Great Lakes-St. Lawrence Seaway ship emissions inventory, 2019

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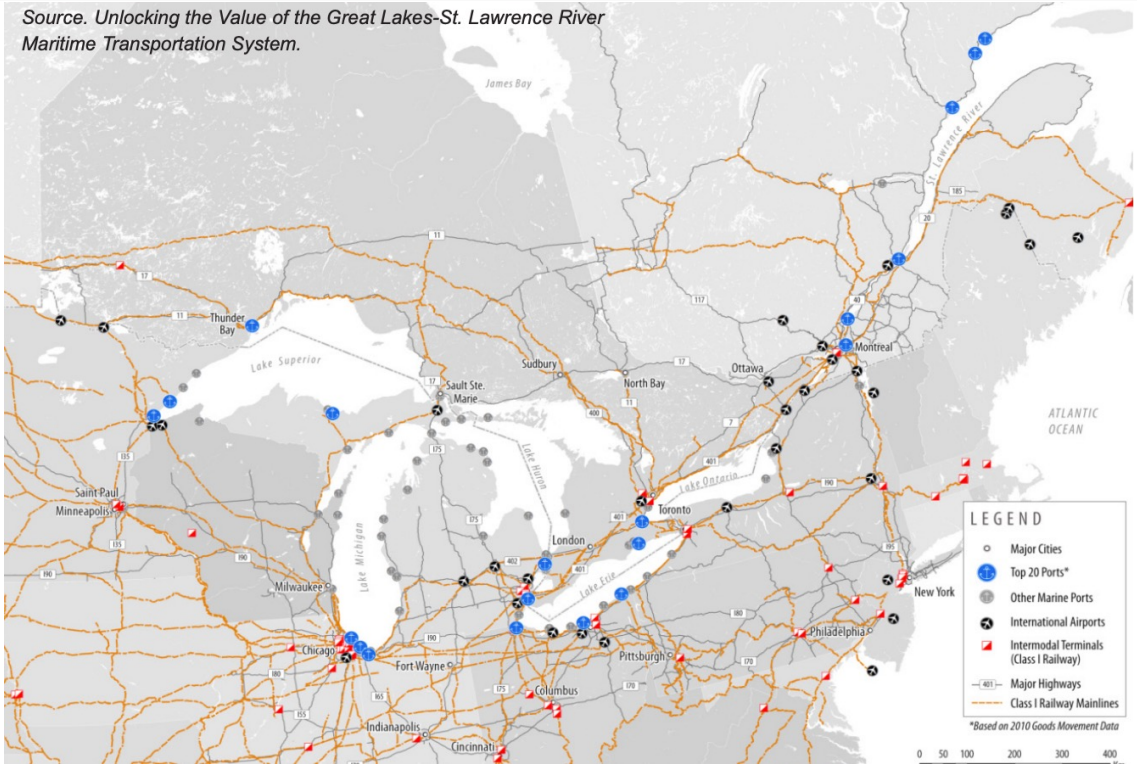
Background of this study

- Stretching more than 3,700 kilometers from Atlantic Ocean to North America, as an important commercial waterway.
- Over 110 ports over the U.S. and Canada shoreline.
- Transporting over 143.5 million tonnes of cargo with a value of $ 15.2 billion, 2017.
- Planning to double maritime trade with Western Europe, double annual passenger traffic in next five years.[1]



[1] Great Lakes St. Lawrence Maritime Five-Year Action Plan (2021-2026), https://gsgp.org/media/gdpcsqz1/five-year-action-plan-9-21-21.pdf

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Background of this study

- the Great Lakes St. Lawrence Governors & Premiers (GSGP) published Green Shipping Action Plan in 2021.
- Tend to improve regional environmental performance.
- Planning to assess current impacts by carrying out detailed annual emission inventories and set reduction targets based on the data.
- Planning to carry out projects on smart shipping, voyage optimization and alternative fuels.

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Background of this study

- Last emission inventory was published by EPA in 2012.[1]
- 541,336 tonnes of CO_2 in 2002 and predicted 704,390 tonnes CO_2 by 2020.
- Only include category 3 vessels, within U.S. portion of the Great Lakes.[2]

Table 4-13 2002 Total C3 Inventory for the U.S. Great Lakes Domain

EMISSION TYPE	ANNUAL EMISSIONS (METRIC TONNES)[a]						
	NO_X	PM_{10}	$PM_{2.5}$	HC	CO	SO_2	CO_2
Port	491	44	41	17	40	346	22,476
Interport	14,528	1,135	1,044	481	1,134	8,420	518,860
Total Emissions	*15,019*	*1,179*	*1,085*	*498*	*1,174*	*8,766*	*541,336*

[a] The port emission totals in this table are slightly less than those in Table 4-12 due to the gridding process and trimming to include only port emissions that fall within the emission inventory boundaries.

Table 4-27 Category 3 Vessel Inventories in the U.S. Great Lakes for 2020 Scenarios[a]

SCENARIO	ANNUAL EMISSIONS (METRIC TONNES)						
	NO_X	PM_{10}	$PM_{2.5}$	HC	CO	SO_2	CO_2
Reference	19,842	1,613	1,484	682	1,607	11,993	740,624
Control	16,420	207	190	676	1,602	420	704,390
Delta Emissions	*-3,422*	*-1,406*	*-1,294*	*-6*	*-5*	*-11,574*	*-36,235*
Delta Emissions (%)	*-17%*	*-87%*	*-87%*	*0%*	*0%*	*-97%*	*-5%*

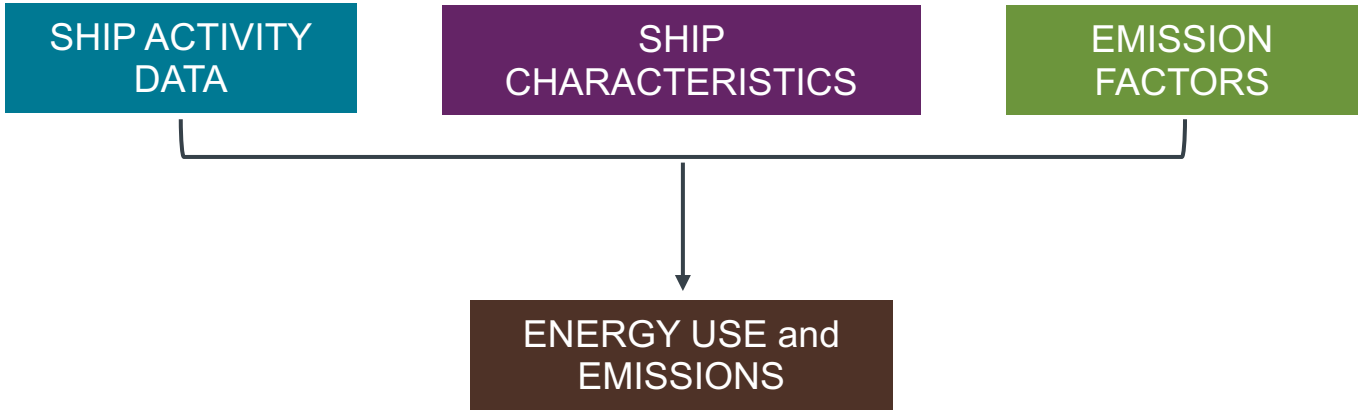
[a] These inventories include all emissions within the U.S. Great Lakes.

[1] Economic Impact of the Category 3 Marine Rule on Great Lakes Shipping, by EPA, 2012, https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=OTAQ&dirEntryID=230803

[2] Category 3 vessels are defined as having engines with a per cylinder displacement of at least 30 liters per cylinder and are usually the largest vessels on the lakes.

Our approach for estimating emissions and energy use

——Systematic Assessment of Vessel Emissions (SAVE) model



Data Source: Satellite AIS | Ship Registry Data | 4th IMO GHG Study

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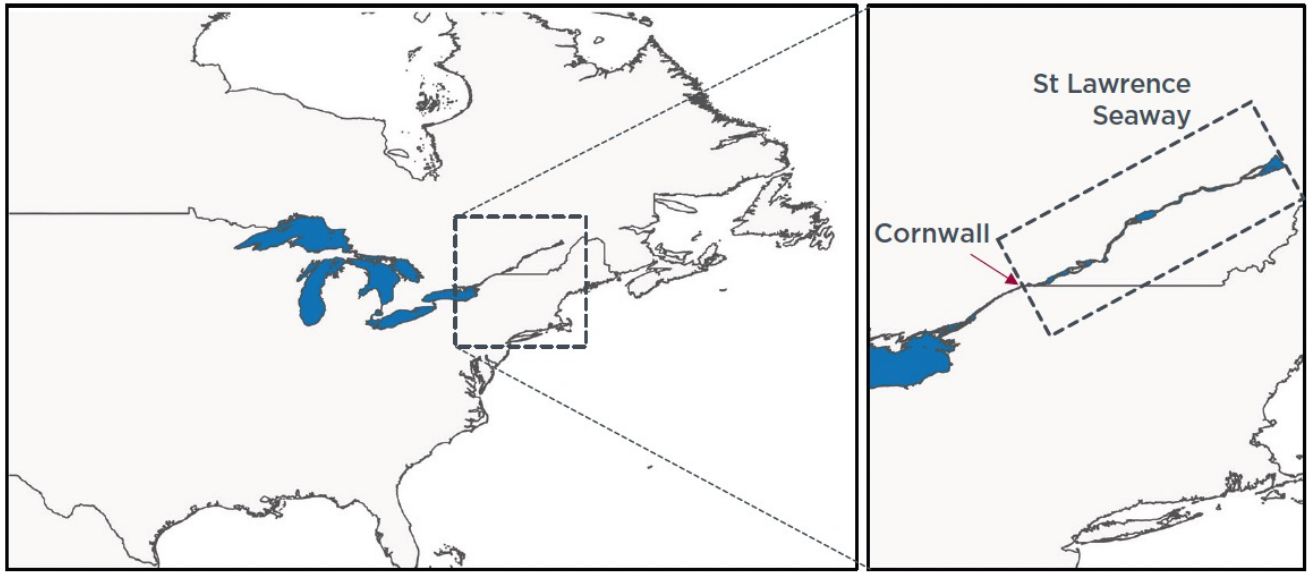
Study area of Great Lakes-St. Lawrence Seaway (GL-SLS)

- Including the whole GL-SLS region of both U.S. and Canada portion.
- Separate regions of GL and SLS, to find more different emission features.



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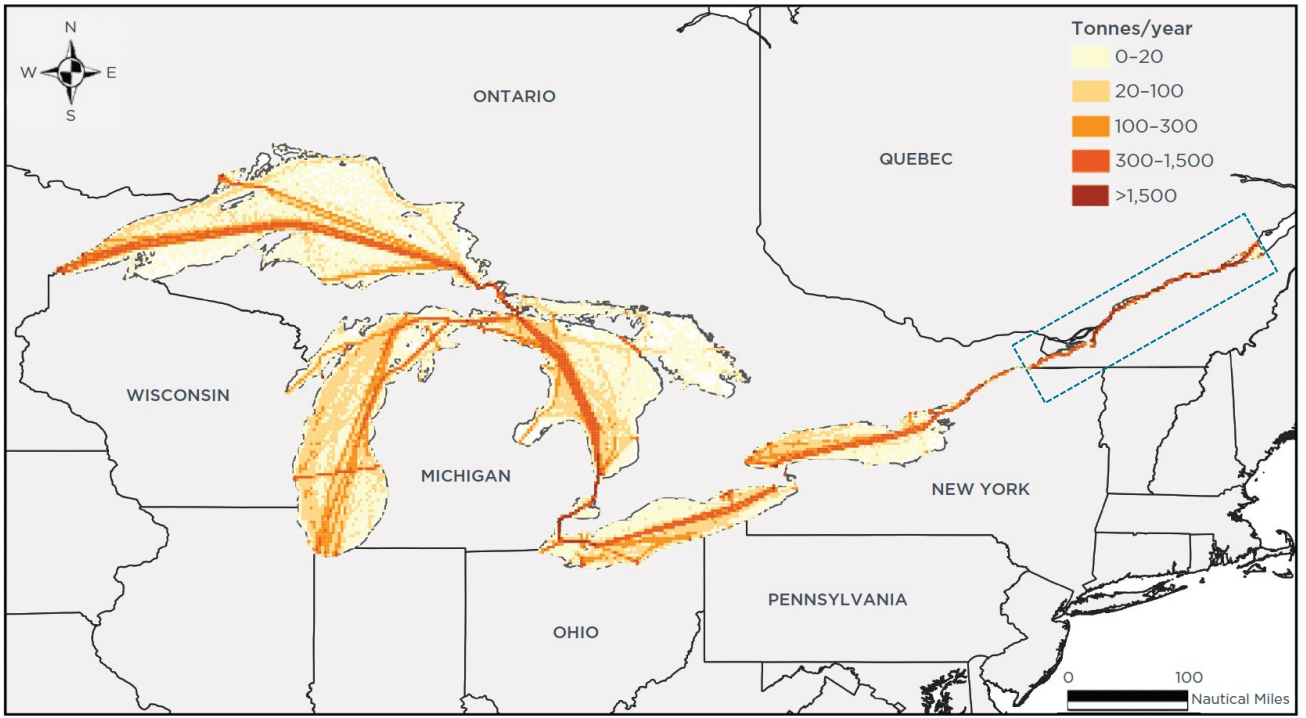
CO_2 emissions from ships in the GL-SLS in 2019

- 1.6 Mt of CO_2 emissions in the GL-SLS
- 1 Mt CO_2 emissions occurred within U.S. waters.
- Higher emissions intensity in the SLS than GL, with relatively narrow sailing channel.



CO_2 emissions from ships in the GL-SLS in 2019, 0.05° grid cell size

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Number and types of identified vessels in GL-SLS in 2019

- Identified 953 vessels operating in the GL-SLS in 2019.
- Bulk carriers were the most common (40%) and second most common were chemical tankers (22%).
- Canada, Marshall islands and U.S. were the top 3 flag states.

Flag state	Bulk carrier	Chemical tanker	Container	Ferry-ropax	Oil tanker	Service-tug	All other ship types	Total
Canada	50	24	1	20	4	47	38	**184**
Marshall Islands	85	45	2	0	14	1	4	**151**
United States	34	0	0	3	0	45	16	**98**
Panama	46	12	26	0	2	0	3	**89**
Liberia	30	20	8	0	10	0	1	**69**
All others	134	107	26	1	40	3	51	**362**
Total	**379**	**208**	**63**	**24**	**70**	**96**	**113**	**953**

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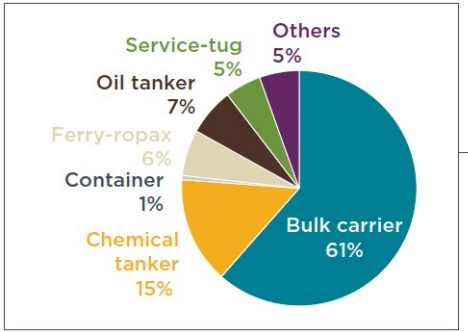
Share of CO_2 emissions by flag state and ship type

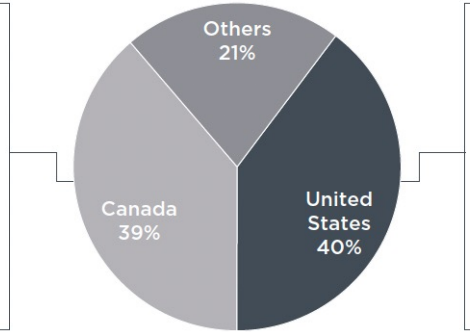
- U.S.- and Canada-flagged vessels each responsible for approximately 40% of total

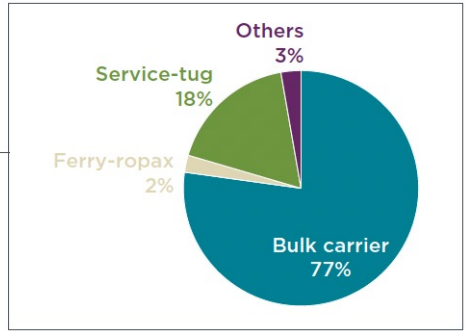
CO_2 emissions in thousand tonnes

Flag state	Bulk carrier	Chemical tanker	Container	Ferry-ropax	Oil tanker	Service-tug	All other ship types	Total
United States	499	0	0	15	0	115	18	**646**
Canada	386	92	4	40	41	31	34	**628**
All others	125	74	88	0	29	0	35	**351**
Total	**1,010**	**166**	**91**	**55**	**70**	**146**	**87**	**1,626**

- 1 Mt (62%) was emitted by bulk carriers; chemical tankers were a distant second with 10% and tugs emitted about 9%







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Ship CO_2 emissions by operating phase

- Over 78% of the emissions were emitted by ships sailing at cruising speeds.
- 10.5% of emissions occurred when ships were at anchor and about 8.5% occurred when at berth.
- 19% of emissions were were from ships at anchor or at berth, which could be reduced or eliminated using a combination of shore power and on-board batteries or fuel cells.

CO_2 emissions in thousand tonnes

Operating phase	Bulk carrier	Chemical tanker	Container	Ferry-ropax	Oil tanker	Service-tug	All other ship types	Total
At-anchor	51	33	38	15	13	8	14	**171**
At-berth	18	57	0	13	34	2	15	**138**
Cruising	922	73	52	24	23	131	54	**1,279**
Maneuvering	19	3	2	3	1	5	4	**37**
Total	**1,010**	**166**	**91**	**55**	**70**	**146**	**87**	**1,626**

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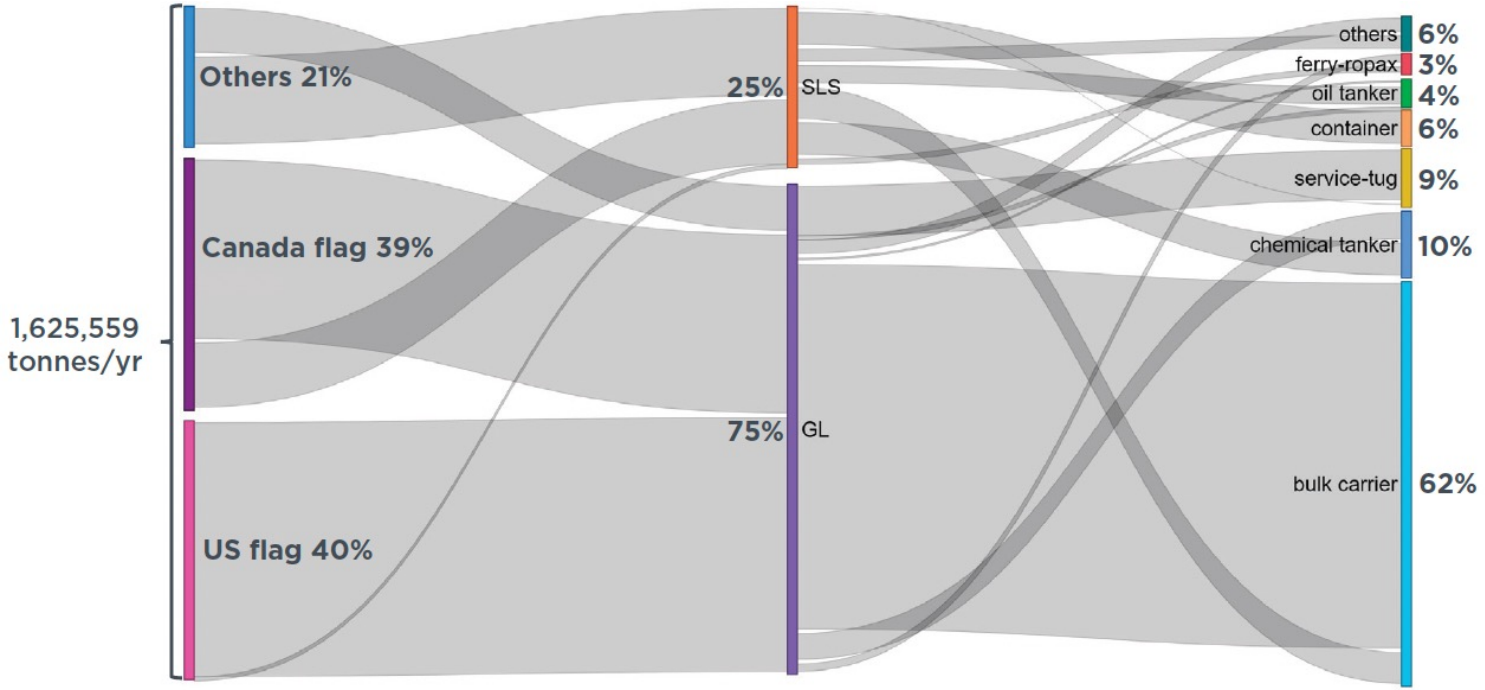
CO_2 emissions in GL and SLS

- 75% were emitted in the GL.
- the SLS represents less than 1% of the GL-SLS geographic area, and yet it is home to 25% of GL-SLS CO_2 emissions.
- The CO_2 emissions within each region were distinct.



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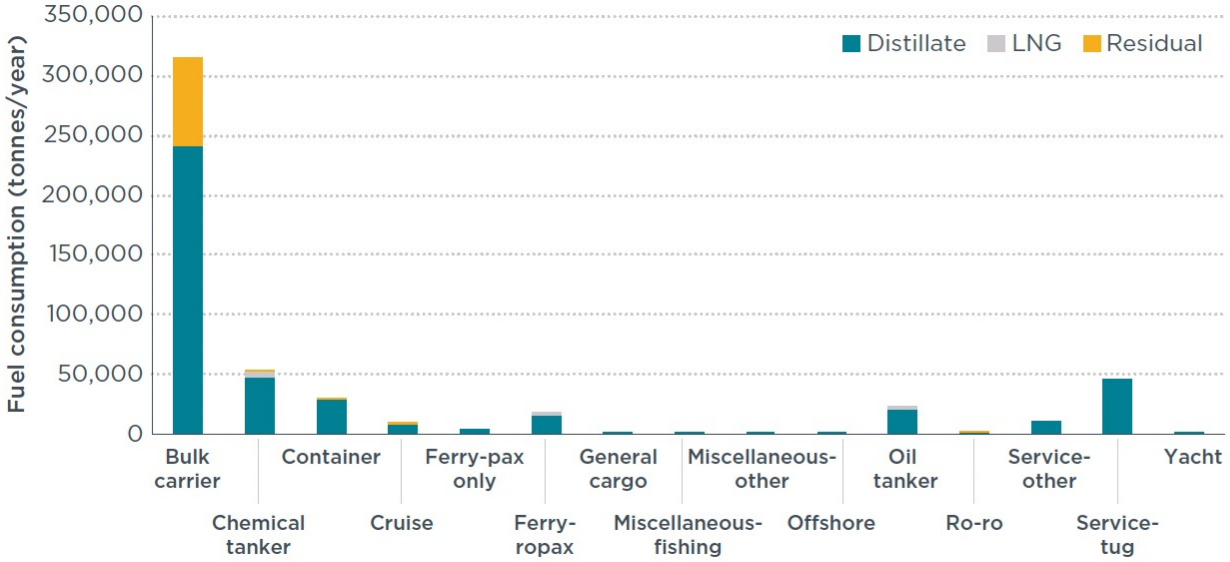
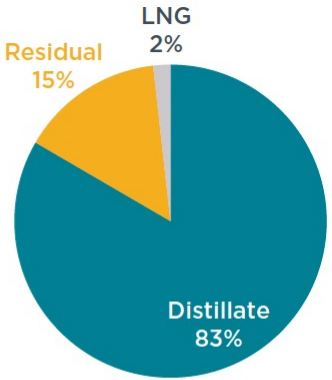
Fuel consumption of vessels in the GL-SLS

- 510,000 t fuel consumed in 2019, equal to 6 terawatt-hours or 20 trillion BTU, about enough to power a 70,000-person GL city for a year.[1]
- Most 83% of the fuel consumption was distillate fuels, still 15% residual fuel consumption, used by ships that have exhaust gas cleaning systems, also known as “scrubbers.”





[1]Based on 289 MMBTU/person/yr energy consumption by Michigan Residents in 2019 according to the US EIA https://www.eia.gov/state/print.php?sid=MI

Takeaway bullets

- Ships consumed more than 500,000 tonnes of fuel, equal to 6 terawatt-hours or 20 trillion BTU, about enough to power a 70,000-person GL city for a year.[1]
- Approximately 1.6 Mt of CO_2 emissions in the GL-SLS in 2019, equivalent to ~350,000 cars.[2]
- By ship type, bulk carriers were the largest contributor to GL-SLS CO_2 emissions, accounting for 62%.
- U.S.- and Canada-flagged vessels emitted 80% of the CO_2 emissions in the GL-SLS region in 2019, split roughly evenly.
- By operating phase, 19% of emissions were from ships at anchor or at berth, which could be reduced or eliminated using a combination of shore power and on-board batteries or fuel cells.

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[1]Based on 289 MMBTU/person/yr energy consumption by Michigan Residents in 2019 according to the US EIA https://www.eia.gov/state/print.php?sid=MI
[2]Based on US EPA estimates that a typical passenger car emits 4.6 t CO_2/yr, https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

More information of this work

The briefing paper is available at https://theicct.org/publication/ships-great-lakes-emissions-mar22.

Appendix of the paper includes:

- CO_2 emission and fuel consumption results of the Great Lakes and St. Lawrence portions of the GL-SLS.
- Other climate and air pollutant emissions results, including BC, SOx, PM_{10}, $PM_{2.5}$, NOx, VOC, etc.
- ArcGIS shapefile contains the gridded CO_2 emissions inventory for the GL-SLS at $0.05^{\circ} \times 0.05^{\circ}$ resolution.

We intended to periodically update this analysis with results for other years, as data and resources allow.

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What questions can I answer?

I’m happy to have a discussion today and you can also reach out to:
Zhihang Meng, Associate Marine Researcher, z.meng@theicct.org.

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