecks?

From 1800-1975, 140 shipwrecks have occurred on the Great Lakes during the month of November; 40 were on Lake Superior and 38 were on Lake Huron.

20. What is the total number of lives lost on the Great Lakes in shipping-related casualties in recorded history? **30,000**

(Questions 1-10 and 16-20 by Joan Chadde; questions 11-13 by Katherine Roll; questions 14-16 by Lisa Bircher)

Appendix G

Great Lakes Maritime Shipping Vocabulary

Aft	Behind or back
Aid to navigation	Device that is external to the vessel whose purpose is to assist a navigator to determine position.
Ballast	Weight added to lower a ship in the water making it less top heavy when traveling without cargo. Fresh or salt water are most commonly used.
Beacon	Light to aid navigation.
Bearing	The direction to an object as measured from the boat.
Berth	A place where a ship anchors or ties up to a dock.
Bow	The front of the ship.
Broach	When a vessel rolls onto its side
Buoy	A floating object moored to the bottom to mark a channel to aid to navigation.
Cargo	Goods carried by a ship. General cargo is boxed, bagged, crated or on a pallet. Bulk cargo is loose---usually granular, such as grain, iron ore, taconite pellets, or coal.
Channel	The deeper part of a river or harbor for ships to pass through; **a** route between two bodies of water.
Chart	Nautical version of a highway road map.
Commodity	Anything that is bought and sold.
Course	Direction in which a boat is intended to be steered.
Danger signal on a ship	Five short toots.
Day beacon	Unlighted fixed aid to navigation.
Deck	Flat surface on the upper part of the ship where the crew and passengers can walk. Passenger ships have several decks, whereas a cargo ship (freighter) may have only one deck.
Dock	A long platform built next to the water as a landing place for ships.
Elevator	A building for storing grain.
Export	To send goods from one country for sale in another.

Foghorn	A horn blown during foggy weather to warn ships of danger.
Greenhouse gas	Gases in the atmosphere, including increased carbon dioxide, methane, ozone, and fluorocarbons that contribute to global warming and may result in greater evaporation from the Great Lakes.
Grounded	When a ship runs aground in shallow waters or on rocky outcrops.
Harbor	A place where ships may anchor.
Hatch	Doorway on a vessel. Hatchcovers are on the deck of a freighter where the vessel is loaded with cargo.
Head	Bathroom on a vessel.
Heading	The direction the boat is pointing.
Hogging	Improper loading can cause a vessel to "hog" creating a convex curve in the hull.
Hull	Lowermost portion of a ship floating partially submerged.
Import	To bring goods into one country from another.
Inter-modal transport	Moving cargo using more than one mode, such as truck, railway, ship, or plane.
Invasive species	Non-native species that are transported to a new area that typically have no natural predators (ex: zebra mussels).
Leg of a journey	Portion of a trip.
Lighthouses	Mark entrances to harbors, and warn ship captains where there are dangerous shallow waters or other obstructions.
Line	All ropes on a vessel are called lines.
Listing	Tipping to the side
Locks	A section of a waterway, in which gates are used to raise or lower the water level to allow ships to move between water bodies of different elevations.
Longshoreman	A person who works on the waterfront loading and unloading ships.
Maritime	Anything having to do with water bodies or the sea; nautical.
Maritime shipping	Transportation of cargo via waterways.
Natural resources	Useful materials found in nature

Radar	Radar helps ships find their way in the dark or in the fog.
Pilothouse	Enclosed structure on the dick of a ship from which it can be navigated.
Port	1. A city or town with a harbor for loading/unloading ships. 2. Left-hand side of a vessel, facing forward.
Quarry	Limestone and other stone used in construction and steel-making is mined from quarries and loaded into Great Lakes ships.
Range	Two visible objects in a line, or the distance to an object
Sagging	Improper loading can cause a vessel to “sag” creating a concave curve in the hull.
Shipping route	Route which a freighter travels from one port to another.
Shipping	Transportation of cargo via water, road, rail or airplane using a freighter, train, truck, or plane.
Starboard	The right-hand side of a vessel, facing forward.
Stern	Back of the ship
Taconite	Iron ore that is refined and formed into small marble-sized pellets
Ton	A unit of weight equivalent to 2,000 pounds.
Track	The path the boat has actually followed.
Tugboats	Help move ships around in harbors or rivers.
U.S. Coast Guard	Protects the Great Lakes in a variety of ways including environmental management (pollution spills, invasive species, etc.), security, navigation of foreign vessels, and search & rescue. Grand Haven, Michigan is Coast Guard City, U.S.A.
Vessel	A broad term for any watercraft.