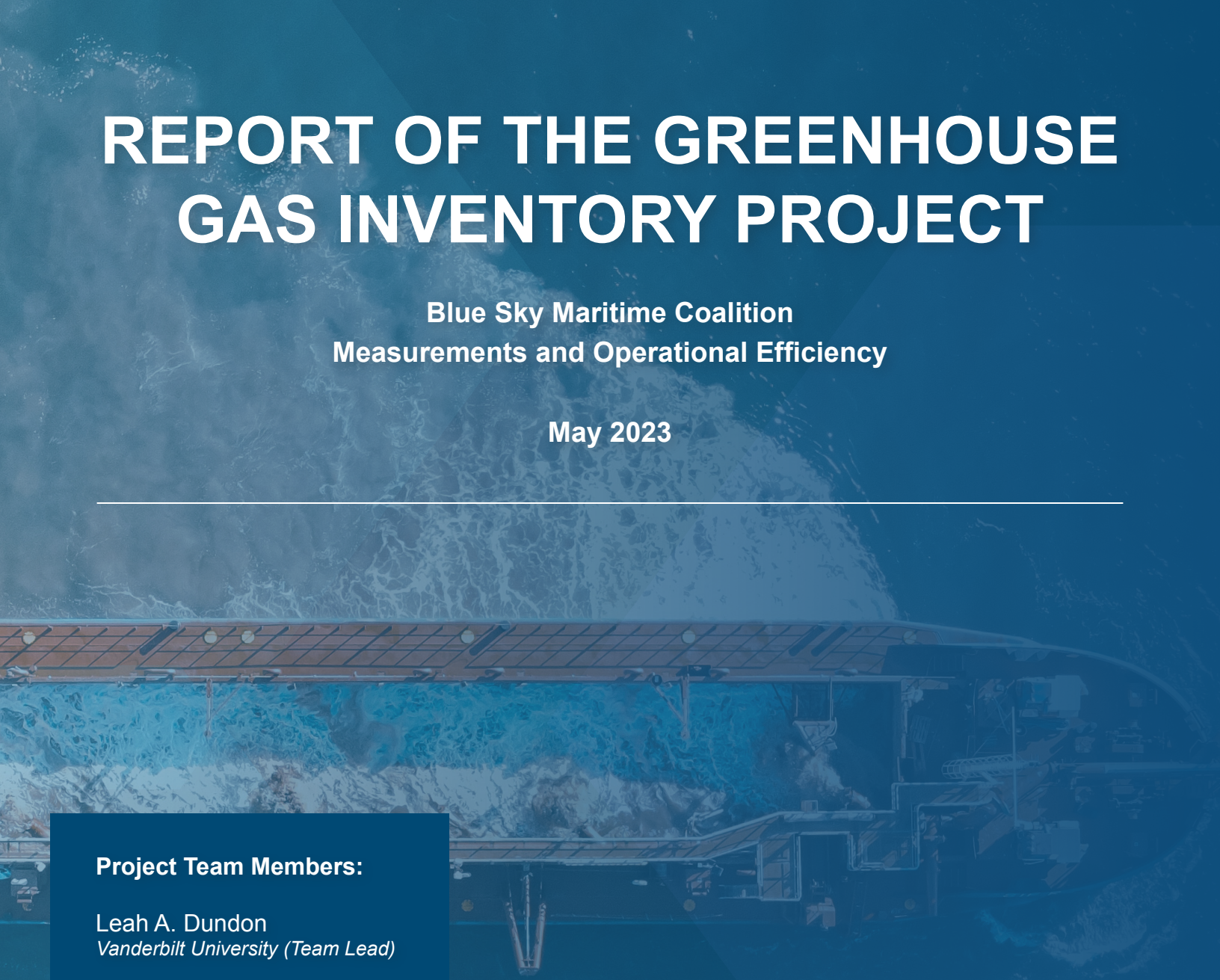
REPORT OF THE GREENHOUSE GAS INVENTORY PROJECT

Blue Sky Maritime Coalition
Measurements and Operational Efficiency

May 2023



Project Team Members:

Leah A. Dundon
Vanderbilt University (Team Lead)

Morgan Johnson
Kirby Corporation

Bradley Trammell
American Waterways Operators

Kai Martin
The Pasha Group

Shankar Vaidhyanathan
American Bureau of Shipping

Ken Gathright
Port Houston

Mimosa Miller
bp

Charlie Meyer
Shell

BLUE SKY
MARITIME COALITION

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I. OVERVIEW

The Measurements and Operational Efficiency Workstream of the Blue Sky Maritime Coalition (Blue Sky) undertook four separate initiatives in 2022. One of these initiatives involved developing a greenhouse gas (GHG) inventory. In particular, the project group was tasked with determining the total GHG emissions associated with the North American marine shipping sector. After research into existing GHG inventories and their methodologies, which included an in depth presentation from a consultant that has conducted numerous GHG inventories for U.S. ports (Starcrest Consulting Group, LLC), the potential enormity of the task quickly became apparent. Many of the studies use advanced computational or proprietary methodologies, are extremely expensive and often funded by large government agencies, require data from multiple sources, and involve many hours of labor. Given the resources of this project group, we approached this task to identify the major reports and assessments that have already been conducted in this field, understand and compare their approaches to GHG inventories, and provide recommendations to standardize approaches. This document summarizes our findings and provides recommendations. A more detailed assessment of our approach and findings regarding each of the reports or assessments we evaluated is set forth in Appendix A.

II. REPORTS/STUDIES IDENTIFIED

Our work identified six separate resources that have reported on GHG emissions associated with the North American marine shipping sector. Five of these focus on U.S. emissions and one focusses on Canadian emissions. The six sources are:

- *UMAS – Future Maritime Fuels in the USA: Options and their Potential Pathways*, January 2022
- U.S. Environmental Protection Agency (EPA) – *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, 1990-2020. EPA 430-R-22-003, April 14, 2022
- U.S. Environmental Protection Agency (EPA) – *EPA National Emissions Inventory*, report prepared for EPA by ERG (Eastern Research Group), Draft 2020 Report (May 2022)
- American Bureau of Shipping (ABS): *Decarbonization of the Inland Waterway Sector in the United States*, September 2021
- Blue Sky Maritime Coalition – Chartering, Finance, and Commercial workstream: Report – Carbon Footprint of the North American Waterborne Fleet
- Environment and Climate Change Canada – *Marine Emission Inventory Tool*

Conclusions and finding from each report is summarized below and provided in more detail in Appendix A.

III. SUMMARY OF EMISSIONS TOTALS AND METHODS FROM REPORTS IDENTIFIED

This section summarizes, for each report, the total emissions, the boundary the report identified to calculate total emissions, and a brief description of the data or methodology applied by that report/study/tool. A more detailed discussion of the methodologies appears in Appendix A.

Report/Study	Total GHG emissions	Boundary	Methods
UMAS	13.3 $MtCO_2$ (2018)	Total calculated from "domestic shipping" (Jones Act vessels connecting ports within U.S. waters)	UMAS Fuel Use Statistics and Emissions (FUSE) model based on AIS data and vessel information to calculate fuel use
EPA – Inventory of Sources and Sinks	23.3 $MtCO_2$ (2018)	U.S. domestic "ships and boats" category	Data from distillate fuel oil sales and residual fuel oil sales, *excluding* recreational boats and international bunker fuels
EPA – National Emissions Inventory	38.6 $MtCO_2$ (2020)	Category 1, 2, and 3 vessel engines operating in the U.S. Exclusive Economic Zone (EEZ)	Emissions were calculated using AIS vessel data based on location and engine information and activity duration, which translates to fuel burn
ABS – Decarbonization of the Inland Waterway	5.6 $MtCO_2$ (2018)	U.S. Inland waterways only – vessels reported in the Inland River Record	Estimate based on Inland Waterways Trust Fund tax receipts, and confirmed using company data
Blue Sky – Chartering, Finance, and Commercial Workstream	47 $MtCO_2$ (45.3-US / 1.7-CA) (2018) Additional: Ports—19 $MtCO_2$	U.S. offshore support, inland, coastal, ferry, tankers/ containerships/RoRo, and Canadian flagged	Estimates based on industry knowledge and total vessel inventory of various classes and owner/operator feedback for fuel usage and ranges by vessel type. Inland sector estimation methods are similar to those used by ABS/ Vanderbilt (with notable difference in estimated percent of total inland fuel use that is *not* subject to Inland Waterways Trust Fund Fee (20%--ABS/Vanderbilt vs. 50%--BSMC)

Report/Study	Total GHG emissions	Boundary	Methods
Canada – Environment and Climate Change tool	8.7 $MtCO_2$ (2019)	All vessels that entered the Canadian EEZ from 2015 to 2020	AIS data, vessel characteristics, and emission factors along with other information such as course correction based on bathymetry or engine load based on currents

IV. DISCUSSION

Our review of the existing reports revealed a lack of consensus and coordination regarding approaches, data sets, and reference points (boundaries) for these emission calculations. The six studies relied on primary data sources from (i) AIS data coupled with vessel operating information and (ii) fuel sales data. However, different approaches (methodology, models, emission factors, etc.) resulted in a variety of total emission calculations. The lack of standardization makes comparability among the reports difficult. While there are some entities that are required to report their GHG emissions under federal or state rules (such as the EPA GHG Reporting Rule or pursuant to the California Air Resources Board regulations), the majority of emissions associated with marine shipping is not required to be reported under any standardized structure, so differences in approaches to voluntary reporting is also an issue. The reports that are focused on U.S. emissions also did not have consistency regarding the emission boundary used. The precise number of gallons of fuel a marine shipping company uses in a given year also tends to be highly confidential business information. Fuel is often the single largest expense for any shipping company. Accordingly, costs related to fuel use are important to competitive advantage. Fuel-burn data is therefore not easily obtainable from individual operators due to legitimate business concerns.

A number of ports in the U.S. have undertaken their own GHG emissions inventory, and we invited a presentation to our group from Starcrest Consulting Group, LLC, which has performed numerous such inventories (including those for six of the largest ports in the U.S.), most recently for the Port of Long Beach. Starcrest's effort received input from many dozens (if not hundreds) of individuals, operational information was provided by port tenants and operators, and a technical working group that included federal and state agencies was involved. The inventory process was a substantial, complex, thorough, and expensive undertaking and it was quickly apparent such an approach was beyond the scope of our group resources. Accordingly, as noted, we undertook a thorough review and understanding of existing reports and methodologies for assessing U.S. or North American GHG emissions.

V. RECOMMENDATIONS

The following are our recommendations based on evaluation and input from all group members:

1. **Use 2021 as a reference "base year" for an emission inventory calculation within Blue Sky**. The most recent year of data available in most of the reports we reviewed was 2018 (which is why 2018 is used above in Section III in the emission summary tables); however, there was consensus in the group that 2021 better reflects current and likely ongoing operations. The pandemic makes 2020 an unrepresentative year. Importantly, Blue Sky's Finance and Commercial Workstream 2022 report used 2018 as a baseline and indicated that is representative of "today's emissions." We recommend that Blue Sky reach consensus on an appropriate baseline year and establishing the baseline has major consequences for future analysis regarding emission increases or decreases.

2. **Submit comments through the regulatory comment process to U.S. Environmental Protection Agency's (EPA) annual "sources and sinks" publication and the National Emission Inventory**. Consistency, standardization, and more reliable inventory accounting methods would be useful in both the EPA annual U.S. GHG Inventory ("sources and sinks" document), and the EPA National Emissions Inventory (issued every three years). Blue Sky should develop detailed recommendations on how an inventory should be undertaken (i.e., data sources, boundaries, emission factors) and submit them to these agencies during the prescribed comment period. This would also provide a mechanism to add the perspective of individual Blue Sky sectors (such as ports, vessel operators, etc.). We also recommend including in these comments a recommendation that each new accounting undertaken should review the prior studies and include some discussion of why the boundaries, standards, or methodologies are or are not followed in the current report. **In March 2023, Blue Sky submitted public commentary and recommendations to the EPA on the Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2021**.

3. **Develop a Blue Sky carbon accounting methodology guidance document specific to the marine shipping sector**. Given the lack of standardization in these accounting approaches, we suggest that Blue Sky work to fill this gap and develop a methodology that would allow for consistency and comparability among the emission sources in the marine shipping value chain. This is likely to be a substantial endeavor and will require a deep analysis of existing methodologies, such as those indicated in the Fourth IMO GHG study (2020) (Fourth-IMO-Greenhouse-Gas-Study-2020), SASB's Marine transportation standard (October 2018) (SASB-Marine Transportation), the GHG Protocol, or others. While these existing approaches may serve to inform our process, Blue Sky should develop its own guidance document, with input and feedback from its members, that is practical and specific to the North American marine shipping industry. The goal is to develop a Blue Sky-approved methodology that could potentially be used or adopted by regulators. Emissions methodologies and approaches are likely to continue to evolve, and to the extent that such approaches are eventually mandated, it is in Blue Sky's interest to develop industry-supported approaches/standards that could contribute to the development of such regulations.

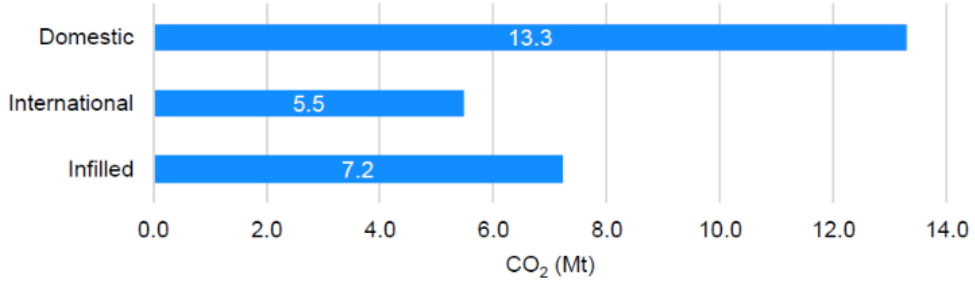
ACKNOWLEDGEMENTS

This Report represents substantial input and support from all members of the Project Team. We would also like to thank Rose Muller, Archana Agrawal, and Guiselle Aldrete from Starcrest Consulting Group, LLC for their time and contribution to our analysis.

APPENDIX A

Summary of sources reporting estimates of U.S. maritime shipping GHG emissions

	Report	Total $MtCO_2$ and year	Summary
1	UMAS – Future Maritime Fuels in the USA – the options and their potential pathways – April 13, 2022 launch (publication date January 2022). References for emissions methodology: • UMAS, The Maritime Fleet of the USA – the current status and potential for the future. 2022. • Fourth IMO Greenhouse Gas Study 2020.	13.3 $MtCO_2$ 2018	• Boundary: Defined U.S. "domestic shipping" as "shipping connecting ports within U.S. maritime waters." International shipping was considered ships "responsible for international trade." • GHG emission total and methodology: Uses the UMAS Fuel Use Statistics and Emissions (FUSE) model – based on AIS data and vessel info to calculate fuel consumption. » Total for U.S. flagged vessels (including international voyages) for 2018: 26 million tons of CO_2 ($MtCO_2$); **U.S. "domestic shipping" is 13.3 $MtCO_2$**. » This 26 $MtCO_2$ is broken down into 3 categories: [1] U.S. domestic (Jones Act vessels in "domestic trade") (13.3 $MtCO_2$); [2] International (5.5 $MtCO_2$); and [3] Infilled (7.2 $MtCO_2$) (see figure 2.1 from report and explanation of "infilled" below). The report then states that "of these emissions" (presumably referring to all 3 categories) "71% relate to domestic trade." Report page 14. However, 71% of the sum of all three categories = 18,460,000, and that number does not calculate from their reported numbers. Rather, it appears that they are excluding entirely the 7.2 $MtCO_2$ of "infilled" emissions, and simply adding domestic (13.3Mt) and international (5.5) = 18.8 $MtCO_2$, so the domestic figure (13.3 $MtCO_2$) is in fact 71% of just the two categories together (domestic and international). It is not clear if excluding entirely from domestic emissions the 7.2 $MtCO_2$ is warranted and doing so may result in undercounting domestic emissions. • Year available: Emissions from 2018 • Assumptions/limitations: » Excludes "infilled" entirely from the calculation of U.S. domestic emissions. UMAS used the Fourth IMO GHG Study to "infill" the emissions missing from incomplete AIS data (poor AIS coverage in certain areas, vessels that are in the inventory but do not have AIS, etc.). The "infilled" amount is reported separately from domestic and international.

	Report	Total $MtCO_2$ and year	Summary
			» These emission numbers and the figure come directly from the related report below, which expressly says that the infilled category (called "unassigned" in the report below) "cannot be specifically assigned to international or domestic trade." --- Emission totals from reports cited and relied on:  • 2022 UMAS Report *The Maritime Fleet of the USA-the current status and potential for the future*. U.S. flagged vessels = 26 million tons of CO_2-e ($MtCO_2$-e)(in 2018) » Page 8 notes the importance of the Jones Act and states that "30% of the current fuel demand comes from domestic trade." Page 9 states: "This highlights the importance of the Jones Act as a driver for decarbonisation, given that around 16.7% of the current fuel demand comes from domestic trade." Unclear why the discrepancy. » The report uses DOT data which it states divides U.S. flagged vessels ("the U.S. maritime fleet") into four categories – non-self-propelled, self-propelled, self-propelled ocean-going vessels (1,000GT and above); and recreational vessels. It lists 182 ocean going vessels, 9,904 self-propelled, and 33,266 non self-propelled. *See* Table 2.1, page 14. » Uses AIS data (from prior IMO study) to distinguish domestic from international voyages ("uses AIS data to identify port calls, which allows for allocation of discrete voyages to distinguish between international and domestic shipping." The 2020 IMO report used a method that detects "port stops and allocates voyages to each vessel . . . [which] allows emissions to be allocated based upon where a vessel has operated (i.e., domestic or international voyages) rather than upon the ship type and/or size." (2020 IMO report, page 33)

<table>
<tr><th></th><th>Report</th><th>Total $MtCO_2$ and year</th><th>Summary</th></tr>
<tr><td>2</td><td>EPA (2022) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. U.S. Environmental Protection Agency, EPA 430-R-22-003. https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020.</td><td>Total U.S. CO_2 emissions from “ships and boats” (excludes international bunker fuels, see table to right): 36.9 $MtCO_2$ ($MtCO_2$-e = 41.1)

Total from highlighted boats = 23.3

2018</td><td>Boundary: U.S. Domestic “ships and boats”

Years available: Every year 1990-2020.

GHG Emissions total: The U.S. “ships and boats” category total for 2018 is 36.9 $MtCO_2$ ($MtCO_2$-e = 41.1); Table 3-13, however, provides the following breakdown,

<table>
<tr><td colspan="2">Data from Table 3-13 in main EPA Inventory report. CO_2 emissions from Fossil Fuel Combustion in Transportation end use Sector</td></tr>
<tr><td>Fuel and category</td><td>Emissions (2018) Million Metric Tons</td></tr>
<tr><td>Gasoline</td><td></td></tr>
<tr><td>Recreational Boats</td><td>10.7</td></tr>
<tr><td>Distillate fuel oil (diesel)</td><td></td></tr>
<tr><td>Recreational Boats</td><td>2.8</td></tr>
<tr><td>Ships and Non-recreational boats</td><td>9.3</td></tr>
<tr><td>International bunker fuels (not included in official total estimate of ships and boats category)</td><td>10.0</td></tr>
<tr><td>Residual Fuel Oil</td><td></td></tr>
<tr><td>Ships and non-recreational boats</td><td>14.0</td></tr>
<tr><td>International bunker fuels(not included in official total estimate of ships and boats category)</td><td>31.4</td></tr>
<tr><td>Total excluding recreational boats and international bunker fuels</td><td>23.3 MMTons CO_2</td></tr>
</table>
</td></tr>
</table>

	Report	Total $MtCO_2$ and year	Summary
			Methods and Notes: Accounting method is based on fuel consumption. "The Inventory estimates for residual and distillate fuel used by ships and boats is based in part on data on bunker fuel use from the U.S. Department of Commerce. Domestic fuel consumption is estimated by subtracting fuel sold for international use from the total sold in the United States. Since 2015, all ships travelling within 200 nautical miles of the U.S. coastlines must use distillate fuels thereby overestimating the residual fuel used by U.S. vessels and underestimating distillate fuel use in these ships." "It may be possible to more accurately estimate domestic fuel use and emissions by using detailed data on marine ship activity. The feasibility of using domestic marine activity data to improve the estimates will continue to be investigated." • Emissions resulting from the combustion of fuels used for international transport activities, termed international bunker fuels under the UNFCCC, are not included in national emission totals, but are reported separately based upon location of fuel sales. The decision to report emissions from international bunker fuels separately, instead of allocating them to a particular country, was made by the Intergovernmental Negotiating Committee in establishing the Framework Convention on Climate Change.85 These decisions are reflected in the IPCC methodological guidance, including IPCC (2006), in which countries are requested to report emissions from ships or aircraft that depart from their ports with fuel purchased within national boundaries and are engaged in international transport separately from national totals (IPCC 2006).86 International marine bunkers comprise emissions from fuels burned by ocean-going ships of all flags that are engaged in international transport. Ocean-going ships are generally classified as cargo and passenger carrying, military (i.e., U.S. Navy), fishing, and miscellaneous support ships (e.g., tugboats). For the purpose of estimating greenhouse gas emissions, international bunker fuels are solely related to cargo and passenger carrying vessels, which is the largest of the four categories, and military vessels. Two main types of fuels are used on sea-going vessels: distillate diesel fuel and residual fuel oil. Carbon dioxide is the primary greenhouse gas emitted from marine shipping. Uncertainties exist with regard to the total fuel used by military aircraft and ships. Total aircraft and ship fuel use estimates were developed from DoD records, which document fuel sold to the DoD Components (e.g., Army, Department of Navy and Air Force) from the Defense Logistics Agency Energy. These data may not include fuel used in aircraft and ships as a result of a Service procuring

	Report	Total $MtCO_2$ and year	Summary
			fuel from, selling fuel to, trading fuel with, or giving fuel to other ships, aircraft, governments, or other entities. Estimating marine fuel consumption for International Transport: In order to quantify the civilian international component of marine bunker fuels, activity data on distillate diesel and residual fuel oil consumption by cargo or passenger carrying marine vessels departing from U.S. ports were collected for individual shipping agents on a monthly basis by the U.S. Customs and Border Protection. This information was then reported in unpublished data collected by the Foreign Trade Division of the U.S. Department of Commerce's Bureau of the Census (DOC 1991 through 2020) for 1990 through 2001, 2007 through 2020, and the Department of Homeland Security's Bunker Report for 2003 through 2006 (DHS 2008). Fuel consumption data for 2002 was interpolated due to inconsistencies in reported fuel consumption data. Activity data on distillate diesel consumption by military vessels departing from U.S. ports were provided by DLA Energy (2021). The total amount of fuel provided to naval vessels was reduced by 21 percent to account for fuel used while the vessels were not-underway (i.e., in port). Data on the percentage of steaming hours underway versus not underway were provided by the U.S. Navy. These fuel consumption estimates are presented in Table 3-107. A longer-term effort is underway to consider the feasibility of including data from a broader range of domestic and international sources for bunker fuels. Potential sources include the IMO greenhouse gas emission inventory, data from the U.S. Coast Guard on vehicle operation currently used in criteria pollutant modeling, data from the International Energy Agency (IEA), relevant updated FAA models to improve aviation bunker fuel estimates, and researching newly available marine bunker data.

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<tr><th></th><th>Report</th><th>Total $MtCO_2$ and year</th><th>Summary</th></tr>
<tr>
<td>3</td>
<td>EPA National Emissions Inventory (NEI), prepared for EPA by ERG (Eastern Research Group, Inc.).

Draft 2020 report on Category 1 and Category 2 Marine Vessels

Draft 2020 Report on Category 3 Marine Vessels

<table>
<tr><th colspan="2">Table 1. Marine Diesel Engine Emission Standards-Engine Category Descriptions</th></tr>
<tr><th>Engine Category</th><th>Displacement per cylinder</th></tr>
<tr><td>1</td><td>disp. <7 liters (and power ″37 kW)</td></tr>
<tr><td>2</td><td>disp. 7 ≥ <30 liters</td></tr>
<tr><td>3</td><td>disp. ≥30 liters</td></tr>
</table>
</td>
<td><u>2017</u>: C1 and C2 total = 14,628,561 (2017)

<u>2020</u> C1,C2,C3

10,578,770 tons CO_2 (C1,C2)

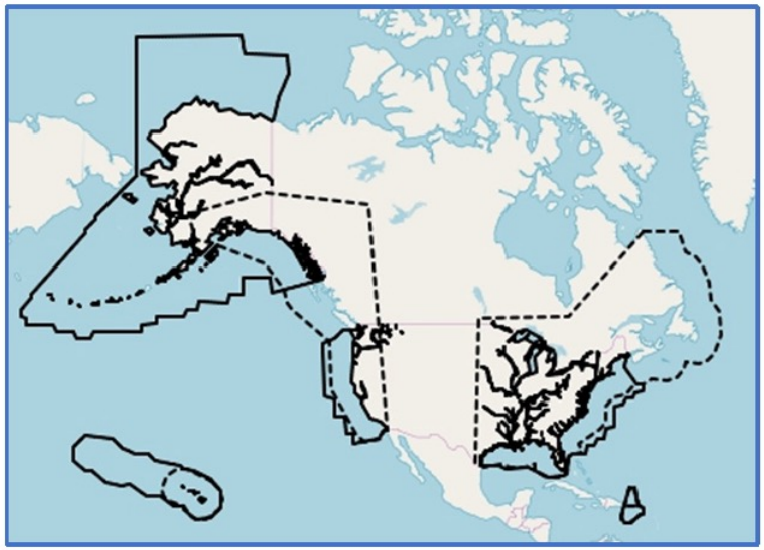
28,064,099 tons CO_2 (C3).

Total 2020 C1,C2,C3: 38,642,869 tons CO_2</td>
<td><u>Totals</u>: 2017 Report (C1 and C2 only): 14,628,561 tons CO_2 emissions in the NEI area. 2020 Report: total C1,C2, and C3 = 38,642,869 tons CO_2.

Category 3 CO_2 emissions total – 2020 – 28,064,099

<u>Year</u>: 2017 and 2020

<u>Boundary</u>: For the 2020 report, the U.S. Exclusive Economic Zone was used – solid line in Figure 1 below.

 
Figure 1. NEI Geographical Extent (Solid) and U.S. ECA (Dashed)

The National Emissions Inventory (NEI) is a comprehensive and detailed estimate of air emissions of criteria pollutants, criteria precursors, and hazardous air pollutants from air emissions sources. The NEI is released every three years based primarily upon data provided by State, Local, and Tribal air agencies for sources in their jurisdictions and supplemented by data developed by the U.S. EPA.</td>
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</table>

	Report	Total $MtCO_2$ and year	Summary
			ERG (Eastern Research Group) developed the methodology, based primarily on AIS data. Coast guard rule requires AIS to continually signal while in US waters. EPA received AIS data from the Coast Guard for Jan 1-Dec 31, 2020. The AIS data extend outside the ECA zone but is "roughly equivalent". Data was compressed by Coast Guard to 5 minute intervals (good refinement) – allows for accurate emissions estimates. (can estimate hours of operations and quantify propulsion engine loads. After duplicates and others were discarded – (eg buoys) --814 million AIS records were used in the 2017 report (C1 and C2), and the 2020 report had 1.7 billion records (for C1, C2, and C3). This inventory represents emissions from each self-propelled, and non-pleasure-craft, marine vessel included in the cleaned AIS activity dataset. Emissions are calculated for each time interval between consecutive AIS messages for each vessel and allocated to the location of the message following to the interval. Emissions are calculated according to Equation: *Emissions interval = Time (hr)interval x Power(kW) x EF(gkWh) x LLAF* Power is calculated for the propulsive (main), auxiliary, and auxiliary boiler engines for each interval and emission factor (EF) reflects the assigned emission factors for each engine, as described below. LLAF represents the low load adjustment factor, a unitless factor which reflects increasing propulsive emissions during low load operations. Time indicates the activity duration time between consecutive intervals. Relevant charts below:

Table 10. C1C2 NEI Emissions by Vessel Group (tons)

Vessel Group	VOC	CO_2	CO	NO_X	$PM_{2.5}$	SO_2	PM_{10}	kWhrs
Bulk Carrier	60.07	132,724.45	281.49	1,847.89	48.12	10.16	49.68	1.71E+08
Commercial Fishing	195.52	412,939.29	973.25	6,283.90	155.31	3.80	160.11	5.51E+08
Container Ship	3.44	15,497.23	15.35	79.54	3.14	5.03	3.27	1.75E+07
Ferry Excursion	196.42	395,295.02	872.33	5,513.03	138.68	3.63	142.97	5.28E+08
General Cargo	843.91	2,376,825.67	3,938.66	26,077.51	759.28	496.37	786.13	2.87E+09
Government	626.48	1,386,101.58	3,269.43	20,969.60	514.66	12.74	530.58	1.85E+09
Miscellaneous	97.07	214,488.02	379.78	2,297.62	56.80	1.97	58.55	2.86E+08
Offshore support	861.36	1,850,168.28	3,848.25	24,588.16	604.51	17.01	623.21	2.47E+09
Pilot	4.97	7,773.00	16.78	116.81	2.99	0.07	3.08	1.04E+07
Reefer	0.69	4,123.17	4.31	23.55	0.59	0.73	0.61	5.06E+06
Ro Ro	143.29	351,990.85	627.75	4,016.80	107.69	39.99	111.28	4.46E+08
Tanker	40.36	110,481.33	179.76	1,158.52	33.44	19.84	34.61	1.35E+08
Tug	1,808.58	3,012,286.66	6,638.74	44,768.52	1,148.67	27.69	1,184.20	4.02E+09
Work Boat	149.86	308,076.22	671.19	4,268.31	108.35	2.83	111.70	4.11E+08

	Report	Total $MtCO_2$ and year	Summary
			Relevant charts below.

Table 4. Total 2020 Category 3 emissions by ship type (tons unless otherwise indicated)

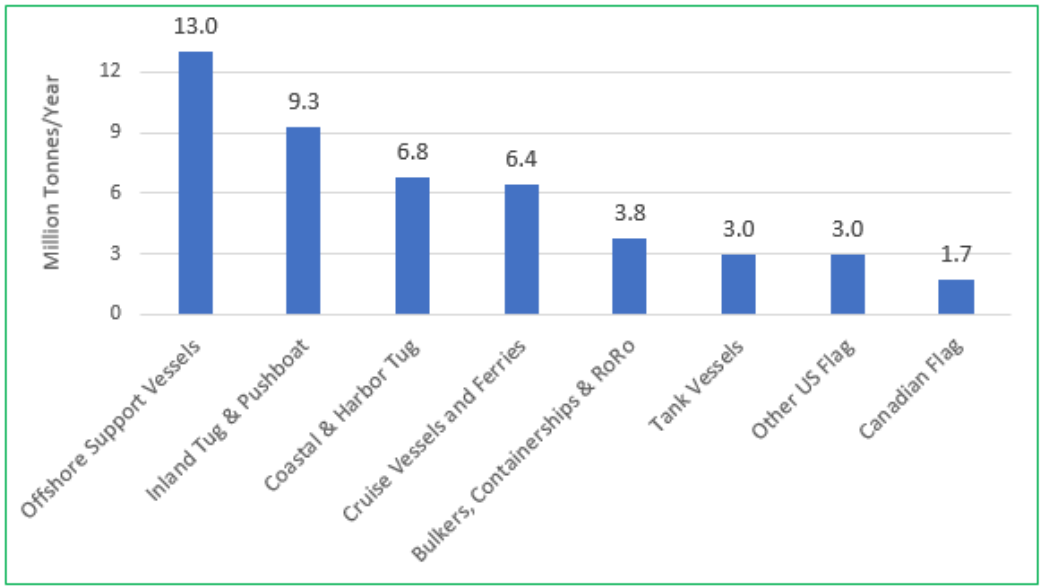
Ship Type	CO	CO_2	NO_x	$PM_{2.5}$	PM_{10}	SO_2	VOC	Energy (kWh)
Bulk carrier	9,080	4,367,498	97,720	2,782	3,024	7,598	4,127	6.16E+09
Chemical tanker	4,260	2,282,164	43,637	847	920	2,158	1,925	3.1E+09
Container ship	21,913	9,395,697	215,621	5,669	6,162	15,055	10,780	1.28E+10
Cruise ship	3,467	2,162,812	36,489	736	800	1,934	1,498	2.76E+09
General cargo	237	152,271	2,575	49	53	127	101	1.96E+08
Miscellaneous other	643	336,800	6,927	150	163	396	309	4.59E+08
Offshore	1,259	548,559	12,610	242	263	588	641	7.5E+08
Oil tanker	77	48,848	832	16	17	41	36	6.18E+07
Other tanker	3,410	1,748,462	33,705	734	798	1,880	1,668	2.33E+09
Reefer	338	190,660	4,106	138	150	413	148	2.55E+08
Ro Ro	3,544	1,846,281	37,964	763	829	1,979	1,629	2.49E+09
Service tug	89	39,592	746	12	13	25	54	4.78 E+07
Fishing	28	10,558	248	11	11	24	20	1.16E+07
Ferry-Ro-Pax	44	26,085	537	11	12	32	19	3.50E+07
Liquified-gas tanker	3,396	2,164,358	32,199	902	980	2,463	1,535	2.8E+09
Yacht	3	1,805	36	0	1	1	1	2.35E+06

Table 3. Total 2020 Category 3 emissions in tons for U.S. waters including federal waters

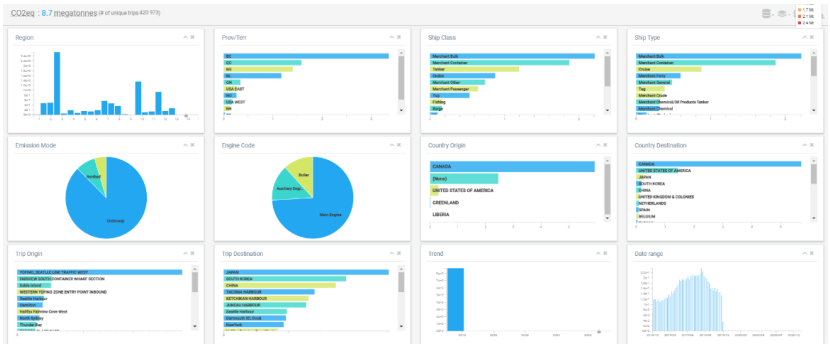
CO	CO_2	NO_X	$PM_{2.5}$	PM_{10}	SO_2	VOC
56,486	28,064,099	585,953	25,933	281,878	193,815	26,499

Table 9. Total C1C2 2020 Emissions for NEI area (tons)

VOC	CO_2	CO	NO_X	$PM_{2.5}$	SO_2	PM_{10}	kWhrs
5,032.01	10,578,770	21,717.06	142,009.8	3,682.24	641.86	3,799.98	1.37E+10

	Report	Total $MtCO_2$ and year	Summary
4	ABS/Vanderbilt Report: Decarbonization of the Inland Waterway Sector in the United States, September 2021	**Total U.S. inland waterway: 5.6 $MtCO_2$**	Total inland waterway: 5.6 $MtCO_2$ Year: 2018 Boundary: U.S. Inland waterway commercial vessels (towboats, fleetboats); all boats listed in the Inland River Record Method: Estimates based on: 1. Actual company fuel burn data extrapolated by market share and 2. Receipts based on per gallon tax receipts into the Inland Waterways Trust Fund. Total tax paid was estimated to be approximately 80% of all fuel use based on actual company data + industry knowledge (the Inland Waterways Trust Fund fee is only assessed on fuel used for propulsion and certain river segments are exempt).
5	Blue Sky Maritime Coalition – Chartering, Finance, and Commercial workstream.	47 $MtCO_2$ (total North American, includes Canada; separately reported Port GHG estimates of 19 $MtCO_2$)	This workstream group developed an estimate of North American Waterborne Transport emissions by source. Their report calculates emissions based on vessel categories (figure below) and accounted for 47 million tons of CO_2 from the below vessel categories, which includes Canadian vessels. 

	Report	Total $MtCO_2$ and year	Summary
			Year: 2018 Boundary: North American (by vessel type, includes Canadian) Methods: The group obtained data from the U.S. Army Corps of Engineers' Institute for Water Resources' annual report on Vessel Characteristics and Inventory by Type, as well as other private and government data sets. The report states that: "The CO_2 emissions were estimated, on the basis of expert analysis of the consumption and operating profile of the vessels in that fleet. The experts contributing to the analysis have many years of experience in the industry and, in many cases, were able to draw upon information from their own fleet." Within each source category, differing methods or validation approaches were utilized. For example, emissions from Offshore Service Vessels were validated "by a combination of technical files and real-time emission data from SailPlan." Note: the total emissions attributed to the Inland fleet varies from total documented in the ABS/Vanderbilt study primarily based on different estimates of how much of the total fuel used is subject to the Inland Waterways Trust Fund fee. The BSMC report estimated that the collected fees represent 50% of all fuel used in the waterways, while the ABS/Vanderbilt study estimated such fuel receipts represent 80% of the overall fuel usage.
6	Environment and Climate Change-Canada-Marine Emission Inventory Tool	8.7 $MtCO_2$/ year-Calendar Year 2019. 2019- Canadian Marine Emissions Inventory EC-MEIT 2010- National Emission Inventory-Canada Report	From Katelyn Wells- Senior Program Scientist, Energy and Transportation Directorate, Environment and Climate Change Canada MEIT is a database of all vessels that enter the Canadian EEZ from 2015 to 2020 and their associated air pollutant and GHG emissions. Use AIS data, vessel characteristics, and emission factors along with other information such as course correction based on bathymetry or engine load based on currents to calculate the emissions. Currently they are working to update the database for 2021 data. The link we are having issue with allows you to visual, filter, and download summarized data from the database. MEIT data does feed into some of Canada's national inventories, however if you are looking for more details on emissions from vessels, going straight to the tool will probably be your best option.

	Report	Total $MtCO_2$ and year	Summary
			

2010- National Emission Inventory- The geographical boundaries for the national inventory include Canada's territorial waters as well as all inland rivers and lakes with significant commercial marine activity. Canada's territorial waters extend 200 nautical miles offshore, with the exception of a portion of eastern Canada where a shared boundary exists between Canada and Greenland. Operational boundaries for the inventory include all commercial marine vessels, with emissions distinguished by:

- Domestic and international voyages;
- Class of vessel (e.g., Merchant Container, Merchant Bulk);
- Type of engine (propulsion, auxiliary) as well as boilers;
- Engine size (installed capacity in kW as well as cylinder size in litres);
- Modes of activity, including underway, berthing and anchoring;
- Type of emission (exhaust and fugitive); and
- Fuel type (distillate and residual oils)

Underway activity is defined to be all ship movements, regardless of speed. Berth activity occurs when a ship is stationary at any identifiable berth location in Canada (e.g., terminal, wharf or wharf section). Anchor activity occurs at all other times when a ship is stationary.

Comparison between 2010 Method and the MEIT Database

Many aspects of the methodology for the 2010 MEIT were used but updated to reflect most current emission factors (4th IMO GHG Study).

It may be important to note that 2015 onwards would be different than the 2010 situation in that the ECA would have been adopted. This may account for more 'transport work' being done at a lower emission rate than before.