



# Supplemental Information

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# Introduction

This document includes information about the interagency maritime team, the University of Michigan project team, the engagement and development process, a needs assessment, as well as detailed information on Michigan's maritime ecosystem including data on vessels, ferry data, commodity movement and trends, port, harbor, and marina locations, and emissions estimations. The data used to generate the Asset Map (Figure 3 in the Michigan Maritime Strategy document) is also provided.

# Project Administration

## Appendix 1: Project Teams

### Interagency Maritime Work Group

Name	Title	Agency
Simon Belisle	Great Lakes Policy Specialist	Michigan Department of Environment, Great Lakes, and Energy (EGLE) Office of the Great Lakes
Breanna Bukowski	Environmental Quality Specialist	EGLE Air Quality Division
Chris Ethridge	Assistant Division Director	EGLE Air Quality Division
Emily Finnell	Great Lakes Senior Advisor and Strategist	EGLE Office of the Great Lakes
Colby Owens	Environmental Quality Analyst, Energy Services Unit	EGLE Materials Management Division
Jeff Spencer	Manager, Energy and Recycling Section	EGLE Materials Management Division
Julie Staveland	Assistant Division Director	EGLE Materials Management Division
Chuck Allen	Departmental Specialist	Michigan Department of Natural Resources (DNR) Parks and Recreation Division
Shafiq Bari	Director of Mobility Policy	Michigan Department of Labor and Economic Opportunity (LEO) Office of Future Mobility and Electrification
Charlie Tyson	Technology Activation Director	Michigan Economic Development Corporation (MEDC) Office of Future Mobility and Electrification
Elisha Wulff	Freight Policy Specialist	Michigan Department of Transportation (MDOT) Bureau of Transportation Planning
Jamie Zmitko-Somers	"Agriculture Development Bureau Director"	Michigan Department of Agriculture, and Rural Development (MDARD)

### University of Michigan Work Group

Name	Title	Department
Thomas Mckenney (PI)	Associate Professor of Engineer Practice	University of Michigan Naval Architecture and Marine Engineering
Logan Cox	Graduate Student (Graduated 2025)	University of Michigan Naval Architecture and Marine Engineering
Owen Baldwin	Graduate Student	University of Michigan Center for Sustainable Systems
Geoffrey Lewis	Research Specialist	University of Michigan Center for Sustainable Systems
Shoshannah Lenski	Previous Associate Director	University of Michigan Center for Sustainable Systems
Gregory Keoleian (Co-PI)	Peter M. Wege Professor of Sustainable Systems	University of Michigan Center for Sustainable Systems

The University of Michigan Working Group acknowledges and expresses their gratitude to their Internal Advisory Committee for supporting the efforts of the Michigan Maritime Strategy. This advisory committee includes Shalanda Baker, Daniel Cooper, James Diana, and Matthew Collette.

## Appendix 2: Engagement Process

### Engagement Process

The Maritime Strategy was developed through a 1.5-year inclusive and comprehensive engagement process, involving 200+ unique participants representing a wide range of sectors, organizations, communities, and interests connected to Michigan’s maritime industries and ecosystems. Recognizing that all Michiganders and those in the broader Great Lakes region have a stake in this work, the process included representation from environmental, health, community, and Tribal representatives alongside business and industry participants. Engagement included in-person meetings, field visits, phone interviews, and a full-day in-person workshop, which enabled deeper exploration of key issues and the identification of stakeholder and maritime interests priorities. Participants also had the opportunity to review and comment on a draft of the strategy. This collaborative and co-creation approach ensured that the strategy reflects diverse perspectives and is grounded in the needs and opportunities identified by those most closely connected to Michigan’s maritime future.

### Maritime Interests Engaged

Maritime Interests/Participant Category	Affiliation
Academia / Education / Research	Great Lakes Maritime Academy - Northwestern Michigan College
	Macomb Community College
	Michigan Sea Grant
	Michigan State University
	Michigan Technological University
	Northwestern Michigan College
University of Michigan	
Boatyard/shipyard	Fincantieri Marine Group
Classification society	American Bureau of Shipping
Commercial associations	Blue Sky Maritime Coalition
	Lake Carriers Association
	Marine Retailers Association
	National Marine Manufacturers Association
Construction	Holcim
Environmental	Green Marine
	The International Council on Clean Transportation
	Tunley Environmental

Maritime Interests/Participant Category	Affiliation
Federal United States (U.S.) government	Argonne National Laboratory
	Great Lakes St. Lawrence Seaway Development Corporation
	Soo Locks - U.S. Army Corps of Engineers (USACE) - Sault St. Marie, Michigan
	U.S. Customs and Border Protection
Impacted Communities Representatives	Beaver Island
	City of Detroit
	Traverse Connect
Innovation	20Fathoms
	Discovery Pier Freshwater Research and Innovation Center
	Lilypad
	National Oceanic Atmospheric Administration's Great Lakes Environmental Research Lab
	Newlab
	Synergist Mobility
International governance	Voltaic Marine
	Great Lakes St. Lawrence Governors & Premiers
Maritime Worker Union / Associations	Great Lakes Commission
	American Maritime Officers
Ports / Harbors / Marinas / Locks	International Association of Machinists and Aerospace Workers
	Detroit / Wayne County Port Authority
	Nicholson Terminal
	Port of Houston
	Port of Monroe
	Port of Muskegon (Muskegon Lakeshore Chamber of Commerce)
Recreational Associations	Freedom Boat Club - Bay City Michigan
	Michigan Boating Industries Association
Ship Designer	Bay Engineering
	Interlake Maritime Services
	Netsco
Ship Owner/Operator	Algoma Central Corp
	Interlake Steamship Co.
	Port City Marine Companies
	Sheplers Inc.
	VanEnkevort Tug & Barge

Maritime Interests/Participant Category	Affiliation
State Government	DNR - Parks and Recreation Division
	EGL - Air Quality Division
	EGL - Materials Management Division
	EGL - Office of Climate and Energy
	EGL - Office of the Great Lakes
	EGL - Water Resource Division
	LEO - Office of Employment and Training
	MDARD - Dept of Agriculture and Rural Development
	MDOT - Bureau of Transportation Planning
	MEDC - Office of Defense & Aerospace Innovation
	MEDC - Office of Future Mobility and Electrification
Tribal Government / Liaisons	MEDC - Outdoor Recreation
	Michigan Infrastructure Office
	Lac Vieux Desert Band of Lake Superior Chippewa Indians
	Little River Band of Ottawa Indians
	Nottawaseppi Huron Band of the Potawatomi Indians
Fuels	Pokagon Band of Potawatomi Indians
	Sault Ste. Marie Tribe of Chippewa Indians
Utilities	Michigan Soybean Committee
	Thumb Bioenergy
	DTE Energy

**\*Note: The project implementation team engaged with more than one member of many of the above companies and organizations.**

## Workshop Attendees Self Affiliations



## Appendix 3: Needs Assessment Summary

### Introduction

The Michigan Maritime Strategy was developed with input from a broad network of maritime interests, from within and outside the state, who provide expertise, perspective, priorities, and feedback. We referenced existing participant categorizations in compiling a set of representative and diverse interests to involve but also augmented and adjusted it based on the unique focus and priorities for this strategy, including a particular emphasis on environmental, health, and community stakeholders as well as Tribal communities and governments in addition to traditional industry participants.

This Needs Assessment report, which is a *draft, interim, and internal* deliverable of the Michigan Maritime Strategy project, and serves as one important input to the strategy, along with a literature review, expertise of the project team, and priorities of the State.

The needs assessment was compiled based on a variety of interactions completed by the project team between October 2024 and April 2025, including:

- Field visits to see relevant infrastructure first-hand (5 participants)
- In-person and virtual meetings and interviews (23 participants)
- In-person, full-day workshop held on March 14, 2025 (66 participants)

Participants above are counted by organization/entity, not individuals, further highlighting our wide engagement efforts. We spoke with multiple individuals at some organizations/entities. Also, some participants took part in more than one of the above interactions.

This report summarizes the maritime priorities, challenges, needs, and preferred solutions *from the perspective of and as identified by participants*. The final strategy document will incorporate the findings from this Needs Assessment but will not be solely based on participants opinions and beliefs.

### Alignment on Strategic Goals

Before going deeper into individual participant's needs, it was important to establish a baseline agreement of what the strategy's goals and their prioritization should be. For this section, impacts of the maritime industry, strategic objectives, and challenges and opportunities were discussed with participants. Our project is utilizing the three sustainability dimensions to ensure a holistic approach is taken for the strategy development including a strong economy, a viable natural environment, and thriving Michigan communities.

*Impacts of the Maritime Industry:* When asked about environmental impacts, participants identified greenhouse gas (GHG) emissions and air quality, water quality and biodiversity, and maritime transportation efficiency. In addition to the main environmental impact categories above, specific activities impacting the environment were also mentioned including dredging and shoreline erosion.

When asked about impacts on people, employment, transportation, health, and community and enjoyment were all topics mentioned.

When asked about impacts on the economy, participants identified that there is already a significant

positive impact of the maritime industry on Michigan's economy as well as a growth opportunity to play an even larger role. Responses such as "unrealized potential" and "ripe for innovation" highlighted the belief that there is still a lot of potential including specific references to tourism and recreation. Employment and transportation were mentioned again as important impacts on the economy in similar ways as they impact people.

*Strategic Objectives:* Participants polled as part of the workshop's plenary session provided input on what their top strategic goals are that should be incorporated into Michigan's Maritime Strategy. There was broad support for multiple goals, showing that the strategy needs to be holistic and cover all dimensions. While there was broad support for multiple goals, the top 5 goals include:

- Create economic opportunities and good jobs
- Ensure efficient movement of goods
- Embrace innovative solutions
- Address environmental / ecosystem impacts
- Address climate pollution

When asked what vessel types should be the primary focus of the strategy, there was clearly an interest in commercial cargo vessels including freighters, cargo barges, and towboats. The interest in commercial cargo vessels align with the understanding that these vessels contribute the largest proportion of the maritime industry's GHG and air pollutant emissions. In addition to commercial cargo vessels, there was interest in ferries, recreational boats, and U.S. Naval/Military Sealift Command/ Coast Guard vessels. These responses confirm the earlier theme that the strategy should be holistic and focus not just on decarbonization, but also critical services such as ferry transportation and growth opportunities such as being a recreational boating leader and leveraging the State's unique industrial base and expertise to support government vessel production.

*Challenges and Opportunities:* Participants polled as part of the workshop's plenary session also gave some initial insight into the top categories of challenges or barriers to achieve the prioritized strategic objectives previously mentioned. There was no clear winner with participants showing roughly equal interest in challenges related to technology and infrastructure, policy and regulation, and market/economics. Another main takeaway was that participants were not too concerned about geopolitical challenges such as trade tensions or disruptions.

The plenary session ended by asking participants what their top opportunity within the maritime industry was that they believe the State of Michigan should leverage. These open-ended responses were categorized into three main themes including funding, innovation and technology developments, and collaboration, awareness, and education.

## Maritime Interests and Stakeholder Needs

Maritime interests and stakeholder needs have been initially organized into three broad categories grouped by physical systems including vessels, ports, harbors, land infrastructure, and impacted communities and ecosystems.

Vessels: Vessel stakeholder and maritime interests highlight the desire to address these interconnected needs—regulatory alignment, technological integration, infrastructure modernization, financial support, and workforce development—as essential or sustaining the Great Lakes fleet’s viability within Michigan’s maritime strategy.

Ports, harbors, land infrastructure: There is a general desire voiced by stakeholder and maritime interests in these categories to preserve and increase deep-water ports that can handle large cargo, both defense-related and commercial. They also expressed the need for an inventory of all port assets in the state that are usable but not currently being used, as these could be incorporated into integrated industrial/transportation facilities. Locating multi-modal shipping facilities (especially rail) in or adjacent to a port could enable higher cargo volumes and more diverse types of cargo.

Drop-in replacement fuels have been suggested as a good first step to decarbonizing operation of the Great Lakes cargo shipping and recreational boat fleets, though this is not likely to be a long-term solution. All candidate alternative marine fuels need to be evaluated for life-cycle impacts, including production, distribution, and bunkering to inform decisions on short and long-term infrastructure planning.

Stakeholder and maritime interests also expressed the need to build out the charging network for electric recreational boats before sales of these vessels can be expected to accelerate. Planning of charging station locations needs to include equity, as well as distance from existing stations and number of electric boats in an area. The final participant need expressed was a desire for more funding mechanisms, especially for smaller projects, but also noted that it would be hard to attract interest from potential funders since maritime is a small fraction of total emissions. There was also a desire for the state to implement a dashboard to display measured progress towards goals, both qualitative and quantitative. While some maritime data has already been collected, there is a need for additional data to be gathered, such as fuel use data for port operations and fuel sales to vessels.

Impacted communities and ecosystems: Stakeholder and maritime interests identified several major impacts of the maritime sector on both human communities and natural ecosystems. We heard that communities are currently, or are concerned about being in the future, negatively affected by the maritime sector from air pollutants that harm human health (emitted from ships but also from the associated truck traffic and other industrial operations located near ports), reduced access to recreational and subsistence fishing, where fish population has declined, reduced overall recreational activity due to water quality degradation and harmful algal blooms, loss of access to historically and/or culturally important sites, and ensuring equity during the maritime industries evolution.

While identifying the challenges or negative impacts from maritime described above, participant and maritime interests also perceived opportunities for the maritime sector to contribute positively

to communities by providing good job opportunities and workforce development in waterfront/port communities as well as increased tourism and recreational opportunities, benefitting visitors and residents alike. Stakeholder and maritime interests also identified impacts of the maritime sector on the health of the environment and natural ecosystems in Michigan including invasive aquatic species, water quality degradation from maritime-related discharges and spills, shoreline and natural habitat degradation due to boat wake and port or marina infrastructure and impacts of increasingly severe weather including increasing lake water temperatures and changing lake levels.

Most stakeholder and maritime interests agreed with all the above impacts to communities and ecosystems and that mitigating or preventing the negative impacts while enhancing positive impacts was a priority for the Michigan Maritime Strategy. Stakeholder and maritime interests nearly universally felt that increased education and outreach was an essential tactic for addressing these impacts. They identified K-12 environmental education, social media campaigns and contests, workforce/career training (including trade schools), and recreational boater education, as preferred approaches.

### **Main Drivers, Levers, and Actions**

After individual participants provided their unique perspectives and inputs based on physical systems, we then grouped these needs by their main driver, lever, or action that should be taken as part of a maritime strategy.

This approach allows diverse participant needs to be combined into cohesive and complementary solutions that can be studied and actioned within a strategy. It also helps certain groups, such as regulators, technology developers, and community leaders, to get a holistic perspective of the needs that need to be addressed by certain solution types. The following sections summarize participant needs within three main groups: 1) regulatory, policy, data, and incentives 2) efficiency, technology, fuels, and infrastructure and 3) workforce, training, education, and outreach.

In terms of regulatory, policy, data, and incentives, stakeholder and maritime interests initially looked to policy and funding that has already been successful like International Maritime Organization's (IMO) 2020 Sulphur Cap and U.S. Environmental Protection Agency (EPA) Clean Ports Program. In terms of funding, the Army Corps of Engineers has had success with the Harbor Maintenance Trust Fund tax where 13% of the total budget goes to the Great Lakes. With those success stories in mind, stakeholder and maritime interests established many new ways in which regulatory action could drive solutions for the maritime industry.

Stakeholder and maritime interests believe both air and water regulations can be helpful as the maritime industry interacts with both areas. Incentives and funding are other established drivers for maritime decarbonization efforts. On the funding side, stakeholder and maritime interests established the large need for local, state, and federal funding. Decarbonization, modernization, and innovation projects cannot happen without funding. Stakeholder and maritime interests proposed starting with smaller, lower-cost initiatives first as larger vessels require significant investment.

When discussing efficiency, technology, fuels, and infrastructure, stakeholder and maritime interests in the maritime industry have identified a range of solutions to enhance operational efficiency,

integrate new technologies, and adopt alternative fuels as part of a broader strategy to decarbonize and drive growth in the maritime sector. Highlighted ideas by stakeholder and maritime interests included working on operational efficiency, electrification and charging infrastructure, alternative fuel development and enhancement, and infrastructure modernization.

Finally, when discussing workforce, training, education and outreach, the main topic of concern from current maritime industry workers is about recruitment levels into the industry, awareness and education about maritime employment opportunities, keeping employees in the industry once they start, and keeping current workers in their jobs during a possible fuel or technology transition. After thorough participant discussions on workforce and training needs, some possible solutions and drivers were established that would help solve these needs. One of the proposed solutions to recruitment of young workers is opening the industry to internships, apprentices, and short-term accelerated training programs. This driver requires a stable funding mechanism so that the high costs for these programs are not a barrier to prospective workers. Another solution to current and future workforce needs is to create a pipeline starting from high school through senior operators, engineers, and other high level mariner jobs.

In addition to the workforce and training drivers discussed above, education and outreach could also help drive solutions and assist in an equitable maritime decarbonization strategy for all groups involved. Education and outreach are strong drivers for the maritime industry and for improved ecosystem health. In terms of the maritime industry, education and outreach can help inform the public and future maritime workers about the industry and get them interested in the opportunities it provides.

## Economic Development Opportunities

In addition to understanding participant needs and their perspectives on potential solutions to address key challenges and barriers, we also collected participant views on potential economic development opportunities. Stakeholder and maritime interests had keen interest in seeing a strategy that addresses improving the State's capacity for shipbuilding and repair as well as multimodal and port infrastructure optimization. Stakeholder and maritime interests expressed excitement and optimism about the potential to enhance Michigan's tourism, recreation, and communities through strategic maritime development. They identified three areas of focus including positioning Michigan as the electric boat capital of the world, expanding non-motorized and "shared" recreational boating opportunities, and enhancing tourism and year-round economic opportunity in Michigan's communities through placemaking that centered Michigan's waters.

## Conclusion

This report summarizes the maritime priorities, challenges, needs, and preferred solutions *from the perspective of and as identified by stakeholder and maritime interests*. Main takeaways from key stakeholder and maritime interests were also summarized including statements that there is a lot of potential with recreational boating for Michigan to be a leader as Michigan can have a more difficult time influencing other sectors and decarbonization is just one pillar in the larger holistic maritime strategy.

# Michigan's Maritime Data

## Appendix 4: Michigan vessels

### 2023 Michigan Vessels

Vessel Type	Vessel Count
<b>Cargo Barge</b>	
Covered Dry	33
Flat/Deck	97
Liquid	9
Open Dry	5
Open Hopper	28
Other	12
<b>Total Cargo Barge</b>	<b>184</b>
<b>Towboat</b>	
Push Boat	8
Tugboat	88
<b>Total Towboat</b>	<b>96</b>
<b>Passenger Carrier</b>	
Cruise	18
Ferry	38
Other	22
<b>Total Passenger Carrier</b>	<b>78</b>
<b>Freighter</b>	
Bulk Carrier	9
Liquid Tanker	1
<b>Total Freighter</b>	<b>10</b>
<b>Other</b>	
General Cargo (Roll-on/Roll-off)	1
General Cargo /Passenger	3
Offshore Support Vessel	3
<b>Total Other</b>	<b>7</b>

Source: USACE 2023 Vessel Inventory<sup>1</sup>

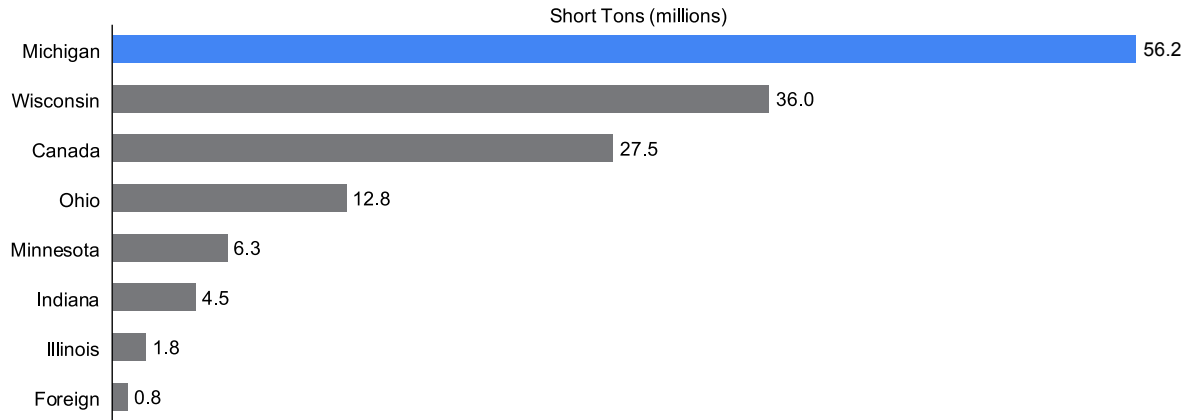
## Appendix 5: Michigan Ferry Data

Ferry Routes			
Company	Origin	Destination	Ridership (2024)
Beaver Island Boat Company	Charlevoix	Beaver Island	40,341
Champion Auto Ferry	Algonac	Harsens Island	
Charlevoix County Transportation Authority	Ironton	East Side of Ironton Narrows	137,794
Eastern Upper Peninsula Transit Authority	DeTour Village	Drummond Island	418,670
Eastern Upper Peninsula Transit Authority	Sault Ste. Marie	Sugar Island	415,960
Eastern Upper Peninsula Transit Authority	Barbeau	Neebish Island	227,558
Grand Island Ferry Service	Munising	Grand Island	
Lake Michigan Car Ferry	Ludington	Manitowoc, Wisconsin	73,876
Shelpers Inc	Mackinaw City	Mackinac Island	Owner Transition in 2024
Shelpers Inc	St. Ignace	Mackinac Island	
The Royale Line	Copper Harbor	Isle Royale	29,158*
Plaunt Transportation Company	Cheboygan	Bois Blanc Island	31,959
Lake Express	Milwaukee, Wisconsin	Muskegon	
Walpole Algonac Ferry	Walpole, Ontario	Algonac	
Isle Royale National Park	Houghton	Isle Royale	29,158*
Manitou Island Transit	Leland	North Manitou Island	
Manitou Island Transit	Leland	South Manitou Island	

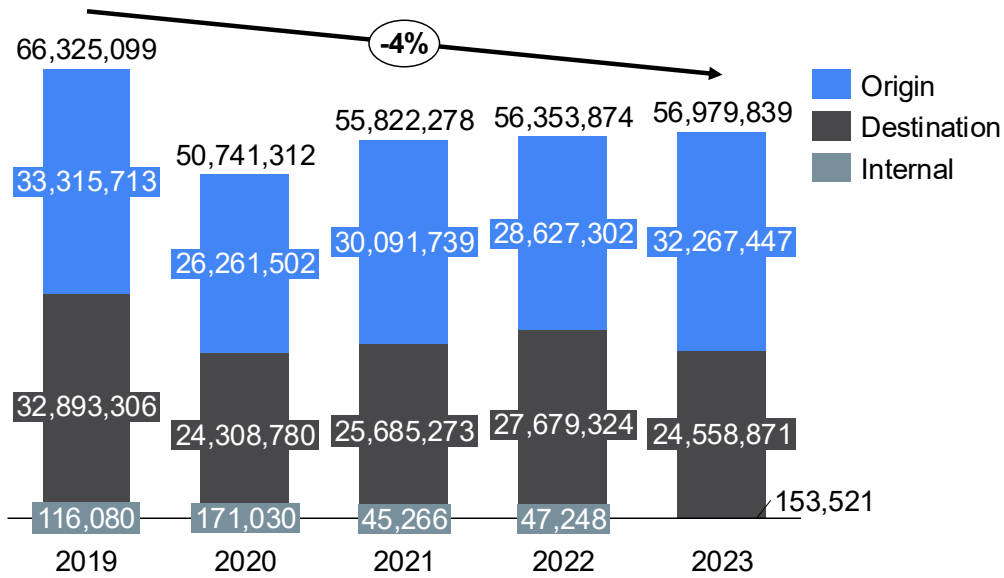
\*Isle Royale had 29,158 trips for 2024 for all 4 vessels combined

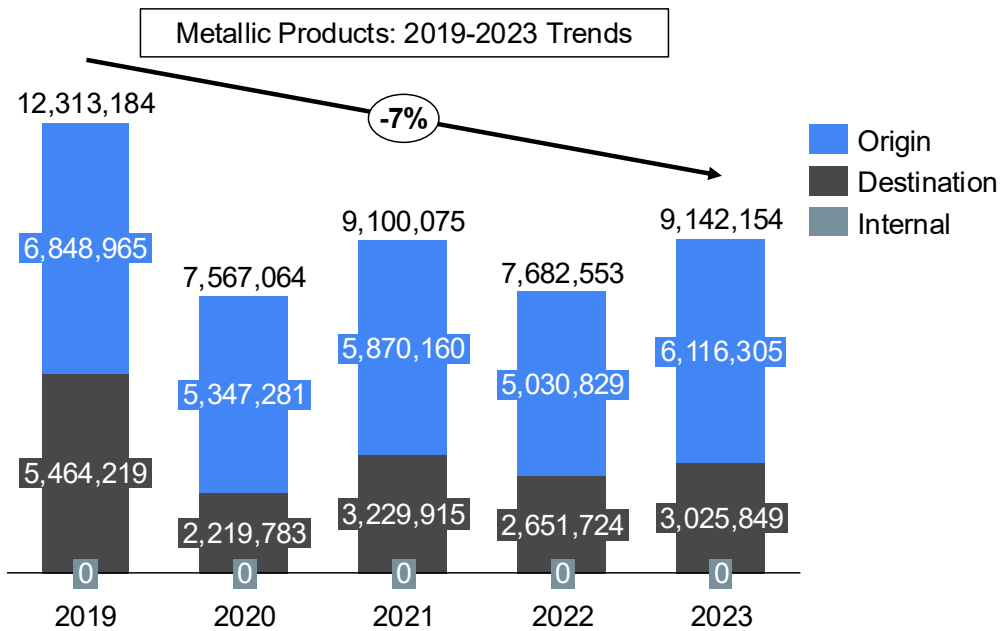
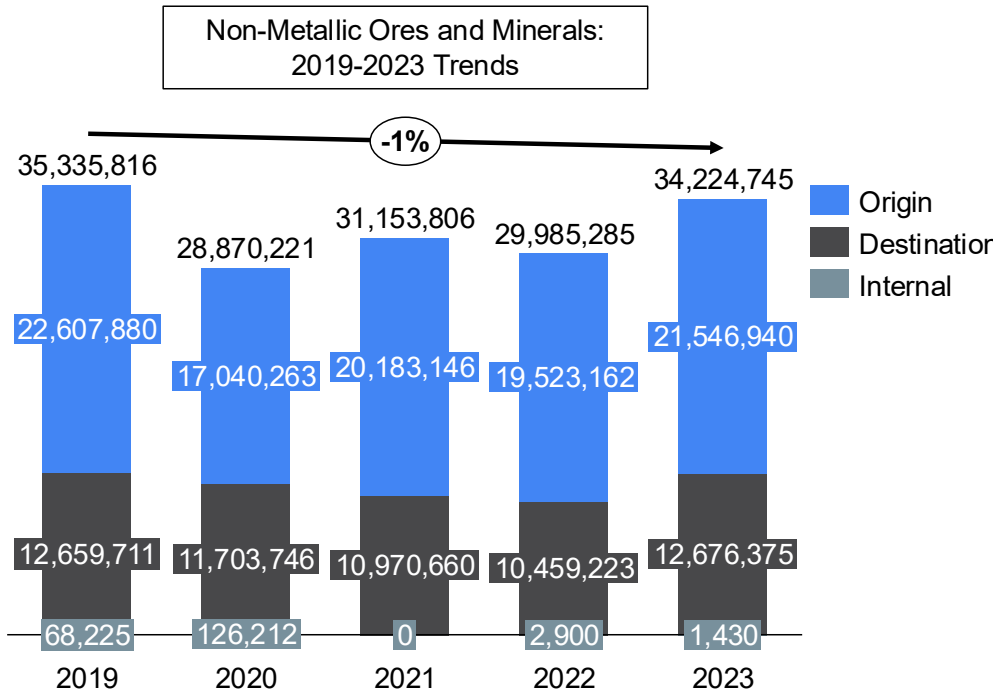
## Appendix 6: Commodity Movement

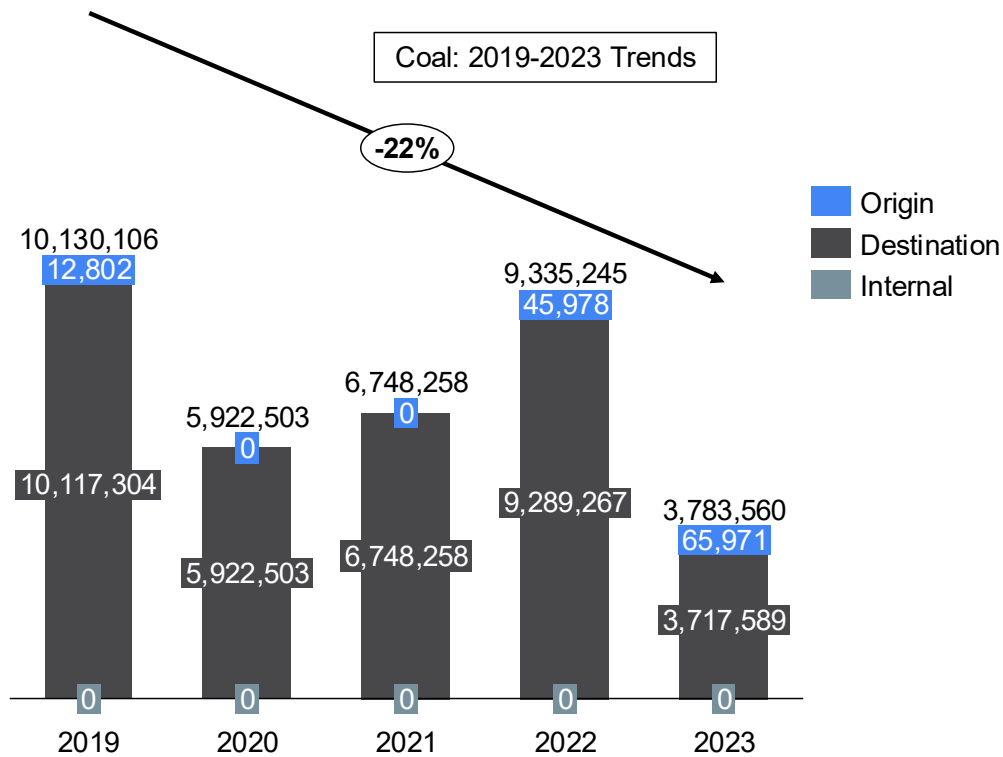
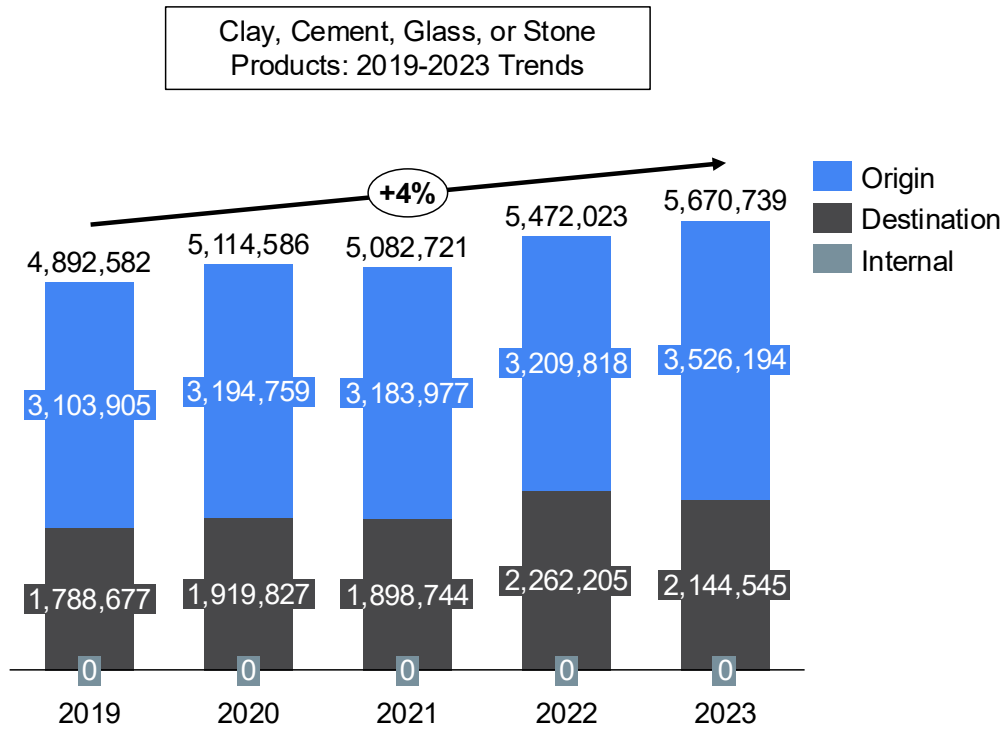
2018-2022 Total Products Received



Michigan 2019-2023 Trends







\*All commodity movement data updated for 2023 and provided by MDOT<sup>2</sup>

## Appendix 7: Asset Map Data

Michigan Assets		
Company Name	City	Asset Classification
Michigan Technological University - Great Lakes Research Center	Houghton	Academic Institution
Northwestern Michigan College - Great Lakes Maritime Academy and Marine Technology Program	Traverse City	Academic Institution
United States Geological Survey - Great Lakes Science Center	Ann Arbor	Academic Institution
Lake Superior State University - Center for Freshwater Research and Education	Sault Ste. Marie	Academic Institution
Grand Valley State University - Robert B. Annis Water Resources Institute	Muskegon	Academic Institution
University of Michigan Naval Architecture and Marine Engineering Department	Ann Arbor	Academic Institution
Oakland Community College - Maritime Engineering	Auburn Hills	Academic Institution
Michigan State University - Michigan Sea Grant	East Lansing	Academic Institution
Newlab Detroit	Detroit	Academic Institution
Macomb Community College - Michigan Maritime Manufacturing Initiative	Warren	Academic Institution
Four Winns	Cadillac	Shipbuilding/Manufacturing
Avalon and Tahoe Manufacturing	Alma	Shipbuilding/Manufacturing
Crest Marine	Owosso	Shipbuilding/Manufacturing
Tiara Yachts	Holland	Shipbuilding/Manufacturing
NOAA - Great Lakes Environmental Research Laboratory	Ann Arbor	Academic Institution
Manitou Pontoon Boats	Lansing	Shipbuilding/Manufacturing
Paddle King, Inc.	Carson City	Shipbuilding/Manufacturing
Van Dam Custom Boats	Boyne City	Shipbuilding/Manufacturing
Grand Craft Boats	Holland	Shipbuilding/Manufacturing
Thoroughbred Boat Co.	Manistee	Shipbuilding/Manufacturing
Moran Iron Works	Onaway	Shipbuilding/Manufacturing
Seefeld Custom Boats	Traverse City	Shipbuilding/Manufacturing

Michigan Assets		
Company Name	City	Asset Classification
Apex Marine (Qwest Pontoons)	St. Louis	Shipbuilding/Manufacturing
Basic Marine, Inc.	Escanaba	Shipbuilding/Manufacturing
Barnwell Boatworks	Charlevoix	Shipbuilding/Manufacturing
North Shore Marine Terminal and Logistics	Escanaba	Shipbuilding/Manufacturing
Ghostworks	Holland	Shipbuilding/Manufacturing
Trident Maritime Systems	Ontonagon, Iron River, Kingsford, Norway	Shipbuilding/Manufacturing

Ferry Routes		
Company	Origin	Destination
Beaver Island Boat Company	Charlevoix	Beaver Island
Champion Auto Ferry	Algonac	Harsens Island
Charlevoix County Transportation Authority	Ironton	East Side of Ironton Narrows
Eastern Upper Peninsula Transit Authority	DeTour Village	Drummond Island
Eastern Upper Peninsula Transit Authority	Sault Ste. Marie	Sugar Island
Eastern Upper Peninsula Transit Authority	Barbeau	Neebish Island
Grand Island Ferry Service	Munising	Grand Island
Lake Michigan Car Ferry	Ludington	Manitowoc, WI
Shelpers Inc	Mackinaw City	Mackinac Island
Shelpers Inc	St. Ignace	Mackinac Island
The Royale Line	Copper Harbor	Isle Royale
Plaunt Transportation Company	Cheboygan	Bois Blanc Island
Lake Express	Milwaukee, WI	Muskegon
Walpole Algonac Ferry	Walpole, ON	Algonac
Isle Royale National Park	Houghton	Isle Royale
Manitou Island Transit	Leland	North Manitou Island
Manitou Island Transit	Leland	South Manitou Island

<b>Commercial Ports</b>	
<b>Commercial Port Name</b>	<b>Port Tonnage Handled (2022)</b>
Gladstone	7,070
Keweenaw Waterway	19,942
St Ignace	20,833
St James	23,391
Mackinac Island	27,113
Munising	40,000
Port Huron	52,413
Escanaba	79,182
Menominee	121,847
Alabaster	184,390
Sault Ste Marie	264,235
St Joseph	278,584
Cheboygan	279,039
Manistee	394,979
Ludington	417,368
Brevort	500,000
Marysville	707,405
Holland	733,284
Port Drummond	954,850
Charlevoix	1,424,781
Grand Haven	1,475,889
Muskegon	1,512,554
Marine City	1,675,227
Alpena	2,197,451
Monroe	2,547,414
Port Dolomite	2,751,495
Saginaw River	3,172,414
Port Inland	3,692,660
Stoneport	4,321,307
St Clair	5,056,433
Marquette	5,534,389
Port Calcite	6,768,390
Detroit	9,054,687

## Appendix 8: Michigan Ports, Harbors, and Marinas

Michigan has an impressive number of ports, harbors, and marinas. An up to date list of these natural resources can be found on the Michigan DNR's Website linked here: [https://www2.dnr.state.mi.us/publications/pdfs/harbor\\_guide/index.htm#t=Cover.htm](https://www2.dnr.state.mi.us/publications/pdfs/harbor_guide/index.htm#t=Cover.htm)

As the DNR site shares, "This publication is designed to offer information, location and amenities of Michigan's many harbors. It provides an aerial photograph and short description of each harbor to offer you a view of what to expect while traveling on Michigan's waters. This guide is not intended for navigational use. Please refer to your lake charts as a guide for navigational information."<sup>3</sup> Information on the harbors for the Upper Peninsula, the West Coast, and the East Coast can be found here.

## Appendix 9: Emissions Estimates

### 1. Introduction: The Need for Maritime Baseline Data

The Great Lakes maritime industry is fundamental to regional economic activity. The sector's aging infrastructure requires substantial investment to maintain operations while simultaneously meeting increasingly stringent environmental standards. Understanding current emissions levels is a crucial first step toward striking a balance between economic sustainability and environmental stewardship.

Multiple approaches exist for estimating maritime emissions, each with distinct advantages.

**Bottom-up methodologies** build emissions totals by tracking individual vessel movements, applying detailed engine performance models, and summing activities across the region. These approaches provide granular spatial and temporal resolution but require extensive data collection. **Top-down methodologies** start with aggregate fuel consumption data and allocate it across regions or sectors, offering broader coverage with less detailed resolution but simpler data requirements.

This section examines three significant baseline estimation efforts that together provide a comprehensive picture of Great Lakes maritime emissions across different years and methodological frameworks.

## 2. Environmental Protection Agency Great Lakes Emissions Inventory

### 2.1 Methodology

In 2012, the U.S. Environmental Protection Agency published a detailed analysis of Great Lakes shipping emissions as part of its Economic Impacts of the Category 3 Marine Rule study<sup>4</sup>. The inventory employed the **Smart Transportation Emissions Evaluation Model (STEEM)**, a sophisticated bottom-up framework that models emissions on a voyage-by-voyage basis.

Vessel movement data were sourced from the U.S. Army Corps of Engineers Waterborne Commerce Statistics Center and U.S. Customs and Border Protection records. Each trip was classified as either a port trip (originating or terminating at one of 28 Great Lakes ports) or an interport trip (transiting between lakes without port calls). For every voyage segment, the model estimated time spent in three operating modes: cruising, maneuvering, and hoteling (at berth), along with corresponding engine loads.

The STEEM model integrated vessel characteristics including engine power, speed, and trip distances to calculate fuel consumption and emissions. Engines were categorized by per-cylinder displacement, aligning with EPA classifications: Category 1 (<5 liters), Category 2 (5–30 liters), and Category 3 (>30 liters). The analysis focused on Category 3 diesel engines, which power most Great Lakes bulk carriers ("lakers") and ocean-going vessels ("salties"). Emission factors for each engine category and operating mode were drawn from EPA and International Maritime Organization datasets<sup>5</sup> appropriate to fuel type and engine age.

### 2.2 Scope and Limitations

The 2002 baseline inventory has an important limitation: it captures only foreign cargo movements, vessels arriving from foreign ports, foreign vessels from domestic ports, U.S. vessels carrying bonded merchandise, and vessels conducting transactions outside U.S. waters. Consequently, domestic Jones Act traffic (U.S.-flagged vessels operating between U.S. ports) is excluded from the 2002 baseline.

For the 2020 projections, EPA incorporated Jones Act traffic to provide a complete picture of Great Lakes shipping activity. Two scenarios were modeled:

- **Business-as-Usual (BAU):** Assumes no new emission controls beyond 2002 standards
- **Marine Rule Scenario:** Reflects full compliance with MARPOL Annex VI and North American Emission Control Area (ECA) requirements, including fuel sulfur caps of 0.1%

Growth in shipping activity between 2002 and 2020 was accounted for through adjustment factors.<sup>6</sup> The controlled scenario assumed vessels would either switch to low-sulfur distillate fuel or employ equivalent controls such as exhaust gas scrubbers. While ECA requirements significantly reduce sulfur oxides and particulate matter, they do not impact CO<sub>2</sub> emissions, as reflected in the small difference between scenarios.

Additional limitations include the exclusion of Category 1 and Category 2 engines (smaller tugs and auxiliary engines) from the emissions estimates, focusing the analysis on propulsion engines only.

## 2.3 Results

**Table 1: EPA Great Lakes CO<sub>2</sub> Emissions Estimates (Metric Tonnes)**

Scenario	2002 Baseline	2020 Projection (US Only)	2020 Projection (Total w/ Jones Act)
Reference (BAU)	541,336	740,624	1,459,029
Control (ECA Compliance)	—	704,390	1,387,648

The 2002 baseline of 541,336 tonnes CO<sub>2</sub> represents foreign cargo operations only. The 2020 projections show substantial increases when Jones Act domestic traffic is included, with total emissions approaching 1.4–1.5 million tonnes annually. The difference between reference and control scenarios (~71,000 tonnes, or 5%) reflects modest efficiency gains from cleaner fuels and updated engine technologies, though the primary benefit of ECA regulations is pollutant reduction rather than carbon reduction.

The EPA inventory's strength lies in its detailed geographic and temporal resolution, enabling policymakers to assess localized environmental impacts and evaluate the effectiveness of specific regulatory interventions. The inclusion of future regulatory scenarios demonstrated that significant air quality improvements could be achieved through fuel switching and emission controls without fundamentally altering operational patterns or substantially increasing CO<sub>2</sub> output.

## 3. International Council on Clean Transportation Great Lakes Emissions Inventory

### 3.1 Methodology

In 2019, the International Council on Clean Transportation (ICCT), an independent nonprofit research organization, produced a comprehensive Great Lakes–St. Lawrence Seaway (GL-SLS) emissions inventory using their Systematic Assessment of Vessel Emissions (SAVE) model.<sup>7</sup> This bottom-up methodology synthesizes three core data sources:

- 1. Ship activity data** from satellite-based Automatic Identification System (AIS) tracking
- 2. Ship characteristics** from vessel registry databases
- 3. Emission factors** from the Fourth IMO Greenhouse Gas Study

The SAVE model combines these inputs to estimate emissions by vessel type, flag state, and operating zone throughout the GL-SLS system. This approach provides comprehensive regional coverage including both U.S. and Canadian waters, including international vessels operating in the region.

### 3.2 Results

**Table 2: ICCT Great Lakes–St. Lawrence Seaway Emissions (2019)**

Category	CO <sub>2</sub> Emissions (Metric Tonnes)	Percentage
<b>By Flag State</b>		
United States	646,413	40%
Canada	628,413	39%
Other Nations	350,671	22%
<b>By Vessel Type</b>		
Bulk Carriers	1,010,113	62%
Chemical Tankers	166,288	10%
Tugs	146,023	9%
Other Vessels	303,134	19%
<b>By Fuel Type</b>		
Low-Sulfur Distillate	1,359,082	83%
High-Sulfur Residual	235,015	15%
LNG	31,462	2%
<b>Total GL-SLS Emissions</b>	<b>1,625,559</b>	<b>100%</b>

**Estimated Total Fuel Consumption: 508,428 metric tonnes**

The ICCT inventory reveals several important insights. First, U.S. and Canadian vessels contribute nearly equal shares of regional emissions (approximately 40% and 39%, respectively), with international vessels accounting for the remaining 22%. Second, bulk carriers dominate emissions at 62% of the total, reflecting the fleet's primary role in moving iron ore, coal, aggregate, and grain. Third, the fuel mix shows strong adoption of low-sulfur distillate fuels (83% of consumption), consistent with ECA compliance requirements implemented in 2015.

### 3.3 Michigan Specific Results

Through collaboration with ICCT, researchers at the University of Michigan developed a Michigan-specific emissions inventory using the SAVE model to estimate the state's share of regional maritime traffic and associated emissions. The inventory estimated 328,974 metric tonnes of CO<sub>2</sub> (333,945 metric tonnes CO<sub>2</sub>-equivalent including other greenhouse gases) from Michigan port-based vessel activity in 2022, representing approximately 20% of total Great Lakes–St. Lawrence Seaway emissions when compared to the 2019 ICCT estimate. This substantial share reflects Michigan's geographic position within the Great Lakes system, with major port facilities on nearly all the Great Lakes as well as the state's role as a gateway for iron ore, limestone, coal, and other bulk commodities essential to regional manufacturing and economic activity. Developing the Michigan-specific inventory exposed key challenges in processing AIS vessel tracking data, particularly voyage misclassification at the Soo Locks and interpolation errors near complex shorelines. These were addressed as much as possible through systematic review, geographic validation, and corrective interpolation to ensure accurate voyage reconstruction and emissions attribution.

## 4. U.S. Energy Information Administration Fuel Sales-Based Emissions Estimate

### 4.1 Methodology

The U.S. Energy Information Administration (EIA), the statistical and analytical agency within the Department of Energy, provides a complementary top-down approach through its annual **Fuel Oil and Kerosene Sales** report.<sup>8</sup> This dataset includes state-level fuel sales by end-use sector, with "Vessel Bunkering" defined as fuel sold to commercial or private boats, including pleasure craft, fishing vessels, tugboats, and ocean-going vessels (excluding U.S. Armed Forces consumption).

While this dataset does not isolate fuel consumed strictly within Great Lakes waters, the concentration of maritime infrastructure in the region makes state-level sales data a reasonable proxy for regional maritime fuel consumption. This analysis focuses on six Great Lakes states with significant port activity: **Michigan, Minnesota, Ohio, Indiana, Illinois, and Wisconsin**. Pennsylvania and New York are excluded due to the influence of their Atlantic coast ports, and Canadian fuel sales are not included in EIA reporting.

Both distillate fuel oil (marine diesel typically used by smaller vessels and tugs) and residual fuel oil (heavy fuel oil used by larger bulk carriers) are relevant for maritime applications. Emissions are calculated using standard conversion factors:<sup>9</sup>

- **Distillate fuel density:** 895 kilograms per cubic meter (kg/m<sup>3</sup>);  
**Emission factor:** 3.206 tonnes CO<sub>2</sub> per tonne fuel
- **Residual fuel density:** 1,001 kg/m<sup>3</sup>;  
**Emission factor:** 3.114 tonnes CO<sub>2</sub> per tonne fuel

## 4.2 Fuel Sales Trends

**Table 3: EIA Fuel Sales (Thousands Gallons)**

Fuel Type	2002	2019	2020
Distillate Fuel Oil	86,455	85,688	83,807
Residual Fuel Oil	30,763	29,380	19,676
<b>Total Consumption</b>	<b>117,218</b>	<b>115,068</b>	<b>103,483</b>

Analysis of EIA data reveals two significant trends. First, distillate fuel accounts for the majority of marine fuel sales in Great Lakes states. In 2019, the six-state total for distillate sales was approximately 85.7 million gallons versus 29.4 million gallons of residual fuel, roughly a 3:1 ratio. This distribution aligns with expectations given the prevalence of tugs, barges, and medium-sized carriers burning distillate fuel, particularly following 2015 ECA sulfur regulations.

Second, total fuel volumes show a gradual decline from 2002 to 2020. Distillate sales remained relatively stable between 2002 and 2019 but dropped in 2020, likely reflecting pandemic-related activity reductions. Residual fuel sales declined more steeply by 2020, reflecting either fuel switching to cleaner distillates or overall reduced consumption of heavy fuel oil in the region.

## 4.3 Results

**Table 4: EIA Fuel Sales-Based CO<sub>2</sub> Emissions Estimates (Metric Tonnes)**

Fuel Type	2002	2019	2020
Distillate Fuel Oil	939,052	930,721	910,290
Residual Fuel Oil	362,990	346,671	232,168
<b>Total Emissions</b>	<b>1,302,042</b>	<b>1,277,392</b>	<b>1,142,458</b>

The EIA-based estimates show relative stability in total emissions between 2002 and 2019 (approximately 1.28–1.30 million tonnes CO<sub>2</sub> annually), with a notable decrease in 2020. The decline in residual fuel consumption is particularly pronounced, dropping from 362,990 tonnes CO<sub>2</sub> in 2002 to 232,168 tonnes in 2020, a 36% reduction. This trend likely reflects both fuel switching in response to ECA requirements and potentially reduced activity by the largest vessels.

## 5. Comparative Analysis and Conclusions

### 5.1 Cross-Inventory Comparison

**Table 5: Comparison of Great Lakes Maritime CO<sub>2</sub> Emissions Inventories**

Source	Year	Scope	CO <sub>2</sub> Emissions (Metric Tonnes)
EPA (Foreign cargo only)	2002	US vessels, foreign trade	541,336
EPA Projection (US only)	2020	US vessels, foreign trade	740,624
EPA Projection (Total)	2020	US vessels, all trade	1,459,029
ICCT (US-flagged only)	2019	US vessels, GL-SLS	646,413 (CO <sub>2</sub> e)
ICCT (Total GL-SLS)	2019	All vessels, GL-SLS	1,625,559 (CO <sub>2</sub> e)
ICCT (GL only)	2019	All vessels, GL-SLS	1,223,695 (CO <sub>2</sub> e)
ICCT (Michigan only)	2022	Michigan operations	333,945 (CO <sub>2</sub> e)
EIA (Six-state total)	2002	Fuel sales proxy	1,302,042
EIA (Six-state total)	2019	Fuel sales proxy	1,277,392
EIA (Six-state total)	2020	Fuel sales proxy	1,142,458

Despite significant methodological differences, these three independent inventories demonstrate remarkable consistency in order of magnitude. Great Lakes maritime operations generate between 1.1 and 1.6 million metric tonnes of CO<sub>2</sub> annually, with variations primarily reflecting differences in scope rather than fundamental measurement discrepancies.

The EPA's 2002 baseline (541,000 tonnes) captures only foreign trade, while its 2020 projection including Jones Act traffic approaches 1.5 million tonnes. The ICCT inventory (1.626 million tonnes) encompasses the entire GL-SLS region including Canadian vessels and waters. The EIA method estimates (1.14–1.30 million tonnes) reflect fuel sales in six U.S. states only, excluding Canadian consumption and potentially some fuel purchased outside these states.

Fuel composition trends are consistent across inventories. All sources show a predominance of distillate fuel consumption (70–83% of total), particularly after 2015 ECA implementation. The shift away from high-sulfur residual fuels reflects both regulatory compliance and fleet modernization, though some large bulk carriers continue to use heavy fuel oil with exhaust gas scrubbers.

Geographic concentration is evident in both vessel activity and fuel sales. Michigan, Ohio, and Illinois consistently account for the largest shares of emissions, corresponding to major port facilities at Detroit, Toledo, Cleveland, Chicago, and Duluth-Superior. Bulk carriers dominate the emissions profile (62% in the ICCT inventory), reflecting the region's fundamental role in moving raw materials for manufacturing and construction.

Bottom-up versus top-down approaches yield comparable results when scopes are aligned. The ICCT's comprehensive GL-SLS estimate (1.626 million tonnes) sits at the high end of the range, while

the EIA six-state estimate (1.28 million tonnes in 2019) is somewhat lower, logical given that EIA excludes Canadian operations and potentially some U.S. fuel purchases outside the six focal states. The EPA's 2020 projection, including Jones Act traffic (1.46 million tonnes), falls between these bounds.

### 5.3 Limitations and Data Gaps

Several limitations affect all three inventories. Incomplete vessel coverage remains a challenge; the EPA analysis focuses on Category 3 engines (large propulsion systems), potentially underestimating emissions from auxiliary engines, small tugs, and recreational vessels. Geographic boundaries are imperfect; state-based fuel sales data cannot perfectly isolate Great Lakes' consumption from other uses, while vessel-tracking approaches must make assumptions about which trips to include when vessels cross regional boundaries. ICCT data distribution also provides an issue utilizing AIS data which can develop errors in locations near land or over approximating vessel signal output.

Lack of yearly estimates limits direct comparisons. The three inventories cover different base years (2002, 2019, 2020), during which operational patterns, fleet composition, and regulatory requirements evolved significantly. Large bottom-up inventories require significant processing for which an area with limited attention proves difficult to do so.

Domestic versus international trade classification significantly impacts results. The Jones Act distinction in EPA's inventory highlights how excluding domestic U.S. trade can underestimate total regional emissions by more than half. For policy purposes, understanding both domestic and international vessel contributions is essential.

## Conclusion

The Great Lakes maritime sector operates at the intersection of economic necessity and environmental responsibility. This analysis of three major emissions inventories establishes that regional maritime operations currently generate between 1.1 and 1.6 million metric tonnes of CO<sub>2</sub> annually, with the range reflecting differences in geographic and operational scope rather than fundamental measurement disagreements.

These baseline estimates provide the foundation for a meaningful understanding of the consumption throughout the Great Lakes region. As the industry confronts the dual challenges of an aging fleet and evolving environmental standards, reliable emissions data enables policymakers, operators, and investors to make informed decisions about technology investments, regulatory frameworks, and infrastructure development.

The path forward requires sustained attention to inventory refinement, targeted support for fleet modernization, and coordinated regional action. With baseline emissions now established through multiple independent methodologies, stakeholder and maritime interests possess the information needed to set ambitious yet achievable reduction targets and track progress toward a cleaner maritime ecosystem that continues to support Great Lakes economic prosperity.

# Endnotes

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