VesselBot

Enabling Sustainable Supply Chains

Decoding Maritime Emissions

Trends and Insights from the First Half of 2024

SEPTEMBER 2024

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1. Introduction

This report delves into the complexities of global container vessel emissions for the first half of 2024, highlighting a critical trend: while CO2 emission intensity continues to decrease, signaling improved efficiency, total CO2 emissions are on the rise. This dichotomy raises concerns about the industry's ability to achieve the ambitious net-zero targets set by the International Maritime Organization[1]. The report explores the factors driving this trend, including geopolitical tensions, trade route disruptions, and port inefficiencies, providing valuable insights for stakeholders seeking to navigate the path to decarbonization in the maritime sector.

According to the Intergovernmental Panel on Climate Change (2023)[2], the need to drastically and quickly reduce CO2 emissions has become mankind's major goal in order to fight global warming and secure a safe future. Due to political initiatives though, emitting CO2 has become more expensive for industries. For example, the price for an EU ETS certificate of one ton of CO2 equivalent increased from 34 € at the beginning of 2021 to about 70,7€ in September 2024. With this rise in cost, alternative options for preventing CO2 entering the atmosphere are widely discussed, especially options that promise to effectively contribute to the ambitious 1.5 °C goal of the Paris Agreement (United Nations, 2015).

Carbon neutrality within the supply chain signifies the attainment of net-zero CO2 emissions. Reaching this objective can be achieved through various means, including carbon taxes, cap-and-trade systems, carbon footprint reporting, and accounting mechanisms. However, the most important tool is visibility. Increased visibility of supply chain emissions is a critical contributor to decarbonizing the global economy and transport. It can advise corporate decisions around procurement, product design, research and development (R&D), financial decision-making by investors, product distribution modes and product transport efficiency.

Types of Data

To meet these requirements, companies need to report trustworthy data. However, policymakers are still grappling with the question of how to correctly measure supply chain emissions. In addition to measuring, reporting and addressing their direct emissions (Scope 1) and indirect emissions from purchased energy (Scope 2), companies are increasingly facing far-reaching expectations to track emissions from upstream and downstream activities in their value chains (Scope 3). Scope 3 reporting has largely been voluntary, driven by consumer, buyer, investor, employee, and civil society expectations, among others. However, legislations like CSRD in EU, SEC in US and standards like ISSB, already require Scope 3 disclosure and others that are underway are shifting the landscape, making this a mandatory requirement. The type of data (**Fig. 1**) used in CO2 emission reporting has a direct influence on the accuracy of the results, and therefore on the degree to which results can be used, analyze the efficiency of transport operations, and track emission reduction actions.

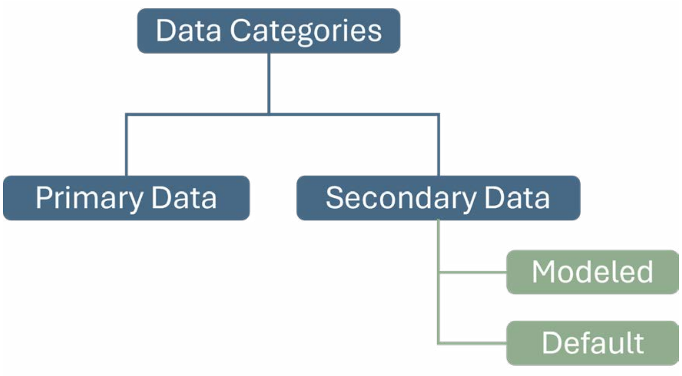

Figure 1: *Types of data in line with ISO 14083.*

- **Primary Data**: Refers to values coming from direct measurements or calculation based on direct measurements.
- **Secondary Data**: Not primary and differentiated into two categories; Modeled and default.
  - **Modeled data** can be generated based on the availability of primary data and are used for further modeling (prediction and forecasting) techniques.
  - **Default data** are those used when no other is available and are representative of average industry operating practices.

Leader in transportation emission analytics, VesselBot highlights **the true value of detailed and accurate primary emission data** for shippers, supply chain stakeholders, and industry leaders. VesselBot's scientific approach, established on primary data collection and optimization, provides the most accurate, real-time, measurements of CO2 emissions along all transport modes. Unlike broad and often inaccurate default/averages, **VesselBot offers precise insights into real-time conditions**, enabling accurate measurement and management of GHG emissions along all transportation modes.

Herein, VesselBot provides a full report of 2024 sea-transport CO2 emissions by incorporating data for the 2nd-trimester of 2024 (January – June 2024).

2. Statistical Analysis

Yearly Statistical Analysis

Incorporation of 2nd-trimester data into our analysis shows a continuous decline in CO2 emission intensity from 2021 (**Fig. 2**). Emission intensity provides an excellent and unique measure of a vessel's and/or a voyage's environmental efficiency by relating cargo load transferred, distance travelled, and actual CO2 emissions. Although essential in assessing the efficiency of global sea-transport it does not necessarily indicate its imprint on the environment. It is essential, therefore, to differentiate between CO2 emission intensity and actual CO2 emissions coming from direct measurements or calculations involving actual measured data. Nonetheless, CO2 emission intensity remains the most important parameter as it is the one that needs to be reduced to obtain a global sustainable vessel fleet.

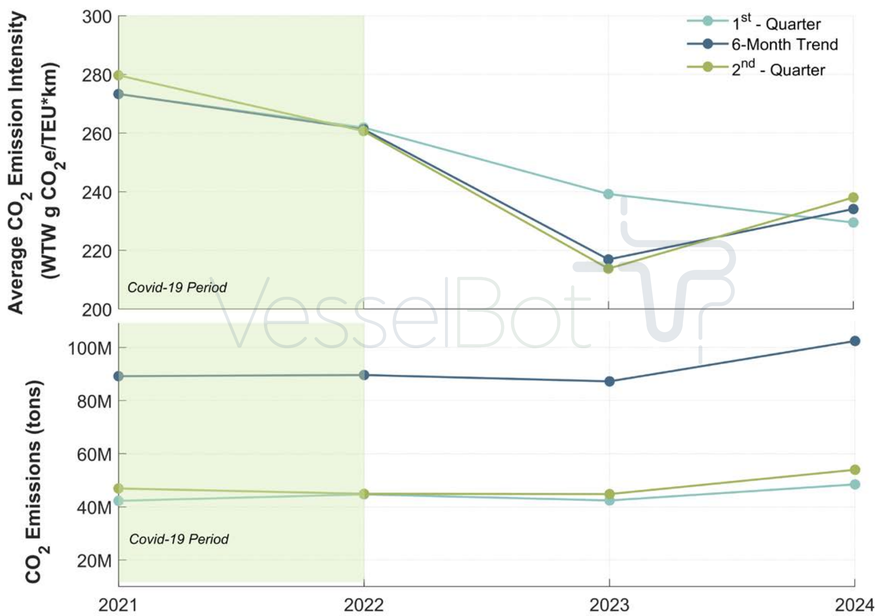

Figure 2: *Emission intensity (WTW CO2e g/ TEU*km) and CO2 emissions (tons) since 2021.*

Emission intensity is steadily reducing throughout the years (for the periods of the 1st and 2nd trimesters, separately, and for the first 6 months of 2021-2024 cumulatively). This is a direct indication of better fleet and voyage efficiency. On the other hand, CO2 emissions are found to have been significantly increased in 2024. However, it is important to mention that the COVID-19 pandemic impacted the years 2021-2022 and might not represent the standard patterns.

These statistics underscore the need of more drastic measures to reach net-zero GHG emissions from international shipping by or around 2050, a commitment set by the International Maritime Organization (IMO) in 2023. Achieving this monumental task necessitates reducing not only the CO2 emission intensity but all direct GHG emissions from the entire shipping sector.

Statistical analysis for the first 6 months of 2024 shows an increase in both emission intensity and CO2 emissions (see **Fig. 3**). This global landscape may reflect the implications of environmental factors and geopolitical tensions in the shipping sector. The continuous turmoil in the Red Sea[3] has sent shockwaves through commercial shipping industries as strategic routes have been compromised. Russia's war against Ukraine has inflicted major disruptions, particularly through the re-routing of commercial and cargo vessels. Finally, the Panama Canal restrictions are forcing shippers to look for alternative options. Unfortunately, the alternative requires choosing longer routes and therefore leads to increased CO2 emissions.

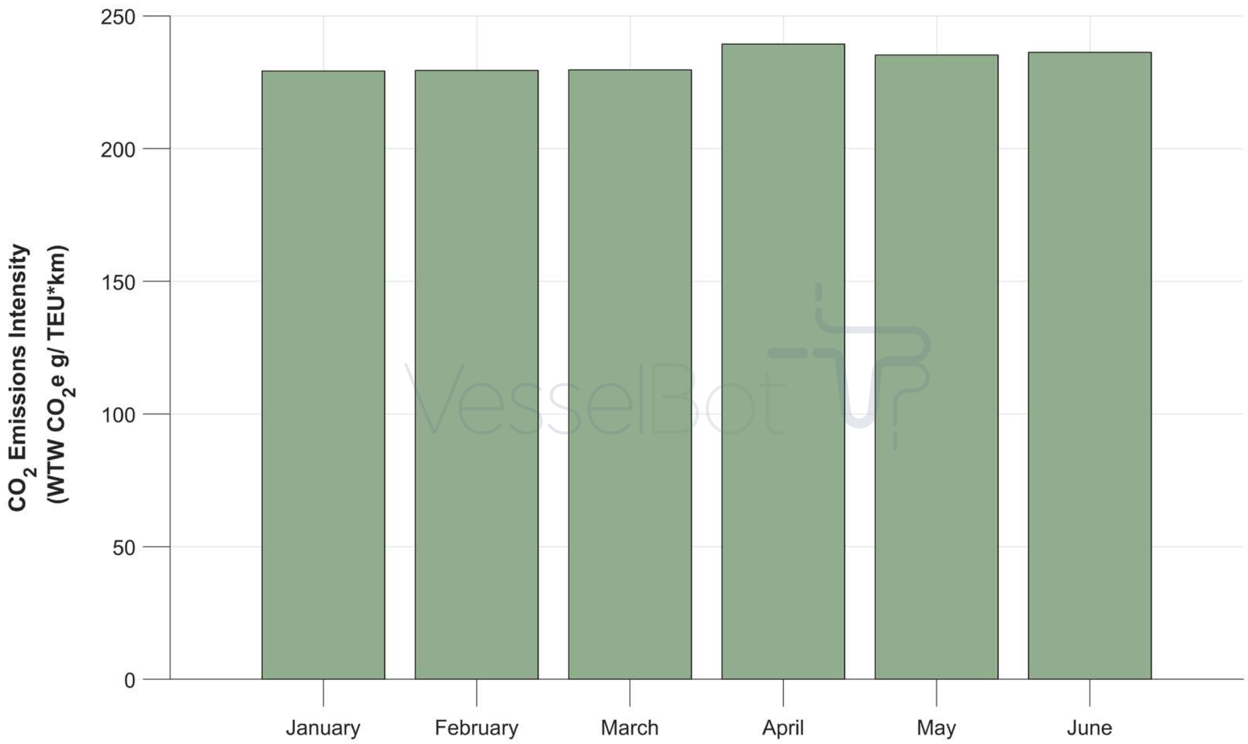

Figure 3: *Monthly variation of CO2 emission intensity for the first 6 months of 2024. Intensity is peaking in April.*

> *At VesselBot, we offer alternative options and route optimization. Tracking shipments along their entire voyages enables for high-precision decision-making and can reduce costs, delivery times, and CO2 emissions.*

3. VesselBot's report "The Red Sea Under the Microscope: A Continuous Impact on Global Trade and Emissions" describes this turmoil and its consequences. You can find the link of the report in the Anex page.

Utilization Factor and Cargo Load for 2024

TEU (Twenty-foot Equivalent Unit) is a unit of measure used to determine cargo capacity for container ships and terminals. The total TEU transferred in global sea transport from January to June was 406.918.481,6, with the majority transferred during the months of March and April 2024 (**Fig. 4**). VesselBot's data show that the average load factor is systematically increasing, suggesting that some vessels are more loaded and thus more efficient despite the reduced number of active vessels per month (**Fig. 4**).

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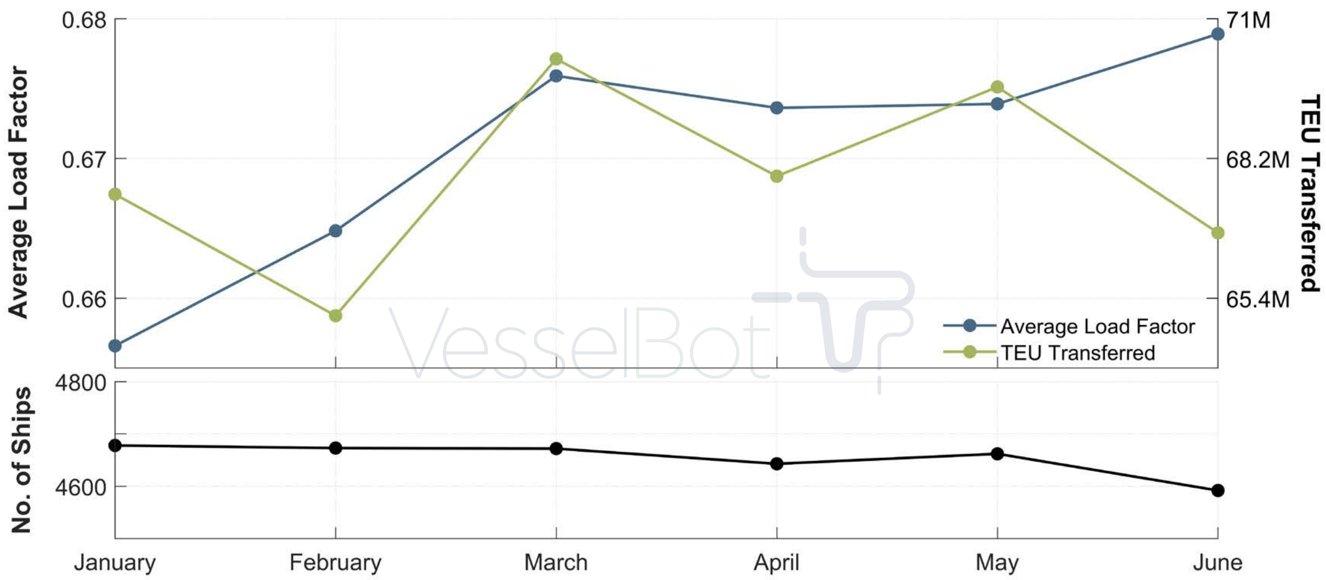

Figure 4: *Variations in average load factor, total TEU transferred, and number of active ships for the first 6 months of 2024. Despite the increase in the average load factor, total TEU varies; a direct consequence related to the number of ships travelling each month.*

To better understand the role of the utilization factor, VesselBot shows each vessel type that undertook journeys in 2024 (**Fig. 5a**). Post-P'max vessels with a minimum capacity of 17.000 TEU have the highest average utilization, almost 70%, while Neo-P'max with a capacity of 12.000-17.000 TEU have the lowest, almost 65%. On the other hand, the total TEU transferred during the first two quarters of 2024 shows that in the second quarter, an additional 1.460.671 TEU were transferred (**Fig. 5b**).

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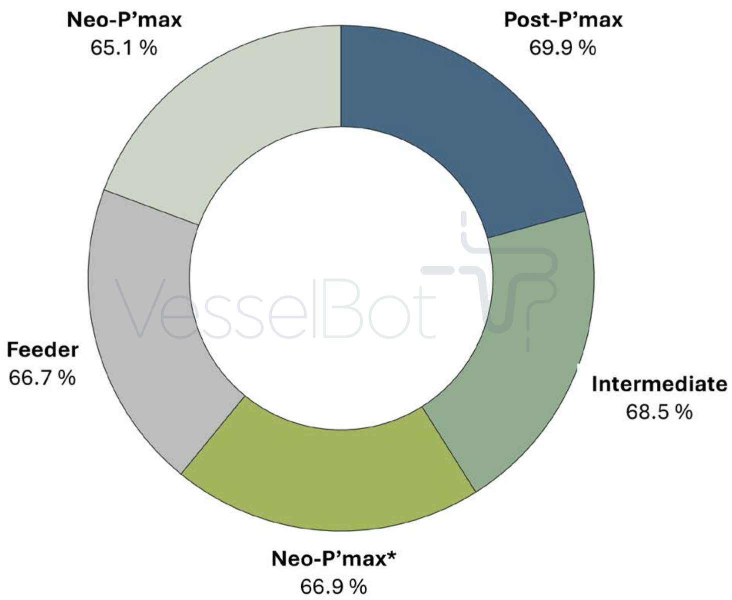


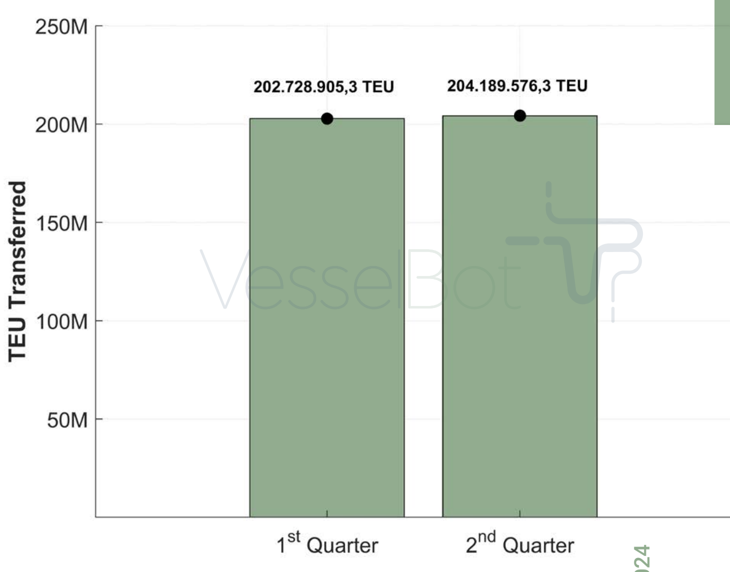
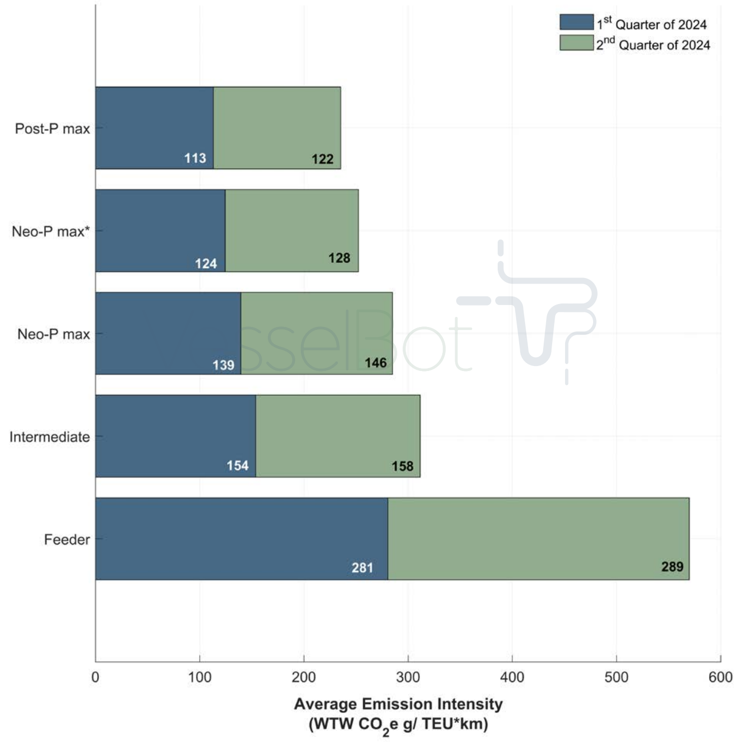


Figure 5: *a) Utilization, i.e., load factor per vessel type conducting journeys during the period of January-June 2024. b) Total TEU transferred during the period of January-June 2024.*

Further investigation of each vessel type's to CO2 emissions reveals that Feeder vessels, with a maximum capacity of 3.000 TEU, have the lowest efficiency with significantly increased average emission intensities, surpassing 280 WTW CO2e g/TEU*km (**Fig. 6**). On the other hand, intermediate vessels are the largest emitters of CO2, followed by Feeder vessels (**Fig. 7**).



Feeder vessels have the lowest efficiency

Figure 6: *Average emission intensity for all vessel types for both quarters of 2024. The highest contributors are Feeder vessels while Post-P'max come last.*

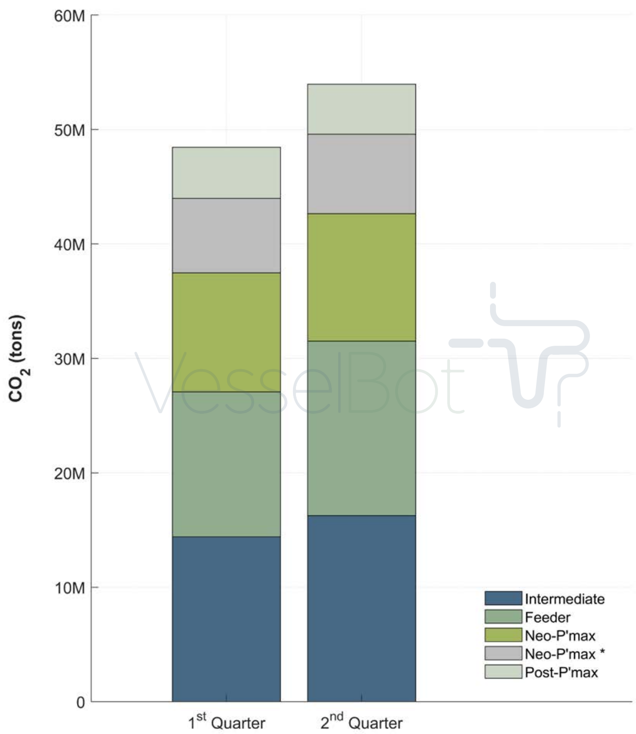


Figure 7: *CO2 emissions for all vessel types, with Intermediate vessels being the highest contributors in both quarters.*

These results, nonetheless, are somewhat expected considering the short-range journeys Feeder vessels conduct and the large volume of Feeder and Intermediate vessels in the global fleet (**Fig. 8**). Finally, regarding vessel types, VesselBot analysis shows that vessel speed (in knots) varies significantly among vessel types, with those for Neo-P'max and Post-P'max significantly decreased during the 2nd quarter, while the opposite trend was observed for the remaining types (**Fig. 9**).

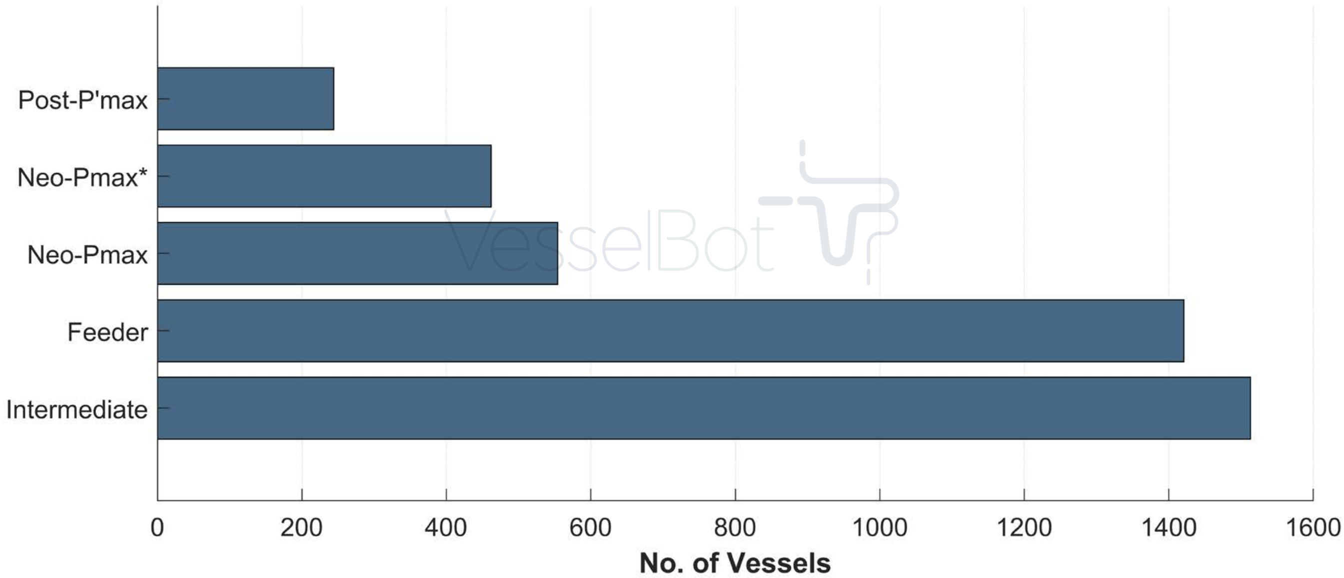


Figure 8: *Number of vessels per type for the period January-June 2024.*

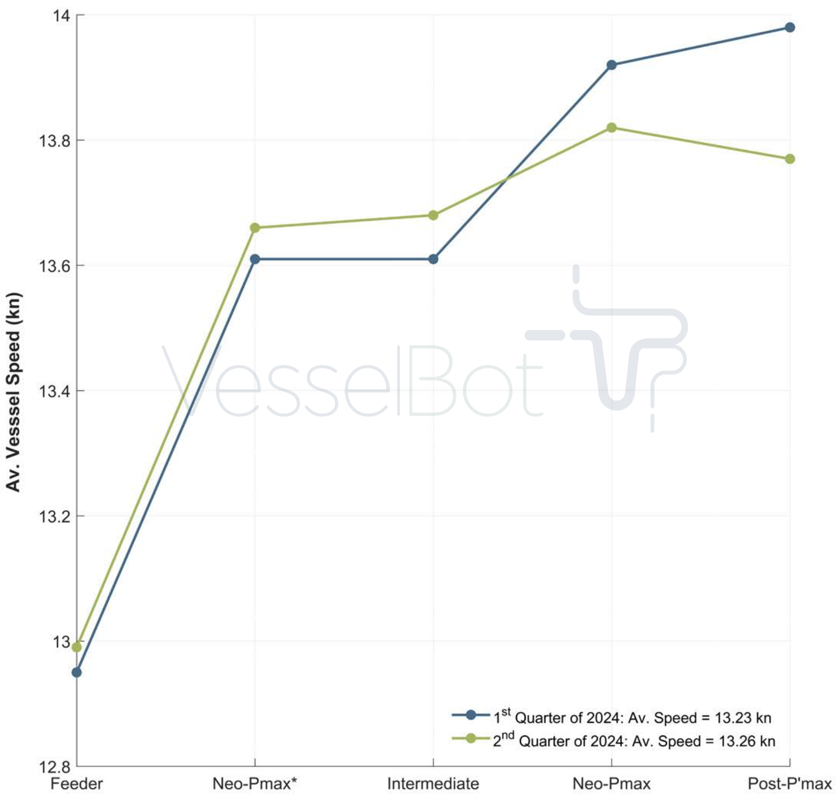


Figure 9: *Vessel speed per type for the period January-June 2024.*

Utilization (i.e., load factor) is likely one of the most important factors to influencing CO2 emission intensity. As it affects vessel and voyage efficiency, vessel capacity should be maximized to increase the total TEU transferred by each vessel. Increasing the total TEU per vessel results in more efficient voyages with less environmental impact.

As seen in **Fig. 10**, there is a direct relationship between the two parameters, following an exponential trend; the lower the TEU a vessel carries, the larger the CO2 emission intensity and hence the environmental and economic impact.

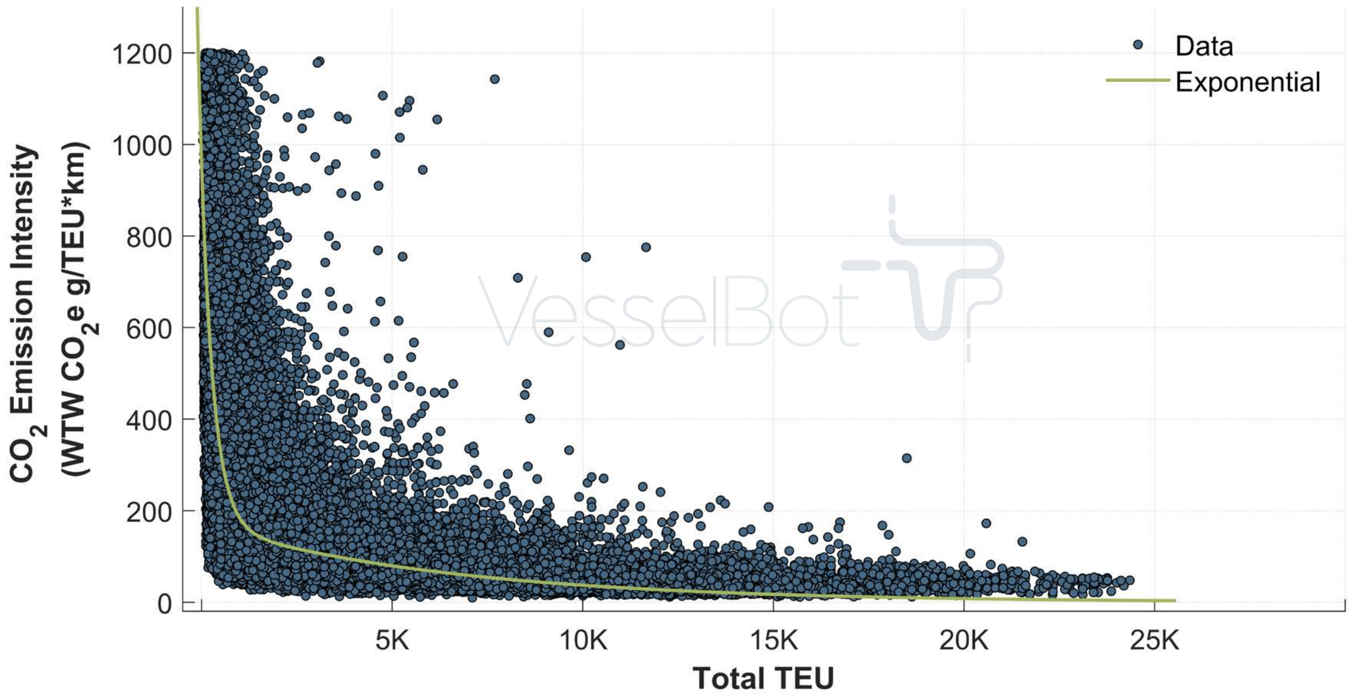


Figure 10: *The relationship between total TEU transport and total emission intensity.The lower the TEU carried by a vessel the higher the CO2 emission intensity.*

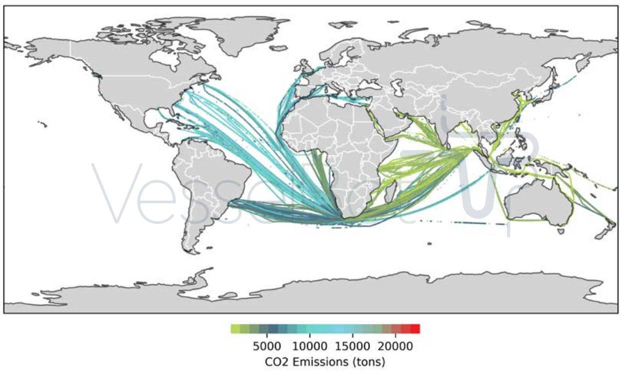
3. Voyage & Trade Lane Analysis for 2024

Real-time monitoring of major trade lanes allows for the direct estimation of CO2 emis-sions (tons) and CO2 emission intensity (WTW CO2e g/TEU*km). By separating the trade lanes based on location we can identify outliers and examine their operation procedures. To better illustrate this, a few examples are presented in following sections.

Voyages Terminating at Singapore

Investigation of voyages terminating at Singapore port (SGSIN) indicate the current implications of the Red Sea crisis, with only a fraction of the voyages departing from Europe transversing through the Red Sea, re-routing around the coast of Africa. Maps in **Fig. 11** show the CO2 emissions (tons) and intensity (WTW CO2e g/TEU*km) of all major voyages arriving at the port of Singapore. The re-routing (from Europe) around the coast of Africa leads to increased emis-sions, ranging between 10,000 to 15,000 tons (**Fig. 11a**). On the other hand, VesselBot data show increased emission intensities between the USA and Singapore, some even exceeding 1,000 WTW CO2e g/TEU*km (**Fig. 11b**). To identify the source of this outlier, we should examine voyage cargo information. Indeed, we discover that vessels departing from the USA have a much lower utilization factor, meaning vessel capacity was poorly utilized (**Fig. 12**).

To better understand this, it’s worth observing China. They are more than 80% occupied and carry the largest cargo load to the port of Singapore, while simultaneously their voyages demonstrate the smallest CO2 emissions and CO2 emission intensities throughout the period of January to June 2024.



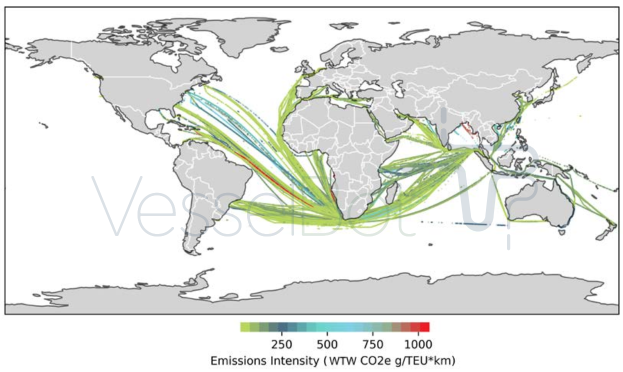


Figure 11: *a) CO2 emissions (tons). b) CO2 emission intensity (WTW CO2e g/TEU km) for all voyages arriving at the port of Singapore, for the period January – June 2024.*

CO2 emissions are found to be the largest for voyages departed from the USA and Europe. Those of Europe, though, may be a result of the re-routing around the coast of Africa that was an immediate response to the tensions within the Red Sea. Voyages originated from the USA also show high emission intensities, a direct outcome of the low vessel utilization and large cargo load (**see Fig. 12**).

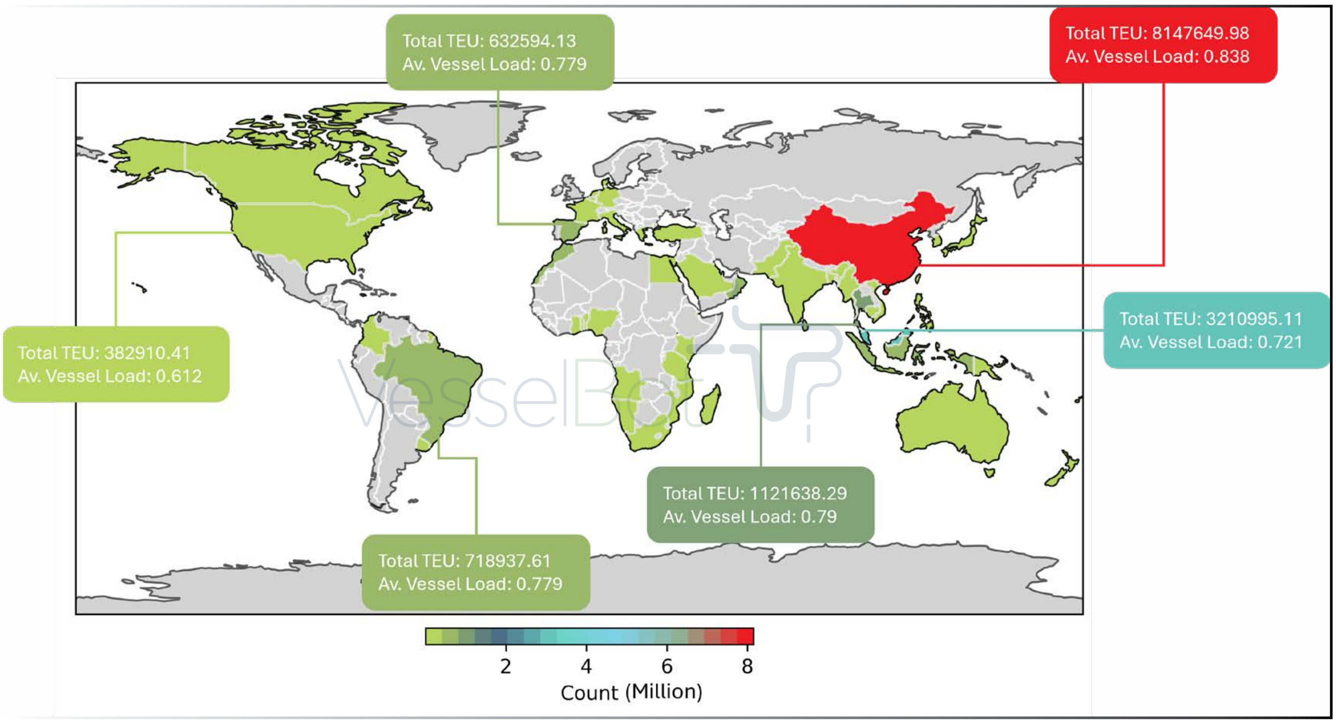


Figure 12: *Cumulative cargo (measure in TEU) arriving to the port of Singapore based on origin country. VesselBot data show that vessels departing from the USA have a low utilization factor and large load. This along with the high number of voyages conducted between the USA and Singapore, will lead to increase emission intensities.*

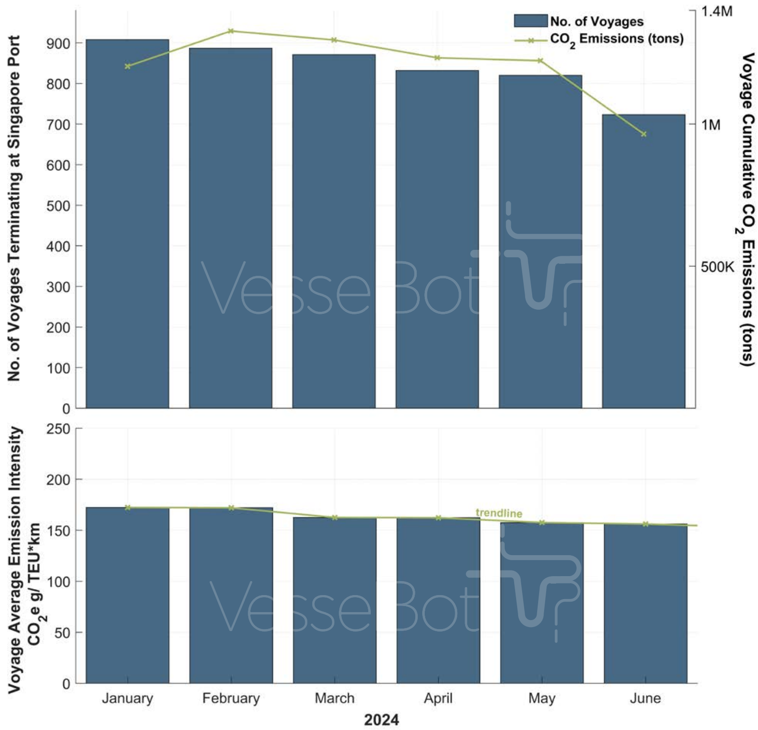


Figure 13: *Number of voyages arriving at the port of Singapore, along with their emitted CO2 and emission intensities.*

Decoding Maritime Emissions - September 2024

Re-routing around South Africa increased CO_2 tons by 20K

Voyages Departing from China

Similarly, examining all major voyages departing from China reveals a pattern similar to those arriving at Singapore. The re-routing around the coast of Africa is again prominent, leading to increased CO_2 emissions, with some even exceeding 20,000 tons (**Fig. 14a**). However, emission intensity remains consistently below 250 WTW CO_2e g/TEU*km, indicating good voyage and vessel efficiency without outliers in major routes (**Fig. 14b**). Indeed, an investigation of the utilization factor shows that most vessels operate at over 85% capacity, with many even above 90%. Only voyages terminating in Russia are at 71% capacity, the lowest detected for vessels departing Chinese ports.

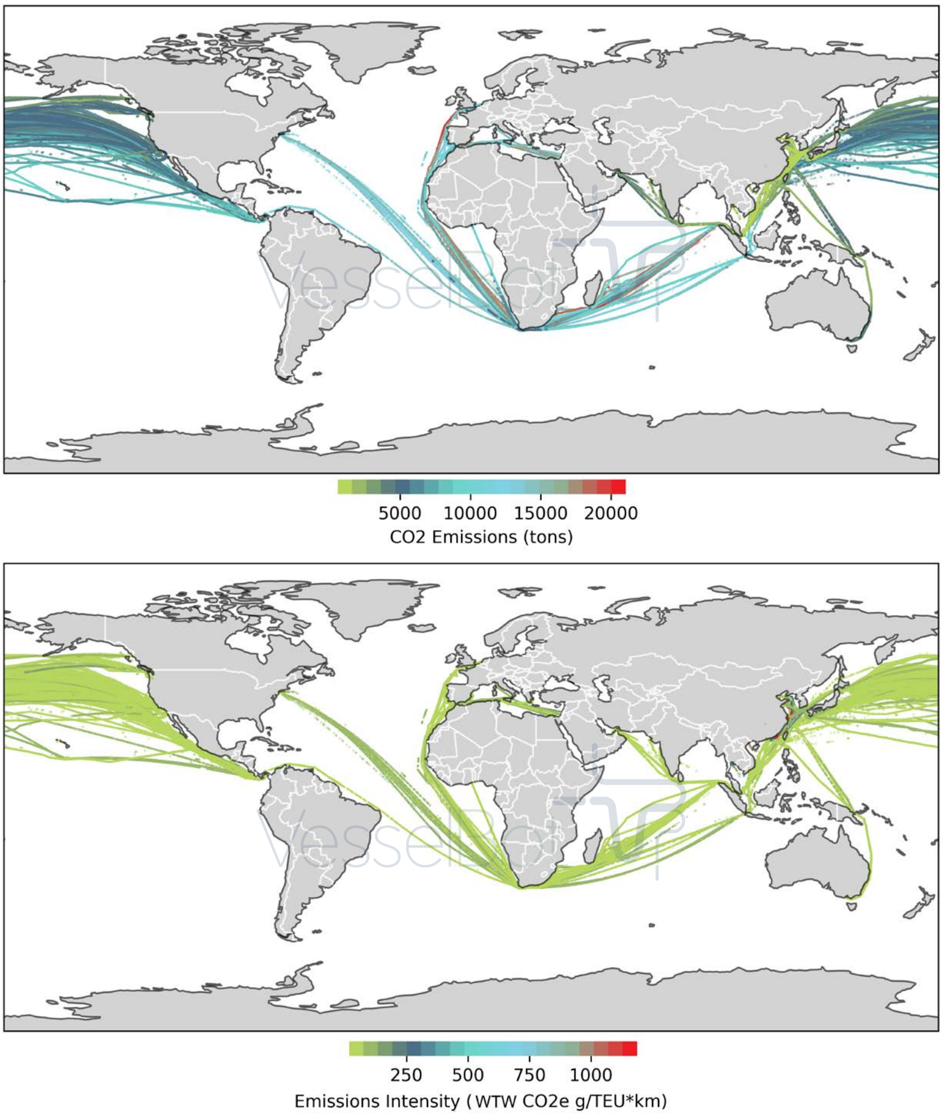
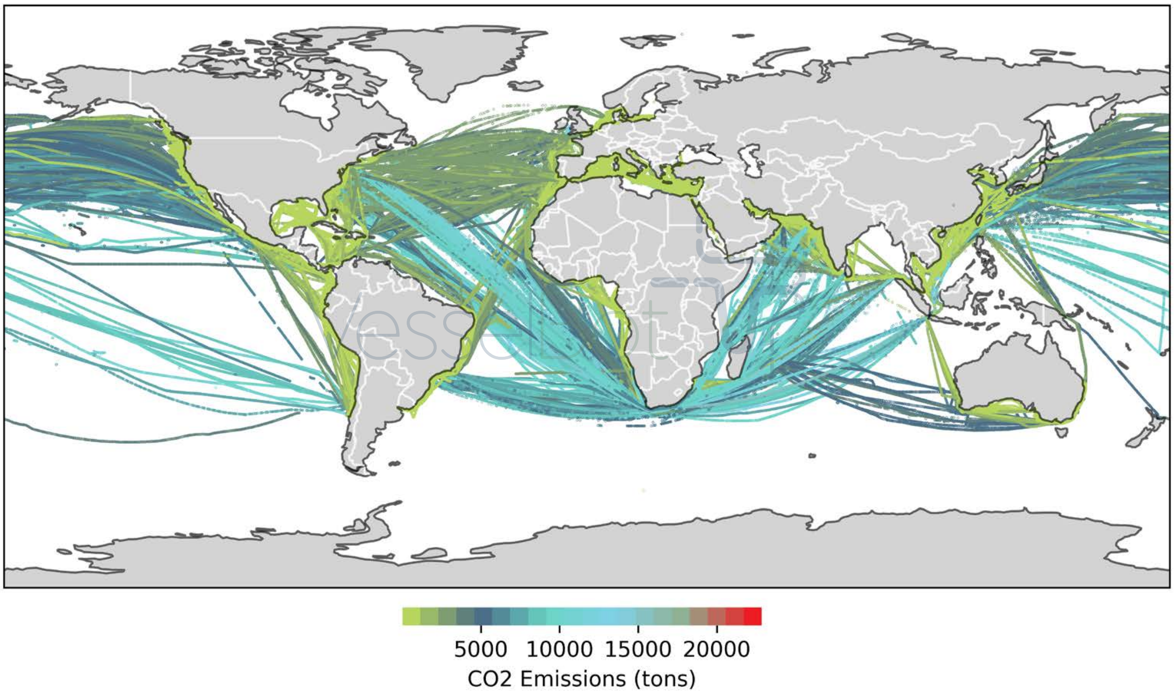


Figure 14: *CO_2 emissions (tons) and CO_2 emission intensity (WTW CO_2e g/TEU km) for all voyages departing the ports of China, for the period January – June 2024. CO_2 emissions are found to be the largest for voyages heading towards Europe, a result of the re-routing around the coast of Africa due to the tensions within the Red Sea. CO_2 intensities, though, remain consistently low, showing good voyage and vessel efficiency.*

Global Investigation

Plotting all major voyages again reveals a similar pattern (**Fig. 15**) but underscores the importance of individual trade lane investigations, as overlapping data can obscure important results and outliers. Overall, **Fig. 15** shows expected results, with high CO2 emissions between Asia and the USA, and Asia and Europe. Reduced congestion is observed within the Red Sea[4], with many voyages re-routing around the coast of Africa.



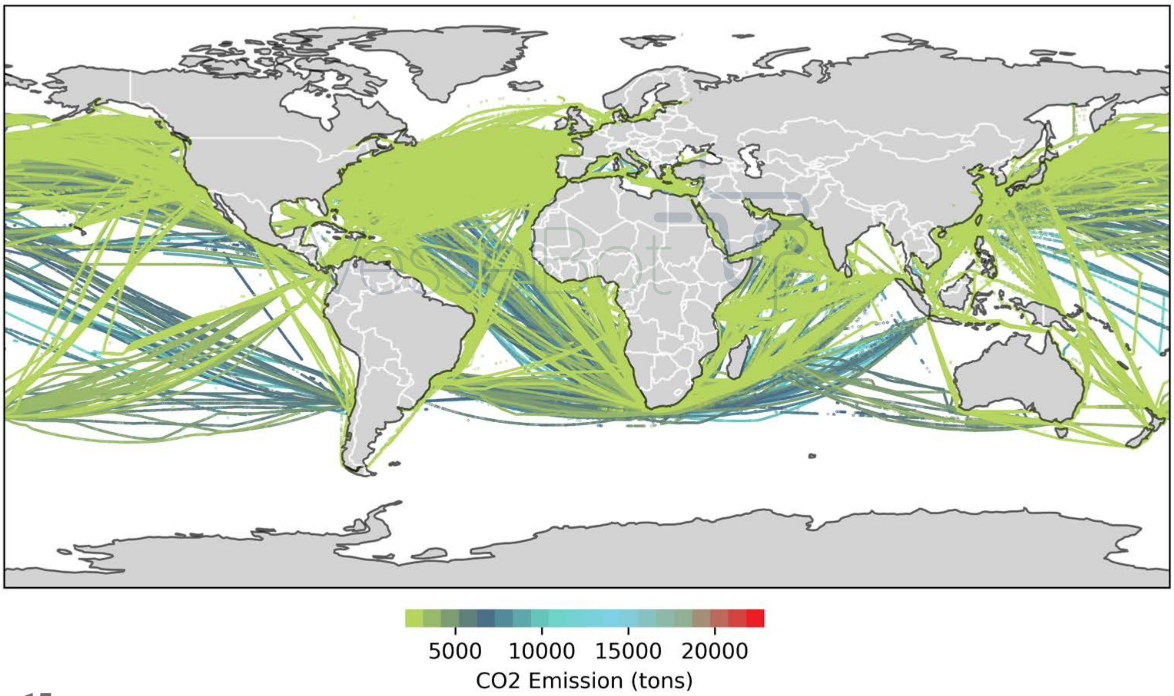


Figure 15:
*CO2 emissions (tons) and CO2 emission intensities (WTW CO2e g/ TEU*km) for major global voyages. CO2 emissions are found to be increased between Asia – USA and Asia – Europe, while USA – Europe and intra-continent/country being reduced; a direct outcome of voyage distance (km) and voyage speed (knots). Intensity on a global scale seem consistently low, below 300 WTW CO2e g/ TEU*km, but with some outliers exceeding 1000 WTWCO2e g/ TEU*km. This map in particular, highlights the need of trade lane specific investigations to avoid data overlapping.*

4. Port Emissions - VesselBot's Unique Approach

In past reports, VesselBot introduced its new mathematical approach for measuring port-specific CO2 emissions by analyzing engine usage (auxiliary and main) for each vessel within a port basin. In general, a vessel conducts four operations within a port basin (**Fig. 16**), with engine usage varying for each (**Table 1**). Engine utilization is the most crucial parameter in this analysis, so each vessel should be carefully examined beforehand to determine its engine-specific characteristics. An additional parameter used in this analysis is the emission factor, measured in g/kwh. This parameter depends on the vessel's speed within port basins (**Table 2**).

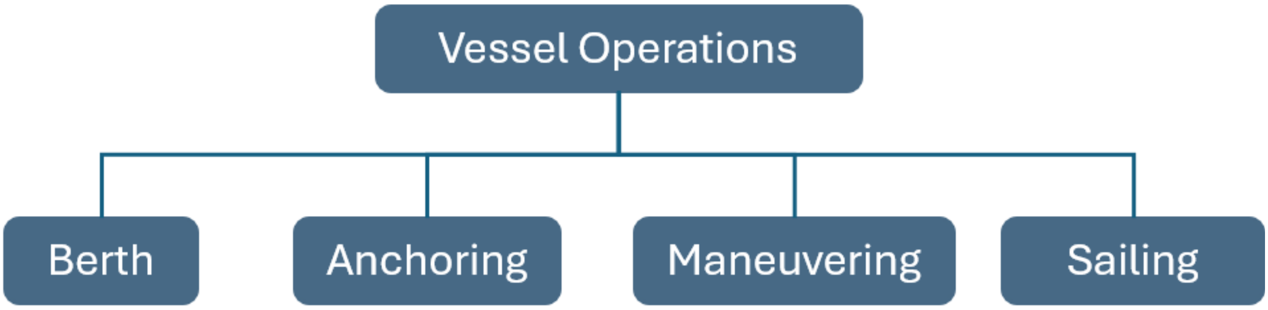


Figure 16: *Vessel operations while within port basins. Each operation requires different usage of the main and auxiliary engines (***see Table 1***).*

Table 1: Vessel engine operation within a port basin.

Engine	Sailing	Maneuvering	Berth	Anchoring
Main	30%	25%	0%	20%
Auxiliary	40%	50%	40%	40%

Table 2: CO2 emission factor of vessel engines during different speed operations.

Engine	Operation	Emission Factor (g/kwh)
Main	Slow speed diesel	620
Main	Medium speed diesel	683
Main	High speed diesel	686
Auxiliary	Medium speed diesel	683

Implementing this technique intends to help port authorities and other port operators; state and local governments, those doing business at ports (such as terminal operators, tenants, and shipping companies), local communities, and other stakeholders who want to detect areas of improvement to reduce port emissions.

In this paragraph, the use of VesselBot's unique collection of primary data allows a detailed investigation of several ports. Examples include ports of the USA, Europe and Asia all showing the different capabilities of VesselBot's data and analytical methodologies.

United States of America

The yearly (2021-2024) pattern of voyages between the USA and other countries varies significantly. The impact of Covid-19 is evident in the year 2021, with global trade increasing rapidly in the following years, particularly with China. Similarly prominent variations are observed in 2023, with no trade with Australia. In 2024, the geopolitical tensions in Europe, between Russia and Ukraine, have altered the pattern, with no voyages between the USA and Russia and massively reduced trade with China. Additionally, in 2024, increased trade with countries in South and West Africa underscores the vessel re-routing due to the Red Sea crisis (**Fig. 17**).

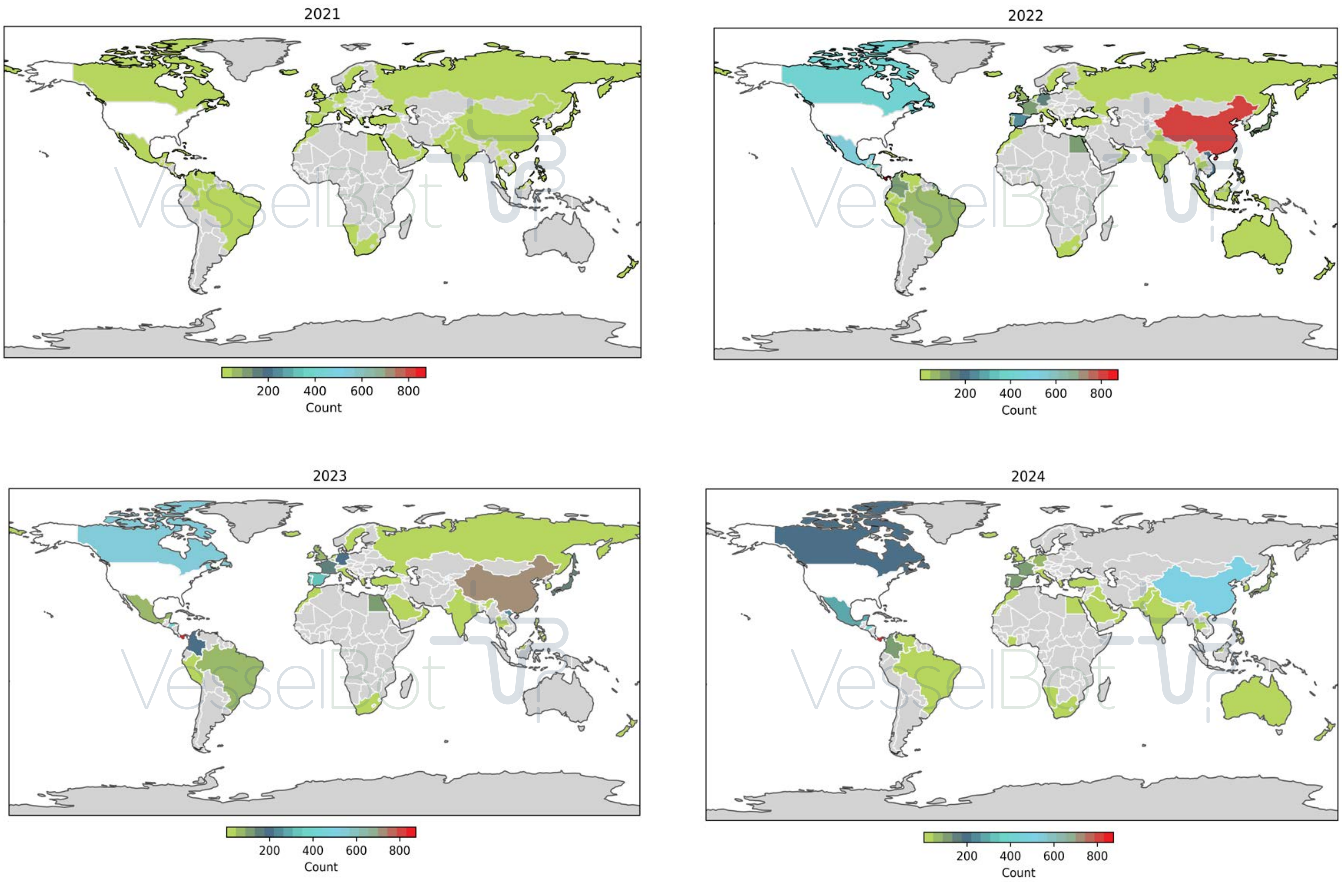


Figure 17: *Yearly count of voyages between the USA and other countries, spanning from 2021 to 2024. The effects of Covid-19 and geopolitical tension are visible and are shaping the global cargo trading pattern.*

Herein, seven (7) ports are investigated for the first 6 months of 2024, including the ports of Long Beach, Norfolk, Houston, Mobile, Savannah, New York and Oakland. To measure port emissions, it is necessary first to record all voyages terminating at these ports and present their statistics. In **Fig. 18** voyage average emission intensity is presented, for each of the first 6 months of 2024, arriving at all 7 abovementioned ports, while in **Fig. 19** shows the cumulative CO2 emissions of those voyages.

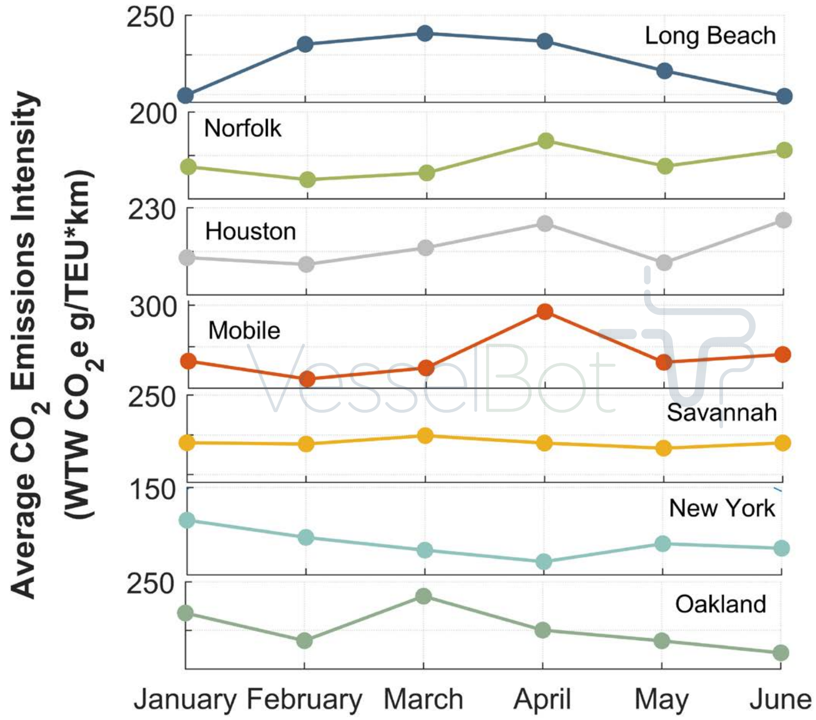


Figure 18: *Average CO2 emission intensity for all voyages terminating at 7 ports of the USA, for the period January – June 2024.*

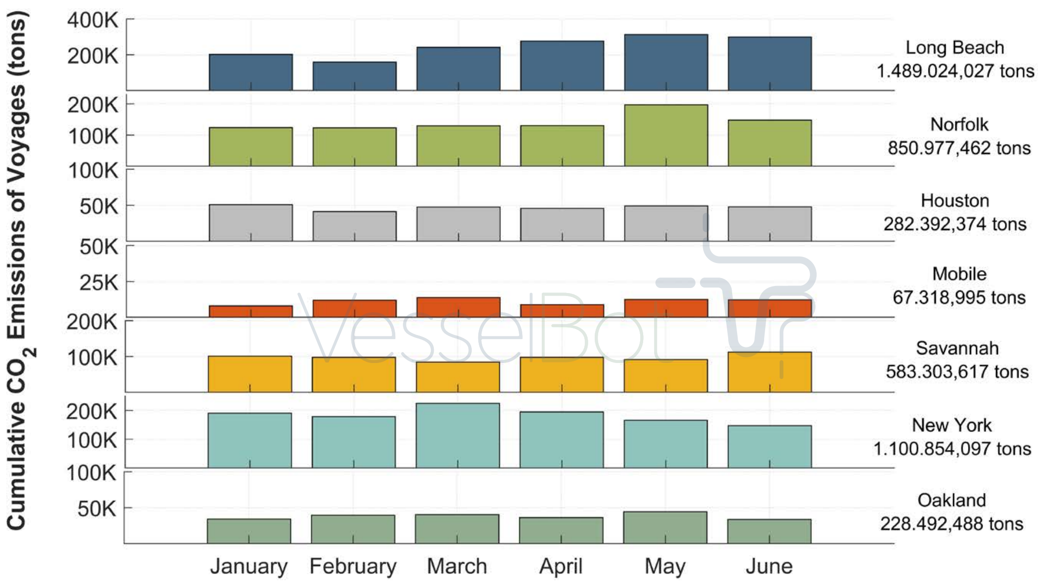


Figure 19: *Cumulative CO2 emissions for all voyages terminating at 7 ports of the USA, for the period January – June 2024.*

The next step in this analysis is to map in detail the ports' geometry and categorize vessel operations. In **Fig. 20** and **Fig. 21**, an example is given for the port of Long Beach, with Terminals and Anchorage areas mapped and vessel speed categorized. Speed = 0 representing berth operation, 0 > speed < 2 representing anchorage, 2 > speed < 5 representing maneuvering and finally speed > 5 representing sailing.

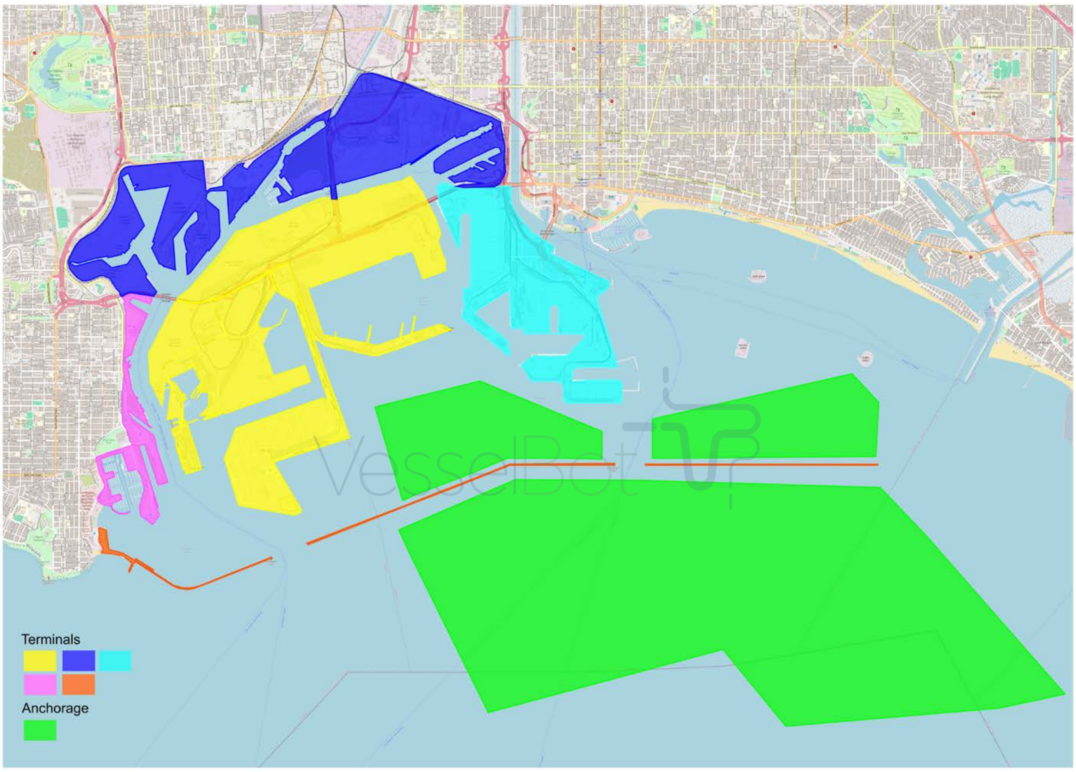


Figure 20: *Mapping of Long Beach port, highlighting Terminal and Anchorage areas.*

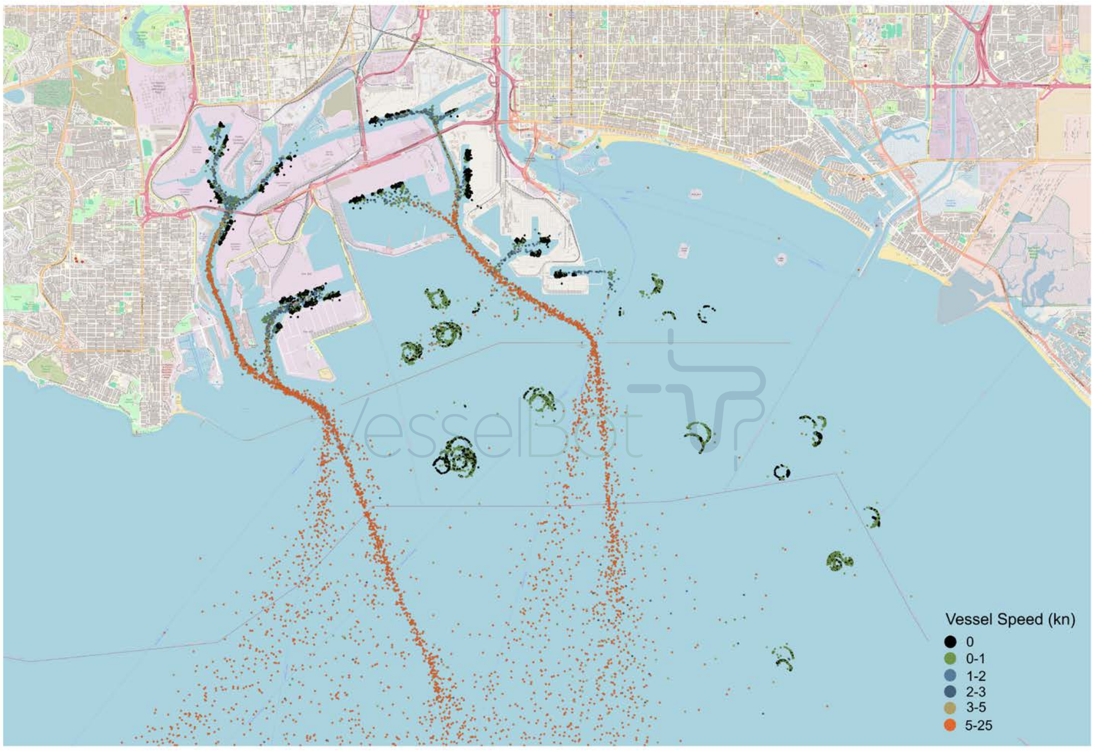


Figure 21: *Vessel speed (in knots) within the port basin of Long Beach.*

Using the technique briefly described above, CO2 emissions can be calculated for each operation. The result is presented in **Fig. 22** with the port of Savannah showing the highest port emissions followed by Norfolk and Long Beach, while the lowest port emissions are recorded for the port of Mobile.

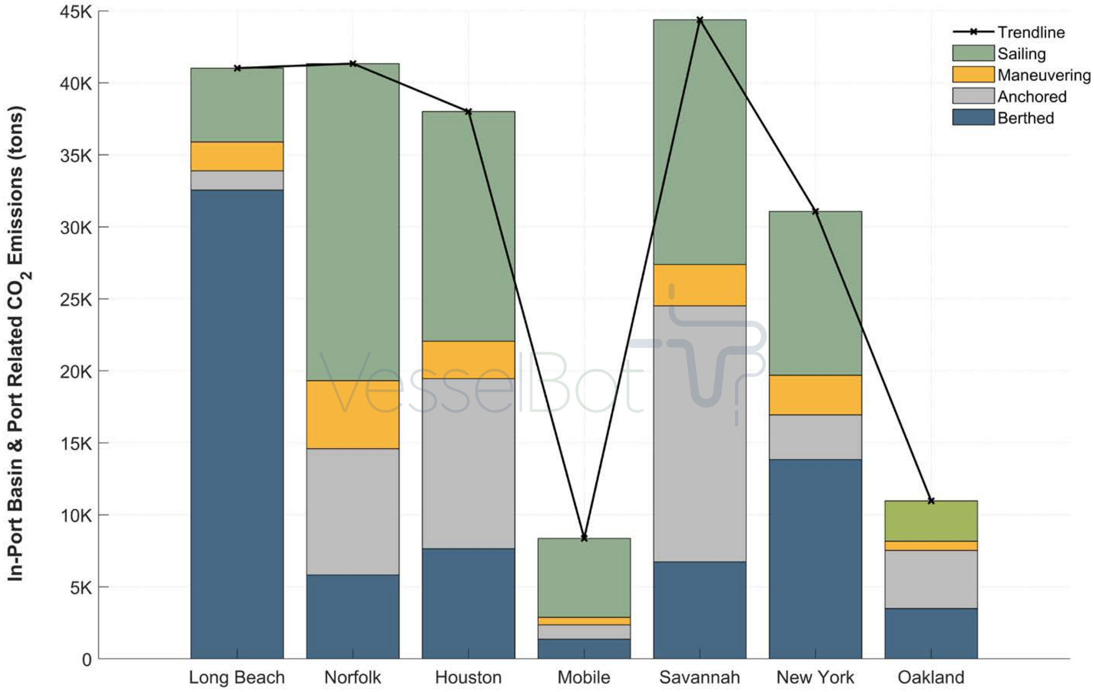


Figure 22: *Total CO2 emissions for all USA ports analyzed in this paragraph, also for each operation.*

The variations seen in **Fig. 22** should be a direct result of the number of vessels and voyages. **Fig. 23** shows that the above claim is not necessarily valid, although there is, and should be, some dependence. The ports of Norfolk and Savannah are indeed receiving the largest volume of vessels and therefore voyages. On the other hand, the port of Long Beach, with the 3rd highest recorded CO2 emissions for the period January – June 2024, receives a smaller volume of vessels.

This implies that port operations may not be very efficient. Another surprising fact detected in **Fig. 22** is the massively increased CO2 emissions of berthed vessels at Long Beach port which may be another indicator of poor terminal performance and geometry.

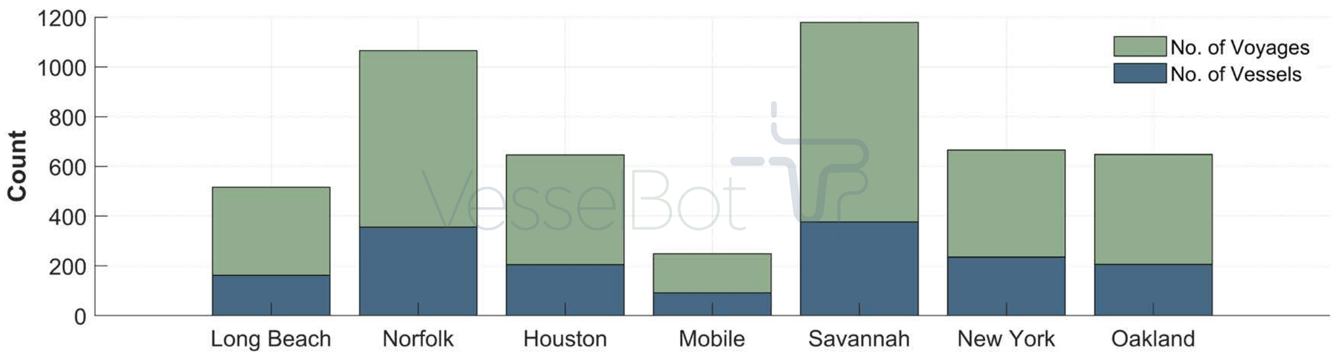


Figure 23: *Cumulative number of voyages and vessels terminating at 7 ports of the USA, for the period January – June 2024.*

Port of Rotterdam

The port of Rotterdam remains the busiest port in Europe. The monthly count of voyages arriving at the port, along with their CO2 emissions and emission intensity is provided in **Fig. 24**. A small decline in voyages terminating at the port is detected in May and June 2024, but the pattern remains overall consistent. Vessel types docking at the port are given in **Fig. 25**. The large volume of Feeder vessels is explained by the high number of short-distance voyages, particularly with the UK and Germany (**Fig. 26**).

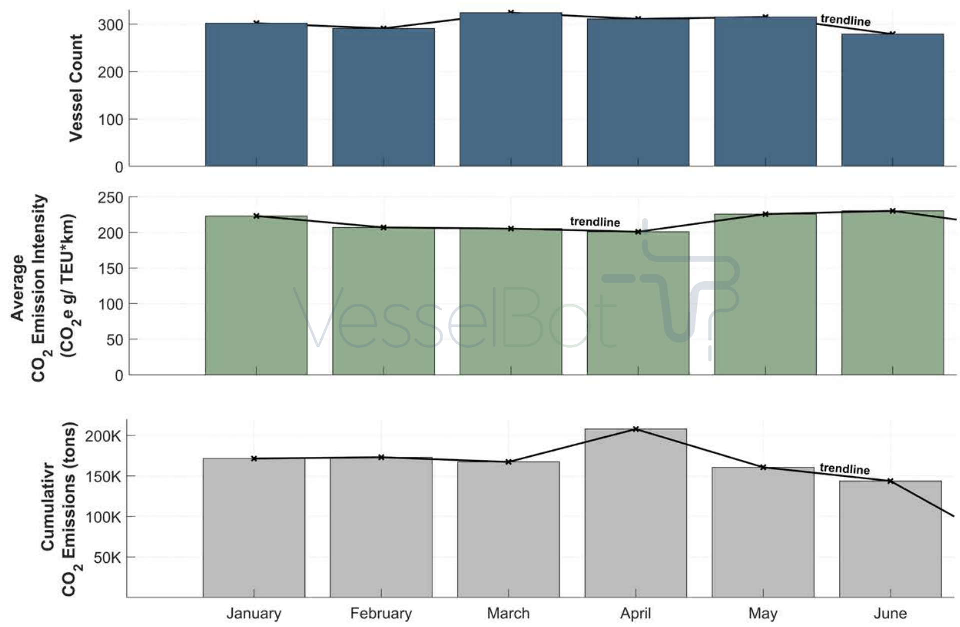


Figure 24: *Monthly variation of voyages and their CO2 emissions and emission intensities. All voyages are terminating at the port of Rotterdam and correspond to the period January – June 2024*

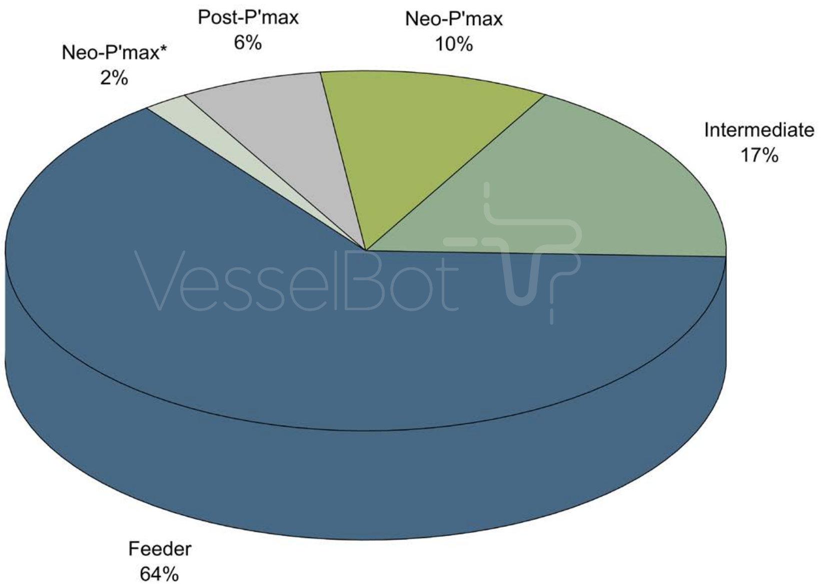


Figure 25: *Vessel types arriving at the port of Rotterdam during the period January – June 2024. The large volume of feeder vessels can be explained by the large volume of short-distance voyages (see Fig. 26).*

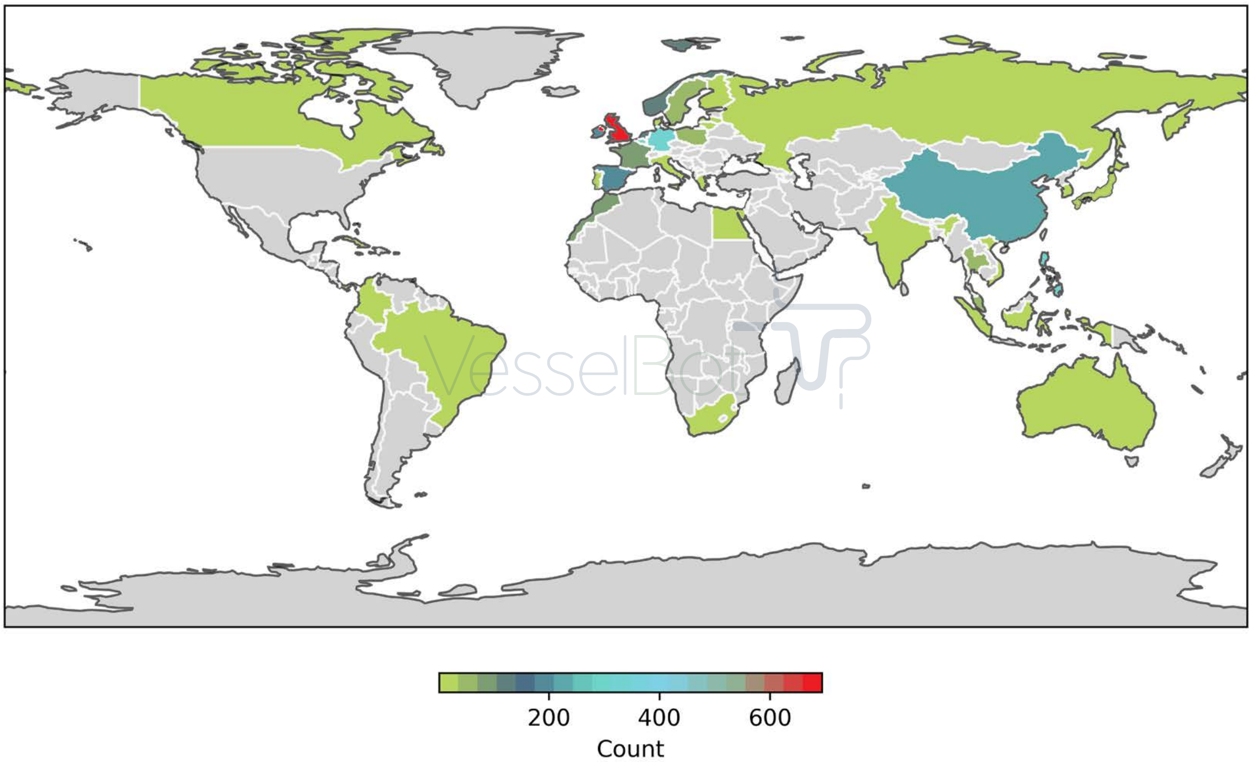


Figure 26: *Number of voyages each country has performed this year terminating at the port of Rotterdam.*

Following the procedure described above, the port of Rotterdam was mapped to mark the terminals and anchorage areas (**Fig. 27**), while subsequent categorization of vessel speed (**Fig. 28**) was conducted to separate each port operation and measure their respective emissions.

Figure 27: *Port of Rotterdam, with all terminals and anchorage areas highlighted with different colours.*

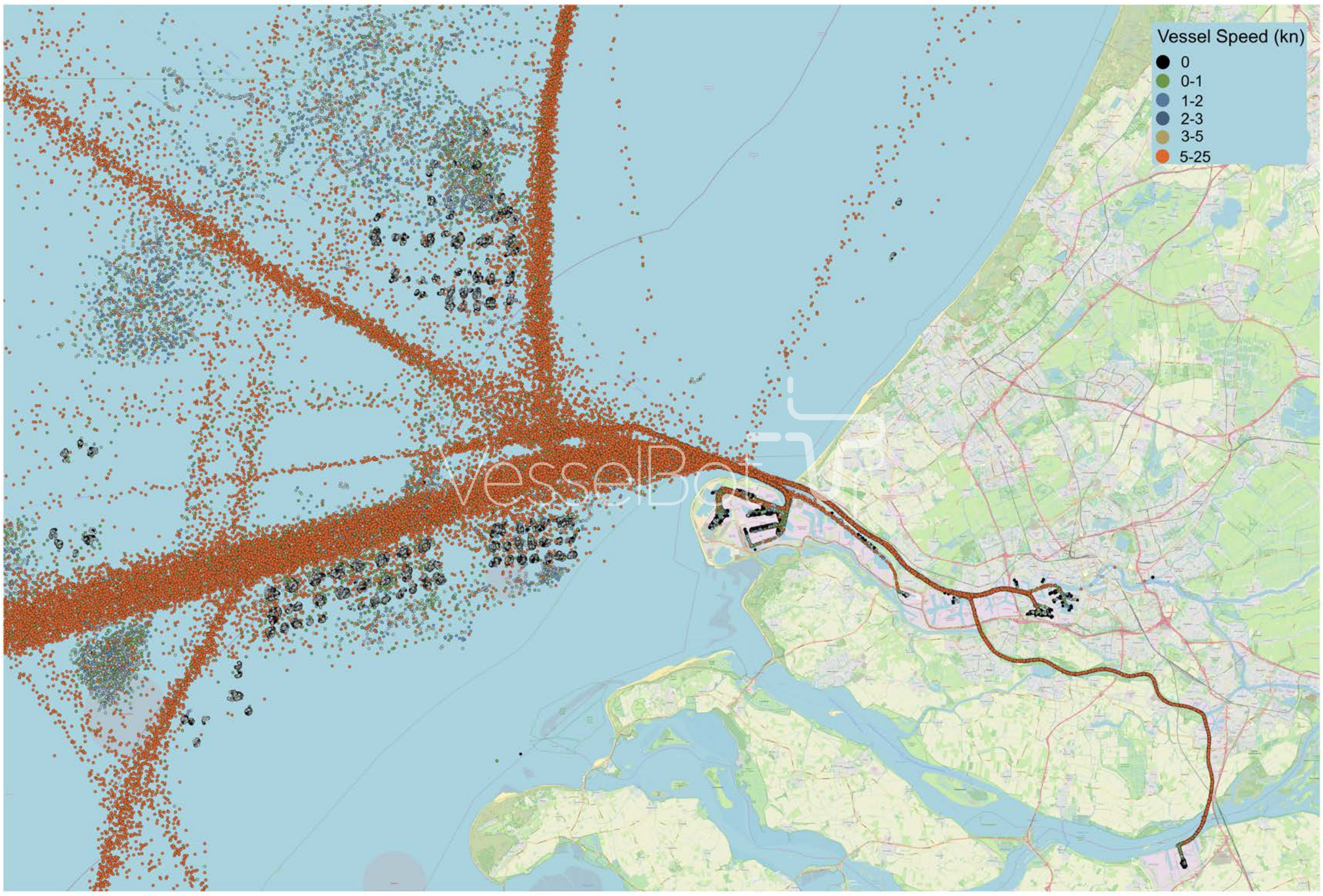


Figure 28: *Vessel speed (in knots) recorded at the port of Rotterdam.*

CO2 emissions per port operation yielding a total of 40.992,8921 tons

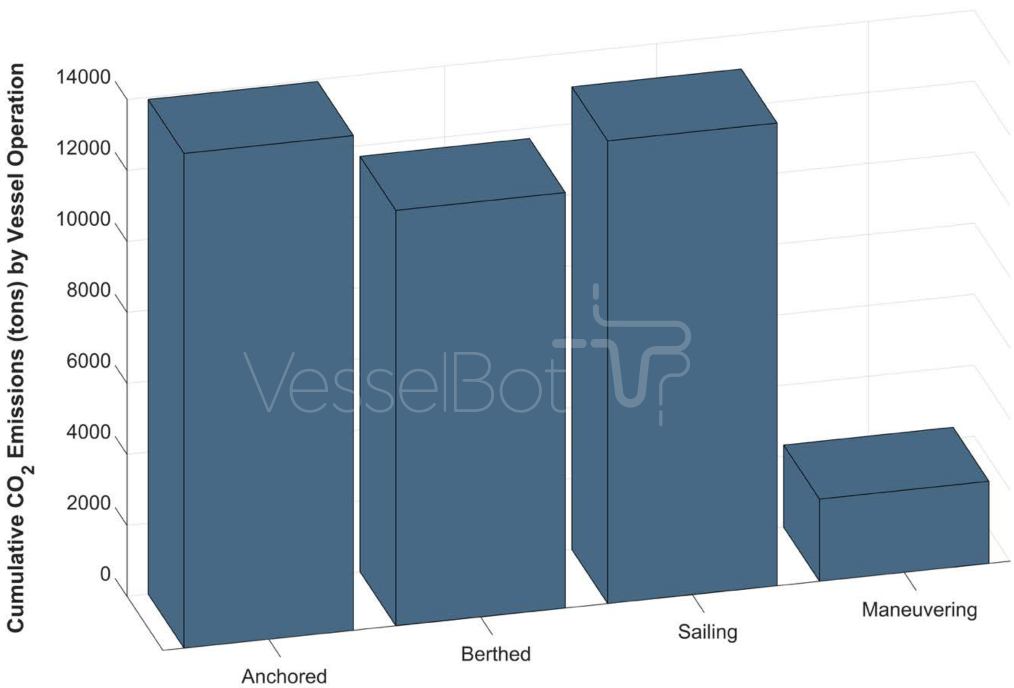


Figure 29: *CO2 emissions per port operation for Rotterdam. Total emissions account to 40.992,8921 tons.*

Port of Singapore

Final example is given for the port of Singapore. In the previous paragraphs CO2 emissions and emission intensity for all voyages terminating at the port were given as an example of voyage analysis. Here, VesselBot data uncover the complex operations taking place at Singapore's port. **Fig. 30** shows a map of the port of Singapore with terminals and anchorage areas highlighted. The extended anchorage areas and small terminals may imply increased congestion and CO2 emissions.

Figure 30: *Port of Singapore, with all terminals and anchorage areas highlighted with different colours.*

Figure 31: *Vessel speed (in knots) recorded at the port of Singapore.*

Calculation of port emissions using main and auxiliary engine utilization shows that a cumulative of 71.747,854 tons of CO2 were emitted during the first 6 months of 2024. Most of these emissions are attributed to berthing (**Fig. 32**). Further investigation into terminal emissions shows that Pasir terminal (**see purple polygon in Fig. 30**) is the highest contributor (**Fig. 33**) accounting for more than half of all emissions at berth.

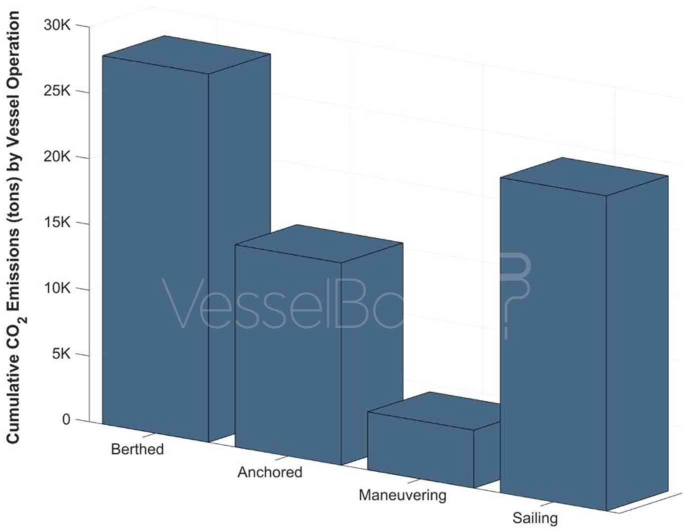


Figure 32: *CO2 emissions per port operation for Singapore. Total emissions account to 71.747,854 tons.*

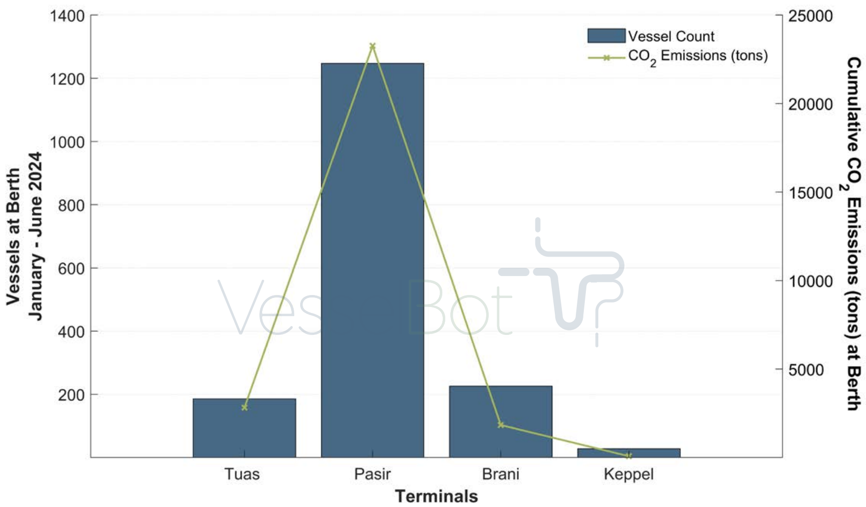


Figure 33: *CO2 emissions for each terminal. Pasir terminal accepts the highest volume of vessels leading to high emissions.*

Comparative Analysis of Port Emissions and Efficiency

An examination of the relationship between TEU and port emissions (**Fig. 34**) suggests that the relationship between them might not be linear. Additionally, it reveals that monthly TEU imports for all destination ports remain consistent throughout the period from January to June 2024, without major variations, indicating normal sea-transport operations without loss or a sudden increase in products. **Table 3** summarizes the data for all ports, while **Fig. 35** illustrates the quasi-linear relationships between TEU, port emissions, and the number of vessels.

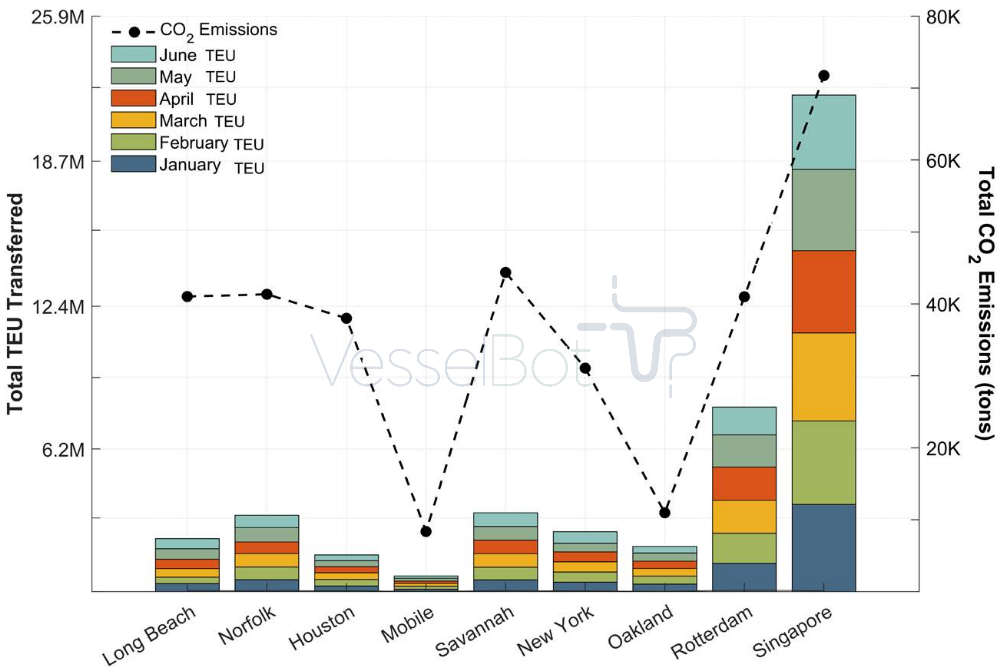


Figure 34: *Relationship between TEU imports and CO2 port-emission. Variation is not entirely dependent on TEU volume. Monthly TEU imports, for all destination ports, remain consistent throughout the period January – June 2024, without major variations indicating to standard/normal sea-transport operations without loss or sudden increase of products.*

Table 3: Port-specific information.

Port Name	Total CO2 Emissions (tons)	No. of Vessels	Total TEU
Mobile	8.366,44	95	733.375,78
Houston	38.002,93	135	1.709.666,47
Oakland	10.968,93	206	2.140.312,38
Long Beach	41.022,28	315	2.345.323,32
Norfolk	41.336,49	377	3.558.027,17
Savannah	44.378,88	401	3.676.322,85
New York	31.074,69	410	2.723.057,37
Rotterdam	40.992,89	874	8.015.360,10
Singapore	71.747,85	1427	21.574.288,9

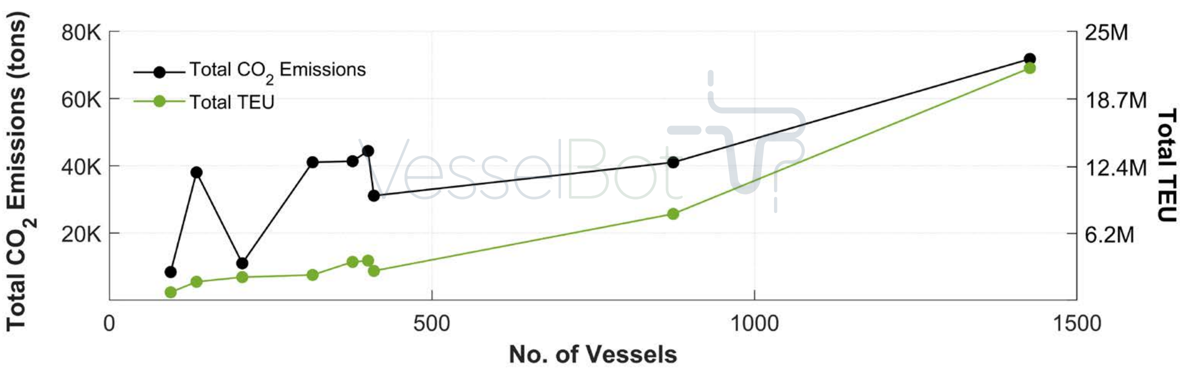


Figure 35: *Quasi-linear relationships between TEU, vessel numbers, and port-emissions. Each circle point represents a port. To show the quasi-linear trends, the data were shorted from minimum to maximum based on the number of Vessels, in the order of: Mobile, Houston, Oakland, Long Beach, Norfolk, Savannah, New York, Rotterdam and Singapore (as in Table 3).*

Looking at **Table 3**, one might argue that Savannah port CO_2 emissions are quite high and do not entirely align with the number of vessels terminating at the port. More specifically, Savannah accepted 401 vessels as opposed to New York that received 410; nonetheless, the former emitted about 12,300 more tons than the latter. In this case, it is worth exploring vessel speeds within all port basins. Indeed, vessel speeds for anchorage and maneuvering at Savannah are extremely high, at 0.28 knots and 3.83 knots, respectively, while the averages from the other ports for the same operations are 0.093 knots and 2.65 knots. **Figure 36** illustrates this result, outlining the influence of a vessel's speed within port boundaries.

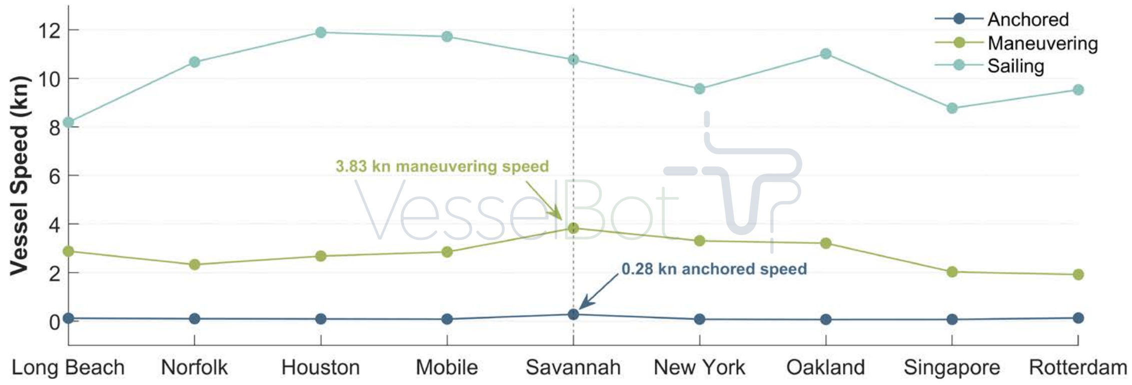


Figure 36: *Variation of vessels' speed for all port operations (noting that speeds at berth equal to zero). At Savannah port, vessels exhibit higher speeds during anchoring and maneuvering thus affecting the emitted volume of CO_2.*

Finally, a better graphical representation of port emissions and TEU is given in **Fig. 37**, with maps showing total emissions for all ports studied in this section. The color on the map corresponds to CO_2 emissions, while the size of the bubble corresponds to the TEU volume arriving at each port.

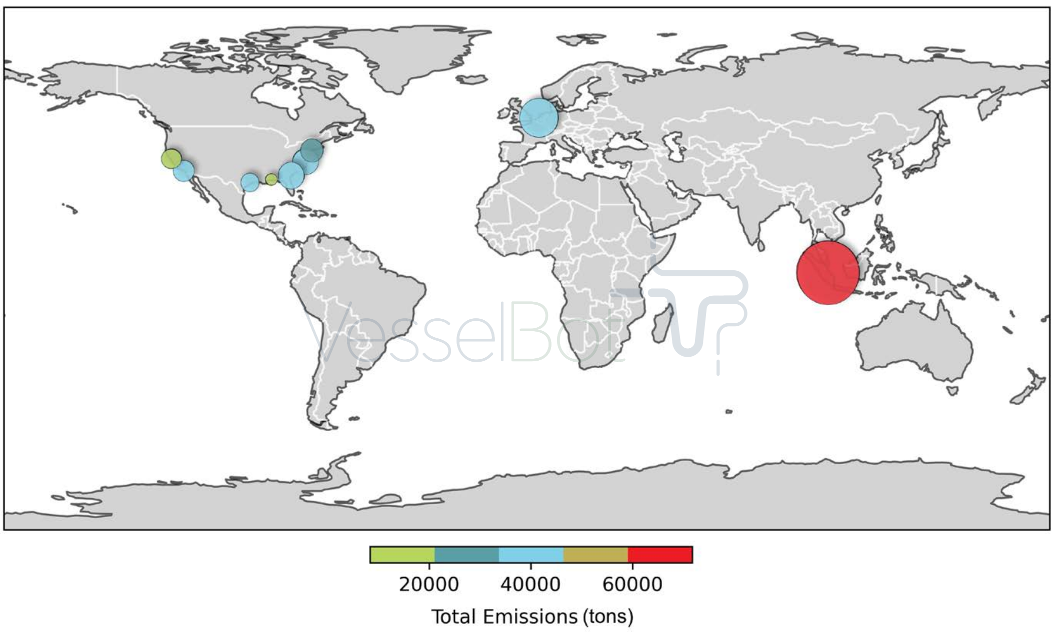


Figure 37: *Port emissions. Bubble size corresponds to TEU volume arrived at each port, while the colourbar to the total CO_2 emitted by all port-operations.*

5. Observations and Conclusions

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

Key Observations:

Importance of CO_2 Emission Visibility:

The increasing costs associated with CO2 emissions have driven the need for transparency and accurate reporting within supply chains. The adoption of primary data for CO2 emission calculations, as advocated by VesselBot, is crucial in achieving precise and actionable insights, particularly as industries work towards the 1.5°C goal of the Paris Agreement.

Decline in Emission Intensity but Increase in Total Emissions:

The analysis of CO2 emission intensity from 2021 to 2024 demonstrates a continuous improvement in fleet and voyage efficiency. However, despite this improvement, total CO2 emissions have risen in 2024 due to external factors, such as geopolitical tensions and the re-routing of vessels. This suggests that while efficiency is improving, external disruptions can still significantly impact overall emissions.

Variations in Cargo Load and Utilization:

The analysis of the 2024 data reveals a monthly trend of increasing average load factors, even as the total number of vessels per month decreases. This indicates a shift towards fewer but more fully loaded vessels. However, the data also highlights inefficiencies, particularly among feeder vessels, which have the highest emission intensity despite being the smallest class of vessels.

Impact of Geopolitical Tensions on Trade Routes:

The re-routing of vessels, particularly around the coast of Africa due to tensions in the Red Sea, has resulted in increased CO2 emissions, as already depicted in previous VesselBot reports (see Annex). The analysis of voyages terminating at major ports such as Singapore and those departing from China, shows that existing geopolitical tensions significantly influence emission levels, particularly when longer alternative routes are required.

Port-Specific Emission Insights:

VesselBot's approach to measuring port emissions by analyzing engine usage within port basins offers detailed insights into port efficiency. For example, ports like Long Beach show high CO2 emissions despite handling fewer vessels, indicating possible inefficiencies in port operations. In contrast, ports like Savannah and Norfolk, which handle a higher volume of vessels, show expected levels of CO2 emissions, while the port of New York reports lower CO2 emissions despite the large vessel and TEU volume.

Global Shipping Emission Trends:

On a global scale, CO2 emissions are highest on major trade routes such as Asia-USA and Asia-Europe. The analysis suggests that while emission intensity remains low in general, specific trade lanes and routes, particularly those impacted by geopolitical tensions, can exhibit significantly higher emissions.

Port Emissions and Terminal Efficiency:

The investigation of port emissions, particularly in ports like Singapore and Rotterdam, highlights the impact of terminal efficiency on overall emissions. For instance, Singapore's Pasir terminal is a significant contributor to port emissions, underscoring the need for improved operational efficiencies to reduce emissions at the terminal level.

Vessel Speed and Port Geometry:

CO2 emissions are tied to vessel speed not only throughout the voyage but also within port barriers. In general, port-related operations seem to be easily categorized based on speed, but there are occasions such as that of Savannah port, where speeds for certain operations are elevated. A potential reason for this phenomenon is the port geometry. Located deep within a river and considering the large volume of TEU load exported at Savannah port, it is necessary for vessels to perform fast movements to enter and leave the area to reduce congestion. It is therefore possible elevated speeds to reflect this process.

Relationship Between TEU Volume and Port Emissions:

The analysis suggests that the relationship between TEU volume and port emissions is not linear. While monthly TEU imports remained consistent, port emissions varied, indicating that factors beyond cargo volume, such as operational inefficiencies and vessel utilization, play a significant role in determining emission levels.

About VesselBot

VesselBot is a technology company with deep logistics market expertise that brings transparency to Scope 3 transportation emissions. It enables companies to be confident in accurately and efficiently calculating their carbon footprint and work effectively toward compliance with ESG regulations. With accurate and actionable data, stakeholders can reduce their GHG transportation emissions and optimize their logistics networks. VesselBot's deep knowledge of transportation, technology, and applied science ensures that we provide actionable and auditable data for trustworthy reports and better net-zero strategy decisions based on data.

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**
   a. Feeder < 2999 TEU
   b. Intermediate < 7999 TEU
   c. Neo-P'max < 11999 TEU
   d. Neo-P'max* < 16999 TEU
   e. Post-P'max > 17000+ TEU

3. **Vessel Operations**
   - *Berthing: When a ship is at a designated space within a port or harbor for loading/unloading cargo or passengers.*
   - *Anchoring: When a vessel is anchored to the seafloor with an anchor attached to the vessel by a rope or chain.*
   - *Maneuvering: The operation during which a vessel enters or exits coastal waters, crosses other ships, and proceeds towards or departs from a berth or jetty at a port.*

4. **CO2 Emission Intensity:** *In shipping, CO2 emission intensity is a 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.*

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

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

7. **EU Emissions Trading System (EU ETS):** Initially established in 2005, EU ETS acted as a market-based mechanism to tackle the growing climate issue of GHG emissions within the EU. As of 2024, ETS makes it mandatory for ship operators with activities in the European Economic Area (EEA) to monitor and report their emissions and purchase allowances for every ton of CO2 they emit.

Citation

[1] https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx
[2] https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf
[3] https://registration.vesselbot.com/the-red-sea-under-the-microscope-july-2024
[4] https://registration.vesselbot.com/the-red-sea-under-the-microscope

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