Great Lakes Shipping Study

National Protection and Programs Directorate
Integrated Analysis Task Force
Homeland Infrastructure Threat and Risk Analysis Center

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Executive Summary

The Great Lakes St. Lawrence Seaway (GLSLS) system is a vast, interconnected series of navigable waterways, with intersecting modes of transportation and landscapes. The enormity and importance of the GLSLS system cannot be overstated as the region is critically dependent upon it; therefore, it is vital to understand the nature of the system, the industries that rely upon it, its economic impact, and major commodities that flow through the GLSLS. This study provides an overview of the GLSLS system, focusing on geography, system infrastructure, economic and employment data derived from the GLSLS, and detailed analysis of three key commodities: iron ore, steel, and refined petroleum products.

The GLSLS, which borders eight states and spans 2,300 miles, comprises Lake Superior, Lakes Michigan and Huron, Lake Erie, Montreal-Lake Ontario, and the Saint Lawrence Seaway, as well as the channels that connect these navigable sections. U.S. and Canadian companies and industries rely on the GLSLS for low-cost, long-distance transportation of raw materials and finished goods.

In 2010, U.S. and Canadian companies that depend on the GLSLS for moving cargo reported revenues of over $30 billion, more than half of which was generated in the United States. The GLSLS is also responsible for the creation of hundreds of thousands of jobs, providing direct employment for mariners, many types of port employees, and support positions within the companies, as well as creating indirect jobs that result from the spending power of the previously mentioned workers. In 2011, more than 225,000 in the United States and Canada were tied either directly or indirectly to the GLSLS system. Of those, 57 percent were located in the United States.

Every year, hundreds of millions of tons of commodities are shipped in the GLSLS. Commodities include iron ore, coal, limestone, cement, salt, sand, and grain, as well as chemicals, petroleum, finished products, and containerized cargo to a lesser extent.

Key findings include the following:

- The Soo Locks, a system of two functioning parallel locks, represent a single point of failure for industries that rely on coal, iron ore, and limestone shipments that transit the GLSLS. Specifically, the Soo Locks System’s Poe Lock is critical, as it is the only lock in the entire GLSLS system that accommodates 1,000-foot vessels. An extended disruption of the Poe Lock can potentially disrupt the operations of the industries that depend on commodities shipped through the Soo Locks system.

- The U.S. Army Corps of Engineers (USACE) assesses that 50 percent of the infrastructure in the GLSLS is failing or had failed, meaning that the infrastructure is unable to adequately serve the navigation needs for which it was designed.

- Low water levels contribute to impact shipping and the challenges of dredging. The GLSLS has experienced low water levels for more than a decade; however, 2012 set a new record low for Lakes Michigan and Huron.

- Some estimates assess that the GLSLS is currently operating significantly below its maximum capacity, and indicate that reliance on the GLSLS for shipping will increase in future years. If dredging backlogs and low water levels remain the norm
for the unforeseeable future, growth projections may intersect with physical constraints in the system.

- Use of the GLSLS system is economically efficient due to economies of scale. A 2007 estimate indicated the average cost savings of shipping on the GLSLS was $14.80 per ton when compared to all other modes. A single Laker (type of ship) can haul approximately 70,000 tons of cargo, which is equivalent to seven 100-car trains. A ship can travel 607 miles on 1 gallon of fuel per ton of cargo, significantly farther than freight trains and trucks.

- Steel mills located on the GLSLS depend on low-cost transport of raw materials as an input to the industry. However, the steel industry is not dependent upon the GLSLS for transport of its outputs, finished steel products, as only 1 percent of finished U.S. steel is shipped on the GLSLS.

- Steel mills that use iron ore as a raw material are more dependent upon the GLSLS for transport of raw materials than electric arc furnace (EAF) mills that do not use iron ore as a primary input.

- Although some communities and companies are dependent on the GLSLS for transport of petroleum, the petroleum industry at large is not dependent on the GLSLS for transport of finished products or raw crude.
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Introduction

The purpose of this report is to provide an orientation to the Great Lakes St. Lawrence Seaway (GLSLS), identify likely risks associated with critical infrastructure, briefly analyze several key commodities that are transported in the system, describe possible economic impacts of a disruption, and identify future study areas for the GLSLS. Although both Canada and the United States use the GLSLS to transport goods over long distances, this report mostly covers U.S. infrastructure, vessels, and commodities. Where available, some figures for Canadian infrastructure, vessels, and commodities have been provided, but with less detail because of constraints on the availability of data.

Critical infrastructure stakeholders in the Great Lakes region have requested analysis of the transit of iron ore, steel inputs, and petroleum products within the GLSLS system. Because the analysis focuses on the shipping of these commodities on the system, it does not include environmental factors or the recreational boating industry. For each of the commodities, the origin of raw materials, the GLSLS’s economic importance, and its dependencies are identified with respect to shipping. The commodity analysis does not account for all dependencies or economic effects of the industry at large. An attempt has been made to estimate the portion of each commodity that is actually shipped on the system.\(^1\)\(^2\)

Methodology

Stakeholders in the Great Lakes Region understand their own relationship to the GLSLS, but this study offers an introductory overview of the system for interested parties both with and without detailed knowledge of the GLSLS. Deciding upon the areas of focus for this study involved collecting and evaluating input from multiple stakeholders, including officials from the State Fusion Centers, the Homeland Security Offices, and the Protective Security Advisors with the Department of Homeland Security’s Office of Infrastructure Protection. Discussions about the system considered what aspects of the shipping industry and infrastructure are important to analyze and which commodities need further analysis. The focus of this analysis is a product of a compromise of those interests and concerns. The consensus view that emerged decided on defining geographic boundaries, related infrastructure, and general patterns of trade. It was then decided that iron ore, steel and petroleum were three commodities that should be explored in detail.

\(^1\) All figures are in short tons (2,000 pounds), and conversions from metric tons to short tons were completed by multiplying metric ton figures by 1.10231.

Key Infrastructure Assets

Geographic Profile

The GLSLS spans 2,300 miles of the northern United States, from eastern Minnesota, through the upper Midwest and southeastern Canada, to the Gulf of St. Lawrence in eastern Canada. The GLSLS borders eight U.S. States: Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York (see Figure 1).

The system can be divided into five main navigable sections: Lake Superior, Lakes Michigan and Huron (hydrographically considered one body of water), Lake Erie, Montreal-Lake Ontario (MLO), and the St. Lawrence Shipping Channel. Six channels connect the navigable sections of the GLSLS and unite the region into one system (see Figure 2). The Soo Locks system controls the eastern entry and exit to Lake Superior. Lakes Michigan and Huron are “down bound” of the Soo Locks system. Lake Erie is situated between the St. Clair River at its west end and the Welland Canal, which separates Lake Erie from Lake Ontario to the east. MLO stretches from the Welland Canal east to the city of Montreal. The last section spans the waterway from Montreal to the St. Lawrence Shipping Channel, which empties into the Atlantic Ocean.
The annual GLSLS shipping season begins in March and generally lasts until late December. During the winter months, the extent and duration of ice cover determines the length of the shipping season. Since 1959, new technologies against ice formation in locks and canals have extended the shipping season by more than 25 days. Between 1996 to 2005, the average navigation season lasted 276 days.

Although the overall shipping season is considered to be approximately 10 months, individual infrastructure is also governed by weather conditions, especially ice in the waterways. In the St. Lawrence Seaway, ice breaking and other ice management activities are often required near the beginning and end of the season, depending on weather conditions. Generally, the Seaway from Montreal to Lake Erie operates on a nine-and-a-half-month season, while on the upper Great Lakes, the Soo Locks are open for approximately 10 months.

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Asset Overview

The composition of the GLSLS system consists mostly of open waterways that act as a series of large reservoirs (a profile of the overall system is shown in Figure 3). These reservoirs are connected by a series of manmade and natural canals, locks systems, and straits that represent the most significant locations for navigational restrictions and hazards. Three lock systems and three canals without locks make up the six channels. The lock systems include: the Soo Locks system (2 locks currently in use, 4 total), Welland Canal (8 locks), and MLO (7 locks). The canal systems include the St. Mary’s River, the Straits of Mackinac, and the Detroit/St. Clair River System.

![FIGURE 3.—Great Lakes – St. Lawrence Seaway Profile. (Courtesy of the St. Lawrence Seaway Management Corporation, 2003.)](image)

Roughly 45 percent of all cargo traffic travels far enough to transit at least one component or a combination of the Soo Locks system, Welland Canal, or MLO lock system. These locks systems represent a limiting factor on cargo volume in terms of ship size and draft depth depending on conditions. For instance, low water levels can cause a ship’s draft to be severely restricted at these critical points. The volume of bulk cargo is constrained by the lowest draft depth in a vessel’s path. The U.S. Army Corps of Engineers (USACE) is charged with maintaining much of the infrastructure and navigation channels in the GLSLS system. Currently, there are 47 deep draft ports, 55 shallow draft ports, and 745 miles of navigation channels that must be dredged and maintained. Between 1995 and 2003, the GLSLS moved an average of approximately 287 million tons of cargo annually. Dry-bulk commodities, such as iron ore, stone, coal, and grain, make up more than 80 percent of the average yearly cargo. The remainder of cargo consists of non-bulk items such as finished products, containerized cargo, and liquid-bulk items.

Other infrastructure which supports shipping or is connected to the GLSLS system includes a network of more than 40 highways and 30 railway lines. Although the GLSLS is a water navigation system, its intersections with other modes of transportation are critical components to

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its functionality and economic viability.\textsuperscript{9} Ports are the main gateway onto and off of the GLSLS. There are more than 85 commercial ports and 117 Federal harbors on the GLSLS that ship and receive freight and provide safety for ships during inclement weather.\textsuperscript{10} The ports generate jobs, personal income, and revenue in the localities they serve.

**Lock Systems**

**Soo Locks**

![FIGURE 4.—Location of Soo Locks.](image)

The Soo Locks system is a vital link between ports at the Canadian Lakehead and Minnesota that move raw materials to ports in the lower Great Lakes. The locks, originally built in 1855, are located on the St. Mary’s River, at Sault Ste. Marie, Michigan. The locks allow ships to traverse the 21-foot drop between Lake Superior and Lake Huron, and connect Lake Superior to the rest of the GLSLS. The facility currently includes four locks: Poe and MacArthur, which are still in operation, and Sabine and Davis, which are no longer operational. Although there are two functioning locks in the system, a ship must pass through only one as the locks are positioned in parallel and not in succession like those in the Welland Canal or the MLO. The MacArthur and Poe locks handle commercial freight in the region but only the Poe lock can accommodate the largest ships on the Great Lakes.\textsuperscript{11}

\textsuperscript{10} DOT MARAD (U.S. Department of Transportation Maritime Administration), *Status of the U.S.-Flag Great Lakes Water Transportation Industry*, 2013, p. 33.
The Poe Lock represents a single point of failure for the many industries that depend on shipments throughout the Great Lakes system. More than 90 percent of the iron ore (the highest volume commodity on the GLSLS) that is produced in the United States must pass through the Soo Locks system in order to reach steel mills in the lower Great Lakes region. Iron ore and coal are the two highest volume commodities shipped through the Soo Locks system, and the annual total traffic through the locks is about 80 million tons of all types of cargo. Because of the Poe Lock’s ability to accommodate all sizes of ships, if the lock were to be taken out of service, approximately 70 percent of all traffic through the St. Mary’s River would be halted, including key commodities essential to the steel industry and potentially cutting off some power plants from their source of coal. There are plans to construct another lock at the Soo Locks site that would be able to handle 1,000-foot vessels in order to add redundancy to the system; however, as of the publishing date of this report, construction on this project has stopped indefinitely because of funding issues.

Other Locks

The USACE also operates the Chicago Lock in Chicago, IL, and the Black Rock Lock in Buffalo, New York. Located in downtown Chicago, the Chicago Lock allows for passage between Lake Michigan and the Chicago River for over 35,000 commercial and recreational boats, transporting 680,000 passengers and approximately 125,000 tons of cargo annually. The Chicago Lock overcomes a 2- to 5-foot change in elevation and helps to control flooding in the Chicago area. The Black Rock Lock provides safe passage between Buffalo Harbor and Tonawanda Harbor by routing boats around obstacles, rapids, and fast currents in the upstream portion of the Niagara River. More than 300 commercial and 1,300 recreational boats navigate this lock annually.

12 USACE, Waterborne Commerce of the United States, 2011.
The St. Mary’s River is a 63-mile-long deep-draft commercial channel composed of both natural features and manmade structures that connect the east end of Lake Superior at the Soo Locks, with the northern end of Lake Huron. Continuous dredging maintains a target depth of 27 feet in order to accommodate the ships that transit the area.\(^\text{19}\) Because the opening of the ship canal has increased the flow of water, there is an extensive system in place to control the flow out of Lake Superior. The control system structures include two hydroelectric plants, five navigation locks (four at the Soo Locks and one Canadian lock), and a 16-gated control structure at the head of the St. Mary’s Rapids.\(^\text{20}\) The average monthly water fluctuations in the St. Mary’s River are about 1 foot; however, the water levels can change daily by several inches to as much as 1 foot. These conditions—along with swift currents, narrow channels, and shallow depths—make the St. Mary’s River a potentially hazardous segment of the GLSLS.


St. Clair and Detroit River System

The St. Clair and Detroit River System connects Lake Huron to Lake Erie. Water from Lake Huron flows through the St. Clair River, connects to a shipping channel through Lake St. Clair, and then flows into the Detroit River and on to Lake Erie. An average of 65 million tons of cargo transit the river annually, generating $1.83 billion and supporting 41,000 jobs in the area.\(^{21}\)

The St. Clair River is approximately 39 miles long and connects the southern end of Lake Huron with the northern end of Lake St. Clair. There is a natural 5-foot change in elevation in the river, and there are no control structures to limit the flow of water through the system.\(^{22}\) The St. Clair River is a deep-draft commercial channel that is maintained at 27.1 to 30 feet in depth through regular dredging cycles, the last of which was completed in 2012. The St. Clair River empties into Lake St. Clair, which contains a 14.5-mile channel.\(^{23}\)

The Detroit River is 32 miles long and connects the southern end of Lake St. Clair to the west end of Lake Erie. The shipping channels are maintained at 25–29 feet deep. Approximately 59.3 million tons of cargo transits the river every year. Major U.S. ports include the Port of Detroit and the Rouge River Wharf, which are both major industrial ports involved in the iron ore trade.\(^{24}\)

\(^{22}\) USACE Great Lakes and Ohio River Division, Supplemental Reconnaissance Report, 2010, p. 35.
Canals

The St. Lawrence Seaway, which includes the MLO and Welland Canal, handles approximately 4,000 ships and 44 million tons of cargo during a single navigation season.\(^\text{25}\) This region is the gateway to ocean shipping for the entire GLSLS system and a transshipment point for cargo arriving from and destined for international markets.

Welland Canal

In its current configuration, the Welland Canal was finished in 1932 and is owned by the Canadian Government and operated by the Canadian St. Lawrence Seaway Management Corporation. Its purpose is to accommodate the 326.5-foot change in elevation between Lake Ontario and Lake Erie and circumvent Niagara Falls (see Figure 8). The entire system is 27 miles long and consists of eight locks with an average lift of 46.5 feet per lock.\(^\text{26}\) Many U.S. ships are too large (1,014 feet long by 105 feet wide) to traverse the Welland Canal, which can accommodate ships that are up to 740 feet long and 78 feet wide, a standard known as the “Seaway Max.” The canal can support Canadian-flag ships, which are usually built to Seaway Max standard or smaller.

The canal handles approximately 41 million tons of cargo annually, most of which consists of iron ore that is up bound from the St. Lawrence River into Lake Erie and grain that is


down bound from the four upper lakes into Lake Ontario. Grain is loaded in the Thunder Bay region of Canada and shipped to ports in the lower St. Lawrence River.

FIGURE 8.—Welland Canal Profile. (Courtesy of the United States and Canada, 2007.)

Montreal-Lake Ontario

FIGURE 9.—Location of Montreal-Lake Ontario.

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The completion of the MLO in 1959 permitted bulk cargo to transit between the St. Lawrence River and Lake Ontario (see Figure 2 for location within the GLSLS). This provided commercial traffic access to the Atlantic Ocean via the entire GLSLS system. This portion of the GLSLS system handles approximately 12 percent of the yearly traffic on the GLSLS.\(^{29}\) Iron ore shipped from the Labrador mining complex in Quebec, Canada, is one of the main commodities moved through the MLO; various grains, coal, salt, stone, and manufactured products are also transported through this section.

Using a series of seven locks, the MLO moves ships over 226 feet in elevation from Montreal, Quebec, to Iroquois, Ontario, Canada. Five of the locks are owned by the Canadian Government: St. Lambert Lock, Cote Ste., Catherine Lock, Beauharnois Lock, and Iroquois Lock. The other two locks are owned by the U.S. Government: Snell Lock and Eisenhower Lock. Similar to the Welland Canal, all seven MLO locks are configured to support Seaway Max standards.\(^{30}\)

To compensate for the increased water flow three major control structures were constructed: the Moses-Saunders, Long Sault, and Iroquois Dams. These dams also control the flow of water during flooding or drought conditions.\(^{31}\)

### Ports and Harbors

Great Lakes ports and harbors are transfer points for all traffic on the GLSLS system. Although the system ports usually have easy road access, fewer ports have rail access. Ports require rail access to receive raw materials from mines or manufacturing plants. In addition, some ports receive commodities by ship and then rely on rail service to deliver them to factories, mills, and markets. In many cases, ports are involved in both shipping and receiving.\(^{32}\)

Great Lakes transportation and shipping networks have been developed to minimize shipping time, cost, and required resources. In order to accomplish this goal, a complex combination of infrastructure investment, ship technology, and intermodal freight transfers all converge at a series of key ports throughout the GLSLS.\(^{33}\) One such port is the Superior Midwest Energy Terminal, constructed in 1976 at the Port of Superior, Wisconsin. The terminal receives coal from the Powder River Basin (PRB) in Wyoming and can handle two 123-car trains simultaneously, offloading them at a rate of 5,000 tons per hour (TPH); the port can store 5 million tons of coal onsite. The terminal loads 1,000-foot vessels at a rate of 11,500 TPH and ships a large portion of this cargo through the GLSLS system for the Detroit Edison Company.\(^{34}\)

There are more than 85 commercial ports (70 serviced by U.S.-flag lakers) and 117 federal harbors on the GLSLS. A small number of ports move most of the cargo on the GLSLS every

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\(^{33}\) DOT MARAD, *Status of the U.S.-Flag Great Lakes Water Transportation Industry,* 2013, p. 32.

For example, from 2002 to 2011, the top ten ports handled 86 percent of all cargo moving throughout the system (see Table 1). Table 1 contains data for several years between 2002 and 2011, the years not included were done so strictly for presentation purposes. Great Lakes port facilities include 772 shore-side facilities (e.g., docks, wharves, piers, slips), many of which are involved in shipping and receiving, and some that are involved in either shipping or receiving. Of the receive-only facilities, 105 have no rail access; most of these facilities receive cement/concrete, sand and gravel, oil/fuel oil, and cargo from freight forwarding companies. It is important to note that six of the facilities without rail access are power plants located on the Great Lakes. These six power plants are totally dependent on the shipment of coal delivered via the GLSLS.

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<td><strong>147,576</strong></td>
<td><strong>137,764</strong></td>
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</table>

**TABLE 1.**—Ten Most Trafficked U.S. Great Lakes Ports (thousands of short tons/year).
(Courtesy of USACE Great Lakes and Ohio River Division.)

**Shipping and Navigation**

Ships used in the GLSLS system are unique because of the high volumes of cargo they carry over the duration of the 10-month shipping season. Most of the ships on the GLSLS are used to transport dry-bulk commodities. These ships are often referred to as “lakers” and are registered to the United States or Canada. Some 1,000-foot vessels carry more than 3 million tons of cargo in a single shipping season. These lakers are able to load in one port, travel to the next, and self-offload their entire payload, and may require only one person at the controls.

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Types of Ships

The three major types of vessels that characterize shipping in the GLSLS system are U.S.-flag lakers, Canadian-flag lakers, and Seaway Max vessels. Although U.S.-flag lakers have a larger per-trip carrying capacity than Canadian-flag lakers, Canadian-flag lakers are more modern and efficient. In 2011, U.S.-flag lakers carried approximately 76 percent of iron ore, 73 percent of coal, 76 percent of limestone, 13 percent of salt, and 70 percent of cement shipped on the Great Lakes (see Table 2). Other ships that transport commodities on the GLSLS include various tug/barge configurations, as well as liquid bulk tankers that transport chemicals, petroleum, and other liquids.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>U.S.-Flag Total</th>
<th>Total Great Lakes</th>
<th>U.S.-Flag Share of Trade (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron Ore</td>
<td>47,224,743</td>
<td>61,354,552</td>
<td>76.97</td>
</tr>
<tr>
<td>Coal</td>
<td>20,239,327</td>
<td>27,616,116</td>
<td>73.29</td>
</tr>
<tr>
<td>Limestone</td>
<td>21,434,839</td>
<td>28,153,642</td>
<td>76.13</td>
</tr>
<tr>
<td>Salt</td>
<td>1,452,134</td>
<td>10,879,102</td>
<td>13.35</td>
</tr>
<tr>
<td>Cement</td>
<td>2,817,846</td>
<td>4,019,675</td>
<td>70.10</td>
</tr>
</tbody>
</table>

TABLE 2.—2011 U.S.-flag Share of Major Commodities (short tons). (Courtesy of LCA 2012.)

U.S.-Flag vs. Canadian-Flag

The 55 U.S.-flag lakers used to transport dry-bulk commodities can be classified as self-propelled and composite tug-barges that the USACE designates with a class number 1 through 10 according to vessel length (see Table 3). All but two of these ships are self-offloading. Fifty-five percent of the vessels in the dry-bulk fleet are in classes 8 to 10; as a result, they are too large to transit the Welland Canal and can only operate on the four upper Great Lakes, and the Poe Lock in St. Mary’s River is the only lock in the Soo Locks system that can accommodate ships in those classes 8 through 10. Though vessels in Classes 1 to 7 can navigate the Welland Canal, it is rare for one to transit the St. Lawrence Seaway. This profile defines not only the fleet but also the infrastructure at the ports that rely on the self-offloading capabilities of U.S.-flag lakers.

In comparison to U.S.-flag lakers, Canadian-flag lakers are smaller and usually conform to the Seaway Max standard, enabling most of the fleet to move freely throughout the GLSLS. Foreign vessels that enter the GLSLS, often called “salties,” also must be built to these dimensions to ensure that they can navigate the Welland Canal and the MLO section. The

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Canadian-flag laker fleet is capable of carrying 70 million tons of cargo per year, which is significantly less than the U.S.-flag fleet’s capacity of 115 million tons of cargo annually.\textsuperscript{44}

<table>
<thead>
<tr>
<th>Vessel Class and Length (feet)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-propelled Vessel</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>13</td>
<td>1</td>
<td>12</td>
<td>42</td>
</tr>
<tr>
<td>Composite Tug-Barge</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>8</td>
<td>5</td>
<td>6</td>
<td>16</td>
<td>1</td>
<td>13</td>
<td>55</td>
</tr>
</tbody>
</table>

\textbf{TABLE 3.—U.S.-Flag Lakers Allocated to USACE Great Lakes Vessel Classification, 2012.}

(Courtesy of DOT MARAD 2013.\textsuperscript{45})

\section*{Current Conditions}

\subsection*{Federal Roles}

The Great Lakes Navigation System (GLNS) is the portion of the GLSLS that is owned, operated, and maintained by the U.S. Federal Government.\textsuperscript{46}

USACE is charged with maintaining many of the structures on the U.S. side of the system, and the U.S. Coast Guard (USCG) is charged with navigation regulations and enforcement. For example the USCG operates the Vessel Traffic Service to coordinate traffic on the St. Mary’s River and to help vessels avoid collision and accidental grounding.\textsuperscript{47} These efforts consume an enormous amount of funding and require detailed planning and a keen understanding of the system. Some of the infrastructure and other services supported by the GLNS include the following:

- Federal harbor access channels, river channels, and vessel turning basins;
- Confined disposal facilities for contaminated dredged material from maintenance of federal channels and harbors;
- Structures built to safeguard navigation in federal harbors from waves and ice (breakwaters, piers, revetments, etc.);
- Federal navigation lock operation and maintenance (Soo Locks, Chicago Lock, Black Rock Lock in Buffalo, New York);
- Port terminals, docks, loading facilities, and port authorities;
- Marine navigation services, pilotage, and ice-breaking services; and

\textsuperscript{45} DOT MARAD, \textit{Status of the U.S.-Flag Great Lakes Water Transportation Industry}, 2013, p. 22.
• Shipping companies and shipping and logistics service providers.\textsuperscript{48}

In 2010, the USACE estimated that 50 percent of the infrastructure in the GLSLS was failing or had failed.\textsuperscript{49} Failing/failed in that assessment was described an inability to adequately serve the navigation needs for which it was designed. Aging infrastructure, decreasing budget, and sustained low water levels are the reasons given for the inability to properly maintain the system. In response, USACE developed the GLNS Five Year Development Plan. Funding and resource allocation issues have delayed or halted progress of the implementation of the plan. The plan focuses on the following five priorities for reducing risk and improving reliability:

• Restoration of locks
• Construction of a new lock at the Soo Locks Complex
• Removal of dredging backlog
• Expansion and construction of dredged material disposal facilities
• Repair of breakwaters and structures

**Dredging**

The lack of dredging in the GLSLS has been a major concern for many years. Dredging is the physical removal of sediments on the bottom of the waterway in order to increase the overall depth of the water in a given area. Dredging is most needed in the connecting canals, rivers, ports, and harbors, where sedimentation tends to build up over time. Currently, the USACE estimates that it costs approximately $40 million annually to keep up with the dredging needs of the GLSLS; however, another $200 million will be required to clear the current dredging backlog.\textsuperscript{50} The Lake Carriers Association estimates that 17 million cubic yards of sediment needs to be dredged from waterways and harbors on the Great Lakes.\textsuperscript{51}

Dredging backlogs resulting from reduced funding coupled with a decade of low water levels has caused significant issues for shippers in the system. Although only 10 percent of the system needs to be dredged, this remains a critical concern because lack of dredging is a major limiting factor for navigation of ships carrying cargo through canals, locks, and ports: for example, for a 1,000-foot vessel, the loss of 1 inch of depth equates to a loss of 270 tons of cargo per trip.\textsuperscript{52,53} The U.S. Department of Transportation Marine Administration (MARAD) equates this to an 8 percent increase in price per ton for a Class 10 laker and an approximately 9 percent increase for a Class 8 laker.\textsuperscript{54}

When dredging is not conducted or is conducted poorly, commercial ships “light load” to reduce the total payload of the ship and reduce the draft. This practice is currently being adopted on a system-wide basis to avoid grounding. For example, Toledo Harbor typically has problems with

\begin{footnotesize}
\begin{enumerate}
\item DOT MARAD, *Status of the U.S.-Flag Great Lakes Water Transportation Industry*, 2013, p. 70.
\end{enumerate}
\end{footnotesize}
dredging due to river sedimentation and agricultural runoff. According to the USACE, 850,000 cubic yards of material are removed from Toledo Harbor every year. This is necessary because, according to USACE calculations, a two- to three-foot loss of channel depth would result in an annual increase in transportation costs of $752,000 to $2 million.\(^{55}\)

<table>
<thead>
<tr>
<th>Vessel Type</th>
<th>Number in Fleet</th>
<th>Trips Per Year</th>
<th>Yearly Loss Per Vessel</th>
<th>Total Yearly Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 10 Laker</td>
<td>13</td>
<td>50 Trips Per Year</td>
<td>$2 Million</td>
<td>$26 Million</td>
</tr>
<tr>
<td>Class 8 Laker</td>
<td>12</td>
<td>50 Trips Per Year</td>
<td>$1.5 Million</td>
<td>$18 Million</td>
</tr>
</tbody>
</table>

**TABLE 4.—Revenue Losses Due to Draft Restrictions for Classes 8 through 10 Lakers (Courtesy of DOT MARAD, 2013.\(^{56}\))**

Low water levels contribute to the challenges of dredging. The GLSLS has experienced low water levels for more than a decade; however, 2012 set a new record low for Lakes Michigan and Huron. Water levels in the Great Lakes depend on many factors, and little can be done to maintain the levels in years of low runoff into the Great Lakes basin, but as long as dredging backlogs and low water levels persist, light loading will continue. As an extreme case, the Port of Dunkirk located on Lake Erie in New York was closed to commercial ship traffic in 2005 due to lack of dredging and low water levels, which has forced the collocated power plant to receive its coal by rail only—which increases coal costs and results in increased environmental impacts associated with rail transportation.\(^{57}\) Because this combination of factors will most likely persist for some time, future studies are necessary to determine the full effect of low water levels on the shipping industry in the GLSLS.

In the GLSLS, a large portion of the sediments removed by dredging must be stored safely because this material is contaminated from decades of industrial chemical use, which increases the cost of the dredging process. Plans for dredging must be made in conjunction with plans to handle dredged materials. The method chosen for removal and storage is site-specific and depends on various factors. For example, the CDF for Cleveland Harbor is near its capacity, and although plans are in place to build a new one, if this process is delayed, dredging operations will cease until an alternative can be established.\(^{58}\)

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\(^{56}\) U.S. Environmental Protection Agency, Office of Solid Waste, *Extraction and Beneficiation of Ores and Minerals, 1994, Volume 3, Iron*, 1994, at www.epa.gov/osw/nonhaz/industrial/special/mining/techdocs/iron.pdf#page=12, accessed June 5, 2013. Table based on 24 inches of lost depth; 30 other vessels that are affected by draft are not included. Dredging is case specific and may not affect ships system wide; there is also one class 9 laker included in the class 8 figures.


Economic Importance

Revenue and Efficiencies

Portions of the Great Lakes have been used to ship both people and goods for hundreds of years, and the GLSLS has functioned as a connected system for more than 50 years. As a result, industries in the region have developed a critical dependence on open shipping throughout the system, which has significant economic influence within the region. The relative low cost to ship goods via the GLSLS, expected increases in cargo volume, and excess operating capacity are likely to lead to increasing reliance on the GLSLS to move international cargo.

Revenue is generated through cargo shipping, recreational use, real estate, and power generation. In 2010, $33.6 billion in revenue was raised by companies (in both the United States and Canada) that handled cargo shipped on the GLSLS, $18 billion of which was generated in the United States. According to the USACE, industries save an average of $3.6 billion per year shipping through the Great Lakes navigation system, compared to other modes of transportation.

The ability to move bulk goods over long distances at low prices with fewer emissions makes the GLSLS system a viable solution for many industries in the United States. A single 1,000-foot-long U.S.-laker can haul approximately 70,000 tons of cargo, which is equivalent to seven 100-car trains, each with a total capacity of 10,000 tons, or 3,000 trucks, each with a 25-ton capacity. Furthermore, a ship on the Great Lakes can travel 607 miles on 1 gallon of fuel per ton of cargo, significantly farther than freight trains and trucks, which can travel only 202 miles and 59 miles per gallon of fuel per ton of cargo, respectively.

Use of the GLSLS system is economically efficient due to economies of scale, primarily achieved via savings from shipping. Industry capitalizes by moving bulk commodities via shipping at a fraction of the cost of rail, truck, or aircraft transportation. An estimate completed in 2007 concluded that an average cost savings of $14.80 per ton in transportation and handling charges was realized.

The volume of goods transported internationally grows each year, a trend expected to continue as economic and trade growth are projected. Traffic bottlenecks in North America’s West Coast have already led shippers to find alternatives through the Panama and Suez Canals. Roads and railways have absorbed some of this redirected traffic. However, both modes are already strained by congestion and tightening capacity, some of which is caused by a small number of transit points and security requirements that slow border crossings. These conditions are expected to lead to increased reliance on the on the GLSLS in the future. Over the next 20 to 40 years, traffic

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in the GLSLS lock systems is expected to increase by 0.7 percent annually in the Soo Locks and the MLO section and by 0.5 percent annually at the Welland Canal. 

Unlike rails and roadways, the GLSLS could handle this increase as it is currently estimated to be operating at about half its maximum capacity. However, backlogs and/or delays could occur with this increase if low water levels and other conditions continue to impact infrastructure.

**Employment Data**

Apart from the revenue generated by the trade of commodities, each individual port in the GLSLS has its own economic input to its respective locality. According to a 2011 study conducted by Martin Associates, a consulting firm that focuses on transportation-related economic analyses and strategic planning, more than 226,833 jobs in the United States and Canada owe their existence to the commodities shipping industry on the Great Lakes. These jobs are held by workers employed as mariners, port workers, and others who provide support to port activity. Of these jobs, 128,227, or 57 percent, are in the United States: 44,634 are direct jobs, 44,057 are induced jobs (created from the spending of direct job employees), and 39,585 are indirect jobs created by companies that support port activities. These numbers result directly from the cargo handling activity at Great Lakes ports.

Iron ore is by far the largest creator of direct jobs and is responsible for more than 37,000 jobs in the ports and steel mills that ship and receive this commodity. In all, 17,000 of these jobs are in steel mills in Canada, and 12,000 are in steel mills in the United States. Miners, steel workers, farmers, manufacturers, shippers, port operators, and all of the businesses and services that support them are directly dependent on the GLSLS system for employment.

Studies that consider more than simply the cargo handled on the GLSLS system estimate that more than 1.5 million jobs can be directly attributed to industries that are supported by access to the Great Lakes (defined as industries that rely on the system for key inputs, e.g., water or fish, or economic viability, e.g., cheap transportation, or are significantly influenced by the Lakes, e.g., by attracting visitors). Manufacturing makes up approximately 66 percent of the jobs that are connected to the GLSLS system. Other major industries include tourism, shipping, agriculture, and mining. Among the eight Great Lakes states, Michigan, Illinois, Ohio, and Wisconsin are the top four in terms of jobs attributed to the Great Lakes, making up about 83 percent of the total number of jobs supported by access to the GLSLS system. Tables 5 and 6 show jobs attributed to the GLSLS by state and by industry, respectively.

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<table>
<thead>
<tr>
<th>State</th>
<th>Great Lakes Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan</td>
<td>525,886</td>
</tr>
<tr>
<td>Illinois</td>
<td>380,786</td>
</tr>
<tr>
<td>Ohio</td>
<td>178,621</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>173,969</td>
</tr>
<tr>
<td>New York</td>
<td>157,547</td>
</tr>
<tr>
<td>Indiana</td>
<td>54,397</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>25,497</td>
</tr>
<tr>
<td>Minnesota</td>
<td>11,877</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,508,580</strong></td>
</tr>
</tbody>
</table>

TABLE 5.—Great Lakes Jobs by State (Courtesy of Vaccaro, 2011).

<table>
<thead>
<tr>
<th>Industry</th>
<th>Great Lakes Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>994,879</td>
</tr>
<tr>
<td>Tourism and Recreation</td>
<td>217,635</td>
</tr>
<tr>
<td>Shipping</td>
<td>118,550</td>
</tr>
<tr>
<td>Agriculture</td>
<td>118,430</td>
</tr>
<tr>
<td>Science and Engineering</td>
<td>38,085</td>
</tr>
<tr>
<td>Utilities</td>
<td>10,980</td>
</tr>
<tr>
<td>Mining</td>
<td>10,003</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,508,562</strong></td>
</tr>
</tbody>
</table>

TABLE 6.—Great Lakes Jobs by Industry (Courtesy of Vaccaro, 2011).

**Key Products and Commodities**

The GLSLS system has evolved over time to accommodate dry-bulk cargos. As previously mentioned, many of the U.S.-flag lakers are self-offloading, and most ports depend on this capability to receive bulk cargoes. While containerized cargo dominates ocean transport, the GLSLS sees very little of this type of traffic. Because of the need to move bulk commodities in the Great Lakes region, the infrastructure in the GLSLS is set up to handle dry-bulk commodities and some liquid bulk commodities. As an example, the Port of Montreal, located just outside of the MLO, ranks fifth in handling containerized cargo on the North American Atlantic Coast, but only a small percentage of that cargo enters the GLSLS; most of the containerized cargo moves by rail from the port.  

Dry bulk commodities, such as iron ore, coal, and stone, are the most common cargo by volume shipped in the GLSLS. From 1993 to 2011, 65.5 million tons of iron ore, 37 million tons of coal, and 34 million tons of limestone, on average, were shipped annually by foreign and domestic

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carriers on the GLSLS. Additional dry bulk commodities shipped on the GLSLS include cement, salt, sand, and grain, as well as chemicals, petroleum, finished products, and containerized cargo, to a lesser extent. Of the commodities represented in Figure 10, most volumes have remained relatively stable since 1993 with a small drop-off after the 2007 recession. The one exception is iron ore: shipments decreased during the 2001 recession, and there was another sharp drop in 2009 because of the 2007–2009 recession; by 2011, shipments then returned to 2008 levels.

![Dry-Bulk Commodities - GLSLS 1993–2011](image)

**FIGURE 10.—Dry-Bulk Commodities - GLSLS 1993–2011. (Courtesy of LCA, 2012.)**

### Key Commodities Analysis

#### Iron Ore

Iron ore is one of the main raw materials used in the steel manufacturing process along with limestone, and coal. The iron ore mining industry is dependent on the GLSLS for both low-cost transport of limestone to the mines to produce pelletized iron ore and shipment of pelletized iron ore from the mines to integrated steel mills. Integrated steel mills account for 40 percent of the steel production in the United States and utilize the basic oxygen furnace (BOF) or blast furnace process to make steel. BOF mills require a dependable supply of iron ore for operations and as a result, most BOF mills in the United States are located on or near major navigable waterways such as the GLSLS which provide low-cost transportation for receiving bulk raw materials used in the steel manufacturing process.

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Iron Ore Mining and Production

In 2011, according to the U.S. Geological Survey (USGS), more than 61.4 million tons of iron ore were produced in the United States.\(^7^4\) The Mesabi Range in eastern Minnesota and the Marquette Range in Michigan’s Upper Peninsula are the two primary iron ore–producing areas in the country. In 2011, about 75 percent of the iron ore shipped on the GLSLS originated in the Mesabi Range; the Marquette Range accounted for the remaining at 25 percent.\(^7^5\)

While called iron ore, the material shipped on the Great Lakes is actually a partially processed substance called taconite pellets. Taconite pellets are created at the mining site by extracting the raw minerals from open pits, grinding it into a powder, and mixing it with limestone and bentonite clay to form pellets. Taconite pellets are shipped by rail to ports on the GLSLS and then loaded onto ships for transport to integrated steel mills throughout the GLSLS region.

GLSLS Iron Ore Shipping Volume

More iron ore is shipped by volume than any other commodity on the Great Lakes. As shown in Figure 11, in 2011 more than 61.3 million total tons of iron ore were shipped within the GLSLS of which 47.2 million tons were shipped by U.S.-flag ships (77 percent). The remaining 14.1 million tons were shipped by either Canadian-flag ships (6.3 million tons representing 10.3 percent), or foreign-flag ships (7.8 million tons representing 12.7 percent).\(^7^6\) As Figure 11 also shows, iron ore shipments on the GLSLS have decreased by almost 20 million tons since the late 1990s. This development is likely a result of the economic recession in 2001 and the recession in 2007–2009. About 80 percent of the iron ore produced in the United States was shipped out of six ports on the GLSLS, which reside in three States: Minnesota, Michigan, and Wisconsin. Access to and operation of these ports is critical to the operation of integrated steel mills located throughout the GLSLS region.

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\(^7^5\) Data from USACE Waterborne Commerce Statistics, 2011.
Iron Ore Shipment Flows

When considering ports that handle iron ore, there are generally two types: those that ship iron ore and those that receive iron ore (see Figure 12). In the United States, iron ore moves generally from eastern Minnesota and Michigan’s Upper Peninsula to the south and east (down bound) to ports in Illinois, Indiana, Michigan, and Ohio. Although some receiving ports are involved in shipping small amounts of iron ore once received, there are primarily six major U.S. ports on the GLSLS that ship iron ore. These shipping ports are associated with iron ore ranges and mines that process the raw ore into taconite pellets and ship the pellets to the ports via rail. The Mesabi Range in Minnesota ships taconite pellets to the ports of Duluth-Superior, Minnesota and Wisconsin; and Two Harbors and Silver Bay, Minnesota. Mining operations in the Upper Peninsula of Michigan’s Marquette Range ship taconite pellets to the Michigan ports of Presque Isle, Escanaba, and Marquette. The biggest U.S. iron ore shipping ports in the GLSLS by far are Duluth/Superior and Two Harbors. Combined, they ship 63 percent of the iron ore mined from the region.

The vast majority (91.7 percent) of the U.S. iron ore shipped on the GLSLS must pass through the Soo Locks. According to the USACE, more than 46 million tons of iron ore were shipped

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through the Soo Locks in 2011, of which 37.9 million tons was domestically produced. The remaining 8.3 percent of iron ore shipped on the GLSLS traveled from Escanaba, Michigan primarily to the Port of Indiana Harbor, Indiana.

![Map of the Great Lakes Steelmaking Lakes System showing shipping routes and ports.](image)

**FIGURE 12.—Flow Of Iron Ore through the GLSLS.**

<table>
<thead>
<tr>
<th>Shipping Port</th>
<th>Tons – Domestic</th>
<th>Tons – Foreign</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duluth-Superior (MN and WI)</td>
<td>11,401,515</td>
<td>4,518,083</td>
<td>15,919,598</td>
</tr>
<tr>
<td>Two Harbors, MN</td>
<td>15,435,036</td>
<td>168,460</td>
<td>15,603,496</td>
</tr>
<tr>
<td>Presque Isle, MI</td>
<td>4,816,379</td>
<td>3,379,182</td>
<td>8,195,561</td>
</tr>
<tr>
<td>Total</td>
<td>5,310,426</td>
<td>0</td>
<td>5,310,426</td>
</tr>
<tr>
<td>Escanaba, MI</td>
<td>3,449,974</td>
<td>0</td>
<td>3,449,974</td>
</tr>
<tr>
<td>Total</td>
<td>41,360,898</td>
<td>8,065,725</td>
<td>49,426,623</td>
</tr>
</tbody>
</table>

**TABLE 7.—Great Lakes Iron Ore Shipping Ports, United States.** (Domestic data courtesy of USACE 2011; foreign data courtesy of USACE Waterborne Commerce Statistics Center 2011.)

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GLSLS iron ore shipments move generally from key ports located in eastern Minnesota and Michigan’s Upper Peninsula to the south and east (down bound) to receiving ports in Illinois, Indiana, Michigan, and Ohio. The receiving ports are usually associated with one or more steel production companies/mills that use the iron ore to make steel of various types as an input to various manufacturing processes. As indicated in Table 8, the ports of Gary, Indiana; Indiana Harbor, Indiana; and Burns Waterway Harbor, Indiana, on Lake Michigan are the top three iron ore receiving ports by volume in 2011. Iron ore shipments also travel through Lake Huron and into the St. Clair and Detroit River system to the receiving ports of Rouge River and Detroit Harbor, Michigan. Other receiving ports include Toledo; Conneaut; Cleveland Harbor; and Ashtabula, Ohio.

<table>
<thead>
<tr>
<th>Receiving Port</th>
<th>Tons Domestic</th>
<th>Tons Foreign</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gary, IN</td>
<td>8,660,500</td>
<td>145,157</td>
<td>8,805,657</td>
</tr>
<tr>
<td>Indiana Harbor, IN</td>
<td>8,684,078</td>
<td>58,069</td>
<td>8,742,147</td>
</tr>
<tr>
<td>Burns Waterway Harbor, IN</td>
<td>5,592,992</td>
<td>312,401</td>
<td>5,905,393</td>
</tr>
<tr>
<td>Toledo, OH</td>
<td>2,776,299</td>
<td>1,768,004</td>
<td>4,544,303</td>
</tr>
<tr>
<td>Rouge River, MI</td>
<td>4,206,093</td>
<td>34,000</td>
<td>4,240,093</td>
</tr>
<tr>
<td>Conneaut Harbor, OH</td>
<td>3,749,160</td>
<td>122,452</td>
<td>3,871,612</td>
</tr>
<tr>
<td>Detroit Harbor, MI</td>
<td>3,225,085</td>
<td>8,191</td>
<td>3,233,276</td>
</tr>
<tr>
<td>Cleveland Harbor, OH</td>
<td>3,171,548</td>
<td>0</td>
<td>3,171,548</td>
</tr>
<tr>
<td>Ashtabula, OH</td>
<td>1,707,450</td>
<td>392,565</td>
<td>2,100,015</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>41,773,205</strong></td>
<td><strong>2,840,839</strong></td>
<td><strong>44,614,044</strong></td>
</tr>
</tbody>
</table>

**TABLE 8.—Great Lakes Iron Ore Receiving Ports, United States. (Domestic data courtesy of USACE 2011; foreign data courtesy of USACE Waterborne Commerce Statistics Center 2011.**

### Limestone Shipment Flows

Because the mines require limestone for taconite pellet processing, the iron ore shipping ports depend on limestone shipments. As indicated in Figure 13, limestone shipments flow to iron ore mining operations from ports located in northern Michigan and Marblehead, Ohio. In 2011, the top five limestone shipping ports by volume were Marblehead, Ohio, and Stoneport, Calcite, Port Inland, and Port Dolomite, Michigan. After departing these ports, limestone is shipped through the GLSLS to the previously mentioned iron ore shipping ports and then via rail for use in iron ore mining operations in the Mesabi and Marquette ranges.

---


FIGURE 13.—Flow of Limestone through the GLSLS to Iron Ore Shipping Ports.

<table>
<thead>
<tr>
<th>Shipping Port</th>
<th>Domestic (Tons)</th>
<th>Foreign (Tons)</th>
<th>Shipping Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stoneport, MI</td>
<td>5,214,479</td>
<td>358,977</td>
<td>5,573,456</td>
</tr>
<tr>
<td>Calcite, MI</td>
<td>4,661,467</td>
<td>689,999</td>
<td>5,351,466</td>
</tr>
<tr>
<td>Port Inland, MI</td>
<td>4,088,103</td>
<td>166,953</td>
<td>4,255,056</td>
</tr>
<tr>
<td>Marble Head, OH</td>
<td>2,602,088</td>
<td>335,659</td>
<td>2,937,747</td>
</tr>
<tr>
<td>Port Dolomite, MI</td>
<td>2,356,822</td>
<td>485,977</td>
<td>2,842,799</td>
</tr>
</tbody>
</table>

TABLE 9.—Top Five Limestone Shipping Ports in 2011. (Domestic data courtesy of USACE 2011; foreign data courtesy of USACE Waterborne Commerce Statistics Center 2011. 83)

Limestone is used in both electric arc furnaces (EAF) and BOF processes, and many of the steel mills on the GLSLS receive this commodity via waterborne transport. Limestone shipped to ports located near steel mills comes from the same regions in Michigan as the limestone used at the iron ore mines. One major difference is that the limestone does not need to pass through the Soo Locks in order to reach its destinations. In the case of a Soo Locks closure, integrated steel mills would still be affected because iron ore would not pass through the locks; however, EAF mills would still be able to receive scrap iron and likely continue operations, assuming that enough vessels were available down bound from the Soo Locks to transport limestone.

Table 11 shows the limestone receipts at ports near steel mills and their associated mill types. The percentage of limestone at each port that would be used in the steel industry versus other industries is unknown; however, the assumption is that the identified steel mills receive limestone from their associated limestone receiving port.

<table>
<thead>
<tr>
<th>Receiving Port</th>
<th>Tons</th>
<th>Associated Mill Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleveland, OH</td>
<td>2,546,536</td>
<td>2 BOF, 1 EAF</td>
</tr>
<tr>
<td>Burns Waterway Harbor, IN</td>
<td>953,824</td>
<td>1 BOF, 1 EAF</td>
</tr>
<tr>
<td>Indiana Harbor, IN</td>
<td>919,416</td>
<td>1 BOF</td>
</tr>
<tr>
<td>Rouge River, MI</td>
<td>850,201</td>
<td>1 BOF</td>
</tr>
<tr>
<td>Lorain, OH</td>
<td>367,731</td>
<td>1 BOF</td>
</tr>
<tr>
<td>Gary, IN</td>
<td>268,377</td>
<td>1 BOF</td>
</tr>
<tr>
<td>Ecorse, MI</td>
<td>104,219</td>
<td>1 BOF</td>
</tr>
<tr>
<td>Detroit Harbor, MI</td>
<td>69,637</td>
<td>1 BOF</td>
</tr>
<tr>
<td>Monroe, MI</td>
<td>809,964</td>
<td>1 EAF</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>Unknown</td>
<td>1 EAF</td>
</tr>
</tbody>
</table>

**TABLE 11.**—Limestone Receipts in Ports near Steel Mills in the GLSLS. (Courtesy of USACE 2011 and American Iron and Steel Institute. 85)

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Economic Importance

The movement of iron ore from its origin to destination contributes to the revenue of multiple industries and geographic locations. Each stage of handling this commodity provides revenue and jobs from the mining process to the sale of a finished product at market. According to a 2012 study conducted at the University of Minnesota Duluth, the iron ore mining industry in Minnesota supports a total of 11,226 jobs and has a total economic effect of $1.9 billion in wages, rent, and profits in the State of Minnesota in 2010 (see TABLE 12).86

<table>
<thead>
<tr>
<th></th>
<th>Direct Effect</th>
<th>Indirect Effect</th>
<th>Induced Effect</th>
<th>Total Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value Added</td>
<td>$1,136,832,423</td>
<td>$349,036,421</td>
<td>$435,339,232</td>
<td>$1,921,208,076</td>
</tr>
<tr>
<td>Output</td>
<td>$1,711,897,209</td>
<td>$602,940,089</td>
<td>$708,088,618</td>
<td>$3,022,925,917</td>
</tr>
<tr>
<td>Employment</td>
<td>3,975</td>
<td>2,273</td>
<td>4,978</td>
<td>11,226</td>
</tr>
</tbody>
</table>

TABLE 12.—Economic Impact of Iron Ore Mining on the Minnesota Economy. (Courtesy of Labovitz School of Business and Economics, University of Minnesota Duluth, 2012.87)

After the iron ore is processed, it must be transported to and handled at the port. At the Port of Duluth/Superior, the top shipping port in Minnesota, roughly 4,362 jobs are supported by iron ore moved through the port at $206.8 million in personal income and a total of $564.6 million in business revenues in 2010.88 Those numbers include jobs and revenue from mining, port handling, shipping, and steelmaking activity, which are conducted over a vast geographic area. The effect is similar in the receiving ports. For example, the Port of Toledo, which handled about 3.5 million tons of iron ore in 2010, supported 2,234 jobs with $180.3 million in personal income and $123.2 million in business revenues.89

Steel Manufacturing Inputs

Introduction

While finished steel is not a major commodity shipped on the GLSLS, steel inputs and raw materials including iron ore, limestone and coal coke, are major GLSLS commodities shipped to steel mill locations within the GLSLS region. In 2011, approximately 115 million tons of steel products were produced in the United States, but only 1 percent of the total was shipped via the GLSLS.90 Overall, steel made up less than 1 percent of the total volume shipped or received in

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87 Labovitz School of Business and Economics, University of Minnesota Duluth, *The Economic Impact of Ferrous and Non-Ferrous Mining on the State of Minnesota and the Arrowhead Region, including Douglas County, Wisconsin*, 2012, pp. 10–13 using 2010 IMPLAN data.
88 Martin and Associates, *The Economic Impacts of the Port of Duluth-Superior*, 2011, Lancaster, Pennsylvania. According to the USACE Waterborne Commerce Statistics Center, 2010, 37.9% of cargo was handled at the Port of Duluth-Superior; that percentage was used for a rough calculation of the percentage of jobs attributed to iron ore handling.
89 Martin and Associates, *The Economic Impacts of the Port of Toledo*, 2011, Lancaster, Pennsylvania. According to the USACE Waterborne Commerce Statistics Center, 2010, 32.3% of cargo was handled at the Port of Toledo; that percentage was used for a rough calculation of the percentage of jobs attributed to iron ore handling.
the GLSLS by the United States in 2011.\textsuperscript{91} According to 2011 data from the USACE Waterborne Commerce Statistics Center, 1.2 million tons of steel products were shipped on the GLSLS, including pig iron and raw steel and about 460,000 tons of that traffic was shipped domestically.

Table 13 shows the total shipping and receiving for steel in the GLSLS and the Chicago Area Waterway System (CAWS). Although not counted in the GLSLS, the CAWS is an important system that includes the Chicago Sanitary and Shipping Canal, the Calumet River, Little Calumet River, Lake Calumet Calumet-Sag channel, the Chicago River, and the north branch of the Chicago River. The CAWS acts as a gateway between Lake Michigan and the inland waterway system which includes the Illinois, Mississippi, and Ohio Rivers. Between 1994 and 2009, iron and steel products ranged between 11 percent (2009) and 20 percent (2005) of the CAWS traffic.\textsuperscript{92} The CAWS ports shipped and received approximately 1.8 million tons of steel products in 2011 (Table 13). Almost all of the steel shipped through the GLSLS domestically occurs on Lake Michigan and most of that steel traffic travels on the waterways that comprise the CAWS.\textsuperscript{93}

<table>
<thead>
<tr>
<th>Region</th>
<th>Domestic</th>
<th>Foreign</th>
<th>Domestic and Foreign</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Traffic Directions</td>
<td>Receipts</td>
<td>Shipments</td>
</tr>
<tr>
<td>Total GLSLS</td>
<td>464,542</td>
<td>135,969</td>
<td>328,573</td>
</tr>
<tr>
<td>Total CAWS</td>
<td>1,393,528</td>
<td>1,202,929</td>
<td>182,966</td>
</tr>
</tbody>
</table>

**TABLE 13.—GLSLS and CAWS Steel Shipments and Receipts 2011.** (Courtesy of USACE Waterborne Commerce Statistics Center 2011.\textsuperscript{94})

Shipments of pig iron through Lake Michigan to Menominee, Michigan, total about 92,000 tons or approximately 7.6 percent of the total; this is the only steel that passes from the CAWS into the GLSLS.\textsuperscript{95} In addition, three Indiana ports—Indiana Harbor, Burns Harbor, and Gary—ship various steel products through the very southern tip of Lake Michigan to the Calumet River just south of Chicago and on to the Illinois and Mississippi River systems.\textsuperscript{96} Unlike iron ore shipping patterns, steel outputs do not have a distinct signature on the GLSLS. Presumably, the consumers of semi-finished steel choose locations based on various factors not necessarily related to waterborne commerce. Available limited detailed information quantifies the movements of foreign steel via waterborne systems. Approximately 61 percent of all steel shipped on the

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\textsuperscript{91} USACE, 2011, Waterborne Commerce of the United States, Part 3 Waterways and Harbors Great Lakes, calendar year 2011.

\textsuperscript{92} USACE, Great Lakes and Mississippi River Interbasin Study GLMRIS, Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System, 2011, p. 11.

\textsuperscript{93} USACE, Great Lakes and Mississippi River Interbasin Study GLMRIS, Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System, 2011, p. iii.


\textsuperscript{96} USACE, Waterborne Commerce data, 2011.
GLSLS is foreign, all of which is imported. Because the CAWS ships more steel domestically, it only has about 24 percent of foreign traffic.\textsuperscript{97}

**Steel Mills and Ports in the GLSLS**

As shown in Figure 14, several areas have integrated steel mills along the shores of the Great Lakes. The Chicago area has three integrated steel mills; the Detroit area has two integrated steel mills, and in Ohio, there are three integrated steel mills—one in Lorain and two in Cleveland. In Canada, about 80 percent of steel mills are located along the GLSLS.\textsuperscript{98}

![Map of Integrated Steel Mills and Flow of Steel on the GLSLS](image)

**FIGURE 14.**—Map of Integrated Steel Mills and Flow of Steel on the GLSLS

Thirteen ports are involved in shipping or receiving pig iron and steel products on the Great Lakes.\textsuperscript{99} Table 14 describes the locations of integrated steel mills in the GLSLS, including the parent company and associated iron ore receiving port.


In 2011, there were two electric arc furnace (EAF) steel mills along the Great Lakes using scrap steel as the major input to their processing. The Burns Harbor, Indiana mill received about 17,000 tons of scrap steel, and the Indiana Harbor, Indiana mill received about 15,000 tons of scrap steel. In 2011, the NLMK Indiana Company, located in Portage, Indiana (near Burns Harbor), produced 672,756 cast tons of steel. Based on those values, the plant received only a small fraction (~0.5 percent) of its scrap steel from the GLSLS, and therefore is not dependent on the GLSLS for steelmaking raw materials.

**Flow of Coke through the GLSLS**

Some processed coke is received by ports on the GLSLS, although it appears that some is made in processing plants near steel mills. Coke derived from the processing of coal is an input to both major types of steel production processes. Locations of coke production tend to coincide with major steelmaking operations. There are coke processing plants in Indiana Harbor, Gary, and Burns Harbor, Indiana; Toledo and Cleveland, Ohio; and Detroit, Michigan. Because much

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101 USACE, Waterborne Commerce data, 2011.
of the coke processing occurs near the steel plants, it is difficult to quantify how dependent the steel industry is on the GLSLS for delivery of coal. The coal is first processed into coke and then shipped to the steel plants, thus this dependency is indirect. A deeper study of the coal industry and coal shipping on the GLSLS will be needed to quantify the steel industry’s dependency on the GLSLS for coal shipments. Generally, however, there are two main sources of coal that could be used for this purpose. One is the Powder River Basin (PRB) in Wyoming, where most of the coal is transported via rail; some of the PRB coal is transported to ports on Lake Superior for delivery to other end users, including coal-fired power plants throughout the GLSLS. If coal from the PRB is used, the Soo Locks once again would be a limiting factor on those shipments. Alternatively, coal could come from mines in Pennsylvania and Kentucky. In this case, the coal would most likely be shipped by rail to processing plants. Although both EAF and BOF steelmaking processes require coal coke input, the degree to which the steel industry depends on coal coke shipped on the GLSLS could not be determined for this analysis. In order to assess this dependency with more precision, information on the distribution of coal from the PRB in Wyoming and a breakdown of how much reaches the coking facilities and steel mills by rail versus water is needed.

**Steel Summary**

In 2011, only 1 percent of all U.S. steel was shipped on the GLSLS. Steel mills near the GLSLS are more dependent on the GLSLS-navigable waterways for their raw material inputs than they are for their product output. For this steel commodity flow, only steel mills located on the GLSLS system were analyzed. Steel mills not located on the GLSLS may have partial dependencies on the GLSLS, but were not considered in this analysis. Future studies are needed to identify all steel mills receiving materials from GLSLS shippers, and whether or not they could receive their raw materials via other forms of transportation, in the event of a closure on the GLSLS. Integrated steel mills are more dependent on waterborne commerce than EAF mills. Integrated mills located on the GLSLS must receive iron ore from either the Upper Peninsula of Michigan or northeastern Minnesota in order to operate. Other materials, such as coke and limestone, are also sometimes received by these mills from the GLSLS. The possibility and cost differences of receiving these items from other modes of transportation are beyond the scope of this study but are an important topic to address.

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Refined Petroleum Products

Introduction

Nearly all of the petroleum products shipped on the GLSLS are refined petroleum products including fuel oils, gasoline, asphalt, tar, and pitch. Crude oil is not shipped on GLSLS because numerous crude pipelines connect the GLSLS ports. Crude pipelines run from Superior, Wisconsin, through Chicago, and Detroit, to Buffalo, New York, routed south of Lake Michigan. Other pipelines connect Superior to Detroit, through the Straights of Mackinac north of Lake Michigan. The presence of these crude oil pipelines means that refineries in the GLSLS region are not dependent on the waters of the Great Lakes for crude oil which is the major input to the refineries. As a result, none of the petroleum shipped in the GLSLS was crude oil in 2011.107,108

The GLSLS Petroleum Network

In 2011, about 3.5 million tons of refined (non-crude) petroleum products were shipped and received from U.S. ports in the GLSLS.109 Most of the petroleum products shipped within the system are from refineries located near the Indiana Harbor and Rouge River ports.110 Four ports in the GLSLS shipped nearly 98 percent of all petroleum products (Indiana Harbor, Indiana; Rouge River, Michigan; Green Bay, Wisconsin; and Toledo, Ohio, in order from highest to lowest in terms of volume shipped). Domestic shipments totaled about 1.66 million tons from 10 ports within the GLSLS. Asphalt, tar and pitch and fuel oil product categories make up more than 90 percent of the petroleum products shipped within the GLSLS. About two-thirds of the products shipped by volume in the GLSLS were in the asphalt, tar, and pitch category and 24 percent of refined petroleum shipments were fuel oils of various weights.

<table>
<thead>
<tr>
<th>Port</th>
<th>Domestic Receipts</th>
<th>Domestic Shipments</th>
<th>Domestic Total</th>
<th>Foreign Receipts</th>
<th>Foreign Shipments</th>
<th>Foreign Total</th>
<th>Domestic and Foreign Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLSLS Total</td>
<td>1,139,238</td>
<td>1,662,482</td>
<td>2,808,638</td>
<td>389,268</td>
<td>317,069</td>
<td>706,337</td>
<td>3,514,975</td>
</tr>
<tr>
<td>CAWS Total</td>
<td>1,164,308</td>
<td>1,220,235</td>
<td>2,384,543</td>
<td>76,626</td>
<td>722,418</td>
<td>799,044</td>
<td>3,183,587</td>
</tr>
</tbody>
</table>

TABLE 15.—GLSLS and CAWS Petroleum Shipments and Receipts 2011. (Domestic data courtesy of USACE 2011; foreign data courtesy of USACE Waterborne Commerce Statistics Center, 2011.111)

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107 USACE, Waterborne Commerce of the United States, 2011.
109 USACE, Waterborne Commerce of the United States, Calendar year 2011 (domestic data); USACE Waterborne Commerce Statistics Center, 2011 (foreign data).
111 USACE, Waterborne Commerce of the United States, Calendar year 2011 (domestic data); USACE Waterborne Commerce Statistics Center, 2011 (foreign data).
Although the CAWS is not part of the GLSLS, it is important to have an understanding of its shipping patterns and flows for petroleum products from its ports. The CAWS ports near Chicago shipped almost the same amount of petroleum products as did Indiana Harbor, Indiana, in 2011 (See Table 16). The Chicago area has two refineries, one in Lemont, Illinois, and one in Joliet, Illinois.\textsuperscript{112} About 90 percent of the petroleum products shipped on the GLSLS from Chicago area are transported south into the inland river system in the United States, which means that only 10 percent of the petroleum products shipped via water actually enter the GLSLS, with much of it destined for ports along Lake Michigan.\textsuperscript{113}

\textsuperscript{113} USACE, 2011, \textit{Waterborne Commerce of the United States, Calendar year 2011}.
<table>
<thead>
<tr>
<th>Port</th>
<th>Domestic Receipts</th>
<th>Domestic Shipment</th>
<th>Domestic Total</th>
<th>Foreign Receipts</th>
<th>Foreign Shipment</th>
<th>Foreign Total</th>
<th>All Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana Harbor, IN</td>
<td>162,305</td>
<td>1,187,712</td>
<td>1,350,017</td>
<td>0</td>
<td>106,427</td>
<td>106,427</td>
<td>1,456,444</td>
</tr>
<tr>
<td>Rouge River, MI</td>
<td>6,851</td>
<td>326,744</td>
<td>333,595</td>
<td>103,822</td>
<td>78,483</td>
<td>182,305</td>
<td>515,900</td>
</tr>
<tr>
<td>Detroit Harbor, MI</td>
<td>0</td>
<td>6,265</td>
<td>6,265</td>
<td>206,429</td>
<td>0</td>
<td>206,429</td>
<td>212,694</td>
</tr>
<tr>
<td>Toledo, OH</td>
<td>57,363</td>
<td>43,919</td>
<td>101,282</td>
<td>0</td>
<td>65,082</td>
<td>65,082</td>
<td>166,364</td>
</tr>
<tr>
<td>Cleveland, OH</td>
<td>139,924</td>
<td>2,286</td>
<td>142,210</td>
<td>0</td>
<td>15,879</td>
<td>15,879</td>
<td>158,089</td>
</tr>
<tr>
<td>Burns Waterway Harbor, IN</td>
<td>105,833</td>
<td>7,667</td>
<td>113,500</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>113,500</td>
</tr>
<tr>
<td>Milwaukee, WI</td>
<td>109,757</td>
<td>0</td>
<td>109,757</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>109,757</td>
</tr>
<tr>
<td>Cheboygan, MI</td>
<td>72,622</td>
<td>27,747</td>
<td>100,369</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100,369</td>
</tr>
<tr>
<td>Buffalo, NY</td>
<td>99,771</td>
<td>0</td>
<td>99,771</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>99,771</td>
</tr>
<tr>
<td>Niagara River, NY</td>
<td>99,771</td>
<td>0</td>
<td>99,771</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>99,771</td>
</tr>
<tr>
<td>Green Bay, WI</td>
<td>11,353</td>
<td>64,665</td>
<td>76,018</td>
<td>13,534</td>
<td>6,375</td>
<td>19,909</td>
<td>95,927</td>
</tr>
<tr>
<td>Alpena, MI</td>
<td>85,318</td>
<td>0</td>
<td>85,318</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>85,318</td>
</tr>
<tr>
<td>Monroe, MI</td>
<td>79,293</td>
<td>0</td>
<td>79,293</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>79,293</td>
</tr>
<tr>
<td>Saginaw River, MI</td>
<td>61,780</td>
<td>0</td>
<td>61,780</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>61,780</td>
</tr>
<tr>
<td>Gary, IN</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Duluth Superior (MN/WI)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27,632</td>
<td>27,632</td>
<td>27,632</td>
</tr>
<tr>
<td>Oswego, NY</td>
<td>12,374</td>
<td>0</td>
<td>12,374</td>
<td>11,936</td>
<td>0</td>
<td>11,936</td>
<td>24,310</td>
</tr>
<tr>
<td>Gladstone, MI</td>
<td>23,821</td>
<td>0</td>
<td>23,821</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23,821</td>
</tr>
<tr>
<td>Lorain, OH</td>
<td>0</td>
<td>21,666</td>
<td>21,666</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21,666</td>
</tr>
<tr>
<td>Calcite, MI</td>
<td>0</td>
<td>0</td>
<td>9,921</td>
<td>0</td>
<td>9,921</td>
<td>9,921</td>
<td>9,921</td>
</tr>
<tr>
<td>Chicago Harbor, IL</td>
<td>0</td>
<td>0</td>
<td>6,918</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,918</td>
</tr>
<tr>
<td>Manistique, MI</td>
<td>6,831</td>
<td>0</td>
<td>6,831</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,831</td>
</tr>
<tr>
<td>Put-In-Bay, OH</td>
<td>1,720</td>
<td>0</td>
<td>1,720</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,720</td>
</tr>
<tr>
<td>Detroit Harbor, WI</td>
<td>1,507</td>
<td>0</td>
<td>1,507</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,507</td>
</tr>
<tr>
<td>Manistique, MI</td>
<td>0</td>
<td>1,044</td>
<td>1,044</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,044</td>
</tr>
<tr>
<td>St. James, MI</td>
<td>1,044</td>
<td>0</td>
<td>1,044</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,044</td>
</tr>
<tr>
<td>Bayfield, WI</td>
<td>0</td>
<td>514</td>
<td>514</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>514</td>
</tr>
<tr>
<td><strong>Total GLSLS</strong></td>
<td>1,139,238</td>
<td>1,662,482</td>
<td>2,808,638</td>
<td>389,268</td>
<td>317,069</td>
<td>706,337</td>
<td>3,514,975</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>1,159,733</td>
<td>1,188,029</td>
<td>2,347,762</td>
<td>43,855</td>
<td>722,418</td>
<td>766,273</td>
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<tr>
<td>Calumet Harbor, IL</td>
<td>4,575</td>
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<td>36,781</td>
<td>32,771</td>
<td>0</td>
<td>32,771</td>
<td>69,552</td>
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TABLE 16.—Petroleum Shipments and Receipts on the GLSLS and CAWS 2011 (Domestic data courtesy of USACE Waterborne Commerce, 2011; foreign data courtesy of USACE Waterborne Commerce Statistics Center, 2011.)

GLSLS Petroleum Flows

There are two petroleum product flows in the GLSLS. The first flow is associated with refined petroleum product flows from oil refineries for use in other industrial applications. The second flow concerns shipments of refined petroleum products to islands and communities that depend on GLSLS shipping to receive these products.

Refined Petroleum Product Flow

The two largest ports for petroleum products on the GLSLS are Indian Harbor, Indiana, and Rouge River, Michigan, which together ship more than 90 percent of the petroleum in the GLSLS. These ports are closely associated with refineries operated by British Petroleum (BP) in Whiting, Indiana and the Marathon Petroleum Company in Detroit, Michigan. Even though these refineries are located along the GLSLS, they do not ship significant percentages of their product on the GLSLS.

The Indiana Harbor port ships approximately 71 percent of all domestic GLSLS petroleum shipments. In 2012, the Whiting refinery produced 360,000 barrels per day of refined petroleum products, or about 19.8 million tons per year. Refined petroleum products shipped from this location include pitch and tar (68 percent), and various fuel oil types (27 percent). While these two products make up 95 percent of the petroleum products shipped from this port, only 6.5 percent of this refinery’s output are shipped on the GLSLS. Almost all of the petroleum from Indiana Harbor shipped on the GLSLS is shipped through the southern tip of Lake Michigan into the CAWS to locations on the Illinois and Mississippi Rivers.

The Port of Rouge River, Michigan, ships nearly 15 percent of total petroleum on the GLSLS. This refinery produces approximately 106,000 barrels per day or about 5.8 million tons annually. The two main products shipped via the GLSLS from the refinery are similar to those from Indiana Harbor: pitch and tar (88 percent) and various fuel oils (12 percent). Approximately 7 percent of the refined petroleum products from the Marathon refinery were shipped on the GLSLS. Rouge River ships petroleum products to Cleveland and Toledo, Ohio, and Buffalo, New York.

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116 Barrels to metric tons conversion obtained from www.bp.com/conversionfactors.jsp; metric tons to tons conversion obtained at www.eia.gov/tools/faqs/faq.cfm?id=7&t=2; calculation used: 360,000 barrels per day × 0.1364 metric tons/barrel × 365 days/year × 1.10231 metric tons/short tons.
GLSLS Island Community Petroleum Product Flow

The second petroleum product flow in the GLSLS involves shipping to island communities that receive supplies via water. Although these shipments make up less than 1 percent of total domestic petroleum receipts in the GLSLS, they are significant because of the total dependency of these communities on GLSLS shipping for these products. These island ports include Put-in-Bay on South Bass Island, Ohio; Detroit Harbor, on Washington Island, Wisconsin, and St. James, on Beaver Island, Michigan. Petroleum products shipped to these locations include gasoline and various fuel oils. In the case of Washington and Beaver Islands, the only power plants on each island are petroleum-fired power plants. A major delay in petroleum shipments to these locations may cause local power outages and fuel shortages.

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121 USACE, Waterborne Commerce of the United States, Calendar Year 2011.
Conclusion

The GLSLS is a vast system that has evolved over time to provide low-cost transportation of raw materials to critical industries. The system itself has been built to accommodate bulk cargo within the region. Current conditions of the GLSLS present significant challenges to the shipping industry. Chokepoints, lock conditions, dredging, water levels, and the state of the economy are all factors that affect the ability to ship on the GLSLS in any given year. In past decades, low water levels coupled with dredging backlogs have detrimentally affected ship capacities in the system. To some degree, this circumstance has been offset by reductions in the demand for bulk commodities due to market forces over the past 5–10 years. The extent to which water levels in the GLSLS have affected the shipping industry and whether those levels will restrict industries operating in the system if economic improvements allow for increased shipment/delivery of commodities remains unclear. Some estimates assess that the GLSLS is currently operating significantly below its maximum capacity, and indicate that reliance on the GLSLS for shipping will increase in future years. If dredging backlogs and low water levels remain the norm for the unforeseeable future, growth projections may intersect with physical constraints in the system. Further study is needed, however, to determine whether current conditions will allow industries to tap into this unused capacity unhindered.

Recommendations for Further Study

Potential areas of focus that would enhance the understanding of the GLSLS include the following:

- All-hazards analysis of the chokepoints and lock systems within the GLSLS.
- Coal dependencies for power generation plants that receive coal from the GLSLS.
- Effects of long-term future low-water levels on the GLSLS.
- More extensive and in-depth economic studies of commodities shipped on the GLSLS to determine the economic effect on states, ports, and communities.
- The effects of dredging shortages on port operations and shipping in the GLSLS.
- The economic effects on the steel industry, from a disruption of inputs that currently travel on the GLSLS, including iron ore, limestone, coal, and metallurgic coke.