VesselBot

Enabling Sustainable Supply Chains

Decoding Maritime Emissions

Global Container Vessel Emissions Report

MAY 2024

In the face of global climate change, the urgency for primary and actionable emissions data has never been more important. However, it is surprising to see how often the power of this kind of data is overlooked.

In this report, VesselBot, a leader in transportation emission analytics, underscores the true **value of primary emissions data** for shippers, supply chain stakeholders, and industry leaders. VesselBot's primary data are not just informative, but they directly guide companies on how to make informed decisions that benefit the environment, optimize resources and enhance operational efficacy. VesselBot's scientific approach, grounded in primary data, provides a clear and current picture of the significant changes occurring in our seas, even over a brief period of three months. Unlike broad and often inaccurate averages, this report offers **precise insights into real-time conditions**, enabling accurate measurement and management of emissions.

2024 Quarterly Reduction in CO2 Emissions

Data from the first trimester of 2024 reveals a significant decrease in CO2 emissions compared to the corresponding periods spanning 2021 to 2023 (**see Fig.1**). However, being a dynamic system, sea transport remains sensitive to various environmental and geopolitical factors that can alter supply chain routes and consequently affect global CO2 emission distribution and magnitude. Therefore, it is essential to remain vigilant and avoid conclusively asserting that CO2 emissions will decline in 2024, as the pattern might change.

Shippers need to understand that historical averages are unreliable for reporting purposes, as they often fail to reflect the current market conditions, operation patterns, and vessel performances. As a result, they can be highly inaccurate and hinder the ability to make data-driven decisions that will lead to actual emissions reduction.

An example illustrating this premise is the change of ship routes within the **Red Sea**, where, after months of missile, drone, and hijacking attacks against supply chain ships by the Houthi, the international supply chain has recorded its largest diversion in sea trading routes in decades*.

The first trimester of 2024 showed a

3.8%

reduction in emission per TEU shipped (CO2 kg/ TEU) as compared to 2023.

*According to Bloomberg (January 24, 2024)

Key Observations:

The primary steps to address global climate change and achieve the warming targets outlined in the Paris Agreement, are to correctly measure and report global transportation GHG emissions that account for up to 60%* of the global oil demand.

In this report, VesselBot analyzes international sea-transport CO2 emissions for the first quarter of 2024, unraveling the intricate web of factors that drive environmental impact on the maritime industry.

According to VesselBot, in the first quarter of 2024, more than 77.000 voyages were recorded between 7.800 trade lanes. As seen in the figure below (**Fig.1**), cumulative and average distance (km) covered in the first quarter of 2024 **increased** due to changes in trade lane distances (e.g., Red Sea). However, **average TEU** intensity and cumulative CO2 emissions were reduced compared to 2023;** a result that was dependent on the number of voyages, speed, distance, and load.

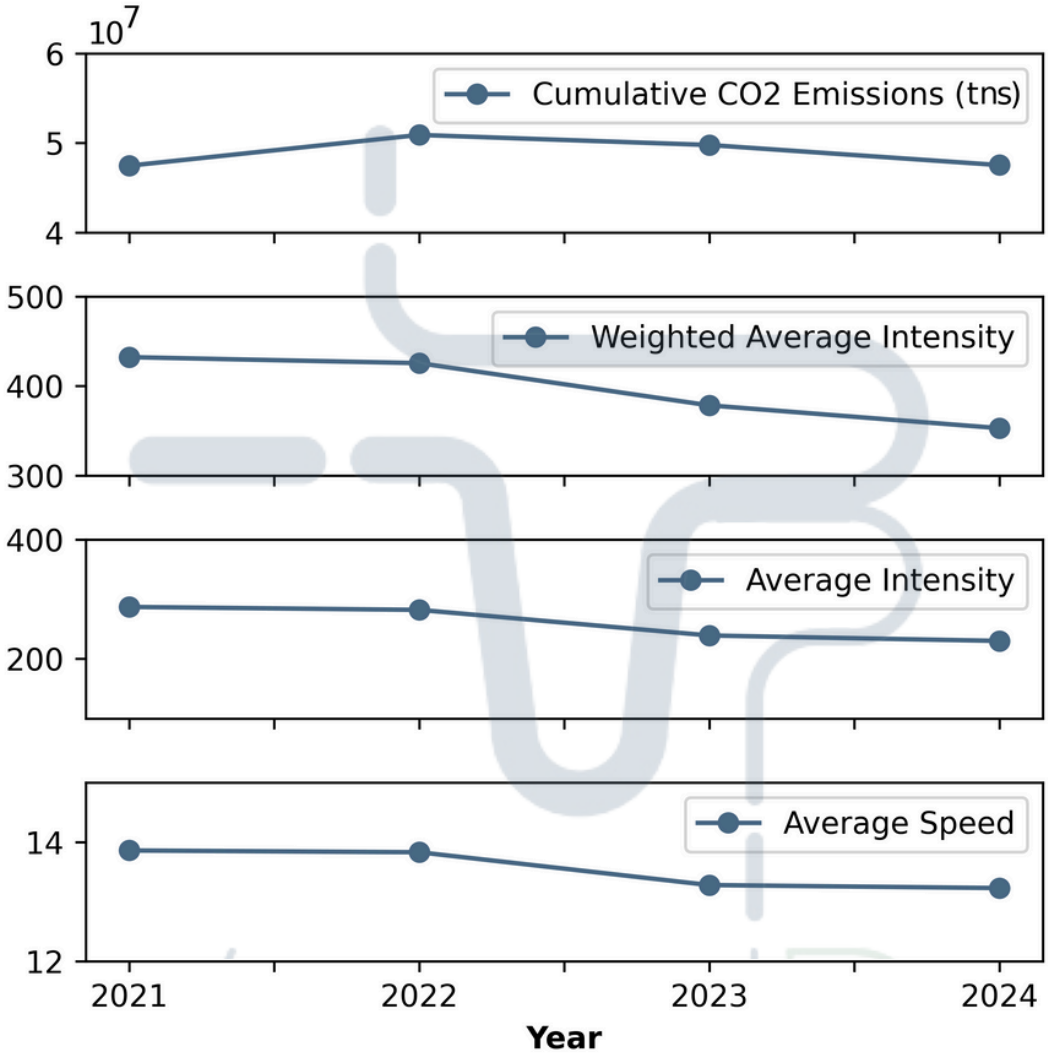

Figure 1: Yearly variation of major KPI parameters for the period January-March.

Source: VesselBot

**GLEC Framework (Introduction to Logistics Emission Accounting Freight Transport's Climate Impact)*

***TEU (Twenty-foot Equivalent Unit): unit of measurement used to determine cargo capacity for container ships and terminals*

In VesselBot's report, the most critical metric analyzed is the **CO2 emission intensity (WTW g CO2e/TEU-km)**. This valuable metric, measured in TEU, offers a standardized approach to assess the environmental efficiency of sea transportation, particularly in the context of container shipping. Measuring emissions in terms of TEU provides valuable insights into the environmental impact per unit of cargo transported, enabling the identification of opportunities to reduce maritime emissions.

A dominant factor impacting the CO2 emission intensity is the vessel's utilization rate/ factor, which reflects how efficiently the vessel's capacity is being used. Total voyage emissions are distributed across the number of containers shipped/carried on each voyage. Consequently, the actual utilization of a vessel's TEU capacity becomes a significant factor, alongside vessel speed, distance traveled, and other parameters, in determining the emissions intensity of each vessel/voyage/shipment.

For example, a vessel with a capacity of 3,000 TEUs operating at 60% capacity by carrying 1,800 TEUs on a voyage has a higher emissions intensity compared to the same vessel operating at full TEU utilization, as the emissions are spread over fewer containers. Thus, the utilization rate is as critical as the vessel's speed and the distance covered in determining the overall emissions efficiency of the voyage.

CO2 emission intensity in shipping is a significant value that measures the amount of CO2 emissions produced per unit of cargo transported, often expressed per gram of cargo per km. It reflects the efficiency of vessel and voyage utilization and is an important indicator of the environmental impact of sea transport.

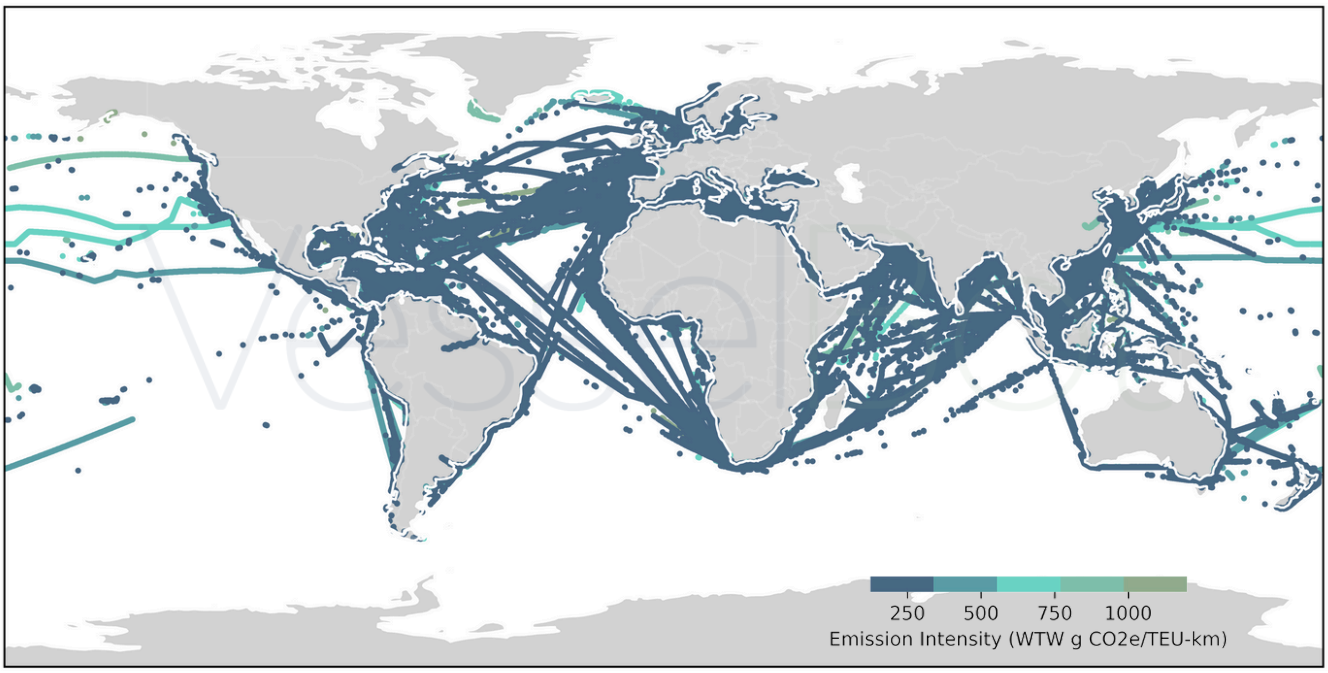

Figure 2: Voyages conducted in the first quarter of 2024. Each trade-lane is colour-coded based on the CO2 intensity produced.

Source: VesselBot

***Vessel Utilization**: The ratio of loaded containers to the total container slots available on a vessel.

After investigating all voyages of the first quarter of 2024 (**Fig.2**), VesselBot identified a good threshold in CO2 intensity, with exceptions, some of which exceeded 1000 WTW g CO2e/TEU-km. VesselBot's primary goal is monitoring these "outliers" to address vessel and route-specific issues that could arise from factors such as route planning, vessel profile and characteristics, and cargo consolidation, and, therefore, propose optimized routes and transport handling.

VesselBot's 2024 Trimester Analysis - CO2 Emissions Auditing Parameters

As seen in **Fig.2** above, the highest intensity voyages (see color bar for values) seem to be along the Pacific Ocean, from Japan to the W. USA, and from the N. Sea to Greenland. However, VesselBot's investigation of the 500 voyages with the highest CO2 intensities, provide a more realistic image, and emphasize that **short-range voyages are in fact the biggest contributors to global emission intensity**. This is illustrated in **Fig.3** with voyages being confined to Eastern Asia (including the ports of Singapore, Hong Kong, Qingdao, and Kaohsiung), the Americas, and Europe (including Rotterdam and Antwerp), with only one long-range route from China to the USA.

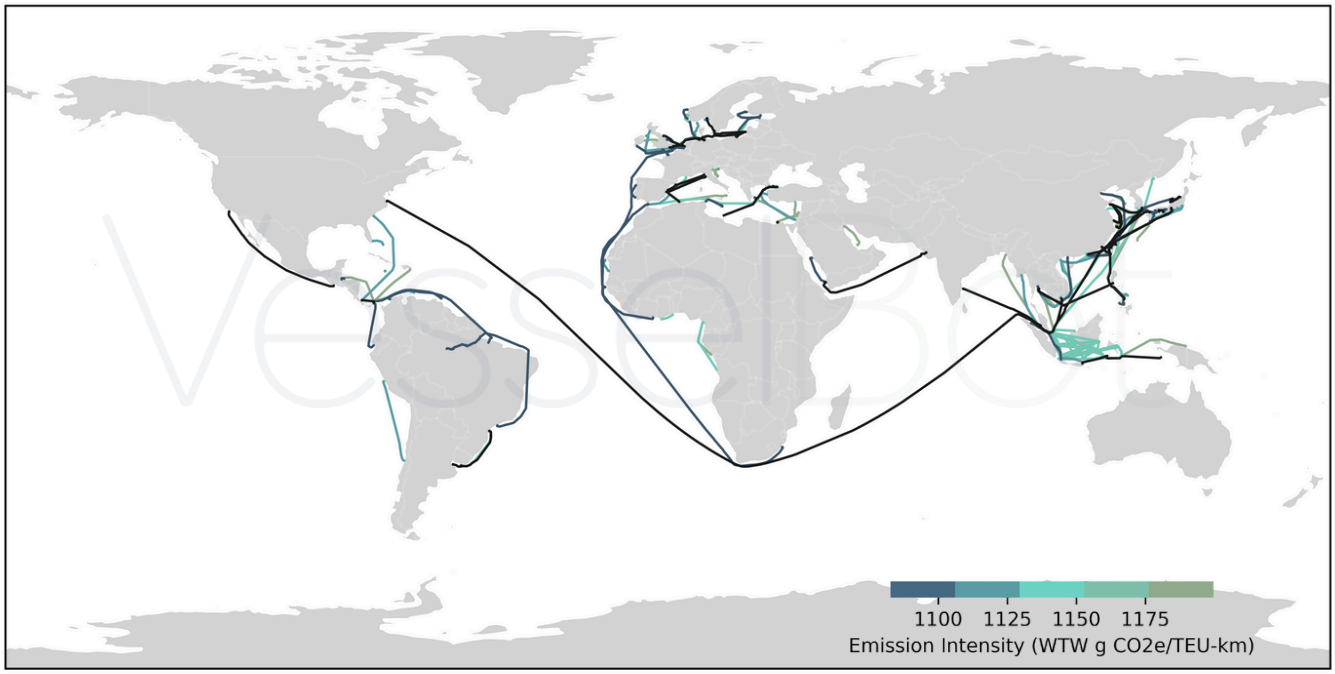

Figure 3: 500 Voyages with largest CO2 Emission Intensities.

Source: VesselBot

Fig.4 shows the 20 most visited ports globally, calculated by **the number of voyages destined or departed from those destinations**. These ports typically experience the highest volume of vessels, so one would anticipate that those ports exhibit or are related to the voyages with the highest CO2 emission intensities.

Although this claim is partly correct, in the sense that these ports are characterized by extreme vessel congestion, it does not take into account other major factors such as vessel profile and characteristics, and port management (i.e., waiting time during berthing, loading, unloading, bunkering) which also impact voyage efficiency.

According to VesselBot, the most frequently visited ports worldwide **(Fig.4**) do not coincide with voyages exhibiting the highest emission intensity (**Fig.3**).

Re-examination of **Figs.3** and **4** reveal that many of these voyages are intra Asia, intra America and within the Mediterranean sea, whose ports are not included in the world's top 20.

Further analysis from VesselBot shows that these vessels are usually feeders < 3000 TEU of which, as of May 2024, 24%* are more than 20 years of age, conducting short-range voyages (average of 1669 km), travelling at low speeds (average 13 kn/hr) and performing excess maneuvering in and out of port. As a consequence, they significantly reduce the total voyage efficiency and increase CO2 emission intensities, stressing the urgent need for better vessel and voyage optimization as well as port management.

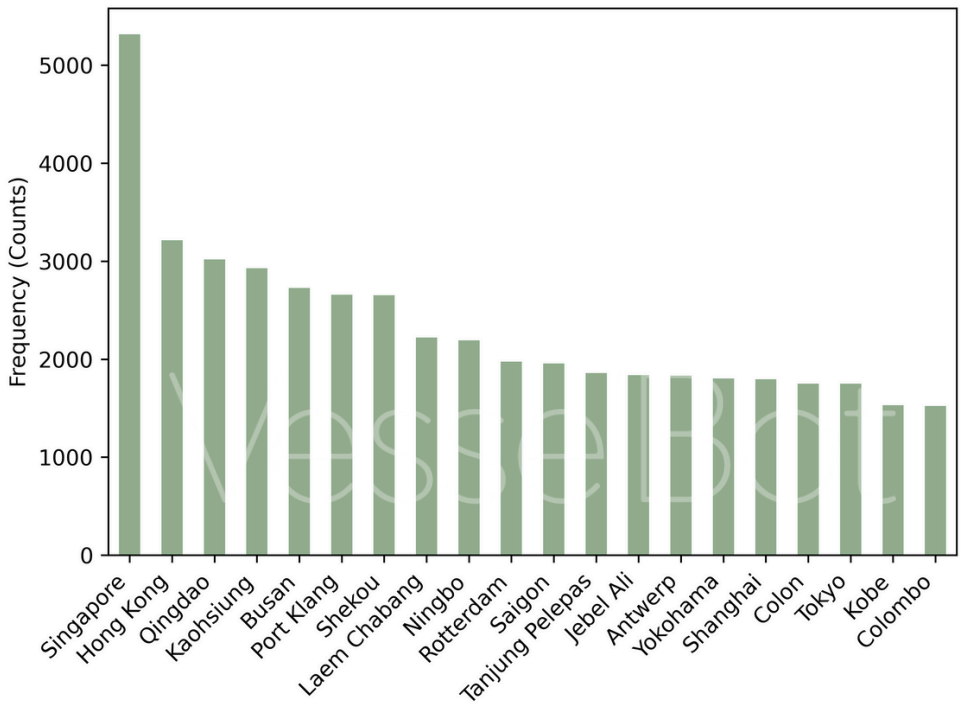

Figure 4: Most visited departure and arrival ports.

Source: VesselBot

*Clarkson Vol 26, No. 5.

VesselBot's primary data can assist shippers in choosing the most **optimal carrier** schedule **with the fewest possible CO2 emissions** per shipment or voyage.

Although realistic for certain journeys, these averages fail to encompass the full spectrum of sea transport emissions, thus missing critical areas of interest such as those of **Fig.3** which, as explained above, are directly related to vessel characteristic and voyage efficiency.

By analyzing these statistics for each vessel while simultaneously monitoring all trade lanes, VesslBot's data can assist shippers in choosing the most optimal carrier schedule with the fewest possible CO2 emissions per shipment or voyage.

The most important observation from **Fig.3**, though, is that VesselBot's data **provide accurate determination of CO2 emission intensities**, that are significantly different from the global standard averages typically used for sea-transport.

For example, while industry average methodologies set fixed values for intra-NE and SE Asia trade lanes, VesselBot shows that CO2 intensity values can, in fact, exceed 1120 WTW g CO2e/TEU-km. Similarly, GLEC, GHG Protocol, or other industry average methodologies, suggest standard intensity values **for any voyage** in this area.

Routes	GLEC
Intra NEA	139.6
Intra SEA	157.9
Intra SA/NA	111.1
Intra MD	200.3

GLEC Standard Emission intensities per region (WTW g CO2e/TEU-km)

VesselBot's Competitive Advantage

VesselBot, emphasizes the importance of accurate GHG emission calculations and reporting, which is a direct outcome of their proprietary technology that allows the collection of realistic primary data, making it possible for them to conduct further calculations along individual trade lanes and individual vessels, by considering factors such as **actual** distance traveled, actual voyage speed, actual voyage vessel load factor, and ship-specific parameters (e.g., engine) that can impact the global CO2 emissions imprint produced by sea transport.

VesselBot Statistics and Data Analytics:

Fig.5 illustrates the correlation between various parameters for all voyages in the first quarter of 2024. VesselBot's data show clear relationships between CO2 emissions (kg) and CO2 emission intensity (WTW g CO2e/TEU-km) and other modeled parameters.

Although these models show large scattering, due to the diversity of the vessels examined, they evidently show a strong correlation allowing for extrapolations, conclusions, and further examination of case studies, such as those of the voyages shown in **Fig.3**.

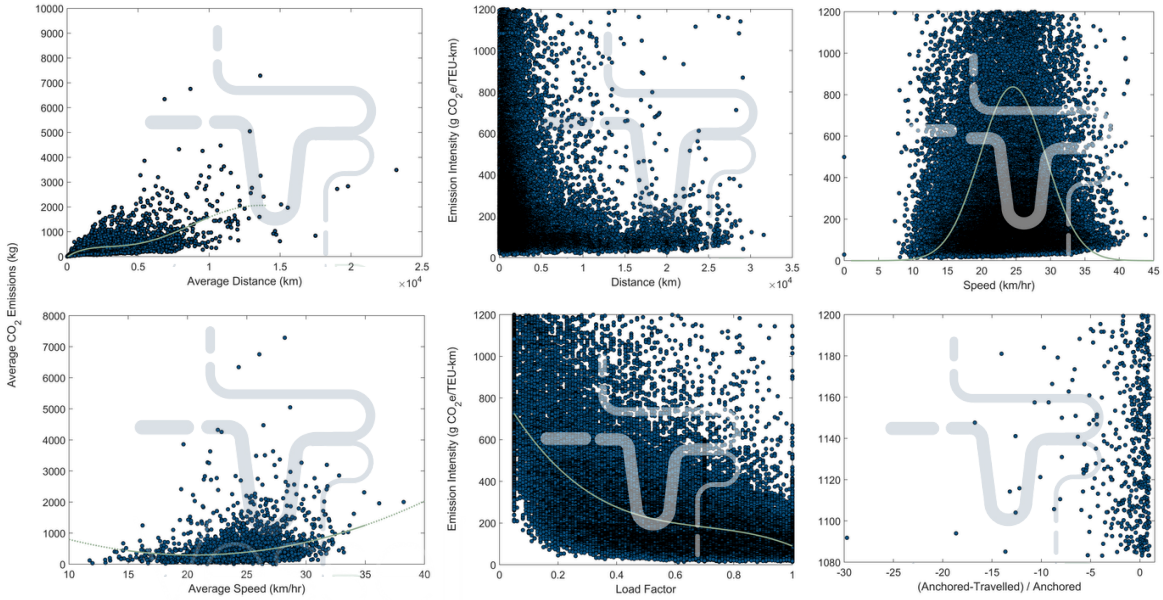

Figure 5: Statistical analysis of various parameters related to CO2 emissions (kg) and CO2 emission intensity (WTW g CO2e/TEU-km).

Source: VesselBot

As seen in **Fig.5**, VesselBot's ability to provide important information about global supply chain behavior, can become more detailed, providing vessel and voyage specific insights. **Fig.6** gives such an example, for voyages in the Pacific and N. Atlantic Oceans with high CO2 intensities, confirming that increased speed, as expected, reduces voyage efficiency.

What is worth mentioning in **Fig.6** is that this relationship differs from vessel-to-vessel, not always following a linear trend and occasionally, for some vessels, showing significantly increased emission intensity even for the same routes.

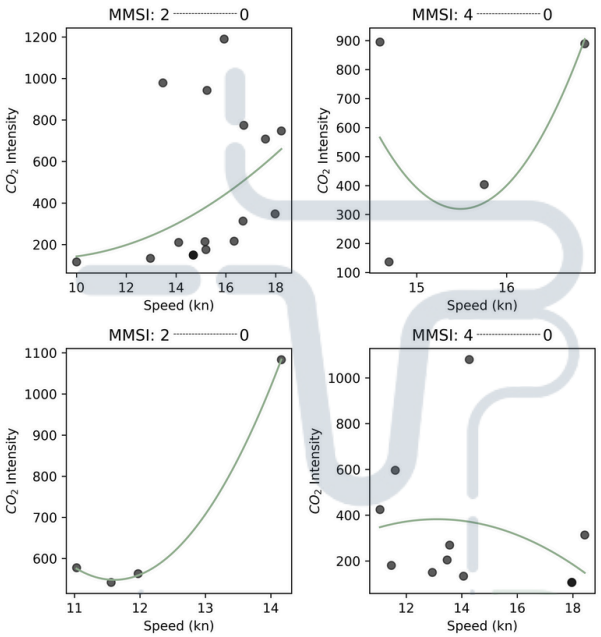

Figure 6: Voyage speed for specific vessels with increase in intensities travelling along the Western Pacific and North Atlantic oceans.

Source: VesselBot

Emissions by Flag States - 2024

Another area of VesselBot's investigation delved into the emissions attributed to flag states, as they play a significant role in emission reductions by setting such policies, and providing incentives to their members to decarbonize their operations.

Fig.8 graphically depicts the average emission intensity per flag by simultaneously showing the size of each flag-state fleet.

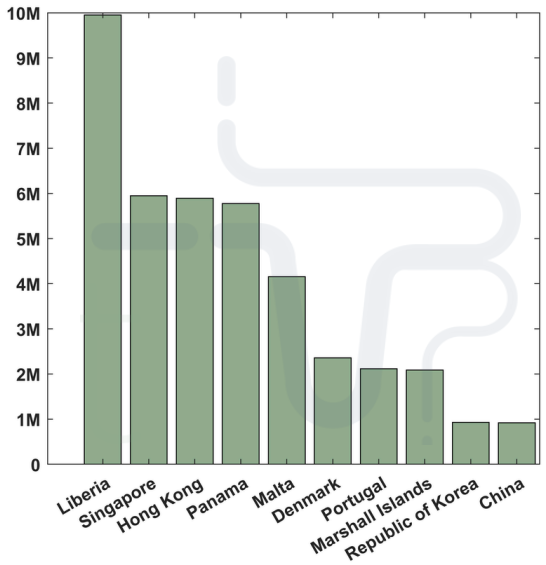

Figure 7: Top 20 Flag States with the highest cumulative CO2 emissions in tons.

Source: VesselBot

Ranking and Analysis of Top Flag States:

As of March 2023, Liberia has emerged as the top flag state with the largest container vessel fleet, followed by Panama, Singapore, Hong Kong, and Malta. A larger vessel fleet implies larger CO2 emissions, but to better illustrate the **contribution of each flag state to global GHG emissions** and to assess the efficiency of each fleet, **it is necessary to analyze not the total CO2 emissions in tons but rather the CO2 emission intensity per vessel per flag state**. **Fig.7** illustrates the cumulative CO2 in tons, but in **Fig.8**, VesselBot graphically represents the volume of each fleet (bubble size) as a function of the average intensity (color bar), allowing one to examine the actual contribution of each flag state rather than taking a cumulative approach.

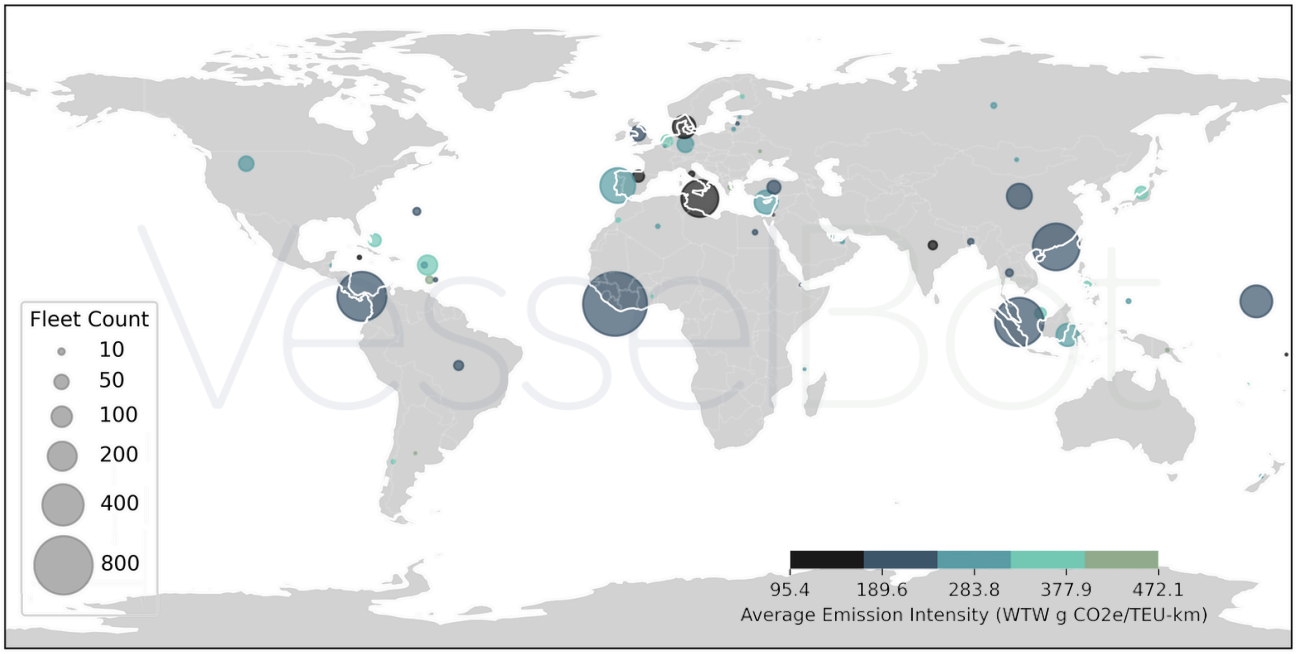

Figure 8: Average CO2 emission intensities (WTW g CO2e/TEU-km) produced by each flag state. The size of each 'bubble' is proportional to the size of the fleet of each flag state, while the color indicates the amount of total emission intensity produced.

Source: VesselBot

Discussion on Leading Contributors:

By closely looking at **Fig.8**, VesselBot provides a much more realistic illustration showing that, while Liberia's flag state owns the largest fleet, its actual CO2 emission intensity per vessel is rather low, suggesting good voyage and vessel efficiency.

Of course, it should be noted that Liberian flag vessels cover cumulative distances ranging from 372 to 69.000 km, with some even conducting 53 voyages during this first trimester of 2024.

On the other hand, VesselBot's data show that Faroe Islands flag-state ships show the largest average intensity (472 WTW g CO2e/TEU-km), which is rather high considering its small fleet of 5 with an average voyage distance of 1289 km.

Finally, with just 3 ships in its fleet, the Cayman Islands flag state shows the lowest average intensities with 95.4 WTW g CO2e/TEU-km and average voyage distances of 2935 km.

Evidently, VesselBot data, enable comparisons between flag-state fleets, providing more details than the common cumulative values, shown in **Fig. 7**, allowing for microscopic investigations which give valuable insights down to vessel-specific level.

Flag-State	Average Intensities
Faroe Islands	472
Tanzania	446
Ukraine	422
Papua New Guinea	413
Saint Vincent and the Grenadines	401

Highest Average CO2 Emission Intensities (in WTW g CO2e/TEU-km) per flag state for the first quarter of 2024.

Flag-State	Average Intensities
Cayman Islands	95
Israel	101
Tuvalu	147
Denmark	151
India	162

Lowest Average CO2 Emission Intensities (in WTW g CO2e/TEU-km) per flag state for the first quarter of 2024.

Quarterly Emissions by Country (2024)

Regional variations were quantified by calculating the total emissions produced by each country. This was determined by considering the number of ports each country hosts and the total kilograms of CO2 emitted by vessels arriving at or departing from these destinations. To accurately represent each country's contribution to global GHG releases, the CO2 emissions in **Fig.9** are normalized against the maximum emission value. Unsurprisingly, **China emerges as the largest contributor to cumulative emissions globally,** given its extensive number of ports, which are among the most frequently used destinations.

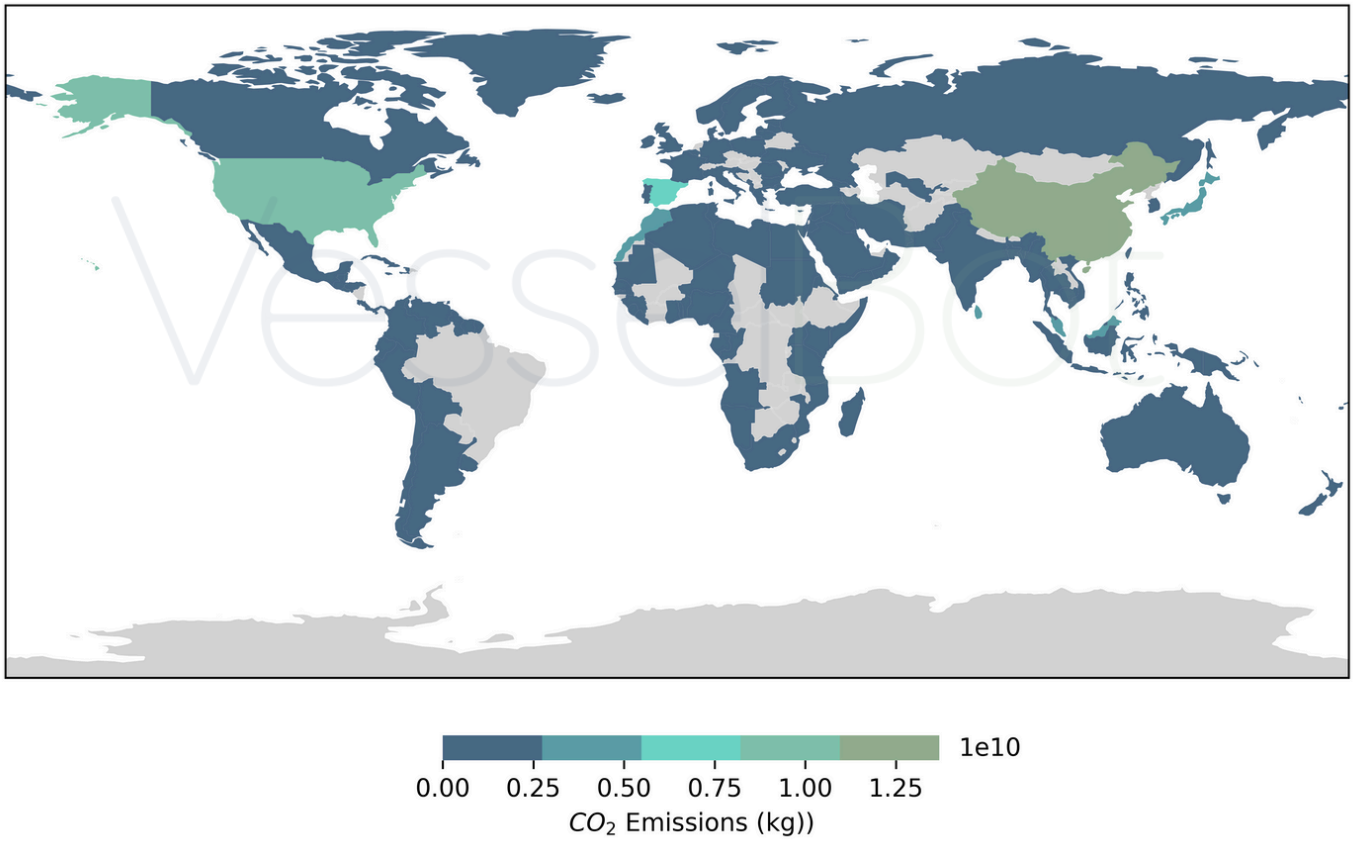

Figure 9: Cumulative CO2 emissions (kg) released by country.

Source: VesselBot

USA Quarterly Emissions (2024)

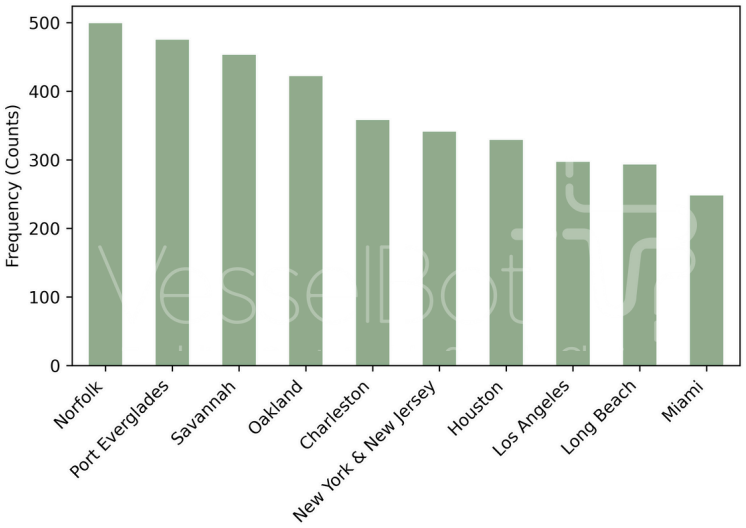

Figure 10: Most visited ports in the (top) USA for the first quarter of 2024.

Source: VesselBot

Following China (140M CO2 kg), the United States show a cumulative 110M value of CO2 kg. Overall, 4931 voyages to and from USA ports are observed in the first quarter of 2024.

Most frequently visited ports are given in **Fig.10** while all 4931 voyages are presented in **Fig.11** color-coded by CO2 intensity measured in WTW g CO2e/TEU-km.

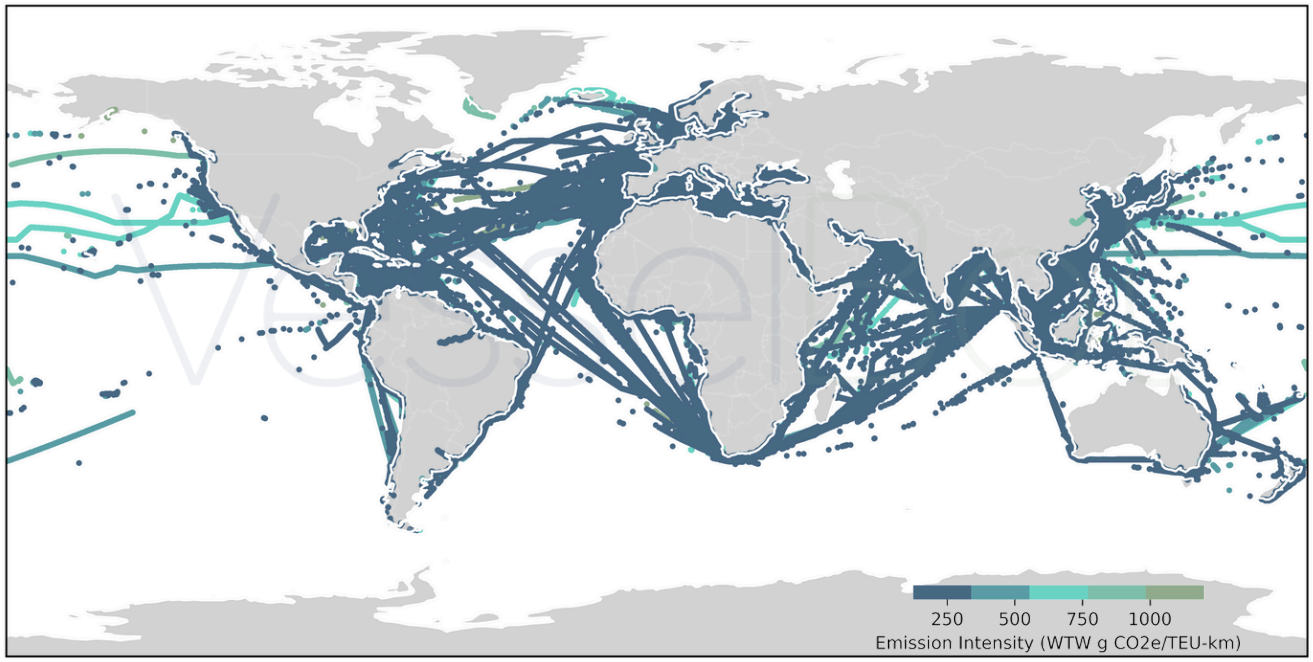

Figure 11: Voyages conducted to and from USA ports during the first quarter of 2024. Each trade line is color-coded based on the CO2 intensity produced.

Source: VesselBot

Observations, Trends, and Conclusion

This final section combines a summary of key findings from VesselBot's 2024 quarterly report with concluding remarks, offering a holistic view of the current state and future implications of maritime emissions, as analyzed by VesselBot.

Key Observations and Trends:

Emissions Reduction in CO2

VesselBot found a decrease in CO2 emission intensity compared to the same quarter from 2021 to 2023, marking a 3.8% reduction from the previous year.

Voyages with the largest CO2 Emission Intensities

Short-range voyages, with average distances of 1669 km, demonstrate the highest intensities globally (>1150 WTW g CO2e/TEU km), suggesting a pressing need for better voyage optimization and port management.

Vessel profile and characteristics are a major factor in assessing CO2 emission intensity. Feeder vessels with < 3000 TEU usually exhibit the highest intensities due to their aged mechanics and operation systems.

Flag State Impact

Although Liberia has the highest total CO2 emissions of ~ 10M, it does not exhibit the highest intensity. After normalizing intensities per fleet volume, the Faroe Islands take first place.

Cayman Islands, Israel, Tuvalu, Denmark, and India are amongst the flag states with the lowest CO2 emission intensities.

Emissions by Country

China emerged as the highest CO2 (kg) emitter, with a value of 140M CO2 kg, followed by the USA, with 110M CO2 kg.

Conclusion

With the International Maritime Organization (IMO) announcing goals for a 70% reduction in emissions by 2050, it is increasingly necessary, if not mandatory, to keep track of CO2 emissions on a global scale.

By including detailed vessel and voyage-specific information, VesselBot ensures the most transparent and accurate reporting of CO2 releases. This enables businesses to precisely track their environmental impact and make informed decisions to reduce their carbon footprint.

By utilizing VesselBot's advanced and fast monitor capabilities, supported by accurate primary data, businesses can address this critical need and align with international sustainability targets and regulations.

As the maritime industry continues its journey toward sustainability, the insights from this report can motivate, facilitate, and contribute to achieving that objective. VesselBot remains dedicated to supporting this progress by offering valuable data and insights for a cleaner and more sustainable maritime future.

About VesselBot

VesselBot is a pioneering technology company that brings transparency to Scope 3 transportation emissions with its Greenhouse Gas Emissions Visibility System. With its deep logistics market expertise, VesselBot enables companies to calculate their carbon footprint accurately and efficiently, facilitating compliance with ESG regulations and helping to reduce GHG transportation emissions. VesselBot provides high-accuracy, primary, and modeled data for all supply chain transportation modes (vessels, airplanes, trains, and trucks).

Definitions

1. All emission measurements are based in Kg of CO2 emitted per tonne of goods shipped or TEU
2. Container Ship sizes by nominal TEU capacity
   - Cellular (100-2500)
   - Panamax (2,500-3,400)
   - Panamax-Max (3,400-4,000)
   - Post Panamax I (4,000-6,000)
   - Post Panamax II (6,000-11,000)
   - VLCS – Very Large Container Ships (11,000-15,000)
   - ULCS – Ultra Large Container Ships (15,000-21,000)
   - Megamax (21,000-25,000)
3. Greenhouse gas (GHG) emissions - Gases that trap heat in the atmosphere are called greenhouse gases[1]. Greenhouse gas emissions are the sum of emissions of various gases: carbon dioxide, methane, nitrous oxide, and smaller trace gases such as hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF6)[2].
4. Carbon Intensity Indicator (CII) – Carbon Intensity Indicator (CII) measures/calculates the efficiency of a ship in transporting cargo or passengers in terms of its CO2 emissions per nautical mile and carrying capacity.
5. Energy Efficiency Existing Ship Index (EEXI) - The Energy Efficiency Existing Ship Index (EEXI) is a measure introduced by the IMO to reduce the greenhouse gas emissions of ships. The EEXI is a measure related to the technical design of a ship.

[1] - https://www.epa.gov/ghgemissions/overview-greenhouse-gases
[2] - https://ourworldindata.org/greenhouse-gas-emissions

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