Status of the U.S.-Flag Great Lakes Water Transportation Industry

U.S. Department of Transportation
Maritime Administration

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Washington, DC

FEBRUARY 2013

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APPS	Act to Prevent Pollution from Ships
BCA	benefit–cost analysis
BTU	British thermal unit
BWC	Ballast Water Collaborative
BWMS	ballast water management system
CAA	Clean Air Act
CCF	Capital Construction Fund
CCR	Coal Combustion Residue
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
CSAPR	Cross-State Air Pollution Rule
CWA	Clean Water Act
CY	calendar year
DERA	Diesel Emissions Reduction Act
EAF	electric arc furnace
ECA	Emission Control Area
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
FEU	40-foot equivalent unit
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FY	fiscal year
GAO	Government Accountability Office
GDP	gross domestic product
GHG	greenhouse gas
GLMRI	Great Lakes Maritime Research Institute
GLRC	Great Lakes Regional Collaboration of National Significance
GLMTS	Great Lakes Marine Transportation System
HC	hydrocarbon
HFO	heavy fuel oil
HMT	Harbor Maintenance Tax
HMTF	Harbor Maintenance Trust Fund
IMO	International Maritime Organization
Laker	large, self-unloading U.S.-flag Great Lakes dry-bulk vessel
LCA	Lake Carriers' Association

LNG	liquefied natural gas
LWD	Low Water Datum
MAP-21	Moving Ahead for Progress in the 21st Century Act
MARAD	United States Maritime Administration
MARPOL	International Convention for the Prevention of Pollution from Ships
MATS	Mercury and Toxic Air Standards
MCF	thousand cubic feet
MDO	marine diesel oil
MMBTU	thousand thousand British thermal units
NAAQS	National Ambient Air Standards
NEPA	National Environmental Policy Act
NMC	National Maritime Center
NOAA	National Ocean and Aeronautics Administration
NO_X	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRLM	nonroad, locomotive, or marine fuel
PCS	Port Community System
PM	particulate matter
ppm	parts per million
Pub. L.	Public Law
RoRo	roll-on/roll-off vessel
SAB	EPA's Science Advisory Board
Short ton	A unit of mass equal to 2,000 pounds (907.2 kilograms)
SO_2	sulfur dioxide
SO_X	sulfur oxides
TEU	20-foot equivalent unit
TIFIA	Transportation Infrastructure Finance and Innovation Act
TIGER	Grants for Transportation Investment Generating Economic Recovery
Title XI	Federal Ship Financing Program
Ton-mile	Physical measure of freight transportation output, defined as 1 ton of freight shipped 1 mile
U.S.	United States
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USCG	United States Coast Guard
USDOT	U.S. Department of Transportation
VGP	Vessel General Permit

Status of the U.S.-Flag Great Lakes

Water Transportation Industry

CHAPTER 1

EXECUTIVE OVERVIEW

The U.S. Department of Transportation's (USDOT) Maritime Administration (MARAD) has conducted a study on the status of the U.S.-flag Great Lakes water transportation industry. MARAD's interest in undertaking this study emerged in 2009 when the industry experienced the confluence of several challenging conditions, including extreme drops in Great Lakes waterborne cargoes caused by the recent recession, uncertainty about Federal regulations on vessel air emissions and ballast water treatment, the existence of multiple and differing State standards for ballast water, and low water conditions on the Great Lakes that emphasized the need for port and channel dredging. Since 2009, there has been a moderate recovery in Great Lakes cargoes as well as resolution of much of the uncertainty regarding regulatory activities. Even with these improvements, however, this study identifies a broad range of issues that are relevant to the current and future success of water transportation on the Great Lakes.

The study finds that the industry is generally healthy and provides efficient, safe, and environmentally sound transportation services. It is competitive with other modes of freight transportation in the movement of dry-bulk commodities and appears to be adequately capitalized to meet current market demands. Supported by responsible regulation and infrastructure maintenance, it will remain an essential part of the regional and national economies by providing reliable and inexpensive transportation of the raw inputs needed by the region's steel mills, construction and manufacturing establishments, and power generation plants. The industry is, of course, dependent on the economic health of the industries it serves.

The study identifies and evaluates cost-beneficial options to revitalize some U.S.-flag vessels on the Great Lakes, particularly by repowering older vessels that still use steam engines with modern liquid-fuel diesel or dual-fuel liquefied natural gas (LNG) diesel engines. The options are evaluated in light of changing Great Lakes operational conditions and new environmental standards. The study identifies specific areas where Federal assistance would be important to facilitate improvements in the Great Lakes fleet and in the supporting water transportation infrastructure.

The U.S.-Flag Great Lakes Fleet: This study is principally concerned with the 55 large, dry-bulk vessels that make up the U.S.-flagged "Laker" fleet as of 2012 (unless specifically indicated it does not address Canadian-flag Lakers).[1] These large, self-unloading carriers transport mostly U.S. domestic cargoes of iron ore, coal, limestone, cement, salt, sand, and gravel—materials that account for the great majority of U.S. cargo movements on the Great Lakes. This fleet operates under Section 27 of the Merchant Marine Act of 1920, known as the Jones Act, which requires that all waterborne shipping between points within the United States be carried by vessels built in the United States, owned by U.S. citizens, and crewed with U.S. citizen mariners. This fleet is "captive" to the Great Lakes, as the vessels are not certified for ocean passage, and many are too large to fit through the locks of the Welland Canal and St. Lawrence Seaway to get to the Atlantic Ocean.

Trends in the Laker fleet, both in terms of number of vessels and their per-trip capacity, are presented in Table 1. The number of vessels in the fleet has declined over the past 30 years, but much of that decline can be attributed to a generational shift in the fleet that occurred during the 1980s. The decline in numbers of vessels and total fleet per-trip capacity between 1980 and 1990 was heavily impacted by the closure of older generation steel mill capacity during and after the severe recession of 1981–82 and the entry into the fleet of thirteen 1,000-foot-long, self-unloading vessels during the 12 years that followed the completion

TABLE 1. **Total Per-Trip Capacity of the U.S.-Flag Laker Vessels, 1980–2012 (in short tons)**

YEAR	SELF-UNLOADING DRY-BULK VESSELS		STRAIGHT-DECK DRY-BULK VESSELS		SELF-UNLOADING CEMENT VESSELS		TOTAL LAKER VESSELS	
	NO.	TOTAL PER-TRIP CAPACITY	NO.	TOTAL PER-TRIP CAPACITY	NO.	TOTAL PER-TRIP CAPACITY	NO.	TOTAL PER-TRIP CAPACITY
1980	58	1,659,157	77	1,353,790	5	38,360	140	3,051,307
1990	54	1,885,925	10	204,700	7	55,360	71	2,145,985
2000	51	1,909,332	5	117,744	6	71,723	62	2,098,799
2010	47	1,844,844	2	64,400	5	74,473	54	1,983,717
2012	48	1,896,128	2	64,400	5	74,473	55	2,035,001

Source: Data from *Greenwood's Guide to Great Lakes Shipping* (1980, 1990, 2000, and 2010 editions) (Boyne City, MI: Harbor Hours Publishers Inc.). www.greenwoodsguide.com.

of the Poe Lock in 1969. Vessels that left the fleet during the 1980s were older, smaller vessels. Between 1990 and 2012, however, the total per-trip capacity of the fleet fell by less than 6 percent overall. Importantly, the industry today appears stable, with significant activity in recent years to repower and upgrade older vessels, acquisition of vessels in 2011 and 2012 (for a net increase of one vessel), and no reports of pending vessel retirements.

Whereas U.S.-flag vessels rely primarily on large-volume hauls of U.S. domestic cargoes on the upper four Great Lakes, Canadian-flag Lakers engage in Canada–Canada and U.S.–Canada trading on all five Great Lakes and through the St. Lawrence Seaway. Canadian-flag vessels carry approximately 36 percent of the dry-bulk cargoes on the Great Lakes and account for more than 80 percent of the U.S.–Canada cross-lake trade. Foreign-flag vessels also enter the Great Lakes via the St. Lawrence Seaway. Foreign-flag vessels usually represent no more than 8 percent of the cargo-carrying capacity on the Great Lakes.

Port Capacity: There are 85 ports with facilities to handle freight or passengers among the eight U.S. States that border the Great Lakes, wherein are located a total of 772 active shoreside facilities.[2] Seventy of these ports are served by Lakers. Approximately 37 of these ports each handled more than 1 million tons of cargo in 2008, collectively accounting for 97 percent of total U.S. domestic cargo moved through Great Lakes ports that year. The top 10 Great Lakes ports by tonnage of cargo are Twin Ports (Duluth, MN–Superior, WI); Chicago, IL; Indiana Harbor, IN; Two Harbors, MN; Detroit, MI; Toledo, OH; Cleveland, OH; Gary, IN; Presque Isle, MI; and St. Clair, MI. Much of the cargo at Chicago, however, moves to or from the U.S. inland waterway system and does not enter the Great Lakes system. With the exception of Chicago, these 10 largest ports primarily handle Laker-borne coal or iron ore. Overall, more than three-quarters of cargo handled by these ports is domestic cargo that must be carried by U.S.-flag vessels, with only Toledo having a majority of nondomestic cargo.

Because almost all of the vessels in the Laker fleet have self-unloading equipment, the majority of ports that principally receive dry-bulk cargoes by water need little shoreside infrastructure to accommodate cargo. Loading of cargo onto vessels generally occurs at a comparatively small number of ports with specialized, privately operated loading facilities. Representatives from the U.S. port sector have expressed the need for harbor and channel dredging, storage facilities for contaminated dredged materials, maintenance of breakwaters and locks, national standards for ballast water management, and other items that require Federal and State resources to accomplish, but have not generally identified unmet landside infrastructure needs as a problem. Federal and State participation in port landside investments may prove valuable, however, in capturing the public benefits associated with the establishment of marine highway freight container and trailer services and LNG fueling stations at ports.

U.S. Great Lakes Waterborne Cargo: Almost all of U.S. domestic cargo (by weight) carried on the Great Lakes is dry-bulk commodities. Table 2 shows total

TABLE 2. **U.S.-Flag Carriage on the Great Lakes, 1995-2011 (in short tons)**

YEAR	IRON ORE		COAL	LIMESTONE	CEMENT	SALT, SAND, & GRAIN	TOTAL
	DIRECT SHIPMENT	TRANS-SHIPMENT					
1995	54,223,610	5,622,590	21,143,967	24,913,305	3,689,192	1,983,515	111,576,179
2000	54,586,514	5,746,164	20,760,474	27,288,089	4,144,774	1,616,944	114,142,959
2005	43,884,572	2,687,547	27,207,350	27,935,513	3,892,822	2,052,645	107,660,449
2008	45,329,607	1,893,887	24,971,623	23,632,070	3,294,071	1,831,557	100,952,815
2009	23,271,702	759,385	20,674,888	17,067,232	2,865,323	1,828,213	66,466,743
2010	39,663,547	2,364,871	21,539,866	20,410,266	2,782,259	1,923,704	88,684,513
2011	44,443,975	2,780,768	20,239,327	21,434,839	2,817,846	2,067,506	93,784,261

Source: Data from *2011 Statistical Annual Report of Lake Carriers' Association,* "U.S.-Flag Cargo Carriage Calendar Years 1993 2011" (Rocky River, OH: Lake Carriers' Association). http://www.lcaships.com/2011-statistical-annual-report.

Note: Totals include U.S. domestic trade and cross-lake trade with Canada carried on U.S.-flag vessels.

movements of dry-bulk commodities by Lakers from 1995 to 2011. It demonstrates a trend of relatively stable cargo levels from 1995 to 2005, with iron ore levels falling but coal levels increasing. The sharp decline in freight movement as of 2009 was the result of the severe recession that began in late 2007, with levels having moderately recovered by 2011—almost fully for iron ore but less so for coal and limestone.

Health of Regional Industries: Regional industries supported by the Lakers continue to rebound from the recent recession, with impressive recoveries in steel and automobile manufacturing. The recovery of regional industry bodes well for the continued carriage of most dry-bulk items on the Great Lakes. In the case of power generation, however, low natural gas prices and, to some extent, regulations pertaining to the environmental impacts of coal-powered electricity generation plants complicate the outlook for the demand for coal.

The following paragraphs provide summary outlooks of future demand for the three major dry-bulk commodities carried on the Great Lakes. Much more detail on these outlooks is provided in the body of this report.

Iron Ore for Steel Production—The U.S. integrated steel industry[3] is concentrated around the Great Lakes. This concentration of mills is not a coincidence, as the region is an optimal environment for new (versus recycled) steel production. Abundant supplies of iron ore, limestone, and metallurgic coal and coke are connected by the highly efficient marine transportation system. Importantly, the restructuring of the steel industry in the three decades after the recession of 1981–82 has created some of the most efficient steel production facilities in the world. Because of the efficiencies of the Great Lakes steel production system and expected growth in national and world demand for steel, the outlook for this important product is positive, translating into long-term growth in waterborne ore cargoes. This industry is, however, subject to periodic disruptions from economic downturns that can abruptly curtail Great Lakes iron ore traffic until steel markets recover.

Coal for Power Generation—The outlook for coal movement on the Great Lakes is very uncertain. The price of natural gas, a fuel that competes with coal, recently fell to historic lows while at the same time coal-burning facilities are being required to comply with new environmental regulations. Further clouding the future for coal movement on the Great Lakes is the decision by the Canadian utility, Ontario Power Generation, to phase out coal for power generation, becoming fully effective on January 1, 2015. This action has already reduced U.S.-flag carriage of Canadian-bound coal by 4 million tons per year to just 625,000 tons. Analysis summarized in this study anticipates that between 2010 and 2015 there will be a drop in domestic coal consumption along the Great Lakes as older and smaller coal-burning power generation facilities are retired and replaced with noncoal alternatives. A strengthening economy should translate into some rebound for coal movements after 2015. The degree and duration of this rebound are difficult to predict; this study assumes that the movement of domestic lake-carried coal will recover to 2010 levels again by 2020 and remain relatively flat thereafter. It is likely that any rebound will be primarily in the form of low-sulfur coal loaded in Superior, WI, or Chicago, IL.

Limestone—Limestone's main uses are as an aggregate material for building and construction, a raw material for cement production, and a fluxing agent for use in steelmaking. Given the close linkage of demand for limestone and aggregate to economic growth (e.g., for construction, road building, etc.) and the competitive advantages of moving limestone by water (particularly from lakeside quarries in northern Michigan and Ohio), this study projects that Laker movements of limestone and aggregate will grow during the foreseeable future in line with expected growth in the regional economy.

Potential Impediments to the Future U.S.-Flag Industry: Studies have demonstrated that, on average, transportation cost savings from $10 to more than $20 per ton of bulk cargo are associated with the use of Lakers compared to the next most competitive transportation mode (rail or truck).[4] Most of these savings would be relative to Laker rates ranging from less than $10 per ton to $25 per ton delivered cost. Another, more recent study by the U.S. Environmental Protection Agency (EPA) indicates, however, that on selected, more competitive domestic routes there are significantly lower transportation rate differentials between Lakers and unit trains, ranging downward to less than $2 per ton of difference.[5]

The cost advantages that Lakers provide to shippers should help to maintain a major role for Lakers in regional bulk freight markets. The robustness of this advantage on many routes, particularly for deliveries to lakeside locations, suggests that normal fluctuations and developments in the transportation market are unlikely to upset current market shares. Further, the regional steel, power generation, and limestone and aggregates markets have developed in

conjunction with the Laker fleet; those markets depend on the cost savings offered by Lakers and will continue to demand their services.

As is the case with all industries, however, there are events that could jeopardize the health of U.S.-flag Great Lakes water transportation services. These include market shocks, such as the drop in bulk shipment volumes caused by the recent recession, as well as potential cost-increasing regulatory requirements such as those that affect vessel engine emissions, ballast water discharge systems, and the market for coal on the Great Lakes. Systemwide and localized navigational factors that increase operating costs, such as silting in of harbors and low water levels on the Great Lakes can also reduce the economic strengths of this industry.

Regulations on Air Emissions and Ballast Water Management: One of the greatest concerns to the Laker industry in recent years has been the regulation of air emissions and ballast water from Laker vessels. Water transportation is generally presented as a "green" alternative to land-based transportation modes (because of greater fuel efficiency per ton-mile of freight moved, particularly when compared to trucks). However, some Lakers, particularly those that have steam power plants or very large diesel engines, currently use fuels with high sulfur content, and some older engines have high emissions. Lakers also must take on and discharge large quantities of ballast water when unloading and loading cargoes at ports, potentially contributing to the spread of nonindigenous aquatic species originally brought into the Great Lakes by saltwater vessels and nonmaritime vectors (including recreational boating, bait fishing, aquaculture, aquaria, canals, and rivers). In an effort to reduce the air and water impacts of the Lakers, the EPA, U.S. Coast Guard (USCG), and State agencies have adopted or proposed various regulations to reduce air and water emissions. While these will reduce vessel impacts, they will increase the capital and operating costs of the Lakers.

Air Emission Regulations—EPA regulates air emissions from vessels and other mobile sources under authority granted by Congress through the Clean Air Act (CAA). In addition, the Act to Prevent Pollution from Ships (APPS) authorizes and requires EPA to implement the provisions of the International Convention for the Prevention of Pollution from Ships (known as MARPOL) and the annexes to MARPOL to which the United States is a party.

Air emissions regulations affect vessels in the U.S.-flag Great Lakes fleet differently, depending on the size and type of engine and the fuel used. Engines with per-cylinder displacements of less than 30 liters (called Category 1 and Category 2 engines) typically use distillate diesel fuel. EPA's 15 part-per-million (ppm) sulfur limit began to apply to land-based, nonroad, locomotive, and marine distillate fuel produced or sold in the United States in 2010; it will be fully phased in for these sources by 2014 (compared to the 500-ppm sulfur fuel limit applicable since June 2007). Of the current 55 Lakers, approximately 30 vessels (55 percent) operate using Category 2 engines. MARAD found no evidence that the transition to the use of low-sulfur distillate fuel will lead to any vessel retirements or route closures.

Engines with per-cylinder displacement at or above 30 liters (called Category 3 engines) typically use residual fuel, such as heavy fuel oil (HFO), which has much higher sulfur content than distillate fuel. Beginning on August 1, 2012, and consistent with MARPOL Annex VI, the sulfur content of residual fuel used onboard vessels operating in the North American Emission Control Area (ECA), which includes the Great Lakes, may not exceed 10,000 ppm (compared to the 35,000-ppm global sulfur cap that would otherwise apply). This limit is reduced to 1,000 ppm beginning January 1, 2015, and is expected to require the use of distillate fuel. Laker vessels with residual fuel Category 3 engines will incur costs to enable them to handle the lower sulfur ECA fuels and will pay a higher price for that fuel compared to the HFO fuel they currently use. It is expected, however, that Lakers with such engines will be able to comply with this new requirement and remain competitive.

Currently, there are 12 Lakers that are powered with steam engines rather than diesel engines. Because of technical issues, steamships are exempt from the ECA sulfur limits that apply on the Great Lakes.[6] Some Great Lakes carriers remain interested, however, in repowering these older vessels with modern engines that can burn low-sulfur fuels and get better fuel efficiency. To facilitate this, on January 18, 2012, EPA finalized a Great Lakes Steamship Repower Incentive Program consisting of an automatic waiver that will allow the owner of a Great Lakes steamship repowered to a modern diesel engine to use higher sulfur, lower priced residual fuel in the replacement diesel engine(s) through December 31, 2025.[7] Although the repowered vessel must thereafter comply with the requirement to burn low-sulfur fuel, the savings in fuel costs and improved fuel efficiency through 2025 will help to defray the cost of repowering, particularly if done sooner rather than later.

Regulations on Ballast Water Management—Ballast water discharged by saltwater vessels entering the Great Lakes via the St. Lawrence Seaway has been a pathway for nonindigenous aquatic species, including (but not limited to) the zebra mussel, round goby, and Eurasian ruffe. Although Lakers do not transit the Seaway or leave the freshwater of the Great Lakes, some authorities are concerned that they could foster the spread of already-introduced species within the Great Lakes. Efforts to regulate or reduce the risk of such an occurrence have come chiefly from three sources: the Federal Government, State governments, and the industry itself. These efforts are discussed at length in this report.

The ballast water systems on the Lakers are designed to expedite cargo loading and unloading times, which contributes to the vessels' economic competitiveness. Fast cargo loading and unloading times of 10 hours or less allow a relatively small number of Lakers and regional ports to service the water transportation needs of the Great Lakes region. If cargo loading and unloading times were to increase significantly in the future (possibly due to changes in ballast water management practices), each vessel would need to remain in port longer and could make fewer trips each year. Fewer trips would cause higher transportation costs per ton of cargo because of the need to recover vessel capital and annual operating costs over a smaller volume of cargo moved each year. The effect of fewer trips and higher costs could disrupt established Great Lakes freight transportation markets, require significant investments in new vessel capital equipment, and significantly reduce the competitiveness of water transportation relative to competing landside transportation modes. Similarly, additional port facilities could be needed to accommodate the same annual cargo flows because of the longer times needed to load and unload vessels, also contributing to higher costs per ton of cargo because of the need to pay for these new investments (by one industry estimate, a new iron ore dock in Minnesota could cost $1 billion to construct).

Recent Federal regulatory actions on ballast water have recognized the lack of suitable ballast water treatment technology for Laker vessels. Accordingly, these regulations continue to mandate best ballast water management practices for Lakers that operate solely within the upper four Great Lakes (Superior, Michigan, Huron, and Erie) rather than compliance with international numeric standards. In 2005, the Great Lakes Regional Collaboration also recommended best management practices for existing confined Lakers. Importantly, in light of the present state of ballast water technology, no Great Lakes State is currently imposing a numeric discharge standard on confined Lakers although some States remain interested in the future application of such a standard.

Federal and State ballast water treatment requirements could change in the near future, as new ballast water management technologies are developed and tested. There is an important role for clear Federal leadership in reducing this uncertainty and thus facilitating new investment.

Dredging and Falling Water Levels: The removal of the silt and sand that accumulates in the harbors and channels of the Great Lakes waterways system is an immediate and growing problem for the Great Lakes maritime industry, particularly during recent years when lower water levels have prevailed on the Great Lakes (including record lows expected for 2013 in Lakes Michigan and Huron). Dredging is a necessary component of Great Lakes navigation—without it most harbors, channels, and rivers would become inaccessible for navigation by the current vessel fleet. Silting of harbors and channels has already led to the widespread light-loading of Lakers, creating inefficiencies because cargo that could otherwise be carried at authorized depths is left on the wharf. The Lake Carriers' Association (LCA), a trade group that represents the U.S.-flag operators, reports that many harbors are in need of 12 to 60 inches of dredging and views the current backlog of dredging needs as a crisis. MARAD estimates that the loss of 24 inches from authorized depths across the system would add $0.65 to $0.95 per ton to the shipping cost of cargo delivered by larger Lakers (this impact becomes more severe with additional loss of draft). In the body of this study, the impacts of dredging policies are discussed in light of other factors that contribute or may contribute to declining water depths such as man-made diversions of Great Lakes water, deepening and erosion of the connecting channels, and climate change.

Condition of Locks and Infrastructure: There are nearly 104 miles of navigation structures that form the 117 federally designated harbors operating within the Great Lakes navigation system.[8] The United States Army Corps of Engineers (USACE) has developed a prioritized list of structures (including breakwaters, piers, and pier heads) to be repaired or replaced pending available funding.[9] Over the long run, these repair and replacement actions will be critical to the continued health of Great Lakes shipping and other important economic activities (e.g., recreational boating and fishing) on the Great Lakes. Two infrastructure issues of critical importance to the Lakers—the condition and capacity of the Soo Locks and the need for adequate icebreaking capacity—are also examined in this report.

Labor and Training: The ability to crew U.S.-flagged Great Lakes vessels with highly-skilled mariners is vital to the future of the Great Lakes water transportation industry. Prior to the recent recession, some Great Lakes carriers had voiced concern about their ability to recruit sufficient numbers of new mariners, and there are reports that at least some carriers are still having recruitment problems. Given a relatively stable outlook for future cargoes and vessel activity, it would appear that there is adequate time for U.S. Great Lakes operators to plan for needed recruitment over the next decade to replace mariners who retire or change jobs. Education and training facilities for replacement mariners are located at the Great Lakes Maritime Academy at Traverse City, MI; other State and Federal academies; unions; and private-sector companies.

Lack of Visibility of Water Transportation in Regional Planning: There is a general perception within the Great Lakes water transportation industry that government planners and shippers do not fully recognize the importance of water transportation in regional freight movement. Many believe that this lack of understanding contributes to a lower priority for waterway funding among State and municipal agencies. The recent passage of the Moving Ahead for Progress in the 21st Century Act (MAP-21), the reauthorization act for the USDOT (signed into law by the President on July 6, 2012), greatly increases the profile of freight movement in the national transportation system. Among many other provisions, MAP-21 requires the USDOT, in consultation with State departments of transportation and other appropriate public and private transportation stakeholders, to develop a National Freight Strategic Plan. USDOT is also directed to encourage States to develop State Freight Plans and create Freight Advisory Committees. These plans and committees offer important new opportunities to incorporate maritime freight components directly into the national, regional, and State freight-planning processes.

Impacts of Identified Factors on Laker Economics: The Lakers enjoy cost advantages when competing with land-based bulk transportation services, particularly over longer distances and to sites such as steel mills and electric generating plants adjacent to the Great Lakes. Given current cost structures and market outlooks, the Lakers and the ports they serve appear to be up to the task of moving these cargoes for decades to come. However, the various needs and potential impediments identified above could jeopardize some Laker operations if not managed and coordinated carefully, particularly in light of cumulative impacts they might impose on the costs of Laker service.

For shorter distance water movement of iron ore and coal, or on longer routes where rail transportation is already within a few dollars per ton of water rates, a cumulative increase in costs associated with fuel costs, low water, and other factors could significantly erode or eliminate the cost advantages of Laker transportation services.

The potential loss of existing Laker markets due to higher operating and capital costs, particularly if coupled with possible long-term decreases in regional demand for coal, could lead to significant reductions of vessels in the Laker fleet. Regional industries such as integrated steel mills that depend on low-cost transportation of ore and other commodities would be adversely impacted due to the need to switch to more expensive land-based transportation or simply pay increased Laker rates for remaining services. A secondary impact to regional industries would be associated with the loss of competitive pressure on railroads and trucking services. Competition from Lakers in the regional freight transportation market compels the other modes of transportation to charge lower rates to obtain cargoes. These "water compelled rates" benefit all shippers, including those who choose not to use water transportation services; any significant reduction in the number or capacity of the Lakers would lead to the reduction or elimination of these water-compelled rates.

Potential Assistance to the Industry: MARAD evaluated the potential benefits of governmental assistance to the Great Lakes water transportation industry as the industry adjusts to new regulations and recovers from the recent recession. Assistance is currently available through various programs, such as EPA's Great Lakes

Steamship Repower Incentive Program, EPA's Clean Diesel Grants, USACE's dredging of channels and maintenance of harbor infrastructure, USCG's ice-breaking operations, MARAD's Title XI Federal Ship Financing Program and Capital Construction Fund, governmental support for research and development, and other Federal and State programs.

Analysis in this study evaluated specific areas where governmental assistance could be beneficial to the Great Lakes water transportation industry, particularly in the repowering of certain Laker vessels. To do so, MARAD quantifies the public and private benefits and costs of potential actions to determine if governmental assistance would be warranted from a public standpoint. The study acknowledges and supports assessments done by USACE on the need for dredging and infrastructure reconstruction. The study also summarizes recent research on the potential to foster new marine highway services on the Great Lakes to transport container and trailer traffic.

The first and primary assistance scenario that MARAD examined looks at the repowering of the 12 steamship Lakers that remain in the Laker fleet. These are older vessels that are associated with disproportionate emissions of sulfur oxides (SO_x) relative to diesel Lakers. Current regulation does not require that the steamships be repowered to burn cleaner fuel, but there are public and private-sector benefits for doing so. Two alternatives were considered for repowering the steamships: 1) repowering with conventional Category 3, Tier 2, liquid-fuel diesel engines in line with the recently announced Great Lakes Steamship Repower Incentive Program; and 2) repowering with dual-fuel LNG/diesel engines. Both of these engine types would conform to EPA regulations for air emissions.

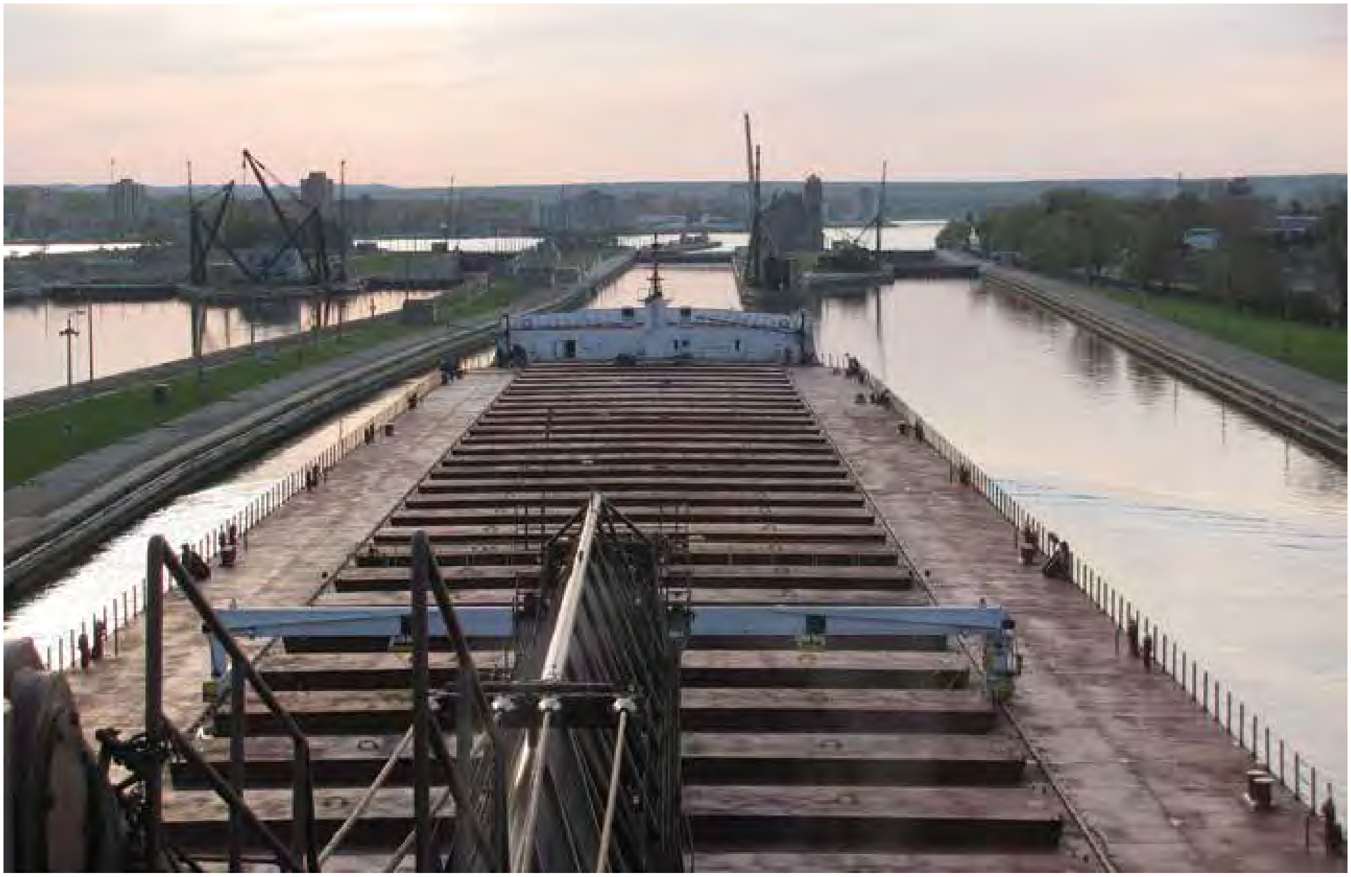
Table 3 contains the findings of the benefit–cost analysis (BCA) for both of these alternatives. There are substantial public benefits (reduced air emissions) from repowering the steamships with either engine type, which when combined with private benefits (improved fuel efficiency and reduced non-fuel operating costs) to vessel owners, would more than cover the costs of repowering these vessels from the standpoint of the Nation. However, the overall value of the private benefits to vessel owners from repowering the vessels are not quite as large as, or are only moderately larger than, the costs to the owners—implying that some vessel owners would not repower without additional incentives. Repowering with LNG engines shows a slightly positive net benefit for private owners, but is subject to more risk than repowering with conventional diesels because of uncertainty about future LNG prices and availability and the lack of LNG experience on the Great Lakes.

These outcomes suggest that even modest Government financial incentives could make a difference in vessel owners' decisions to repower their steamships by reducing risk and the cost of capital. Loan guarantees

TABLE 3. Repowering of U.S.-Flag Great Lakes Steamships ($million 2010, 7 percent real discount rate, 30-year analysis period, all values in net present value)

	STEAMSHIP REPOWERING SCENARIO	
BENEFIT–COST ANALYSIS SUMMARY	Alternative 1: Category 3, Tier 2, Diesel Engines With EPA Repowering Incentive	Alternative 2: Dual-fuel LNG Engines
Total benefits	$247	$336
Public benefits	$65	$87
Private benefits	$182	$248
Total private costs	$199	$223
Net benefits (public and private)	$47	$113
Net benefits (private only)	–$18	$25
Benefit–cost ratio (public and private)	1.24	1.50
Benefit–cost ratio (private only)	0.91	1.11

Note: In the LNG analysis, only 10 steamships are assumed to be repowered, whereas 12 steamships are assumed to be repowered in the diesel repowering scenario.



under the Title XI Federal Ship Financing Program, for instance, could potentially reduce the cost of borrowed capital to vessel owners to a level where repowering to conventional or LNG diesels would be attractive to them. Federal grants to ports could also be instrumental in establishing LNG fueling facilities that would benefit both lake and landside transportation at the port. Thus, at a relatively modest cost to the Government, there is a generational opportunity to encourage the repowering of the steamships to realize cost-beneficial reductions in air pollution in the Great Lakes region and facilitate more efficient vessel operations that would benefit private operators. There is, however, a high demand among U.S. maritime interests for a limited amount of Title XI and grant resources, and the receipt of loan guarantees or grants is by no means assured even for well-qualified projects.

MARAD found that EPA's Great Lakes Steamship Repower Incentive Program has already greatly improved the economic case for repowering the steamships with Category 3 liquid-fuel diesel engines, representing approximately $61 million of the private benefit totals shown in Table 3. Dual-fuel LNG engines cannot burn residual fuel, and therefore LNG repowering could not benefit from the EPA program unless modifications to the program were to be implemented. Such modifications would greatly strengthen the economic case for repowering steamships to dual-fuel LNG/diesel engines.

MARAD considered the possibility of replacing steamships with new builds rather than repowering existing vessels as a second possible scenario for upgrading the steamships, but concluded that the great majority of benefits associated with the new Lakers would be attributable to their new diesel engines. The hulls of existing Laker vessels are well suited to navigating the locks, channels, and harbors of the Great Lakes and are not subject to excessive structural and corrosive forces while operating on the Great Lakes. Thus, the vessel replacement scenario would generate about the same benefit stream as the repowering scenario, but at four times the cost per vessel, which would cause the outcome of a new building program not to be cost-beneficial. This finding, which would be applicable to the possible replacement of existing diesel-powered Lakers as well, is generally consistent with the demonstrated behavior of the U.S.-flag Great Lakes carriers, who have been opting to maintain or repower vessels rather than build new vessels.

Finally, MARAD considered a third scenario, which would involve repowering some or all of the 43 existing diesel Lakers with new diesel engines. MARAD determined, however, that there is a diversity of diesel engine types and the range of options for upgrading or replacing these engines is sufficiently complex that it would be unrealistic to model these variations. Moreover, unlike the steamships, the existing diesel vessels must already burn reduced- or low-sulfur fuel (reducing sulfur accounts for a large share of public benefits under the steamship repower scenario but would not for the diesel vessels). Accordingly, MARAD decided not to model the economic justification for private-sector decisions to upgrade or replace diesels, with the full awareness that owners will continue to make appropriate decisions to meet their business requirements. MARAD did conclude, however, that Federal assistance for repowering diesel Lakers would be appropriate if the benefit to the public from cleaner air (e.g., reduced nitrogen oxide (NO_x) and particulate matter (PM)) would exceed the cost to the Government of the loan guarantee or other form of assistance, and such assistance would cause or expedite the repowering action. In the case of an EPA grant to the recent repowering of a diesel Laker, these conditions were successfully met.

MARAD has previously explored the opportunity to develop new marine transportation services that would carry general cargo in containers and trailers, principally through the development of a roll-on/roll-off (RoRo) marine highway service on the Great Lakes. Water transportation of containers would yield important public benefits relative to landside transportation, including reduced traffic congestion and wear and tear on regional highways, reduced greenhouse gas (GHG) emissions, and improved safety. This study cites recent research in this area and identifies the conditions that have prevented a marine highway service from being developed on the Great Lakes to date. These conditions include the high acquisition cost of new, specialized vessels not currently in the U.S.-flag Great Lakes fleet; the complexity of introducing water transportation of containers and trailers into existing regional supply chain practices; suspension of water service during winter months because of ice cover; payment of the Harbor Maintenance Tax (HMT) on containers arriving at ports; and bifurcation of the regional container markets because of the different cabotage regimes of the United States and Canada. Specialty container and trailer services using U.S.-flag vessels may prove viable in the near term (such as cross-lake ferry services). Lake-wide U.S.-flag marine highway networks using multiple dedicated vessels, however, would almost certainly require significant Federal and State government support to establish, particularly in the acquisition of appropriate vessels.

CHAPTER 2

INTRODUCTION

This study assesses the status of the U.S.-flag Great Lakes fleet, ports, and infrastructure and identifies and analyzes factors that will impact the future of the fleet. It concludes by identifying and evaluating options to revitalize U.S.-flag vessels on the Great Lakes in a manner that would generate net benefits for the Nation.

The U.S.-flag Great Lakes shipping industry plays a vital role in supporting the economies of the States of the Great Lakes region and, because of the importance of this region to the national economy, the economic health of the Nation at large. The industry has, in fact, helped to define the Great Lakes regional economy, having developed in conjunction with the steel mills, manufacturing establishments, and power generation plants that rely on safe, reliable, and inexpensive waterborne transportation of raw materials.

MARAD's motivation to conduct this study first emerged in 2009 when the U.S.-flag Great Lakes water transportation industry was encountering several challenging conditions, including extreme drops in Great Lakes waterborne cargoes caused by the recent economic downturn, uncertainty about Federal regulations on vessel air emissions and ballast water treatment, the existence of multiple and differing State standards for ballast water, and low water conditions on the Great Lakes that emphasized the need for port and channel dredging. Since 2009, there has been a moderate recovery in Great Lakes cargoes as well as resolution of much of the uncertainty regarding regulatory activities. Even so, this study identifies a broad range of issues that remain relevant to the current and future success of water transportation on the Great Lakes.

As of 2012, U.S.-flag Great Lakes water transportation industry appears to be generally healthy, well suited to its transportation role, and able to finance necessary capital improvements within reason. As is the case with all industries, however, there are potential economic and regulatory events that could jeopardize its future health. For example in 2009, the severe recession caused iron ore volumes on the Lakes to drop to levels not seen since the Great Depression. Although volumes of ore have largely recovered since 2009, another sharp economic downturn could prove very damaging. Federal agencies and industry continue to engage in complex discussions on dredging needs and on reducing the threat of nonindigenous aquatic species, which if not managed carefully could undermine the competitiveness of this industry. The diminishment of this industry would, in turn, affect the health of the important regional and national industries dependent on its low-cost services.

Accordingly, this study looks carefully at the impacts of potential governmental actions on the industry, determining where actions may be helpful. It identifies potential benefits to both the public and the industry associated with actions to facilitate improvements to Great Lakes vessels and infrastructure.

The Economic Importance of the Great Lakes Region

The U.S. Great Lakes region, as described in this study, is made up of the eight States that border the Great Lakes (see Figure 1). These States—Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin—play a key role in the

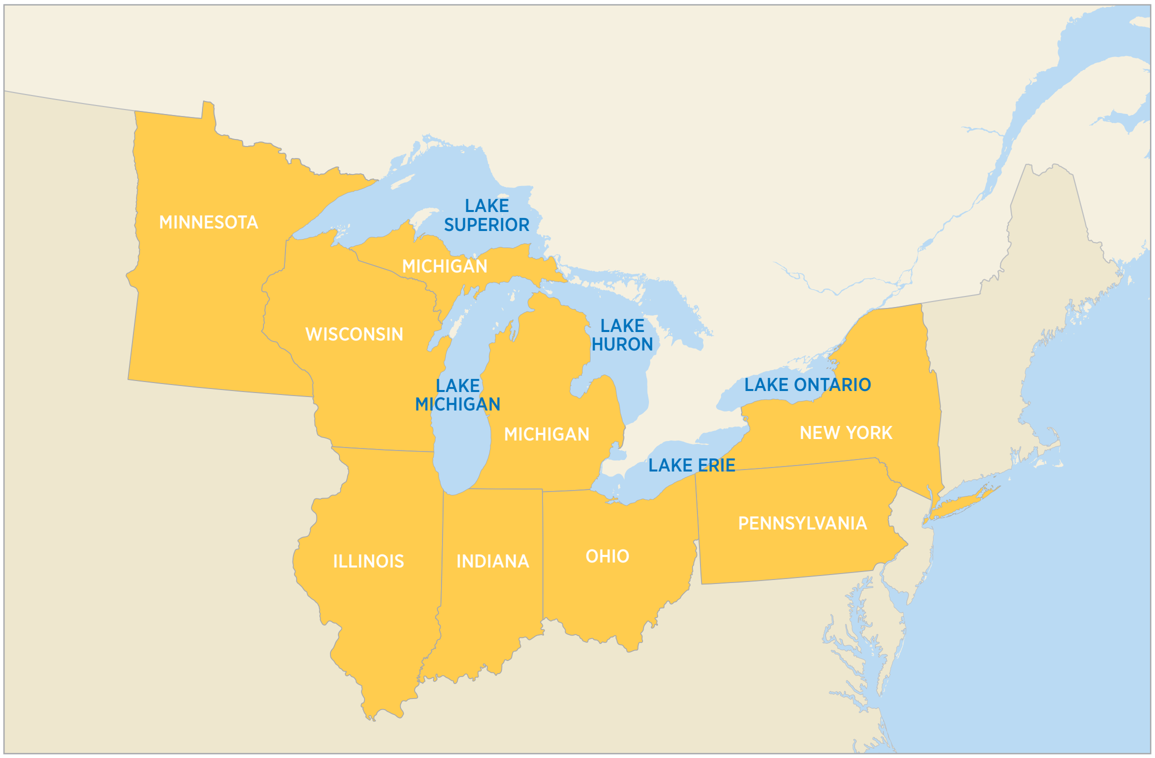


FIGURE 1. Map of eight States bordering the Great Lakes.

U.S. economy and as a group make up one of the largest economic engines on Earth.[i]

Table 4 shows that the region's gross domestic product (GDP) represented 28 percent of the national GDP in 2010. As such, its GDP exceeded the GDPs of all but three countries in the world (the United States ($14.6 trillion), China ($5.9 trillion), and Japan ($5.5 trillion)).[10] The region accounted for almost a quarter of U.S. exports in 2010. Employment as of July 2010 was 36.9 million, 28 percent of the total employment in the United States. Population in the region as of 2010 was almost 84 million, or 27 percent of the total U.S. population in that year.

The States included in Table 4 have diverse and complex economies, with major industries (e.g., financial activities, education, and health care) and population areas (e.g., New York City, Philadelphia) that are not affected or are only indirectly affected by water transportation on the Great Lakes. Even so, the Great Lakes water transportation industry plays a critical role in supporting vital components of the Great Lakes regional economy by providing low-cost transportation of materials and fuel for steel production, construction, power generation, and manufacturing. A recently completed study by Martin Associates, which looked at the economic impact of the Great Lakes–St. Lawrence Seaway System, reports that U.S.-flag maritime commerce supports 103,000

i. Other definitions are used for the Great Lakes Region. The Bureau of Economic Analysis includes only Illinois, Indiana, Michigan, Ohio, and Wisconsin in its Great Lakes regional definition (see U.S. Department of Commerce, Bureau of Economic Analysis, "Gross Domestic Product by State, Great Lakes Region," http://www.bea.gov/newsreleases/regional/gdp_state/gspGL_glance.htm). The Brookings Institution defines the Great Lakes Region to include all or parts of 12 States, including western New York, Pennsylvania, and West Virginia; northern Kentucky; all of Ohio, Indiana, Michigan, Illinois, and Wisconsin; and eastern Minnesota, Iowa, and Missouri (John C. Austin and Britany Affolter-Caíne, *The Vital Center: A Federal-State Compact to Renew the Great Lakes Region,* 2006, p. 8, at http://www.brookings.edu/~/media/research/files/reports/2006/10/metropolitanpolicy%20austin/20061020_renewgreatlakes). The Brookings Institution further notes that, from an economic standpoint, the Great Lakes region also incorporates the major metropolitan communities of Ontario, Canada. The eight-State region used for this report is selected because it covers all of the States with borders on the Great Lakes and conforms to the definition used by various other sources in the literature, including the one used by Martin Associates (*The Economic Impacts of the Great Lakes–St. Lawrence Seaway System,* Oct. 18, 2011, p. 5, http://www.greatlakes-seaway.com/en/pdf/eco_impact_full.pdf).

TABLE 4. **Statistical Indicators for Eight Great Lakes States, 2010**

STATE	GDP[a] ($million)	Exports[b] ($million)	Employment[c]	Population[d]
Illinois	651,518	50,058	5,601,700	12,830,632
Indiana	275,676	28,745	2,814,200	6,483,802
Michigan	384,171	44,768	3,876,000	9,883,640
Minnesota	270,039	18,904	2,661,100	5,303,925
New York	1,159,540	69,696	8,529,700	19,378,102
Ohio	477,699	41,494	5,046,800	11,536,504
Pennsylvania	569,679	34,928	5,607,300	12,702,379
Wisconsin	248,265	19,790	2,730,300	5,686,986
Total Great Lakes States	4,036,587	308,382	36,867,100	83,805,970
Total United States	14,551,782	1,278,263	130,109,900	308,745,538
Percentage Great Lakes States of U.S. Total	28%	24%	28%	27%

a Data from U.S. Department of Commerce, Bureau of Economic Analysis, "GDP and Personal Income." http://www.bea.gov/iTable/index_regional.cfm.

b Data from U.S. Department of Commerce, International Trade Administration, "TradeStats Express." http://tse.export.gov.

c Data from U.S. Department of Labor, Bureau of Labor Statistics, "Regional and State Employment and Unemployment—July 2010," USDL-10-1144, Aug. 20, 2010, Table 5. http://www.bls.gov/news.release/archives/laus_08202010.pdf.

d Data from Paul Mackun and Steven Wilson, "Population Distribution and Change: 2000 to 2010: 2010 Census Briefs" (Washington, DC: U.S. Census Bureau, Mar. 2011). http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf.

U.S. jobs, of which more than 35,000 are direct jobs generated by seaport activity (the balance are indirect and induced jobs supporting seaport activity and workers), $7.7 billion in annual income to U.S. citizens, and $14.8 billion in annual U.S. business revenues.[11] Overall maritime commerce on the Great Lakes–St. Lawrence Seaway System, including U.S., Canadian, and foreign flag activity, supports more than 128,000 U.S. jobs, of which more than 44,600 are direct jobs generated by seaport activity, $14.1 billion in annual income to U.S. citizens, and $33.6 billion in annual U.S. business revenues.[12]

The Martin Associates study further reveals that there are an additional 393,000 U.S. jobs associated with shippers and supporting industries that move cargo through the ports and marine terminals on the Great Lakes–Seaway system.[13] These "related user" jobs include (but are not limited to) employment linked to mining of iron ore shipped via Great Lakes–St. Lawrence Seaway ports, producing steel from that ore, mining of coal carried by Lakers, and use of that coal at electrical utilities.[14] Although some related-user jobs likely depend on low-cost waterborne delivery of raw materials (this may be true for some integrated steel mills), in other instances such jobs are at companies that can also move cargo by rail or through ports outside of the Great Lakes–St. Lawrence Seaway System. Other related user impacts identified in the study include $22 billion in annual U.S. income and $115.5 billion in annual U.S. business revenue.[15]

CHAPTER 3

THE U.S.-FLAG GREAT LAKES FLEET

While commercial trade has taken place on the Great Lakes for centuries, three distinct trade patterns have evolved on the modern Great Lakes Marine Transportation System (GLMTS).[16] The first category is referred to as the "Great Lakes Trade." The shipping in this trade is confined to the Great Lakes themselves and consists of both intralake (within a single lake) and interlake (involving two or more lakes) trade among the five lakes. Trade in this market is dominated by large dry-bulk freighters known as Lakers operated under U.S. or Canadian registries, or "flags."

Lakers under U.S. registry (the U.S. flag)[17] operate exclusively within the Great Lakes. Although U.S.-flag Lakers (hereafter referred to as "Lakers" unless otherwise specified) rely primarily on domestic cargoes, they carry some cross-Lakes U.S–Canadian cargoes as well. Lakers range in length from 487 to 1,013.5 feet and chiefly move iron ore from the Mesabi and Marquette ranges to steel mills along the Great Lakes basin, western coal (mostly from Wyoming and Montana) via Lake Superior terminals to lakeside electric utility plants, and limestone from quarries along Lake Huron and Lake Erie to port cities throughout the region. Other bulk cargoes such as eastern coal (mostly from West Virginia and Kentucky), cement, salt, sand, and grain are moved as well. The largest Lakers principally rely on dedicated one-way hauls of dry-bulk cargoes. Smaller Lakers often carry dry-bulk cargoes on both outbound and inbound legs of a voyage (they carry both "head haul" and "back haul" cargoes).

Many of the Lakers are too large to fit through the locks of the Welland Canal and thus are limited to trading on the upper four Great Lakes (Superior, Huron, Michigan, and Erie). Lakers of 740 feet or less can travel through the Welland Canal to Lake Ontario and onward through the Seaway Locks and the St. Lawrence River. However, there are comparatively few U.S. ports on or below Lake Ontario and the U.S.-flag vessels are neither designed nor certified for ocean passages. Therefore, even Lakers that can travel through the Welland Canal rarely leave the upper four Great Lakes. For these reasons, Lakers are deemed to be captive or confined to the Great Lakes.

Canadian-flag Lakers participate in the Great Lakes trade on all five Great Lakes, but can travel through the Welland Canal and St. Lawrence Seaway locks. Because they operate through the St. Lawrence Seaway, they are discussed immediately below.

The second category of maritime trade on the Great Lakes is called the "Seaway trade" or "Laker/Seaway Trade," which involves international or Canadian domestic shipping entering or exiting the Great Lakes via the St. Lawrence Seaway.[18] This trade is performed by domestic Canadian-flag Lakers and foreign-flag oceangoing vessels (referred to as "salties") that are sized to transit the Seaway (vessels that transit the Seaway can be no more than 740 feet in length and 78 feet in beam and draft no more than 26.5 feet). Whereas U.S.-flag vessels rely primarily on large-volume hauls of U.S. domestic cargoes on the upper four Great Lakes, Canadian-flag vessels engage in Canada–Canada and U.S.–Canada trading on all five Great Lakes and the St. Lawrence Seaway. Canadian-flag vessels also carry 82 percent of U.S.-Canadian cross-lake trade.[19] A major domestic market for Canadian-flag vessels is the movement of grain from Lake Superior ports to Quebec grain elevators, then picking up iron ore along the St. Lawrence River to carry back to steel plants on Lakes Ontario and Erie on the return voyage.[20]

Salties operate between Great Lakes ports and overseas locations under foreign registry (i.e., neither U.S. nor Canadian) and use international crews, although the vessels often are Canadian-owned. A typical voyage would bring specialty and finished steel products into the Great Lakes region from Europe and return overseas with grain cargoes. Salties represent no more than 8 percent of the cargo-carrying capacity on the Great Lakes.[21]

The final category of waterborne trade affecting some Great Lakes ports is the "Inland Trade." This trade involves the transporting of cargo on river barge tows to and from the Great Lakes region (principally Chicago) and the U.S. inland river network (the Mississippi River via the Chicago Ship Canal and Illinois Waterway System).[22] This trade constitutes only a small component of cargo moved on the Great Lakes (although a major share of cargo handled at the Port of Chicago) and is not covered in this report.

The Regional Role and Composition of the U.S.-Flag Great Lakes Fleet

The U.S.-flag Great Lakes fleet operates under Section 27 of the Merchant Marine Act of 1920, known as the Jones Act, which requires that all waterborne shipping between points within the United States be carried by vessels built in the United States, owned by U.S. citizens, and crewed with U.S. citizen mariners.[23]

The primary focus of this study is on the Laker fleet, but there are many other U.S.-flag vessels on the Great Lakes. Based on USACE's U.S. Waterway Vessel Characteristics data, there are close to 600 commercial U.S.-flag vessels that provide transportation services solely or primarily on the GLMTS.[24] This number, which excludes fishing and recreational boats, includes approximately 400 self-propelled vessels with the remainder being barges. Of the self-propelled vessels, there are 55 Lakers (including composite tug-barge vessels), more than 160 tugboats and tow boats, 130 car ferries and passenger vessels, and almost 50 other vessels including a variety of offshore support vessels, small tankers, and small cargo carriers.

Laker Fleet

These dry-bulk vessels range in size from 487 to 1,013.5 feet in length and carry almost all of the domestic freight tonnage moved from port to port on the Great Lakes.[26] As of 2012, there are 48 self-unloading Laker vessels (able to carry multiple types of bulk cargoes except cement), 2 straight-deck Lakers (without self-unloading gear), and 5 cement carriers (specialized self-unloading vessels categorized separately from other self-unloaders) identified in the 2010 edition of *Greenwood's Guide to Great Lakes Shipping*,[27] updated by LCA's 2012 member vessel listing.[28] Of these vessels, 42 are self-propelled and 13 are composite tug-barge units. USACE has developed a vessel-size classification system for vessels[29] that operate on the Great Lakes, shown in Table 5. U.S.-flag Lakers fall into Classes 2 through 10, with vessels in Classes 8 and 10 constituting 55 percent of the fleet by number.

The Laker vessels in Table 5 are operated by 17 companies who are also members of the LCA. The largest of these companies are the American Steam-

TABLE 5. U.S.-Flag Lakers Allocated to USACE Great Lakes Vessel Classification, 2012

	Vessel Class[a] and Length[b] (ft)										
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	
VESSEL TYPE	<400	400–499	500–549	550–599	600–649	650–699	700–729	730–849	850–949	950–1,099	Total
Self-propelled vessel	0	0	1	1	7	5	2	13	1	12	42
Composite tug-barge	0	2	2	0	1	0	4	3	0	1	13
Total	0	2	3	1	8	5	6	16	1	13	55

a Categorization matches USACE designations.

b Vessel lengths from *Greenwood's Guide to Great Lakes Shipping*, 2010 edition. Numerous vessels and barges on the Great Lakes are less than 400 feet in length but are not generally classified as Lakers.

ship Company (18 vessels), Interlake Steamship Company (10 vessels), Great Lakes Fleet/Key Lakes Inc. (9 vessels), and Grand River Navigation Company (7 vessels).[30]

Average Vessel Age. Vessels of the Great Lakes are, on average, significantly older than their saltwater counterparts. This longer life is made possible by the freshwater of the Great Lakes (which does not corrode steel hulls and superstructures as rapidly as saltwater does) and the more benign operating conditions (waves on the Great Lakes do not reach the length, height, or period of ocean waves). If measured by the age of original construction, the average Laker would be 46 years old as of 2012, with an average new-build date of 1966. Within the vessel mix, however, are 12 steamship vessels with an average build date of 1948 (individual vessel new-build dates range from 1906 to 1960, with the modal and median values being 1952).[31] The diesel-powered Laker fleet is younger with an average new-build date of 1971 (individual vessel new-build dates range from 1929 to 2011, with the modal date being 1973 and median date being 1976).

The fleet could be interpreted as being significantly younger than 46 years if vessel age were measured based on the date of the last significant rehabilitation work performed on the vessels. Twenty-six of the Lakers have had significant work done once, and 14 have had such work done twice or more since they were originally built. If the latest major rehabilitation work date is substituted for the new-build date of the rehabilitated vessels, the average age of the fleet (as of July 2012) would be 27 years (1985). Broken out by engine type, the average age of the vessels (adjusted for the date of latest major work) would be 34 years (1978) for the steamships and 25 years for the diesel-powered vessels (1987).

Fleet Capacity. Table 6 shows the capacity of the Laker fleet over the last three decades. As is evident, there was a sharp decline in fleet numbers and capacity between 1980 and 1990. This dropoff was driven principally by two factors—the arrival of very large, highly efficient vessels and the severe recession of 1981–82.

In the 1970s and 1980s, Laker carriers introduced new classes of large and highly efficient self-unloading vessels. These new vessels, which became eligible for Title XI loan guarantees and tax benefits under the Merchant Marine Act of 1970, were built to maximize the economies of vessel size permitted by the completion in 1969 of the Poe Lock, one of the Soo Locks at Sault Ste. Marie, MI. The Poe Lock, at 1,200 feet long, 110 feet wide, and 32 feet in depth, can accommodate vessels that are up to 1,100 feet long and 105 feet wide, carrying up to 72,000 tons of cargo. Prior to 1969, the biggest lock at Sault Ste. Marie was the MacArthur Lock, built in 1943, which at 800 feet long, 80 feet wide, and 29.5 feet deep could accommodate vessels 730 feet long and 75 feet

TABLE 6. Total Per-Trip Capacity of the U.S.-Flag Great Lakes Fleet Vessels, 1980–2012 (in short tons)

	SELF-UNLOADING DRY-BULK VESSELS		STRAIGHT-DECK DRY-BULK VESSELS		SELF-UNLOADING CEMENT VESSELS		TOTAL LAKER VESSELS	
YEAR	NO.	TOTAL PER-TRIP CAPACITY	NO.	TOTAL PER-TRIP CAPACITY	NO.	TOTAL PER-TRIP CAPACITY	NO.	TOTAL PER-TRIP CAPACITY
1980	58	1,659,157	77	1,353,990	5	38,360	140	3,051,507
1990	54	1,885,925	10	204,700	7	55,360	71	2,145,985
2000	51	1,909,332	5	117,744	6	71,723	62	2,098,799
2010	47	1,844,844	2	64,400	5	74,473	54	1,983,717
2012	48	1,896,128	2	64,400	5	74,473	55	2,035,001

Source: Data from Greenwood's *Guide to Great Lakes Shipping,* 1980, 1990, 2000, and 2010 editions, supplemented by LCA member fleet vessel data.

Note. Comparison of per-trip capacity across decades is difficult because of differing uses of long tons and short tons to measure capacity and significant changes in certified same-vessel capacities from decade to decade. However, for the 44 Lakers that have been in the fleet for the entire period of 1980 through 2012, the measured total per-trip capacities for these vessels (based on the data used to generate Table 6) are within 3.6 percent of each other over the entire period (although higher in 2012 than in 1980).

wide, carrying up to 28,000 tons of cargo.[32] Thirteen Class 10 Lakers, 1,000 to 1,013.5 feet long, were introduced in the 12 years following 1969, each capable of carrying up to 2.5 times the cargo per trip of the earlier 730-foot Class 7 vessels, but with the same crew size. In addition to the 1,000-footers, 12 other vessels exceeding Class 7 dimensions were introduced, and 8 traditional bulk vessels were also converted to self-unloading vessels.

The large vessels that were introduced after the opening of the Poe Lock were all equipped with high-capacity, self-unloading devices. With self-unloading technology, cargo is unloaded using a system of conveyors built into the ship underneath the cargo holds. The cargo holds are slanted on their sides (the top of the hold is wider than its bottom, making a "V" shape) so that the cargo will flow downward through gates located at the bottom of the holds. When the gates are opened, the cargo drops onto a tunnel conveyor belt that transports the cargo to one end of the ship. Once at this end, the cargo is transferred onto a loop or inclined conveyor belt system. This system carries the cargo up to the main deck of the ship where it is transferred onto a boom conveyor belt. The boom conveyor can be lifted and swung left or right to position the cargo on the dock or into a receiving hopper as needed by the customer.[33]

Self-unloading vessels, which are an innovation of the Great Lakes maritime industry,[34] are much more efficient in the handling of free-flowing bulk cargoes than comparably sized, straight-deck, bulk vessels that must be unloaded using shoreside equipment such as gantry cranes. Whereas a straight-deck Laker carrying iron ore can take 50 hours to unload,[35] a large self-unloader can discharge its 70,000 tons of ore at rates up to 10,000 tons per hour, or in 7 to 10 hours. Also, because a self-unloader does not rely on shoreside equipment or labor to discharge its cargo, it can unload at any hour of the day or night and onto virtually any flat surface adjacent to a sufficiently deep channel. Depending on route length, an individual self-unloader can make between 50 and 130 cargo transits a year, whereas a straight-deck vessel might only make between 40 and 70 such trips. It is noteworthy that the first purpose-built self-unloading vessels started service on the Great Lakes in 1908, but the use of this technology was not widespread until the 1970s because it was not suitable for transferring the high-grade natural iron ores that dominated Laker trades prior to 1970. Cargoes carried by self-unloading vessels must be free flowing, whereas the natural ores did not flow well and would hang up in the hold. However, with the depletion of these natural high-grade iron ores beginning in the 1950s, lower grade taconite ores were processed into rounded pellets (about the size of marbles) with high iron contents. Taconite pellets flow easily and are well suited to self-unloading systems.

The entry of very large self-unloading vessels in the late 1970s and early 1980s coincided with the sharp recession of 1981–82, which was particularly severe for the large integrated steel producers of the Great Lakes region, who are the major consumers of iron ore. Capacity utilization by the steel industry fell at one point during the recession to 29.8 percent.[36] Older and less efficient steelmaking capacity was eliminated in the 1980s and thereafter; the U.S. steel industry moved to a greater reliance on electric arc furnaces and recycled steel (more about this industry is provided in Chapter 5); and competition from foreign steel mills increased. Iron ore was, of course, not the only commodity affected by the 1981–82 recession.[37] Total domestic cargo carried by the Lakers began to fall precipitously in the year preceding the official start of the recession, dropping from almost 144 million tons in 1979 to 115 million tons in 1980, and then to a low of 72 million tons by 1982.[38] By 1988, it had recovered to 110 million tons—a level approximately equal to levels held in years prior to the recession of 2007–2009 (see detail in Chapter 5).[39]

The combined impacts on the Laker fleet of the new self-unloading vessels and the recession of 1981–82 were severe (see Table 6). Between 1980 and 1990 a significant number of vessels were retired, resulting in a net loss of 67 non-self-unloading, straight-deck vessels representing over 1.15 million tons of per-trip capacity in this vessel category. A net reduction of four self-unloading vessels also took place during this period, although per-trip capacity in this vessel category rose by 227,000 tons as Class 8 and 10 vessels replaced smaller self-unloading vessels. The result of the turnover in the fleet from 1980 to 1990 was that, at the end of the decade, vessels were on average larger, more efficient, and newer, even as the overall number of vessels and per-trip capacity of the fleet fell sharply from 140 vessels and 3.05 million tons in 1980 to 71 vessels and 2.15 million tons in 1990.

Since 1990 the trends in the fleet, while still declining, have been much more stable. This is true even though there have been three recessions during this period (July 1990–March 1991; March 2001–November 2001; and the recent severe recession of December 2007–June 2009).[40] A net reduction of nine vessels occurred between 1990 and 2000, with only a 47,000-ton loss in fleet per-trip capacity (see Table 6). An additional net decline of 7 vessels has occurred since 2000, leaving 55 Lakers in the fleet as of 2012, with per-trip capacity at 2.035 million tons, down 3 percent relative to the capacity in 2000 and less than 6 percent relative to 1990. This decline is largely the result of the loss of smaller, straight-deck (non-self-unloading) vessels, which fell from 10 vessels and 205,000 tons of per-trip capacity in 1990 to 2 vessels at 64,400 tons in 2012.[41] As of 2012, with the cargo markets on the Great Lakes still recovering from the recent recession, there are no reports of plans to retire additional vessels (although one was retired in 2011) and two vessels (composite tug-barges) were recently added to the fleet. Resale values of existing vessels, when reported, appeared sound as of 2012.

Cement-carrying vessels are listed separately in Table 6 because of their specialization to one cargo type.[42] Although the number of cement-carrying vessels has declined from seven vessels in 1990 to five vessels in 2012, the total per-trip capacity of the cement-carrying vessels has increased from about 55,000 tons to 74,000 tons. The average per-trip capacity per vessel has increased from about 7,900 tons in 1990 to 14,900 tons in 2012 (see Table 7). This increase is largely attributable to the addition to the fleet of two 17,600-ton-capacity barges, one in 1996 and the other in 2006. In addition, three smaller cement carriers left the fleet between 2000 and 2012 and are now serving as cement storage vessels. The amount of cement carried on the Lakes has been declining since 1999 and has decreased by more than 1 million tons since 2006, likely attributable to the reduction in construction activity caused by the recent recession (see Chapter 5 for year-by-year detail).

Average Vessel Size. The net effect of the loss of smaller vessels over the last several decades shows up as an increase in the average per-trip capacity of the Lakers. Per-trip average capacity by vessel category is shown in Table 7. The average per-trip capacity of the self-unloading Lakers grew by 38 percent from 1980 to 2012.[43] The average per-trip capacity of the straight-deck bulk vessels grew by 83 percent (because of conversion to self-unloaders, transfer to Canadian flag, or retirement of smaller vessels—there are currently only two left) and by 94 percent for the cement carriers. The changes to the composition of the fleet to meet industries' need for larger self-unloading vessels were largely completed in the 1990s.

Mitigating Effects of Greater Trip Numbers. Total per-trip capacity shown in Table 6 overstates the actual drop in capacity of the U.S.-flag Laker fleet since 1980 because it does not capture the full impact of efficiency improvements to the U.S.-flag Laker fleet since 1980. As noted previously, self-unloaders are both larger on average than straight-deck bulkers and can make more trips per year because of their ability to unload cargoes much more quickly. The almost complete adoption of self-unloading technologies since the 1970s and the eventual retirement of all but two of the non-self-unloading dry-bulk vessels means that today's average U.S.-flag Laker can make more trips in a year than could the average vessel that existed in 1980. Thus, rather than a 36-percent drop in annual fleet tonnage capacity for bulk vessels between 1980 and 2012, the effective drop in capacity was under 28 percent.[44]

Expanding Role of Composite Tug-Barges. Composite tug-barges, a group of vessels that includes integrated tug-barges and articulated tug-barges, is an important subcategory of the self-unloading Lakers shown in Table 6 and Table 7. As indicated in Table 8, 24 percent of the vessels in the Laker fleet are composite tug-barge units,[45] although they provide just 17 percent of overall per-trip capacity because their average per-vessel trip capacity is about 29 percent smaller than that of the overall fleet. Barges are important to the cement carriage segment of the fleet, comprising 60 percent of vessel numbers and total per-trip capacity.

The Great Lakes composite tug-barges are, on average, younger than vessels in the overall Laker fleet if measured by the later of new-build or rehabilitation dates (1998 versus 1985, respectively). Because they operate at lower speeds and use Category 2 engines, they are "greener" than some larger vessels and can operate with crews of 14 or less rather than 19 to 23 for self-propelled vessels.[46] Composite tug-barges will remain an important if not growing part of the U.S.-flag Great Lakes fleet of the future, with the most recent additions to the U.S.-flag Great Lakes fleet being the articulated tug-barge *Ken Boothe Sr./Lakes Contender* (completed in 2011 by Donjon Shipbuild-

TABLE 7. Average Per-Trip Capacity of the U.S.-Flag Great Lakes Fleet Vessels, 1980–2012 (in short tons)

YEAR	SELF-UNLOADING DRY-BULK VESSELS		STRAIGHT-DECK DRY-BULK VESSELS		SELF-UNLOADING CEMENT VESSELS		TOTAL LAKER VESSELS	
	NO.	AVERAGE PER-TRIP CAPACITY	NO.	AVERAGE PER-TRIP CAPACITY	NO.	AVERAGE PER-TRIP CAPACITY	NO.	AVERAGE PER-TRIP CAPACITY
1980	58	28,606	77	17,582	5	7,672	140	21,795
1990	54	34,925	10	20,470	7	7,909	71	30,225
2000	51	37,438	5	23,549	6	11,954	62	33,852
2010	47	39,252	2	32,200	5	14,895	54	36,736
2012	48	39,503	2	32,200	5	14,895	55	37,000

Source: Greenwood's Guide to Great Lakes Shipping, 1980, 1990, 2000, and 2010 editions.

TABLE 8. Capacity of U.S.-Flag Great Lakes Fleet Tug-Barges by Vessel Type, 2012

VESSEL TYPE	ALL VESSELS			SELF-UNLOADING DRY-BULK VESSELS			SELF-UNLOADING CEMENT VESSELS		
	No.	Total Per-Trip Capacity	Average Per-Trip Capacity Per Vessel	No.	Total Per-Trip Capacity	Average Per-Trip Capacity Per Vessel	No.	Total Per-Trip Capacity	Average Per-Trip Capacity Per Vessel
Overall Lakers	55	2,035,001	37,000	48	1,896,128	39,503	5	74,473	14,895
Tug-Barges	13	339,119	26,086	10	294,399	29,440	3	44,720	14,907
(% Tug-Barges)	(24%)	(17%)	(71%)	(21%)	(16%)	(75%)	(60%)	(60%)	(100%)

Source: Vessel data from *Greenwood's Guide to Great Lakes Shipping,* 2010 edition, and from data provided by LCA for vessels entering and leaving the fleet after 2010.

ing and Repair, LLC, of Erie, PA)[47] and the *Defiance/Ashtabula* (purchased from outside the Great Lakes and refurbished at Bay Shipbuilding of Marinette, WI, in 2012).[48] At the same time, self-propelled Lakers will continue to dominate the fleet for the foreseeable future. Several large self-propelled Lakers have been repowered in the last decade rather than being converted to tug-barge units.[49] While this may indicate that the faster self-propelled vessels have economic advantages over composite tug-barges in longer distance markets (particularly when repowered to modern diesel engines), one industry expert suggested that conversions of self-propelled vessels to tug-barges may reduce the efficiency of the self-unloading equipment. New purpose-built tug-barges are reported to be much more efficient than converted ones.

In 2012, the average age for the three cement barges was 16 years and the average age for the non-cement barges was 13 years if measured by the later of new-build or rehabilitation dates. Six of the 13 barges are constructed from the hulls of former self-unloading self-propelled vessels.

As shown in Table 9, the amount of cargo carried by the composite tug-barges of the Laker fleet was somewhat higher than their share of the entire Laker fleet's per-trip capacity from 2008 to 2010 (see Table 6). During the worst year of the recession in 2009, the composite tug-barges' total tons carried dropped by about 29 percent, whereas the drop in cargo for the overall fleet was about 33 percent. By 2010, the composite tug-barges' total tons carried surpassed their 2008 levels, although the total ton-miles carried by the U.S.-flag fleet were lower than the 2008 levels. Also of note is that the composite tug-barges typically carry their cargoes a relatively shorter distance than the other vessels in the fleet as a whole, suggesting that their lower speeds are less of a competitive disadvantage over shorter distances.

Current Performance and Status of U.S.-Flag Laker Fleet. The Lakers and other vessels move materials at low cost between the various U.S. and Canadian ports of the Great Lakes, including some 85 U.S. ports (70 served by Lakers) with active shoreside facilities (e.g., docks, wharves, piers, slips).[50] Among these U.S. ports are approximately 772 active marine port facilities, of which 105 facilities[51] do not have direct access to rail for the receipt of bulk freight. A large Laker can move a ton of iron ore from loading facilities in Minnesota to a lakeside facility at a steel mill in Indiana at a cost of less than $10 per ton—a small fraction of the current per-ton value of the ore itself and at rates below those offered by unit trains.[52]

The operators of the U.S.-flag Great Lakes fleet manage their vessels to maximize their value to the regional industry through low-cost and reliable freight service. Self-propelled Lakers typically operate at speeds of 15 knots[53] or less. Vessels operating at these relatively low speeds can attain high fuel efficiency and can be designed to have boxy dimensions without unduly adverse hydrodynamic consequences. The speeds are appropriate for lower value bulk commodities and particularly over the relatively short distances (less than 1,000 miles) such cargoes are moved on the Great Lakes. Boxy vessels are well suited to maximizing the amount of cargo that can be carried through the locks and connecting channels of the Great Lakes system. Lakers can

TABLE 9. Great Lakes Domestic Cargo Share Carried by U.S.-Flag Great Lakes Fleet Barges, 2008–2010

	ALL VESSELS			COMPOSITE TUG BARGES		
YEAR	Total Tons Domestic	Average Miles per Trip	Total Ton-Miles Domestic	Barge Tons Domestic (% of total)	Average Miles per Trip	Barge Ton-Miles Domestic (% of total)
2008	87,898,576	567	49,795,296,798	14,834,534 (17%)	504	6,930,477,535 (14%)
2009	62,007,289	537	33,271,096,793	11,712,532 (19%)	442	4,930,890,952 (15%)
2010	79,781,576	566	45,141,055,159	15,204,876 (19%)	450	6,835,000,889 (15%)

Source: Vessel information from *Greenwood's Guide to Great Lakes Shipping,* 2010 edition; per-vessel freight carriage information from USACE, "Waterborne Commerce of the United States," 2008, 2009, and 2010 datasets.

also be longer in length relative to width (beam) than can oceangoing ships (10:1 versus 7:1, respectively) because they do not have to take the stresses of ocean navigation, further maximizing the amount of cargo they can carry through the locks at Sault Ste. Marie. The conditions on the Great Lakes also allow Lakers to operate with smaller engines than comparable oceangoing vessels.

Vessel performance is maximized by the use of self-unloading technologies (described earlier) and widespread use of advanced navigation technology. Vessels are equipped with bow and stern thrusters,[54] variable pitch propellers, and rudders that can turn to 45-degree angles in each direction (versus 35 degrees for ocean vessels), thus enabling large vessels to navigate in most narrow channels and harbors without assistance from tugboats.[55] Navigation costs are also reduced because most licensed officers on Lakers are qualified and registered as pilots for the Great Lakes, eliminating the need to hire pilots. Finally, because the Lakers operate in fresh water, their hulls experience little degradation relative to those of saltwater vessels and can last 100 years or more, thus reducing capital and maintenance expenses and the need for frequent vessel replacement. The vessel owners are also able to take advantage of the winter months from January into March, when portions of the Great Lakes are covered with ice, to schedule routine maintenance for the vessels in shipyards that are expert in making repairs to Lakers.

In summary, Lakers can operate for many decades, are equipped and operated to meet the needs of regional and local markets, and are able to move and transfer cargoes efficiently so as to minimize the costs of moving freight. However, over time, as with any asset, it is necessary to periodically replace or refurbish vessels, and it appears that some of the vessels in the fleet are entering a time of transition and needed revitalization. Although steel does not corrode quickly in freshwater, it does become thinner over time and must be replaced periodically. Older engines, particularly steam engines, are increasingly difficult to maintain due to age and lack of replacement parts. Laker owners periodically evaluate vessels built or refurbished in the 1980s and earlier for potential capital work, including replacement or modification of engines for better fuel efficiency and to accommodate low-sulfur fuels, compliance with ballast water best management practices, and replacement of wornout equipment and steel.

Owners will make decisions on upgrades or replacement according to specific circumstances, expectations of future fuel or labor costs, availability of capital, and other factors. A significant disincentive to make major improvements, however, is the uncertain outlook for regulation of ballast water and, to a lesser extent, air emissions (which can also affect the demand for coal cargoes and therefore future market demand for Laker services). Owners are understandably reluctant to make major investments that may need to be redone in the near future if the regulatory environment changes. Also, the uncertain outlook for dredging of harbors and connecting channels presents the risk that owners of improved vessels will not be able to recover their cost of investments if they lose access to some ports and markets. Much more about the regulatory situation of the Great Lakes is presented in later chapters of this report.

Passenger Vessels

The primary focus of this study is that portion of the U.S.-flag Great Lakes fleet that carries freight. A brief discussion of the Great Lakes passenger and cruise industry is informative, however. This once-prominent segment of the Great Lakes water transportation industry has declined significantly over the last 70 years and has not yet recovered.[56]

On the Great Lakes in 2011, there were approximately 130 U.S.-flag vessels carrying passengers on a commercial basis.[57] These vessels primarily fit into three broad categories: passenger-only ferries, car ferries, and attraction and excursion vessels. A few freight vessels are also certificated to carry passengers. All but four of these vessels register less than 100 gross tons. Passenger vessels under 100 gross tons are covered under the Title 46 Code of Federal Regulations (CFR), Chapter I, Subchapter K or T, rules[58] that allow for different crew, construction, and equipment requirements than would apply to a larger vessel regulated under Title 46 CFR, Chapter I, Subchapter H.[59] Operating under Subchapters K or T reduces cost but also limits the vessel's operation to a maximum distance of 20 nautical miles offshore.[60] These Great Lakes passenger vessels were built between 1922 and 2008.[61]

The majority of the passenger fleet consists of ferries that transport people and vehicles to and from various islands in the Great Lakes. Two U.S.-flag car ferry services, however, transport people and vehicles across Lake Michigan. One, the Lake Michigan Carferry Service, operates a 4,244 gross ton, coal-fired steamship, the *S.S. Badger,* which links Ludington, MI, and Manitowoc, WI.[62] A second cross-lake service, Lake Express, operates a high-speed (34 knot) 1,757 gross ton catamaran by the same name between Milwaukee, WI, and Muskegon, MI.[63]

The passenger fleet is a small vestige of what it was a century ago. Successful passenger ship services operated on the Great Lakes from 1850 through 1940, with about 30 overnight passenger services operating early in the 20th century.[64] Passenger vessel service was complemented by an extensive passenger rail system that allowed passengers to make land connections at origin and destination ports. The expansion of air and highway travel in the 1930s, however, led to a rapid decline in both rail and vessel passenger service. By the 1970s, all of the passenger fleets had disappeared from the Great Lakes with the exception of the car and passenger ferries.

It is unlikely that the Great Lakes will again be used to move large numbers of passengers for transportation purposes. The speeds of such services are relatively slow and cannot compete in convenience with air, automobile, and train alternatives. Cruising for pleasure offers a greater potential for growth. Numerous efforts have been made to restart the cruise industry on the Great Lakes over the last several decades, supported by various marketing studies, but with limited success.[65] In 2002, seven U.S.-flag vessels carried 6,400 passengers on cruises. By 2011, only four overnight passenger cruise vessels (of which one was a foreign-flag vessel) served U.S. ports on the Great Lakes.

At the same time, Canadian cruise services on the St. Lawrence River in Canada are doing well, with more than 100,000 passengers in recent years.[66] This success suggests the potential for a larger Great Lakes passenger industry, although nowhere near to the passenger levels of many millions annually reached early in the last century.[67] Smaller cruise vessels operating on the Great Lakes will have difficulty competing directly with the abundant supply of luxury ocean cruise services in the United States and abroad, easily reachable by air services to coastal ports. Various factors, including different U.S. and Canadian requirements for cabotage, security, and customs; prohibitions on gaming onboard vessels; and pilotage and environmental requirements may also serve to impede the growth of cruise activities on the Great Lakes.[68] However, cruise services marketed to niche markets, particularly short overnight cruises to domestic attractions and islands, will likely continue and even grow over time.[69]

Tugboat and Barge Services

Although not engaged in the movement of large volumes of bulk materials, important services are provided by approximately 165 U.S.-flag tugboats and 190 U.S.-flag liquid and dry-bulk barges that operate on the Great Lakes. These vessels are distinct from the composite tug-barges described above under the category of Lakers. In this case, the tugs are typically of lower horsepower and the barges are of various smaller sizes (usually 200 feet in length or less) and are not notched.[70] These vessels provide a host of important services. Tugboats move barges loaded with petroleum, construction supplies, special equipment, and other materials to locations throughout the Great Lakes. The tugboats also provide support to harbor construction projects (pilings, seawalls, docks, etc.), harbor and channel dredging, icebreaking and removal of ice dams, vessel salvage, and deployment of buoys. The widespread use by Lakers of bow and stern thrusters and other steering equipment has greatly reduced the need for routine navigational assistance to Lakers by tugboats. Tugboats, however, are still needed to assist Lakers when vessel maneuvering equipment breaks down, in certain river channels (e.g., the Cuyahoga River), when ice conditions trap vessels, and when occasional vessel groundings occur.[71] Tugboats also deliver pilots to saltwater vessels and provide maneuvering services to these vessels.

Although the size of the tugboat fleet on the Great Lakes has diminished over the decades along with the reductions in the number of Lakers and the Lakers' greater use of thrusters and variable pitch propellers, the current industry appears to be healthy. Recently, for instance, the Great Lakes Towing Com-

pany, which operates the largest U.S-flag tugboat fleet engaged in harbor assist and towing operations on the Great Lakes, initiated what it reports to be a major overhaul program for its Great Lakes fleet of 37 harbor-assist tugboats.[72] Tugboats, like other vessels on the Great Lakes, have long lifespans because of the fresh water environment in which they operate.

Other Service and Cargo Vessels

Approximately 50 self-propelled commercial vessels of various types round out the almost 600 commercial U.S.-flag vessels on the Great Lakes (not including fishing boats). These vessels include service boats, small cargo delivery vessels, small tankers and specialized carriers, and smaller general cargo vessels that also carry passengers. In most cases, these vessels are less than 100 feet in length.

Developments in the Canadian-Flag Fleet and Their Impact on the U.S.-Flag Great Lakes Fleet

The Canadian-flag Great Lakes fleet is capable of carrying approximately 70 million tons of cargo annually, compared to up to 115 million tons of cargo that the U.S.-flag Great Lakes fleet can carry annually.[73] The Canadian Great Lakes fleet is composed of vessels under 740 feet in length and 78 feet in beam that are capable of traversing the St. Lawrence Seaway and Welland Canal. The Canadian-flag vessels carry cargoes between the ports on the five Great Lakes and Montreal, Halifax, and beyond. These vessels carry approximately 36 percent of overall bulk cargoes on the Great Lakes[74] and more than 80 percent of the cross-lakes (U.S.–Canada) traffic, typically moving inbound ore from the Gulf of St. Lawrence and grain outbound to deep-water ports on the St. Lawrence such as Montreal.[75] They are not eligible to carry U.S. domestic cargoes, which are reserved under the Jones Act to U.S.-flag ships built in the United States. Similarly, U.S.-flag vessels are not eligible to carry Canadian domestic cargoes under Canada's Coasting Trade Act of 1992, which regulates vessels that operate between two contiguous Canadian ports.[76]

On October 1, 2010, the Canadian government removed the 25-percent duty that it had previously imposed on vessels imported into Canada for use in the Canadian domestic trades.[77] Partially in response to this duty waiver, the Canadian maritime industry has ordered at least 12 new vessels built in China and Japan.[78] These vessels have modern cargo-handling systems, fuel-efficient diesel engines with scrubbers that allow them to burn residual oil, and other features such as improved hull designs. Canadian operators are also purchasing new vessels that will move cargoes through the St. Lawrence Seaway but operate under foreign flags.[79] The first of these new foreign-flag vessels, Montreal-based Fednav Group's Japan-built and Hong Kong–flagged MV *Federal Yukina,* is 12 percent more fuel efficient than its predecessors and was deployed for the 2011 shipping season.[80] Publicly available information on the recent orders indicates these vessels are being acquired at prices (approximately $50 million per vessel) substantially below what they would cost to build in North American shipyards.[81]

Even prior to the recent surge in new vessel purchases, the Canadian-flag fleet was more modern than the U.S.-flag fleet, possibly due in part to the availability of limited shipbuilding subsidies to Canadian companies prior to 1986.[82] After a surge in shipbuilding in the 1970s and early 1980s (most notably the construction of the Class 10 Lakers), U.S. carriers have acquired only four new Lakers since 1990 (tug-barge units, including one recently completed by Donjon Shipbuilding and Repair, LLC, of Erie, PA).[83] There are no outstanding orders for new U.S.-flag vessels.

The question arises as to whether U.S. operators will be able to compete effectively with the Canadian-flag operators, given the recent upgrades to the Canadian vessels. The answer is that, with the exception of cross-Lakes cargoes (already dominated by the Canadian vessels), the two fleets have different economic parameters and do not compete with each other in most markets.

The U.S.-flag Great Lakes vessels operate under the Jones Act to move taconite ore, coal, limestone, and other bulk materials from U.S. suppliers to U.S. consumers along the Great Lakes. U.S.-flag Class 8, 9, and 10 vessels (larger than Canadian vessels) are too big to traverse the St. Lawrence Seaway, limiting one avenue of competition. They are designed to maximize the capacity of the Poe Lock and specific ports they serve and thus attain scale economies, with the Class 10 vessels carrying more than twice the cargo of a Canadian "Seaway-max" bulk ship.

The hulls of the U.S.-flag vessels, although not equipped with bulbous bows or special coatings to minimize water resistance as are some of the new Canadian vessels, are adequate for efficient operation under the low operating speeds (15 knots or less) needed for relatively short-distance bulk movements characteristic of the U.S. domestic trades on the Great Lakes.[84] One-way voyages for a U.S.-flag vessel on the Great Lakes may range from 6 hours (Port Inland, MI, to Escanaba, MI, at 78 miles) to as long as 74 hours (Duluth/Superior to Buffalo, NY, at 988 miles), and are substantially shorter than the 5- to 6-day voyages made by Canadian-flag vessels through the St. Lawrence Seaway.[85] The steel hulls of the U.S.-flag vessels last for many decades in the fresh water of the Great Lakes[86] and undergo little wear and tear because of minimal passage through locks (U.S.-flag vessels pass only through one of the Soo Locks—of which the Poe Lock is the largest—rather than the 16 locks needed to transit the entire Great Lakes/St. Lawrence Seaway System).[87] Canadian-flag vessels, on the other hand, can be exposed to brackish water on the lower St. Lawrence and may also sustain more damage because of lock passage, leading to more frequent replacement needs than is the case for the vessels of the U.S.-flag fleet.

Importantly, U.S.-flag vessels can be rejuvenated through repowering, allowing them to gain most of the engineering efficiency of newly built vessels. New, efficient, diesel and dual-fuel LNG/diesel engines, even if foreign built, can be installed in the vessels provided the installation takes place in a U.S. shipyard. In recent years, several Lakers have been repowered with modern, efficient, diesel engines.

In summary, the vessels being added to the Canadian-flag and Canadian-owned fleets are not likely to have a large competitive impact on the U.S.-flag Lakers. The vessels of each country carry their respective domestic cargoes, reserved for them under the cabotage laws of each country. Each fleet is well suited to the types of cargo it carries, with U.S.-flag Lakers moving domestic bulk cargoes and some high-volume, cross-lake cargoes in the fresh-water environment of the upper four Great Lakes. These vessels can be sized up to 1,000 feet in length (or just over) and 105 feet in beam because they do not need to transit the St. Lawrence Seaway. Canadian-flag vessels are well suited to the Seaway and longer voyages. Cross-lake cargoes have predominantly been carried by Canadian-flag vessels, but U.S.-flag carriage of such cargoes, particularly in backhauls or for very-large-volume cargoes where economies of vessel size are significant, will remain common for Canadian origins or destinations in the upper four Lakes. Foreign-flag vessels will continue to carry cargoes to overseas destinations through the St. Lawrence Seaway.

CHAPTER 4

U.S. PORTS OF THE GREAT LAKES

Waterborne commerce has been essential to the establishment and growth of the Great Lakes region. Natural harbors along the Great Lakes became the sites of many of the U.S. cities of the region today, including Buffalo, Chicago, Cleveland, Detroit, Duluth, Green Bay, Milwaukee, and Toledo, as well as other important cities in the United States and Canada. The ports of these cities and other areas of the Great Lakes continue to play an essential role in the movement of goods throughout the region.

One cannot understand the development of Great Lakes vessels and commerce without an understanding of the improvements in Great Lakes ports' infrastructure and loading facilities. The efficiencies possible with larger vessels require a complex set of government and private-sector investments throughout the Great Lakes system, with ports playing the essential role as the interface between vessels, shippers, and land-based transportation modes.

Government efforts to deepen and improve harbors and associated infrastructure at these ports began early in the Nation's history. USACE participated in improvements after 1824, helping to oversee the deepening of harbors and channels, construction of lighthouses and piers (including early uses of concrete in pier construction), and other activities.[88] Deeper harbors and channels permitted larger vessels and even greater economies of transportation.

Private enterprise leveraged the deeper channels and improved harbors by making major investments and innovations in cargo-handling facilities, vessels, and connecting landside infrastructure. A relatively recent example of private-sector innovation is the Superior Midwest Energy Terminal at Superior, WI, commissioned in 1976. This state-of-the-art transshipment facility incorporates the economic advantages of both unit-train receipts of western low-sulfur coal and the efficiencies of the largest Laker vessels. The facility can unload unit trains at a rate of 5,000 tons of coal per hour (and can handle two trains of 123 cars each at a time) and load the 1,000-foot-long Lakers at a rate of 11,500 tons of coal per hour. Up to three dissimilar quality coals can be blended simultaneously during the vessel-loading process.[89]

Whereas the facilitation of waterborne commerce has traditionally been the primary emphasis of Great Lakes port authorities, in recent years they and their State and local government counterparts have focused on environmental stewardship and other objectives as well. As noted in a recent survey of port and navigation needs, "Port development practitioners face increasingly complex challenges of managing development of waterfront assets to accommodate all the interests involved, including working port operations, public access, environmental protection, recreational activity and residential/commercial development, among many others."[90]

Locations, Sizes, and Ownership of Ports

This study does not list the specific facilities or describe the conditions of individual U.S. ports on the Great Lakes. The preponderance of evidence indicates, however, that the Great Lakes ports are sufficiently capitalized on the landside to meet the needs of the Laker (dry-bulk) fleet.[91] Based on a 2012 Federal Policy Agenda paper from the American Great Lakes Ports Association,[92] the ports' greatest concerns focus on harbor dredging, marine infrastructure (locks and breakwaters), and ballast water regulations. Much more information about dredging, marine infrastructure, and ballast water management is provided later in this report.

There are 117 federally recognized harbors operating within the Great Lakes Navigation System.[93] Harbors are landforms where a part of a body of water is protected and deep enough to furnish anchorage to a vessel, particularly during severe weather. Ports are facilities for loading and unloading vessels and are usually located within harbors, although not all harbors have ports. Overall, this study identified 85 Great Lakes ports with active freight- or passenger-handling facilities among the 8 U.S. States that border the Great Lakes (see Figure 2, which shows most of these ports). Seventy of these ports are served by U.S.-flag Lakers.[94] A total of 772 shoreside facilities (e.g., docks, wharves, piers, slips) are located at these 85 ports. Of these facilities, 50 are federally owned, and 28 are owned and operated by a variety of State and local agencies (e.g., fire, police, natural resources, etc.). Of the remaining facilities, the majority (588) are privately owned, whereas other facilities are publicly owned—by cities, counties, port authorities, and other public institutions—but leased to private companies for operation.

Most of these facilities specialize either in shipping or receiving materials. There are 344 facilities on the Great Lakes engaged in the receipt of materials of all types and 151 facilities engaged in any type of outbound shipment of cargo, with some of these facilities engaged in both activities. Only 45 (30 percent) of the 151 outbound shipping facilities do not also receive waterborne materials. Conversely, 238 (nearly 70 percent) of the 344 facilities engaged in receiving waterborne cargo are not involved in shipping outbound cargo. These 238 "receive only" facilities are limited to

FIGURE 2. Map of U.S. ports and major Canadian ports on the Great Lakes.
(Source: Data from Great Lakes Maritime Research Institute Information Clearinghouse, at http://www.maritime.utoledo.edu/index.aspx; LCA, "Great Lakes and St. Lawrence Seaway Ports, available on request (http://www.lcaships.com); and USACE, "Ports and Waterway Facilities," at http://www.ndc.iwr.usace.army.mil/ports/ports.asp.) Large ports in Canada are shown for reference.

handling dry-bulk cargoes of various commodities. They are frequently located at the point of consumption of the raw materials (e.g., power plants, steel mills, etc.).[95]

Major railroads serving the Great Lakes region include Norfolk Southern, Canadian National, CSX, Conrail, BNSF, Canadian Pacific, and Union Pacific. Most port facilities have access to one or more of these railroads. However, of the 238 receive-only facilities, 105 do not have a direct connection to the region's railroad network. Some of these facilities without rail service, such as steel mills at Indiana Harbor, IN, Burns Harbor, IN, and Cleveland, OH, are very large; the steel mill at Gary, IN, has only limited rail access. These facilities are described in Table 10.[96]

Approximately 37 of the U.S. ports along the Great Lakes handled more than 1 million tons of cargo in 2008. (Erie, PA, is included in this total because it routinely handled more than 1 million tons of cargo prior to 2008.) These 37 ports are listed, along with their total domestic and overall cargoes, in Table 11. Collectively, these ports account for the great majority (97 percent) of U.S. international and domestic cargo loaded or unloaded at Great Lakes ports.

Within the 37 ports listed in Table 11, there are 313 individual port facilities. These facilities handle a variety of cargo types. The geographic distribution of these facilities and their cargo-handling capabilities are shown in Table 12.

The great majority of the facilities at the top 37 U.S. ports are dedicated to handling bulk freight. Most of this bulk freight moves on the Great Lakes, but a major share of the bulk freight at Chicago travels between Chicago and the U.S. inland waterway system and does not enter the Great Lakes system. Currently there is little shoreside equipment at most of these facilities to support other cargo types. Of these 37 ports, the top 10 account for 65 percent of freight tonnage handled, indicating the concentration of activity in the largest ports. More about the concentration of activity at large ports is provided immediately below.

TABLE 10. Facilities Without Direct Rail Service, by Cargo or Purpose of Facility

TYPE OF FACILITY	NO.
Cement/Concrete	21
Aggregate (Sand and Gravel)	20
Oil/Fuel Oil	15
Trucking/Storage/Freight Forwarding	11
Port Authority/Marine Terminal	7
Power Plants	6
Chemical	6
Coal	5
Steel	4
Paving	3
Miscellaneous	3
Fishery	2
Salt	2
Total	105

Concentration of Loading Activities at a Limited Number of Ports

For each of the major commodities shipped within the GLMTS, loading operations are concentrated in a smaller number of ports than are unloading operations. For iron ore, two ports handle over 50 percent of the loadings, and over 98.7 percent of the U.S. domestic iron ore shipped on the Great Lakes is loaded from five ports. Coal loading is even more concentrated, with Duluth–Superior handling 76 percent of the U.S. domestic loadings and four ports handling nearly 98 percent of all loadings. The majority of the U.S. domestic limestone shipped on the Great Lakes is loaded from six Michigan ports, which account for over 88 percent of the cargo loaded (another 10 percent of the total limestone cargo is loaded from Marblehead, OH). Alpena, MI (the site of a major cement manufacturer), accounts for more than 75 percent of U.S. domestic cement loaded at Great Lakes ports.[97] For a more detailed list of shipments and receipts by port, see Appendix A of this study.

The concentration of loading operations at a relatively small number of ports has implications for the ballast water discharge standards discussed later in this report. Because ballast water is discharged while vessels are loaded, any standards requiring treatment of the discharged ballast will likely slow that loading process. Any significant reduction in loading speeds could cause vessels to occupy limited berth

TABLE 11. Tonnage for the Top 37 U.S. Great Lakes Ports, 2008 (in short tons)

PORT NAME	TOTAL	DOMESTIC RECEIPTS	DOMESTIC SHIPMENTS	INTRAPORT	FOREIGN IMPORTS	FOREIGN EXPORTS
Duluth, MN–Superior, WI	45,341,808	3,395,500	26,883,469	53,556	485,952	14,523,331
Chicago, IL[a]	22,659,554	8,286,660	6,316,926	4,480,776	2,723,098	852,094
Indiana Harbor, IN	15,380,630	13,611,730	1,378,063	—	318,761	72,076
Two Harbors, MN	13,432,959	59,803	13,373,156	—	—	—
Detroit, MI	12,836,319	8,700,945	589,655	210,299	3,006,726	328,694
Toledo, OH	10,954,686	2,275,779	1,658,323	—	4,055,009	2,965,575
Cleveland, OH	10,637,330	5,985,283	548,145	2,060,714	1,743,754	299,434
Gary, IN	9,030,152	8,588,299	164,027	—	246,635	31,191
Marquette/Presque Isle, MI	8,807,609	2,430,186	3,413,212	—	—	2,964,211
St. Clair, MI	7,880,383	7,819,425	60,958	—	—	—
Ashtabula, OH	6,905,941	2,706,230	460,062	—	1,384,264	2,355,385
Stoneport, MI	6,625,427	—	6,305,912	—	—	319,515
Silver Bay, MN	6,603,511	579,006	5,939,722	—	—	84,783
Escanaba, MI	6,339,642	1,050,706	5,172,220	—	35,069	81,647
Burns Harbor, IN	6,283,154	5,565,880	210,132	—	459,471	47,671
Calcite, MI	5,833,596	348	5,214,604	—	24,153	594,491
Port Inland, MI	5,705,843	170,265	5,311,719	—	—	223,859
Conneaut, OH	4,654,172	3,845,584	148,075	—	16,601	643,912
Milwaukee, WI	3,240,169	2,000,475	23,318	2,120	1,146,320	67,936
Alpena, MI	3,098,860	378,745	2,168,889	—	201,547	349,679
Marblehead, OH	3,022,166	—	2,179,416	—	19,219	823,531
Sandusky, OH	2,764,977	43,480	945,152	—	—	1,776,345
Green Bay, WI	2,476,909	2,095,659	—	—	381,250	—
Lorain, OH	2,186,022	1,528,744	—	18,704	558,070	80,504
Port Dolomite, MI	2,168,562	—	1,769,144	—	—	399,418
Muskegon, MI	2,115,672	1,790,678	102,510	—	222,484	—
Fairport Harbor, OH	1,797,863	835,247	368,703	24,208	311,372	258,333
Buffalo, NY	1,456,602	637,870	4,037	29,067	417,384	368,244
Charlevoix, MI	1,351,050	119,778	1,120,889	—	94,887	15,496
Buffington, IN	1,333,849	1,144,485	—	—	189,364	—
Marquette, MI	1,221,913	880,845	235,369	—	105,699	—
Drummond Island, MI	1,116,074	—	927,720	—	—	188,354
Grand Haven, MI	1,080,097	881,377	60,930	—	137,790	—
Monroe, MI	1,059,394	1,052,879	6,515	—	—	—
Marine City, MI	1,010,326	826,679	—	—	183,647	—
Huron, OH	1,001,633	968,708	—	—	32,925	—
Erie, PA[b]	748,526	646,611	18,321	—	41,103	42,491
Totals	240,163,380	90,903,889	93,079,293	6,879,444	18,542,554	30,758,200

Source: USACE, "U.S. Waterways Data: Port and Waterway Facilities," Feb. 2010.

a Tonnage for Chicago largely consists of materials shipped on barges via the inland waterways system.

b Erie, PA, is included as it typically had cargo volumes above 1 million tons in the years preceding 2008.

TABLE 12. **Geographic Distribution and Cargo-Handling Capabilities of Port Facilities for Top 37 U.S. Ports, 2008**

FACILITY TYPE	IL	IN	MI	MN	NY	OH	PA	WI	Total
Total facilities[a]	57	25	53	24	32	70	2	50	313
No. handling bulk freight only	45	20	42	19	24	60	1	42	253
No. handling break-bulk only	3	1	1	2	0	4	0	2	13
No. handling bulk freight and break-bulk	8	3	3	2	1	3	1	3	24
No. Handling self-unloading vessels only	8	9	31	8	10	37	0	17	120

Source: Developed using data from USACE, "U.S. Waterways Data: Port and Waterway Facilities," February 2010.
a There is overlap between the first category, Bulk Freight Only, and the last category, Self-Unloading Vessels Only.

space for a day or longer instead of hours, leading to queues of waiting vessels at loading ports and potentially reducing the capacity and efficiency of the U.S.-flag Great Lakes fleet. Under this scenario, the need for additional and expensive port dry-bulk handling capacity could become pronounced.

General Cargo Facilities

The larger ports on the Great Lakes are equipped to handle limited volumes of general cargo (see Table 12), particularly to accommodate international trade. General cargo consists of non-bulk items that are stowed separately on vessels or in containers, including manufactured goods, steel coils, and other items. It should be emphasized that U.S.-flag Lakers are dry-bulk vessels that do not carry general cargo; accordingly, general cargo is moved by Canadian-flag and foreign-flag vessels (and therefore is imported or exported) or in some cases is carried by smaller U.S.-flag vessels.

The volumes of general cargo handled at the Great Lakes ports have fallen over the last decades in large part because there has been a sustained global trend toward the containerization of such cargoes and the movement of the containers by rail or truck directly to and from coastal seaports.[98] Use of containers reduces the time required to load and unload general cargo at ports and enables these cargoes to move on specialized vessels such as containerships and RoRos. During the 1970s, the ports of Chicago, Cleveland, Green Bay, Milwaukee, Toledo, and Duluth–Superior handled some regularly scheduled international container traffic from oceangoing vessels that traveled through the St. Lawrence Seaway.[99] Containerships of that era typically had capacities of less than two thousand 20-foot equivalent (TEU) containers; thus, the 1,000–1,500 TEU vessels that can navigate through the St. Lawrence Seaway were competitive in size with containerships serving coastal seaports. By the 1980s, however, oceangoing containerships of 3,000–4000 TEU were being built, and today such vessels can range upwards from 5,000 TEU to as high as 14,000 TEU or more—offering large cost savings per TEU relative to smaller vessels. Thus, the small containerships that can travel through the Seaway are no longer competitive on trips to most overseas locations, nor can they offer the speed of service or sailing frequencies possible through intermodal service to and from coastal seaports.[100] Accordingly, one source estimates that international container volumes carried on the Great Lakes are less than 2,000 TEUs annually.[101] Some Great Lakes port authorities, particularly at locations far inland from the St. Lawrence Seaway, believe that there are potential markets for smaller containerships between their ports and European ports for specialized outbound cargoes such as "identity preserved" grains or other cargoes that are flexible with regard to sailing schedules.[102] Such services, if established, would almost certainly use foreign-flag vessels, and appropriate inbound cargoes would need to be identified.

There is also very little movement of U.S. domestic and U.S.–Canada containers and trailers through Great Lakes port facilities and vessels. Over the last two decades, however, there has been sustained interest in implementing services to transport domestic and regional containers and trailers on

short sea routes (referred to as "marine highway" services). Such services could provide a low-cost transportation option for freight and reduce the volume of traffic on landside transportation infrastructure (particularly in congested urban areas such as Chicago) by taking advantage of abundant but underutilized water transportation capacity.

The Port of Cleveland has been actively pursuing short-sea container service to Montreal with a Canadian-flag vessel but would not need new investment to handle this service, having space, equipment, labor, and a terminal operator that can accommodate containers.[103] The Port of Milwaukee offers the Milwaukee Intermodal Terminal with a full range of rail, truck, storage, and container inspection services. Some regional ports, such as Chicago, have excellent intermodal connectivity with highways, rail, air service, and barges, and could, with appropriate investments, accommodate waterborne movement of containers and trailers. Recently, the Mayor of Chicago announced plans to revitalize the port.[104] Similarly, the Port of Duluth has applied to the USDOT for grants to improve its ability to handle general cargo both in the port and on the surrounding highways.[105] Investments such as these are useful for serving existing international shipping and the development of marine highway container and trailer cargo services on the Great Lakes. Close coordination between ports and private vessel operators will be essential to accommodate any particular needs of marine highway services for container storage, transfer, and handling. More about the potential for short-sea movements of containers and trailers is provided in Chapter 10.

Lack of modal integration at ports is frequently cited by regional industry as a major barrier to the improvement of the multimodal freight transportation system in the Great Lakes region.[106] One promising technology that could alleviate this barrier is the Port Community System (PCS). The PCS is an "information entity that makes available logistical information among the actors involved in port-related freight distribution."[107] It is an electronic interface (Web portal) where freight forwarders, terminal operators, customs, carriers, inland carriers, and the port authority can interact, effectively linking databases and management systems and facilitating intermodal coordination. Implementation of PCS technology at larger Great Lakes ports would likely be essential in the development of more extensive intermodal general cargo traffic, including marine highway operations.

Role of Federal and State Funding of Port Infrastructure

Given the preponderance of private ownership of port facilities, and the general health of the Great Lakes bulk shipping industry, it is to be expected that private owners and operators will make appropriate investments to maximize the profitability of dockside infrastructure for handling bulk materials. The same cannot be assumed, however, for channels and waterways that are by law the responsibility of the Federal Government. Dredging and other Federal actions, which are funded in part through the HMT, are subject to congressional appropriations that may or may not be timely and adequate relative to needs. Much more about the dredging issue is presented in Chapter 6 and Chapter 8.

Federal and State assistance to ports could also be critical to establishing facilities and equipment needed to accommodate containerized cargoes as part of the establishment of marine highway services. Marine highway services, because they shift freight from congested land routes to uncongested water routes, generate public benefits such as reduced transportation emissions, reduced landside traffic congestion, improved landside traffic safety, and reduced wear and tear on roads. The costs of realizing these public benefits cannot generally be charged by ports and marine highway vessel operators to private shippers, because to do so would discourage use of the service by the shipper. Rather, such public benefits could appropriately be achieved by cost-beneficial investments of public funds.

Similarly, Federal and State assistance to ports to establish LNG fueling infrastructure may be warranted (see the discussion on vessel repowering to LNG in Chapter 8 and Chapter 9). The adoption of LNG to fuel Lakers and other private vessels would generate significant public benefits because of cleaner emissions and reduced GHGs. LNG fueling facilities could also be used to power trucks working at ports and municipal vehicles (garbage trucks, transit vehicles, etc.), for which public funding would be appropriate. Port authorities, of course, would need to participate in discussions about the scope, implementation, and funding of such facilities.

The Great Lakes Maritime Research Institute (GLMRI), a consortium of the University of Wisconsin–Superior and the University of Minnesota Duluth, has entered into a 5-year cooperative agreement with MARAD to address environmental issues that face shipping and marine transportation, including natural gas fuel applications.[108] One study under this agreement is to explore the LNG supply chain needed to support the fuel demand for the fleet with the potential for this fuel to be used by other modes of transportation. As of 2012, GLMRI is working with the gas suppliers and pipeline companies on this study.

CHAPTER 5

U.S. GREAT LAKES MARINE CARGOES: STATUS AND OUTLOOK

The importance of the economic health of regional industries on the demand for Laker services was amply illustrated in 2009, the final year of the severe recession that began late in 2007. Cargoes moved on the Great Lakes by U.S.-flag carriers fell by almost 30 percent from the levels of the preceding several years and put enormous stresses on the Laker industry. Fortunately, by late 2009 the regional industries and their demand for waterborne cargoes began to recover.

The great majority of goods carried on the Great Lakes by weight are dry-bulk commodities. Table 13 shows total movements of dry-bulk commodities by U.S.-flag Lakers from 1993 through 2011. In addition to the sums shown in Table 13, an additional 4 million to 5 million tons of petroleum products are moved on U.S.-flag vessels each year. The table shows that U.S.-flag Laker cargo volumes have fluctuated during this time period, trending downward from above 120 million tons in the late 1990s but reaching 110 million tons in 2006 before falling sharply to 66 million tons by 2009. Cargoes have recovered moderately since 2009. In 2011, U.S.-flag vessels carried nearly 94 million tons of cargo, not yet equal to pre-recession levels (except for iron ore).

Trends for different cargo types are illustrated in Figure 3. Of dry-bulk commodities, iron ore, coal, and limestone constitute by far the largest cargoes in terms of tonnage. Accordingly, the future health of the U.S.-flag Laker fleet will largely be driven by the demand for these commodities. The most essential cargo to the Lakers is iron ore, but significant erosion in coal and limestone cargoes would almost certainly lead to the retirement of some existing Laker capacity. The purpose of this section of the study is to evaluate the demand for these commodities in the future.

Outlook for Lake-Carried Iron Ore

The U.S.-flag Great Lakes fleet is both a product of the regional steel industry and a key enabler of the development and profitable operation of that industry. The region is an optimal environment for "prime" (or new, as distinct from recycled) steel production in inte-

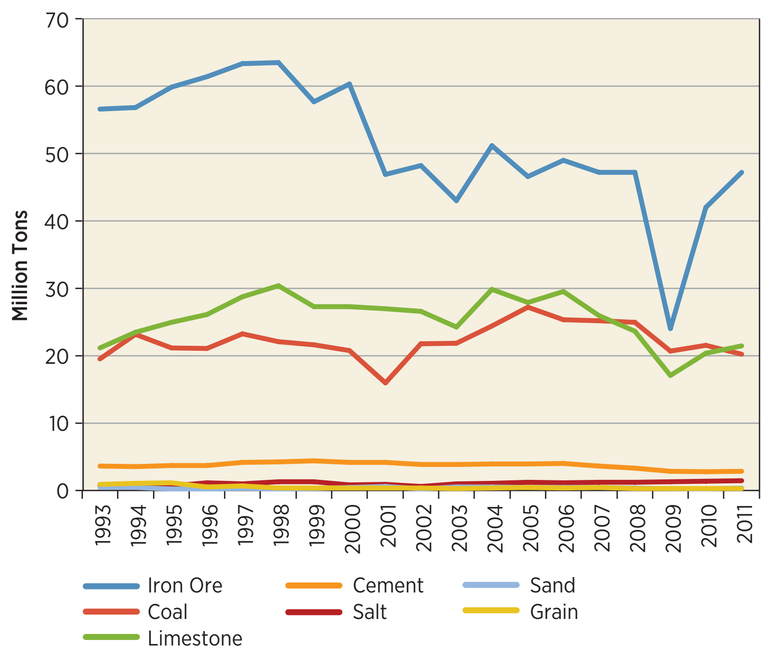


FIGURE 3. Great Lakes U.S.-flag dry-bulk cargo carriage, 1993–2011. (Source: Data from Lakes Carriers' Association, *2011 Statistical Annual Report of Lake Carriers' Association,* "U.S.-Flag Dry-Bulk Cargo Carriage 1993–2011," at http://www.lcaships.com/2011-statistical-annual-report.)

TABLE 13. **U.S.-Flag Carriage of Bulk Cargo on the Great Lakes, 1993–2011 (in short tons)**

YEAR	IRON ORE		COAL	LIMESTONE	CEMENT	SALT, SAND, & GRAIN	TOTAL
	DIRECT SHIPMENT	TRANS-SHIPMENT					
1993	51,435,685	5,166,649	19,540,306	21,169,370	3,607,593	2,088,322	103,007,925
1994	51,333,001	5,494,246	23,164,768	23,481,283	3,532,783	2,384,820	109,390,901
1995	54,223,610	5,622,590	21,143,967	24,913,305	3,689,192	1,983,515	111,576,179
1996	54,663,331	6,741,365	21,056,459	26,137,520	3,734,530	1,918,393	114,251,598
1997	56,727,630	6,643,000	23,244,252	28,755,341	4,159,146	1,944,893	121,474,262
1998	57,545,538	5,977,686	22,057,219	30,358,476	4,251,903	1,898,540	122,089,362
1999	52,160,147	5,523,530	21,633,198	27,310,498	4,417,055	1,905,946	112,950,374
2000	54,586,514	5,746,164	20,760,474	27,288,089	4,144,774	1,616,944	114,142,959
2001	43,829,971	3,094,732	15,965,758	26,988,622	4,136,897	1,852,205	95,868,185
2002	45,861,075	2,334,252	21,743,831	26,554,243	3,817,911	1,147,511	101,458,823
2003	41,343,509	1,672,776	21,879,426	24,239,110	3,851,487	1,758,127	94,744,435
2004	48,265,018	2,936,493	24,416,349	29,861,141	3,965,401	1,889,249	111,333,651
2005	43,884,572	2,687,547	27,207,350	27,935,513	3,892,822	2,052,645	107,660,449
2006	45,850,298	3,121,814	25,360,113	29,489,410	3,997,703	1,912,416	109,731,754
2007	45,049,721	2,156,662	25,170,629	25,966,057	3,602,488	2,095,694	104,041,251
2008	45,329,607	1,893,887	24,971,623	23,632,070	3,294,071	1,831,557	100,952,815
2009	23,271,702	759,385	20,674,888	17,067,232	2,865,323	1,828,213	66,466,743
2010	39,663,547	2,364,871	21,539,866	20,410,266	2,782,259	1,923,704	88,684,513
2011	44,443,975	2,780,768	20,239,327	21,434,839	2,817,846	2,067,506	93,784,261

Source: 2011 Statistical Annual Report of Lake Carriers' Association, "U.S.-Flag Dry-Bulk Cargo Carriage 1993–2011." http://www.lcaships.com/2011-statistical-annual-report.

Note: Totals include U.S. dry bulk domestic trade and cross-lake trade with Canada carried on U.S.-flag Lakers. An additional 4 to 5 million tons of liquid petroleum and petroleum products are carried each year on barges and other vessels.

grated steel mills. The region has abundant supplies of iron ore, limestone, and metallurgic coal and coke that are used in the production of steel and that can be affordably transported over distances ranging from less than 100 miles to many hundreds of miles by the Great Lakes fleet. Figure 4 shows the locations of iron ore production sites and steel mills served by Lakers.

Iron ore is transported in the form of concentrated taconite pellets.[109] Taconite pellets are delivered by rail to Great Lakes ports and then shipped on Lakers in quantities of up to 70,000 tons at one time, taking advantage of the economies of size associated with water transportation to minimize shipping costs. Actual shipping rate information is highly proprietary and difficult to obtain. However, USACE recently estimated that the per-ton savings of moving metallic minerals (ore) by water as opposed to rail were up to $11 per ton.[110] The National Resource Research Institute's Technical Report 2008/19, *The Economics and Logistics of Transporting Taconite Mining and Processing Byproducts (Aggregate): Minnesota and Beyond,* supports this figure. The report provides estimates that the per-ton cost of transporting taconite aggregate stone (a byproduct of taconite pellet production) via Great Lakes vessels is $10 to $17 (40 to 70 percent) lower than transport by unit train, the next most efficient mode.[111] Transportation cost comparisons can be misleading, however, because they do not standardize for differences in the speed, timeliness, and seasonality of deliveries, which can vary significantly among transportation modes.[112] These costs also represent averages—some routes will be more competitive (with closer or different cost rankings) among Laker, rail, and truck providers than other routes.

EPA released a report, *Economic Impacts of the Category 3 Marine Rule on Great Lakes Shipping,* in

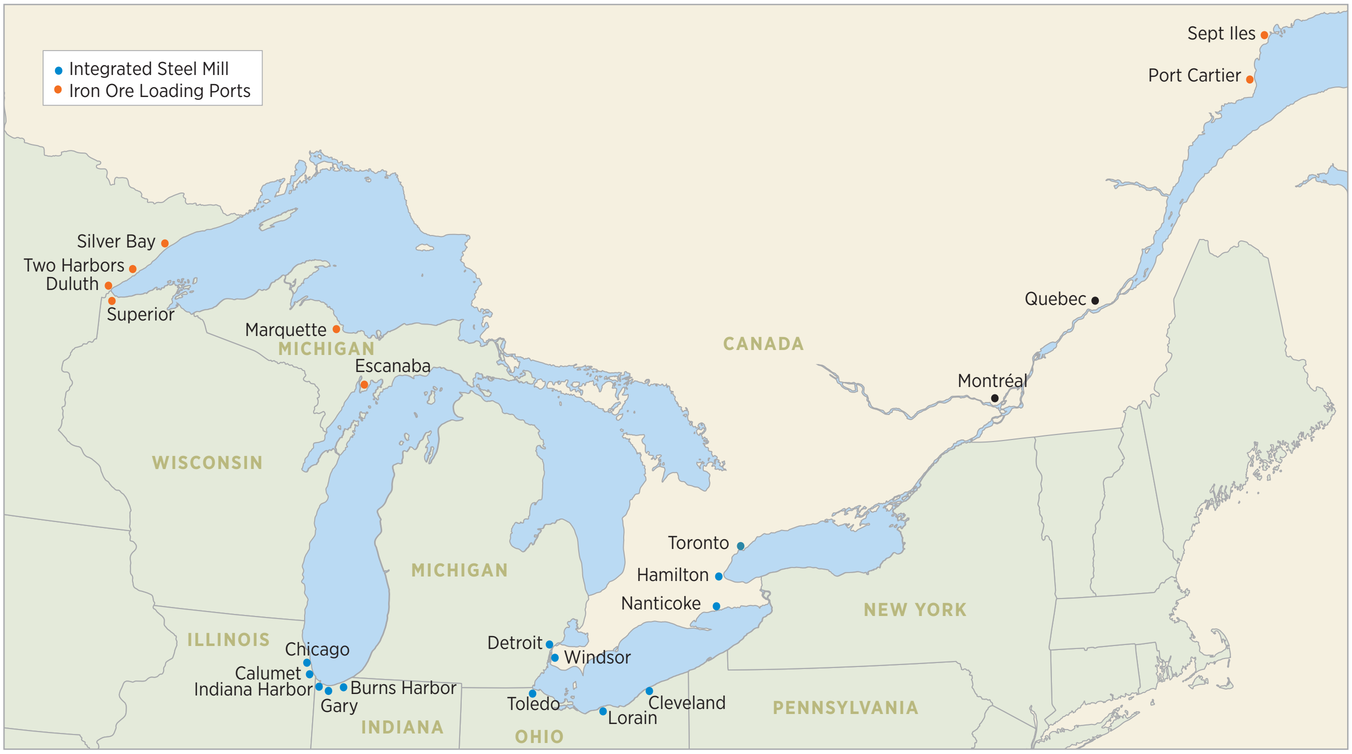


FIGURE 4. Iron ore loading ports and steel mills along the Great Lakes.
(Source: USACE, Huntington District, "Iron Ore," at http://outreach.lrh.usace.army.mil/Industries/Iron%20Ore/Iron%20Ore%20GL.htm.)

April 2012, which looked at shipping routes identified by the industry as potentially vulnerable to a modal shift from water to rail.[113] Data from this study show cost differences in favor of water of more than $5 per ton of taconite ore on one domestic route and more than $11 per ton for a second domestic route. A third route, from Michigan to Ontario, was more vulnerable to modal shift, with a cost difference of only $1 per ton in favor of water.[114]

At a more basic level than modal competition in freight rates, however, the outlook for future transportation of iron ore on the Great Lakes is fundamentally affected by the future strength of the U.S. and Canadian integrated steel industries, principally located around the Great Lakes. These industries are the dominant North American consumers of taconite pellets. The health of this industry is subject to a number of factors, including industry efficiency, overall demand for steel, competition from imports, and competition from electric arc furnace (EAF) steel mills.

A full description of the economic, technological, environmental, and political developments affecting the U.S. steel industry over the last three decades is beyond the scope of this study, so only a brief overview is provided here. Following difficulties in the late 1970s that reached their nadir during the recession of 1981–82, the steel industry made major investments and restructured in the 1980s and 1990s, leading to a situation whereby in 1996 U.S. steel companies were the third most productive in the world.[115] However, softening of prices, low-cost imports associated with excess world capacity, increasing EAF steel production, and a legacy of high labor costs, led to a wave of bankruptcies among integrated steel mills between 1998 and 2002 (including major producers such as Bethlehem Steel, National Steel, LTV, and Wheeling-Pittsburgh Steel).[116] These bankruptcies were followed by a period of consolidation and labor contract renegotiations, enabling the industry to shed major financial obligations and debt, and leading to a major turnaround. One article reports that "the 17 leading companies went from a combined loss of $1.1 billion in 2003 to an after-tax profit of $6.6 billion in 2004."[117] The industry was sufficiently strong not only to withstand the recent severe recession but to play a lead role in the economic recovery, bouncing back to prerecession consumption of Great Lakes iron ore by 2011 (see Figure 3).

Overall, because of developments over the last three decades, the integrated steel industry in the United States is well positioned to withstand competition from steel imports and to share in what is expected to be a growth market for steel in the United States over the next decade. IHS Global Insight projects that U.S. production of iron and steel will increase from an index level of 95.5 in 2011 (2007 = 100) to an index level of 141 in 2024, after which the index drops to 127 by 2032 and 110 by 2042.[118] IHS Global Insight projects that real U.S. GDP growth will average 2.6 percent per year during the period from 2011 through 2042—about the same as over the last 30 years—and that U.S. foreign industrialized trade partners will experience similar growth patterns.[119] Of course, any long-term outlook is subject to disruptions from recessions, which generally cannot be predicted in advance.

The principal risk to the integrated steel industry is competition from EAF mills. Integrated steel manufacturing is one of two principal methods used to produce steel. In the integrated steelmaking process, iron is extracted from iron ore in a blast furnace and the molten product is then mixed with recycled steel and refined with oxygen in a basic oxygen furnace. The alternative method to integrated steel production is EAF steelmaking, in which recycled steel is the primary input (virtually 100 percent), although other iron-bearing materials may be used. The less energy-intensive EAF process accounted for about 62 percent of U.S. steelmaking in 2011.[120]

Although steel industry experts are of the opinion that EAF steelmaking will continue to dominate domestic production, there are reasons to believe that integrated steel capacity around the Great Lakes will continue to consume ore at present or growing rates (although subject to short-term disruptions during economic downturns). During periods of strong world demand for steel, domestic heavy melt scrap steel—the key feedstock of EAF steel—can approach prices of $400 per metric ton or greater.[121] Taconite ore can be mined and processed into taconite pellets at costs much lower than recent prices of scrap steel on a per-ton-of-steel basis. In particular, it takes 1.5 tons of taconite pellets (which are approximately two-thirds pure iron) to produce 1 ton of steel, whereas taconite pellets were produced and sold for prices of $30 to $35 per long ton in recent decades (the price for taconite pellets was $32 per ton as of 2002).[122,123] Moreover, much of the taconite production capacity in the Great Lakes region is owned by integrated steel producers, both domestic and foreign.[124,125] Accordingly, while EAF steel mills must purchase scrap steel at market prices,[126] integrated steel producers have access to large quantities of ore that can be produced at costs considerably below recent prices of scrap steel on a per-ton basis.[127] These company-owned ore supplies also serve as a buffer against high or erratic iron ore prices on world markets.[128] Finally, the reserves of taconite ore around the Great Lakes can sustain steelmaking for the indefinite future at current consumption rates.[129] Assuming that economic growth continues both in the United States and abroad, and that world demand for steel continues to grow, U.S. integrated steel production along the Great Lakes should at least hold its current market relative to EAF production.

Most forecasts are for long-term growth in the national and world economies that would support growing demand for steel. Of course, world commodity prices are subject to sharp short-term declines during times of economic downturn, which in turn lead to pronounced short-term declines in steel production and demand for ore and scrap steel. This effect was recently demonstrated on the Great Lakes during the recession of 2007–2009 (see Figure 3). However, because of the new efficiencies of the Great Lakes integrated steel production system, these facilities should be able to weather such downturns (as they did in 2009) and take advantage of future growth in the demand for steel from the revitalized U.S. automobile industry, heavy equipment industry (e.g., Caterpillar®), and natural gas drilling operations, sustaining a long-term demand for taconite pellets. On the other hand, a combination of long-term, low scrap steel prices or rising integrated steel mill production costs (possibly because of new environmental regulations) would undermine this outlook.[130]

As discussed above, it is generally expected that most taconite ore cargoes to U.S. integrated steel mills will move by U.S.-flag Lakers given the current cost advantages of Lakers over unit trains. This expectation is contingent on Lakers maintaining their current advantage over rail with regard to transportation costs. Analysis later in this report will evaluate the risk that Laker costs could escalate because of issues associated with regulation and dredging, potentially causing the loss of some markets to rail.

This positive qualitative outlook for taconite cargoes on the Great Lakes is reflected in a forecast produced for MARAD as part of this study (Table 14). The forecast (which is in ton-miles) is for modest growth of just over 1 percent on the Lakes over the next 32 years.

TABLE 14. Projected Trade in Iron Ore by Ton-Mile on the Great Lakes, 2010–2045

YEAR	IRON ORE (million ton-miles)
2010	28,468
2015	28,789
2020	30,992
2025	33,151
2030	35,340
2035	37,532
2040	39,712
2045	41,365

Outlook for Lake-Carried Coal for Power Generation

Of the three major commodities moved on the Great Lakes, the outlook for coal is the most uncertain. The sudden abundance of natural gas resulting from the hydraulic fracturing of shale is challenging the traditional status of coal as the low-cost energy source for electricity generation. At the same time, regulatory actions to reduce adverse environmental and health effects of electricity production from coal may further influence decisions by some utilities to replace older coal-fired facilities with gas-fired ones. The net effect of these and other factors has changed the outlook for coal usage and transportation; previous outlooks of growth in demand for coal have been replaced by expectations of flat or declining demand. The long-term diminishment of the coal trades on the Great Lakes would be a significant blow to the Laker industry because of both the large volumes of coal currently moved on the Great Lakes and the previously reliable nature of this market, which tended to be somewhat less volatile from year to year compared to iron ore and limestone.

The Energy Information Administration's (EIA) 2012 outlook for coal at the national level is as follows:

> In the AEO2012 Reference case, domestic coal production increases at an average rate of 0.3 percent per year, from 22.1 quadrillion BTU (1,084 million short tons) in 2010 to 23.5 quadrillion BTU (1,188 million short tons) in 2035. Mines in the West account for nearly all the projected increase in overall production, although even Western coal production is expected to decline somewhat between 2010 and 2015 as low natural gas prices and the retirement of a sizable amount of coal-fired generating capacity leads to a decline in overall coal consumption in the electricity sector. On a BTU basis, the share of domestic coal production originating from mines in the West increases from 47 percent in 2010 to 56 percent in 2035, and the Appalachian share declines from 39 percent to 29 percent during the same period, with most of the decline occurring by 2020. In the Interior region, coal production remains relatively stable over the projection period, with production in 2035 higher than in 2010.[131]

This outlook contrasts sharply, however, from EIA projections of only a few years earlier, in which EIA reported:

> As in AEO2006, coal is projected to play a major role in the AEO2007 reference case, particularly for electricity generation. Coal consumption is projected to increase from 22.9 quadrillion BTU (1,128 million short tons) in 2005 to more than 34 quadrillion BTU (1,772 million short tons) in 2030, with significant additions of new coal-fired generation capacity over the last decade of the projection period, when rising natural gas prices are projected.[132]

EIA qualified its 2007 projection by noting the sensitivity of the forecast to GHG regulations and other policies, but clearly the outlook for coal has changed abruptly over a relatively short span of time.

Regulatory Environment

EPA rules or rulemakings that currently affect decisions to build and operate coal-fired generation facilities are as follows:[133,134]

- National Emissions Standards for Hazardous Air Pollutants from Coal and Oil Fired Electric Utility Steam Generating Units, usually referred to as Mercury and Air Toxics Standards (MATS). Establishes limitations on emissions of mercury and other toxic pollutants (rule finalized in February 2012 but is being challenged by multiple groups in the District of Columbia Circuit Court);[135]
- National Ambient Air Quality Standards (NAAQS), with revised standards for NO_x, SO_2, carbon monoxide (CO), ozone, and fine particulates (rules finalized between 1996 and 2011);[136]
- Cross-State Air Pollution Rule (CSAPR) to reduce ozone and particulate levels via control of NO_x and SO_2 emissions (rule finalized in August 2011 but overturned by the U.S. Court of Appeals for the District of Columbia Circuit on August 21, 2012);[137]
- Coal Combustion Residue (CCR) rule to designate combustion residues (ash) as either solid or hazardous waste (no schedule for finalization);
- Standards under Section 316(b) of the Clean Water Act (CWA), which requires EPA to establish standards for water withdrawn and used for cooling thermoelectric generating units that reflect the best technology available for minimizing adverse environmental impacts (scheduled for finalization in June 2013);[138]
- Regional haze program standards to improve visibility via reduction in NO_x, SO_2, and particulates (rule finalized in July 1999 and subsequently amended);[139] and
- Proposed GHG rule that would affect new coal-fired electrical generating units but not existing or reconstructed facilities.[140]

Additionally, individual States are implementing standards that encourage a movement away from coal. Michigan, for instance, has established a Renewable Energy Standard under Public Act 295 to promote the use of renewable fuels as alternatives to coal.[141]

The above regulations have important potential public benefits but would also impose costs on utilities. The Government Accountability Office (GAO) states, however, that "It is unclear how power companies will respond to the four key EPA regulations [MATS, CSAPR, CCR, and CWA Section 316(b)], in part because there is uncertainty about the regulations themselves and other factors affecting the industry, including future natural gas prices."[142] GAO reviewed 10 studies that attempted to assess how much coal-fueled capacity that power companies might retire at a national level, of which 3 studies attempted to ascertain retirements driven by all 4 of the principal regulations. GAO reports that the projections in these 3 studies range from power companies retiring from 2 percent to 12 percent of coal-fueled capacity nationally, with another study of the Midwest (consisting of 11 States and a Canadian Province) showing the retirement of 18 percent of capacity.[143] EPA and some in the industry, however, told GAO that some of these retirements would occur even without the regulations; thus, as noted, the overall effect of regulation on retirements is uncertain.[144]

Outlook for Natural Gas Prices

The coincidence of several factors has sent natural gas prices plunging from levels reached a just few years ago. These factors include the following:

- A recent surge in natural gas supplies as a result of the widespread application of hydraulic fracturing;
- Reduced demand for natural gas in the aftermath of the severe recession of 2007–2009; and
- A mild winter in 2012.[145]

TABLE 15. U.S. Coal Shipments and Receipts, 2009

COAL SHIPMENTS			COAL RECEIPTS		
PORT	TONS	%	PORT	TONS	%
Duluth, MN–Superior, WI	14,375,370	76.6	St. Clair, MI	8,072,387	43.2
Chicago, IL	1,803,534	9.6	Marquette/Presque Isle, MI	1,883,774	10.1
Toledo, OH	1,460,206	7.8	Monroe, MI	1,183,606	6.3
Sandusky, OH	858,329	4.6	Muskegon, MI	1,153,767	6.2
Ashtabula, OH	183,724	1.0	Detroit, MI	928,554	5.0
Marquette, MI	58,350	0.3	Green Bay, WI	671,591	3.6
Monroe, MI	13,041	0.1	Milwaukee, WI	657,428	3.5
Detroit, MI	8,383	0.0	Saginaw River, MI	595,478	3.2
Marquette/Presque Isle, MI	7,947	0.0	Taconite Harbor, MN	577,406	3.1
			Manistee, MI	417,684	2.2
			Toledo, OH	399,560	2.1
			Silver Bay, MN	374,236	2.0
			Ashtabula, OH	334,148	1.8
			Escanaba, MI	252,640	1.4
			Alpena, MI	229,522	1.2
			Marquette, MI	213,868	1.1
			Duluth, MN–Superior, WI	184,869	1.0
			Grand Haven, MI	139,044	0.7
			Holland, MI	119,816	0.6
			Ashland, WI	74,533	0.4
			Marysville, MI	74,202	0.4
			Trenton, MI	48,233	0.3
			Manitowac, MI	39,441	0.2
			Gladstone, MI	32,427	0.2
			Menominee, MI	24,544	0.1
			Indiana Harbor, IN	9,960	0.1
			Harbor Beach, MI	7,947	0.0
			Chicago, IL	3,171	0.0
Total	18,768,884	100%	Total	18,703,836	100%

Source: Data from USACE, *Waterborne Commerce of the United States,* Part 3—Great Lakes, 2009.

Note: This table is limited to domestic coal movements (excluding coal coke) and does not capture coal cargoes moved between U.S. ports and Canadian ports or internationally; thus totals are less than the 2009 total reported for coal in Table 13. Note that domestic receipts and shipments may not balance because some coal volumes may include intraport movements or because some coal may move between Great Lakes ports and inland waterway ports.

Natural gas futures prices fell to below $2.30 per thousand cubic feet (MCF) in March 2012.[146,147] Rates for natural gas had exceeded $11 per MCF as recently as 2008.

These extremely low prices for natural gas are, however, unlikely to be sustained over the long term. A continued recovery in national economic activity, future winters with average temperatures closer to historic norms (i.e., nearly 4 degrees Fahrenheit colder than the winter of 2012), and new contracts for natural gas made during this period of low prices will likely serve to increase natural gas demand and prices over the long run. More significantly, market analysis shows that recent prices (below $3 per MCF) are not economically sustainable for natural gas producers. One analyst, citing gas production costs tracked by Bloomberg LP, notes the following:

> Over the long term, the price of the commodity cannot deviate materially from the marginal cost of production which still sits in the $6/MCF region. Producers must have hedges in place, be selling a substantial amount of natural gas liquids (NGL's) which are still well priced as

> they are tied to the price of oil, or have some other external force that is in play to be drilling in this environment. An unhedged producer of dry natural gas is not making any money and is better off halting production at current prices. And, that's what they are doing.[148]

Other analysts also suggest that the price of natural gas will be above early 2012 levels in the future. The *Economist* magazine reported in July 2012 that most experts agree that natural gas prices will eventually settle around $4 to $5 per MMBTU (thousand thousand British thermal units, on average equivalent to one MCF of natural gas).[149] By October 2012, natural gas prices for November delivery had recovered to $3.50 per MMBTU.[150]

Some analysts believe the price of natural gas could go significantly higher than $5 per MMBTU. The price of natural gas has traditionally been linked to the price of its close substitute, oil, usually at a 10:1 ratio (for example, a $50 price for a barrel of West Texas Intermediate crude oil would indicate that natural gas should trade at $5.00 per MMBTU at Henry Hub). The historical relationship between the price of oil and natural gas, which has averaged 10:1 over the past two decades, moved to approximately 20:1 as of January 2011[151] and more than 40:1 in early 2012. The development of LNG markets (including export markets), increasing demand for natural gas at current prices (including for petrochemical production), and the switching of drilling operations from gas to liquids may lead to a reconnection of gas prices (per MMBTU) to those of oil and coal.[152] At the same time, the uncertain environmental consequences of gas production, including gas leakage from wells and pipelines (molecule per molecule, natural gas is many times more potent as a GHG than is CO_2) and possible ground water contamination associated with drilling,[153] could result in additional costs being assigned to the production and distribution of natural gas in the future.

Recent Developments

As of 2012, low natural gas prices and, to an unknown extent, uncertainty about the cost of new and potential future environmental requirements, are reducing the demand for coal in the Great Lakes region. The port of Duluth saw a 20-percent drop in coal cargo in 2011 attributable in large part to the decision of an Ontario, Canada–based electric utility to reduce its orders for that year from 8 million tons to about 300,000 tons. The Ontario utility is working to phase out the use of coal to produce electricity by the end of 2014, investing in nuclear and renewable energy power generation sources.[154,155] A significant amount of coal was delivered to Ontario on the largest U.S.-flag vessels prior to the phase-out decision; annual carriage on these vessels has dropped by 4 million tons of coal with only 625,000 tons remaining.[156]

A major utility company in Michigan recently announced that it will be closing several coal burning electric plants, including a lakeside facility in Muskegon County, MI, and small plants near Luna Pier and Bay City.[157] The company publicly reported that it would be too costly to upgrade the Muskegon County facility to meet State and Federal clean air regulations.[158] Similarly, other recent announcements of closures of older coal-fired facilities have come from Chicago and Ohio.[159,160] Of the recently announced U.S. closures, the Muskegon County closure is the most significant to Laker markets—accounting for 1.15 million tons (6.2 percent) of domestic Lake-delivered coal receipts in 2009 (see Table 15). Figure 5 shows the location of coal ports and larger Laker-supplied power plants in the Great Lakes region.

A much more significant impact on U.S.-flag Lakers would result if one or more of the major U.S. coal-fired facilities (particularly the Saint Clair Power Plant in Michigan) currently supplied by Laker-carried coal were to be closed or converted to other fuels. Important decisions concerning continuation of coal operations in the Great Lakes region are expected in the next year or two.

Long-Term Demand Outlook for Laker-Supplied Coal

Although it is likely that some smaller and older coal-fueled generating plants will continue to be closed, Great Lakes regional utility companies have not announced plans to discontinue coal usage at the largest Laker-supplied generating plants. Moreover, there are substantial reasons to support an outlook that a large portion of current coal-generation capacity along the shores of the Great Lakes will be sustained in the future.

As noted above, it is unlikely that the price of natural gas will remain at the very low levels reached in

FIGURE 5. Locations of coal ports and coal-fired power plants along the Great Lakes.
(Source: USACE, Huntington District, "Coal," at http://outreach.lrh.usace.army.mil/Industries/Coal/Coal%20GL.htm.) Note that not all of the power plants shown on the map are currently served by Lakers.

2012, and the overall impact of existing and potential regulation on the burning of coal, while uncertain, is not expected of itself to cause the retirement of a large number of power plants. Perhaps the most compelling factor supporting the continued use of coal, however, is the great abundance of low-sulfur Powder River Basin coal (also called western coal).

The Powder River Basin of southeast Montana and northeast Wyoming represents the source of the great majority of coal that moves on the Great Lakes. Its low-sulfur coal reserves are the largest low-cost source of energy on Earth, with seams up to 80 feet thick and able to support more than 400 years of coal production at current mining rates.[161] Moreover, because approximately half of the delivered cost of coal to electricity producers is transportation, the access to low-cost, Lake-transported coal further argues for continued reliance on coal for lakeside generating facilities.[162]

Recent analysis suggests that even the very low natural gas prices reached in early 2012 would not eliminate the competitive position of Powder River Basin coal for electricity generation in the Great Lakes region.[163] This analysis, conducted in March 2012 and summarized in Figure 6, shows that the natural gas fuel-cost component of power generation in the Great Lakes Basin (as measured in dollars per megawatt hour ($/MWh)) is projected to approach but not fall below the coal fuel cost in 2012 and then move upward in 2013.[164] As noted above, several underlying factors in the supply and demand for natural gas suggest that the very low prices reached in 2012 for natural gas cannot be sustained.

It is thus likely that the competitiveness of coal will be reinforced in the future. Accordingly, the assumption in this study is that coal traffic on the Great Lakes will mirror the broader long-term national outlook for coal provided by the EIA in the beginning of this section; i.e., coal consumption will be about the same or slightly higher in 2035 than it was in 2010. MARAD assumes that there will be a drop in Lake-carried coal cargoes between 2010 and 2015 as older and smaller generating facilities are retired, with demand recovering again by 2020 due to modest growth in electricity demand driven by economic growth in the region. To the extent that some

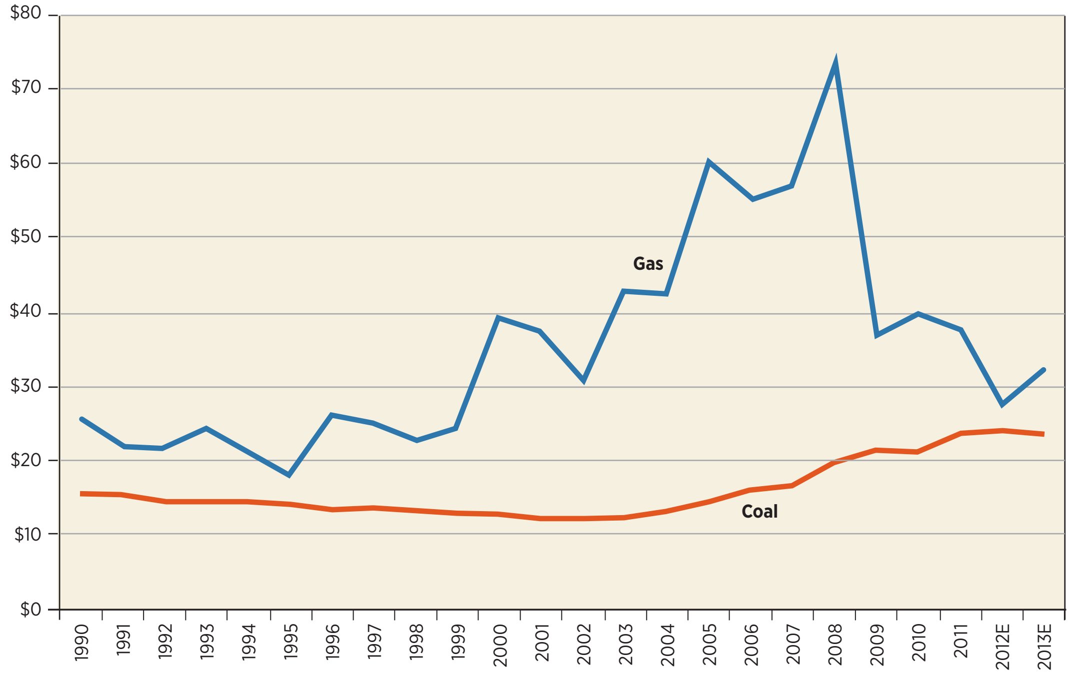


FIGURE 6: Estimated fuel cost component of power generation, $/MWh, East North Central (Great Lakes) region, 1990–2013. Stifel Nicolaus estimate using EIA cost and quality of fuels data, 1990–2011. The 2011 data are year-to-date through October 2011. Assumed heat rates are national averages for 1990–2010 for gas and coal, with 2010 heat rates applied to 2011–2013. For 2012–2013, Stifel Nicolaus assumes no change in delivered coal prices vs. 2011. For natural gas in 2012–2013, Stifel Nicolaus uses Henry Hub natural gas forward pricing as of January 25, 2012, plus an assumed $0.30/Million BTU basis differential.

(Source: Reprinted by permission, Stifel Nicolaus. In Paul Forward and George Panageotou, "U.S. Coal Market: Current Trends and Potential Impact on U.S. Railroad Traffic Volumes," Slide 12, Mar. 9, 2012, at http://www.scribd.com/doc/84722432/Stifel-U-S-Coal-2012-03-09-Current-Trends-and-Potential-Impact-on-U-S-Railroad-Traffic-Volumes.)

TABLE 16. Projected Trade in Domestic Coal by Ton-Mile on the Great Lakes, 2010–2045

YEAR	COAL (million ton-miles)
2010	10,236
2015	9,866
2020	10,224
2025	10,087
2030	10,183
2035	10,272
2040	10,288
2045	10,298

of the Laker-supplied coal trade is displaced, coal from the Appalachian region would likely be replaced by western coal. As measured in ton-miles of coal carried by U.S.-flag ships, and extrapolated to 2045, the forecast is shown in Table 16. Of course, there is a major downside risk to this forecast because of the possibility that one or more electric utilities could decide to close major coal-fired generation facilities.

Outlook for Lake-Carried Limestone and Aggregates

Several types of stone and aggregate materials are shipped on the Great Lakes, including limestone, sand and gravel, gypsum, and materials such as soil and fill. Limestone is by far the most prevalent of these materials, at approximately 85 percent of the total, followed by sand and gravel at more than

12 percent.[165] Because of the volumes involved, limestone is included in the "big three" bulk cargoes for U.S.-flag vessels on the Great Lakes along with iron ore and coal.

Limestone's main use is as an aggregate material for building and highway construction,[166] along with other stone products of sand and gravel.[167] It is a key component in the manufacture of cement and numerous industrial and food products (e.g., glass, paper, detergents, sugar). Limestone is used in steelmaking as a fluxing (filtering) material to remove sulfur and other impurities from the steel.[168] Electric utilities also use limestone as an ingredient in the scrubber materials that control sulfur emissions to comply with U.S. air emission standards.[169]

The majority of the limestone shipped on the Great Lakes is quarried and shipped from ports in northeastern Michigan (Ohio also supplies limestone) (see Figure 7 for the locations of the six ports that account for more than 98 percent of loadings).[170] Michigan is fortunate in having large deposits of very pure, high-calcium limestone in the northern part of the State on or near the shores of Lake Huron.[171] Water transportation is the lowest cost means of transporting it, and this has resulted in the concentration of the major part of Michigan's limestone production in a few large, highly mechanized quarries operated in the lakeside deposits. Stone from these quarries can be transported to the many harbors along the Great Lakes and used by local construction industries throughout the region.

The importance of limestone on the Great Lakes grew in the 1990s because of its use by coal-burning industries as an important reagent for the reduction of sulfur emissions through the use of scrubbers and fluidized bed combustion systems.[172] However, because limestone's most extensive uses are as an aggregate stone in concrete and for cement manufacture, demand for limestone moves with the construction markets. Over the last 20 years, limestone shipments on the Great Lakes grew from 21 million short tons in 1993 to peak at over 30 million short tons in 1998 (see Table 13, above). Limestone shipments peaked a second time between 2004 and 2006 at over 28 million short tons per year. However, the demand for Laker-carried limestone fell along with the decline in the U.S. housing market during the recession of

FIGURE 7. Major U.S. limestone loading ports of the Great Lakes.
(Source: Adapted from American Steamship Company, "Great Lakes Trade Patterns: Limestone Aggregates," at http://www.americansteamship.com/great-lakes-trade-patterns.php.)

2007–2009, hitting a low of 17 million short tons in 2009. Limestone shipments have since rebounded moderately, and any significant increase in limestone shipments will probably coincide with increased regional construction activities for buildings, residences, and roads.

J.P. Morgan/Chase recently reported that the Midwestern States, which include six of the eight States on the Great Lakes, are benefiting from the recovery in the motor vehicle industry and, more generally, the industrial sector.[173] Moreover, it notes that although the Midwest lagged the national economy for most of the 2000s decade, it is now beginning to pace the national economic recovery. Not only is it expected to parallel the national economic trends, J.P. Morgan/Chase expects the region to gradually close the gap that opened versus the national economy prior to 2010. Assuming that the regional construction industry grows in tandem with the regional economy, and the regional economy at least keeps pace with the national economy, the demand for limestone and limestone products used by the construction industry should grow in the future.[174]

Growth in demand for limestone does not automatically translate into increased Laker traffic. Water has traditionally been the lowest cost means to transport limestone in the region, however, and recent increases in the cost of petroleum fuel should favor waterborne delivery. Actions that could adversely affect future Laker carriage of limestone include increases in waterborne costs unmatched by comparable increases in rail and truck costs. Such increases could result from recent air emission regulations, potential ballast water treatment requirements, and unmet dredging needs (see later in this report for more about these potential costs). Also representing a potential risk would be a national revision in truck size and weight restrictions that would allow heavier trucks to operate in interstate commerce, which could reduce truck per-ton delivery costs from limestone quarries competing with lakeside quarries.

Higher waterborne delivery costs would probably not cause a shift of limestone cargo from water to rail since most major quarry sites in northern Michigan are not served by rail. A shift from water to long-distance movement of limestone by truck from existing quarries is also unlikely because of the much higher per-ton-mile cost of trucks (5 to 9 times higher than water).[175] One recent study found that trucking limestone 125 miles by truck would cause transportation costs to exceed the quarry price of limestone by 3 times on a per-ton basis, whereas the waterborne charge would be less than the quarry cost per ton.[176] The quantity of heavy trucks needed to replace Laker deliveries, including their impact on road traffic congestion and the wear and tear on roads and bridges, also would militate against a significant shift to trucks for long-distance movement.

Instead, if Laker delivery costs were to increase disproportionately to truck delivery costs, some purchasers of limestone would purchase stone from inland quarries nearer to their operations and have the materials delivered directly by truck over shorter haul distances. Even here, however, the tendency to shift modes may be limited in some circumstances. LCA has noted that:

> While aggregate is not in short supply, several Lakes quarries ship a type of limestone that has the chemical properties ideal for use in scrubbers in coal fired power plants. Its high calcium carbonate (>97 percent) and low bond work index make it easier and less expensive to grind in mills. The high $CaCO_3$ scrubs more SO_2 with less stone.[177]

In other words, Michigan limestone may not have close substitutes in specialized applications.

Even in the case of aggregate used for road and other construction, the ability to shift sources is probably limited. For instance, based on freight cost for Laker voyages of under 400 miles (the Michigan quarries are centrally located on the Great Lakes) and per-mile cost truck factors developed by Langer et al.,[178] a buyer considering the purchase of stone from a non-Lake source that is an additional 10 miles away from the buyer's location would only do so if Laker transportation costs increased by almost 25 percent per ton from current levels.[179] This latter estimate may help explain why limestone production is dominated by the Michigan quarry sites at Stoneport, Calcite, Port Dolomite, and Port Inland even though limestone deposits are ubiquitous throughout Michigan and across the region.[180]

Given expected growth in the U.S. and regional economies, the close linkage of demand for limestone and aggregate to economic growth (e.g., for construction, road building, etc.), and the likelihood that northern Michigan and the Lakers will at least maintain their share of the limestone market, MARAD is projecting that Laker movements of limestone and aggregate will grow in the future. Table 17 shows, in millions of ton-miles, how the expected growth trend may materialize over the next 30 years.

TABLE 17. Projected Trade in Limestone by Ton-Mile on the Great Lakes, 2010–2045

YEAR	LIMESTONE AND AGGREGATE (million ton-miles)
2010	8,735
2015	8,894
2020	9,550
2025	10,690
2030	11,595
2035	12,505
2040	13,491
2045	14,142

CHAPTER 6

FACTORS IMPACTING THE FUTURE OF THE U.S.-FLAG GREAT LAKES INDUSTRY

As discussed in previous chapters, the current status of the current U.S.-flag Great Lakes marine transportation industry is one of relative stability. Although hit hard by the recession of 2007–2009, Great Lakes cargoes have recovered moderately. Lakers in operation today are efficient self-unloading vessels that are often able to move bulk cargoes at costs significantly lower than those of rail or truck services.

Studies by USACE to support its 2010 *Supplemental Reconnaissance Report* show major freight cost savings associated with the use of Lakers compared to the next most competitive transportation mode (rail or truck). Most of these savings would be relative to Laker freight (transportation) rates of from less than $10 to $25 per ton delivered cost (which includes landside transport and port costs) (see Table 18).[181]

With regard to Table 18, it should be emphasized that generic transportation rate comparisons can be misleading because they do not standardize for differences in the speed, timeliness, and seasonality of deliveries. For instance, rail shipments can take place in winter, whereas most Laker traffic stops in January and does not resume again until late March because of ice restrictions. Moreover, transportation rates applied on an average basis to the overall market for a commodity do not capture the effects of competition between transportation modes on specific routes, or even the effects of competition between individual U.S.-flag Great Lakes vessel operators. Accordingly, not all rate studies indicate cost savings per ton at the levels shown in the table. A recent study by EPA, for instance, indicates lower transportation rate differentials between Lakers and rail on more competitive

TABLE 18. Sample Movement Saving Rates per Ton With Use of Lakers (in 2008 Dollars)

COMMODITY GROUP	CANADA–US	FOREIGN–US	US–US	US–CANADA
Wheat	—	—	$32.67	$48.10
Corn	—	—	—	30.36
Soybeans	—	—	—	28.23
Other grains	—	$50.81	—	—
Aggregates	$20.32	—	22.39	20.77
Nonmetallic minerals	32.03	49.11	12.37	20.24
Metallic minerals	27.37	48.02	10.82	10.99
Coal, coke, pet coke	18.18	—	20.00	16.87
Petroleum products	28.78	—	20.75	19.29
Iron and steel	47.15	53.92	44.27	31.09

Source: USACE, Supplemental Reconnaissance Report, Great Lakes Navigation System Review, Appendix C, Economic Summary of the GLNS, Table 3.4, 2010, p. 18. http://www.lre.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=6979&destination=ShowItem.

domestic routes, ranging down to less than $2 per ton.[182]

Thus, Lakers offer cost advantages to shippers that should help assure that the Lakers maintain a continued, major role in regional freight markets. The robustness of this advantage is, on average, significant, indicating that normal fluctuations and developments in the market are unlikely to upset current market shares. However, there are factors that could impact this advantage, particularly in the following areas:

- Environmental regulations;
- Water depths and the need for dredging;
- Condition of Great Lakes infrastructure; and
- Shipyard capacity to enable the rehabilitation of older vessels or the construction of new vessels.

Of course, other factors could also affect Laker competitiveness, such as more aggressive pricing by railroads or unanticipated changes in the efficiencies of surface mode technologies. Because such factors are particularly difficult to anticipate, however, they are not addressed in this study.

Environmental Regulations and Their Impact on the U.S.-Flag Great Lakes Fleet

One of the greatest concerns to the Laker industry in recent years has been the regulation of air emissions and ballast water from Laker vessels. Water transportation is often viewed as a more environmentally friendly transportation alternative to land-based transportation modes (because of greater fuel efficiency per ton-mile of freight moved). However, some Lakers, particularly those that have steam power plants or very large diesel engines, currently use fuels with high sulfur content, and some older engines have high air emissions. Lakers also must take on and discharge large quantities of ballast water when unloading and loading cargoes, potentially contributing to the spread of nonindigenous aquatic species originally brought into the Great Lakes by saltwater vessels and other, nonmaritime vectors such as recreational boating and fishing.[183] EPA, USCG, and State agencies have adopted or proposed various regulations to reduce air and water emissions. While these will reduce vessel impacts, they will increase the capital and operating costs of the Lakers.

Air Emission Regulations

EPA regulates domestic air emissions from vessels and other mobile sources under authority granted by Congress through the CAA.[184] In addition, the APPS authorizes and requires the United States to implement the provisions of MARPOL and the annexes to MARPOL to which the United States is a party.[185] APPS gives EPA sole authority to certify that U.S. marine engines meet the MARPOL requirements.[186]

Air emissions regulations affect vessels in the U.S.-flag Great Lakes fleet differently, depending on the vessel's size and type of engine and the fuel used. Marine diesel engines with per-cylinder displacement less than 30 liters are called Category 1 and Category 2 engines; these typically use distillate diesel fuel. Larger engines, with per-cylinder displacement at or above 30 liters, are called Category 3 engines; they typically use residual fuel.

With respect to Category 1 and Category 2 engines on U.S. Great Lakes vessels, EPA adopted a rule in 2008 that set Tier 3 and Tier 4 standards for NO_x, PM, CO, and hydrocarbon (HC) emissions.[187] These standards apply to new engines installed on ships flagged or registered in the United States. With respect to fuels, EPA adopted a rule in 2004 that sets fuel sulfur content limits for land-based nonroad, locomotive, or marine distillate diesel fuel (called "NRLM" fuel) produced or sold in the United States.[188] A 15-ppm sulfur limit began to apply in 2010; it will be fully phased in by 2014 (compared to the 500-ppm fuel sulfur limit applicable since June 2007).[189] Of the 55 Lakers currently working on the Great Lakes, approximately 30 vessels (55 percent) operate using Category 2 engines that burn distillate diesel fuel subject to the NRLM sulfur limits. To date, however, MARAD has found no evidence or reports that these requirements have excessively harmed Laker vessel competitiveness.

With respect to Category 3 engines on U.S. Great Lakes vessels, EPA adopted a rule in 2010 that sets standards for new engines installed on ships flagged or registered in the United States. The NO_x limits are equivalent to the international NO_x limits contained in MARPOL Annex VI.[190] In addition, EPA's requirements include HC and CO limits,[191] and engine manufacturers are required to report PM emissions.[192] With regard to fuels, Great Lakes vessels with Category 3 engines are required to comply with the fuel sulfur limits applicable in the North American ECA, which includes the Great Lakes.[193] Beginning August 1, 2012, the sulfur content of fuel used onboard any Category 3 ship operating in the North American ECA may not exceed 10,000 ppm (compared to the 35,000-ppm global sulfur cap that would otherwise apply), reduced to 1,000 ppm beginning January 1, 2015.[194] Twelve Lakers (principally Class 8 and Class 10 vessels) currently operate with Category 3 engines that use residual fuel.[195]

The Category 3 Rule also contains several provisions that specifically address the unique operating environment faced by the Great Lakes fleet.[196] These include an economic hardship waiver and a fuel availability waiver that permits a Category 3 Great Lakes vessel to use fuel that exceeds the 10,000-ppm interim ECA fuel sulfur limit until January 2015 on the condition that the vessel operator purchases fuel with the lowest sulfur content available. In addition, because of technical issues, steamships are exempt from the ECA sulfur limits that apply on the Great Lakes.[197] This exemption applies only to ships propelled by steam engines and operated within the Great Lakes before October 30, 2009, and which continue to operate exclusively on the Great Lakes and Saint Lawrence Seaway.[198]

In January 2012, EPA adopted the Great Lakes Steamship Repower Incentive Program.[199] This program provides an automatic, limited, fuel waiver for qualifying Great Lakes steamships that are repowered to diesel engines. In particular, the program allows the owner to use higher sulfur residual fuel in the repowered vessel until December 31, 2025, after which date ECA-compliant fuel must be used. The cost saving of using the higher sulfur fuel through 2025 (higher sulfur fuel costs less per ton than low-sulfur fuel) creates a financial incentive in addition to the greater fuel efficiency of the diesel engine for conversion from steam to diesel. Environmental benefits begin immediately because of the higher fuel efficiency of the diesel engine and continue for the life of the engine, becoming more pronounced after 2025 when low-sulfur fuel is burned. Steamship owners who repower earliest to diesel engines would realize the greatest private benefits from the program. MARAD evaluates the incentive effect of this program later in this study (see Chapter 9).

The repower incentive program would not be usable for conversions of steamships to dual-fuel LNG/diesel engines, however, because these engines cannot burn residual or blended (intermediate) fuels. Some Laker industry representatives have suggested modifications to the program that would provide sufficient flexibility to enable steamships to repower to dual-fuel LNG/diesels, perhaps by transferring the permission to burn higher sulfur fuel to a diesel vessel of comparable size or setting up a "fuel credit" of a fixed quantity of fuel to be used by other vessels in the fleet. However, EPA reports that it has not been formally approached by any company with respect to such a project.

Great Lakes vessels that do not have steam engines are not exempted from the fuel emissions requirements (except under limited circumstances pertaining to fuel availability and economic hardship waivers as noted above). In 2003, EPA estimated that it would cost from $48,000 to $71,000 per vessel to install hardware on Category 3 vessels to accommodate the use of low-sulfur fuel.[200] Additionally, Category 3 vessels that currently use residual fuel will pay a higher price for ECA-compliant fuel compared to the higher sulfur HFO they currently burn. Fuel that will comply with the long-term 1,000-ppm ECA sulfur limit is expected to cost as much as 50 percent more per ton than HFO.[201] MARAD estimates that for low-transportation-rate cargoes such as iron ore, total operator costs per ton of cargo (port and water only, including variable and fixed costs) carried on the 12 Lakers with Category 3 engines could increase from $0.75 to $1.02 per ton depending on vessel size (a 10-percent cost increase overall) following the implementation of the regulation (see Chapter 7, Table 20, for detail). EPA recently reached a similar conclusion for iron ore cargoes in a study on vessels with Category 3 engines, but showed lower percentage cost increases for cargoes, such as coal, that have high landside transportation cost components.[202] For most Laker markets, this cost increase due to higher fuel expense is not predicted to, of itself, lead to a shift of cargoes from Lakers to rail or trucks because of the significant freight cost savings currently available using water transportation.

Ballast Water Management Regulations

All of the U.S.-flag Lakers operate internally to the Great Lakes and are not a source for the introduction of new species into the overall Great Lakes system. However, some authorities are concerned that the Lakers might play a role in facilitating the dispersion of introduced species from one location on the Great Lakes to another. Accordingly, the issue of ballast water management for these vessels has been widely discussed and debated.[203] Rules and guidance for how best to manage ballast water discharges of internal (confined) Lakers arise chiefly from three sources: the Federal Government, State governments, and the industry itself.

Federal Ballast Water Regulations. There are two major U.S. Federal laws that provide the authority for ballast water regulation. The first is the CWA, pursuant to which EPA has issued the National Pollutant Discharge Elimination System (NPDES) Vessel General Permit (VGP).[204] The current VGP (2008 VGP) became effective in 2008 and remains applicable through December 18, 2013.[205] The 2008 VGP permits discharges of effluents (including ballast water, deck runoff, bilge water, and gray water) "incidental to the normal operation of a vessel" in U.S. waters.[206] Since 2008, all applicable vessels, including Lakers, must have coverage under the NPDES VGP before they can legally discharge and operate in U.S. waters.[207] Laker vessels have operated under the 2008 VGP requirements by applying best management practices for ballast water discharges.

In December 2011, EPA published a Draft VGP (Draft 2013 VGP) for public comment.[208] The Draft 2013 VGP will be finalized by March 15, 2013,[209] and will become effective upon the expiration of the 2008 VGP in December 2013 so that vessel owners have time to prepare for and comply with the new requirements.[210] A new provision of the Draft 2013 VGP is a numeric standard to control the release of nonindigenous aquatic species in ballast water discharges.[211] The new ballast water discharge standard addressing aquatic species is generally consistent with the limits contained in the International Maritime Organization's (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediments (IMO standard). The Draft 2013 VGP does not require Lakers built before January 1, 2009, that operate exclusively in the Great Lakes upstream of the Welland Canal (referred to as "confined" Lakers) to comply with the numeric standard, but rather to employ Best Management Practices.[212] This requirement recognizes that no systems that can accommodate Lakers' ballast water flow rates exist or are likely to be developed during the time of the VGP.[213] The Draft 2013 VGP notes that alternative technologies are being researched and is seeking comment as to whether the numeric ballast water treatment limits should be applicable to existing confined Lakers.[214] EPA states that it will "closely follow the state of technologies currently being tested for the confined Lakers and will consider revising permit requirements during the term of the permit when such technologies do become available."[215] All confined Lakers built after January 1, 2009, would be required to meet the numeric technology-based effluent limits for ballast water treatment found in the VGP.[216]

Instead of numeric limits, EPA has proposed three ballast water management measures for Lakers built before January 1, 2009.[217] These measures are developing sediment management measures, minimizing the amount of ballast taken in near-shore environments, and requiring inspection of sea chest screens and repair as necessary.[218] EPA stated that these requirements are available and economically achievable, as they represent "simple to implement and common sense approaches."[219]

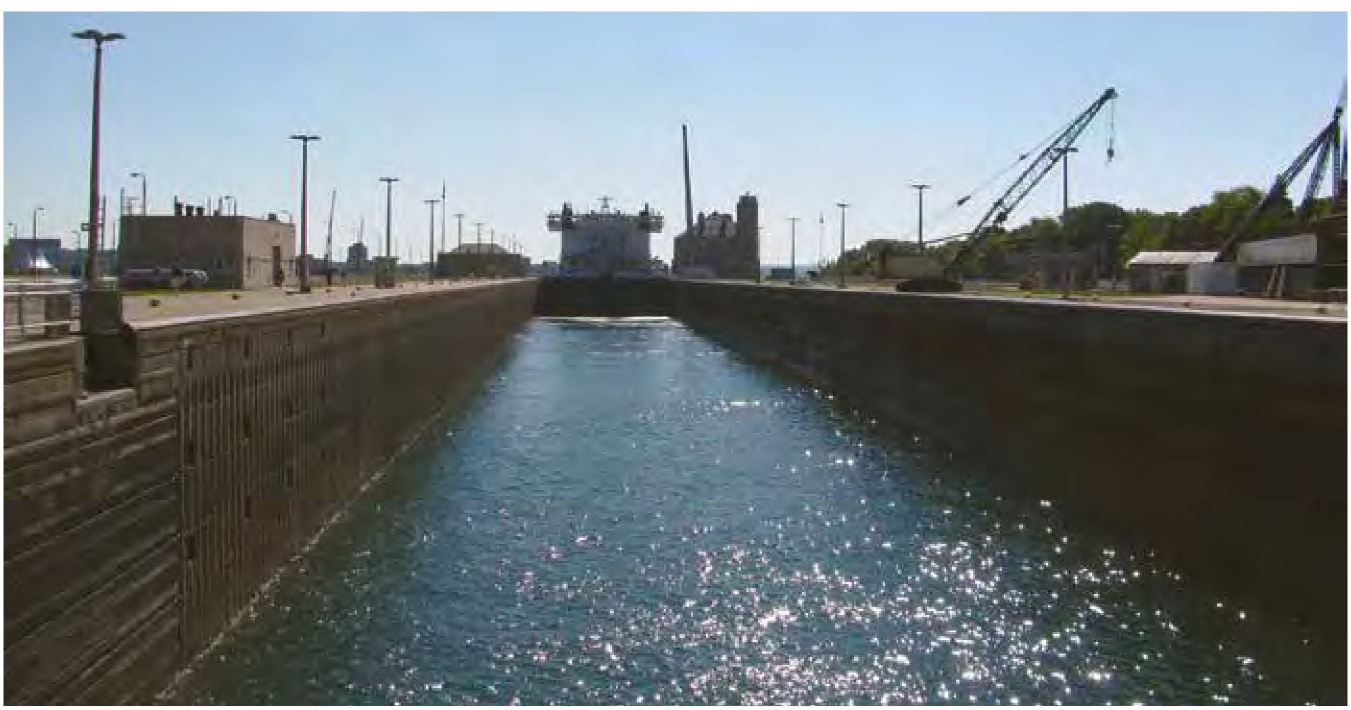
The second Federal regulatory source for the management of ballast water is the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended by the National Invasive Species Act of 1996, pursuant to which the USCG promulgated the "Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters" (USCG BW rule), issued as a final rule on March 9, 2012, and published in the *Federal Register* on March 23, 2012.[220] Similar to the Draft 2013 VGP, the USCG BW rule limits the numbers of living organisms in particular volumes of water discharged from vessels in U.S. waters and reflects the standards established by the IMO.[221] The rule requires vessel owners to meet the ballast water discharge standard. One option for doing so is to install ballast water management systems (BWMS) on oceangoing vessels that discharge ballast in U.S. waters.[222] As is the case with the Draft 2013 VGP, the USCG BW Rule does not require vessels operating exclusively within the Great Lakes to treat ballast water.[223] In particular, USCG states that it is

> . . . not requiring vessels that operate exclusively in the Great Lakes to comply with the BWDS [ballast water discharge standard(s)] in this final rule…. The Coast Guard intends to re-examine this decision in the near future, and will keep these commenters' requests in mind when developing subsequent rulemakings.[224]

Accordingly, whereas Lakers are not required to comply with numeric standards in the final rule, they may eventually be covered by a follow-on rule.[225]

Industry Response to New Ballast Water Regulations. In comments submitted on EPA's Draft 2013 VGP in February 2012, LCA requested some changes to the ballast water provisions of the VGP.[226] In general, LCA strongly supported the findings of EPA's Science Advisory Board (SAB), which EPA relied on in its decision to not require the Lakers to comply with numeric limits in the Draft 2013 VGP.[227] The SAB concluded:

> In addition to specific environmental and vessel applications, vessel type and vessel operations can dictate BWMS applicability. Although a multitude of vessel designs and operation scenarios exist, a few important examples of specific constraints can greatly limit treatment options. Perhaps the most dramatic limitations are found with the Great Lakes bulk carrier fleet that operates vessels solely within the Great Lakes with large vol-



umes of fresh, and often cold, ballast water ("Lakers"). The vessels in this fleet have ballast volumes up to 50,000 m^3, high pumping rates (up to 5,000 m^3/hour), uncoated ballast tanks (older vessels), and some vessels have separate sea chests and pumps for each ballast tank. A further confounding issue is that voyages taken by Lakers average four to five days, with many less than two days. Given these characteristics, a number of limitations are imposed: electrochlorination and ozonation may only work in freshwater with the addition of brine (in particular Cl [Chlorine] and Br [Bromine], respectively); oxidizing chemicals may increase the corrosion rate of uncoated tanks; deoxygenation and chemical treatments that require holding times to effectively treat water (or for the breakdown of active substances) may not be completely effective on short voyages; and the space and power needed for the required numbers of filtration + UV treatments may simply not be available.[228]

LCA agrees with EPA and SAB about the lack of a BWMS that would be suitable for Laker operations in fresh water.[229] It concurs with the SAB's statement that many Laker voyages are less than 2 days and asserts that a significant number of voyages are just a few hours.[230] LCA reports that its vessels must load and discharge cargo as quickly as possible to remain competitive with the railroads.[231] Fast loading and unloading expedites the rates of cargo movement and increases the number of voyages a given vessel can make in 1 year, reducing costs per ton of cargo moved. LCA notes that the largest Laker self-unloaders can transfer almost 70,000 tons of cargo in less than 10 hours. To accommodate these requirements, the largest vessels each must be able to discharge up to 16 million gallons of ballast at maximum flow rates approaching 80,000 gallons per minute.[232]

The quick loading and unloading times enable a relatively small number of Lakers and regional ports to service the water transportation needs of the Great Lakes region. If loading times were to increase, each vessel could make fewer trips each year, resulting in the need to recover vessel capital and operating costs over a smaller number of tons of cargo moved and therefore increasing transportation rates. As noted in LCA's comments on the Draft 2013 VGP:

> The reason a vessel in the Head-of-the-Lakes trade (Lake Superior to the Lower Lakes) can make 50-plus trips in a season is because it can load and discharge cargo in 10 hours or so. Lengthen those times to 20 or 30 hours and the vessel will forfeit trips. Based on a five-day roundtrip and increasing both the load and discharge times from 10 to 20 hours would reduce a vessel's seasonal carrying capacity by almost 15 percent.[233]

LCA states that its members have conducted research that indicates the capital cost for a theoretical BWMS that would meet IMO standards on a 1,000-foot-long vessel could range from approximately $17 million to $20 million.[234] If accurate (as noted, a BWMS suitable for confined Lakers does not yet exist), the cost of outfitting the 13 such vessels operating on the Great Lakes would be about $235 million. LCA estimates that the theoretical cost for smaller vessels would start at $3 million and peak at roughly $8.5 million.[235] Using an average of $5.75 million for the other 43 LCA Laker vessels, the costs would be nearly $250 million. In total then, LCA argues that its members could have to spend $485 million to retrofit their vessels with a compliant BWMS.

LCA also asserts that additional potential vessel expenses could include costs of as much as $1.1 million per year in fuel to operate the BWMS on the largest ships, annual maintenance costs of $100,000 for some vessels, and the loss of significant cargo capacity because of the need to accommodate large BWM systems.[236]

Finally, port constraints caused by longer vessel loading and unloading times could be severe and not easily remedied. New investments in port docks and supporting rail, space permitting, would be expensive (by one industry estimate, a new iron ore dock in Minnesota could cost $1 billion to construct) and would need to be recovered through higher cargo-transfer fees charged to Lakers or their customers.[237]

In summary, LCA has cited a range of potential impacts of ballast water treatment that it believes could adversely affect the competitiveness of Laker services if BWM systems are required in the future. MARAD notes, however, that until such time that a suitable BWMS can be developed and studied, it cannot provide an independent estimate of additional vessel loading and discharge times or the capital and operating costs of such a system.

Regional Policy Concerning Ballast Water. The Great Lakes Regional Collaboration of National Significance (GLRC) was established in December 2004 to develop a strategic plan to restore and protect the ecosystem of the Great Lakes.[238] It was formed as a partnership of key members from Federal, State, and local governments, tribes, and other stakeholders. One of the eight strategy teams formed under the GLRC focused on nonindigenous aquatic species. Among this team's multiple recommendations, reported in 2005, was to immediately require, verify, and enforce best performing shipboard ballast water treatment and hull management methods for oceangoing vessels (with increasing standards as treatment performance improves) and to "review and apply best-performing ballast water management practices to non-oceangoing vessels operating exclusively within the Great Lakes (including application of ballast water treatment for new ships) to eliminate the spread of AIS [aquatic invasive species] already introduced into the system."[239] Other recommendations focused on control through other vectors (including canals and waterways and trade of live organisms), rapid response to species introductions, and outreach and education programs.[240]

State Regulation of Ballast Water. The emphasis above is on Federal regulation of ballast water management. Under the CWA, however, individual States can impose standards that are more restrictive than those established by Federal agencies.[241] A State may issue regulations under authority of the State legislature as well as permits and conditions attached to the State's certification of the VGP under Section 401 of the CWA.[242]

Lakers almost always serve multiple States—LCA reports that only one of its members' vessels (a supply boat) serves only a single State, so the actions of one State can have impacts over the entire Great Lakes system.[243]

Under the current 2008 VGP, several of the eight States with shorelines on the Great Lakes imposed ballast water standards on Lakers that were more stringent than the Federal management measures.[244] In addition to the best management practices contained in the 2008 VGP, Minnesota and Illinois required compliance with IMO numeric standards for all vessels, including Lakers, built before January 1, 2012, by January 2016, whereas vessels built after January 1, 2012, must comply by time of delivery. Ohio also required IMO numeric standards for vessels in its waters, but excluded existing Lakers from the numeric standards and extended the compliance schedule for new-built Lakers to January 1, 2016. Pennsylvania established IMO standards but withdrew them. Until February 2012, New York required standards 100 times more stringent than the IMO for existing confined Lakers (effective by August 2013) and 1,000 times more stringent than IMO for new-built Lakers launched in January 2013 and after. On February 22, 2012, New York deferred its proposed standards, leaving in place EPA's 2008 VGP standards, and agreed to work toward a national standard.[245]

The Laker industry indicated through LCA's comments on the Draft 2013 VGP that it is unlikely that it could comply with the IMO standard during the period covered by the 2013 VGP (through December 18, 2017), noting that "We have already explained why it is effectively impossible for our members' vessels to comply with these ballast water treatment standards now and not likely during the period covered by this permit."[246] Based on the 401 Certifications for the Draft 2013 VGP made available for public review and comment as of May 2012, no Great Lakes State has imposed a numeric discharge standard on confined Lakers. Some States remain interested in future application of such a standard.[247]

Great Lakes Ballast Water Collaborative. In 2009, USDOT's Saint Lawrence Seaway Development Corporation initiated the Great Lakes Ballast Water Collaborative (BWC) in conjunction with the International Joint Commission.[248] The BWC serves to bring together marine industry representatives, researchers, and State and Federal regulators to find workable and effective solutions to the nonindigenous aquatic species challenge in the Great Lakes–St. Lawrence Seaway System. One of the primary goals of the BWC is to share relevant, useful, and accurate information and foster better communication and collaboration among the key stakeholders. The aim of the BWC is not to take away from any pre-existing efforts in this regard, but rather to complement those efforts.

In September 2009, the BWC held its first meeting in Detroit, MI. To date, the Saint Lawrence Seaway Development Corporation has co-hosted six BWC meetings at different locations throughout the region surrounding the Great Lakes–St. Lawrence Seaway System. BWC meeting attendees have included representatives from State and Provincial governments

(Minnesota, Wisconsin, Illinois, Ohio, Michigan, New York, and Ontario); U.S. and Canadian regulatory agencies; senior executives from the U.S.-flag Laker, Canadian-flag Laker, and international fleets; and leading academic ballast water researchers from Canada and the United States. Recent discharge permit actions by two States indicate that information shared by the BWC is contributing to a more uniform regulatory approach for ballast water for the Great Lakes.

Voluntary Management Protocols. The Laker industry has been involved in establishing and promoting best practices for ballast water management. In 1993, LCA developed a voluntary ballast water management policy designed to limit the spread of invasive species within the Great Lakes basin.[249] LCA updated the policy annually and expanded its scope over time until the implementation of the 2008 VGP, which superseded the need for a voluntary policy. Laker carriers now update their vessel management plans periodically in response to new VGP, Federal, or State requirements. Prior to the 2008 VGP, LCA developed specific management plans for particular threats, such as LCA's *Supplemental Voluntary Ballast Water Management Plan for the Control of Viral Hemorrhagic Septicemia Virus,* 2008 Edition.[250] The voluntary plans and protocols were discontinued with the advent of the 2008 VGP.[251]

Water Depths of the Great Lakes and Impacts on Navigation

The Great Lakes contain more than 5,500 cubic miles of water, covering a total area of 94,000 square miles. Collectively, they represent the largest system of liquid fresh water on the Earth's surface. The fresh water in the Great Lakes represents approximately 21 percent of the world's supply and 84 percent of North America's supply. Only the polar ice caps contain more fresh water.[252]

Figure 8 illustrates the Great Lakes water table, with Lake Superior having the greatest maximum depth (1,333 feet), followed by Lake Michigan (923 feet), Lake Ontario (802 feet), Lake Huron (750 feet), and Lake Erie (210 feet). The average depth of the Great Lakes also varies by lake, with Lake Superior having the greatest average depth of 483 feet and Lake Erie having the shallowest average depth of 62 feet.[253]

Despite this abundance of water, overall controlling depths[254] for navigation on the Great Lakes are determined by the congressionally authorized depths of the Soo Locks complex at Sault Ste. Marie, MI, and the channels that connect the Great Lakes to each other,

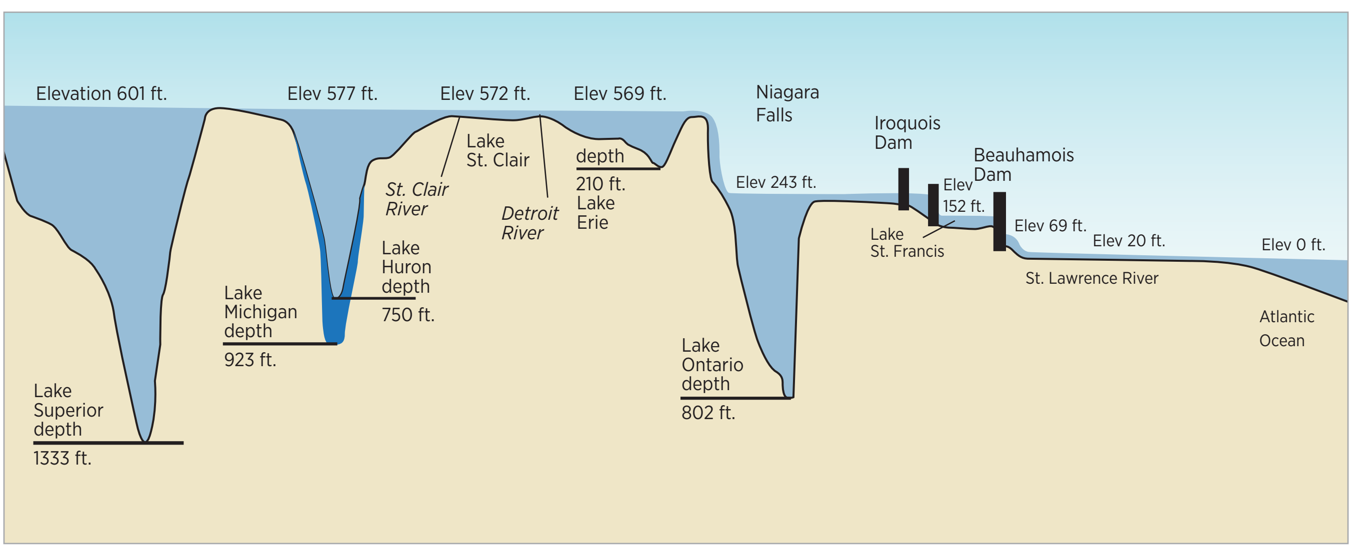


FIGURE 8. Great Lakes system profile.

(Source: NOAA, Great Lakes Environmental Research Laboratory, "Water Levels of the Great Lakes," Feb. 2012, at http://www.glerl.noaa.gov/pubs/brochures/lakelevels/lakelevels.pdf.)

including the St. Mary's River (connecting Lake Superior to Lake Huron); the St. Clair River, Lake St. Clair, and Detroit River (connecting Lake Huron to Lake Erie); and the Straits of Mackinac (connecting Lake Michigan and Lake Huron).[255] The controlling depths of these connecting channels range from 27 feet for the St. Mary's and St. Clair rivers to 30 feet for the Straits of Mackinac at Low Water Datum (LWD).[256]

The controlling depths cited above are measured relative to the LWD depth; the water levels in the lakes and connecting channels are typically higher. Lake water levels will, by definition, be above LWD depth 95 percent of the time.[257] Thus, in the case of the St. Clair River, Lake St. Clair, and Detroit River, for instance, vessels can usually pass through this system safely with drafts of 27.5 feet, and in periods of high water levels, vessels have passed through this system with drafts as deep as 28.5 feet.[258]

Every inch of draft at these channel depths is important to Laker operators. Many Lakers can operate at drafts of more than 27 feet, with some vessels able to operate at drafts of more than 30 feet.[259] The deposition of sand, silt, and small gravel in channels by currents and streams leads to localized shallowing (shoaling) relative to authorized depths. Shoaling can impede navigation due to loss of draft unless removed through dredging. Each inch of lost draft relative to authorized channel and port depths can lead to the loss of 267 tons of cargo capacity for a 1,000-foot Laker and 71 tons of cargo for a 500-foot Laker.[260] MARAD estimates that the loss of 2 feet of draft from a vessel that would otherwise carry 68,000 tons of cargo would add approximately $0.65 to the cost of each ton of iron ore delivered (see Chapter 7, Table 20, for detail). Note that this estimate assumes a consistent demand for iron ore at full vessel cargo capacity and a 135-hour round-trip voyage without a return cargo. Lost revenue could exceed $40,000 per roundtrip voyage.

During periods of low water on the Great Lakes, such as during the last 10 years (see Figure 9), the water levels in the lakes and the connecting channels drop and may approach or be lower than the LWD depth. For some ports and channels, more dredging may be needed. The following discussion focuses on the factors that affect lake levels and water management.

Great Lakes Water Levels

The water levels on the Great Lakes can change substantially from day to day, season to season, and year to year. These changes can complicate navigation on the Great Lakes, particularly during periods of low water.

Short-term events can lead to marked changes in water levels. These events include prevailing winds, storm surges, water oscillations within the Lake basin (called "seiches"), and aquatic plant growth and ice dams in connecting channels.[261] Sometimes these effects can be dramatic, such as when ice dams materialize quickly and cut water flows on the St. Clair River by as much as 65 percent in extreme circumstances.[262] Seasonal factors, particularly those that impact the relative changes in the balance of precipitation and evaporation rates, lead to water level fluctuations on the Great Lakes that average between 12 and 18 inches, lowest in winter and highest in summer. Seasonal rises begin earlier (June or July) on the more southern lakes where it is warmer, and later in the summer for Lake Superior (August or September).[263]

The Great Lakes are subject to long-term fluctuations in water levels, occurring over periods of several consecutive years, because of either continuous wet and cold conditions that cause water levels to rise or to consecutive warm and dry years that cause water levels to fall.[264] These changes, attributable to natural climatic variability, can lead to differences of nearly 4 feet between high and low extremes on Lake Superior and between 6 and 7 feet for the other Great Lakes. The Great Lakes system experienced extremely low water levels in the late 1920s, mid-1930s, and again in the mid-1960s. The Great Lakes saw extremely high water levels in the 1870s, early 1950s, early 1970s, mid-1980s, and mid-1990s.

Water levels have been falling from their most recent peak in the mid-1990s, reaching near-record lows in 2007 in some cases.[265] USACE reported that by November and December 2012, the water levels on Lake Michigan and Lake Huron matched their record lows for those months, and projected that they would set new all-time record lows in January through March 2013.[266] USACE also predicted that Lake Superior would be within 7 inches of the record low water level set in 1926 by late March 2013.

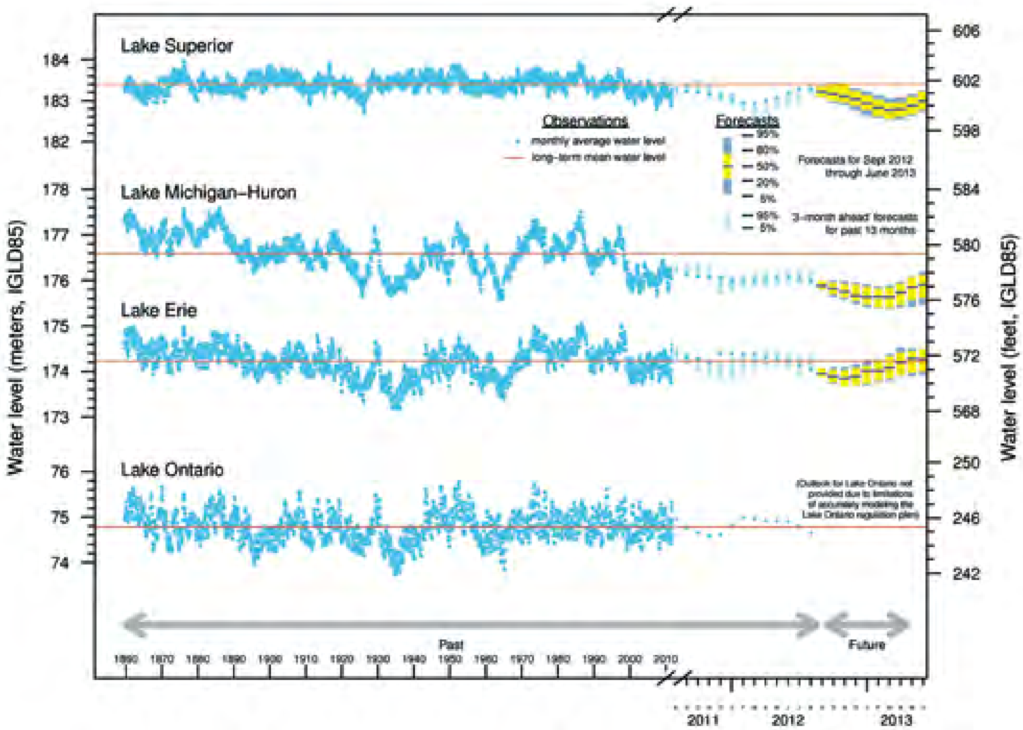


FIGURE 9. Observed and predicted water levels for the Great Lakes through June 2013.

(Source: NOAA, Great Lakes Environmental Research Laboratory, "Water Levels of the Great Lakes," Sept. 2012, at http://www.glerl.noaa.gov/pubs/brochures/lakelevels/lakelevels.pdf.) Note that GLERL produces a seasonal forecast for research purposes. The official "operational" Great Lakes water level forecast is produced by the coordinated efforts of the USACE and Environment Canada.

Figure 9 graphs Great Lakes water levels from 1860 to June 2013 and demonstrates the relative reduction in Great Lakes levels since 2000, particularly on Lakes Michigan, Huron, and Superior.

Geologic and Human Impacts on Great Lakes Water Levels

Although much of the long-term variation in Great Lakes water levels is attributable to natural climatic factors (which are difficult to predict into the future), there are geologic and manmade factors at work as well. Geologic impacts are represented by "crustal rebound." Water levels at different locations in the Great Lakes change over periods of decades by the gradual rebounding of the Earth's crust as it adjusts to the removed weight of the glaciers that carved out much of the Lakes more than 14,000 years ago. Crustal rebound is most pronounced where the glacial ice was the thickest and remained the longest—in the northeastern part of the Great Lakes basin. Accordingly, the Earth's crust is rising by 18 to 21 inches per century in the most northeasterly part of Lake Superior but not at all in southern Lake Michigan.[267]

This crustal adjustment does not change the volume of water in the Lakes but rather "tips" the lake water to the southwest away from the northeast.[268] In the case of Lake Superior, where the crustal rebound is most pronounced, the water level near Duluth is higher and the water level at Thunder Bay is lower than they were a few decades ago (all else being equal). The effect is much less pronounced elsewhere on the Great Lakes.[269]

More significant and controversial impacts on lake levels are associated with human activities. There are several activities that are deemed most significant, including water diversion and removal, deepening and dredging of connecting channels, and, over the longer term, climate change caused by GHG emissions. The complexity of these factors is such that a consensus view of their collective impacts has yet to emerge.

Diversions. Diversion of water out of Lake Michigan has taken place since 1848, but there are also diversions into Lake Superior.[270] Overall, USACE estimates that the net effect of interbasin diversions (the Ogoki and Long Lac diversions from Canada to Lake Superior and the Lake Michigan diversion at Chicago) has been to transfer more water into the Great Lakes than out of it.[271] Nonetheless, the diversion of any water is controversial.

The U.S. Supreme Court issued a decree in 1967 (amended in 1980) that allows Chicago to divert a total of 3,200 cubic feet of water per second from Lake Michigan for navigation, domestic water use, and sanitation.[272] This amount reduces the water level in Lakes Michigan and Huron by 2.5 inches, Lake Erie by 2 inches, and Lakes Ontario and Superior by 1 inch from what would prevail without the diversion.[273]

In 1995, a dispute arose between Michigan and Illinois because Chicago (for technical reasons, including leakage through the Chicago Sanitary and Ship Canal locks) was diverting approximately 309 cubic feet per second more water from Lake Michigan than allowed by the 1967 court decree, as amended in 1980.[274] The Federal Government and the eight Great Lakes States went to mediation over this dispute. In October 1996, an agreement was reached whereby Illinois reduced the diversion of water from Lake Michigan to the 1967 level, as amended. The eight Great Lakes States agreed in turn not to take legal action over the diversion violations that had already occurred.[275]

In 2003, the eight U.S. States bordering the Great Lakes and the Canadian provinces of Ontario and Quebec negotiated the Great Lakes–St. Lawrence River Basin Water Resources Compact (commonly referred to as "Annex 2001"). In September 2008, the U.S. Congress gave its approval to Annex 2001, with the President signing the compact into law on October 3, 2008.[276] The compact bans most new diversions of water from the Great Lakes Basin, requires a consistent standard throughout the Great Lakes Basin to review proposed uses of water from the Great Lakes, and requires development of regional, State, and Province goals and objectives for water conservation and efficiency.[277] As such, the compact establishes the framework for protecting the Great Lakes from water diversions that could lead to significant changes in water levels.

Deepening of Connecting Channels. Efforts to deepen the connecting channels between the Great Lakes, including the removal of shoals, have taken place almost since the start of commercial navigation on the Great Lakes. Channels were at 20 feet in depth by 1900, reaching 25 feet in the 1930s and 27 feet or more by the 1960s.[278]

Deepening of channels enables greater water flows from the upper lake to the lower lake, and leads to a drop in the water levels of the upper lake (all else being equal), although this effect is anticipated by planners and expected to stabilize over a period of time after the deepening occurs.[279] In the case of deepening of the St. Clair River in 1960–62, water levels on Lakes Michigan and Huron had been expected to fall by about 5 inches (0.13 meter) over a 10-year period.[280] One analysis reports, however, that significantly more water has been lost because of increased flows associated with continuing erosion caused by the water flow through the deepened channel,[281] leading to water level declines from Lakes Michigan and Huron through 2007 of more than 9 inches.[282]

Although there is no consensus on the degree to which deepening of channels can accelerate erosion and lead to greater water loss (many factors, such as changing rainfall, complicate the analysis), the concern about deepening of connecting channels has led to a cessation in planning for future deepening. In its *Supplemental Reconnaissance Report,* USACE notes that

> . . . due to concerns about lower lake levels potentially being exacerbated by such deepening and potential social and environmental impacts, alternatives involving major dredging of the connecting channels will not be carried forward. However, minor dredging of specific locations that act as control points may be considered on a case-by-case basis.[283]

Climate Change. Perhaps the greatest unknown regarding future lake levels is the impact of global warming and climate change. GHG emissions, including CO_2, are anticipated by many scientists to lead to significant warming of the Earth's atmosphere. If warming does occur, effects could include reductions in rainfall, increased evaporation off the Great Lakes, and increased evapotranspiration (the sum of evaporation and plant transpiration from the Earth's land surface to the atmosphere) and therefore reduced water runoff to the Great Lakes.[284] These effects would translate to lower lake levels basinwide to varying degrees on each lake.

Estimated reductions in future water levels because of climate change vary widely. Recent studies, summarized by USACE in 2010, suggest potential reductions over the next half-century from 4 to 14 inches on Lake Superior; 10 to 44 inches on Lakes Michigan and Huron; 8 to 38 inches on Lake St. Clair (which is part of the connecting channel between Lake Huron and Lake Erie); and 5 to 32 inches on Lake Erie.[285] Reductions at the high end of these ranges, particularly on Lakes Michigan and Huron, could create significant problems in the next decade (particularly when combined with water losses from other sources described above). However, more recent work released by National Oceanic and Atmospheric Administration (NOAA) scientists[286] based on revised modeling assumptions indicates a less extreme range of possible water losses of up to 36 inches on Lakes Huron and Michigan, with possible rises of up to 20 inches.[287] Another recent study indicates losses of 24 inches or less.[288] In any case, such changes will take decades to play out.

In summary, the various long-term factors influencing the water levels of the Great Lakes suggest that the trend will be toward lower water levels in the future. Year-to-year changes in rainfall could lead to more or less water entering the Great Lakes and disguising the effects of longer term trends such as climate change. However, whereas deepening of connecting channels below currently authorized depths is problematic because of effects on interlake flows, there is a critical need, particularly during low-water periods, to pay close attention to dredging of ports and channels to their federally authorized depths for safe vessel passage, as discussed below.

Dredging to Authorized Depths

Silt accumulation in the harbors and channels of the Great Lakes waterways system is an immediate problem for the Laker industry. Dredging is a necessary component of Great Lakes navigation—without it most rivers and harbors would become inaccessible for navigation by the current vessel fleet. For instance, St. Joseph Harbor in southwest Michigan was closed to navigation in December 2011 because of shoaling caused by a storm. This shoaling prevented the arrival of a number of vessels and required the use of heavy trucks to transport cement and gravel from as far away as Muskegon, MI (emergency funds were obtained to dredge the harbor in January 2012).[289] It should be noted that St. Joseph Harbor has a shallower authorized depth (18 feet) than the principal ports served by the Lakers. In general, however, LCA asserts that silting of harbors and

channels has led to light-loading vessels, thus increasing shipper costs because cargo that could otherwise be carried at authorized depths is left on the wharf. LCA states that many harbors are in need of 12 to 60 inches of dredging[290] and considers what it calls the current backlog of dredging needs to be a "crisis."[291]

Dredging on the Great Lakes presents particular challenges, not the least of which is the appropriate use or disposal of dredged materials. Significant quantities of these materials are contaminated with industrial materials and must be deposited in Confined Disposal Facilities or Dredged Material Disposal Facilities. Many of these facilities are at or near capacity, and either they must be expanded or new facilities must be built.[292]

MARAD notes that USACE is fully engaged in resolving issues pertaining to dredging. USACE identified the scope of needed dredging in its recent *Supplemental Reconnaissance Report*.[293] In particular, USACE estimates that it would cost $40 million per year to dredge sediment from Great Lakes ports and channels at the average rates at which sediment is deposited across the system. The Corps has also identified $200 million (one-time) in additional potential work to dredge sediment from these ports and channels, although this work is considered a lower priority than the Operations and Maintenance work that is now being funded nationwide (on the Great Lakes and elsewhere) on an annual basis.[294] Funding for dredging is financed from the Harbor Maintenance Trust Fund (HMTF) but must be appropriated by Congress. Access to HMTF funds is a source of controversy throughout the U.S. marine transportation industry, not only on the Great Lakes. The HMTF has a surplus that is approaching $7 billion.[295]

Deepening Beyond Current Authorized Depths

USACE has identified a list of 26 Great Lakes harbors (as opposed to connecting channels) that could potentially benefit from deepening to below currently authorized depths.[296] These harbors (listed in Figure 10) handle significant tonnages of cargo from vessels that for various reasons (e.g., water depth, wind conditions) are frequently light-loaded or delayed. Other ports, such as Green Bay (WI) and Frankfort, Manistique, and St. Joseph (MI) are also interested in potential deepening. USACE notes that deepening of individual ports or port pairs would not negatively impact water levels "such as may occur with expanding the entire connecting channel system." Its 2010 report recommends feasibility studies to examine options for possible deepening of these harbors, based on more detailed assessment of the costs and benefits, if interested non-Federal cost-sharing sponsors can be identified.[297]

Condition of Locks and Infrastructure

USACE reports that there are nearly 104 miles of navigation structures (over 100 miles of which are breakwaters) that form the 117 federally recognized har-

PORT	PORT	PORT
1. Superior, WI	10. Detroit, MI	18. Calcite, MI
2. Indiana Harbor, IN	11. Calumet Harbor, IL	20. Alpena, MI
3. Dearborn, MI	12. Taconite Harbor, MN	21. Lorain, OH
4. Escanaba, MI	13. Silver Bay, MN	22. Cleveland, OH
5. St. Clair, MI	14. Two Harbors, MN	23. Ashtabula, OH
6. Duluth, MN	15. Presque Isle\Marquette, MI	24. Conneaut, OH
7. Saginaw, MI	16. Gary, IN	25. Fairport, OH
8. Monroe Harbor, MI	17. Burns Harbor, IN	26. Toledo, OH
9. Sandusky Harbor, OH		

FIGURE 10. USACE preliminary list of harbor deepening candidates.

bors operating within the Great Lakes Navigation System.[298] USACE has developed a prioritized list of structures (including breakwaters, piers, and pier heads) to repair or replace pending available funding.[299] Over the long run, these repair and replacement actions will be critical to the continued health of Great Lakes shipping and other important economic activities (e.g., recreational boating and fishing) on the Great Lakes. In the near term, however, apart from the need for dredging, the focus of concern for the Laker industry with regard to infrastructure is on the Soo Locks.

Soo Locks

The Poe Lock at the Soo Locks facility at Sault Ste. Marie, MI, is the single greatest infrastructure vulnerability for navigation on the Great Lakes. It alone has the necessary dimensions to pass all Lakers that carry ore and coal from Lake Superior to the lower Lakes. Were it closed to traffic because of an accident or structural failure, USACE estimates that approximately 70 percent of commercial tonnage would be unable to transit the facility except by offloading cargo to smaller vessels or land-based modes.[300]

USACE has established that proactive maintenance of the Soo Locks will prove far more cost effective than reacting to unplanned failures. Accordingly, it has developed a detailed 6-year Soo Locks Asset Renewal Plan to rehabilitate and modernize the existing infrastructure of the Soo Locks facility.[301] This plan outlines the work necessary over the next 6 years to reduce the risk of unscheduled closures and to provide reliable infrastructure through the year 2035 at the Soo Locks.

Congress also authorized a second Poe-sized lock in the Water Resources Development Act of 1986, and in 2007 allowed the project to go forward without a non-Federal cost-sharing partner. To date, $17 million of the estimated total cost of $580 million has been appropriated.

Breakwaters

The Great Lakes coastline of over 10,000 miles is often subjected to harsh weather and wave conditions, with storm-generated waves sometimes reaching 10 to 24 feet in height. These storm-generated waves exert powerful forces on coastal structures, especially when accompanied by ice. Breakwater structures serve to protect commercial ports and harbors (as well as municipal waterfronts) from erosion or damage from this excessive wave action. They also provide critical flood and storm protection for local buildings, roads, and facilities built near the waterfront.[302]

The maintenance and periodic repair of these breakwater structures is important to reducing the risk of impacts such as:[303]

- Deterioration of harbor structures;
- Reduced protection of coastal assets, putting critical city infrastructure at risk;
- Increased shipping costs if failures occur in key commercial harbors; and
- Substantial damage to urban areas.

The need to repair many of the breakwaters on the Great Lakes system is identified as a critical need in USACE's 2010 *Supplemental Reconnaissance Report,*[304] and the American Great Lakes Ports Association has identified 12 regional ports that have breakwater structures in urgent need of repair and rehabilitations.[305] These structures, along with harbor dredging, help insure against loss of port capacity on the Great Lakes.

Icebreaking Capacity

Although not typically treated as transportation infrastructure, icebreaking capacity on the Great Lakes is critical to navigation. Ice typically begins to form on the Great Lakes in early December and can stay well into April and even into May in some years, with thicknesses of 3 to 4 feet and windrows (slabs of ice piled atop one another by the wind) reaching 12 to 15 feet high.[306] Beginning in December of each year, the USCG operates icebreaking vessels on the Great Lakes to provide search and rescue, make urgent responses to vessels, respond to critical community service requests (including flood control and opening channels to icebound communities or breaking ice for ferry services), and facilitate navigation to meet the reasonable demands of commerce.[307] The two principal Great Lakes icebreaking operations are Operation Taconite and Operation Coal Shovel. Operation Taconite encompasses Lake Superior, the St. Mary's River, the Straits of Mackinac, Lake Michigan, and northern

Lake Huron. Operation Coal Shovel encompasses southern Lake Huron, the St. Clair/Detroit River systems, and Lakes Erie and Ontario, and includes the St. Lawrence Seaway.[308]

USCG has eight icebreakers stationed on the Great Lakes, of which one (the *Mackinaw*) is a modern, purpose-built icebreaker.[309] Five icebreakers (140-foot icebreaking tugs) were built in the 1970s and are reported to be nearing the end of their design service lives.[310] Two vessels built in the last decade, designed to be buoy tenders but strengthened to break ice, experience difficulty in heavy ice.[311] To supplement its capacity, the USCG is able to bring East Coast icebreakers into the Great Lakes via the Seaway. In 2012, the Coast Guard approved the homeport change of one icebreaker from the East Coast to the Great Lakes. Additionally, USCG reports that the 140-foot icebreaking tugs are scheduled to undergo Service Life Extension Projects over the next several years to extend their service lives beyond the original design service lives.

In 2006, the heavy icebreaker USCGC *Mackinaw* (WAGB-83, launched and commissioned in 1944) was replaced by a new USCGC *Mackinaw* (WLBB-30).[312] The new *Mackinaw*, built at Marinette Marine Corporation Shipyard in Marinette, WI, has modern systems and diverse capabilities including servicing buoys, search and rescue, law enforcement, and the ability to deploy an oil-skimming system to respond to oil-spill situations, in addition to its primary mission of icebreaking.

Even with the arrival of the new *Mackinaw,* Laker operators have expressed concern about the adequacy of the icebreaker fleet. In the spring of 2008, LCA reported that its members lost $1.3 million due to ice damage to vessels.[313] In 2009 some companies delayed sailing until ice conditions could ease to avoid more vessel damage.[314] In February 2010, LCA reported that heavy ice conditions—especially an ice jam on the Detroit River—had caused the cancellation of coal cargoes that totaled more than 100,000 tons in January of that year.[315] LCA supports the overhaul of the five 1970s-built icebreakers (perhaps with repowering to LNG engines) and the permanent relocation of another vessel of this class to the Great Lakes.[316] LCA also supported a congressional effort to fund a second heavy icebreaker at $153 million in 2009.[317] The Great Lakes Maritime Task Force continues to call for a second heavy icebreaker, equivalent to the new *Mackinaw,* to offset the downsizing of Canada's icebreaking fleet on the Great Lakes, which has fallen from seven vessels to two in recent years.[318]

Shipyard Capacity

Shipbuilding on the Great Lakes has a rich history. Wooden sailing vessels have been built for navigation on the Lakes since 1679 and, following the War of 1812, thousands of sailing vessels built on the Lakes, particularly schooners, carried the grain, lumber, and other materials in commerce.[319] The first steamboat on the Great Lakes, built on Lake Erie, entered commerce in 1818.[320] The first iron-hulled steamship built on the Great Lakes was launched at Cleveland in 1882, followed by steel-hulled ships 10 year later.[321] Steel-hulled ships built on the Great Lakes since 1920 have been built using a system of longitudinal framing on the deck and bottom and transverse framing in the sides.[322] This system, which emphasizes longitudinal strength, enabled Great Lakes vessels to grow to 640 feet in length during the Second World War, 730 feet in 1958, and, with the opening of the expanded Poe Lock, to slightly more than 1,000 feet by 1973.[323]

At peak activity during the Second World War, 23 Great Lakes shipyards could build vessels up to 300 feet in length, 23 could build vessels up to 400 feet in length and 14 could build vessels of 500 feet or more.[324] Activity fell off rapidly after the war, followed by some resurgence in the 1970s and early 1980s. Thereafter, following the recession of 1981–82, new building of Lakers almost ceased. Since 1990, only four composite tug-and-barge U.S.-flag Laker units have been built (in 1996, 2000, 2006, and 2012),[325] although the shipyards have refurbished or repowered various Lakers and have maintained the overall fleet in good condition.

As of 2011, there are eight active U.S. shipyards with major dry docks along the Great Lakes, accounting for a total of 12 dry docks among them.[326] These dry docks are split between five floating dry docks and seven graving docks.[327] Of the eight shipyards, four have dry docks that can accommodate vessels over 400 feet in length, of which two have dry docks that can accommodate vessels over 1,000 feet long (see Table 19).[328] Other shipyards (as of 2011) with major dry docks include Great Lakes Towing Company Shipyard (Cleveland, OH); Basic Marine (Escanaba, MI); Nicholson Terminal and Dock (Detroit, MI); and Soo Marine Dredging (Sault Ste. Marie, MI).[329] Marinette Marine (Marinette, WI) builds littoral combat ships for the U.S. Navy and various other smaller vessels for USCG and other customers. Vessel topside repair and equipment services are also available at various U.S. locations, including (but not limited to) Buffalo, NY; Chicago, IL; Cleveland, OH; Muskegon, MI; Toledo, OH; and Milwaukee, WI.[330]

Great Lakes shipyards are heavily engaged during the winter off-season in making upgrades and repairs to the Laker fleet. LCA estimated that its members would spend $75 million (averaging $1.4 million per vessel) in the 2012 off-season to make improvements to its vessels.[331] The shipyards also support occasional

TABLE 19. U.S. Great Lakes Shipyards With Dry Docks Accommodating Lakers

COMPANY	LOCATION	DRY DOCK 1 Maximum Length Overall (ft)	DRY DOCK 1 Maximum Width (ft)	DRY DOCK 2 Maximum Length Overall (ft)	DRY DOCK 2 Maximum Width (ft)
Donjon Shipbuilding and Repair	Erie, PA	1,100 Graving	130	—	—
Bay Shipbuilding	Sturgeon Bay, WI	1,158 Graving	140	604 Floating	76
Fraser Shipyards	Superior, WI	830 Graving	85	621 Graving	66
Ironhead Marine	Toledo, OH	768 Graving	100	540	101

new constructions (such as a new tug and 740-foot-long, self-unloading barge at the Donjon shipyard in Erie, PA, in 2012)[332] and major repowering operations (such as the winter-long repowering of the 1,013.5-foot-long MV *Paul R. Tregurtha* at Bay Shipbuilding in 2010 or the repowering of the MV *Edwin H. Gott* by the same shipyard in 2011).[333,334]

The demand for new Lakers is not large, however. Long vessel service lives for U.S.-flag Great Lakes vessels, periodic vessel repowerings, and the dropoff in Lake-carried cargo after 1979 are the principal causes of this low demand. The demand for new builds is further reduced by the decisions of many ship owners to refurbish vessel hulls by building new mid-bodies and reusing the bows and sterns, including machinery. In the case of vessels or barges that are less than 740 feet in length and 78 feet in width, Jones Act vessels built in U.S. coastal areas can also be acquired and brought into the Great Lakes via the St. Lawrence Seaway. As a result of these demand factors, Great Lakes shipyards do not have significant opportunities to produce vessels in series and at lower per-unit costs, thus further reducing the demand for new vessels.

Laker construction, refurbishment, and maintenance are not the only activities of the Great Lakes shipyards, of course. They also produce and overhaul large numbers of smaller vessels such as harbor tugs and service boats. For instance, the Great Lakes Towing Company recently announced that it had begun a major overhaul program for its Great Lakes fleet of 37 harbor-assist tugboats at its shipyard in Cleveland, OH. This work is being undertaken along with work underway on Lakers and new construction of new tugs and service boats, including tugs for export.[335]

Thus, the current shipyard base on the Great Lakes has proven itself be quite capable to meet the routine needs of the Great Lakes industry. It is sufficiently sized to maintain the condition of the relatively stable number of long-lived freshwater U.S.-flag fleet, including the repowering of several vessels over the last 10 years. It appears to have the capacity to add occasional new-build Lakers. At its current capacity, however, it would not be able to repower a large number of Lakers or refit them with ballast water treatment systems requiring major hull work over a period of just a few years. Regulations or incentive programs that would create significant new demands for vessel refurbishment or construction must carefully address the ability of Great Lakes shipyard capacity to meet program timelines and cost estimates.

Labor and Training

The ability to crew Laker vessels with highly skilled mariners is vital to the future of the Great Lakes water transportation industry. LCA reported in February 2012 that its 17 members, operating 56 vessels, employed more than 1,600 men and women. These personnel are categorized as either licensed officers (captains, mates, chief and assistant engineers) or unlicensed seamen (able-bodied and ordinary seamen, qualified members of the engine department, conveyormen, chief and second cooks). A typical self-propelled Laker will have 19 to 23 crew positions, whereas a composite tug-barge will have 14 or fewer crew positions. Positions on board Laker vessels are approximately split at 40-percent licensed officers and 60-percent unlicensed seamen. It is important to note that the licensed and most of the unlicensed positions are skilled positions that cannot easily be filled unless trained personnel are available.

The outlook for the demand for and availability of mariners on the Great Lakes is influenced by several factors, including future U.S.-flag fleet size (itself tied to cargo availability and other factors) and vessel type, USCG safe manning standards, and the ability to train and educate new crews. Over the last decade, the number of U.S.-flag Lakers has remained relatively constant, although falling slightly in numbers. As noted elsewhere in this report, current Laker numbers are expected to hold at present levels over the next decade, with increases in ore and limestone cargoes offsetting near-term reductions in coal.

MARAD could uncover little information about the age profile of the Great Lakes mariner workforce or about the volume of pending retirements. However, prior to the recent recession, some lake carriers had voiced concern about their ability to recruit mariners.[336] Perceived recruitment problems included licensing and training requirements that have become more rigorous in recent years, higher safety standards for workers, and greater use of computers and other technology that require specialized skills.[337] Also identified as factors impeding recruitment are greater competition for workers from other water sectors, including offshore service boats in the Gulf of Mexico, and the reluctance of some younger workers to spend extended periods away from home (2 months at a time while serving on Laker vessels, with 6 to 8 months total time on the water in a year).[338,339] The recent recession led to significant layoffs of mariners, and even during the subsequent recovery, the issue of recruitment problems has not been raised by LCA. On the other hand, anecdotal reports from the industry indicate that some (but not all) Laker operators are still concerned about recruitment problems. Given the expected stability in the Great Lakes' water transportation industry and the modest size of the overall fleet, however, it would appear that there is adequate time for Laker operators to plan for needed recruitment over the next decade.

Training

The U.S. maritime education and training system has solid capabilities to meet industry demand for new employees. There are seven merchant marine academies in the United States that graduate over 700 ship officers and engineers annually, with USCG licenses to crew ships.[340] Most relevant to the Great Lakes water transportation industry is the Great Lakes Maritime Academy at Traverse City, MI. The Great Lakes Maritime Academy is the only freshwater maritime academy, offering graduates the opportunity to obtain licensing on both the Great Lakes and the oceans along with an additional credential of First Class Great Lakes Pilot. The Academy seeks to admit 60 to 75 cadets into its licensing programs each year to meet known demand for officer jobs afloat as well as maritime-related jobs ashore.[341] Private operators, labor unions, and other associations also provide training at their own educational facilities.[342] MARAD operates the Great Lakes Fire Training Center at Toledo, OH, which provides training in the specialized fields of controlling fires and performing fire rescue on board vessels.

Lack of Visibility of Water Transportation in Regional Planning

There is a general perception within the Great Lakes water transportation industry that government planners and shippers do not fully recognize the importance of water transportation in regional freight movement. A recent study notes that

> In terms of marine transportation, many agreed that there is a general lack of understanding of the value of marine for regional supply chains (both among policy makers and shippers), which hinders the development of the marine mode. One stakeholder summarized this succinctly: "most people are not aware of Great Lakes." [343]

Members of the water transportation industry believe that this lack of understanding contributes to a lower priority for waterway funding among State and municipal agencies, impeding the ability of the Great Lakes region to take advantage of surplus capacity on the Great Lakes to alleviate or divert highway congestion. In general, public and private sectors should seek greater collaboration in policy development and program planning to leverage the contributions of water transportation to the regional transportation network.[344] The difficulty of incorporating water transportation into regional planning is not unique to the Great Lakes region, and some in the national industry have suggested that States might designate specific personnel or offices to represent maritime interests in State and local planning exercises.

MARAD notes that the recent passage of MAP-21 for USDOT increases the profile of freight movement in the national transportation system. Among many other important features of MAP-21, the act firmly establishes national leadership in improving the condition and performance of the Nation's freight transportation system. It directs the USDOT, in consultation with State departments of transportation and other appropriate public and private transportation stakeholders, to develop a National Freight Strategic Plan. USDOT is also directed to encourage States to develop State Freight Plans and create Freight Advisory Committees. These plans and committees offer important, new opportunities to incorporate maritime freight components directly into the national, regional, and State freight planning processes.

CHAPTER 7

CUMULATIVE IMPACT OF IDENTIFIED FACTORS ON LAKER ECONOMICS

The Lakers enjoy significant cost advantages when competing with land-based bulk transportation services, particularly over long water distances and to sites such as steel mills and electric power generation facilities adjacent to the lakes. The advantage is less so for commodities such as coal with long rail legs or relatively short movements on the Great Lakes. Given current cost structures and market outlooks, the Lakers and the ports they serve appear up to the task of carrying these cargoes for decades to come. However, the infrastructure and regulatory issues identified in the previous section could jeopardize some Laker operations. Table 20 shows estimated impacts on the port and water segments of a Class 10 (1,000 foot) Laker with a Category 3 engine carrying 68,000 tons of iron ore (without a backhaul cargo) on a 135-hour roundtrip voyage, and a Class 8 (800 foot) Laker with a Category 3 engine carrying 35,000 tons of iron ore (without a backhaul cargo), on a roundtrip voyage of 127 hours.

For the water and port segment only, this analysis indicates that the simultaneous implementation of low-sulfur fuel requirements and light loading in response to channel siltation of 2 feet above authorized depths would increase the per-ton cost to transport iron ore on the Class 10 and Class 8 vessels.

The impact of shifting from HFO high-sulfur fuel to low-sulfur marine diesel oil (MDO) for existing Category 3 vessels is assumed to increase the price per metric ton of fuel by 50 percent, which is the price differential between these fuel types that has generally prevailed since 2011.[345] This increase has the effect of increasing the delivered cost per ton of ore by 9 to 10 percent. The price of low-sulfur MDO has, however, exceeded the price of HFO by 70 percent or more during the last decade.[346] Were a 70-percent increase in the price of fuel to occur, low-sulfur fuel compliance would increase the cost of carrying iron ore by 13 to 14 percent relative to the base cost for the Class 10 and Class 8 vessels.

The added cost to a Class 10 Laker that would otherwise carry 68,000 tons of cargo, but which must light-load cargo because of the loss of 2 feet of draft from shoaling, would be approximately $0.65 for each ton of iron ore delivered. The added cost per ton for a Class 8 vessel that would otherwise carry 35,000 tons of iron ore cargo would be somewhat higher at $0.95 per ton. Light loading due to shoaling could thus increase the delivered cost per ton of ore by 9 to 10 percent relative to authorized depth conditions. Note that this estimate assumes a consistent demand for iron ore at full vessel cargo capacity and a round-trip voyage without a return cargo. According to LCA, harbors may experience shoaling conditions that lead to more or less than 2 feet of lost draft.[347]

As discussed in the previous section of this study, Lakers are not required to comply with numeric ballast water requirements under existing and pending regulations and will not incur incremental costs for ballast water treatment under the current regulatory structure. Laker industry representatives remain very concerned, however, about what they believe could be significant cost impacts in addition to fuel and light-loading costs if numeric ballast water requirements are implemented (either at a Federal or State level) for confined Lakers in the future. Cost impacts for ballast water treatment cannot be assigned to Table 20 until a viable BWMS technology for confined

TABLE 20. **Impact of Identified Factors on Laker Freight Cost per Ton of Iron Ore**

FACTORS	CLASS 10 LAKER 135-Hour Roundtrip Voyage		CLASS 8 LAKER 127-Hour Roundtrip Voyage	
	Cost in $/Ton	% Increase in Cost	Cost in $/Ton	% Increase in Cost
Base cost per ton	$8.02		$10.34	
Additional costs per ton				
Low-sulfur fuel	0.75	9%	1.02	10%
Light loading because of shoaling	0.65	8%	0.95	9%
Total additional cost	1.40	17%	1.97	19%
Base cost plus additional costs	9.42		12.31	

Note: MARAD calculated these risk factors using the vessel cost data contained in USACE, *Supplemental Reconnaissance Report, Great Lakes Navigation System Review,* February 2010, p. 61 and Appendix C, Economic Summary of the GLNS, Section 8.0, Vessel Fleet and Operating Costs (http://www.lre.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=6984&destination=ShowItem) as well as other industry sources. MARAD increased USACE's estimated fuel cost for 2008 by 20 percent to reflect changes in petroleum prices since 2008 and used Class 10 vessel labor cost for the Class 8 vessel because of equivalent crew sizes. The estimate includes a cost for vessel amortization using a 7 percent cost of capital. Costs included in this table do not reflect required profit margins, port fees, HMT, or costs associated with conditions specific to customers and routes. Note that each cost factor is calculated in sequence, beginning with higher fuel cost, to which is added the cost of light loading due to shoaling. As such, the cumulative impact is somewhat higher than if the impacts were measured independently of each other.

Lakers is developed and the requirements, if any, to use such a system are established.

Rail rates for some iron ore and coal routes are only a few dollars per ton more expensive than the base costs for Laker service shown at the top of Table 20.[348] Additionally, rail carriers are able to make use of differential pricing to lower rates in some markets to capture market share,[349] and thus may have incentives to price competitively once a differential falls below a certain threshold. Finally, unlike some Laker services, rail service is not subject to closure during the ice season, a benefit that, in combination with increases in Laker rates, may swing customers to rail. Future decisions or requirements that could influence Laker costs by only a dollar or two per ton could lead to a loss of at least some Laker markets.

It is also notable that the estimates in Table 20 pertain to iron ore, which is transported by water for the great majority of its route from mine to mill. Routes for coal often involve major rail components (e.g., delivery to Superior, WI, from the Powder River Basin in Montana) followed by Laker voyages of comparatively shorter distances. These routes may prove particularly vulnerable to all-rail competition due to the cost factors identified above.

Consequences of Loss of Laker Capacity

Although not anticipated by this study, the potential loss of existing Laker markets due to higher operating and capital costs, particularly if coupled with possible long-term decreases in the regional demand for coal, could lead to significant reductions of vessels in the Laker fleet. At some point, such reductions could undermine the economic ability to maintain fleet, port, shipyard, and waterway infrastructure, leading to further losses of Laker service throughout the region. These losses could have serious, adverse consequences for regional industry.

U.S.-flag Lakers are workhorses for the regional economy of the Great Lakes States, providing efficient and economical transportation of commodities from their mines and quarries to the mills and factories where they are used. The sources and consumers of the cargoes are often located close to the ports so that the efficiency of water transport is maximized and surface transportation over land is minimized. It is noteworthy that the great majority of integrated steel production in the United States is located along the Great Lakes even as it has diminished elsewhere in the country.

In many locations, rail is an existing or potential alternative to Laker service, but the use of rail can add significantly to shipping costs for customers (see

Table 18). Approximately 105 lakeside facilities currently served by Lakers are dependent on marine transportation for the receipt (and in some cases the shipment) of large volumes of bulk commodities, having no direct access to rail (see Table 10). In other cases, even where rail access exists, it is not clear that existing rail links could handle the volumes of commodities needed by the user. Where direct service by rail is either unavailable or inadequate, shipping bulk commodities short distances by truck to or from the closest rail line is an option, provided appropriate material transfer and handling facilities are available along the rail line. This practice would, however, add to the expense of rail shipping.[350] Alternatively, where multiple alternative sources of a commodity exist regionally, as in the case of limestone or sand and gravel, a more likely response to a loss of Laker service or escalating Laker costs would be for commodity users to switch to commodity producers who are located in closer proximity to the customer and then rely on local truck delivery. Again, this would add to the cost of commodity acquisition and may not be practical for high-volume movements.

High-volume, long-distance movements of bulk goods by truck are significantly more expensive than Laker or rail service and would generally not be practical as a replacement for Laker services. The largest Lakers can transport up to 70,000 tons of cargo or even more when navigation conditions allow it. By contrast, nearly 3,000 semi-truckloads or 7 trains of 100 cars each would be required to transport the same amount of cargo.[351] Moreover, each heavy truckload contributes to traffic and to wear and tear on regional highways. For instance, the Federal Highway Administration's (FHWA) *Cost Allocation Study* estimated that a truck with a gross vehicle weight of 80,000 pounds operating on urban interstate highways causes almost $0.41 in pavement damage per vehicle mile traveled (this cost falls to less than $0.13 per vehicle-mile traveled on rural interstates).[352] Adverse impacts can be greater, however, particularly for overloaded trucks that operate at gross vehicle weights exceeding 80,000 pounds.[353] Thus, the transfer of 3,000 truckloads of cargo (associated with one large Laker) to the highways could (if allocated on 10 percent to urban highways and 90 percent to rural highways and assuming 150-mile hauls) contribute almost $68,000 in road wear and tear, a significant portion of which would probably not be compensated by fully allocated fuel taxes paid by the trucks.[354] Safety and congestion impacts would also be significant, in that Lakers present almost no fatalities per ton-mile of cargo and do not add to congestion on highways (particularly around urban areas), whereas trucking has greater adverse impacts in these areas.

The loss of Laker service could also lead to increases in the freight rates charged to regional railroad and trucking customers. It has long been understood that competition by the Great Lakes fleet in the regional freight transportation market likely compels other freight modes (particularly rail) to charge lower rates than they might otherwise offer.[355] These "water compelled rates" benefit all shippers, including those who choose not to use water transportation services; any significant reduction in the number or capacity of the U.S.-flag Great Lakes vessels could lead to the reduction or elimination of these water-compelled rates. Although MARAD could not identify recent estimates of the impact of Laker service on regional freight rates, research pertaining to water-compelled rates on the Upper Mississippi and Illinois River systems[356] indicates that there would be additional costs of almost $0.40 per ton of coal and almost $2.50 per ton of grain if the water transportation option there were to disappear. [357]

CHAPTER 8

AREAS OF U.S. FEDERAL GOVERNMENT INVOLVEMENT

The Federal Government can support the U.S.-flag Great Lakes marine transportation industry first and foremost by recognizing the industry's inherent strengths and efficiencies in the movement of freight. This industry has developed largely through investments and innovations from the private sector with long-standing USACE support in building and maintaining locks and channels, as well as USCG support for navigation and safety. With this in mind, necessary initiatives to protect the environment of the Great Lakes must be undertaken in a manner that causes the least harm possible to the industry while accomplishing cost-beneficial environmental objectives. In some cases, where a desired environmental objective could cause unacceptable economic harm to the industry, Government incentives to Great Lakes carriers could encourage them to take actions to voluntarily meet the objectives. A recent example of such an inducement is EPA's Great Lakes Steamship Repower Incentive Program. Other planned and potential actions by the Federal Government could also facilitate more efficient operations of Laker vessels and ports, generating environmental benefits to the public, costs savings to the Laker industry, and regional economic growth attributable to the continuation of low-cost and reliable transportation on the Great Lakes.

Based on material summarized in the preceding sections of this study, MARAD has identified several areas of potentially beneficial Federal interventions. These are briefly described below. Some areas that would involve new or specific applications of financial or other assistance are studied more extensively in Chapter 9 using a BCA methodology.

Dredging and Infrastructure Maintenance

Periodic dredging of harbors and connecting channels is essential to optimal performance by the Lakers. As noted previously, USACE is committed to meeting the dredging needs of the industry, although Congress must appropriate adequate funds to accomplish this goal. USACE has well-developed technical and BCA techniques that it routinely applies to waterway projects. It has also completed major studies in recent years to evaluate investments in infrastructure projects on the Great Lakes, including dredging and building or maintaining locks, dams, breakwaters, and other coastal structures affecting navigation.[358] MARAD strongly supports USACE in its efforts to identify and meet the dredging and infrastructure needs of the Great Lakes. As noted in an earlier section of this study, USACE determined that $40 million in funding is required annually to keep up with the annual dredging requirements on the Great Lakes and that an additional $200 million overall is required to remove the current dredging backlog.[359]

MARAD notes that a single Class 10 Laker making 50 trips a year would incur extra costs of almost $2 million a year because of light loading of cargo if operating at a depth shortfall of 24 inches. Costs for a Class 8 Laker under the same conditions would approach $1.5 million per year. These losses would grow if silting continues ahead of the pace of dredging and more depth is lost. There are 13 Class 10 Lakers, 12 Class 8 Lakers (including 1 Class 9 vessel), and 30 other Lakers that are affected by loss of draft. If silting becomes sufficiently severe, Laker service would be cut back or cease and significantly higher transportation costs would result because of the need to use alternative transportation modes. MARAD roughly estimates that over a 30-year period the present value of benefits to domestic shipping from reaching and maintaining authorized channel depths throughout the Great Lakes (measured in the form of avoided costs of light loading as shown in Table 20 of Chapter 7) would exceed the present value of costs (costs being equal to the USACE-proposed annual Great Lakes dredging budget of $40 million plus the one-time backlog dredging requirement of $200 million).[360] MARAD notes, however, that USACE is the official source of benefit–cost information on all dredging requirements, and in its analyses of projects, USACE focuses on detailed and site-specific information not reflected in MARAD's general estimate.

Port Infrastructure

Federal and other governmental assistance to ports for surface infrastructure projects is a relatively complex subject and beyond the scope of this study, although Great Lakes ports are eligible for such assistance. Eligible port projects include land acquisition, docks and wharfs, port equipment (e.g., cranes), hard surface storage, rail infrastructure, connecting roadways, and utilities. Federal sources of assistance include the U.S. Department of Commerce Economic Development Administration funds (for projects that promote job creation or retention in economically distressed industrial areas), EPA Brownfields Grants, U.S. Department of Housing and Urban Development Community Development Block Grants, USDOT/FHWA Congestion Mitigation and Air Quality Grants (for projects that improve air quality in non-attainment and maintenance areas), and tax-exempt private activity bonds (issued by States from annual Federal allocations).[361] Port projects are also eligible for funding through USDOT's Transportation Investment Generating Economic Recovery (TIGER) grants when funding for this program is available.[362]

In July 2012, Section 1108 of MAP-21 extended eligibility for funding under FHWA's Surface Transportation Program to certain port projects. An eligible project is one that, if located within the boundaries of a port terminal, includes only such surface transportation infrastructure modifications as are necessary to facilitate direct intermodal interchange, transfer, and access into and out of the port.[363] An identical eligibility provision for port projects has applied to FHWA's Transportation Infrastructure Finance and Innovation Act (TIFIA) credit assistance program since 2005.[364]

Shipyards

In the recent past, Congress has made Federal assistance available to shipyards through the Assistance to Small Shipyards Grant Program and the Title XI Program (both of which are administered by MARAD; see the Financial Incentives discussion below for more on the Title XI Program). Congress created the Small Shipyard Grant Program in the National Defense Authorization Act of 2006. Congress first funded this program with $10 million through the Consolidated Appropriations Act of 2008, with subsequent appropriations in each following fiscal year (FY), supplemented by $98 million in grant authority under the American Recovery and Reinvestment Act of 2009.[365] The program is intended to improve the ability of domestic shipyards to compete for commercial ship construction. Grants, which can range from under $100,000 to several million dollars, have been awarded to shipyards across the Nation to fund drydock construction and modernization, acquisition of large Travelifts®; other material-handling equipment such as cranes and forklifts, steelworking machinery; other shipyard infrastructure improvements; and training of shipyard employees. Various Great Lakes shipyards have benefited from these grants, including Fraser Shipyards, Marinette Marine, Basic Marine, Bay Shipbuilding, and the Great Lakes Towing Company.[366] Funding for the program is subject to annual appropriations by Congress; in the current fiscal environment, it is difficult to anticipate what future appropriations may be.

Research and Development

The analysis in Chapter 9, which focuses on repowering certain Lakers, draws heavily from primary research that MARAD is funding on the potential for LNG/diesel engines on the Great Lakes. These engines are environmentally cleaner than their liquid-fuel diesel alternatives and are much cleaner than steam engines. The lower cost of natural gas relative to petroleum fuel may offer significant cost savings to vessel operators adopting LNG engine technology.

Primary and applied research into LNG engines is an example of how the Federal Government can help to identify promising technologies and practices and support improvements by private enterprise that would yield many social benefits. Particularly in new categories of technologies, where it is often difficult for private-sector investors to capture profits from research, Government support can be essential by removing the "first mover disadvantage."[367] In the particular case of LNG-powered vessels, one reason for a potential first mover disadvantage is that deploying LNG vessels involves costs in the form of evaluating new engine types and developing fueling infrastructure. The first operator to deploy LNG engines would have to resolve how to fit vessels with LNG tanks and acquire fuel for the LNG engines, involving significant expense. Once these puzzles are solved, however, other vessel operators can take advantage of this effort and deploy vessels with LNG engines at a potentially lower cost (possibly making improvements based on the first operator's experience). By funding research and development on LNG-powered vessels, MARAD (in cooperation with other Federal and State agencies) is attempting to reduce the first mover disadvantage and thereby encourage the use of a technology with lower emissions levels.

There is a wide array of additional research and development underway on the Great Lakes, including research on cost-effective ballast water management, use of diesel electric engines, beneficial reuse of dredged materials, and other topics. GLMRI and its university affiliates play a leading role in conducting and coordinating such research, supported by MARAD and other Federal Government agencies such as USCG, EPA, USACE, NOAA, and the Department of the Interior, as well as State and Provincial agencies.[368] Other government, academic, and industry research organizations in Canada and Europe make important contributions to research pertaining to Great Lakes navigation. MARAD strongly supports the provision of adequate research funding to regional research organizations.

Financial Incentives to Revitalize or Replace Existing U.S.-Flag Great Lakes Vessels

The U.S.-flag Great Lakes fleet provides low-cost and reliable transportation to the regional economy. The vessels are well maintained and comply with USCG requirements. With few exceptions, the fleet is employed, and no pending vessel retirements have been announced as of the writing of this report.

Even so, given escalating fuel costs, major advances in recent years in fuel-efficient engines and automated systems, and changing environmental standards, operators might decide to repower or replace at least some of these vessels. Clear evidence of this interest is the spate of recent repowering actions, including the *Charles M. Beeghly* (now the *James L. Oberstar*) (2009), the *Edwin H. Gott* (2011), the *Lee A. Tregurtha* (2006), the *Paul R. Tregurtha* (2010), and the *Kaye E. Barker* (2012).

Analysis presented in Chapter 9 explores various alternatives by which components of the fleet might be rejuvenated, including through repowering or vessel replacement. This analysis emphasizes repowering the 12 remaining steamships in the U.S. Great Lakes fleet, but also considers repowering older diesel Lakers and replacing vessels. The findings of this analysis highlight areas where Federal assistance is or could be beneficial to maximizing the public and private net benefits of Great Lakes water transportation. In particular, the analysis shows where Federal programs to reduce the cost of investment capital and risk could induce vessel owners to undertake repowering who might otherwise not do so.

Two MARAD programs could potentially be used to reduce the cost of capital: the Title XI Federal Ship Financing Program (Title XI) and the Capital Construction Fund (CCF). The Title XI program provides Federal guarantees for bonds issued or bank loans extended to finance the construction or rebuilding of vessels in U.S. shipyards or U.S. shipyard improvement projects. It can save the borrower as much as $500,000 in cash required at the time of loan closing for a $10-million project relative to a conventional bank loan for the same project, enable much longer repayment periods (up to 25 years) when compared to commercial bank loans, cover a larger share of the project cost (up to 87.5 percent), accommodate fixed or floating interest rates, and significantly reduce the interest rate and present value of loan payments as well (depending on loan terms, tax rates, etc.).[369] Because the loan guarantee essentially removes the repayment risk from the lender, the borrower can obtain an interest rate that is typically priced at 80 to 120 basis points above a Treasury bill having the same average life to maturity.[370] The U.S. Office of Management and Budget reports that the nominal interest rate on a 20-year Government bond was 3.5 percent as of 2012; equaling a real interest rate (nominal interest less the rate of inflation) of 1.7 percent.[371] With the addition of 100 basis points, this would equal a nominal interest rate of 4.5 percent and a real interest rate of less than 3 percent.

New Laker construction and rebuilding are eligible for Title XI loan guarantees. Moreover, MARAD would generally interpret vessel repowerings to be eligible projects for Title XI, particularly if the repowerings involved the installation of new engine types (e.g., replacement of a steam engine with a Category 3, Tier 2, diesel or LNG engine). Other repowering actions (replacement of older diesel engines) would be considered for eligibility on a case-by-case basis, particularly if associated with other improvements to the vessel. However, there is high demand among U.S. maritime interests for a limited amount of Title XI resources, and the receipt of Title XI loan guarantees is by no means assured even for well-qualified projects.

The CCF encourages construction, reconstruction, or acquisition of vessels through the deferment of Federal income taxes on certain deposits of money or other property placed into a CCF account, representing, in effect, an interest-free loan from the Government.[372] The CCF program is the responsibility of two agencies within the Federal Government—MARAD and, in the Department of Commerce, NOAA. MARAD administers the program with respect to vessels operated in the commerce of the United States other than in the fisheries of the United States. NOAA administers the program with respect to vessels operated in the fisheries of the United States. For vessels operated in commerce, new building, rebuilding, repowering, and other reconstruction and new-build actions exceeding $1 million (or more than $100,000 in some instances), if approved by MARAD, are deemed to be qualifying uses of CCF account funds.[373]

There are other Federal programs to promote and assist with the repowering of vessels. Grant programs administered by EPA under the Diesel Emissions Reduction Act (DERA) are used to help fund projects that reduce emissions from existing diesel engines (including through engine replacement).[374] DERA grants are offered to five industry sectors (construction and distributed generation, trucking, locomotive and rail, marine vessels and ports, and agriculture) with no set-aside of funds specifically for the use of the maritime sector. Appropriations for DERA grants fell from $60 million in both FY 2009 and FY 2010 (supplemented by $300 million from the American Recovery and Reinvestment Act of 2009) to $49.9 million in FY 2011 and $29.9 million in FY 2012.[375] Thus, awards of DERA grants are very competitive and will become even more so given the current fiscal climate.

Even so, DERA funds have been used for Laker and other vessel repowers. A DERA grant was awarded in 2010 to assist in the repowering of the Laker *Edwin H. Gott*.[376] DERA funding was also used to assist in the replacement of auxiliary-service diesel generators on two Lakers in 2010.[377] However, because costs of repowering Lakers and other large marine vessels are much greater per vessel than costs for vehicles in other sectors (such as trucks), the outlook for significant new DERA aid to the Laker industry seems limited in light of current program funding.

Recognizing the limited Federal funding available for marine vessel repowers, MARAD recently implemented a program of Vessel Emissions Reduction Cooperative Agreements. The program was developed to research the public benefit of a maritime-specific emissions reduction incentive program. Under this program, MARAD will provide a cost-share incentive for projects that demonstrate reductions in criteria pollutant or carbon emissions from marine vessels through repowering or installation of other pollution-reduction technologies or through the use of alternative fuel/energy sources. The first awards for this program, for which Great Lakes vessels are eligible, began in 2012.[378] Future awards are planned but will depend on congressional appropriations. The focus of this program on marine engines and marine emission reductions will elevate the visibility of Laker vessels for Federal repowering assistance.

Incentives to Establish Marine Highway Services

Prior analysis (described in Chapter 10, New Market Possibilities) suggests that, from a freight cost standpoint and with sufficient cargo volumes, marine highway operations on the Great Lakes could prove feasible. "Marine highway services" are defined as the water transportation of general cargo in containers and trailers between U.S. domestic locations and also (in the Great Lakes region) between the United States and Canada. The startup of marine highway services would be contingent upon adequate port equipment and facilities, acquisition of appropriate vessel types, sufficient vessel numbers to offer frequent scheduled service, access to sufficient cargo volumes, building relationships with shippers, and proving the reliability of the marine highway service. Additionally, because the Great Lakes shipping season largely closes in the winter (January to March), the marine highway service provider or the shipper must have arrangements to switch to land-based modes during this time.

Over the last several years USDOT, through MARAD, has sought to promote the establishment of such services through various incentives and promotional activities.[379] On August 11, 2010, the Secretary of Transportation designated three corridors and crossings in the Great Lakes—the M-90, M-75, and M71/77—to be among the Nation's 18 designated Marine Highway corridors, connectors, and crossings (collectively referred to as "corridors") (see the map of corridors in Chapter 10).[380] Designation as a Marine Highway corridor can facilitate the development of new services on a corridor. In particular, for designated corridors, MARAD will help to coordinate among Federal, State, and local government agencies to gain access to facilities and cargoes, support data collection and dissemination, conduct research, and encourage and participate in planning activities.[381] Eligible marine highway services on designated corridors can also qualify for MARAD grant funding as Marine Highway projects (subject to competitive selection and the appropriation of program funding by Congress).[382] Improvements to accommodate marine highway services and other freight and passenger objectives have also been eligible for USDOT TIGER grants.[383]

Finally, MARAD and the Department of Defense are exploring the concept of developing "dual use" RoRo vessels that can serve the needs of both military sealift capacity and America's Marine Highway Program.[384] Although the "dual use" program is still in the discussion stages, the physical dimensions of one ship design under consideration could be within the dimensions needed to transit the St. Lawrence Seaway and Welland Canal; thus vessels of this design could potentially serve on Great Lakes markets. These vessels, if partly funded by the U.S. Government, could reduce the large capital costs associated with establishing a U.S.-flag marine highway service.

Analysis reported in Chapter 10 investigates the economic potential of establishing U.S.-flag Marine Highway services on the Great Lakes.

CHAPTER 9

ECONOMIC ANALYSIS OF FLEET REVITALIZATION OPTIONS

The U.S.-flag Great Lakes fleet, while well maintained and suited to its markets, is aging. High fuel prices, in particular, and a desire to reduce other operating costs are causing some vessel owners to repower vessels. New building is much less common. Factors of increasing age and high operating costs are most significant for the remaining 12 steamships in the U.S.-flag Great Lakes fleet.

In this section, MARAD considers options for revitalizing the fleet.[385] The first revitalization scenario, and the one expected to be most attractive to public and private parties, is the repowering of the steamship fleet. In this analysis, MARAD considers replacing the steam turbine engines with Category 3, Tier 2, conventional diesel engines (as one alternative) and dual-fuel LNG/diesel engines (as a second alternative). A second revitalization scenario briefly considers building new vessels to replace the steamships. A third scenario draws upon the steamship analyses to make qualitative conclusions about repowering or replacing existing diesel-powered Lakers.

These scenarios are premised on the use of new engine technologies that would comply with EPA emissions standards in effect when the vessels are refurbished or rebuilt. It is critical to note that these scenarios are informational only—none is based on a requirement or obligation on the part of the vessel owners to take repowering or new building actions. Owners are free under current regulations to operate their current vessels for the indefinite future (subject to the use of appropriate fuels and best ballast water management practices).

Benefit–Cost Analysis Methodology

BCA is an economic analysis tool for measuring and comparing the social (i.e., public and private) benefits to the social costs of one or more projects or programs.[386] The analysis covers a multiyear period that typically incorporates much or all of the operational lifespan of the project being evaluated. The analysis quantifies the costs (e.g., the resources expended to build, maintain, and operate the project) and the direct benefits of the operational project (e.g., potential transportation cost savings to system users and the public value of reduced emissions) and puts them into dollar terms to the degree possible. Costs and benefits of the project are measured only to the extent that they are incremental to a "no action" base case. For instance, in the case of a project to repower a steamship, the benefits and costs of repowering to a diesel engine would be measured against continued operation of the steamship with its steam-turbine power plant.

Unless adjusted, dollars earned or spent in different years of the analysis period for the project are not directly comparable to each other. For instance, a dollar in hand today has a greater value to its holder than the promise of the same dollar 10 or 20 years in the future (e.g., the holder could invest the dollar today and earn dividends in the near term rather than wait to receive returns). To enable comparison of dollar values realized in different years, the dollar amounts of benefits and costs in any given future year must be converted into a "present value" equivalent through the use of a discount rate. The discount rate measures the annual opportunity cost of money, which is similar in concept to an interest rate that would have been earned on the invested funds had they not been expended on the project. Discounting causes dollars realized in the future to have lower present values than current dollars. For instance, at a 5-percent discount rate, $1 million in benefits received 30 years from now would be worth $231,277 to the eventual recipient today, whereas $1 million received 1 year from today would be worth $952,381 in present value.

Once calculated, the stream of present values of a project's lifecycle benefits and costs relative to the "no action" base case can be summed into total benefits and total costs. The two sums can then be compared to each other using a variety of measures to see if the sum of the present value of the benefits exceeds the sum of the present value of the costs (i.e., if the project has a positive net present value). Projects with benefits that exceed costs (i.e., projects that generate positive net benefits over their lifecycles) are generally worth pursuing from an economic standpoint if funds are available to undertake them. In a situation of limited budgets, the projects with the highest ratio of benefits to costs[ii] can be selected on a priority basis (until available funds are exhausted) to enable the greatest public benefit for each invested budgetary dollar.

Public and Private Benefits and Costs

BCA measures the value of direct benefits and costs of a project or program even if those effects do not actually take the form of cash flows when the project is underway. In other words, if a project reduces harmful air emissions, the value of those reduced emissions is assigned a monetary value, even if the cash flow is indirect (e.g., reduced long-term public health care expenditures). Moreover, the value is counted even if the party making the investment does not receive this value in the form of cash compensation from the direct beneficiary.

Public agencies investing resources for the public at large are typically the practitioners of BCA. Private companies, on the other hand, analyze investments using financial analysis. Financial analysis may be seen as a special subset of BCA that focuses only on those benefits and costs of a project that take the form of cash transactions that are realized by the project's owner. For example, the financial analysis would focus on how much fuel and other operating cost savings a new engine would generate to the vessel owner.[387] The owner is not indifferent to the public benefit of cleaner air as a result of using the new engine, but typically cannot capture this benefit as cash flow, and therefore the public benefit of cleaner air does not enter the financial analysis (except possibly as a monetized credit for public "good will"). If the private costs exceed the private benefits, the project may not be undertaken even though the inclusion of public benefits would justify the project from a social BCA perspective. In the presentation of BCA results below, "public" versus "private" benefits are broken out separately, where appropriate, to highlight some investments that might be cost-beneficial from a BCA standpoint but not from a financial analysis standpoint.

Distinction Between BCA and Economic Impact Analysis

The BCA methodology used in this analysis does not attempt to interpret how repowering (or making other investments in the U.S.-flag Great Lakes fleet or ports) will filter through the broader regional economy in the form of changes in regional employment, wages, business sales, or property values. These latter issues, which involve the final impact or distributional equity of a transportation project, would be pursued through economic impact analysis (EIA). EIA modeling is beyond the scope of this study. One recent example of EIA is the report *Economic Impacts of the Great Lakes–St. Lawrence Seaway System*.[388]

It is easiest to make the distinction between BCA and EIA with an example. Assume that a water transportation project is being built to reduce transportation costs. BCA would be used to calculate the reduction in transportation costs caused by waterborne transportation relative to surface transportation alternatives. EIA would measure how these reduced costs might induce factory owners to expand operations or to relocate from other locations to take advantage of water transportation, thereby affecting local employment, business revenues, and land values.

ii. A benefit–cost ratio (BCR) puts the present value of benefits in the numerator and the present value of costs in the denominator. Assuming that the different projects being evaluated with BCA are independent from each other and subject to fixed budgets, a project costing $1 million with a BCR of 3:1 (also described as 3/1 or 3.0) would be preferred over a $1 million project with a BCR of 2:1. A project with a BCR of less than 1:1 (also described as 1/1, 1.0, unity, or breakeven) would not be cost-beneficial to pursue even if funds were available.

BCA is sufficient to determine if a project is worth undertaking from a public and private economic standpoint. It is also much easier to interpret than EIA, which if used improperly can overstate the actual generation of new net benefits. Problems in interpreting EIA results include the following:

- Some of the regional impacts that are often counted in EIA, such as diversion of economic activity from one region of the country to another, represent gains to one part of the country but losses to another part, so they are not "gains" from the standpoint of the Nation as a whole.
- Effects measured by EIA are often double counts of each other. Higher business revenues caused by reduced shipping costs may lead to higher payrolls or become capitalized into higher land values and rents. In other words, the company that generates the higher net revenue *transfers* (does not retain) a large portion of the revenues to other parties in the form of higher wages and rents. Adding the value of business revenues, wages, and rents together as part of an EIA (these effects are often difficult to disaggregate from one another) would overstate the net addition to social wellbeing by failing to account for some of these as transfer payments rather than new wealth generation.

In summary, BCA measures the reduced transportation costs to shippers and the public without regard to job or income gains or losses or where they occurred. In general, economists hold that a project generating net positive benefits by using a BCA methodology would also generate a net positive value of economic impacts.[389]

BCA Benefit and Cost Categories

The revitalization scenarios and alternatives considered in this section are evaluated by using the BCA methodology developed for the USDOT's TIGER Discretionary Grant Programs. This methodology has been used in three rounds of TIGER awards to date and conforms to the USDOT's assessment of established best BCA practices.[390]

Because USDOT funds transportation projects with revenues collected from the overall U.S. population, all BCA performed for the USDOT measures the dollar value of the benefits and the costs to residents of the United States. The benefits represent a dollar measure of the extent to which people are made better off by the project: that is, the benefits represent the amount that all the people in the society would collectively be willing to pay to carry out the project. In this study's analysis of repowering or rebuilding steamships, for example, the principal benefits are the public health benefits of reduced emissions from more efficient engines and low-sulfur fuels; reduced vessel operator costs associated with the use of more fuel-efficient engines, which burn less fuel (although at a higher cost per ton of fuel); and lower non-fuel operating and maintenance costs.

Operating costs were assessed for Lakers based on information summarized by USACE[391] (updated for fuel cost increases) and other sources, including information assembled by EPA as part of its recently completed study on the economic impacts of its Category 3 emissions rule.[392]

In the following analysis, MARAD presents all future costs and benefits in terms of "real dollars." A real dollar is able to buy the same amount of goods and services in a future year as in the base year of the analysis.[iii] MARAD discounts future benefit and cost streams to present values for 2012 by using both a 7-percent and 3-percent real discount rate. A real discount rate can be estimated by removing the rate of inflation from a market (or nominal) interest rate. Use of the 7-percent real discount rate is recommended by the U.S. Office of Management and Budget in formal guidance to U.S. agencies that are engaged in decisions to allocate Federal funds on a discretionary basis.[393] It is also reflective of a rate that might apply to internal investment decisions by companies with limited access to capital, particularly where there is significant risk

iii. In the case of economic analysis of investments with public-sector benefits or costs, it is best practice to forecast lifecycle costs and benefits of a project without inflation (i.e., in real or base-year dollars). Inflation is very hard to predict, particularly more than a few years into the future. More importantly, if inflation is added to benefits and costs projected for future years, it will only have to be removed again before these benefits and costs can be compared in the form of present value dollars. Dollars that include the effects of inflation are known as "nominal," "current," or "data year" dollars, and would be discounted using a nominal discount rate. For more about this subject, see USDOT/FHWA, *Economic Analysis Primer* (FHWA IF-03-032), Aug. 2003, p. 10, http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer.pdf.

involved in an investment (such as may be the case in the current Great Lakes environment with the potential for future reductions in coal cargoes). The 3-percent real discount rate would be more applicable to a situation characterized by little or no risk or where a firm has access to substantial reserves of capital. It would also be applicable to the cost of capital to a firm that can obtain a Federal loan guarantee, such as MARAD's Title XI program (described in Chapter 8).

Description of Repowering and New-Build Laker Scenarios

MARAD initially considered a range of scenarios for repowering and rebuilding Great Lakes self-unloading bulk vessels. There is no one event that would compel carriers to revitalize their vessels; carriers can comply with new or pending regulations by burning cleaner fuel (eligible steamships are exempted from this requirement) and following best-practice ballast water management. On the other hand, the cumulative effects of higher fuel costs for low-sulfur fuels (as well as rising petroleum fuel prices in general), the continued use of older and less fuel-efficient engines, and increased maintenance expenses among existing vessels creates an incentive to repower some vessels with more efficient engines. The repowering of several Lakers during the last decade, even during the recent recession, indicates that there is interest in the industry to revitalize at least some of the current fleet.[394]

Although it appears likely that revitalization will take the form of repowering, there is the possibility that new vessels will be acquired in some instances, such as the recent construction of an articulated tug-barge by a shipyard on Lake Erie.

SCENARIO 1: Repowering the Steamships

The first scenario MARAD evaluated involves the potential repowering of the 12 steamships that operate under the U.S. flag and for which no decision has yet been made to repower.[395] Of the various options for U.S. Government incentives to revitalize the Laker industry, those that are targeted to steamship repowering have perhaps the most potential for positive results in the short run.

EPA's Final Rule for Category 3 marine engines and their fuels exempted eligible Great Lakes steamships from the sulfur limits that apply to fuel used in ships using Category 3 engines.[396] During the rulemaking process, Great Lakes carriers noted that the boilers used on these vessels were designed to burn HFO (also called *residual oil*, or RO) and could not safely burn lighter, low-sulfur fuel grades.[397] In 2009, Congress prohibited funds from the Interior Appropriations Act of 2010 from being used to establish fuel sulfur standards for existing Great Lakes steamships.[398] Had the vessels not been exempted, it is unlikely that they could have continued in operation after 2012 without being repowered, and many would likely have been retired. With the exemption, however, the vessels can continue to operate with their steam power plants burning HFO.[399]

The Laker steamships are an important part of the U.S.-flag Great Lakes fleet. These vessels provide approximately 15 percent of the per-trip capacity of the U.S.-flag Great Lakes self-unloading fleet and 40 percent of the cement-carrying fleet.[400] In 2008, before the full impact of the recent recession was felt on the Great Lakes and before the conversion of two vessels to diesel engines, steamships carried about 18 percent of the ton-miles moved by the self-unloading fleet and 35 percent of the cement fleet.[401] In 2009, when the worst impacts of the recession impacted regional industries, the self-unloading steamships carried only about 10 percent of the ton-miles carried by the self-unloading fleet, and the cement vessels carried about 29 percent of the ton-miles carried by the cement fleet. This reduction in market share is probably because the steamships are some of the first vessels laid up during a downturn because of their lower fuel efficiency compared to diesel-powered vessels.

The U.S. public has a vested interest in vessels of the size and capacity of the steamships continuing to operate. As just noted, the vessels carry significant quantities of raw materials to the regional steel, power generation, and construction industries. Their low-cost freight movements create competition in the transportation market, increasing the quality of regional transportation services while helping to minimize the price. Additionally, the steamships offer resiliency to Laker services. Their average per-trip capacity is over 25,000 tons per vessel, as compared to 52,000 tons in per-trip capacity for the vessels with Category 3 engines and 36,000 tons in per-trip capacity for the vessels with Category 2 engines. While many of the newer diesel-powered vessels were built to utilize the larger Poe lock, the steamships are able to fit through the smaller MacArthur lock and would be a critical resource in the event of an emergency closure of the Poe Lock. The steamships can also service ports that cannot accommodate the larger vessels, either because of pier or channel constraints, or that do not require the cargo capacities of the larger vessels.

At the same time, the continued operation of the steamships under the exemption granted to them by the Category 3 final rule would make them among the highest emitters of SO_x of all U.S.-flag vessels. In 2015, when Category 3 vessels will be using fuel with 1,000 ppm of sulfur, the steamships burning high-sulfur HFO will emit up to 25 times more SO_x than comparably sized Category 3 vessels.[402] SO_x emissions have significant adverse environmental impacts. The reduction of such emissions has benefits for human health.

Why consider repowering of the steamships? Repowering the steamships to modern Category 3 diesel engines would enable the vessels to meet the Category 3 Rule emissions standards, thus benefiting the public through cleaner air and continued freight service. From the standpoint of the steamship owners, repowering the vessels would make them more fuel efficient, decreasing their fuel use by an estimated 30 to 50 percent, and reduce non-fuel operating costs. The higher fuel efficiency and other operating cost savings could compensate for the higher expense of purchasing low-sulfur fuel (depending on future fuel price trends), but may not be enough to compensate for the capital cost of repowering (purchasing and installing a new engine along with necessary structural modifications to the vessel).

Even without the issue of fuel efficiency, however, the age of the steamships might compel their operators to consider vessel repowering. The steamships were built between 1906 and 1960, and in 2010, they had an average age of 62 years from when first built. Many of the oldest steamships were rebuilt between 1967 and 1991, and if those rebuild years are taken into account, the average age of the steamships in the fleet becomes 49 years. Escalating maintenance costs,

hard-to-find replacement parts for engines and boilers, and greater unreliability of the vessels add to the costs of operating these older vessels. In a recent article in the Great Lakes Echo, the chief executive officer of Interlake Steamship Co., one of the largest U.S.-flag Great Lakes operators, stated that his company was choosing to repower its steamships because of concern about the cost and ability to maintain them if they were not repowered.[403] Interlake converted the steamships *Charles M. Beeghly* (now named *James L. Oberstar*) and *Lee A. Tregurtha* to diesel engines in 2009 and 2006, respectively, and completed the repowering of the *Kaye E. Barker* in August 2012.[404]

The principal advantage to carriers for continuing to operate the vessels as steamships is that the vessels can burn lower cost HFO under the Category 3 Rule, thus largely compensating for the lower fuel efficiency of the steam engines. On January 18, 2012, however, EPA finalized the Great Lakes Steamship Repower Incentive Program, which provides an automatic waiver that will allow owners of a repowered Great Lakes steamship to use higher sulfur HFO in replacement diesel engines through December 31, 2025. To be eligible for this program, a steamship must be repowered with an EPA-certified Category 3, Tier 2, or later marine diesel engine, operate exclusively on the Great Lakes (defined to include the St. Lawrence Seaway), and have been in service as a steamship on October 30, 2009.[405] Under this program steamship owners can gain better fuel efficiency and avoid the higher costs of using ECA-compliant 10,000-ppm sulfur fuel from August 2012 through 2014 and 1,000-ppm sulfur fuel from January 1, 2015, through December 31, 2025 (a period of 11 years)—helping to recoup the cost of the new power plants.

The Great Lakes Steamship Repower Incentive Program does not apply to steamship conversions to notched barges.[406] This exclusion may cause some steamship owners to reject the option of converting their steamships to composite tug-barge units in favor of maintaining self-propelled capability and qualifying for the use of HFO through 2025. In the analysis below, all steamships are assumed to be repowered as self-propelled vessels. Moreover, the Repower Incentive Program would not, in its current format, be beneficial to vessel owners seeking to repower their steamships to dual-fuel LNG/diesel engines (as opposed to conventional liquid-fuel diesels) because the dual-fuel LNG engines cannot accommodate HFO.

Base Case Development for Steamship Repowering. The first step in developing the benefits and costs of repowering the steamships with diesel engines is to establish a "no action" base case. The base case for this analysis assumes that steamship owners take advantage of the exclusion granted them under the Category 3 Rule and continue to burn HFO throughout the analysis period. The assumptions are as follows:

- The 12 U.S.-flag Great Lakes steamships will continue to be able to purchase higher sulfur HFO. Access to this fuel is not a certainty, however, as existing vessels with Category 3 diesel engines are no longer allowed to burn it. For such vessels, the cap on fuel sulfur content was reduced to 1.0 percent beginning on August 1, 2012 (from the previous 2+ percent sulfur of uncapped fuel), and will be further reduced to 0.1 percent (1,000 ppm), effective from January 1, 2015.[407]
- The steamships, which are already (on average) the oldest vessels in the U.S.-flag fleet, will be physically able to operate for at least the next 30 years with regular maintenance and repair actions, even if not repowered. Replacement parts for the steam engines would be fabricated as needed.
- The real price of HFO remains constant at $650 per metric ton. This rate is below peaks reached in 2011 and 2012, but still reflects high world oil prices.
- Steamships are assumed to move 246,000 ton-miles of cargo per metric ton of fuel.
- Cargoes are projected into the future based on ton-miles of transportation by water.

In Table 21, steamships are shown to carry approximately 18 percent of the overall bulk ton-miles per year, representing utilization of all steamships. MARAD allocated the overall estimates of ton-miles to individual steamships using vessel-specific information from the 2010 *Greenwood's Guide to Great Lakes Shipping* and the per-vessel movement data from USACE's Waterborne Commerce data for 2008 and 2009.

First Alternative Case of Scenario 1: Repowering with Category 3 Diesel Engines. Under this first alternative,

TABLE 21. Forecast of Bulk Cargoes Transported by U.S.-Flag Lakers by Vessel Category, 2010–2045 (million ton-miles)

YEAR	TOTAL	STEAMSHIP	CATEGORY 3 LAKERS	OTHER DIESEL LAKERS
2010	49,683	8,903	17,297	23,483
2015	49,725	8,911	17,312	23,503
2020	53,008	9,499	18,455	25,054
2025	56,291	10,087	19,598	26,606
2030	59,574	10,676	20,741	28,158
2035	62,858	11,264	21,884	29,710
2040	66,141	11,852	23,027	31,261
2045	68,498	12,275	23,848	32,376

Note: An unknown portion of the ton-miles reported in this table are backhaul cargoes. In the benefit–cost analysis calculations of fuel consumption and emissions associated with movement of cargo ton-miles, MARAD scaled up these values by a factor of 1.33 to allow for empty backhauls made under ballasted conditions (equivalent to 60 percent of the deadweight capacity of the vessels).

it is assumed that the remaining steamships in the U.S.-flag Great Lakes fleet are repowered to modern Category 3, Tier 2, liquid-fuel diesel engines and take full advantage of the Great Lakes Steamship Repower Incentive Program. The assumptions for this alternative are as follows:

- Vessel repowerings occur incrementally, with one vessel each in 2013 and 2014, and then between two and three vessels per year from 2015 through 2018. The replacement engine is assumed to be a Category 3 Rule–compliant, Category 3, Tier 2, engine.[408]
- Each repowering is assumed to cost $20 million, including engine acquisition and installation.
- A chief source of benefits of repowering is assumed to be higher efficiency of fuel consumption and reduced emissions. The improved engines are projected to reduce fuel consumption by 30 to 50 percent relative to the steam engines. A median reduction in fuel consumption of 40 percent is assumed for this analysis.
- Repowering results in reduced annual maintenance and non-fuel operations costs (a 10-percent reduction compared to the base case).[409]
- The long-term price of MDO fuel needed to comply with the Category 3 sulfur caps is assumed to be $975 per metric ton (see Table 22). This is approximately 50 percent higher than the $650 per metric ton for HFO assumed in the base case.[410]
- Vessels repowered with modern diesel engines are assumed to move 413,000 ton-miles of cargo per metric ton of fuel.
- Operators of the repowered steamships will use the HFO fuel as long as permitted by the Great Lakes Steamship Repower Incentive Program (through December 31, 2025) and then switch over to the 1,000-ppm sulfur MDO fuel after the exemption ends.
- Emission levels by ton-mile for different engine types are shown in Table 23.
- Economic values for avoided emissions are shown in Table 24 and Table 25.

This assumption that each repowering would cost $20 million is supported by three recent examples of repowering Lakers. The first example is the repowering of the *Edwin H. Gott,* a Laker with a Category 3, Tier 2, engine, which provides a likely lower bound for the capital cost of repowering at $15 million (as the *Gott* was not a steamship, its repowering cost might not be representative of the cost of repowering a steamship, which requires significant structural modifications to accommodate a diesel engine).[411] A second vessel, the Canadian-flag steamship *Michipicoten,* was repowered at the cost of $15 million.[412] The *Michipicoten* was built and operated by U.S. domestic carriers as the *Elton Hoyt 2nd* until it was sold in 2003, so although it is a Canadian-flag ship at this time, it is likely representative of the steamships in the U.S.-flag Great Lakes fleet. The final instance of repowering a Great Lakes steamship is mentioned in a September 2009 letter from LCA to EPA regarding the air emission compliance requirements for vessels with Category 3 engines. In that letter, LCA reported that the last U.S.-flag steamship repowering (at the time of the letter's writing) took 2 years including planning and engineering, of which the vessel spent 7 months in dock and out of service (November 2008–June 2009), and cost $22 million.[413]

Public-sector benefits of repowering reflect the value of reduced emissions. The ton-mile figures in

TABLE 22. Estimated Fuel Cost for Lakes Fleet, 2012

YEAR	HEAVY FUEL OIL (Steam Engine)	HEAVY FUEL OIL (Diesel Engine)	MARINE DIESEL OIL
Cost per ton	$650	$650	$975
Cost per ton-mile	$0.0026	$0.0026	$0.0024

Note: An unknown portion of the ton-miles reported in this table are backhaul cargoes. In the benefit–cost analysis calculations of fuel consumption and emissions associated with movement of cargo ton-miles, MARAD scaled up these values by a factor of 1.33 to allow for empty backhauls made under ballasted conditions (equivalent to 60 percent of the deadweight capacity of the vessels).

TABLE 23. Emission Levels by Pollutant for Marine Engines

POLLUTANT/ GREENHOUSE GAS	STEAM TURBINE	DIESEL ENGINE (REPOWERED STEAM TURBINE)		
	Residual Oil 2% Sulfur (HFO)	Category 3, Tier 2 Residual Oil 2.0% Sulfur (HFO) (2012–2026)	Category 3, Tier 2 MDO 1.0% Sulfur (2012–2015)	Category 3, Tier 2 MDO 0.1% Sulfur (2016 onward)
SO_x [g/kWh]	11.90	7.62	4.11	0.41
PM [g/kWh]	1.16	0.83	0.58	0.58
NO_x [g/kWh]	0.00	13.2	9.5–10.5 (used 10)	9.5–10.5 (used 10)
CO_2 [g/kWh]	580–630 (used 605)	580–630 (used 605)	580–630 (used 605)	580–630 (used 605)
CO [g/kWh]	0.20	0.20	1.10	1.10

Note: MARAD calculated these values using U.S. EPA emissions factors provided in Richard W. Harkins, "Great Lakes Marine Air Emissions—We're Different Up Here!," *Marine Technology,* Vol. 44, No. 3, pp. 151–74, 2007; and Michael Parsons, Patrick J. O'Hern, and Samuel J. Denomy, "The Potential Conversion of the U.S. Flag Great Lakes Steam Bulk Carriers to LNG Propulsion—Initial Report," *Journal of Ship Production and Design,* Vol. 28, No. 3, August 2012, p. 100. The grams per kWh were converted to grams per ton-mile by the formula: (vessel capacity in tons x vessel speed in miles per hour) / engine kW power usage = ton-miles per kWh. For this study, MARAD used 84.77 ton-miles per kWh for a vessel carrying 24,080 tons of cargo at 15.62 miles per hour with an engine producing 4437 kW at 85 percent power for normal cruise speed, based on advice from Dr. Michael Parsons. The ton-mile per kWh figure used in the analysis represents loaded tons, and if used directly it would underestimate the public and private benefits of repowering by not counting operational savings and air emissions reductions for those miles when the repowered vessel travels empty to pick up new cargoes (e.g., trips under ballast without backhaul cargo). MARAD did not have access to data on empty vessel return trips but, based on conversations with industry, assumed that the smaller steamships are significantly less likely to return empty (under ballast without cargo) than are larger Lakers. Accordingly, MARAD scaled up operational savings and emission benefits per ton-mile of cargo by 33 percent to capture operational saving and emission benefits while traveling empty. BCA results are generally consistent over a range of scale-up factors from 25 percent to 50 percent.

TABLE 24. Cost per Ton of Pollutants (in 2010 dollars)

POLLUTANT	COST PER TON
VOC	1,370
CO	na[a]
NO_x	1,100
SO_x	4,130
PM-10	12,400

Note: Except as noted, values are from Nicholas Muller and Robert Mendelsohn, "Weighing the Value of a Ton of Pollution," *Regulation,* Summer 2010, p. 22. http://www.cato.org/pubs/regulation/regv33n2/regv33n2-5.pdf. Note that the literature contains a wide range of potential values for emissions, ranging from very low to very high. Differences can reflect different estimation methodologies (estimates of the marginal damage caused by pollutants vs. emission allowance prices) as well as the fact that the adverse impact of an incremental ton of emissions can be much greater in urban areas than in rural areas. The Muller and Mendelsohn methodology attempts to value marginal damage at the county level, with calculated pollution values varying by county location. This table uses the 99th quantile value to be conservative, although many locations along the Great Lakes would warrant lower quantile values. MARAD did sensitivity analyses using higher and lower values (based on higher assumed valuations of statistical life and lower quantile values, respectively), but the levels of public benefits associated with lower emissions levels remained significant across reasonable value ranges and did not alter the overall findings reported below.

a National Highway Traffic Safety Administration, *Corporate Average Fuel Economy for MY 2011 Passenger Cars and Light Trucks* (March 2009), Table VIII-5, p. VIII-60, (in 2007 dollars). http://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/CAFE_Final_Rule_MY2011_FRIA.pdf. A value of $0 per ton of CO is assumed.

TABLE 25. Cost per Ton of Greenhouse Gas CO_2 (in 2010 dollars)

Year 2010	Year 2020	Year 2040
$22.5	$27.6	$41.2

Source: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, United States Government (February 2010), p. 39, Table A-1 (in 2007 dollars). The values were adjusted for inflation to 2010 dollars. http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2011-0660-0064.

Table 21 were multiplied by the emission per-ton-mile factors in Table 23 to calculate the annualized emission levels for each engine category. The emission levels after repowering (i.e., when operating with Category 3, Tier 2, diesel engines) are subtracted from the emission levels before repowering (i.e., when operating with steam engines) to calculate tons of reduced emissions resulting from repowering. Those emission levels are then multiplied by the costs of each pollutant, provided in Table 24 and Table 25, to develop a dollar value for the emission savings.

The outcome of the benefit and cost analysis is shown in Table 26. From a combined public and pri-

TABLE 26. Costs and Benefits of Repowering the U.S.-Flag Great Lakes Steamships With Category 3, Tier 2, Engines Under the EPA Great Lakes Steamship Repower Incentive Program (in million 2010 dollars)

BENEFIT–COST ANALYSIS SUMMARY	NET PRESENT VALUE at 7% Discount Rate	NET PRESENT VALUE at 3% Discount Rate
Total benefits	$247	$410
Public benefits	$65	$120
Private benefits	$182	$290
Total private costs	$199	$231
Net benefits (public and private)	$47	$179
Net benefits (private only)	–$18	$59
Benefit–cost ratio (public and private)	1.24	1.77
Benefit–cost ratio (private only)	0.91	1.26

Note: For detailed benefit–cost analysis tables, please see Appendix B.

vate standpoint, the repowering of the 12 steamships is economically justified based on positive net benefits to society. Overall, at a 7-percent real discount rate, benefits exceed costs by $47 million over the 30-year analysis period for the 12 vessels collectively. Approximately $65 million (26 percent) of the benefits accrue to the public because of the reduction of emissions. Table 27 summarizes the physical emissions reductions in tons for representative years of 2020 and 2040.

Benefits that would accrue to the private vessel owners are valued at $182 million at a 7-percent real discount rate.[414] The majority of these private savings are generated by the increased engine fuel efficiency, with about 46 percent from other operational savings attributable to the reductions in non-fuel operating costs and maintenance costs. The analysis indicates that the combined private savings from repowering the steamships would cover most, but not all, of the $199 million in present-value costs to owners from purchasing and installing the new Category 3, Tier 2, diesel engines even after incurring the higher cost of MDO fuel after 2025 (when the fuel waiver from the Great Lakes Steamship Repower Incentive Program expires). Even so, the owners would collectively realize a net loss of $18 million—close to economic breakeven but still indicating that repowering may not be attractive to at least some owners at a 7-percent discount rate.

At a 3-percent real discount rate, the combined present value of public and private net benefits (benefits minus costs) of repowering steamships to diesel engines would be more pronounced at $179 million,

TABLE 27. Projected Annual Emissions Savings From Repowering U.S.-Flag Great Lakes Steamships With Category 3, Tier 2, Engines and Burning Fuel Under the EPA Steamship Repower Incentive Program

POLLUTANT	ANNUAL PROJECTED EMISSIONS SAVINGS (tons) 2020	2040
CO	11	–77
NO_x	–1,063	–1,004
PM-10	90	137
CO_2	33,118	41,321
SO_x	996	1,967

of which $120 million is attributable to public benefits caused by the reduction in emissions. Because private benefits exceed private costs, this would indicate that it would be financially beneficial for owners to repower under the current economic outlook if their opportunity cost of money (discount rate) was 3 percent in real terms. In reality, however, owners face risk and uncertainty when making large lump-sum investments and often will not have access to capital at 3 percent. Accordingly, the 7-percent discount rate described in the preceding paragraph is considered more realistic.

EPA's Great Lakes Steamship Repower Incentive Program is a significant inducement to convert to diesel engines. MARAD estimates that the program contributes approximately $61 million to the private benefit totals shown in Table 26 at a 7-percent real discount rate and $84 million at a 3-percent real discount rate. This impact is critical at both discount rates. At the 7-percent real discount rate, if the EPA incentive program were not in effect, the benefit–cost ratio for the steamship repowering scenario shown in Table 26 would fall below 1.0 (breakeven) for combined public and private benefits and to just 0.61 if only private benefits are considered. At the 3-percent real discount rate, the benefit–cost ratio for combined public and private benefits would still exceed 1.0 (at 1.42), but the ratio for private benefits only would fall below the economic breakeven point (at 0.90).

A key assumption in the analysis of the steamship repowering alternative is that the new diesel engines would burn 40 percent less fuel per ton-mile than did the steam engines. Analysis summarized in Table 28 shows that the justification for repowering erodes significantly at lower gains in fuel efficiency (e.g., if, instead of reducing fuel consumption by 40 percent, the new engines were to reduce fuel consumption by a third). Similarly, if the price difference between HFO and MDO were to increase, the attractiveness of repowering would diminish. Changes in efficiency have two impacts on the net benefits provided below. First, because vessels use less fuel as they become more efficient, the environmental benefits increase when engine efficiency goes up. Second, and more important to the net benefits to private operators, increases in engine efficiency require operators to spend less on fuel per ton-mile of freight moved, increasing the economic competitiveness benefits that go to the vessel operator.

In summary, the results of this analysis indicate that repowering steamships with Category 3, Tier 2, liquid-fuel diesel engines would yield significant public and private benefits, but is not quite at the breakeven point of being economically attractive to steamship owners at a 7-percent real discount rate. As noted, however, EPA's Great Lakes Steamship Repower Incentive Program greatly strengthens the economic rationale for repowering. At a 3-percent real discount rate, the case would be attractive to steamship owners.

The finding of a private-sector benefit–cost ratio that exceeds unity (1.0) at a 3-percent real discount rate and under the terms of the Repower Incentive Program is consistent with industry actions to repower steamships with Category 3 engines in 2006 and 2009, prior to the Category 3 Rule in 2010. In particular, prior to the Category 3 Rule, the repowered vessel could have been assumed to burn standard HFO (as it can now through 2025 even under the Category 3 Rule because of the Repower Incentive Program). If a Laker company was well capitalized during the strong economic years prior to 2008 or had access to low-cost capital, repowering to diesel would have been attractive in the last decade.

As of 2012, Lakes carriers are still recovering from the recent recession and may have limited access to capital. Moreover, the uncertain outlook for coal on the Great Lakes may make them particularly risk averse. If their opportunity cost of money (i.e., discount rate) adjusted for risk were 7 percent or higher,

TABLE 28. Sensitivity of Repowering Laker Steamships With Category 3, Tier 2, Engines to Assumptions About Fuel Efficiency (in million 2010 dollars) (7% real discount rate)

BENEFIT–COST ANALYSIS SUMMARY	REDUCTION IN ENERGY USE ($million 2010)		
	Case 1, 46%	Case 2, 40%	Case 3, 33%
Total benefits	$274	$247	$209
Public benefits	$69	$65	$59
Private benefits	$211	$182	$150
Total private costs	$199	$199	$199
Net benefits (public and private)	$75	$47	$10
Net benefits (private only)	$6	-$18	-$49
Benefit–cost ratio (public and private)	1.38	1.24	1.05
Benefit–cost ratio (private only)	1.03	0.91	0.75

as it likely is, repowering steamships to diesel could be deferred indefinitely even under the EPA program. [415] It is for this reason that additional incentives to vessel owners to repower may be warranted. One Federal incentive (for which Great Lakes vessels are eligible) would be Title XI loan guarantees, which would reduce the interest rate on commercial loans by eliminating the uncertainty to lenders of repayment (the loans would be federally guaranteed). As noted in the discussion of financial incentives in Chapter 8, Title XI loan guarantees could reduce the effective real cost of capital to private borrowers to near 3 percent (up to 87.5 percent of the eligible cost of the repowering project could be financed under Title XI). As noted above, at a 3-percent real discount rate, repowering would likely be attractive to steamship owners when combined with the Great Lakes Steamship Repower Incentive Program.[416] These guarantees, if funding for them is available, would leverage more than $65 million in public benefits from repowering all 12 vessels (see Table 26) and generate significant work at Great Lakes shipyards.[417]

Receipt of a Title XI loan guarantee is not automatic, however. An applicant must meet eligibility requirements to receive a Title XI loan guarantee.[418] Additionally, funding for the Title XI program is subject to congressional appropriation; steamship repower projects would need to compete with other industry demands for limited Title XI budget authority.[419]

Capital costs could also be reduced through use of tax-deferred funds from the CCF program, although Great Lakes carriers have not stored sufficient funds in this program to cover repowering. Finally, there is the possibility of access to other grants to incentivize environmentally beneficial actions, such as EPA Clean Diesel Grants under DERA. Federal and State incentives for repowering can be justified based on the significant public benefits derived from lower emissions.

Because the repowered steamships would be close to breaking even from a financial standpoint if repowered to diesel engines using Title XI or other Federal incentives (i.e., the private benefits to owners would approximately equal the private costs), MARAD does not expect that the provision of Federal incentives to the repowered vessels would upset the competitive balance among existing Laker operators.

Second Alternative Case of Scenario 1: Repowering Steamships with LNG Engines. Alternative 1 indicates that repowering the U.S.-flag Great Lakes steamships with modern Category 3 liquid-fuel diesel engines would be cost-beneficial from a combined public and private net benefits standpoint and close to cost-beneficial from a private-only benefits standpoint. Steamship owners who undertake repowering would benefit from EPA's Great Lakes Steamship Repower Incentive Program and could also benefit from other incentives such as Title XI loan guarantees. As demonstrated in the sensitivity analysis shown for Alternative 1, the fuel efficiency increases and other non-fuel operating cost savings generated by the repowering to diesel engines from steam engines have a large impact on the outcome of the analysis.

In this second alternative for repowering the steamships, MARAD explores repowering 10 of the 12 U.S.-flag Great Lakes steamships[420] with dual-fuel LNG/diesel engines.[421] This repowering scenario is more speculative than the preceding one, in that LNG technologies are still under development and no LNG-powered dry-bulk vessels have yet been deployed in the U.S.-flag Great Lakes fleet. However, this alternative is interesting in that it demonstrates the rationale for upgrading vessels with a more expensive engine if the primary fuel source (LNG) is likely to be less expensive and environmentally cleaner than petroleum distillate fuels.

The United States has abundant supplies of natural gas and currently has the opportunity to make much broader use of this clean-burning fuel for transportation. There are many potential benefits to using LNG-powered vessels, which are described below. In recognition of these potential benefits, MARAD initiated a study in November 2011 at GLMRI of the feasibility of using LNG to power marine vessels, both on the Great Lakes and nationally. The GLMRI study is specifically considering the repowering of existing steamships to engines that burn natural gas, either compressed natural gas or LNG, as their primary fuel source.[422] This research also is looking at many relevant issues pertaining to LNG use including modifications to landside supply chains and other infrastructure. The findings of this research will be transferrable to vessels other than steamships. Information developed in the GLMRI study, once final, would enable a more accurate assessment of a broader fleet transition to LNG-powered vessels.

Exploring LNG propulsion for Great Lakes vessels is justified by the potential benefits of using LNG. Some of the potential benefits are as follows:

- Use of LNG as a fuel would surpass the most stringent EPA emissions standards and further increase the benefit to the public from reductions of vessel emissions;
- The LNG engines are projected to reduce fuel consumption by up to 50 percent relative to the steam engines. An overall reduction in fuel consumption (as measured in BTUs) of 40 percent is assumed for this analysis. The engines would be as efficient as newer diesel engines that only burn liquid petroleum;[423]
- Supplies of LNG are potentially large and the current costs of natural gas are low, particularly when compared to petroleum distillates;[424] and
- Other benefits could be achieved if other uses for the port LNG infrastructure (e.g., powering of port equipment and vehicles, rail locomotives) can be established.

Repowering Great Lakes steamships with LNG engines would provide environmental benefits in two ways. First, LNG is a much cleaner fuel when burned than the HFO currently used in the steamships for most emissions categories, as indicated in Table 29 below. Second, the increased efficiency of the LNG engines means that relatively less fuel is consumed for the same amount of energy output by a steam engine, further compounding the environmental gains.

TABLE 29. Typical Specific Emission Levels From Marine Engines

POLLUTANT	ENGINE TYPE/FUEL TYPE/EMISSION CATEGORY	
	Steam Turbine/ Residual Oil/2% Sulfur (HFO)	Dual-Fuel LNG Engine/ LNG/ 0.0% Sulfur
SO_x [g/kWh]	11.90	0.00
PM [g/kWh]	1.16	0.00
NO_x [g/kWh]	Low (used 0)	2.00
CO_2 [g/kWh]	580–630 (used 605)	430–480 (used 455)
CO [g/kWh]	0.20	n.a.

Source: Data from Michael Parsons, Patrick J. O'Hern, and Samuel J. Denomy, "The Potential Conversion of the U.S. Flag Great Lakes Steam Bulk Carriers to LNG Propulsion—Initial Report," *Journal of Ship Production and Design,* Vol. 28, No. 3, August 2012, p. 100.

As shown in Table 29, engines burning LNG fuel do not emit SO_x or PM. NO_x emissions are lower from an LNG-powered engine than for conventional Category 3 diesel engines (see Table 23) but higher than for steam engines running on HFO fuel. LNG-powered engines also emit less CO_2 than steam and conventional diesel engines. The reduced emissions of LNG-powered vessels justify a major public and governmental interest in potential adoption of this technology. The improved fuel efficiency of the LNG-powered engines could also be a big benefit to vessel operators, particularly because the relative cost of LNG fuel per MMBTU is lower than for petroleum-based fuels.

The Great Lakes is a promising operating environment for introducing LNG fuel use. U.S.-flag Great Lakes operators usually spend no more than 5 to 7 days per roundtrip as opposed to much longer voyages for many oceangoing vessels. Work for the feasibility study by Parsons et al. indicates that the existing steamships in the U.S.-flag Great Lakes fleet have sufficient room to accommodate LNG fuel tanks that would supply 10 to 13 days' worth of fuel.[425]

Repowering of the steamships with LNG-fueled engines will initially be more viable than the repowering of conventional diesel vessels. Parsons et al. note that steamships have reasonable centerline volumes (because of room in the hull currently occupied by boilers and the fuel bunkers) to accommodate LNG fuel storage for voyages (although accommodating LNG tanks will still be a challenge). They note that bulk vessels built initially with diesel engines have no equivalent space available to accommodate LNG storage and are less likely candidates for conversion to LNG unless the hulls could be lengthened. In the case of vessels already fully-sized to lock capacity, cargo capacity would need to be reduced to accommodate LNG storage.[426]

Although the potential for LNG fuel on Lakers is strong, the MARAD-funded GLMRI study is looking at the technological challenges presented by the use of LNG as a marine fuel, particularly for larger vessels such as the Lakers. These challenges include:

- The design and construction of landside infrastructure capable of delivering LNG to ports;
- Delivering LNG from a landside storage tank to the special cryogenic fuel tanks on the vessel, including the possible requirement for specially trained bunkering staff;[427]
- Storing a sufficient volume of fuel to achieve an acceptable operating range (referenced above);
- Location of the storage tanks on vessels, especially for retrofitted vessels (referenced above);
- Working with regulators to address unanswered questions on fuel-storage decisions, fueling procedures, and other safety issues;
- Protecting the vessel's hull structure from LNG fuel spills; and
- Developing an increased safety culture aboard the vessels so that crews are aware of how to respond to the risks from LNG fuel.

Most of the LNG handling and storage issues are likely to prove manageable. The GLMRI LNG feasibility study team—and also vessel operators in the Great Lakes region—are examining the issue of the potential landside infrastructure for delivering LNG to ports. Potential solutions include onsite LNG liquefaction plants and also trucking LNG from liquefaction plants to ports. In any case, the use of dual-fuel LNG/diesel engines would allow MDO fuel to be burned if LNG proved unavailable at one or more ports when a refueling need arose.

Significant uncertainty, however, centers on what the future price of LNG will be, particularly relative to MDO and residual fuel oils. EIA in 2011 projected that the price ratio per MMBTU of low-sulfur crude oil to Henry Hub natural gas prices[428] will increase from approximately 3 in 2011 to nearly 4 in 2020, and after that point the ratio will begin to decrease (see Figure 11). Under this projection, the cost of 1 MMBTU of energy in the form of low-sulfur crude oil would cost 3 to 4 times the cost of 1 MMBTU of energy from unprocessed natural gas.

The ratio shown in Figure 11 does not reflect processing costs needed to produce LNG. A long-term price of natural gas of $4 to $5 per MMBTU[429] at Duluth or Cleveland would be equivalent to an LNG price (after adding in a fixed liquefaction fee of $3 per MMBTU and a fee of 15 percent of the natural gas price to fuel the liquefaction facility) of $8 to $9 per MMBTU.[430] This cost does not include a transportation cost of LNG to the port if the port is not co-located with the LNG liquefaction facility. At $650 per metric ton, HFO would be priced at approximately $103 per barrel, with one barrel containing 6,400,800 BTU, equal to just over $16 per MMBTU.[431] Thus, LNG would cost as little as half of HFO per MMBTU. Moreover, if the relatively stable ratio of raw energy products shown in Figure 11 prevails, this price advantage for LNG may be sustained (HFO and crude petroleum have comparable prices per MMBTU). It would appear that vessel operators could realize significant fuel-cost savings per MMBTU by switching to engines that can accommodate LNG, even if such vessels are currently burning HFO.

There is a risk, of course, that projections of the future per-MMBTU cost of LNG, based on the current market for natural gas, could underestimate future costs. Since the market for natural gas is still

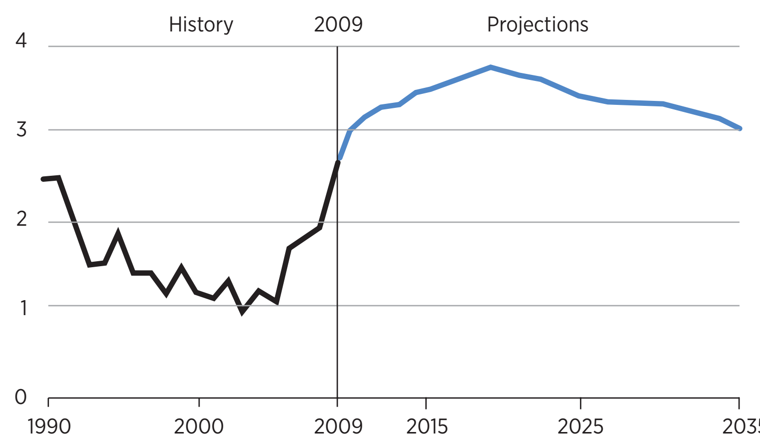


FIGURE 11. Ratio of low-sulfur light crude oil price to Henry Hub natural gas price on an energy-equivalent basis, 1990–2035.

(Source: U.S. Energy Information Administration, *EIA 2011 Annual energy outlook 2011 with projections to 2035,* DOE/EIA-0383(20 II), Apr. 2011, p. 78, at http://www.eia.gov/forecasts/aeo/pdf/0383%282011%29.pdf (accessed May 1, 2012)). Note that residual fuel prices typically track those of crude oil, but isolated factors, including speculation in the crude market or difficulties for vessel operators in either storing or hedging fuel, can create pricing distortions. In general, 1 metric ton is equal to 7.2 barrels of crude. As of August 2012, for instance, 1 ton of crude would have cost approximately $660 (at $92 per barrel) whereas 1 ton of IFO 380 (a heavy residual oil) would cost $650 ("TSA Bunker Fuel Charges: A Refined Approach, Fact Sheet" at http://www.tsacarriers.org/fs_bunker.html and Bunkerworld Prices at http://www.bunkerworld.com/prices).

responding to significant recent increases in both supply and demand, the current pricing outlook might not reflect what will be the ultimate long-term pricing structure. For instance, future LNG prices could become indexed to the price of petroleum, particularly if the market share of natural gas as a transportation and power generation fuel within the U.S. were to grow significantly, increasing the long-term demand for natural gas. Potential export markets of U.S. LNG may also lead to price increases, especially if long-haul transportation costs can be lowered. The consensus opinion for now, however, is that LNG will cost significantly less in the future than liquid petroleum fuels on a per-MMBTU basis.[432]

Another source of uncertainty is the cost of transporting the LNG to the refueling port. This study assumes that, as demand for LNG grows in the Great Lakes regional economy, some LNG liquefaction facilities will be built at lakeside locations, either at or in close proximity to ports, from where LNG could be distributed at low cost by barge to other locations. At such facilities, transfer costs of LNG fuel to Lakers would be relatively minor. However, if such facilities are not built, LNG would likely be transported to ports by truck, which could cost as much as $4 per MMBTU depending on distances.[433]

The following BCA of repowering the steamships with dual-fuel LNG/diesel engines uses data from the Parsons et al. study[434] as well as from other sources to inform the analysis. The assumptions for the alternative are as follows:

- Ten of the steamships are suitable for being repowered with LNG propulsion units;
- The timeframe for LNG repowering is for one vessel to be repowered prior to the 2014 operating season and up to three vessels per year from 2015 to 2018. MARAD acknowledges that this repowering scenario is ambitious, but notes that the overall results of deferring vessel repowering by a few years would not materially change the results of this analysis;
- When the full repowering is completed in 2018, approximately 30 million gallons (52,000 tons) of LNG would be required per year to support the 10 vessels;[435]
- Each repowering will cost approximately $25 million, based on the assessment that LNG-powered engine capital costs are 15 to 20 percent higher than those for a comparable diesel engine, in part because of the cryogenic storage tanks and fuel-handling systems required;[436]
- LNG is assumed to cost one-half the price of HFO per MMBTU;[437]
- Emission levels in grams per ton-mile for steam turbines burning HFO and dual-fuel engines burning LNG are measured using the emissions rates specified in Table 29;
- Port equipment to fuel the vessels from portside LNG liquefaction facilities is estimated to be $4 million per port.[438] For this analysis, it is assumed that there is a $4-million port development cost per vessel, for a total of $40 million (meaning 10 or more ports receive LNG fueling infrastructure); and
- Maintenance and repair costs for the LNG vessels are assumed to be equivalent to those for a repowered diesel vessel;[439] the overall savings in non-fuel operating costs associated with repowering to a dual-fuel LNG/diesel is assumed to be a 10-percent reduction compared to the steamships.[440]

TABLE 30. Costs and Benefits of Repowering the U.S.-Flag Great Lakes Steamships With Dual-Fuel LNG/Diesel Engines (million 2010 dollars)

BENEFIT–COST ANALYSIS SUMMARY	NET PRESENT VALUE AT 7% DISCOUNT RATE	NET PRESENT VALUE AT 3% DISCOUNT RATE
Total benefits	$336	$582
Public benefits	$87	$152
Private benefits	$248	$430
Total private costs	$223	$259
Net benefits (public and private)	$113	$324
Net benefits (private only)	$25	$171
Benefit–cost ratio (public and private)	1.50	2.25
Benefit–cost ratio (private only)	1.11	1.66

Note: For detailed benefit–cost analysis tables, see Appendix B.

The outcome of the BCA is shown in Table 30. As was the case of repowering with Category 3, Tier 2, liquid-fuel diesel engines, the combined public and private benefits would exceed the costs of repowering the vessels. Overall, at a 7-percent real discount rate, combined public and private benefits exceed costs by $113 million over the 30-year analysis period. Approximately 26 percent of total benefits accrue to the public.

Benefits that would accrue to the private vessel owners are valued at a present value of $248 million over 30 years at a 7-percent real discount rate. Relative to the private costs of repowering, the private benefits result in net benefits to private owners of $25 million. Overall, this outcome is better than that estimated for a conventional diesel repowering in the previous alternative even though EPA's Great Lakes Steamship Repowering Incentive Program would not apply in this instance (the LNG engines cannot burn HFO fuel) and only 10 steamships are repowered to LNG compared to the 12 steamships repowered in Alternative 1. However, there is clearly more uncertainty associated with LNG repowering than repowering to conventional diesels (see below).

The public benefit of repowering the U.S.-flag Great Lakes steamships with LNG-powered engines is the reduction in engine emissions (see Table 31). These benefits are calculated based on ton-miles of freight from Table 21 (pro-rated to apply to 10 vessels) multiplied by per-ton-mile emission factors derived from data in Table 29. Because emissions reductions factors for CO were not available, these figures only include reductions in NO_x, SO_x, PM, and CO_2. Even though only 10 of the 12 steamships are assumed to be candidates for LNG engines, the overall emissions reductions in 2020 and 2040 in this scenario are generally significantly better than the emissions reductions in 2020 and 2040 for Alternative 1 (see Table 27) because LNG is a cleaner-burning fuel than diesel and LNG fuel use begins immediately after repowering. Per-vessel emissions reductions in the LNG scenario are larger in all categories than for repowering with conventional diesels.

TABLE 31. Projected Annual Emissions Reductions From Repowering the U.S.-Flag Great Lakes Steamships With LNG Engines

POLLUTANT	ANNUAL PROJECTED EMISSIONS SAVINGS (tons)	
	2020	2040
CO	-54	-67
NO_x	–140	–175
PM-10	137	170
CO_2	39,356	49,105
SO_x	1,402	1,749

Private vessel owners and operators of steamships receive three benefits from the repowering with dual-fuel LNG/diesel engines. First, the repowering would increase the fuel efficiency of the former steamships by at least 68 percent, reducing by 40 percent the MMBTUs of fuel they need to purchase per year. The second benefit of using LNG engines is that the price the operators pay per MMBTU of LNG is expected to be significantly lower than for liquid fuels. In Alternative 1, the conversion of the steamships to diesel engines that must use low-sulfur fuel after 2025 increases per-ton fuel costs for the remainder of the 30-year analysis period. LNG thus has the added benefit of changing what was a cost (the eventual transition to a higher cost fuel) into a benefit (use of a lower cost fuel throughout the life of the asset). The combined greater fuel efficiency and lower fuel cost account for the majority of private benefits.

Third, repowering the vessel reduces other non-fuel operating and maintenance and repair costs when moving from a steam engine to a diesel or LNG/diesel engine. In this analysis, an overall non-fuel operating cost reduction of 10 percent is assumed, which is the same level used in the first repowering alternative (Category 3, Tier 2, diesels).[441] These non-fuel, cost-reduction benefits total about $70 million over 30 years at a 7-percent real discount rate and about $119 million over 30 years at a 3-percent real discount rate.[442]

The two principal cost elements examined in the BCA for this alternative are the capital costs of repowering the vessels and the per-vessel cost of setting up fueling facilities at the ports. As previously stated, the vessel repowering cost is assumed to be $25 million per vessel, compared to $20 million per vessel for the cost of repowering the U.S.-flag Great Lakes steamships with liquid-fuel diesel engines. The present value cost to repower 10 U.S.-flag Great Lakes steamships is $193 million at a 7-percent real discount rate or $223 million at a 3-percent real discount rate (not including port LNG fuel facility costs). The total present value of port-equipping cost is calculated to be $31 million at a 7-percent real discount rate or $36 million at a 3-percent real discount rate. This cost does not take into account the cost of LNG liquefaction plants, as it is assumed that the liquefaction costs are reflected in the price of the LNG.[443]

The above-mentioned findings must be qualified by the large degree of uncertainty surrounding the use of LNG engines on bulk ships. There is uncertainty regarding the ability to store LNG fuel on vessels, the availability of such fuel at lakeside locations, the handling of such fuel, safety requirements, the cost of repowering the vessels, and the future cost of LNG fuel. There are no large bulk vessels operating on the Great Lakes using such engines, and it may take several years before the viability of LNG as a Laker fuel can be established.[444] Thus, even with the use of dual-fuel LNG/diesel engines, which make the use of MDO fuel an option if LNG is unavailable or noncompetitive in price, the factors summarized above will likely lead to caution.

In particular, some vessel owners will wish to wait until there is more certainty about the long-term price of LNG as a fuel. Table 32 reveals that the benefit–cost ratio of the steamships repowered to LNG engines would fall substantially below unity (breakeven) if LNG reaches parity with HFO costs per MMBTU. Were LNG not available, owners would need to purchase MDO at prices substantially above HFO prices.

In summary, the first implication of this BCA exercise is that repowering steamships with dual-fuel

TABLE 32. Sensitivity Analysis of the Impact of Fuel Cost Differential on the Repowering of U.S.-Flag Great Lakes Steamships With LNG Engines (in million 2010 dollars and at 7% discount rate)

	RATIO: Price per MMBTU of LNG to the Price per MMBTU of Petroleum			
BENEFIT–COST ANALYSIS SUMMARY	Case 1, 1:1	Case 2, 2:1	Case 3, 3:1	Case 4, 4:1
Total benefits	$204	$336	$380	$402
Public benefits	$88	$87	$88	$88
Private benefits	$116	$248	$292	$314
Total private costs	$223	$223	$223	$223
Net benefits (public and private)	–$20	$113	$157	$179
Net benefits (private only)	–$107	$25	$69	$91
Benefit–cost ratio (public and private)	0.91	1.50	1.70	1.80
Benefit–cost ratio (private only)	0.52	1.11	1.31	1.41

Note: MMBTU = 1 million British thermal units.

LNG/diesel engines makes economic sense if reliable engine and vessel fuel storage technologies can be installed at under $25 million per vessel, LNG supplies are available at portside, and LNG can maintain a pronounced per-MMBTU price advantage over liquid fuels over the long term. Alternatively, steamship owners considering repowering would be more likely to turn to conventional Category 3, Tier 2, diesel engines that burn liquid fuel if they believe that LNG prices are too prone to future increases (or are simply too uncertain) or that supplies of LNG will not be forthcoming at ports (except with major delivery costs from inland locations). Use of conventional diesels engines is also made attractive by the Great Lakes Steamship Repower Incentive Program, which allows the use of HFO in Category 3, Tier 2, diesels through 2025.

The second implication of this BCA is that there is justification for a potential role for Federal and State governments in encouraging the development of an LNG-powered fleet. Because of the very low air emissions associated with burning LNG fuel, pollutants such as SO_x and PM can be eliminated, and CO_2 can be reduced as well when compared to steamship consumption of HFO fuel. Inclusion of the monetary value of these public benefits makes repowering with LNG-fueled engines substantially more cost-beneficial than would be the case if only private benefits and costs are considered.

Potential assistance from the Federal and State governments would include the facilitation of vessel repowering and the construction of LNG infrastructure at ports. Title XI loan guarantees to vessel owners would significantly reduce interest rates of loans to vessel owners to fund repowering (enabling real interest rates of about 3 percent). Given the uncertainty surrounding LNG repowering, commercial lenders may be especially reluctant to lend even at interest rates of 7 percent or higher unless repayment is guaranteed. EPA Clean Diesel grants or grants under MARAD's Vessel Emissions Reduction Cooperative Agreements could also facilitate repowering. Assistance could take the form of grants to ports (e.g., in the form of TIGER grants if funds are available) to install LNG fueling facilities and expedited environmental reviews of port LNG projects. Continued strong support of research and development activities pertaining to new LNG technologies will help to lower costs and reduce risk. More research would disclose specific information on the cost of engine repowering; the long-term difference in cost between LNG, MDO, and residual fuels such as HFO; the cost of equipping ports to fuel LNG vessels; and the number of fueling stations needed to support fleet activities.

Another means to encourage the repowering of steamships with LNG engines would be to extend the well-received Great Lakes Steamship Repower Incentive Program to LNG engines. Although these engines could not burn HFO, some in the industry have suggested that permission to burn HFO through 2025 could be transferred to a diesel vessel of comparable size, or a fuel credit could be set up for a fixed quantity of HFO to be used by other vessels in the fleet. Based on the Alternative 1 analysis, the value of this credit ranges from $61 million to $84 million for 12 steamships, depending on the discount rate, and if adjusted for 10 LNG ship conversions, would be $51 million to $70 million. This amount could significantly reduce the risk associated with higher than expected LNG prices (see Cases 1 and 2 in Table 32).

A government role in promoting the use of LNG as a transportation fuel is appropriate for reasons not exclusive to Laker transportation services, as LNG fueling facilities at the ports could be developed in a way that would support the use of LNG-powered trucks, service vehicles, and port equipment as well. These fueling stations, if fully utilized, would likely decrease the air emission footprint of the ports with LNG fueling facilities, and the greater use of LNG would also increase the incentive for natural gas companies to build liquefaction plants near the ports. FHWA grants from the Congestion Mitigation and Air Quality program could be available to support the development of LNG fueling facilities to reduce truck and vehicle emissions in port communities.

SCENARIO 2: Replacing Steamships With New Builds

MARAD initially proposed a scenario whereby, instead of repowering existing steamships, the vessels would be replaced in whole by new builds. The results of the Category 3, Tier 2, diesel repowering scenario shown in Table 26, however, suggest strongly that this scenario could not be justified on a benefit–cost basis under the current economic and regulatory environment. The

great majority of benefits associated with revitalizing a Laker are attributable to the new engines (both in terms of fuel efficiency and reduced maintenance and non-fuel operating costs). The hulls and superstructure of the vessels are long-lived and durable in the fresh water of the Great Lakes. Assuming that current vessel sizes would be sustained to meet market demand for smaller vessels and to accommodate space constraints at smaller ports, replacement of existing steamships would cost approximately $80 million per vessel compared to $20 million for repowering. These much higher capital costs would greatly exceed any incremental efficiency savings to operators that would not be captured by repowering alone. Table 26 indicates that the costs of repowering alone at a 7-percent discount rate already exceed by a small margin the private benefits of doing so—the extra capital costs of new hulls would send the benefit–cost ratio far below unity even at a 3-percent discount rate. The same argument in favor of repowering versus new building would apply to the LNG engine alternative.

Moreover, the commitment of very large sums of private capital to new vessels with potential lifespans of 50 years or more introduces a new element of risk to investors. Although the Great Lakes commodity markets appear likely to sustain stable demand or positive growth, investors may perceive risks that lake-borne commodity trades could diminish in the future. USACE found in 2002 that vessel owners at that time were reluctant to order new vessels because of uncertainty in the iron ore trades.[445] Similarly, recent uncertainty about the coal trade will likely contribute to a comparable reluctance to build new vessels (with occasional exceptions).

Finally, the ability of the shipyards on the Great Lakes to support new vessel construction would be limited, although for vessels of this size (the steamships are under 740 feet in length), which can travel through the St. Lawrence Seaway, U.S. coastal shipyards could also be employed if a new building program were pursued.

SCENARIO 3: Repowering Existing Diesel-Powered Lakers

The emphasis in the preceding scenarios has been on the potential benefits of repowering the U.S.-flag steamships that operate on the Great Lakes. These vessels are clear candidates for repowering in that they consume large amounts of fuel and account for a disproportionate amount of emissions from the Laker fleet. Repowering would make these vessels much more fuel efficient, and particularly if done with dual-fuel LNG/diesel engines, would place these vessels among the cleanest forms of freight transportation on Earth.

For this study, MARAD originally intended to consider an option for repowering the broader range of existing Laker vessels, including the 30 Category 2 diesel-powered vessels and 13 Category 3 diesel-powered vessels. Research revealed, however, that the greatest source of public benefits associated with repowering the steamships in Scenario 1 (reduced SO_x emissions) would already be accommodated for existing diesel vessels through the mandatory use of low-sulfur fuels. In particular, the Category 2 diesel-powered vessels are required to burn ultra-low-sulfur diesel fuel (15 ppm sulfur) beginning on June 1, 2012; Category 3 vessels are currently (as of August 2012) burning 1-percent sulfur fuels and will, beginning in 2015, burn 0.1-percent sulfur fuels.

Contrary to the older generation steam engines considered in Scenario 1, which have comparable efficiencies, there is a wide variety of diesel engines with different performance characteristics among the Lakers, including the following engine types: EMD 645 (Category 2), Caterpillar (Category 2), Alco 16-251 (Category 2), Nordberg 1316-H5C (Category 2), Fairbanks 38D 8-1/8 (Category 2), Pielstick PC-2 (Category 3), Enterprise (Category 3), and Mirrlees KV-16 (Category 3).[446] The EMD 645 engines, which are the most common of the diesel Laker engines (they are typically used in series of up to four engines in a vessel), can be upgraded to comply with EPA Tier 2 requirements and gain in fuel efficiency, can be repowered with more efficient engines that fit into the footprint of the older engines, or can even be modified to dual-fuel engines that burn natural gas.[447] The range of options for upgrading or replacing these engines is sufficiently complex that it would be unrealistic to model these variations. Moreover, the circumstances of individual owners and engines vary such that no one approach would be appropriate to all, even for a specific engine type or category. Accordingly, MARAD decided not to model the economic justification for private-sector decisions to upgrade or replace diesels, with the full awareness that owners will continue to make appropriate decisions to meet their business requirements.

This is not to say that the Federal Government is disinterested in the owners' decisions. For instance, in 2010, the Class 10 *Edwin H. Gott* was repowered to Category 3, Tier 2, diesel engines, having previously been powered by Enterprise Category 3 diesel engines. EPA, which supported the vessel's repowering with a $750,000 Clean Diesel grant, reports that the new engines will generate annual savings of 7 tons of PM, 239 tons of NO_x, and 53 tons of CO.[448] For this particular vessel, over a 30-year timeframe, the present value of the reduced emissions to the public (using the values in Table 24 and Table 25 and a 7-percent real discount rate) would be approximately $5 million. This compares to a total repowering cost of the $15 million, of which more than $14 million were funds provided by the vessel owner.

Acknowledging that there are benefits to the public because of reduced emissions of newer diesel and dual-fuel LNG/diesel engines, it could be appropriate for the Government to assist vessel owners who are seeking to repower diesel vessels. This would be most justifiable if the benefit to the public from cleaner air would exceed the cost to the Government of the loan guarantee or other form of assistance offered by the Government, and such assistance would cause or expedite the repowering action.

Finally, MARAD notes that the majority of public and private benefits associated with revitalizing Laker diesel vessels are realized by repowering. New builds to replace existing vessels in sound condition will generally not prove to be cost-beneficial. On the other hand, occasional new builds will be needed in the future to replace scrapped vessels or add fleet capacity, particularly if iron ore or limestone markets grow and coal markets hold steady. Provided this growth is gradual, it can be accommodated by private investment, using the current shipyard base of the Great Lakes, although Government incentives could be used to leverage public benefits that might not otherwise occur without such aid (e.g., engines that exceed regulatory standards for emissions).

CHAPTER 10

NEW MARKET POSSIBILITIES

The maritime community has expressed significant interest in recent years about the potential for greater use of the Nation's waterways to move containers and trailers between domestic ports in the continental United States. These operations between domestic ports are often referred to as *short-sea* or *marine highway services.* Recent studies indicate that there may be some potential for growth in this market because of lower water transportation costs compared to truck freight (where origins and destinations of freight are reasonably accessible by water) and growing highway and rail congestion, particularly around urban areas such as Chicago. In response to these and other studies, Congress directed USDOT to establish a Marine Highway program.[449] USDOT fully implemented the America's Marine Highway Program in April 2010 through publication of a Final Rule in the Federal Register pursuant to the legislative requirement.[450] Figure 12 shows the location of Marine Highway Corridors designated by the Secretary of Transportation under this program in 2011.

As of the writing of this report, there is no scheduled container-on-barge, RoRo vessel, or containership service on the Great Lakes. A recent attempt at such a service, the Canadian-flag Sea3 service which provided container-on-barge service between Montreal and Hamilton, was launched in July 2009 but was unable to capture market share and was discontinued.[451] The Sea3 service provided the first regular container movements on the Great Lakes in recent years and was intended, in part, to demonstrate the viability of short-sea shipping linking Great Lakes ports with St. Lawrence River and East Coast gateway ports.[452] Nonetheless, there continues to be strong interest in establishing container and trailer water services.

Perhaps the foremost justification for marine highway services is that they offer an alternative to congested land-based modes. By all accounts, the capacity of U.S. waterways, and particularly the Great Lakes, for the movement of freight and passengers is underutilized. Highways and railroads, on the other hand, have been strained for capacity for decades, most noticeably in urbanized areas. Figure 13 shows a map of congested areas of the Great Lakes region. As an alternative to land-based modes, water transportation offers the potential of reduced landside traffic congestion (including removing trucks from crowded roadways), reduced wear and tear on roadways (due to the removal of heavy trucks), low freight costs, reduced emissions (because of inherent fuel efficiency of water modes), improved safety (water is the safest of the transportation modes per ton-mile of freight moved), and other benefits.[453]

The successful introduction of marine highway services to the Great Lakes will be challenging. Although water transportation is an area of long history and expertise on the Great Lakes, the particular requirements of moving containerized goods are very different than those for moving bulk goods. The current Great Lakes marine transportation system is focused on the movement of dry-bulk products where transportation costs are a significant portion of the final landed cost of the product. Thus, the competitive strength of the current Laker vessels is their ability to carry high volumes of cargo at a low cost per ton, operating at relatively low speeds, and accommodating the needs of individual customers for reliability,

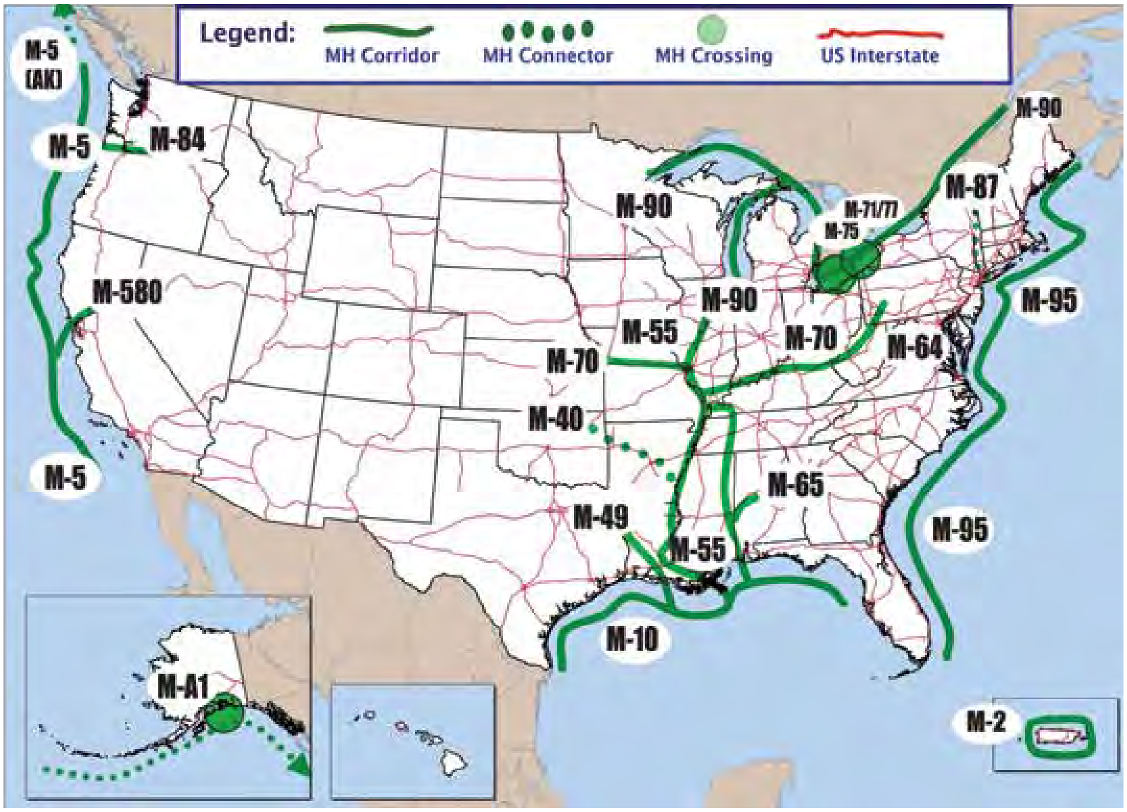


FIGURE 12. Map of marine highway corridors, connectors, and crossings.
(Source: USDOT, MARAD, "America's Marine Highway Program," at http://www.marad.dot.gov/ships_shipping_landing_page/mhi_home/mhi_home.htm.)

scheduling, and onsite delivery. Dry-bulk cargoes are well-suited for storage; thus, they can be stockpiled to meet the needs of industry during winter months when most water service on the Great Lakes is suspended because of ice cover.

For Great Lakes carriers to enter into a new market carrying domestic trailers and containers, a substantially different set of capabilities is required. Vessels that move containers must be of different design than dry-bulk ships. They must be faster and generally smaller than existing Lakers, and in most cases must be capable of passage through the Welland Canal and St. Lawrence Seaway locks to access Montreal and coastal ports. The carriers who operate the vessels must be able to accommodate demands of customers for scheduled, relatively fast, and highly reliable service. The carriers must also be able to provide door-to-door delivery between numerous inland origins and destinations for many different customers on any given voyage (unless they provide line-haul wholesale transportation services to a larger intermodal operator, such as a rail or trucking company). In other words, marine highway carriers must accommodate the needs of modern supply chain management, which involves managing the physical flow of materials and goods, the associated information and cash flows, and relationships with suppliers, service providers, and customers.

MARAD chose not to do a new evaluation of the benefits and costs of establishing marine highway services on the Great Lakes for this study. This decision was made for two principal reasons:

- There has been an abundance of recent research on the viability of Great Lakes container and trailer services, including the 2007 study, *Great Lakes–St. Lawrence Seaway New Cargoes/New Vessels Market Assessment Report;* and
- Unlike the issue of repowering, which largely is specific to known engineering and environmen-

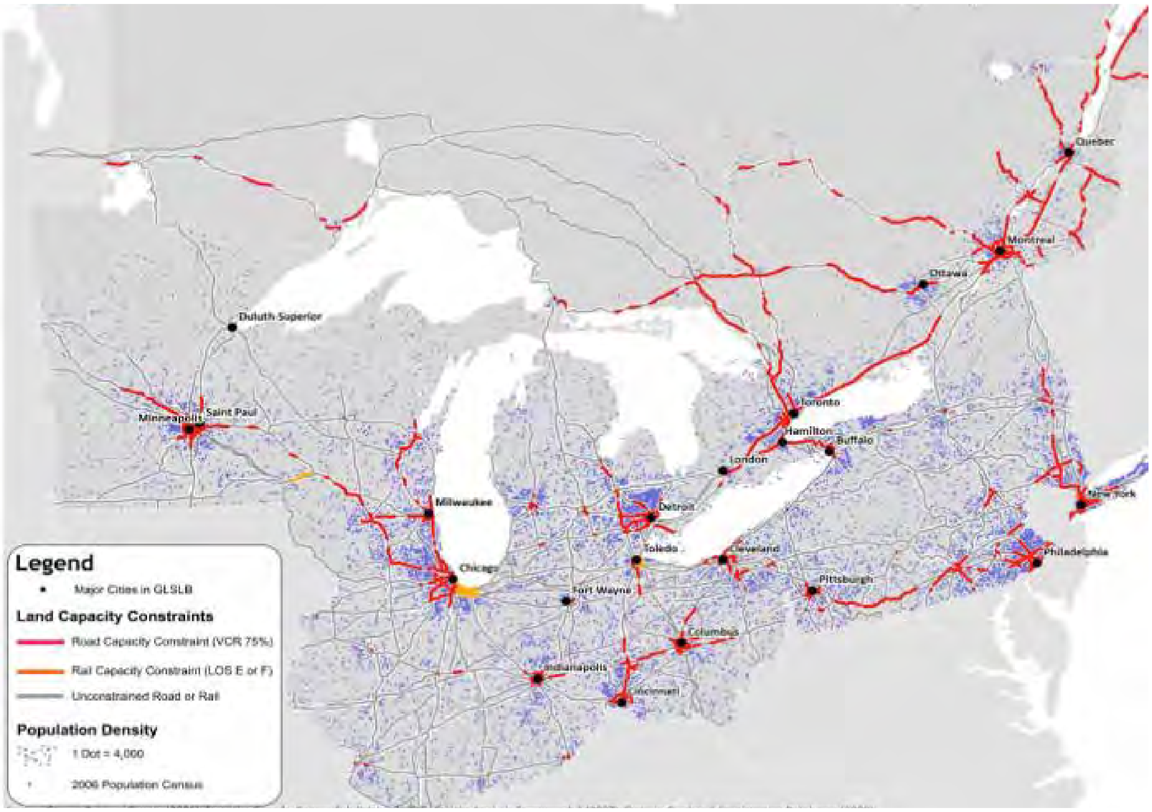


FIGURE 13. Land capacity constraints in the Great Lakes Region.

(Source: Reprinted by permission of the Transportation Research Board of the National Academies, Washington, DC. CPCS Transcom Limited, *NCFRP Report 17: Multimodal Freight Transportation Within the Great Lakes–Saint Lawrence Basin,* 2012, Figure 3-45, p. 58, at http://www.trb.org/Railroads/Blurbs/167517.aspx.)

> tal impacts, economic analysis of marine highway services requires extensive information on landside, port, and water transportation costs associated with containers and trailers, estimation of the value to shippers of reliability and schedule frequency for the general cargoes shipped in containers, and the competing transportation and handling expenses of cargoes moved by trucks and railroads. This information is very difficult to obtain (most of it is proprietary), and the range of potential freight markets and routes makes generic conclusions about comparative benefits and costs difficult. The analysis of specific markets is possible but is beyond the scope of this study effort.

Instead, a summary of recent reports on marine highways and intermodalism in the Great Lakes region is provided.

A recent study funded by the Transportation Research Board's National Cooperative Freight Research Program on intermodal transportation on the Great Lakes found that there are many barriers to establishing a marine highway system, stating:

> The GLSLB [Great Lakes St. Lawrence Basin] marine system is most competitive for carrying heavy and low-value bulk and liquid bulk traffic (i.e., traffic already moving on waterways). For intermodal container or roll-on/roll-off (RORO) traffic, the waterways have proven less competitive for a host of reasons (slower transit times, lower frequency of service, increased handling requirements, closure of Seaway for three months of the year, regulatory barriers, perception, competition from railways, etc.). There is nevertheless great interest among GLSLB ports and St. Lawrence Seaway stakeholders to increase the competitiveness of the marine mode, particularly for the movement of containers.[454]

A study done by the Pennsylvania Transportation Institute, *Analysis of the Great Lakes/St. Lawrence River Navigation System's Role in U.S. Ocean Container Trade,* focused on ocean containers moving in international trade.[455] This study did not examine interlake or intralake container trade. The study team did not find that the Great Lakes–St. Lawrence Seaway system would be favored by ocean container vessel operators.

It concluded that the relatively long transit times on the system are likely to dissuade containership operators from offering service on the system and shippers of container cargo from using the service.

MARAD and the Office of the Secretary of Transportation funded a 2006 research report, *Four Corridor Case Studies of Short-Sea Shipping Services: Short-Sea Shipping Business Case Analysis,* which included a supply chain analysis of a Great Lakes route.[456] The study presented carriers' costs for the respective transportation modes (truck, rail, and water) on each corridor and the total cost for moving a trailer load of freight on the particular corridor that would be incurred by the shipper of that freight. The cost to the freight shipper included an estimated profit margin added to the carrier's costs as well as the incremental inventory carrying costs for each mode and the HMT that would apply to the short-sea option. A supply chain analysis was done for a Great Lakes route from Madison, WI, to Detroit, MI.[457] The study concluded that, for this particular route, "the short-sea mode is superior to trucking in terms of both transit time and cost." The analysis assumed that, initially, a single vessel would offer a daily service in each direction.

MARAD funded a more extensive market survey of the freight transportation needs of shippers in the United States and Canada through the *Great Lakes–St. Lawrence Seaway New Cargoes/New Vessels Market Assessment Report.*[458] The survey, conducted by Transportation Economics and Management Systems, Inc. (TEMS) and RAND Corporation (TEMS/RAND), revealed willingness among shippers to use water container services if the water services were comparable and competitive to truck and rail in terms of time, cost, and reliability. The survey found that shippers could adjust to the "seasonality" of water service (the lack of service from January through March because of ice cover on the Great Lakes and Seaway) if offered rate reductions relative to rail and truck service. The rate reductions for the types of goods likely to be containerized (e.g., semi-finished and finished goods) would need to be about 14 percent (almost 25 percent in the case of food).[459]

The TEMS/RAND study looked at three potential intermodal routes that would use Great Lakes vessels:

- I-H20 East—Provides inland distribution from the East Coast container ports of Halifax and Montreal to Lake Ontario and Lake Erie ports such as Hamilton and Cleveland.
- I-H20 West—Provides access to inland container markets such as Detroit, Cleveland, and Hamilton using a mini-land bridge (rail) from the Northwest Coast ports of Seattle, Tacoma, Vancouver, and Prince Rupert to Great Lakes ports such as Duluth and Thunder Bay.
- GLSLS Domestic Connector—Provides an inter-lake/inter-Seaway connection for containers that would bypass major rail and road congestion areas such as Chicago, Detroit/Cleveland, Buffalo/Toronto, Montreal, and Northeast coastal cities. This particular route was deemed to have the best potential for success.

The TEMS/RAND study team considered a range of different vessel types on these routes, ranging from 8- to 12-knot tug-barges to 20-knot RoRo vessels (later transitioning to 20-knot containerships) to 20- to 40-knot Partial Air Cushion Support Catamaran vessels. They ultimately concluded that the most efficient vessels, once markets are fully developed, would be modern 20-knot, Seaway-max containerships each with up to 665 forty-foot equivalent units (FEU) capacity that would carry both international and domestic traffic.[460] Initially, however, the service would begin with 20-knot RoRo vessels, possibly sized up to Seaway-max size with 350 FEU of capacity, although service would likely start with smaller vessels.[461] The study team determined that RoRo vessels, although less efficient in container stowage than containerships, are needed at the start because of the lack of container-handling facilities at many Great Lakes ports and the flexibility RoRos permit for accommodating accompanied (i.e., with tractor and driver) and unaccompanied truck trailers, containers, neo-bulk cargoes, and possibly railcars on the same vessel. The ability to stow trailers is particularly important since the great majority of the cargo that water services would hope to capture currently moves by truck.[462]

It was anticipated by the TEMS/RAND study team that the marine highway service would need to provide, at a minimum, a daily service to be competitive with inland trucking services.[463] For one route discussed (Chicago to Halifax), this would entail approximately a 5.5-day (135 hour) one-way transit,[464] which would require from 10 to 12 vessels to cover the route (once fully developed) with daily sailings (assuming roundtrip sailings of 11 days and no intermediate port calls). However, if service stops at Montreal rather than Halifax, the one-way sailing time would be 3.5 days (85 hours), allowing 7 vessels to provide daily service. The TEMS/RAND study suggests that a startup service could involve more limited vessel deployments, with hub transfers from Lake Superior to the lower Lakes at Cheboygan, MI.[465]

Securing up to 350 FEU of cargo per day would initially require hub port connections on some routes to consolidate cargoes.[466] The mix of U.S. and Canadian domestic cargoes also complicates the mix of flag ships because of cabotage requirements, requiring a hybrid U.S.-flag and Canadian-flag service.[467] The study team estimated that the line-haul costs per FEU-mile of RoRo and rail service would be comparable and that both would be less costly than truck cost per FEU mile.[468] The study team conducted modal diversion analysis to show that at a minimum speed of 20 knots, a modern RoRo/container service could have captured a market share of 2 percent of containerizable goods in 2005, similar to that of intermodal rail in that year. With growing landside congestion, the share of regional containerized cargo would rise to 4 percent by 2050.[469]

These line-haul cost comparisons do not include drayage or port container-handling expenses, which can be expensive particularly when hub transfers are involved and cargo must be transferred from vessel to vessel. The HMT is also not included, which can add more than $100 per FEU to the shipping cost of a waterborne container arriving at a domestic port.[470] It is also notable that the line-haul estimates do not appear to reflect the full cost of acquiring vessels to serve in the U.S. domestic trade. U.S.-flag ships carrying domestic cargo must be built in U.S. shipyards. The cost for a RoRo vessel with a 342-FEU capacity could be more than $120 million.

There are other qualifiers to the TEMS/RAND forecast. Shippers must make long-term commitments to the service. The new service must be successfully integrated into the complex supply-chain management systems of the regional economy. Assembling the capital and vessels needed to start a major, high-volume service (such as envisioned by the TEMS/RAND study team) could take many years and would compete with other demands for such investment. If a new marine highway service is successful in establishing a presence in the movement of regional containers, there is a risk that railroads (which would presumably carry the marine highway containers during the winter ice season) would attempt to retain such cargoes year-round. To date, the TEMS/RAND study notes that railroads have had a relatively minor presence in Great Lakes intraregional container flows,[471] but this may change with ongoing major capital investments by both east and western railroads. In particular, investments in the Chicago region, such as the CREATE project, will likely result in the ability to move more containers more quickly through the region.

Given the large sums of capital involved, it is very likely that short-sea shipping operations under the U.S.-flag would require U.S. Government participation, perhaps in the development and partial funding of militarily useful, dual-use, RoRo vessels. Without such participation, U.S.-flag movement of containers and trailers, if implemented, would likely be in cross-lake ferry services that represent shortcuts for land-based systems. Lakewide short-sea networks using multiple dedicated vessels, if implemented, would likely begin with Canadian-flag vessels moving export and import containers (and some Canadian domestic containers) between Great Lakes ports and Montreal. In this latter instance, appropriate vessels could be acquired more quickly from foreign markets (either as new or used vessels) and at relatively lower cost. The success of such operations could open the door to U.S.-flag operations in the future.

CHAPTER 11

CONCLUSION

The U.S. Department of Transportation's Maritime Administration has conducted a study of the status of Great Lakes water transportation industry, with an emphasis on the U.S.-flag Laker fleet of dry-bulk cargo vessels. This study assessed the conditions, cargo and regulatory outlooks, and operating environments of the Lakers and the ports and shipyards that support them. It used information on changing Great Lakes operational conditions and new environmental compliance requirements to identify and evaluate options to revitalize components of the water transportation industry through public- and private-sector investments. The study also summarized recent research on the potential for new general cargo services on the Great Lakes. The study findings are summarized below.

System Assessment

The U.S.-flag Laker fleet and the broader regional water transportation infrastructure is well-sized and managed to accommodate the long-term demand for dry-bulk cargo movements, although one important cargo—coal for electric utilities—is at risk of decreasing due to competition from natural gas.

- *Vessels:* The Laker fleet of dry-bulk vessels 400 feet in length or longer has declined in number from 146 vessels in 1980 to 55 vessels in 2012, with most of this drop occurring in the decade after 1980. Total per-trip capacity of the fleet fell by almost 36 percent during this period, although the loss in per-trip capacity since 1990 has been less than 6 percent. Because the decline in vessel numbers was accompanied by an increase in vessel size and efficiency, the current fleet efficiently meets regional transportation demands for low-cost and reliable waterborne movement of dry-bulk cargoes.
- *Ports:* The Laker fleet serves 70 of the 85 U.S. Great Lakes ports. Almost all of U.S. domestic cargo originates or terminates in the 37 largest ports, each of which handled more than 1 million tons of cargo in 2008. Because almost all of the vessels in the Laker fleet have self-unloading equipment, ports that principally receive bulk materials need little shore-side infrastructure to accommodate the bulk materials delivered by the vessels. Representatives from the U.S. port sector have expressed the need for harbor and channel dredging, storage facilities for contaminated dredged materials, maintenance of breakwaters and locks, national standards for ballast water management, and other items that require Federal and State resources to accomplish, but have not generally identified unmet port land-side infrastructure needs as a problem.
- *Cargo:* The great majority of U.S.-flag Great Lakes fleet cargoes consist of three commodities: iron ore (concentrated taconite pellets), coal, and limestone. The study projects that iron ore and limestone transportation demand will remain at current levels or grow gradually (although subject to declines during recessions), while coal is projected to drop through 2015 as electric utilities close some older coal-fired units or convert them to natural gas. MARAD expects that the lake-delivered domestic coal market will recover to 2010 levels by 2020, although there is a clear risk that tonnages could continue to fall if electric utilities were to switch larger coal-fired units to natural gas and

other energy sources (as did Ontario Power Generation after 2009). The outlook for coal, which constituted 24 percent of domestic Laker cargo in 2010, is thus particularly uncertain.

- *Regulatory Environment:* One of the greatest concerns to the Laker industry in recent years has been the regulation of air emissions and ballast water from Laker vessels. In an effort to mitigate adverse environmental impacts, EPA, USCG, and State agencies have implemented or proposed various regulations. Since 2009, however, much of the regulatory uncertainty facing the Laker industry has been resolved in a manner that is both responsive to environmental needs and the economic needs of the Lakers. A remaining source of concern to the industry, however, is the possibility of future Federal and State actions that could impose numeric ballast water standards on Lakers.

- *Dredging and Infrastructure Maintenance:* Dredging is a necessary component of Great Lakes navigation. Silting of harbors and channels has already led to the light-loading of Lakers, increasing shipper costs because cargo that could otherwise be carried at authorized depths is left on the wharf. USACE has identified work that it could perform to maintain authorized depths and to repair locks and breakwaters.

- *Shipyards:* The maintenance needs of the U.S. Great Lakes water transportation industry are chiefly served by U.S.-Great Lakes shipyards and their 12 dry docks (4 of these shipyards have dry docks that can handle Lakers). The current shipyard and service supplier base meets the routine needs of the industry, including occasional repowering of vessels or new builds, but it would need to add to its capacity if there were an abrupt need to repower or make major structural modifications to a large number of existing vessels or to build new vessels.

General Findings of the Study

- The Great Lakes maritime industry is generally healthy and provides efficient, safe, and environmentally sound transportation services. Although the Laker vessels are on average older than comparable oceangoing vessels, they operate in freshwater conditions that contribute to long life and are designed for Great Lakes conditions and commodities that have not changed significantly over time.

- Supported by sensible regulation and infrastructure maintenance, the fleet will remain an essential part of the regional economy by providing reliable and inexpensive transportation of the raw inputs needed by regional industries. Integrated steel mills and many coal-fired power generation plants are located at lakeside in part to take advantage of low-cost delivery of raw materials.

- The Great Lakes marine transportation system is competitive with other transportation modes, and its vessels, ports, and shipyards appear to be adequately capitalized to meet current market demands. Continued and adequate dredging and maintenance of waterway channels and infrastructure is essential, however, to the industries that depend on Great Lakes navigation. Selected and limited forms of Federal assistance to vessel owners, ports, and shipyards could also yield important public benefits.

Long-Term Challenges

The study assesses potential impediments to the future of the U.S.-flag Great Lakes fleet and ports, including possible higher costs to accommodate requirements for reducing air emissions and ballast water management, dredging backlogs, condition of Great Lakes locks and infrastructure, and labor/training issues. Lakers can comply with the current regulations on air emissions and ballast water (if such ballast water requirements involve best management practices), but could incur major expenses if future regulatory efforts should impose new requirements and are not coordinated with each other with regard to their cumulative impacts. As noted, there is a critical ongoing need for dredging of ports and channels to authorized depths.

Long-Term Opportunities

The study analyzed repowering and replacing Great Lakes freight vessels to examine possible opportunities for Federal involvement.

- There is an important opportunity for the Federal Government to incentivize the repowering of the U.S.-flag Great Lakes steamships with new conventional diesel engines or dual-fuel LNG/diesel engines. EPA implemented an important program toward this end with its Great Lakes Steamship Repower Incentive Program, but additional support to lower the cost of capital and reduce risk to vessel owners could be advantageous. Additionally, it may be appropriate to modify this program to incentivize dual-fuel LNG/diesel repowerings. Repowering of the steamships could generate net benefits for both the vessel owners and operators and the public. Other forms of Federal assistance could be used to encourage repowering of older diesel Lakers.
- Building new vessels to replace existing vessels does not appear to be cost-beneficial at this time, although occasional new builds and replacements will be needed.
- Marine highway services, involving the movement of domestic and international containers on the uncongested Great Lakes waterways, may prove viable in some instances. However, because of the high startup costs needed to purchase modern RoRo and container vessels, Federal Government participation would very likely be necessary to establish U.S.-flag services in this region.

APPENDIX A

COMMODITY FLOW DATA: DOMESTIC GREAT LAKES

TABLE 33. U.S. Domestic Iron Ore Shipments and Receipts, CY 2009

IRON ORE SHIPMENTS			IRON ORE RECEIPTS		
Port	Tons	%	**Port**	Tons	%
Two Harbors, MN	7,083,562	31.5	**Indiana Harbor, IN**	6,457,469	28.7
Duluth, MN–Superior, WI	5,162,325	23.0	**Gary, IN**	5,690,766	25.3
Escabana, MI	4,040,522	18.0	**Detroit, MI**	3,150,913	14.0
Marquette/Presque Isle, MI	3,187,238	14.2	**Burns Waterway, IN**	2,544,117	11.3
Silver Bay, MN	2,691,726	12.0	**Conneaut, OH**	2,529,813	11.2
Detroit, MI	163,490	0.7	**Toledo, OH**	1,079,089	4.8
Calcite, MI	76,821	0.3	**Cleveland, OH**	898,562	4.0
Chicago, IL	51,697	0.2	**Ashtabula, OH**	112,355	0.5
Lorain, OH	23,766	0.2	**Duluth, MN–Superior, WI**	51,693	0.2
Indiana Harbor, IN	6,384	0.0	**Chicago, IL**	6,092	0.03
Menominee, MI	1,492	0.0			
Total	22,489,023	100%	**Total**	22,520,869	100%

Source: Data from USACE, "Waterborne Commerce of the United States," Part 3—Great Lakes, 2009.

Note: This table is limited to domestic iron ore movements and does not capture ore cargoes moved between U.S. ports and Canadian ports. Note that domestic receipts and shipments may not balance because some ore volumes may include intraport movements, and because some ore may move between Great Lakes ports (e.g., Chicago) and inland waterway ports.

TABLE 34. **U.S. Domestic Coal Shipments and Receipts, CY 2009**

COAL SHIPMENTS			COAL RECEIPTS		
Port	Tons	%	Port	Tons	%
Duluth, MN–Superior, WI	14,375,370	76.6	St. Clair, MI	8,072,387	43.2
Chicago, IL	1,803,534	9.6	Marquette/Presque Isle, MI	1,883,774	10.1
Toledo, OH	1,460,206	7.8	Monroe, MI	1,183,606	6.3
Sandusky, OH	858,329	4.6	Muskegon, MI	1,153,767	6.2
Ashtabula, OH	183,724	1.0	Detroit, MI	928,554	5.0
Marquette, MI	58,350	0.3	Green Bay, WI	671,591	3.6
Monroe, MI	13,041	0.1	Milwaukee, WI	657,428	3.5
Detroit, MI	8,383	0.0	Saginaw River, MI	595,478	3.2
Marquette/Presque Isle, MI	7,947	0.0	Taconite Harbor, MN	577,406	3.1
			Manistee, MI	417,684	2.2
			Toledo, OH	399,560	2.1
			Silver Bay, MN	374,236	2.0
			Ashtabula, OH	334,148	1.8
			Escanaba, MI	252,640	1.4
			Alpena, MI	229,522	1.2
			Marquette, MI	213,868	1.1
			Duluth, MN–Superior, WI	184,869	1.0
			Grand Haven, MI	139,044	0.7
			Holland, MI	119,816	0.6
			Ashland, WI	74,533	0.4
			Marysville, MI	74,202	0.4
			Trenton, MI	48,233	0.3
			Manitowac, MI	39,441	0.2
			Gladstone, MI	32,427	0.2
			Menominee, MI	24,544	0.1
			Indiana Harbor, IN	9,960	0.1
			Harbor Beach, MI	7,947	0.0
			Chicago, IL	3,171	0.0
Total	18,768,884	100%	Total	18,703,836	100%

Source: Data from USACE, "Waterborne Commerce of the United States," Part 3—Great Lakes, 2009.

Note: This table is limited to domestic coal movements (excluding coal coke) and does not capture coal cargoes moved between U.S. ports and Canadian ports or internationally. Note that domestic receipts and shipments may not balance because some coal volumes may include intraport movements and because some coal may move between Great Lakes ports (e.g., Chicago) and inland waterway ports.

TABLE 35. **U.S. Domestic Limestone Shipments and Receipts, CY 2009**

LIMESTONE SHIPMENTS		
Port	**Tons**	**%**
Stoneport, MI	4,560,320	29.2
Calcite, MI	3,909,813	25.0
Port Inland, MI	2,721,324	17.4
Port Dolomite, MI	1,946,164	12.5
Marblehead, OH	1,607,093	10.3
Drummond Island, MI	807,869	5.2
Chicago, IL	28,084	0.2
Detroit, MI	22,120	0.1
Marine City, MI	12,265	0.1
Total	15,615,052	100%

LIMESTONE RECEIPTS		
Port	**Tons**	**%**
Duluth, MN–Superior, WI	2,129,754	13.7
Saginaw River, MI	1,641,729	10.5
Cleveland, OH	1,537,228	9.9
Buffington, IN	915,048	5.9
Ashtabula, OH	875,845	5.6
Detroit, MI	824,894	5.3
Indiana Harbor, IN	631,837	4.1
Burns Waterway, IN	606,436	3.9
Green Bay, WI	590,989	3.8
Fairport Harbor, OH	581,319	3.7
Escanaba, MI	507,595	3.3
Huron, OH	400,859	2.6
Lorain, OH	389,315	2.5
Erie, PA	382,901	2.5
Port Island, MI	374,718	2.4
Marysville, MI	352,342	2.3
Marine City, MI	331,245	2.1
Toledo, OH	329,211	2.1
Conneaut, OH	308,327	2.0
Marquette, MI	237,530	1.5
Muskegon, MI	175,435	1.1
Grand Haven, MI	168,189	1.1
Holland, MI	162,759	1.0
Gary, IN	155,465	1.0
Milwaukee, WI	153,535	1.0
Buffalo, NY	146,455	0.9
Monroe, MI	139,553	0.9
Marquette/Presque Isle, MI	126,828	0.8
St Joseph, MI	121,636	0.8
Ludington, MI	91,922	0.6
Chicago, IL	60,457	0.4
Port Dolomite, MI	31,134	0.2
Cheboygan, MI	28,314	0.2
Alpena, MI	25,874	0.2
Sault Ste Marie, MI	24,800	0.2
Put-In-Bay, OH	7,595	0.0
Calcite, MI	3,517	0.0
Total	15,572,590	100%

Source: Data from USACE, "Waterborne Commerce of the United States," Part 3—Great Lakes, 2009.

Note: This table is limited to domestic limestone movements and does not capture limestone cargoes moved between U.S. ports and Canadian ports. Note that domestic receipts and shipments may not balance because some limestone volumes may include intraport movements and because some limestone may move between Great Lakes ports (e.g., Chicago) and inland waterway ports.

TABLE 36. **U.S. Domestic Cement Shipments and Receipts, CY 2009**

CEMENT SHIPMENTS			CEMENT RECEIPTS		
Port	Tons	%	**Port**	Tons	%
Alpena, MI	1,556,198	75.7	**Chicago, IL**	903,807	31.1
Chicago, IL	371,930	18.1	**Milwaukee, WI**	567,790	19.5
Milwaukee, WI	90,201	4.4	**Green Bay, WI**	303,656	10.4
Green Bay, WI	21,059	1.0	**Waukegan, IL**	233,838	8.0
Manitowac, MI	9,509	0.5	**Cleveland, OH**	187,547	6.4
Grand Haven, MI	4,652	0.2	**Detroit, MI**	144,525	5.0
Cleveland, OH	2,283	0.1	**Manitowac, MI**	141,038	4.8
			Duluth, MN–Superior, WI	112,048	3.9
			St Joseph, MI	85,894	3.0
			Grand Haven, MI	84,529	2.9
			Toledo, OH	75,106	2.6
			Muskegon, MI	59,518	2.0
			Buffalo, NY	7,022	0.2
			Saginaw River, MI	2,480	0.1
Total	2,055,832	100%	**Total**	2,908,798	100%

Source: Data from USACE, "Waterborne Commerce of the United States," Part 3—Great Lakes, 2009.

Note: This table is limited to domestic cement movements and does not capture cement cargoes moved between U.S. ports and Canadian ports. Note that domestic receipts and shipments may not balance because some cement volumes may include intraport movements and because some cement may move between Great Lakes ports (e.g., Chicago) and inland waterway ports.

TABLE 37. **U.S. Domestic Salt Shipments and Receipts, CY 2009**

SALT SHIPMENTS			SALT RECEIPTS		
Port	Tons	%	**Port**	Tons	%
Cleveland, OH	747,711	70.6	**Chicago, IL**	1,617,681	63.4
Fairport Harbor, OH	279,951	26.4	**Toledo, OH**	245,226	9.6
Detroit, MI	19,649	1.9	**Milwaukee, WI**	144,665	5.7
Two Harbors, MN	12,124	1.1	**Detroit, MI**	108,084	4.2
			Burns Waterway, IN	92,329	3.6
			Erie, PA	62,393	2.4
			Duluth, MN–Superior, WI	46,050	1.8
			Ashtabula, OH	42,086	1.6
			Cleveland, OH	40,852	1.6
			Green Bay, WI	39,389	1.5
			Saginaw River, MI	27,256	1.1
			Gladstone, MI	25,330	1.0
			Sandusky, OH	20,303	0.8
			Lorain, OH	19,649	0.8
			Indiana Harbor, IN	12,124	0.5
			Holland, MI	10,004	0.4
Total	1,059,435	100%	**Total**	2,553,421	100%

Source: Data from USACE, "Waterborne Commerce of the United States," Part 3—Great Lakes, 2009

Note: This table is limited to domestic salt (4900 Non-Metallic Mineral NEC) movements and does not capture salt cargoes moved between U.S. ports and Canadian ports. Note that domestic receipts and shipments may not balance because some salt volumes may include intraport movements and because some salt may move between Great Lakes ports (e.g., Chicago) and inland waterway ports.

TABLE 38. U.S. Domestic Sand and Gravel Shipments and Receipts, CY 2009

SAND AND GRAVEL SHIPMENTS			SAND AND GRAVEL RECEIPTS		
Port	Tons	%	Port	Tons	%
Chicago, IL	387,000	56.7	Chicago, IL	616,926	54.5
Grand Haven, MI	105,759	15.5	St Joseph, MI	117,106	10.4
Port Inland, MI	51,391	7.5	Cleveland, OH	100,841	8.9
Calcite, MI	46,472	6.8	Duluth, MN–Superior, WI	89,696	7.9
Stoneport, MI	43,224	6.3	Erie, PA	86,272	7.6
Port Dolomite, MI	28,646	4.2	Grand Haven, MI	41,540	3.7
Marblehead, OH	11,494	1.7	Buffalo, NY	40,192	3.6
Duluth, MN–Superior, WI	5,717	0.8	Muskegon, MI	21,434	1.9
Holland, MI	5,716	0.8	Marine City, MI	11,494	1.0
Waukegan, IL	1,400	0.2	Holland, MI	5,716	0.5
Bayfield, WI	1,118	0.2			
Total	682,221	100%	Total	1,131,217	100%

Source: Data from USACE, "Waterborne Commerce of the United States," Part 3—Great Lakes, 2009.

Note: This table is limited to domestic sand and gravel movements and does not capture sand and gravel cargoes moved between U.S. ports and Canadian ports. Note that domestic receipts and shipments may not balance because some sand and gravel volumes may include intraport movements and because some sand and gravel may move between Great Lakes ports (e.g., Chicago) and inland waterway ports.

TABLE 39. U.S. Domestic Grain and Oilseed Shipments and Receipts, CY 2009

GRAIN AND OILSEED SHIPMENTS[a]			GRAIN AND OILSEED RECEIPTS[a]		
Port	Tons	%	Port	Tons	%
Duluth, MN–Superior, WI	308,361	47.0	Buffalo, NY	308,361	89.9
Chicago, IL	247,135	37.6	Chicago, IL	23,211	6.8
Burns Waterway, IN	78,579	12.0	Burns Waterway, IN	11,359	3.3
Milwaukee, WI	22,345	3.4			
Total	656,420	100%	Total	342,931	100%

Source: Data from USACE, "Waterborne Commerce Statistics," Part 3—Great Lakes, 2009.

Note: This table is limited to domestic grain and oilseed movements and does not capture grain and oilseed cargoes moved between U.S. ports and Canadian ports. Note that domestic receipts and shipments may not balance because some grain and oilseed volumes may include intraport movements and because some grain and oilseed may move between Great Lakes ports (e.g., Chicago) and inland waterway ports.

[a] Grain and oilseed include wheat, corn, rice/sorghum, soybeans, and animal feed.

APPENDIX B

BENEFIT–COST ANALYSIS RESULTS

Scenario 1, Alternative 1: Steamship Repowering Alternative Scenario Results—Category 3, Tier 2, Engines

TABLE 40. Benefits and Costs of Repowering the U.S.-Flag Great Lakes Steamships With Category 3, Tier 2, Engines (in millions of 2010 dollars)

BENEFIT–COST ANALYSIS FRAMEWORK	NPV 7%	NPV 3%	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
BENEFIT CATEGORIES												
ENVIRONMENTAL SUSTAINABILITY[a]												
Reduced emissions because of fuel change	33.3	69.1	0.1	0.2	0.4	0.7	0.8	1.0	1.0	1.0	1.0	1.0
Reduced emissions because of increased fuel efficiency	31.7	50.6	0.2	0.8	1.6	2.6	3.3	3.7	3.8	3.8	3.9	3.9
ECONOMIC EFFICIENCY												
Savings from increased engine efficiency	175.8	320.9	0.8	2.7	5.8	9.0	11.5	13.2	13.4	13.5	13.7	13.9
Difference in fuel costs (MDO vs. RO)	−77.3	−172.7	0	0	0	0	0	0	0	0	0	0
Other operational savings from engine repower	83.3	142.2	0.7	1.4	3.3	5.3	6.7	8.3	8.3	8.3	8.3	8.3
TOTAL BENEFITS	246.8	410.0	1.8	5.1	11.1	17.6	22.3	26.2	26.4	26.7	26.9	27.1
COST CATEGORIES												
CAPITAL COSTS												
Vessel repowering costs	199.3	231.2	20.0	20.0	53.3	60.0	60.0	46.7	0.0	0.0	0.0	0.0
TOTAL COSTS	199.3	231.2	20.0	20.0	53.3	60.0	60.0	46.7	0.0	0.0	0.0	0.0

[a] Benefits attributable to environmental sustainability accrue to the public at large. Other benefits and costs in this table accrue to private vessel owners and operators.

TABLE 40. Benefits and Costs of Repowering the U.S.-Flag Great Lakes Steamships With Category 3, Tier 2, Engines (in millions of 2010 dollars) *(continued)*

BENEFIT–COST ANALYSIS FRAMEWORK	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
BENEFIT CATEGORIES										
ENVIRONMENTAL SUSTAINABILITY										
Reduced emissions because of fuel change	1.0	1.0	1.0	6.3	6.4	6.4	6.5	6.6	6.6	6.7
Reduced emissions because of increased fuel efficiency	4.0	4.0	4.1	2.0	2.0	2.0	2.1	2.1	2.1	2.1
ECONOMIC EFFICIENCY										
Savings from increased engine efficiency	14.0	14.2	14.4	21.7	22.0	22.2	22.5	22.7	23.0	23.2
Difference in fuel costs (MDO vs. RO)	0	0	0	−17.8	−18.0	−18.2	−18.4	−18.6	−18.8	−19.0
Other operational savings from engine repower	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.5	8.5	8.5
TOTAL BENEFITS	27.4	27.6	27.9	20.6	20.8	20.9	21.1	21.2	21.4	21.6
COST CATEGORIES										
CAPITAL COSTS										
Vessel repowering costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL COSTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 40. Benefits and Costs of Repowering the U.S.-Flag Great Lakes Steamships With Category 3, Tier 2, Engines (in millions of 2010 dollars) *(continued)*

BENEFIT–COST ANALYSIS FRAMEWORK	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
BENEFIT CATEGORIES										
ENVIRONMENTAL SUSTAINABILITY										
Reduced emissions because of fuel change	6.8	6.9	6.9	7.0	7.1	7.2	7.2	7.3	7.4	7.4
Reduced emissions because of increased fuel efficiency	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.3	2.4
ECONOMIC EFFICIENCY										
Savings from increased engine efficiency	23.5	23.7	24.0	24.2	24.5	24.7	25.0	25.2	25.4	25.6
Difference in fuel costs (MDO vs. RO)	−19.2	−19.4	−19.6	−19.8	−20.0	−20.2	−20.4	−20.7	−20.8	−20.9
Other operational savings from engine repower	8.5	8.5	8.5	8.5	8.6	8.6	8.6	8.6	8.6	8.6
TOTAL BENEFITS	21.7	21.9	22.0	22.2	22.3	22.5	22.6	22.8	22.9	23.0
COST CATEGORIES										
CAPITAL COSTS										
Vessel repowering costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL COSTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Scenario 1, Alternative 2: Steamship Repowering Alternative Scenario Results—LNG Engines

TABLE 41. Benefits and Costs of Repowering the U.S.-Flag Great Lakes Steamships With LNG Engines (in millions of 2010 dollars)

NPV BENEFIT–COST ANALYSIS FRAMEWORK	NPV 7%	3%	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
BENEFIT CATEGORIES												
ENVIRONMENTAL SUSTAINABILITY[a]												
Reduced emissions because of fuel change	$80.9	$140.6	0.0	1.2	3.2	5.3	6.9	7.4	7.5	7.6	7.7	7.8
Reduced emissions because of increased fuel efficiency	$6.6	$11.6	0.0	0.1	0.3	0.4	0.6	0.6	0.6	0.6	0.6	0.6
ECONOMIC EFFICIENCY												
Savings from increased engine efficiency	$89.8	$156.3	0.0	1.4	3.5	5.9	7.6	8.2	8.3	8.4	8.5	8.6
Savings from fuel switch to LNG	$88.7	$154.4	0.0	1.3	3.5	5.8	7.5	8.1	8.2	8.3	8.4	8.5
Other operational savings from engine repower	$69.8	$119.4	0.0	0.8	2.6	4.7	6.7	6.9	7.0	7.0	7.0	7.0
TOTAL BENEFITS	$335.8	$582.1	0.0	4.8	13.1	22.1	29.3	31.3	31.6	32.0	32.3	32.6
COST CATEGORIES												
CAPITAL COSTS												
Vessel repowering costs	$192.5	$222.9	0.0	25.0	66.7	75.0	75.0	8.3	0.0	0.0	0.0	0.0
Preparing ports to handle LNG vessels	$30.8	$35.7	0.0	4.0	10.7	12.0	12.0	1.3	0.0	0.0	0.0	0.0
TOTAL COSTS	$223.3	$258.5	0.0	29.0	77.3	87.0	87.0	9.7	0.0	0.0	0.0	0.0

[a] Benefits attributable to environmental sustainability accrue to the public at large. Other benefits and costs in this table accrue to private vessel owners and operators.

TABLE 41. Benefits and Costs of Repowering the U.S.-Flag Great Lakes Steamships With LNG Engines (in millions of 2010 dollars) *(continued)*

BENEFIT–COST ANALYSIS FRAMEWORK	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
BENEFIT CATEGORIES										
ENVIRONMENTAL SUSTAINABILITY										
Reduced emissions because of fuel change	7.9	8.0	8.1	8.1	8.2	8.3	8.4	8.5	8.6	8.7
Reduced emissions because of increased fuel efficiency	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
ECONOMIC EFFICIENCY										
Savings from increased engine efficiency	8.7	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7
Savings from fuel switch to LNG	8.6	8.7	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6
Other operational savings from engine repower	7.0	7.0	7.0	7.0	7.1	7.1	7.1	7.1	7.1	7.1
TOTAL BENEFITS	32.9	33.2	33.6	33.9	34.2	34.5	34.8	35.2	35.5	35.8
COST CATEGORIES										
CAPITAL COSTS										
Vessel repowering costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Preparing ports to handle LNG vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL COSTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 41. Benefits and Costs of Repowering the U.S.-Flag Great Lakes Steamships With LNG Engines (in millions of 2010 dollars) *(continued)*

BENEFIT–COST ANALYSIS FRAMEWORK	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
BENEFIT CATEGORIES										
ENVIRONMENTAL SUSTAINABILITY										
Reduced emissions because of fuel change	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.5	9.6
Reduced emissions because of increased fuel efficiency	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
ECONOMIC EFFICIENCY										
Savings from increased engine efficiency	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7
Savings from fuel switch to LNG	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.5
Other operational savings from engine repower	7.1	7.1	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
TOTAL BENEFITS	36.1	36.4	36.8	37.1	37.4	37.7	38.1	38.4	38.6	38.8
COST CATEGORIES										
CAPITAL COSTS										
Vessel repowering costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Preparing ports to handle LNG vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL COSTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX C

GREAT LAKES STUDY PUBLIC OUTREACH MEETINGS THEMES REPORT

Introduction

The Great Lakes region of the United States is made up of the eight States that border the Great Lakes. These States, consisting of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, play a key role in the U.S. economy and as a group make up one of the largest economic engines on Earth. These States accounted for 28 percent of the national Gross Domestic Product (GDP) in 2010. As such, the Great Lakes region's GDP exceeded the GDPs of all but three countries in the world (the United States ($14.6 trillion), China ($5.9 trillion), and Japan ($5.5 trillion)).[472] The region accounted for almost a quarter of U.S. exports in 2010. Population in the region as of 2010 was almost 84 million, or 27 percent of the total U.S. population in that year.

This massive economy benefits greatly from the water transportation system of the Great Lakes for the efficient transport of goods, particularly raw materials such as iron ore, coal, and limestone. The Great Lakes transportation system spans more than 1,100 miles from the western terminus in Duluth, MN–Superior, WI on Lake Superior to the far eastern outlet of Lake Ontario that connects to the St. Lawrence River. The series of five lakes and the St. Lawrence Seaway provided for the transport of over 152 million short tons of cargo through U.S. ports in 2008, according to USACE, of which more than 99 million short tons were domestic.[473] U.S.-flag service is largely restricted to the upper four lakes, consisting of Lakes Superior, Huron, Michigan, and Erie.

Prepared for MARAD by ABS Consulting, Alexandria, VA, May 31, 2011, under Contract GS-10F-0242L.

In order to better understand the needs and challenges of this unique transportation system, and to inform the study on Great Lakes Shipping, MARAD sponsored a series of three outreach meetings in the Great Lakes region to meet with a variety of stakeholders. The meetings were open to the public and announced through a variety of means, including the *Federal Register* and various regional and trade publications. In addition, personal invitations signed by the Maritime Administrator were sent via e-mail and the U.S. Postal Service. The goal was to engage with a broad base of stakeholders from a variety of perspectives and identify key issues related to shipping and the lakes in general. Meetings were held at three locations (Cleveland, OH; Duluth, MN; and Chicago, IL) during the "ice season" on the lakes in order to capture the largest number of stakeholders. The Cleveland meeting had the largest stakeholder attendance as it was also planned to coincide with the 2011 Great Lakes Waterways Conference taking place in Cleveland.

This report summarizes the key themes discussed at the meetings and provides detailed meeting notes in the appendices for reference.

Meetings Overview

The meetings were announced in the *Federal Register* and a variety of press releases targeted to the maritime industry in the Great Lakes region.

Working in conjunction with the Great Lakes Gateway office of MARAD, other local contacts and networks, as well as the Director of Public Engagement in the Office of the Secretary of Transportation, the team compiled an invitation list of over 400 individual stakeholders. They represented various industry segments (shippers, shipping companies, shipyards, port authorities, labor organizations) as well as academia, non-governmental organizations from the environmental and economic development sectors, and numerous governmental agencies (local, State, and Federal).

For those individuals with an e-mail address, electronic invitations were sent with the Maritime Administrator's signature. Where no valid e-mail address could be obtained, paper invitations were printed and mailed on Administration letterhead.

Meeting Participation

Across the three meetings, a total of 125 stakeholders participated as shown in Table 42. A list of the meeting attendees and their affiliations is provided in the Meeting Attendees section of this report. The attendees represented the distribution of organizations shown in Figure 14.

TABLE 42. Great Lakes Study Public Outreach Meetings Participation

TYPE	CLEVELAND Feb. 15, 2011	DULUTH Feb. 23, 2011	CHICAGO Feb. 25, 2011
Pre-registrants	74	23	36
Attended	55	16	23
Walk-ins	14	7	10
Total	69	23	33

Meeting Organization

An informal discussion format was used for the public meetings with small group "break-out" sessions arranged to provide opportunity for dialogue and sharing of ideas among the stakeholders. Four key topic areas were identified in advance on the following topic areas: Economics and Markets, Environmental Regulations, Ship Assets, and Shore Infrastructure. MARAD personnel presented a brief introduction of each topic. Following the introduction, the stakeholders were asked to review a list of questions specific to each topic area and discuss them in their small group. The topic areas and discussion

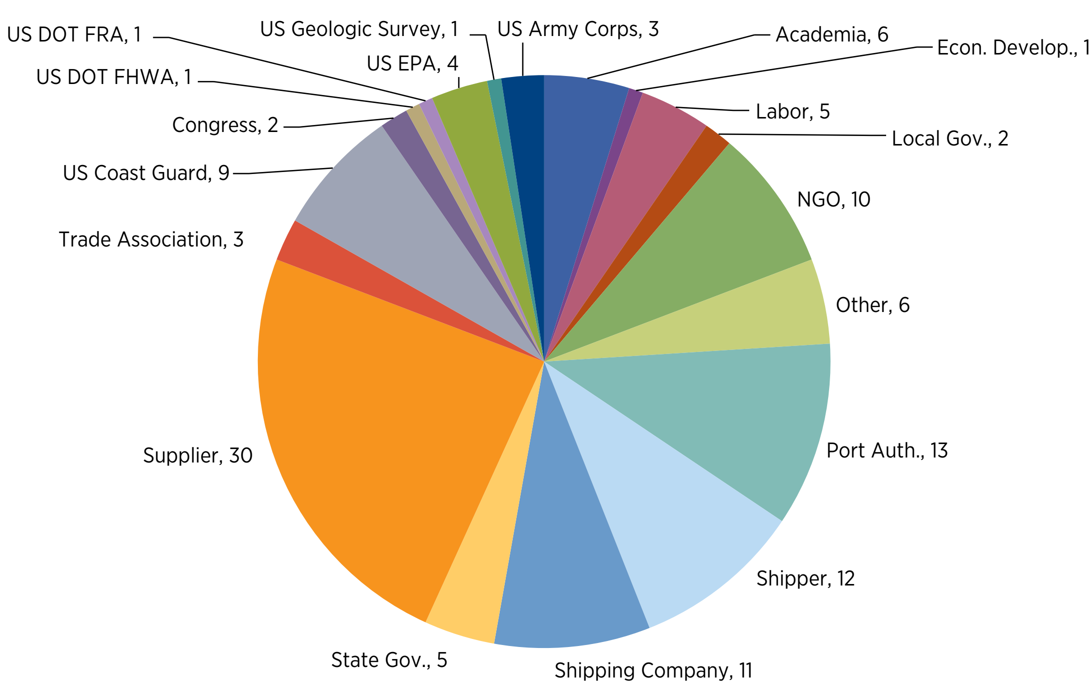


FIGURE 14. Distribution of organizations of attendees at Great Lakes Study Public Outreach meetings.

questions are provided in the "Discussion Topics" section at the end of this report. After a period of discussion, each small group was asked to present the key points of their discussion to all of the attendees. The reports from the small groups to the meeting attendees were captured in the meeting minutes and a brief opportunity to discuss and clarify the small groups' reports was provided.

Feedback Vehicles

In addition to the discussions at the stakeholder meetings, provisions were made for stakeholders to provide written comments both during and after the meetings. A specific e-mail address was established to allow stakeholders to submit their comments after the meetings.

Stakeholder Feedback—Overview

The meetings were intended for stakeholders to share their insights about the shipping industry on the Great Lakes. The focus was on generating discussion and collecting ideas. While there was no attempt to generate consensus, in all three of the meetings, certain topics were consistently raised. These included long-term planning concerns, regulatory reform and consistency, financing, infrastructure concerns, and the need for greater advocacy, facilitation, and outreach. Many of the points made were in recognition of the current problems and what is needed to solve these immediate issues.

The stakeholders were most consistent in raising issues with what they described as the current "patchwork" of regulations mandated by the numerous agencies and regulatory bodies (Federal and State) with overlapping jurisdictional areas. The stakeholders indicated that there is potential for growth in the industry; however, they were concerned that what they viewed as a lack of regulatory coordination and seaway barriers would impact the growth opportunities of the maritime sector. Stakeholders said that better coordination and harmonization of regulations is necessary not only to successfully address the concerns of the regulators, but also to reduce regulatory hurdles to operators. Ship operators on the Great Lakes are faced with complying with the regulations of two national governments, eight U.S. States, and two Canadian provinces.

The participants also stated a strong desire for MARAD to engage in outreach, facilitation, education, and advocacy to improve the awareness, standing, and image of the industry. Parallels to the advocacy campaign in place by and for the U.S. Railroad industry were often mentioned.[474] Participants also saw the advocacy and outreach opportunity as a way to encourage greater cooperation and partnering opportunities between all the various stakeholders in the region. Concerns were raised about the looming potential for a generational knowledge gap that is growing because of the lack of education, shipbuilding, and new job opportunities necessary to sustain a consistent knowledge base.

Representatives also pointed to a need for a more unified and coordinated policy effort and longer-term planning. The stakeholders indicated that fragmented transportation policy is creating barriers to efficient transportation, and the governmental agencies are ineffective in addressing the issue. Greater communication is required, along with more simplification and better harmonization of policies. These elements need to focus on both a regional view and an international perspective.

It was noted that the different modes of transportation are often in competition with each other. The stakeholders indicated that long-term development will need to make efficient use of all modes integrated under a transportation system perspective. The stakeholders sought greater advocacy on the State and regional level of an intermodal system, which they believed would be beneficial for an effective transportation system. It was highlighted that only a few of the States' Departments of Transportation (DOTs) have a maritime branch or office, and that in those cases, this is often a single person.

RECURRING THEMES

- Regulatory Coordination
- Advocacy, Facilitation, Outreach, and R&D
- Long-Term Planning (Financial Incentives)
- Intermodal and Intergovernmental Cooperation
- Infrastructure Repairs
- Harbor Maintenance Tax Utilization

Stakeholders commented that the infrastructure is also in need of varying degrees of repair. The most commonly heard comments relating to infrastructure concerned the need for dredging. Other infrastructure needs highlighted included bulkhead and breakwater restoration. Chronic underfunding of these infrastructure maintenance costs was frequently noted by the attendees.

Some representatives advocated for the removal or elimination of the Harbor Maintenance Tax (HMT). More stakeholders urged the efficient utilization of the HMT funds by applying them back into the region to address the numerous infrastructure issues, particularly dredging. Some representatives would also like to see better utilization of the HMT, as well as the continued support of grant and other programs to aid in the repowering of the fleet. In addition to repowering, some representatives recommended appropriate funding of programs to create long-term regulatory and economic incentives to build a new fleet or improve the existing one. This is likely to reduce the number of older vessels in operation and would also maintain a level of shipbuilding capability and long-term knowledge and expertise beyond a generational gap that the region currently faces.

The following sections provide additional insight into each of the recurring themes. For each theme, the issue is summarized, a few key specific items provided by the stakeholders are cited, and a sampling of the stakeholder suggestions is provided. While not all of the suggestions made at the meetings are captured in this summary, the ones listed here highlight the range of ideas offered by the stakeholders. No attempt was made to judge the stakeholders' suggestions for their feasibility, practicality, or effectiveness.

Regulatory Coordination

ISSUE: Stakeholders commented at each of the meetings that the complex and sometimes contradictory regulatory framework is a significant barrier to growth of the industry. They indicated that there were too many regulators and confusing jurisdictional boundaries. These conditions lead to a patchwork of policies that are cumbersome to understand and difficult for industry to ensure compliance. Although environmental regulations are perhaps the most visible, regulatory coordination is needed across several areas, including maritime licensing and security. They stated that some regulations pertain to salt water issues not present in the Great Lakes. The stakeholders noted that they appreciate the sense of urgency required for some regulatory action, but in other cases, a sudden regulatory change is expensive for operators. The other regulatory concern was the bi-national nature of cross-lake trade between the U.S. and Canada. Stakeholders want greater cooperation between the two countries so that a more "level playing field" can be created.

SPECIFICS: One particular concern was the recent unilateral action by certain States to implement State-level regulations for ballast water treatment. The stakeholders are concerned that they could end up facing a system of eight different State regulatory schemes compounded with Federal and international requirements. Another key regulatory concern offered as an example was the multiple Federal agencies concerned with maritime security, and the lack of a coordinated and consistent policy for security screening of crew and passengers. Increasingly stringent air-emissions standards are also a concern for the industry as they try to bring aging assets and older technology into compliance with more exacting regulations.

STAKEHOLDER SUGGESTIONS: The meeting attendees offered a variety of suggestions as to how the regulatory arena could be improved. Stakeholders suggested that MARAD engage with other Federal agencies and impress upon them the benefits of regulatory harmonization. It was noted that significant benefits could be gained by facilitating interagency discussions and coordination between the U.S. Coast Guard (USCG), the Environmental Protection Agency (EPA), and Customs and Border Patrol. Several attendees suggested that MARAD could serve as the "voice of the industry" in Washington and ensure that the regulators are fully aware of the impacts and ramifications of their regulatory proposals on the industry. The attendees thought that an improved awareness would lead to more rational regulatory policies that could achieve the regulatory aims, while allowing for the phasing in of more stringent standards as technology improves or existing systems become obsolete. The preference of the stakeholders would be for the agencies to enact realistic solutions with an appropriate amount of time to implement on existing vessels. Stakeholders expressed the desire for the Administration to facilitate something like the "California model"[475] of a single regulatory body, or the creation a Memorandum of Understanding between regulatory agencies like EPA and USCG. Finally, attendees indicated that consistency among security policies should also be addressed. It was noted that in order to promote other industries like ferries and passenger transport, the security regulations of various agencies should be aligned.

Advocacy, Facilitation, Outreach, and Research and Development

ISSUE: The stakeholders in each of the meetings expressed a concern that the Great Lakes shipping industry has an image problem. They said that the enormous contributions of the industry to the regional and National economies were neither well understood nor appreciated by the general public or the policymakers. The participants stated a desire for MARAD to engage in outreach, education, and advocacy to improve the standing and image of the industry. The stakeholders indicated that there is a need for the Administration to foster greater cooperation and partnering opportunities between the various stakeholders in the region. Innovation and new technologies can bring improved operating efficiencies and safer, cleaner shipping, but the research and development of these technologies are viewed as high-cost and high-risk investments. Industry is reluctant to invest in technologies that may not pay off, or may be rapidly overcome by regulations and newer technologies.

SPECIFICS: Several stakeholders noted the public awareness campaign underway touting the efficiency and environmental benefits of using rail over highways as the transportation mode. They noted that the bulk carrier ships are even more efficient than trains, but that this is largely an unknown, even in the transportation community. The attendees also expressed concern that the maritime sector is often a non-entity in the various State DOTs. Some participants noted that with awareness often comes opportunities. Their belief is that increased awareness will stimulate interest in the maritime industry and may serve as a way to encourage more people to consider careers in the industry. This was seen as a way to ensure long-term knowledge and expertise. Difficulties such as inconsistent opening and closings of waterways were noted as factors that complicate operations. Stakeholders commented that new and innovative technologies are costly and come with some risk. With operating margins in the industry being low, there are too few resources for investment in research and new technologies.

SUGGESTIONS: Representatives pointed to a need for a more unified and coordinated policy effort. Fragmented policy is creating barriers to transportation, and is ineffective in addressing the issue; thus, what is required is greater communication, greater simplification, and greater harmonization of policies with a regional and international approach. Coordination is also required between the various modes of transportation to create an effective and efficient transportation system, not just modes of transportation. The stakeholders look towards MARAD to: (1) aid in information promulgation and promotion of the industry; (2) advocate for additional funding for the region; and (3) promote cooperation among regulators, State and local governments, and the various transportation industry sectors. The representatives are seeking for the Administration to take a more proactive approach to the market and to current and future issues in the region. As part of the USDOT, stakeholders would like MARAD to increase the visibility of maritime transport within the Department and Nation. The stakeholders would like to see maritime trade on an equal footing with rail and highway, and believe the Administration should help facilitate that. Finally, the stakeholders suggested that MARAD assume a role in the research and development of new technologies. This could be implemented through cooperative research grants or some type of cost-sharing basis with industry.

Long-Term Planning (Financial Incentives)

ISSUE: There is a belief among some stakeholders that there are opportunities to expand the market, but that certain conditions or factors may need to be addressed first. Representatives stated that policy fragmentation and implementation schedules not amenable with technology implementation are creating market forces to implement short-term fixes, instead of long-term planning. Funding was cited as a major concern and issue facing the industry. Meeting attendees identified a need for market incentives for long-term planning and investment. The current grants and other financial incentives are too sparse and too complicated to be effective. Participants consistently believed that the current commodities being transported on the Great Lakes were likely to be the primary cargoes involved in any future market growth. The participants were of mixed opinions on the future of containerization and passenger ferries.

SPECIFICS: Vessel owners stated that repowering and retrofitting is far preferable than building/buying new vessels. This position is based on the return on investment periods for new vessels and the likelihood of policy or regulation changes making the investments obsolete. The stakeholders shared a belief that the current policies regarding the region are fragmented between too many jurisdictions and entities, and are too short-sighted. These facts provide an incentive for inaction rather than retrofitting or buying new, compliant vessels. Attendees noted that the current grant programs and other financial incentives are limited and often too slow or too complicated to be attractive alternatives to pursue. Stakeholders noted that both passenger trade and containerized cargoes had been tried in the past with limited success and some notable failures. Passenger ferry operations were cited as a failed venture (specifically the case with the Toronto to Rochester route), but are still viewed by some to be a viable future market. A potential route would be Cleveland, OH, to Port Stanley, Ontario, and with increased ice-breaking, this market can be extended year-round (utilizing the experience of ferries in the Baltics as a guide). Fuel price fluctuations and market volatility were also noted as impediments to making significant investments in new ship designs for new cargo types. The concern is that market shift may make the vessel unattractive and underutilized.

SUGGESTIONS: The stakeholders identified the need for market incentives and policy changes to enhance and enable long-term planning and investment. Currently, the market volatility makes these types of investments high risk. The stakeholders felt that MARAD would be well-suited to help establish this regional, multi-modal perspective as a counter to the current competition between modes and individual ports. Regarding future investment in the region, attendees urged MARAD to push for more grant opportunities and greater investment into research and development. Some attendees thought that the Marine Highways program is a good one that should be exploited in the region. They suggested that this become a priority for the Administration and that perhaps Federal resources could be expanded to aid in funding the development.

Intermodal and Intergovernmental Cooperation

ISSUE: The Great Lakes stakeholders repeatedly stressed the need for greater uniformity, coherency, and integration in terms of planning, policy, and implementation. This entails greater integration of all modes (marine, rail, and highway) to ensure effective utilization of the current capacity in the transportation system. Attendees highlighted a need for reformation of policies and increased cooperation between the U.S. and Canada, as well as cooperation between the various States. Participants indicated that the maritime industry often stands alone and would benefit from integration with other modes of transport. They indicated that expanded outreach also needs improvement. The meeting attendees shared the belief that the current policies regarding the region are fragmented between too many jurisdictions and entities and seem too short-sighted.

SPECIFICS: A key item mentioned that highlighted this lack of governmental cooperation was Canada's recent repeal of their 25-percent duty on foreign-built ships. Canada's removal of their protective regulation has produced increases in their new vessel builds in foreign shipyards and creates the potential of an imbalance in competition between the U.S. and Canadian fleets. Other examples mentioned were State DOTs focused on highway and rail programs that often have little consideration for the maritime mode. Stakeholders also noted that States and local development commissions and planning boards are often too narrowly focused and do not have the needed regional perspective.

SUGGESTIONS: The representatives see potential for MARAD to be an advocate for the industry by promoting the industry to Congress and to sponsor increased funding for more icebreakers (140 class) to ensure safety and create a set season (or perhaps an expanded season) on the Great Lakes as a system. The attendees would like to see MARAD serve as a coordinator with the various State DOTs to ensure consistent policies and practices. MARAD should also assume a presence by coordinating the maritime message and representing a unified industry to Government agencies to help increase funding of the industry. One suggestion was for increased support for programs like the Great Ships Initiative to help foster a flourishing of the maritime industry. It was suggested that MARAD reach out to the various Governors' offices or work more closely with the Council of Great Lakes Governors to establish some more consistent policies that would be more favorable to the entire Great Lakes maritime community.

Infrastructure and Vessel Repairs and Upgrades

ISSUE: Infrastructure and vessel maintenance, repair, and construction were identified as critical needs by stakeholders at every meeting. Both vessel and shoreside infrastructures are aging, but another critical infrastructure need is maintenance of the seaways through dredging. The current Federal budget crisis was noted as compounding the issue, since expensive repairs, re-investment, and dredging are often deferred, and maintenance is delayed allowing conditions to further deteriorate. Representatives believe that the industry is responsive to customer needs and that the fleet is currently well designed; no major modifications are needed in terms of vessel configurations.

SPECIFICS: Stakeholders noted that the current infrastructure is in need of repair, but there is also the requirement to develop the ports for future markets. A frequently cited specific issue related to the infrastructure was the need for the largest Laker vessels to "light load" because of draft constraints in certain ports where dredging has been delayed or deferred. This inefficient operating scheme is costly in terms of both shipping costs and environmental effects. Other infrastructure issues noted by the stakeholders include the need to develop the ports to better accommodate the needs of future markets. Intermodal facilities, transfer capabilities, and even Roll-on/Roll-off terminals were identified as deficient in the region, and as a limitation to the development of potential new markets. In addition, the seawalls, breakwaters, and cargo-handling facilities are largely dated and many are in need of repair. Stakeholder rough estimates for costs of infrastructure repairs alone are currently in the hundreds of millions. Obviously, there will need to be a stratification placed upon the most urgent needs to prioritize those that would be most beneficial to the flow of commodities.

SUGGESTIONS: Many of the comments made in the meetings pointed to general self-sufficiency of the region, but noted that additional financial aid from the Federal Government, including through MARAD, could be very beneficial. It was discussed that MARAD's advocacy of Great Lakes Shipping, especially with regard to the critical need for dredging of ports and channels, would be helpful. The stakeholders felt that USACE might benefit from having USDOT and MARAD (an operating administration of USDOT) as allies in the budgetary process. To solve the issues currently affecting the region, the representatives advocated for greater funding for both vessel improvements and, particularly, for infrastructure re-investment. Also proposed was the desire for a program that uses public–private partnerships for funding infrastructure investments. Stakeholders suggested that MARAD open and expand Title XI to all vessels to create a financing body accessible to all. It was noted that revision of Title XI should ensure that oversight and the overall process would not be so cumbersome and expensive, which currently is discouraging participation. EPA DERA repowering grants have been provided for trucks, trains, and some vessels, and should also be expanded to cover more ships as well. Attendees stated that grants or low-interest loans from the Federal Government to local authorities could greatly improve port infrastructure and address the backlog of necessary repairs. Specific requests for such infrastructure investments include: grants for technology to lower emissions (e.g., scrubbers) while shipping companies prepare financially for more permanent solutions (e.g., repowering), assistance to facilitate pooled equipment purchases, and sponsorship of a grant program to repower ships in a 30/70 Federal/private cost-share type program.

HMT Utilization

ISSUE: The current implementation and utilization of the HMT and Harbor Maintenance Trust Fund (HMTF) were viewed by many of the attendees as unfair or inadequate. Several representatives urged the elimination of the HMT as being unfair since there are not similar taxes levied on other transport modes.[476] Most participants, however, were of the opinion that the HMT was a given and that the greater issue was the failure to apply the HMT funds back into the region to address the myriad of infrastructure and needs.

SPECIFICS: Attendees voiced concern over the inability to fully utilize the HMTF to fund port and channel infrastructure needs. It was reported that the trust fund surplus at the end of FY 2010 was over $5 billion. Stakeholders also noted that recent annual expenditures for dredging were less than half of the HMT revenues for the same year. They stated that USACE's budget for dredging in the Great Lakes region was greatly reduced. Stakeholders indicated that the HMT serves as an impediment for the development of new markets in the region.

SUGGESTIONS: Stakeholders consistently expressed the need for HMT funds to be spent as designed by supporting USACE's efforts in the operation and maintenance of commercial ports and navigation channels in the Great Lakes. They shared the belief that MARAD should serve as another "voice in Washington" that could aid in advocating for the expenditure of HMTF resources to support the maritime industry in the area. A recurring suggestion was that HMTF expenditures should be more closely aligned with annual HTF revenues. Meeting attendees also suggested that the Administration explore select exemptions to the HMT for certain cargoes as an incentive to stimulate new or emerging markets, such as container feeder services.

Meeting Attendees

Cleveland, OH: February 15, 2011

Organization

American Coal Liquefaction
American Maritime Officers
American Steamship Company
Canadian Shipowners Association
Carmeuse Lime & Stone
City of Lorain, Ohio
Cleveland–Cuyahoga County Port Authority
Conneaut Port Authority
Detroit/Wayne County Port Authority
DLS Marine Services—Great Lakes
Duluth Seaway Port Authority
Economic Development Corporation
EnSafe, Inc.
Erie–Western Pennsylvania Port Authority
FEDNAV, Limited
GEA Mechanical Equipment U.S., Inc.
Great Lakes Commission
Great Lakes Fleet
Great Lakes Maritime Academy
Great Lakes Science Center
Great Lakes/Seaway Review & Greenwood's Guide to Great Lakes Shipping
Greater Buffalo–Niagara Regional Transportation Council
Harbor House Publishers
International Longshoremen's Association
International Organization of Masters, Mates & Pilots
John Carroll University
Koch Mineral Services
Latinex
Moffatt & Nichol
Netherlands Consulate
NETSCo, Inc.
NOACA
Ohio Department of Natural Resources, Division of Wildlife
Ohio Department of Transportation
Polaris Marine Associates, Inc.
Port of Toledo
PPG Protective and Marine Coatings
R W Armstrong
Rolls-Royce Commercial Marine, Inc.
SEACOR Ocean Transport, Inc.
SeaSnake, LLC
The Great Lakes Towing Company
Toromont
Transportation Institute
United States Great Lakes Shipping Association
University of Michigan
Vanenkevort Tug & Barge
W&O Supply Company
World Shipping, Inc.

Federal Partners
U.S. Army Corps of Engineers–Buffalo
U.S. Army Corps of Engineers–Detroit
U.S. Coast Guard
U.S. Coast Guard Sector Sault Ste. Marie
U.S. Department of Transportation—Saint Lawrence Seaway Development Corporation
U.S. Environmental Protection Agency
U.S. Merchant Marine Academy
U.S. Senator Sherrod Brown (Represented)

Duluth, MN: February 23, 2011
Organization
AMI Consulting Engineers P.A.
Burlington Northern Santa Fe Railway
Board of Harbor Commissioners, City of Superior
Cliff's Natural Resources
Duluth Seaway Port Authority
GEA Westfalia Separator
Hallett Dock Company
LHB Corp.
Marine Tech, LLC
Metropolitan Interstate Council
Midwest Energy Resources Company
Minnesota Department of Transportation
Propeller Club
Rolls-Royce Commercial Marine, Inc.
University of Minnesota Duluth

Federal Partners
U.S. Army Corps of Engineers
U.S. Coast Guard

Chicago, IL: February 25, 2011
Organization
AECOM
Aggregates & Metallurgical Stone
Alliance for the Great Lakes
ArcelorMittal
Bank of America Merrill Lynch
Canadian Consulate of Chicago
Chamber of Marine Commerce
Chicago Metropolitan Agency for Planning
DJMP Engine Solutions, LLC
Engine Manufacturers Association
Great Lakes and St. Lawrence Cities Initiative
Illinois Department of Natural Resources
International Ship Masters Association
KCBX Terminals
Lake Michigan Air Directors Consortium
Logicos, LLC
MM&R Law
National Cargo Bureau, Inc.
PM Shipping
Port of Burns Harbor
Rockford Bergé
Rolls-Royce Commercial Marine, Inc.
Wärtsilä North America, Inc.

Federal Partners
U.S. Army Corps of Engineers
U.S. Coast Guard
U.S. Department of Transportation—Federal Highway Administration
U.S. Department of Transportation—Federal Railroad Administration
U.S. Environmental Protection Agency—Region 5
U.S. Senator Mark Kirk (Represented)

Discussion Topics
Session Topic 1: Economic needs and emerging trends—This topic involves a discussion of the current state of the Great Lakes maritime transportation system (ships, ports, facilities, locks, etc.) and whether this infrastructure can meet the current and projected market demands.

Discussion Questions:
- What are the current market demands on the Great Lakes for freight, passenger, and ferry service?
- What are the projected market demands and opportunities to increase the demand for freight, passenger, and ferry service?
- What factors impact the demand for marine transportation services in the region?
- Are there emerging trends in the Great Lakes maritime transportation market that MARAD should be aware of?

Session Topic 2: Finding environmental solutions—This discussion session will include an assessment of the challenges in meeting the current and foreseeable environmental and regulatory requirements.

Discussion Questions:

- What are the specific environmental challenges facing the Great Lakes both in the short term and long term?
- What are the regional ports and the Great Lakes U.S.-flag fleet doing to meet those challenges?
- What is required to assist the maritime industry in meeting and overcoming these environmental challenges?
- What are the specific environmental opportunities facing the Great Lakes, both in the short and long term?
- What is required to assist the maritime industry in achieving and fully realizing these environmental opportunities?

Session Topic 3: U.S.-flag Great Lakes fleet ships and shipping—The U.S.-flag Great Lakes fleet is aging, with the average age of U.S.-flag self-propelled dry-bulk vessels being 45 years old. In the coming decade, many of the vessels may need to either be replaced or they will need to be adapted to remain competitive, comply with environmental regulations, and address new operating realities (such as potentially lower water levels).

Discussion Questions:

- Are there any industry-planned changes to vessel designs or fleet mix based on expected future market demands, changes in the operating environment, or to improve competitiveness?
- Is there a need to revitalize the Great Lakes fleet? Is it more economically feasible to repower/retrofit existing vessels or to purchase new vessels?
- What is needed for vessels to meet current or projected market demands, i.e., vessel design, infrastructure, economic conditions, regulations?
- Are there opportunities that will facilitate compliance with EPA and State regulatory requirements for air emissions and ballast water by those regulations' enforcement dates?

Session Topic 4: Shore Facilities and Infrastructure—The Great Lakes ports and nearby intermodal linkages are a critical part of the Great Lakes maritime transportation network. For years, the Great Lakes ports have served the needs of the Laker fleet and the greater regional maritime transportation industry.

Discussion Questions:

- What are the opportunities to meet projected market demands for regional port facility infrastructure (berths, piers, etc.)?
- What are the plans for current short- and long-term alterations to ports and other shipping facilities in the region?
- What opportunities exist for strengthening the intermodal linkages between Great Lakes ports, railroads, and highways to maximize the efficiency of the regional transportation system?
- What is the condition of the regional navigational infrastructure (locks, Nav Aids, etc.) to meet current and projected market demands?

NOTES

1. Unless noted otherwise, in this report the term "Lakers" refers to U.S.-flag vessels, although Canadian-flag vessels operating on the Great Lakes are also referred to by this term.
2. Great Lakes Maritime Research Institute (GLMRI), Information Clearinghouse, http://www.maritime.utoledo.edu/Port_Info.aspx.
3. "Integrated" steel manufacturing is one of two principal methods used to produce steel. In the integrated steelmaking process, iron is extracted from iron ore in a blast furnace and the molten product is then mixed with recycled steel and refined with oxygen in a basic oxygen furnace. The alternative production method is electric arc furnace steelmaking, in which recycled steel is the primary input.
4. U.S. Army Corps of Engineers (USACE), Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report, Great Lakes Navigation System Review*, Economics Appendix, Feb. 2010, p. 18, p. 18, Table 3.4, http://www.lre.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=6979&destination=ShowItem.
5. U.S. EPA, Office of Transportation and Air Quality, *Economic Impacts of the Category 3 Marine Rule on Great Lakes Shipping*, EPA-420-R-12-005, Apr. 2012, p. 10, http://www.epa.gov/oms/regs/nonroad/marine/ci/420r12005.pdf.
6. 40 CFR § 1043.95(a).
7. EPA, "Great Lakes Steamship Repower Incentive Program" (regulatory announcement), Jan. 2012, http://www.epa.gov/otaq/regs/nonroad/marine/ci/420f12003.pdf.
8. A harbor is a landform where a part of a body of water is protected and deep enough to furnish anchorage to a vessel, particularly during severe weather. Ports are facilities for loading and unloading vessels that are usually located within harbors, although not all harbors have ports.
9. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, 2010, p. 37.
10. International Monetary Fund, "World Economic Outlook Database—September 2011," "Nominal GDP list of countries for the year 2010." http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx.
11. Martin Associates, *The Economic Impacts of the Great Lakes–St. Lawrence Seaway System,* Exhibit III-3, p. 45. (http://www.greatlakes-seaway.com/en/pdf/eco_impact_full.pdf)
12. Ibid., Exhibit II-2, p. 5.
13. Ibid., Exhibit VI-1, p. 12.
14. Ibid., p. 84.
15. Ibid., Exhibit VI-1, p. 12.
16. Richard D. Stewart, "Great Lakes Marine Transportation System: White Paper Prepared for the Midwest Freight Corridor Study," Midwest Regional University Transportation Center, Madison, WI, Apr. 2006, p. 2, http://wupcenter.mtu.edu/education/great_lakes_maritime/lessons/Grt-Lks-Maritime_Transportation_System_Report_Stewart.pdf.
17. A U.S.-flag vessel is a vessel that is registered and operated under the laws of the United States (46 U.S.C. § 106). The vessel must be owned by U.S. citizens (46 U.S.C. §§ 12103 and § 50501).
18. Information on this trade can be found in the 2007 *Great Lakes St. Lawrence Seaway Study: Final Report*, a bi-national study (Transport Canada et al., http://www.marad.dot.gov/documents/GLSLs_finalreport_Fall_2007.pdf) and in Martin Associates' 2011 study, *The Economic Impacts*.
19. James H. I. Weakley, "Future Navigation Needs: Great Lakes Systems Approach," presented in Niagara Falls, NY, July 27, 2011, p. 8, at http://chl.erdc.usace.army.mil/dirs/events/405/09%20Weakley%2088CERB2011.pdf.
20. USACE, Great Lakes and Ohio River Division, *Reconnaissance Report, Great Lakes Navigation System Review, Appendix A—Economic Analysis*, June 2002, p. 2–3, http://www.lre.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=2878&destination=ShowItem.
21. Weakley, "Future Navigation Needs," p. 8.
22. Stewart, "Great Lakes Marine Transportation," p. 3. A minor amount of cargo moves on the New York State Barge Canal.
23. 46 U.S.C. §§ 12103, 12112, 12131. See also 19 CFR § 4.80.
24. USACE, Navigation Data Center, Waterborne Commerce Statistics Center, "Vessel Company Summary and Vessel Characteristics from the Waterborne Transportation Lines of the United States." http://www.ndc.iwr.usace.army.mil//veslchar/veslchar.htm, Sept. 2, 2010.
25. Tugboats and towboats are typically vessels used to move unpropelled barges or other vessels and to assist larger vessels with mooring and unmooring. Towboats are specialized tugs, usually with square bows that usually push barges on rivers.
26. Lake Carriers' Association (LCA), "Members, Vessel Rosters," http://www.lcaships.com/members.
27. *Greenwood's Guide to Great Lakes Shipping*, 2010 Edition (Boyne City, MI: Harbor Hours Publishers, Inc.), http://www.greenwoodsguide.com.
28. Lake Carriers' Association (LCA), "Members, Vessel Rosters," http://www.lcaships.com/members.
29. USACE, Great Lakes and Ohio River Division, *Reconnaissance Report, Appendix A—Economic Analysis*, p. 5–6.
30. See http://www.lcaships.com/members for a list of LCA members. Note that 13 members are listed at this site, but several of these companies consist of more than one operating unit. American Steamship Company includes Armstrong Steamship Company and Bell Steamship Company; Interlake Steamship Company includes the Lakes Shipping Company; and Port City Marine Services includes Port City Steamship Services.
31. Note that many recent accounts cite 13 steamships, but one of these vessels was repowered to a diesel engine in August 2012.
32. John W. Lawson, *History of Great Lakes Navigation*, U.S. Army Engineer Water Resources Support Center, Institute for Water Resources, Jan. 1983, p. 77, http://www.iwr.usace.army.mil/docs/iwrreports/HISTORYOFGREATLAKESNAVIGATIONJANUARY1983.pdf.

Note that slightly longer (e.g., 767 ft) and wider vessels can be accommodated with permission.

33. American Steamship Company, "Self-Unloading Technology," http://www.americansteamship.com/self-unloading-technology.php.
34. The first purpose-built, self-unloading vessel in the world was a U.S.-flag Laker named the *Wyandotte*, built in 1908. The pioneering unloading system was invented by George B. Palmer, Chief Engineer for Wyandotte Chemicals Corp. in Wyandotte, MI. The vessel remained in service until 1966 (Mark L. Thompson, *Steamboats & Sailors of the Great Lakes* (Detroit, MI: Wayne State University Press, 1991), p. 43). Note that another Laker, the wood-hulled *Hennipen*, is often cited as the first self-unloading vessel, having been converted from a straight-deck vessel in 1902.
35. Jeff Thoreson, referring to the *Edward L. Ryerson* (IMO 5097606), at http://www.shipspotting.com/gallery/photo.php?lid=276994.
36. Bruce S. Old, *The Competitive Status of the U.S. Steel Industry* (Washington, DC: National Academy Press, 1985), pp. 115–16.
37. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, p. 49. Cargo trends on the Great Lakes are recorded for the United States. This source shows domestic and international traffic.
38. USACE, *Waterborne Commerce of the United States, Calendar Year 2005*, Part 5—National Summaries, p. 1–5.
39. Factors other than the 1981–82 recession and foreign import competition contributed to the cargo decline, including changes in trade patterns following the fall of the Soviet Union that led to the diminishment of grain cargo volumes moved on the Great Lakes. As noted above, a significant drop in cargo occurred between 1979 and 1980.
40. National Bureau of Economic Research, "US Business Cycle Expansions and Contractions," http://www.nber.org/cycles.html.
41. *Greenwood's Guide,* 1980, 1990, 2000, 2010 editions.
42. The unloading system used on cement carriers precludes these vessels from discharging other commodities.
43. Nine of the 1,000-ft, self-unloading Laker vessels are included in the 1980 line of Table 6 although these large vessels had just entered service in the years immediately prior to 1980. This effect disguises the major change in per-trip capacity of the fleet caused by the introduction of these vessels.
44. This estimate applies to self-unloaders and straight-deck vessels and does not include cement vessels. It is based on an average 45-hour one-way voyage with no backhaul, 10 hours of unloading for a self-unloader and 50 hours for a straight-deck vessel, 10 hours loading for each, and 280 days per year of operation.
45. The use of the term "barge" in this context indicates a hull at least 400 ft long and typically 75 ft wide. The largest of the Great Lakes barges is the *Presque Isle*, which when combined with its tug (also named the *Presque Isle*), is 1,000 ft long and 104.5 ft wide. These vessels are much larger than the standard hopper barges (195 ft long, 35 ft wide) used on the Inland Water System and also on the Great Lakes.
46. C. James Kruse and Nathan Hutson, *NCFRP Report 5: North American Marine Highways*, National Cooperative Freight Research Program (NCFRP), Transportation Research Board, Washington, DC, 2010, pp. 14–15. http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_005.pdf. Note that Great Lakes tug-barge crews exceed levels reported by this source.
47. "New Tug/Barge Sails the Lakes for American Steamship Company," *Marine Delivers*, June 19, 2012. Note that actual crew size for tug-barges on the Great Lakes is higher than listed in this source. http://www.marinedelivers.com/featurearchive/new-tugbarge-sails-lakes-american-steamship-company.
48. Tom Hynes, "Tug *Defiance* and barge *Ashtabula*," Boatnerd.com, Nov. 2012. http://www.boatnerd.com/pictures/fleet/Defiance-Ashtabula.htm.
49. The repowered vessels are the *Charles M. Beeghly* (2009) (now named the *James L. Oberstar*), the *Lee A. Tregurtha* (2006), the *Paul R. Tregurtha* (2010), the *Edwin H. Gott* (2011), and the *Kaye E. Barker* (2012).
50. GLMRI, Information Clearinghouse; LCA, "Great Lakes and St. Lawrence Seaway Ports" (for information on ports served by U.S. Lakers—available from LCA on request); and USACE, "Ports and Waterway Facilities," at http://www.ndc.iwr.usace.army.mil/ports/ports.asp. Note that in its fact sheet "The U.S. Waterway System—Transportation Facts" for 2009, USACE reported 48 Great Lakes ports that handled more than 250,000 short tons of cargo in 2008, with a total of 646 cargo-handling docks (http://www.ndc.iwr.usace.army.mil/factcard/factcard09.pdf).
51. GLMRI Information Clearinghouse data provided by ABSG Consulting.
52. EPA reports a saving of more than $6 per ton of ore moving from Minnesota to Indiana relative to a unit train (EPA, *Economic Impacts of the Category 3 Marine Rule*, p. 10).
53. A knot is a unit of speed equal to 1 nautical mile per hour, or approximately 1.151 statute miles per hour.
54. A bow thruster or stern thruster is a transversal propulsion device built into, or mounted to, either the bow or stern, of a ship or boat to make it more maneuverable. Bow and stern thrusters make docking and maneuvering in tight channels and harbors easier, since they allow the vessel to move to port or starboard without using the main propulsion mechanism, which requires some forward motion for turning.
55. Richard H. Harkins, "Great Lakes Marine Air Emissions—We're Different Up Here!" *Marine Technology*, Vol. 44, No. 3, July 2007, pp. 151–74. Mr. Harkins notes that of the 54 Lakers he studied for his article, 54 had bow thrusters and 29 had both bow and stern thrusters. http://trid.trb.org/view.aspx?id=837851.
56. Much of the material in this section is based on Richard D. Stewart, *Regulations and PoliciesThat Limit the Growth of the U.S. Great Lakes Cruising Market*, University of Wisconsin–Superior Paper No. 02-21:1 (Madison: University of Wisconsin, National Center for Freight and Infrastructure Research and Education, Oct. 2011). http://www.wistrans.org/cfire/documents/FinalPaper_CFIRE0221.pdf.
57. USACE, Navigation Data Center, Waterborne Commerce Statistics Center, "Vessel Characteristics, Waterborne Transportation Lines of the United States."
58. 46 CFR Ch. I, Subch. T—Small Passenger Vessels (Under 100 Gross Tons) (http://www.law.cornell.edu/cfr/text/46/chapter-I/subchapter-T) and 46 CFR Ch. I, Subch. K—Small Passenger Vessels Carrying More Than 150 Passengers or with Overnight Accommodations for More Than 49 Passengers (http://www.law.cornell.edu/cfr/text/46/chapter-I/subchapter-K).
59. 46 CFR Ch. I, Subch. H—Passenger Vessels (http://www.law.cornell.edu/cfr/text/46/chapter-I/subchapter-H) (accessed May 8, 2012).
60. Stewart, *Regulations and Policies*, pp. 10–11 of 24.
61. USACE, Navigation Data Center, *Vessel Characteristics, Calendar Year 2010*, Vol. 3 of *Waterborne Transportation Lines of the United States*. http://www.ndc.iwr.usace.army.mil//veslchar/pdf/wtlusvl3_10.pdf.
62. "*Badger*," MarineTraffic.com, http://www.marinetraffic.com/ais/shipdetails.aspx?MMSI=367155430; and Don Davenport, "Crossing Lake Michigan By Car Ferry," *Chicago Tribune*, Aug. 2, 1998, at http://articles.chicagotribune.com/1998-08-02/travel/9808020261_1_badger-car-ferry-car-deck.
63. "*Lake Express*," MarineTraffic.com, http://www.marinetraffic.com/ais/shipdetails.aspx?mmsi=366941210.
64. Stewart, *Regulations and Policies*, p. 4 of 24.
65. Ibid., p. 7 of 24.
66. Ibid., p. 11 of 24.
67. Ibid., p. 4 of 24.
68. Ibid., pp. 19 and 20 of 24.
69. For instance, see Myron Kukla, "Great Lakes cruise ships scheduled for Lakeshore port visits for first time in 83 years," MLive.com. http://www.mlive.com/news/grand-rapids/index.ssf/2012/06/great_lakes_cruise_ships_sched.html.
70. Note that several U.S.-flag tank barges exceed 300 ft in length (*Greenwood's Guide*, 2010 Edition, pp. 7.1–7.3).

71. A good description of the numerous tasks performed by tugboats is provided by Malcolm Marine, Inc., "A Brief History of Malcolm Marine," http://www.malcolmmarine.com/history.htm.
72. "From Major Fleet Overhaul to New Tug Construction," *The Journal of Commerce Online*, Mar. 27, 2012, http://www.joc.com/press-release/major-fleet-overhaul-new-tug-construction.
73. Weakley, "Future Navigation Needs," p. 8. The 115 million ton U.S.-flag fleet capacity reflects more recent information sent to MARAD by LCA.
74. LCA, *2011 Statistical Annual Report of Lake Carriers' Association*, "U.S.-Flag Dry-Bulk Cargo Carriage 1993–2011" and "Great Lakes Dry-Bulk Commerce," http://www.lcaships.com/2011-statistical-annual-report.
75. Weakley, "Future Navigation Needs," p. 9, and USACE, Great Lakes and Ohio River Division, Supplemental Reconnaissance Report, p. 58.
76. *Niagara to GTA Corridor Planning and Environmental Assessment Study: Area Transportation System Alternatives Report*—Appendix A, Individual Transportation Alternatives, Draft for Consultation, Mar. 2010, p. A-19, http://www.niagara-gta.com/pdf/4-5-10/Appendix%20A%2003Mar10.pdf.
77. "Government of Canada Approves Duty Removal for Ships," *Canada Newswire*, Ottawa, Oct. 2010, http://www.newswire.ca/en/story/624271/government-of-canada-approves-duty-removal-for-ships.

    > The removal of duty on ships imported into Canada for use in Canada's coasting trade is an important measure to help maintain the competitiveness of Canadian industry, particularly in Canada's industrial heartland along the Great Lakes/St. Lawrence marine highway. Duty removal will encourage new marine transportation initiatives in Canada to take advantage of the underutilized marine highway and relieve congestion currently experienced on ground-based modes of transport.

78. Canada Steamship Lines has ordered four new vessels (The CSL Group Inc., "CSL Doubles New Vessel Order," Sept. 7, 2011, http://www.csl.ca/Press_New_vessel_order.html); Algoma Central Corp. has ordered six new vessels, and the Canada Wheat Board has ordered two new vessels to be operated by Algoma Central Corp. (Scott Dunn, "Shipping company invests $500 million in new ships," *The Sun Times*, Feb. 2012, http://www.owensoundsuntimes.com/ArticleDisplay.aspx?e=3469683).
79. FedNav Ltd. has also ordered new vessels, but it is unclear how many of these will be Canadian-flagged ("Fednav invests $400 million in the renewal of its fleet," *Hellenic Shipping News Worldwide*, Mar. 14, 2012, http://www.hellenicshippingnews.com/News.aspx?ElementId=5fc55320-7f79-4d77-bdb8-0660a42eb448).
80. Ron Samson, "FEDNAV brings new 'green' ship to Great Lakes—Federal Yukina makes inaugural voyage to Port of Hamilton," *Canadian Sailing: Transportation and Trade Logistics*, July 4, 2011, http://canadiansailings.ca/?p=2409. Flag data comes from Clarkson's Shipping Intelligence Network, accessed Mar. 29, 2012.
81. Algoma Central Corp., "Algoma Central Corporation Announces the Arrival in Canada of New Self-unloading Bulk Carrier, the M.V. *Algoma Mariner*," Aug. 3, 2011, http://www.algonet.com. Algoma has announced an investment of approximately $300 million to construct six new state-of-the-art Equinox Class vessels consisting of four full-size self-unloading vessels and two full-size gearless bulkers.
82. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, p. 58. Until 1986, Canadian vessels were eligible for limited construction subsidies (Robert J. McCalla, *Water Transportation in Canada* (Halifax, NS: Formac Publishing, 1994), p. 77). U.S. vessels, however, benefited in the 1970s from Title XI loan guarantees and tax-deferred benefits established by the Merchant Marine Act of 1970.
83. "American Steamship Company charters new articulated tug barge," *Great Lakes Seaway Review*, Feb. 6, 2012, http://www.greatlakes-seawayreview.com/digdateline/#022712-2.
84. One industry source noted that raked and bulbous bows are not always suited for ice conditions on the Great Lakes.
85. LCA, Docket (EPA-HQ-OW-2011-0141), p. 10, http://www.lcaships.com/wp-content/uploads/2012/07/EPA-VGPII-Final-02212012.pdf.
86. LCA, Docket (EPA-HQ-OW-2011-0141), pp. 19–20. Note that there is still some corrosion in fresh water, and once a vessel reaches 25 years of service, the actual thickness of the metal is measured and compared to the original thickness. Even so, Lakers have reached ages of 100 years or more—far longer than vessels operating in salt or brackish water.
87. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, p. 4, shows the location of locks along the Seaway. See also "Locks, Canals, and Channels" at the Great Lakes St. Lawrence Seaway web site at www.greatlakes-seaway.com/en/seaway/locks/index.html.
88. Lawson, *History*.
89. Midwest Energy Resources Company, "The Superior Midwest Energy Terminal" Web site, at http://www.midwestenergy.com/about.php.
90. U.S. Department of Commerce, U.S. National Oceanic and Atmospheric Administration Coastal Services Center, and the Great Lakes Commission, *Great Lakes Needs Assessment: Ports and Navigation (P&N), Draft Interim Report*, Aug. 16, 2006, p. 35, at http://glc.org/regionalneeds/documents/PNdraftinterimreport8-18-06revised.doc.
91. The potential needs of the non-bulk vessels operators, including marine highway services, for additional port facilities are discussed later in this chapter.
92. American Great Lakes Ports Association, "2012 Federal Policy Agenda," http://greatlakesports.org/pp/uploads/2012_AGLPA_Policy_Positions_v2.pdf.
93. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, p. 37.
94. GLRMI, Information Clearinghouse; LCA, "Great Lakes and St. Lawrence Seaway Ports"; and USACE, "Ports and Waterway Facilities." Note that the New York ports on Lake Ontario are not currently served by U.S.-flag Lakers.
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97. Data from USACE, Waterborne Commerce Statistics, 2009.
98. Martin Associates, *Port of Cleveland's Strategic Action Plan: Technical Appendices*, Appendix D: Port of Cleveland Cargo Market Assessment, Apr. 6, 2011, pp. D-5, D-9, D-10. http://www.portofcleveland.com/wp-content/uploads/2012/08/Appendix-D-Cargo-Market-Assessment.pdf .
99. Lawson, *History*, p. 83.
100. John C. Taylor and James L. Roach, *Ocean Shipping In the Great Lakes: An Analysis of Issues, Phase II* (Allendale, MI: Grand Valley State University, Oct. 7, 2007), pp. 5–6, http://www.lakeinvaders.com/Learn_More_files/OceanShippingPhaseII.pdf.
101. Ibid.
102. "Identity preservation" of grain (as well as soybeans) requires careful handling of the grain through production, processing, transportation, and customer delivery. Identity-preserved grains cannot be mixed or co-mingled with other grains; therefore they are often carried in sealed containers. The purpose of identity preservation is to preserve the quality and consistent identity of premium-value grains (see Midwest Shippers Association, "About Identity Preservation" (undated), http://www.midwestshippers.com/IdentityPreservation.php).
103. Saint Lawrence Seaway Development Corporation, "Cleveland Port, Vessel Owner Advance Effort to Start International Container Service," *Seaway Compass*, Fall 2010, p. 7, http://www.seaway.ca/en/pdf/slsdc_newsletter_fall_2010.pdf.
104. Paul Merrion, "Chicago hopes to turn long-neglected port into a contender," *Chicago Business* (Crains), Jan. 9, 2012, http://www.chicagobusiness.com/apps/pbcs.dll/article?AID=/20120107/ISSUE01/301079974.

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107. Hofstra University, Port Community Systems. "The Geography of Transport Systems," http://http://people.hofstra.edu/geotrans/eng/ch4en/conc4en/port_community_systems.html.

108. GLMRI, "Conversion to Natural Gas Would Be A First on the Lakes: Great Lakes Maritime Research Institute to Study Repowering the Great Lakes Commercial Fleet Including the Historic Carferry, the S.S. Badger" (Press Release), Dec. 2, 2011, http://www.glmri.org/downloads/news/LNGProjec2011.pdf.

109. Unprocessed taconite ore typically has iron concentrations of 25 to 30 percent and must be concentrated to approximately 65-percent iron to make it usable for steel production. The concentrated taconite ore is then prepared in the form of marble-sized pellets that make it easier to handle and process. To manufacture taconite pellets, the raw ore is first crushed and the iron (in the form of magnetite) is separated from crushed waste rock by using strong magnets. The powdered iron concentrate is combined with bentonite clay (as a binder) and limestone (as a flux) and rolled into pellets about 1 cm in diameter. These pellets are then fired at high temperature to make them durable (Minnesota Department of Natural Resources, "Taconite," http://www.dnr.state.mn.us/education/geology/digging/taconite.html; Minnesota Department of Transportation, Wisconsin Department of Transportation, and Duluth-Superior Metropolitan Interstate Council, *Northern Minnesota & Northwestern Wisconsin Regional Freight Plan*, Nov. 2009, p. 36, http://www.dot.state.mn.us/ofrw/PDF/northernregionalfreightplan.pdf).

110. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, Appendix C, Economics Appendix, 2010, p. 18, Table 3.4, http://www.lre.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=6979&destination=ShowItem.

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112. Also see the discussion on freight rates in Chapter 6, and data in Table 18.

113. EPA, *Economic Impacts of the Category 3 Marine Rule*.

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119. IHS Global Insight, U.S. Economy: Report, p. 4 of 6. This information was last updated Apr. 5, 2012.

120. U.S. Department of Energy, Advanced Manufacturing Office, "Steel Industry Profile," Web site at http://www1.eere.energy.gov/manufacturing/industries_technologies/steel_profile.html.

121. IHS Global Insight, Pricing and Purchasing: Report, Steel Scrap (updated Apr. 9, 2012, 10:11 a.m. EDT), p. 4 of 6. Note that in June 2012, however, scrap steel prices fell below this projection due to concerns about economic growth in China and Europe, and while they recovered thereafter, had not returned to $400 per metric ton by October 2012.

122. John Myers, "Taconite is back," *Duluth News Tribune*, Mar. 27, 2011, http://www.iseek.org/news/fw/fw7853FutureWork.html.

123. Fran Howard, "The World Comes to the Iron Range," *Twin Cities Business Magazine*, Apr. 2008, http://www.tcbmag.com/print.aspx?print_page=/industriestrends/economicdevelopment/98541printp1.aspx.

124. John Myers, "Cliffs predicts good times ahead for taconite industry on the Range," *Duluth News Tribune*, Mar. 9, 2012, http://www.duluthnewstribune.com/event/article/id/225169/.

125. Howard, "The World Comes to the Iron Range." United States Steel and ArcelorMittal are the largest operators in the U.S. integrated steel sector and are also owners of large taconite mines.

126. Some countries that are heavily dependent on imported scrap, such as Turkey, are expanding EAF capacity dramatically, which will put further upward pressure on scrap prices. See Thomas Danjczek and Alan Price, "Scrap Supply in the Global Steel Industry: A Better Path," Presentation, OECD Steel Committee, Dec. 2010, p. 6, http://www.oecd.org/dataoecd/50/48/46584778.pdf.

127. In 2011, demand for steel drove the price of pelletized taconite ore from Minnesota to as high as $200 per long ton (relative to a Lake delivery cost of approximately $10 per ton). More recent taconite ore prices have exceeded production costs by 4 times. Given the competitive strength of U.S. integrated steel producers and the low domestic transportation cost of Lake-delivered taconite, it would seem unlikely that taconite ore consumed by these plants would be exported abroad (at significantly higher transportation costs).

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139. 64 *Federal Register* (FR) 35765), July 1, 1999, as amended at 70 FR 39156, July 6, 2005; 71 FR 60631, Oct. 13, 2006. At 77 FR 33656, June 7, 2012, § 51.308 was amended by revising paragraph (e)(4), effective Aug. 6, 2012.

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141. Energy Innovation Business Council, "MI Public Service Commission: Renewables Less Expensive than Coal, Spark Economy" (Press Release), Feb. 23, 2012, http://www.mieibc.org/news/article/press-release-1.

142. *EPA Regulations and Electricity* (GAO-12-635), pp. 24–25. In addition to low natural gas prices contributing to pressure to retire coal-fired generators, GAO cited factors such as possible low growth in future electricity demand and greater development of alternative energy sources.

143. Ibid., pp. 28–29.

144. Ibid., p. 29.

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185. 33 U.S.C. § 1901.

186. U.S. EPA, Office of Transportation and Air Quality, "EPA Finalizes More Stringent Standards for Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder," Dec. 2009, p. 4, http://www.epa.gov/oms/regs/nonroad/marine/ci/420f09068.pdf.

187. "Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder," 73 FR 25,098-01 (May 6, 2008).

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> any diesel fuel or other distillate fuel that is used, intended for use, or made available for use, as a fuel in any nonroad diesel engines, including locomotive and marine diesel engines, except the following: Distillate fuel with a T90 at or above 700 °F that is used only in Category 2 and 3 marine engines is not NRLM diesel fuel, and ECA marine fuel is not NRLM diesel fuel. 40 CFR § 80.2(nnn).

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190. "Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder," 75 FR 22896, 22968 (Apr. 30, 2010) (hereinafter "Category 3 Rule"). A Category 3 engine means a marine engine with a specific engine displacement greater than or equal to 30 liters per cylinder (40 CFR § 94.2).

191. 40 CFR § 1042.104.

192. Ibid. at Parts 1039 and 1042.

193. Ibid. at Part 1043. See also 33 U.S.C. §§ 1901–1915. Note that all ships operating in the North American ECA are required to comply with the ECA fuel sulfur limits; distillate fuel sold in the United States meeting the 500- and 15-ppm limit will comply with the ECA requirements.

194. Ibid.

195. U.S. EPA, *Economic Impacts of the Category 3 Marine Rule*, pp. 6-2–6-3.

196. 40 CFR § 1043.95; Category 3 Rule at 23018. See also U.S. EPA, "Frequently Asked Questions about the Great Lakes Residual Fuel Availability Waiver," http://www.epa.gov/otaq/regs/nonroad/marine/ci/420f12008.pdf.

197. 40 CFR 1043.95(a).

198. Ibid. There were 13 steamships as of early 2012, but the repowering of one vessel (the Kaye E. Barker) was completed in August 2012.

199. U.S. EPA, Great Lakes Steamship Repower Incentive Program.

200. U.S. EPA, *Final Regulatory Support Document: Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder*, p. 115, Table 6.2-1, http://www.epa.gov/nonroad/marine/ci/r03004.pdf.

201. Estimates of the differential between the price of low-sulfur fuel and HFO vary depending on the time period when the comparison is made. See LCA comments on Category 3 Rule at p. 12. EPA reports that the price of HFO fuel ranged between 50 and 72 percent of the price of MDO over the period from 2000 to 2007 (EPA, *Economic Impacts of the Category 3 Marine Rule*, p. 2-19). The 50-percent higher cost of low-sulfur fuel used in this analysis conforms to price trends since 2011.

202. U.S. EPA, Economic Impacts of the Category 3 Marine Rule, p. 10.

203. Hull fouling, also referred to as biofouling, has also been identified as a vector of the introduction of aquatic nonindigenous species, particularly in ocean and estuarine environments. The Transportation Research Board reports, however, that evidence indicates that hull fouling has played a very minor role in introducing aquatic nonindigenous species into the freshwater ecosystem of the Great Lakes (Transportation Research Board, *Great Lakes Shipping, Trade, and Aquatic Invasive Species*, p. 58). LCA reports that hull fouling on Lakers confined to the Great Lakes is minimal.

204. 33 U.S.C. §§ 1251 *et seq.*

205. U.S. EPA, 2008 VGP, available at http://www.epa.gov/npdes/pubs/vessel_vgp_permit.pdf.

206. Ibid. Note that recreational vessels and vessels of the armed forces are exempt from the requirement to obtain a NPDES permit, and with the exception of ballast water discharges, commercial fishing vessels and nonrecreational vessels less than 79 ft are not subject to the 2008 VGP.

207. Ibid.

208. U.S. EPA, "Draft National Pollutant Discharge Elimination System (NPDES) General Permits for Discharges Incidental to the Normal Operation of a Vessel," 76 FR 76716 (Dec. 8, 2011), http://www.gpo.gov/fdsys/pkg/FR-2011-12-08/html/2011-31576.htm (hereinafter "Draft Notice of 2013 VGPs"). In this notice, EPA is issuing two draft VGPs. One would continue to permit discharges from vessels more than 79 ft in length (2013 VGP) that are currently permitted by the 2008 VGP. EPA is also proposing a draft NPDES Small Vessel General Permit (sVGP) to authorize discharges incidental to the normal operation of nonmilitary and nonrecreational vessels less than 79 ft in length. For purposes of this report, only the impacts of the 2008 VGP and Draft 2013 VGP are studied.

209. Ryan Albert, U.S. EPA, "Extension of the VGP deadline," e-mail sent on November 28, 2012, http://www.brymar-consulting.com/wp-content/uploads/incidental%20discharges/EPA121128.pdf.

210. FR notice of 2013 VGPs.

211. Draft 2013 VGP, Part 2.2.3.5, http://www.epa.gov/npdes/pubs/vgp_draft_permit2011.pdf.

212. Ibid. at Part 2.2.3.5.3.3. Other classes of vessels not required to comply with numeric standards are vessels operating exclusively within a limited area on short voyages and unmanned, unpowered barges. See also Parts 2.2.3.5.3.1 and 2.2.3.5.3.2. Note that the VGP is intended to control the release of all living nonindigenous aquatic organisms. Only some of these organisms may become invasive.

213. U.S. EPA, Draft Notice of 2013 VGPs at 76720.

214. Ibid.

215. Ibid.

216. Ibid.

217. U.S. EPA, 2011, "Proposed Issuance of National Pollutant Discharge Elimination System (NPDES) Vessel General Permit (VGP) for Discharges Incidental to the Normal Operation of Vessels Draft Fact Sheet" (hereinafter "Draft 2013 VGP Fact Sheet"), p. 75, available at http://www.epa.gov/npdes/pubs/vgp_draft_factsheet2011.pdf.

218. Ibid.

219. Ibid.

220. 16 U.S.C. §§ 4711, 4725, Coast Guard, "Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters," 77 FR 17254 (Mar. 23, 2012), http://www.gpo.gov/fdsys/pkg/FR-2012-03-23/pdf/2012-6579.pdf (hereinafter "USCG BW rule").

221. Ibid. 17262; 33 CFR §151.1511.

222. USCG BW rule, 77 FR at 17312, defines BWMS to be "any system which processes ballast water to kill, render harmless, or remove organisms. The BWMS includes all ballast water treatment equipment and all associated control and monitoring equipment." Some in the industry use the term "ballast water treatment system" instead of BWMS to mean the same thing, but "BWMS" is consistent with IMO terminology.

223. Ibid. at 17260.

224. Ibid at 17260.

225. The same is true for EPA's Draft 2013 VGP. The VGP is renewed at least every 5 years.

226. LCA comments submitted by James H. I. Weakley, President, LCA, on Draft National Pollutant Discharge Elimination System (NPDES) General Permits for Discharges Incidental to the Normal Operation of a Vessel, Feb. 21, 2012, Docket ID: EPA-HQ-OW-2011-0141-0527, at www.regulations.gov (hereinafter, "LCA comments on Draft 2013 VGP").

227. U.S. EPA, Science Advisory Board, *Efficacy of Ballast Water Treatment Systems: a Report by the EPA Science Advisory Board*, July 12, 2011, http://yosemite.epa.gov/sab/SABPRODUCT.NSF/6FFF1BFB-6F4E09FD852578CB006E0149/$File/EPA-SAB-11-009-unsigned.pdf (hereinafter "SAB Report").

228. Ibid. at p. 40.

229. Research on fresh water ballast treatment is conducted through the Great Ships Initiative (GSI) (http://www.nemw.org/gsi/index.htm), the Great Lakes Ballast Water Collaborative (http://www.great-lakes-seaway.com/en/environment/ballast_collaborative.html), the Bi-National Ballast Water Working Group, and various Federal, State, and private entities. U.S. and Canadian Lake carriers participate in these efforts to develop effective BWMS for vessels visiting or captive to the Great Lakes. For instance, American Steamship Company has worked with the National Park Service on experiments to test the efficacy of applying biocides (sodium hydroxide or sodium hypochlorite) to ballast water on the Class 10 Laker Indiana Harbor (see Sharon Moen, "Report from the Great Lakes Ballast Water Collaborative Meeting: Toronto," prepared for The Great Lakes Ballast Water Collaborative, Toronto, Jan. 19, 2011, pp. 13–15, http://www.greatlakes-seaway.com/en/pdf/Toronto_Ballast_Water_Collaborative_Report(Final).pdf). Other examples of industry efforts to evaluate BWMS technology are described in "LCA comments on Draft 2013 VGP," p. 22.

230. LCA comments on Draft 2013 VPT at p. 10.

231. Ibid. at p. 9.

232. Ibid.

233. Ibid. at p. 9.

234. Ibid. at p. 23.

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237. Ibid at p. 10.

238. Great Lakes Regional Collaboration of National Significance (GLRC), *Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes*, Dec. 2005, p. 4, http://www.glrc.us/documents/strategy/GLRC_Strategy.pdf.

239. Ibid., p. 18.

240. Ibid., pp. 19–22.

241. CWA, 33 U.S.C. §1370; Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended by National Invasive Species Act of 1996, 16 U.S.C. §4725.

242. See *Lake Carriers' Ass'n v. EPA*, 652 F.3d 1, 3-4 (D.C. Cir. 2011) (describing the 401 certification process).

243. "LCA comments on Draft 2013 VGP" at p. 25.

244. State 401 Certification Letters to the 2008 VGP, available at http://cfpub.epa.gov/npdes/docs.cfm?document_type_id=6&view=Program%20Status%20Reports&program_id=350&sort=name (accessed May 29, 2012).

245. New York Department of Environmental Conservation, "New York Pursues Uniform, National Ballast Water Requirements: DEC Will Work with Other States and Stakeholders to Advocate a Strong National Standard" (Press Release), Feb. 22, 2012, http://www.dec.ny.gov/press/80495.html.

246. "LCA comments on Draft 2013 VGP," pp. 21–22.

247. For instance, see Minnesota Pollution Control Agency, RE: Federal Clean Water Act Section 401 Water Quality Certification of U.S. Environmental Protection Agency Vessel and Small Vessel General Permit, Aug. 17, 2012, p. 21 of 147, http://www.pca.state.mn.us/index.php/view-document.html?gid=18390. The document notes that,

> As the receiver of the vast majority of ballast water discharge from Lakers, and the potential for spread of invasive species from the lower lakes to Minnesota Waters, Minnesota remains interested in Lakers being considered as part of the fleet to which numeric ballast discharge limits are applicable to protect our water resources.

248. Great Lakes St. Lawrence Seaway System, "Great Lakes Ballast Water Collaborative" Web site, http://www.greatlakes-seaway.com/en/environment/ballast_collaborative.html.

249. Joseph A. Keefe, "Focus: Invasive Species Threaten the Great Lakes—Working to Maintain & Foster Commerce While Protecting an Ecosystem," *The Maritime Executive*, Second Quarter, 2003, p. 51, http://media.tmmarket.com/marex/media/pdf/Invasive_Species.pdf.

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251. Keefe, "Focus: Invasive Species," p. 51.

252. U.S. EPA, "Great Lakes Fact Sheet," http://www.epa.gov/greatlakes/factsheet.html.

253. Ibid.

254. "Controlling depth" is the least depth in the approach channel to an area, such as a port or anchorage, governing the maximum draft of vessels that can enter the channel.

255. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, p. 108.

256. USACE. Great Lakes and Ohio River Division, *Reconnaissance Report, Great Lakes Navigation System Review*, Appendix A—Economic Analysis. June 2002, p. 3-2, http://www.lre.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=2878&destination=ShowItem. Controlling depths are given at low water datum, which is an approximation of mean low water adopted as a standard reference for a limited area.

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258. Ibid.

259. Ibid., pp. 7-1–7-32.

260. Weakley, "Future Navigation Needs."

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263. Ibid., p. 16.

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265. Felicity Barringer, "Water Levels in 3 Great Lakes Dip Far Below Normal," *New York Times*, Aug. 14, 2007, http://www.nytimes.com/2007/08/14/us/14lakes.html.

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269. Rob Nairn, W.F. Baird & Associates Coastal Engineers, "Decline of Lake Michigan-Huron Levels," Mar. 19, 2008, p. 8, http://www.glc.org/stclair/documents/Nairn_PP.pdf.

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315. LCA, "Cancelled cargoes trim lakes coal trade in January," Feb. 2010, *Great Lakes & Seaway Shipping News Archive*, http://www.boatnerd.com/news/archive/2-10.htm.

316. Communication from James Weakley of the LCA.

317. "Lake Carriers hails effort to build new Coast Guard icebreaker for lakes," *Great Lakes & Seaway Shipping News Archive*, Sept. 2009, http://www.boatnerd.com/news/archive/9-09.htm.

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319. David J. Singer, *A Review of Great Lakes Shipbuilding and Repair Capability: Past, Present and Future*, Great Lakes Maritime Research Institute, Oct. 31, 2007, pp. 2-17. (Not available on the internet as of Oct. 2012).

320. James Donahue, "Strange Steamboat Walk-in-the-Water," http://perdurabo10.tripod.com/ships/id126.html.

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322. Singer, *A Review of Great Lakes Shipbuilding and Repair Capability*, p. 8.

323. Ibid., p. 8.

324. Ibid., p. 11.

325. *Greenwood's Guide*, 2010 Edition, pp. 9.1–9.4.

326. Ibid., pp. 19.1–19.4. Several Canadian shipyards have dry docks in excess of 400 ft in length, either alone or in combination. All but one of these shipyards are located at or below Lock One of the Welland Canal (i.e., on Lake Ontario or on the St. Lawrence Seaway) and are not accessible to larger Lakers. Moreover, U.S.-flag domestic (Jones Act) vessels, with few exceptions, must be constructed in U.S. shipyards.

327. Ibid., pp. 19.1–19.4. A graving dock is a basin with three sides that has a gate opening to a body of water. Once the vessel is inside, the gate is closed, the water is pumped out, and the vessel rests on blocks. A floating dry dock is a pontoon that has a U-shaped cross-section (a floor with two wing walls rising on both sides along its length) that is flooded to sit lower in the water than the ship's keel. Once the ship is positioned inside, the water is pumped out of the buoyancy chambers, and the ship is raised out of the water.

328. Ibid., pp. 19.1–19.4.

329. "Employment Peaking at Great Lakes Shipyards," *The Maritime Executive*, Jan. 27, 2011, http://www.maritime-executive.com/article/employment-peaking-great-lakes-shipyards.

330. *Greenwood's Guide*, 2010 Edition, pp. 20.1–20.19.

331. LCA members operate all of the U.S.-flag Laker vessels of 400 ft or greater length.

332. "Lakes Contender, Ken Boothe Sr. christened Tuesday at Erie ceremony," *Great Lakes and Seaway Shipping News*, Apr. 11, 2012, http://www.boatnerd.com/news/archive/4-12.htm. In April 2012, the 34,000-ton capacity self-unloading articulated tug-barge *Ken Boothe, Sr./Lakes Contender* were christened at Donjon Shipbuilding and Repair in Erie, PA. The American Steamship Company will operate the new articulated tug–barge, the first built on Lake Erie since the *Presque Isle* was launched in 1972.

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334. "Employment Peaking at Great Lakes Shipyards."

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340. U.S. Department of Transportation, Statement of the Maritime Administrator David T. Matsuda before the Sub-Committee on Coast Guard and Maritime Transportation, U.S. House of Representatives, on the State of the United States' Merchant Fleet in Foreign Commerce, July 20, 2010, http://testimony.ost.dot.gov/test/pasttest/10test/matsuda3.htm.
341. Great Lakes Maritime Academy, "Maritime Careers," https://www.nmc.edu/maritime/maritime-industry/maritime-careers.html.
342. USCG, National Maritime Center, at http://www.uscg.mil/nmc/approved_courses_state.asp?short=MI&long=Michigan#list.
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345. Bunkerworld prices for BW380 and BWDI for Aug. 2011 to Aug. 2012 at http://www.bunkerworld.com/prices/index/bwi.
346. U.S. EPA, *Economic Impacts of the Category 3 Marine Rule*, p. 2–19.
347. Weakley, *Future Navigation Needs*, p. 10.
348. U.S. EPA, *Economic Impacts of the Category 3 Marine Rule*, p. 10.
349. U.S. EPA, Office of Transportation and Air Quality, "Peer Review of 'Economic Impacts of the Category 3 Marine Rule on Great Lakes Shipping'"(comments by Bradley Z Hull), Jan. 2011, p. E-6. http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=500655.
350. Zanko et al., *The Economics and Logistics of Transporting Taconite Mining and Processing Byproducts*, p. iii. This study considers various alternatives for moving bulk aggregate materials, including truck, rail, water, and bimodal truck/rail systems.
351. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, p. 68.
352. U.S. Department of Transportation, Federal Highway Administration (USDOT/FHWA), *Addendum to the 1997 Federal Highway Cost Allocation Study Final Report*, May 2000, Table 13, "2000 Pavement, Congestion, Crash, Air Pollution, and Noise Costs for Illustrative Vehicles Under Specific Conditions" and "Summary and Conclusions," http://www.fhwa.dot.gov/policy/hcas/addendum.htm. The 80,000-pound gross vehicle weight truck in the FHWA study is a five-axle combination truck.
353. Federal commercial vehicle maximum standards on the Interstate Highway System are Single Axle, 20,000 lb; Tandem Axle, 34,000 lb; and Gross Vehicle Weight, 80,000 lb. Federal weight limits also apply to bridges on the Interstate Highway System as specified in the Bridge Formula. Federal law includes provisions, exemptions, and variations applicable to particular States, routes, vehicles, or operations that allow heavier trucks to operate.
354. USDOT/FHWA, *Addendum to the 1997 Federal Highway Cost Alocation Study*, Table 7, "Ratios of 2000 Federal User Charges to Allocated Costs by Vehicle Class."
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356. Tennessee Valley Authority and Center for Transportation Research, University of Tennessee, *Water-Compelled Rates and Available Navigation in the Upper-Mississippi and Illinois River Basins: An Update*, Feb. 2007, http://www2.mvr.usace.army.mil/UMRS/NESP/Documents/Water-Compelled%20Rates%20and%20Available%20Navigation%20in%20the%20UMR%20and%20IL%20Rvr%20Basins.pdf.
357. Ibid., p. 5, Table 1. Derived by dividing the table column "water compelled rate impact" by the "affected tonnage" column.
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360. This estimate assumes 94 million tons of domestic cargo each year, the removal of an average of 2 ft of silt from harbor channels, 4 years to remove the dredging backlog, a saving of $0.70 per ton of cargo due to full loading of vessels (with full benefits from dredging beginning 4 years from the start of the backlog removal), and a 7-percent real discount rate. The net benefits of dredging would be substantially higher at a 3-percent real discount rate.
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362. The TIGER Discretionary Grant program provides an opportunity for USDOT to invest in road, rail, transit, and port projects to achieve critical national transportation objectives. TIGER grants were recently awarded in four separate rounds (the first round was funded by $1.5 billion in budget authority from the American Recovery and Reinvestment Act of 2009) between 2009 and 2012 (see USDOT, TIGER Grants, http://www.dot.gov/tiger). The Administration has requested additional funding for this program.
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364. USDOT/FHWA, "Fact Sheets on Highway Provisions: Transportation Infrastructure Finance and Innovation Act (TIFIA)," http://www.fhwa.dot.gov/safetealu/factsheets/tifia.htm.
365. USDOT/MARAD, *Maritime Administration Annual Report to Congress Fiscal Year 2009*, p. 10, http://www.marad.dot.gov/documents/Maritime_Annual_Report_to_Congress_2009.pdf.
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369. Brett Esber, "Title XI Financing for Vessel and Shipyard Improvement Projects," MarineLink.com, http://www.marinelink.com/news/article/title-xi-financing-for-vessel-and-shipyard/322695.aspx.
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372. USDOT/MARAD, "Capital Construction Fund" Web site," http://www.marad.dot.gov/ships_shipping_landing_page/capital_construction_fund/capital_construction_fund.htm.
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374. U.S. EPA, National Clean Diesel Campaign, "Grants and Funding Overview" Web site at http://www.epa.gov/diesel/grantfund.htm.
375. Ibid.
376. U.S. EPA, "EPA awards $750,000 Midwest Clean Diesel grant to Great Lakes Maritime Research Institute," EPA News Release, July 30, 2010, http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/75cd9f52016007df85257776005aa9cf!OpenDocument.
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378. Grants.gov, "Air Emissions and Energy Initiative," http://www07.grants.gov/search/search.do?oppId=169653&mode=VIEW.
379. USDOT/MARAD, *America's Marine Highway: Report to Congress*, Apr. 2011, pp. 38–48, http://www.marad.dot.gov/documents/MARAD_AMH_Report_to_Congress.pdf.
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381. USDOT/MARAD, *America's Marine Highway: Report to Congress*, p. 42.
382. USDOT/MARAD, *America's Marine Highway Grant Notice of Funding Availability*, 75 FR 49017, Aug. 12, 2010, http://edocket.access.gpo.gov/2010/2010-20013.htm.
383. USDOT, TIGER Grants Web site, http://www.dot.gov/tiger/.
384. USDOT/MARAD, *America's Marine Highway: Report to Congress*, p. 30.

385. MARAD contracted the American Bureau of Shipping Group Consulting arm and their team members the Great Lakes Maritime Research Institute; Transportation Economics and Management Systems; TEC, Inc.; and Martin Associates to develop a BCA framework to analyze the alternative scenarios.

386. National Surface Transportation Policy and Revenue Study Commission, *Transportation for Tomorrow: Report of the National Surface Transportation Policy and Revenue Study Commission, Final Report—Volume III: Section 1—Technical Issues Papers*, "Analysis of Future Issues and Changing Demands on the System, Part K. Planning and Implementation of Transportation Infrastructure Projects, Commission Briefing Paper 4K-0, Benefit–Cost Analysis in Public Sector Infrastructure Investment Decisions," Jan. 10, 2007, at http://transportationfortomorrow.com/final_report/volume_3_html/technical_issues_papers/paper8fcc.htm?name=4k_05.

387. Private-sector financial analysis must also address issues of taxes to the firm making the investment, including potential tax credits, accelerated depreciation of assets, and deductions for interest on loans, which will affect specific investment decisions. The impact of these factors will vary from firm to firm depending on access to capital, taxable income streams, and other factors. The social BCA in this study does not attempt to measure tax effects of investment decisions, which are considered to be transfer payments between public and private sectors, rather than costs or benefits.

388. Martin Associates, *The Economic Impacts*.

389. For more information on the differences between BCA and EIA, please refer to the TIGER III Notice of Funding Availability, *Federal Register*, Vol. 76, No. 127, Friday, July 1, 2011, p. 38734, http://www.dot.gov/tiger/docs/FY11_TIGER_IntNOFA.pdf.

390. Ibid.

391. USACE, Great Lakes and Ohio River Division, *Supplemental Reconnaissance Report*, Table 14, Vessel Operating Costs, p. 61, and *Great Lakes Navigation System Supplemental Reconnaissance Economics Appendix*, "8.0 Vessel Fleet and Operating Costs."

392. U.S. EPA, *Economic Impacts of the Category 3 Marine Rule*, p. 10.

393. U.S. Office of Management and Budget, Circular No. A-94, "Revised, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs."

394. The repowered vessels are the *Charles M. Beeghly* (2009) (previously a steamship, now named the *James L. Oberstar*), the *Lee A. Tregurtha* (2006) (previously a steamship), the *Paul R. Tregurtha* (2010) (Category 3 diesel), the *Edwin H. Gott* (2011) (Category 3 diesel), and the *Kaye E. Barker* (2012) (previously a steamship). Two of the steamship repowering decisions were made prior to the Category 3 Rule in 2010, which requires Category 3 diesel vessels to use more expensive, low-sulfur fuel in place of HFO fuel.

395. There were 13 steamships as of early 2012, but the repowering of the *Kaye E. Barker* to diesel was completed in August 2012. These vessels range in length from 520 ft to 767 ft (average 700 ft), have steam engines ranging in shaft horsepower from 3,500 to 9,000 (average 6,380), and can carry from 12,700 tons to 28,600 tons of cargo (average 25,100 tons).

396. Category 3 Rule at 22936,

> For the purpose of this exclusion, Great Lakes steamships means vessels, operating exclusively on the Great Lakes and Saint Lawrence Seaway, whose primary propulsion is a steam turbine or steam reciprocating engine. In addition, these steamships must have been in service on the Great Lakes prior to October 30, 2009. This does not include diesel propulsion Category 3 vessels with auxiliary boilers.

397. LCA comments on Category 3 Rule at p. 12.

398. Interior Appropriations Act of 2010, Pub. L. 111-88, § 442.

399. There is no provision in the rule for a termination of this exemption.

400. Based on *Greenwood's Guide*, 2010 edition. This estimate includes the recently repowered *Kaye E. Barker*. Note that the cement-carrying fleet is treated here as a subset of the self-unloading fleet.

401. Calculated using the 2008 and 2009 USACE Waterborne Commerce Statistics data.

402. MARAD estimated these values from U.S. EPA emissions factors provided in Harkins, "Great Lakes Marine Air Emissions," Table 8, and the grams per ton-mile assumptions contained in Table 23.

403. Brian Bienkowski, "Feds propose a fuel exemption for steamships that switch to diesel engines," *Great Lakes Echo*, Jan. 31, 2012, http://greatlakesecho.org/2012/01/31/feds-propose-a-fuel-exemption-for-steamships-that-switch-to-diesel-engines/.

404. The Interlake Steamship Company Web site, "Our Fleet," http://www.interlake-steamship.com. See tabs on the *James L. Oberstar, Lee A. Tregurtha*, and *Kaye E. Barker*. The *Kaye E. Barker* participates in the EPA's Great Lakes Steamship Repower Incentive Program.

405. U.S. EPA, "Great Lakes Steamship Repower Incentive Program," Jan. 2012, http://www.epa.gov/otaq/regs/nonroad/marine/ci/420f12003.pdf.

406. Ibid. Regarding its exclusion of steamships converted to tug-barge units, EPA states that,

> Removal of the engine section of the vessel and replacing it with a tug is more consistent with replacing the existing vessel rather than repowering it. In addition, the replacement tug would likely be powered by a Category 2 engine that does not use residual fuel, because of the space restrictions on tugs and the requirements for fuel handling equipment to use residual fuel, and therefore a residual fuel waiver would be irrelevant. (77 FR 11, Jan. 18, 2012, p. 2475)

407. Category 3 Rule.

408. Technically, repowerings in 2016 and thereafter would need to be Category 3, Tier 3, engines, but because of a lack of specific information on the cost and availability of such engines for repowering Great Lakes steamships, Category 3, Tier 2, replacement costs and emissions were used in this analysis.

409. Michael Parsons, Patrick J. O'Hern, and Samuel J. Denomy, "The Potential Conversion of the U.S. Flag Great Lakes Steam Bulk Carriers to LNG Propulsion—Initial Report," *Journal of Ship Production and Design*, Vol. 28, No. 3, Aug. 2012, p. 100. Parsons et al. report that automation of engine-room functions associated with the installation of new diesel and LNG engines can reduce non-fuel operating costs by $600,000 to $700,000 per year per vessel. This would be approximately 10 percent of non-fuel operating costs.

410. The actual prices of HFO and MDO, and the relative differences between their prices, have varied significantly over the last decade; the values here are based on 2011–2012 prices.

411. U.S. EPA, "EPA awards $750,000 Midwest Clean Diesel grant to Great Lakes Maritime Research Institute," EPA News Release, July 30, 2010, http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/75cd9f52016007df85257776005aa9cf!OpenDocument. In 2010 EPA awarded a Midwest Clean Diesel Initiative grant to the Great Lakes Maritime Research Institute, which partnered with Key Lakes, Inc., to repower the diesel-powered *Edwin H. Gott* with two new engines. The $750,000 EPA grant was leveraged with $14 million in private investment. The vessel, a 1,000-ft (Class 10) Laker, was successfully repowered and re-entered service in March 2011. It is estimated that the new engines in the *Edwin H. Gott* will reduce NO_x emissions by 27 percent, CO emissions by 75 percent, and PM by 31 percent.

412. "RAND Logistics to Repower Lakes Steamship," *Marine Log*, July 27, 2010, http://www.marinelog.com/DOCS/NEWSMMIX/2010jul00271.html.

413. LCA comments on Category 3 Rule at p. 7.

414. Owners are assumed to operate the repowered vessels as well, but in the case of an owner chartering a vessel to another operator, the vessel owner could capture operating and maintenance cost savings attributable to repowering in the form of a higher vessel charter rate.

415. Lenders may be reluctant to offer capital if they are concerned about vessels remaining employed in the future and thus may assign substantial interest premiums to loans that they do make to cover this risk.

416. This analysis does not reflect the particular financial conditions facing individual carriers. A thorough financial analysis, reflecting cash flows, depreciation schedules, interest and tax deductions, expected future nominal costs for repowering, and other carrier-specific conditions, would be mandatory for a carrier considering such an investment.

417. The budgetary cost of the Title XI program to the U.S. Government is equivalent to the "subsidy cost" of providing credit assistance. Per the Federal Credit Reform Act of 1990, the subsidy cost of Federal credit programs reflects the present value of expected losses due to loan defaults (offset by partial recoveries of the defaulted loans and fees collected from borrowers), presented as a percentage share of the loan principal amounts.

418. USDOT/MARAD, [Title XI] "Program Requirements," http://www.marad.dot.gov/ships_shipping_landing_page/title_xi_home/title_xi_prog_reqs/title_xi_prog_reqs.htm.

419. As of October 2012, the loan amounts for which Title XI applications are already pending at MARAD exceeded the funding available to accommodate them. Although not all of the pending applications will necessarily receive loan guarantees, additional Title XI appropriations from Congress are needed to facilitate MARAD's ability to approve new applications.

420. MARAD relied on assessments made by Parsons et al. that only 10 of the 12 steamships are viable for LNG repowering. Alternative 1 assumed all 12 vessels could be repowered to conventional diesels. The selection of 10 vessels, relative to the 12 vessels used in Alternative 1 for conventional diesel repowering, does not significantly bias comparisons between the two alternatives.

421. Dual-fuel LNG/diesel engines are selected in large part because they are 1) available and 2) would enable a vessel to switch to distillate fuel in the event that it cannot access LNG fuel at a particular port, thus minimizing the risk that LNG supply problems could disrupt vessel service.

422. "Great Lakes Steamships May Get Natural Gas," *NGV Global News*, Dec. 2, 2011, http://www.ngvglobal.com/g-lakes-steamships-may-get-natural-gas-1202.

423. Parsons et al., "The Potential Conversion," p. 99.

424. Mike Corkhill, "Feature: US weighs up revitalized coastal shipping and LNG fuel as green options," BIMCO, Dec. 29, 2011, https://www.bimco.org/News/2011/12/28_Feature_Week_52.aspx.

425. Parsons et al., "The Potential Conversion," pp. 106–107. Based on 215 m^3 of LNG needed for a 5.6-day trip and two 250-m^3-capacity fuel tanks.

426. Ibid., p. 101. The authors note that the lower energy content of LNG per unit of volume requires tankage with about 70 percent more net volume than on a MDO vessel of equal range.

427. Ibid., p. 102.

428. The Henry Hub price is currently the basis for natural gas future contracts traded on the New York Mercantile Exchange.

429. "America's bounty: Gas works: Shale gas is giving a big boost to America's economy," *The Economist*, July 14, 2012. *The Economist* reports that most experts agree that gas prices will eventually settle around $4 to $5 per MMBTU.

430. Michael Levi, *A Strategy for U.S. Natural Gas Exports*, The Hamilton Project, Brookings Institution, Discussion Paper 2012-04, June 2012, p. 13, http://www.brookings.edu/~/media/research/files/papers/2012/6/13%20exports%20levi/06_exports_levi.

431. HFO weighs 8.3 lb/gal, meaning that a barrel (42 gal) of HFO would weigh 349 lb, of which 6.32 barrels would equal a metric ton (2,204.6 lb). One barrel of HFO has 6,400,800 BTU, which at $650 per metric ton for HFO, would equal $16.07 per MMBTU. Source for HFO BTU content is "Energy Content in Common Energy Sources," The Engineering ToolBox, http://www.engineeringtoolbox.com/energy-content-d_868.html.

432. This cost outlook is also reflected in the recent report by the American Clean Skies Foundation, *Natural Gas for Marine Vessels: U.S. Market Opportunities*, Apr. 2012, pp. 10 and 15, http://www.cleanskies.org/wp-content/uploads/2012/04/Marine_Vessels_Final_forweb.pdf.

> Despite LNG production almost doubling the price of delivered natural gas, the fuel is still attractive relative to EIA's projected prices for residual and distillate fuel oil…. Over the next ten years, delivered LNG for marine use is projected to cost at least 41% less than residual fuel and 57% less than distillate fuel per unit of energy delivered. (p. 15).

433. Bob Kamb, "LNG as a Marine Fuel: Keeping It Real," presentation at the Great Lakes Maritime Community Days SNAME Regional Conference, Great Lakes & Great Rivers, 23, 24, 25 Feb. 2012, p. 17. http://higherlogicdownload.s3.amazonaws.com/SNAME/3c0e6c2a-f51c-462d-86f6-7061658df062/UploadedImages/Winter%202012/RW%20Kamb%20Presentation%20-%20SNAME%20GL&GR%20Meeting%20-%20Cleveland,Ohio%20-%20February%2023-24,%202012.pdf.

434. Ibid.; Parsons et al., "The Potential Conversion," pp. 97–111.

435. Parsons et al., "The Potential Conversion," p. 101.

436. Ibid., p. 102. The cost estimate is rounded to the nearest unit of $5 million. The American Clean Skies Initiative reported a similar conversion cost. It noted that "conversion of vessels to LNG operation is expensive—it can cost up to $7 million to convert a medium-sized tug to operate on natural gas, almost $11 million to convert a large car and passenger ferry, and up to $24 million to convert a Great Lakes bulk carrier." (*Natural Gas for Marine Vessels*, p. 6).

437. The price advantage was held to 2 to 1 to reflect the likely cost of liquefaction and handling of the LNG (see prior discussion). A sensitivity analysis later in this analysis looks at the impact of changes in that price ratio.

438. This figure is an approximation based on discussions with a MARAD consultant. It does not include the cost of liquefaction plant(s), but rather the specialized equipment needed to refuel Lakers from lakeside LNG liquefaction plants. The cost of liquefaction plants is assumed to be included in the cost of the LNG fuel.

439. Cedar River Group, *Evaluating the Use of Liquefied Natural Gas in Washington State Ferries, Final Report*, prepared for the Joint Transportation Committee, Jan. 2012, p. vii, http://www.leg.wa.gov/JTC/Documents/Studies/LNG/LNG_FINALReport_Jan2012.pdf. Note that while maintenance costs for LNG vessels may initially be higher than for equivalent diesel vessels, these costs are assumed to converge to those for similar diesel vessels.

440. Parsons et al., "The Potential Conversion," p. 100.

441. Ibid.

442. See Appendix B for Alternative 2.

443. Note that the analysis above added a fixed liquefaction fee of $3 per MMBTU and a fee of 15 percent of the natural gas price (to fuel the liquefaction facility) to the cost of natural gas in the price of LNG.

444. Parsons et al., "The Potential Conversion," p. 99, report that the Norwegians have successfully repowered an oil/chemical product tanker, the 25,000-deadweight-ton *Bit Viking*, which is in the size class of the smaller Lakers. Information on the commercial viability of this design should be available soon.

445. USACE, Great Lakes and Ohio River Division, *Reconnaissance Report, Appendix A*, p. 5-9, at http://www.lre.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=2878&destination=ShowItem.

446. Harkins, "Great Lakes Marine Air Emissions," pp. 34–35,151–74.

447. Numerous industry advertisements for the EMD engines cite Tier 2 kits, remanufacturing options, and dual fuel conversion.

448. U.S. EPA, "FY2009/FY2010 Clean Diesel Grants Home Page," http://www.epa.gov/midwestcleandiesel/grants/mcdirfp0910.html. The *Edwin H. Gott* previously had Category 3 diesels and was repowered to ECA-compliant Category 3 diesel engines. SO_x reductions, although reduced somewhat due to better fuel efficiency of the new engines, would have largely been realized even without the repowering due to the Category 3 rule caps on fuel sulfur content.

449. Energy Independence and Security Act of 2007 (Pub. L. 110–140), Title XI—Energy Transportation and Infrastructure, Subtitle C—Marine Transportation; Sec. 1121—Short Sea Transportation Initiative.

450. USDOT/MARAD, America's Marine Highway Program, Final Rule. 75 *Federal Register* 18095, Apr. 9, 2010, http://edocket.access.gpo.gov/2010/pdf/2010-7899.pdf.

451. CPCS Transcom Limited, *NCFRP 17: Multimodal Freight Transportation*, p. 60.

452. Hamilton Port Authority, "Sea3 means weekly container movements Hamilton-Montreal container feeder service commences July 3" (Press Release), June 26, 2009, http://www.hwyh2o.com/pdf/news090626.pdf.

453. USDOT/MARAD, America's Marine Highway Report to Congress, pp. 11–37.

454. CPCS Transcom Limited, *NCFRP 17: Multimodal Freight Transportation*, pp. 22–23.

455. Pennsylvania Transportation Institute, *Analysis of the Great Lakes/St. Lawrence River Navigation System's Role in U.S. Ocean Container Trade*, 2003, p. vii, http://www.mautc.psu.edu/docs/PSU-2002-04.pdf.

456. Global Insight, *Four Corridor Case Studies of Short-sea Shipping Services: Short-sea Shipping Business Case Analysis* (Ref. #DTOS59-04-Q-00069), (MARAD), 2006, http://www.marad.dot.gov/documents/USDOT_-_Four_Corridors_Case_Study_(15-Aug-06).pdf.

457. Ibid., p. 49.

458. Transportation Economics and Management Systems, Inc. (TEMS) and RAND Corporation. *Great Lakes–St. Lawrence Seaway New Cargoes/New Vessels Market Assessment Report*, Jan. 2007, http://www.marad.dot.gov/documents/NCNV_Report-Part_1.pdf and http://www.marad.dot.gov/documents/NCNV_Report-Part_2.pdf.

459. Ibid., pp. 97–98.

460. Ibid., p. 154.

461. Ibid., pp. 133–34, 154.

462. Ibid., pp. 153, 155.

463. Ibid., pp. 134, 154.

464. Ibid., p. 76.

465. Ibid., pp. 135, 156.

466. Ibid., pp. 134–35.

467. Ibid., pp. 134–35 (see footnotes).

468. Ibid., pp. 63, 65. RoRo water service would be less per FEU than rail for 350 FEU vessels and more than rail for 90 FEU vessels.

469. Ibid., p. 153.

470. The Federal Maritime Commission (FMC) recently calculated that $109 is a reasonable approximation of the average weighted HMT charged per FEU at U.S. ports. See FMC, *Study of U.S. Inland Containerized Cargo Moving Through Canadian and Mexican Seaports*, July 2012, pp. 41 and 55, http://www.fmc.gov/assets/1/News/Study_of_US_Inland_Containerized_Cargo_Moving_Through_Canadian_and_Mexican_Seaports_Final.pdf.

471. Transportation Economics and Management Systems, Inc., and RAND Corporation, *Great Lakes–St. Lawrence Seaway*, p. 153.

472. International Monetary Fund, "Nominal GDP list of countries for the year 2010, World Economic Outlook Database—September 2011," http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx.

473. USACE, Waterborne Commerce of the United States, Calendar Year 2008, Table 3-10 (p. 3-12), http://www.ndc.iwr.usace.army.mil//wcsc/pdf/wcusnatl08.pdf.

474. "Freight Rail Works" Advocacy Campaign, Association of American Railroads, Washington, DC, 2010.

475. Although no further clarification was provided on this topic, it is assumed the reference is to the California Air Resources Board (CARB).

476. It should be noted, however, that the trucking mode pays fuel and other taxes, whereas fuel used by Great Lakes carriers is not taxed.

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PHOTOGRAPH CREDITS

Front cover	The *Hon. James L. Oberstar,* outbound from the Port of Duluth–Superior and loaded with iron ore. The vessel is passing beneath the Blatnik Bridge, which connects the "Twin Ports," the two cities of Duluth, Minnesota, and Superior, Wisconsin. Photo by Duluth photographer Robert Welton/courtesy Duluth Seaway Port Authority.
Inside front cover	South Pier, catwalk, and lighthouse, South Haven, Michigan.
Page 11	The *American Valor* and *H. Lee White* at the Toledo Coal Terminal operated by CSX Transportation. Photo courtesy of the Toledo–Lucas County Port Authority.
Page 16	M/V *James R. Barker* in the Poe Lock. Photo courtesy of Carol J. Wolosz, Great Lakes Maritime Research Institute.
Page 25	The *Arthur M. Anderson* moving into dry dock at the Toledo Shipyard, which is operated by Ironhead Marine, Inc. Photo courtesy of the Toledo–Lucas County Port Authority.
Page 30	The *J.W. Wescott II* delivering supplies to the M/V *James R. Barker* on the Detroit River, May 2012. The *J.W. Westcott II* ferries pilots and delivers mail and other items to and from large vessels by way of a tradition called "mail in the pail." Photo courtesy of Carol J. Wolosz, Great Lakes Maritime Research Institute.
Page 37	Heavy traffic near the Ambassador Bridge in the Detroit River, May 2012, viewed from the M/V *James R. Barker.* Photo courtesy of Carol J. Wolosz, Great Lakes Maritime Research Institute.
Page 42	The M/V *Walter J. McCarthy* unloading cargo at the steel mill, and the Detroit-Windsor Ferry transiting the Detroit River, May 2012. Photo courtesy of Carol J. Wolosz, Great Lakes Maritime Research Institute.
Page 53	Photo by Bob Hom/courtesy Duluth Seaway Port Authority.
Page 55	Laker departing the Poe Lock, at the Soo Locks on the St. Mary's River, July 2012. Photo courtesy of Carol J. Wolosz, Great Lakes Marine Research Institute.
Page 62	Dredging operation in Duluth, Minnesota, circa 2003. Image from the archives of the Great Lakes section of the epa.gov site. Courtesy of Thoth, God of Knowledge. Licensed under the Creative Commons Attribution 2.0 Generic license.
Page 65	Winter ship entering the Duluth Harbor. Brett Groehler, University of Minnesota Duluth Photographer, in conjunction with the Great Lakes Maritime Research Institute.
Page 81	The U.S.-flag Laker *Paul R. Tregurtha* is the largest vessel ever to work the "Inland Seas." The ship measures 1,013.5 feet from stem to stern and when fully loaded can carry nearly 70,000 tons. Photo by Duluth photographer Robert Welton/courtesy Duluth Seaway Port Authority.
Page 90	The M/V *Mesabi Miner* entering the St. Mary's River (from Lake Huron), May 2012. Photo courtesy of Carol J. Wolosz, Great Lakes Maritime Research Institute.
Page 94	The *Cason J. Callaway.* Since her launching in 1952, the *Callaway* has been lengthened and converted to a self-unloader, for all practical intents and purposes making her as efficient as a new build. Photo courtesy Rod Burdick.

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February 2013