A PERSPECTIVE ON IMO EFFICIENCY MEASURES: OPPORTUNITIES FOR IMPROVEMENT

Prepared for Blue Sky Maritime Coalition

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INTRODUCTION

Absolute reduction of carbon emissions produced by the maritime industry is a generally accepted common goal of all carriers. The IMO has set a goal of 50% reduction of CO_2 emissions by 2050. The Blue Sky Maritime Coalition has challenged its members to achieve an even more ambitious goal of achieving “net zero” emissions within that same time frame. Much work has been done to construct both the reporting regimes necessary to consistently measure emissions produced as well as to steer vessel Owners towards improved operational performance through the application of various formulae developed by the International Maritime Organization (“IMO”). We acknowledge that the majority of U.S. flagged tonnage is engaged in inland water trading. However, the USA has a vested interest in the global shipping industry and therefore supports the effective implementation of the IMO’s GHG Strategy.

In order to measure and rate the fuel efficiency of ships in operation worldwide, the IMO has settled on two measures. The first is a “design measure” called Energy Efficiency Existing Ship Index, or EEXI. This measure is similar in overall nature to the efficiency ratings given to automobiles in the United States by the Environmental Protection Agency, where the unit is tested in controlled conditions to accurately assess the effect of fuel savings technologies that are incorporated into the design of the unit. In the case of cargo-carrying ships, EEXI is calculated using available data sources like model test results and sea trials results which are conducted under controlled conditions (e.g. limited wind force, calm seas and negating the effects of current). These activities result in highly accurate measurements of the fuel efficiency of the particular vessel through calm water. However, for older hulls these supporting data sources are not always available compared to newer vessels that were required to comply with MARPOL’s 2013 Energy Efficiency Design Index (EEDI) regulation. The IMO has set a maximum limit for EEXI for each type and size of vessel and has issued accompanying calculation guidelines which take into account any necessary modifications that an older vessel needs to meet the EEXI requirement.

The Carbon Intensity Index, or CII, is another efficiency measure that will be enforced on ships worldwide by the IMO, but this one is being dubbed an “operational measure” as opposed to a “design measure.” This is likely in recognition of the fact that two ships with identical designs and EEXI ratings can have vastly different real-world efficiencies due to the way they are operated as will be demonstrated below. This is similar to how identical automobiles with the same EPA efficiency rating can have vastly different real-world efficiencies if one car only makes short trips around town and the other only makes long trips on the highway.

This paper has as its goal an illustration of flaws that exist within carbon measurement methods currently proposed by the IMO. Specifically, the rating methodology intended to degrade the acceptability in service of vessels determined by the Carbon Intensity Index (“CII”) is concerning in two ways. First, the CII regulation does not address decisions taken by Charterers that impact the CII. In this way the approach unfairly penalizes vessel Owners for formulaic outcomes, the results of which are beyond their control. Second, the CII formula’s focus on perceived efficiency overly favors longer voyages and incentivizes activity which may often produce higher absolute levels of carbon emissions. Ships are unfairly punished with low CII grades, not because of any technical deficiency with the ship itself, but rather resulting from the trading pattern (e.g., short voyages and/or frequent waiting time) required to satisfy charter requirements.

Implementation of an effective regime to reduce carbon emissions needs to address these two identified concerns in the current CII approach in order to succeed in the long-term goal of reducing overall emissions produced by the maritime industry.

THE CII EQUATION

CII is calculated by the following simplified formula, where the numerator istotal CO_2 emitted from the vessel during the calendar year, regardless of whether the vessel was sailing at loaded or ballast draft, discharging cargo in port, waiting at anchor, sustaining cargoduring transit (refrigeration, heating or special services), or any other typical activity. The denominator is the official deadweight capacity of the vessel multiplied by the total miles traveled during the year, again regardless of the activity or the condition of the vessel. Some correction factors are currently under consideration for certain activities. As can be seen from the formula, a vessel that sits at anchor all year running her generators could theoretically achieve a CII of infinity.

$$CII = \frac{\text{Actual } CO_2 \text{ Emissions}}{\text{DWT x Actual Miles Traveled}} \text{ x Correction Factors}$$

Based on the result of the above equation, the ship is assigned a ranking in letter grade format (A, B, C, D, or E). An A ranking resultsfrom a CII value that is well below the maximum allowable value for that type of vessel, and an E ranking results from a CII value that is well above the maximum allowable value.[1] A vessel that receives a D ranking for three consecutive years, or an E ranking for one year, will be required to develop a plan for corrective action or it will not be issued a Statement of Compliance related to fuel oil consumption reporting and operational carbon intensity rating.[2] The inference is that the vessel will eventually not be allowed to continue trading if it does not receive this Statement of Complianceor improve its ranking in accordance with the corrective action plan.

The problem many Owners have with CII is that they are often not in control of whether the vessel makes short trips or long trips, or even how fast the vessel needs to transit between ports in order to be in position for when the third-party terminal is ready to transfer the cargo to or from the vessel. Those decisions rest primarily with the charterers of the vessel, the operators of the terminals, and are affected by market dynamics in general. But currently it is solely the vessel Owner who will bear the consequences (commercial or otherwise) if those operational decisions result in a poor CII grade.

Another shortcoming with CII is that it does not take into account the *actual* weight of cargo carriedby the vessel during the course of the year. Instead, it assumes the ship is carrying its full rated DWT capacity all of the time. This makes it impossible to differentiateand rewardships that are operatedmore efficiently by their Owners and/or Charterers on a ton-mile basis. A ship that carries more cargo longer distances throughout the year provides a greater benefit to society per unit emission than a ship that sails around empty most of the year. A proposed alternative to CII which takes this concept into account is the Energy Efficiency Operational Indicator, or EEOI. EEOI is similar to CII except that it is calculated using the *actual* ton-miles achieved by the vessel. But EEOI was ultimately rejected as an efficiency measure to be enforced by the IMO because it would unfairly punish Owners and/or Charterers whose ships tend to carry cargoes of lower densities. Perhaps a fair compromise would be to base the calculation on *volume* of cargo actually carried instead of *weight*, so that a ship whose holds are filled with wheat is treated the same as one whose holds are filled with iron ore.

1 Resolution MEPC.339(76), 2021 Guidelines on the Operational Carbon Intensity Rating of Ships (CII Rating Guidelines, G4).

2 Resolution MEPC.328(76), 2021 Revised Marpol Annex VI, Chapter 2, Regulation 6.

WIDE VARIANCE AMONG SISTER VESSELS

Overseas Shipholding Group, Inc. (OSG) operates a fleet of 16 MR tankers in a variety of trades worldwide, ranging in size from 45,600 to 51,700 DWT. Nine tankers are exact sisterships. See Table 1 for a summary of the principal characteristics of these sisterships. Five additional tankers are near-sisterships with similar capacity, speed and consumption. All fourteen of these tankers are Hyundai Mipo Dockyard (HMD) designs delivered between 2007 and 2011. The fifteenth tanker is an old design, one of the "Double Eagle" tankers delivered by Newport News Shipbuilding in 1999. The sixteenth MR tanker was delivered by HMD in 2019, the design of which is several generations newer than the other tankers in OSG's fleet, but still of similar size and capacity.

Table 1.

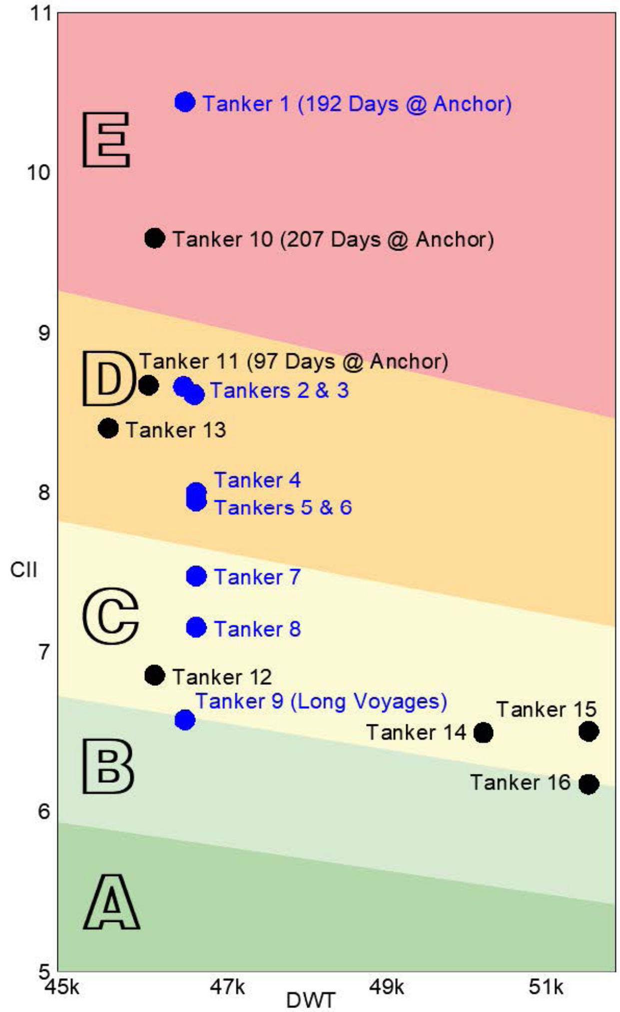
Principal Characteristics of OSG's Typical MR Tanker

LOA (m)	183.2	Main Engine	Man B&W 6S50MC
LBP (m)	174.0	Propulsion Power	8,580 kW @ 127 rpm
Beam (m)	32.2	Auxiliary Engines	3x 800 kW
Design Draft (m)	11.0	Inert Gas Generator	4,500 m3/hr
Depth (m)	18.8	Propeller	1x fixed pitch, 5.8m dia.
Cargo Capacity (m3)	53,800	Year Delivered	2007-2011
Cargo Capacity (DWT)	46,700	Type	MR (medium range)
Cargo Tanks	6 Pair + 2 Slop	Class	ABS + A1 Oil/Chemical

The nine exact sisterships have the same engine design, propeller, and hull form. They have nearly identical EEXI scores, so one may assume them to have very similar CII scores as well. However, Figure 1 demonstrates just how wrong that assumption would be. CII scores are plotted based on CO_2 emitted and miles run in 2020, but against the grades that would be assigned in 2023, the first year that CII grades are to be assigned to all applicable vessels. The nine sisterships, shown in blue in Figure 1, fall on a vertical line on the graph because they have nearly identical deadweight capacities. *Tanker 1* is at the top of the graph and *Tanker 9* is at the bottom. What is so striking is that while *Tanker 9* achieved a "B" grade in 2020, *Tanker 1* achieved an "E" grade. And the remaining seven vessels of the class are distributed evenly between those two extremes. How can nine exact sister vessels achieve such a wide variance in CII scores? The variance has nothing to do with their design and everything to do with the individual trades they are in and their respective commercial requirements which affect the average length of their voyages and the amount of time they are required to wait.

Figure 1.

CII Scores for OSG MR Tankers (2020 data, 2023 grades)

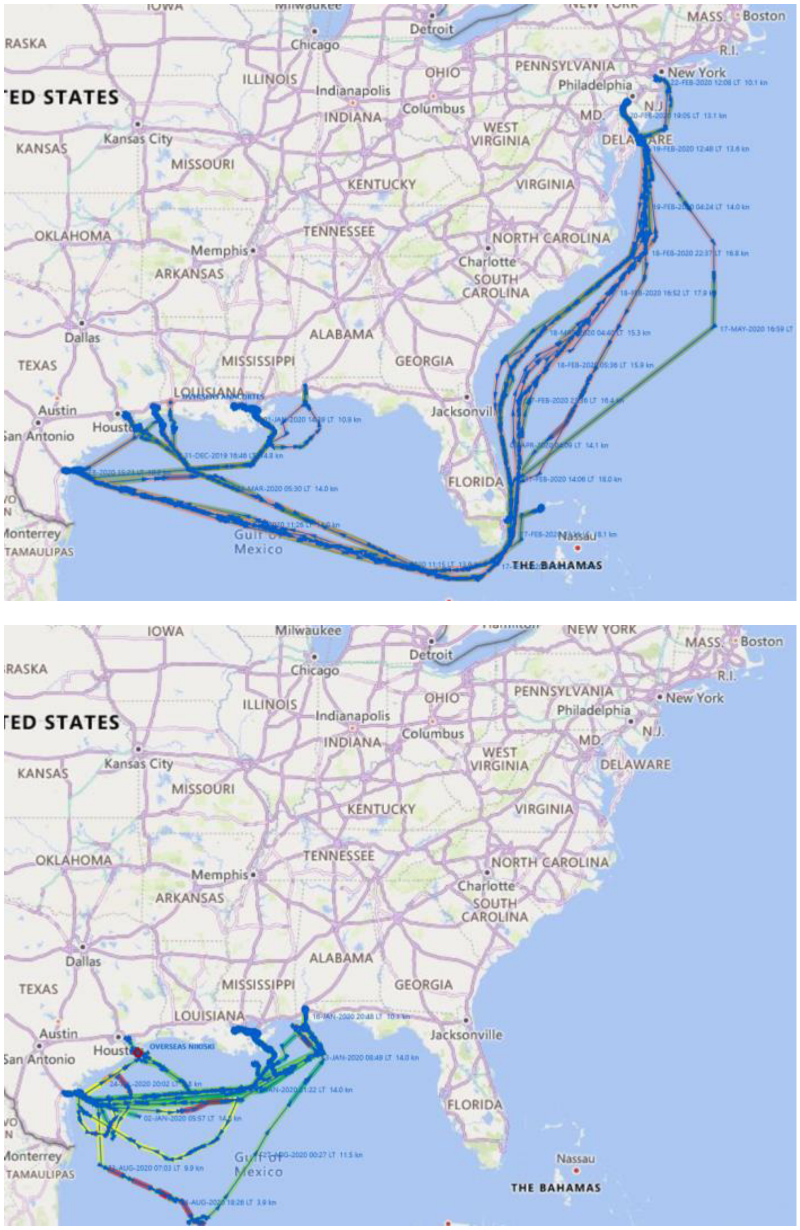


Tanker 1 achieved a poor CII score in 2020 because she was on the spot market and spent more than half of the year (192 days) at anchor between charters, waiting for her next job. She was a good performer during the 173 days that she was actively moving cargo. But when a ship remains idle for extended periods of time at anchor or in port, running her generators to keep engine fluid temperatures maintained for a quick startup and to power hotel loads in the accommodations house for proper care of the crew, the CII score goes to infinity. With no accumulation of miles transited, the denominator of the equation is zero. This has a significant negative impact on the CII score and resulting grade. *Tanker 2* suffered similarly, having spent 207 days at anchor that year waiting for cargoes to be ready for loading.

At the other end of the spectrum, the sister vessel *Tanker 9* achieved a grade of "B" despite her 15-year-old design. Examining her operational profile that year, she kept very busy making long voyages from Texas to Philadelphia. Long voyages are highly favorable in the CII calculation because they result in fewer voyages in a given year and therefore less time in port where the ship emits CO_2 from the generators but does not accumulate miles run in the denominator of the CII equation. Figure 2 provides a visual description of the vastly different operating profiles of the two sisterships in 2020.

Figure 2.

Voyages in 2020, Tanker 9 (top) and Tanker 1 (bottom)



For another example, *Tanker 7* kept relatively busy in 2020 and 2021, transporting petroleum products between the Gulf Coast refineries and the U.S. East Coast. In 2020 her runs were on average a little longer, with several runs up to Philadelphia and New York, as well as one to Puerto Rico. She also had very little waiting time, being on a continuous time charter the entire year. Conversely, in 2021, she had had none of the longer runs up to the Northeast or Puerto Rico, and she spent 68 days at anchor waiting for work between spot charters. See Figure 3. As a result, her CII grade dropped from a "C" in 2020 to a "D" in 2021 (based on grades that would be assigned in 2023), despite her average speed being reduced from 14.5 knots to 14.0 knots. It is apparent that it doesn't take much waiting time or shorter voyages to affect the CII score in a significantly negative way.

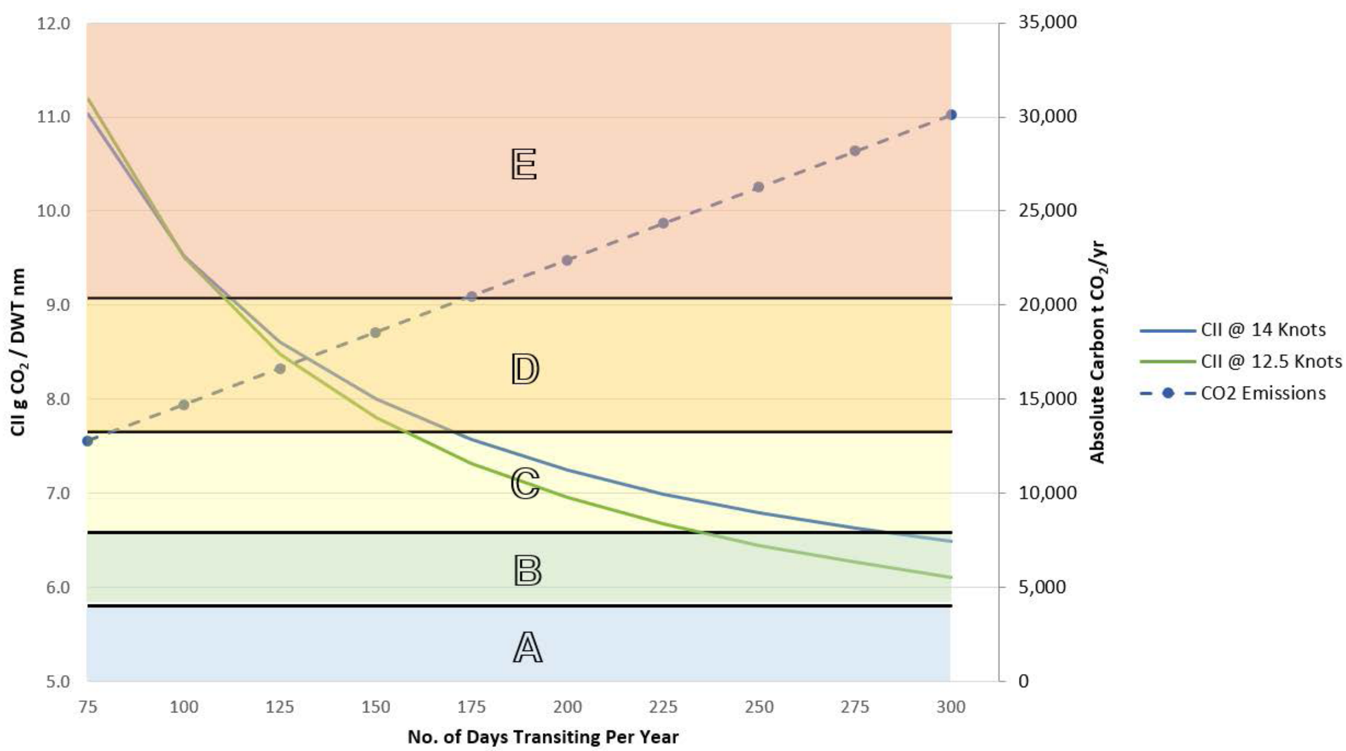
Figure 3.
Tanker 7 Voyages in 2020 (top) and 2021 (bottom)

DAYS IN TRANSIT VERSUS CII

A simple sensitivity analysis can be performed to prove that waiting time alone has a profound impact on the CII score. In this analysis, a standard MR tanker is assumed to consume 30 tons per day at a 14-knot service speed, and an average of 6 tons per day in port. The only parameter that is varied is days transiting with a higher figure corresponding to a vessel with long voyages and relatively little time in port. Conversely a low figure for days transiting corresponds to a vessel with short voyages and a higher percentage of time in port over the course of a year. As shown in Figure 4, the same vessel with the same fuel efficiency can achieve anywhere from a “B” grade to an “E” grade depending on the number of days transiting, all else being equal. In this exercise, the effects of adverse weather conditions are excluded.

Figure 4.

Days Transiting Versus CII



Transit Days	75	100	125	150	175	200	225	250	275	300
Port / Anchor Days	290	265	240	215	190	165	140	115	90	65
Average Transit Speed (knots)	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Average Transit Cons (t/day)	30	30	30	30	30	30	30	30	30	30
Average Port Cons (t/day)	6	6	6	6	6	6	6	6	6	6
Total Cons (tons)	3,990	4,590	5,190	5,790	6,390	6,990	7,590	8,190	8,790	9,390
Miles Travelled	25,200	33,600	42,000	50,400	58,800	67,200	75,600	84,000	92,400	100,800
CII (g CO_2 / DWT-nm)	11.0	9.5	8.6	8.0	7.6	7.2	7.0	6.8	6.6	6.5
Assigned Letter Grade	E	E	D	D	C	C	C	C	C	B
CO_2 Emissions (tons)	12,792	14,716	16,639	18,563	20,486	22,410	24,334	26,257	28,181	30,104

As the graph above shows, reducing overall average speed from 14 knots to 12.5 knots would have improved the vessel's grade only within relatively narrow ranges of annual days transiting. The grade would have improved from a "D" to a "C," but only if the days transiting fell within approximately 155 and 170 annually. The grade would have improved from a "C" to a "B" if the days transiting fell within approximately 230 and 270 annually. But in most other cases the vessel's grade would not have improved if ship's speed were reduced from 14 knots to 12.5 knots.

If the goal is to reduce absolute carbon emissions, the above analysis points directly to the inherent flaws of the formula as constructed. The higher the number of transit days, the higher the absolute level of carbon emissions. Yet, the highest absolute level of carbon emissions perversely corresponds with the best CII rating. A rethinking of the CII is needed to address the differing operational conditions of the vessel so as to weigh the emissions impact of activities other than "underway, making way."[3]

3 "Underway, making way" is a nautical term meaning the vessel is not moored or anchored, and it is moving through the water under power (not drifting).

A BULK CARRIER CASE

To reinforce the lessons learned from the above analyses using an MR tanker, an additional analysis has been performed using a typical Supramax 58,000 DWT bulk carrier built in 2011. See Table 2 for a general description of the bulk carrier studied.

Table 2.
Supramax Bulker Principal Characteristics

LOA (m)	189.9	Main Engine	Man B&W 6S50
LBP (m)	185.5	Propulsion Power	9,465 kW @ 127 rpm
Beam (m)	32.2	Auxiliary Engines	3x 620 kW
Draft (m)	12.8	Propeller	1x fixed pitch
Depth (m)	18.8	Cranes	4x 30t SWL
Cargo Capacity (m3)	72,700	Year Delivered	2011
Cargo Capacity (DWT)	58,000	Type	Supramax
Cargo Holds	5 Hatches		

Table 3 summarizes voyage profiles and provides key data details for the 2011-era bulker across a wide range of voyage lengths from short voyages of only 500 nautical miles to long-haul international voyages of 9,000 nautical miles. These voyages utilize the common term "discharge to discharge nautical miles" for that voyage as may occur during the calendar year that the CII is measured.

Table 3.

Supramax Voyage Profiles Over Short Regional and Long International Voyage Patterns

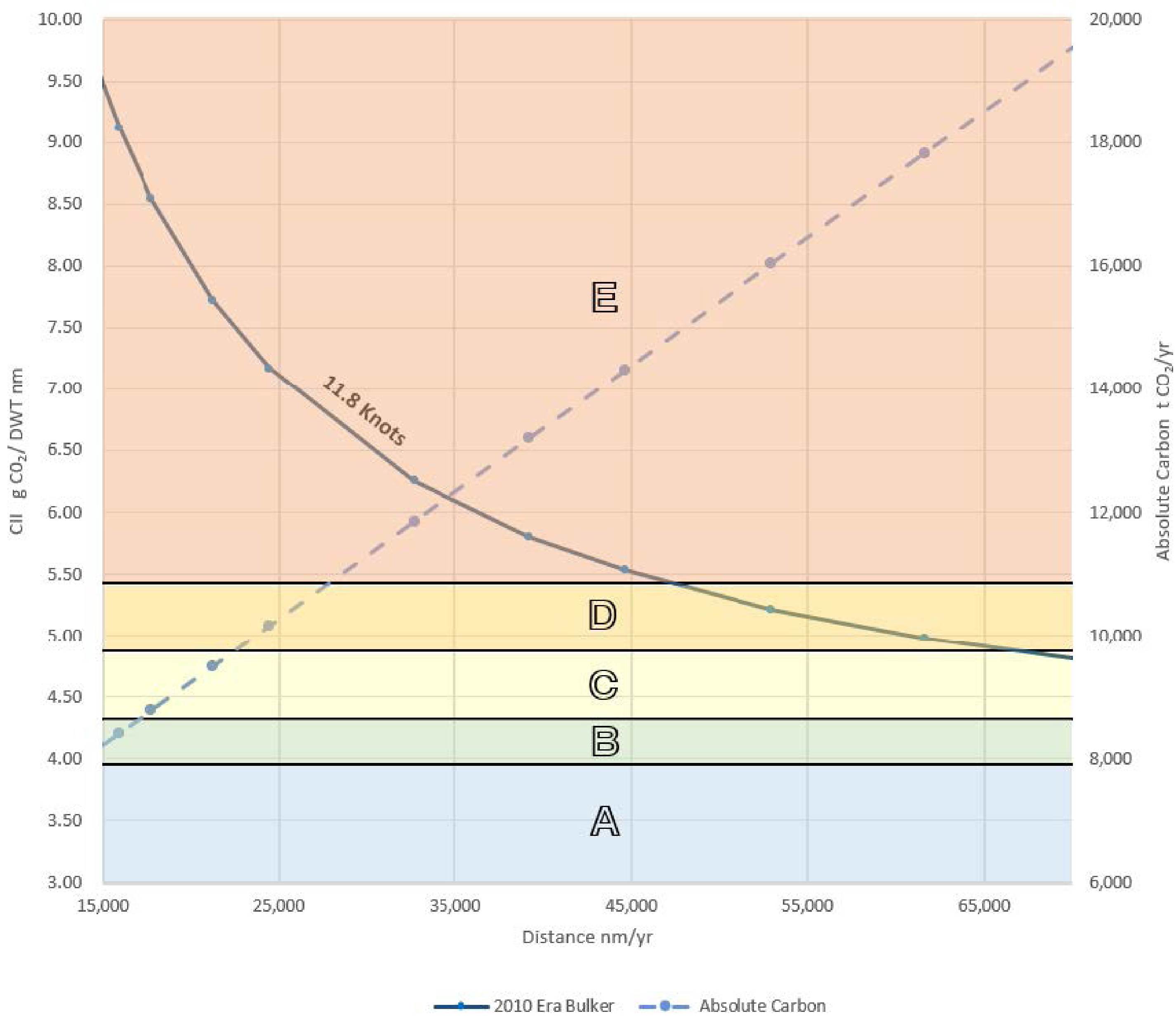
Description	Units	Value											
Disch - Disch	nm/voy	500	600	700	800	1000	1200	1800	2400	3000	4200	6000	9000
Average Transit	nm/hr	11.8											
Sea Days	day/voy	1.77	2.12	2.47	2.82	3.53	4.24	6.36	8.47	10.59	14.83	21.19	31.78
Wait Load Days	day/voy	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Loading Days	day/voy	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Wait Unload Days	day/voy	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Unload Days	day/voy	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Disch - Disch Days	day/voy	14.77	15.12	15.47	15.82	16.53	17.24	19.36	21.47	23.59	27.83	34.19	44.78
Year	day/yr	365	365	365	365	365	365	365	365	365	365	365	365
Days Offhire	day/yr	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)	(14)
Available Days	day/yr	351	351	351	351	351	351	351	351	351	351	351	351
Annual Voyages	voy/yr	23.77	23.22	22.69	22.18	21.23	20.36	18.13	16.34	14.88	12.61	10.27	7.84
Transit Distance	nm/yr	11,886	13,930	15,881	17,744	21,233	24,435	32,641	39,228	44,631	52,971	61,603	70,545
Sea Days	day/yr	42.0	49.2	56.1	62.7	75.0	86.3	115.3	138.5	157.6	187.0	217.5	249.1
Wait Load Days	day/yr	71.3	69.6	68.1	66.5	63.7	61.1	54.4	49.0	44.6	37.8	30.8	23.5
Loading Days	day/yr	47.5	46.4	45.4	44.4	42.5	40.7	36.3	32.7	29.8	25.2	20.5	15.7
Wait Unload Days	day/yr	71.3	69.6	68.1	66.5	63.7	61.1	54.4	49.0	44.6	37.8	30.8	23.5
Unload Days	day/yr	118.9	116.1	113.4	110.9	106.2	101.8	90.7	81.7	74.4	63.1	51.3	39.2
Avg Sea Cons	mt/day	21.3											
Wait Cons	mt/day	3.0											
Loading Cons	mt/day	5.0											
Unload Cons	mt/day	3.0											
Fuel Cons	mt/yr	2,161	2,496	2,622	2,741	2,965	3,170	3,697	4,120	4,466	5,001	5,555	6,129
Deadweight	DWT	58,000											
CII	g Co2/DWT nm	10.049	9.906	9.125	8.539	7.719	7.172	6.261	5.805	5.532	5.219	4.985	4.802
Absolute Carbon	t Co2/yr	6,927	8,003	8,405	8,788	9,506	10,164	11,852	13,207	14,319	16,034	17,810	19,650

CONFLICTING METRICS

The voyage profile table outcome is presented in Figure 5, "***58K DWT 2011 Supramax CII and Absolute Carbon***." The left-hand vertical Y axis shows CII (g CO_2/DWT-nm) which is represented by the solid dark blue line for a vessel speed of 11.8 knots. The right-hand vertical Y axis is the absolute carbon generated for the year, CO_2 in metric tons, represented by the dashed blue line. The CII score shows a downward trend which indicates improvement as the annual transit mileage increases. The vessel achieves a grade of "E" below 47K miles per year but improves to a "C" rating above 67K miles per year. As the transit mileage increases each year the absolute carbon, measured in metric tons CO_2 annually, increases dramatically by nearly 2 ½ times from 8,000 metric tons annually toward 20,000. This illustrates a contradictory outcome. The conflict with environmental objectives is that the CII score improves as transit distances increase while conversely generating a higher release of carbon at the expense of the environment. The ultimate environmental goal is reduction of absolute carbon emissions and this demonstrates how the CII metric falsely portrays a vessel achieving improvement.

Figure 5.

58K DWT 2011 Supramax CII and Absolute Carbon



Note: 58K DWT 2011 Supramax CII and Absolute Carbon shown for IMO rating A, B, C, D, E; year 2026.

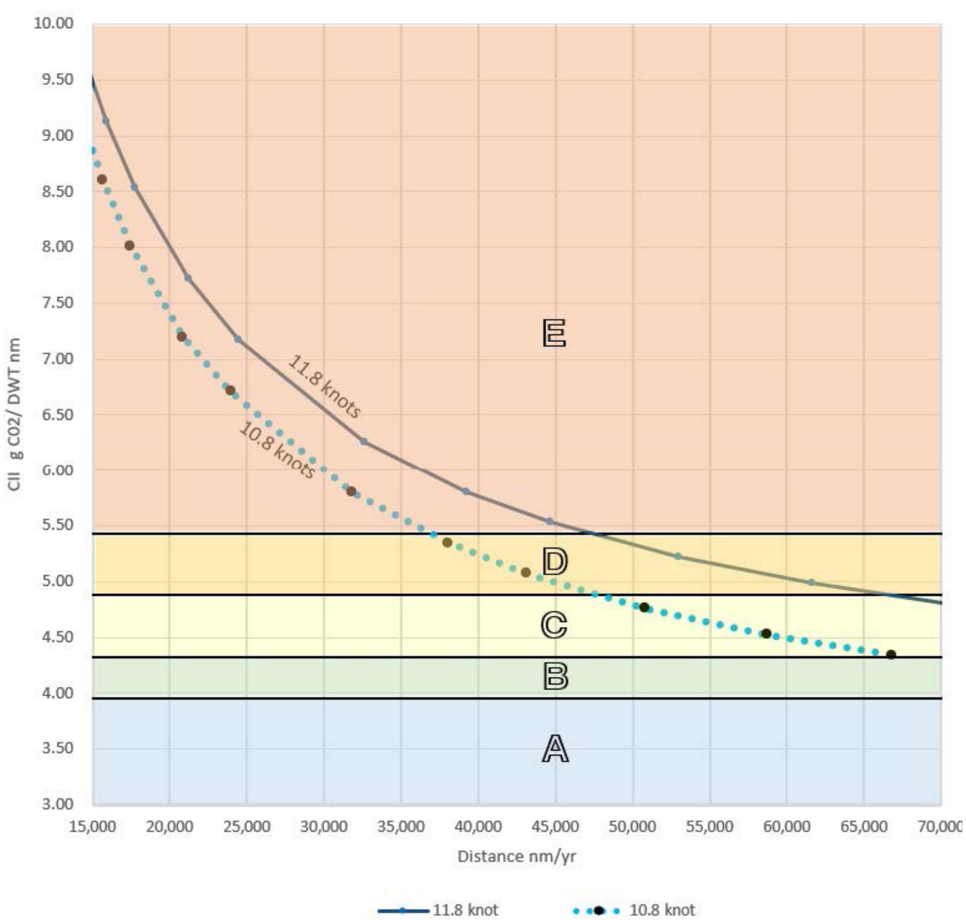
LOWER SPEED STRATEGY CONFLICTS

The impact of Charter orders to reduce the average speed of the Supramax provides a favorable reduction in CII score. However, a speed reduction also lowers the macro transport supply capacity measured in ton-miles for the Charter marketplace. Figure 6, "***58K DWT Supramax 2011 Era & Charter Speeds***" illustrates the pros and cons associated with a 1 knot speed reduction from 11.8 to 10.8 knots.

At a Charterer-ordered reduced transit speed of 10.8 knots, the vessel's IMO score for year 2026 remains at the "E" rating until transit miles exceed 36,000 where the vessel finds improvement to "D." This rating improves to IMO "C" rating at more than 48,000 annual transit miles. However, when the Charterer orders the vessel to reduce speed it has the unintended consequence of removing actual ton-miles from the market supply, which diminishes available transport capacity at the macro level. Lower market supply would in general result in higher freight rates at a constant demand level. As such, it is logically doubtful that a Charterer would unilaterally opt for slower speeds to achieve improved emission outcomes. Conversely, when ordered to proceed at higher speeds, the impact of a lower CII grade is borne entirely by the Owner under the current CII approach. An asymmetry in costs and benefits is thus created.

Figure 6.

58K DWT Supramax 2011 Era & Charter Speeds



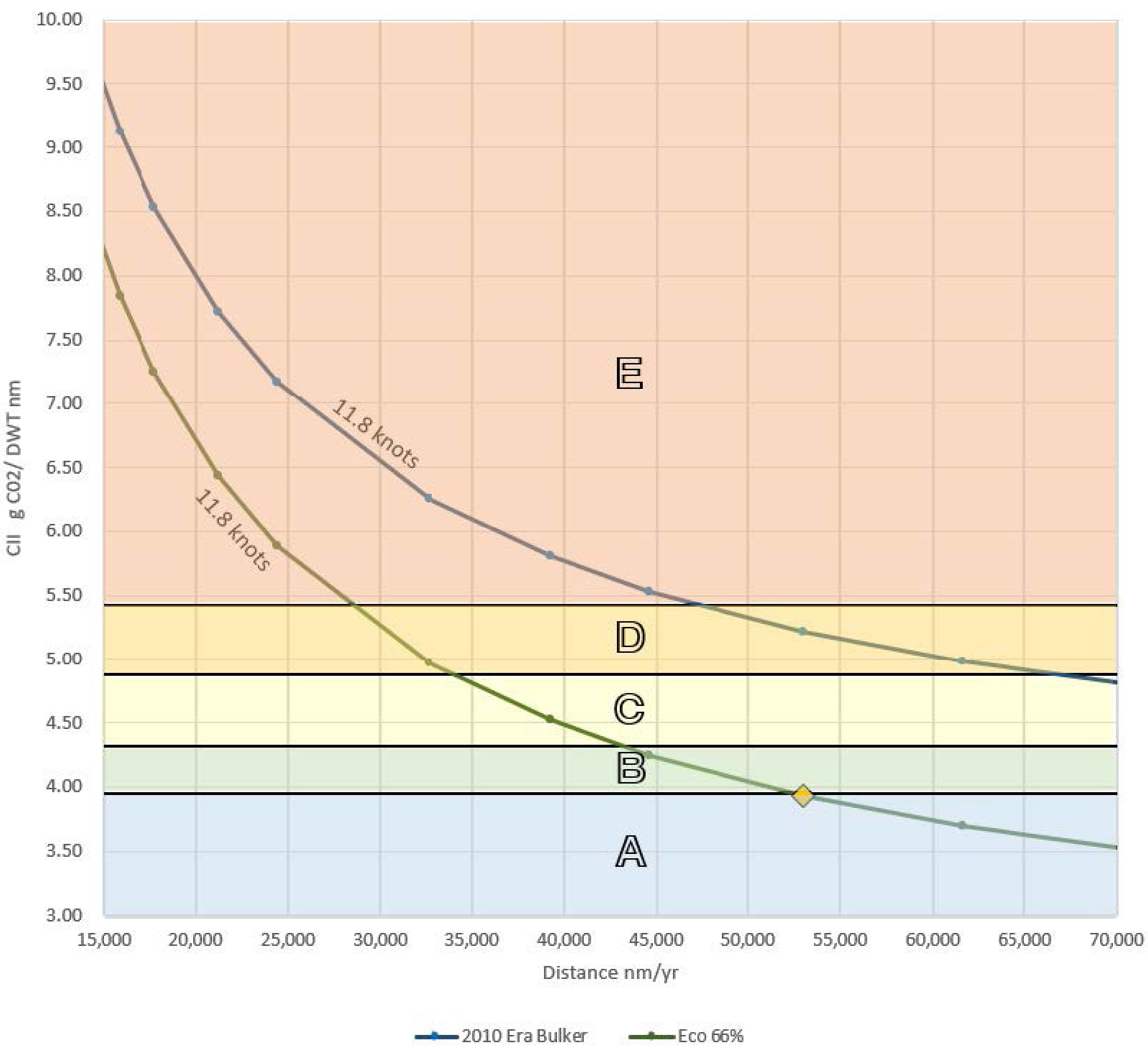
Note: 58K DWT Supramax 2011 Era & Charter Speeds with resulting IMO CII rating A, B, C, D, E: year 2026.

CHARTER OPERATIONS DIMINISH SHIP EFFICIENCY

The introduction of ECO ships during the 2010's mid-decade found a step change toward greater energy efficiency compared to vessels built a few years earlier. The next investigation assumes an ultra-modern decarb era vessel, based upon the ECO design advantages that incorporates several additional energy savings measures. Energy savings measures (ESM) include the incorporation of energy savings operations (ESO) and retrofit adoption of energy savings devices (ESD) sometimes referenced as energy saving technology (EST). The decarb era enhanced vessel assumes a substantial improvement where the main propulsion burden is reduced toward 66% of the energy required for the 2011 vessel. Figure 7, "***Supramax 2011 Era vs. Modern ECO Decarb***" illustrates improved carbon intensity CII scores attained over equal market distance to restore macro market capacity.

Figure 7.

Supramax 2011 Era vs. Modern ECO Decarb



Note: Supramax 2011 Era vs. Modern ECO Decarb, with resulting IMO CII rating A, B, C, D, E: year 2026. Yellow diamond is the reference voyage pattern for sensitivity analysis detailed in Table 3.

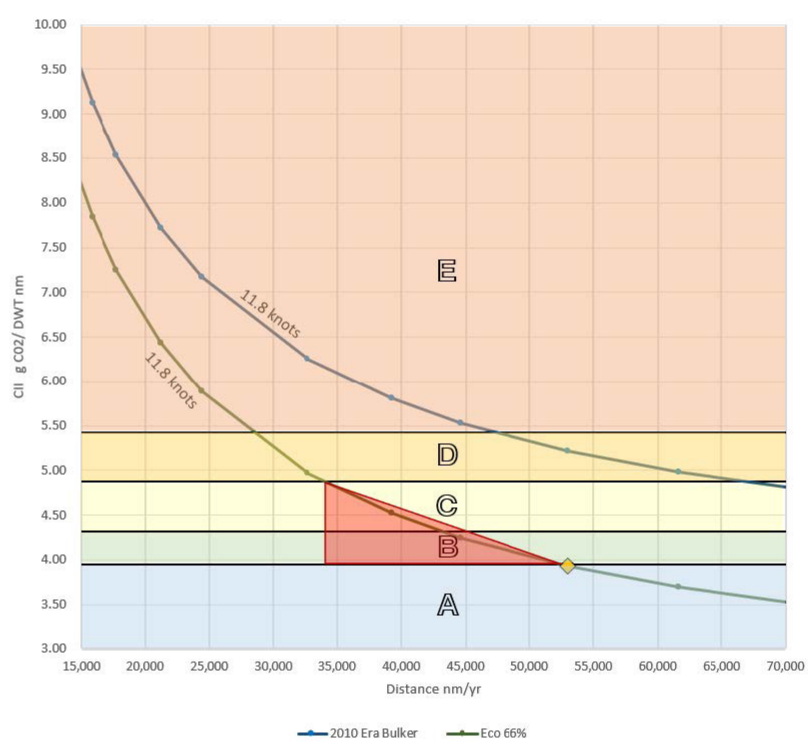
The yellow diamond on the ECO curve in Figure 7 shows that the Modern ECO Decarb vessel achieves an "A minus" IMO rating at the reference voyage of 53,000 miles for the year. Figure 7 shows that the Modern ECO Decarb vessel's energy saving attributes elevate IMO ratings upward nearly 2 grades over that of the 2011 Era vessel for same market capacity ton-miles at the reference 11.8 knot speed. However, the Charter voyage orders and resulting operational profile often diminish the apparent advantage as discussed below.

Oversimplification, however, can be deceiving. The apparent advantage afforded by superior engineering attributes is quickly overcome by Charter voyage orders that command the vessel Owner to operate the ship in profiles that often nullify those technical advantages. Charterer orders determine the vessel performance over a distance required for cargo transport and at a speed necessary to meet the cargo owner's logistic needs. These Charter orders impact the IMO carbon intensity index "CII" score, in many cases causing undesirable rating deterioration.

Figure 8: "***Charter Distance Impacts Supramax 2011 Era vs. Modern ECO Decarb***," shows the negative impact of transit distance reductions. These principally arise when the Charterer orders the vessel to make a series of short regional runs where port intervals represent a large proportion of the voyage time and vice versa for long ocean route transits that accumulate greater distances over the year. A secondary Charter negative impact occurs for a time charter when the actual number of voyage port calls or frequency is less than originally anticipated, as a result of various delays, which also cause a fall in accumulated transit distance for the year. Both outcomes are outside the control of the vessel Owner, but each causes a deterioration in the CII score that remains as a residual burden attached to the vessel.

Figure 8.

Charter Distance Impacts Supramax 2011 Era vs. Modern ECO Decarb



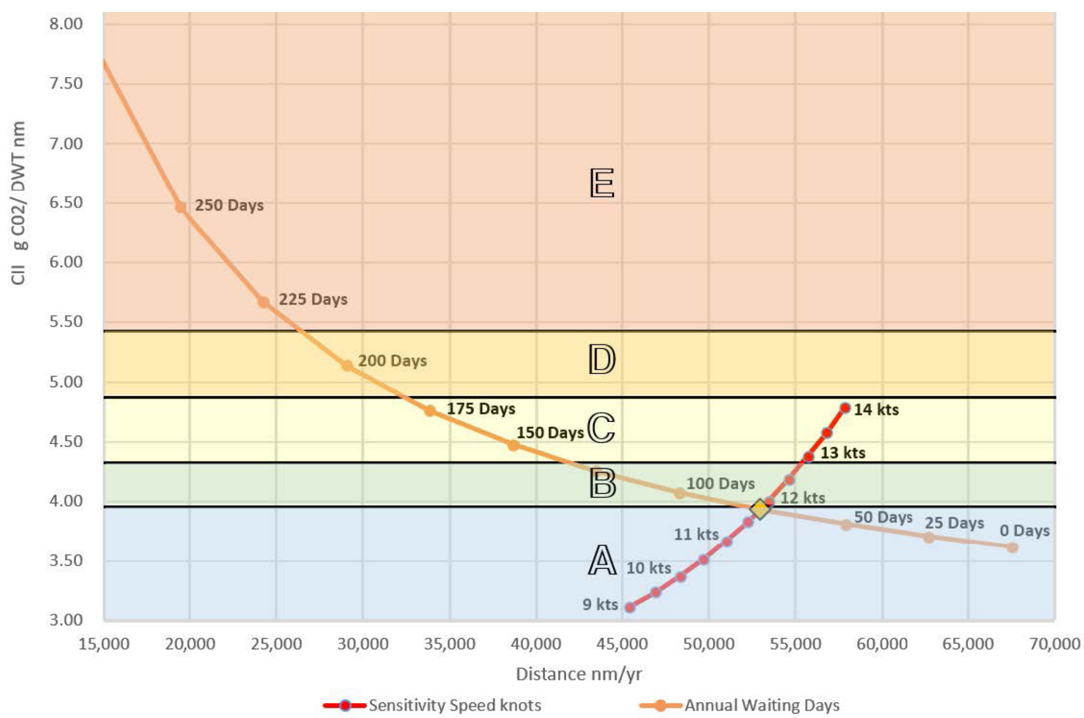
Note: "Charter Distance Impacts Supramax 2011 Era vs. Modern ECO Decarb" with resulting IMO CII rating A, B, C, D, E: year 2026. The orange triangle illustrates a distance reduction from the reference yellow diamond voyage.

The orange triangle illustrates (reading from right to left) a distance reduction of 19K miles from the reference yellow diamond 53K transit annual miles to only 34K miles for the year. The reduction in transit miles causes a substantial deterioration in the IMO CII rating to fall 3 letter grades from "A minus" to "D plus". A rule of thumb observation from the figure; for about every 8,000 miles of reduced transit per year as dictated by the Charterer (outside of the vessel Owner's responsibility), the CII vessel rating falls nearly a full letter grade.

Charter orders for a vessel often alter a vessel's profile as to speed underway or waiting days for berthing availability to load or discharge cargo. Charterers dictate vessel speed to accommodate complex logistics needs and to mitigate risk. Charter profiles include vessel waiting time which is dependent on port congestion that may arise for many reasons, or represent floating storage. These delays may often expand beyond original estimates. Figure 9: "***Modern ECO Decarb CII Sensitivity Speed and Waiting Days***" illustrates the impact that these two voyage parameters have on CII rating scores.

Figure 9.

Modern ECO Decarb CII Sensitivity Speed and Waiting Days



Note: "Modern ECO Decarb CII Sensitivity Speed and Waiting Days" illustrates the sensitivity impacts of these two voyage parameters on the CII rating grade scores. IMO CII ratings A, B, C, D, E: year 2026.

The yellow diamond reference voyage is based on an underway speed of 11.8 knots with 76 annual waiting days for the Modern ECO Decarb vessel achieving a CII rating of "A minus."[4] Charter orders to increase speed by 1.1 knots from 11.8 to 12.9 result in a drop of 2 grades from "A minus" to "C plus." A similar drop in the CII rating of 2 grades occurs when Charter orders increase the annual time waiting to load or discharge by 56 days from 76 to 132 days. A rule of thumb observation from the figure: for every 50 additional days waiting in port per year, delays that are outside the vessel Owner's responsibility, the CII rating drops nearly a full letter grade.

4 Yellow diamond voyage details are shown in table 3 column heading "4200" discharge to discharge distance miles.

THE SYSTEM ALTERNATIVES AND THEIR EFFECT ON OVERALL EMISSIONS

An evaluation of the impact of the CII formula on "systems operations" can further illustrate shortcomings of the current approach. As has been demonstrated in a previous submission to the IMO dated 29th January 2022, delivery systems comprised of a combination of large ocean going tankers aided by "shuttle tankers" preforming lightering operations at or near the final discharge destination enable a flexible and lower carbon supply chain. The use of lightering vessels in a system which lighters Aframax and Suezmax tankers in the Big Stone Anchorage of Lower Delaware Bay and transports that lightered cargo up to one of several terminals on the Delaware River provides a similar illustration of this conclusion. Due to the short voyage distance, averaging approximately 65 nautical miles, an average of 122 round trips made by the lightering vessel is assumed for this analysis which is within the actual historical range. The larger tankers to be lightered tend to come mostly from West Africa, with some coming from Mexico, the Caribbean and Canada. To keep this analysis relatively simple yet still realistic, it is assumed that the lightering vessel services 122 Aframax tankers each year, with two-thirds coming from West Africa and one-third coming from southern Mexico. The lightering vessel is assumed to lighter 37,500 tons of cargo from the 112,500 tons that Aframax tanker transported from its source. After having been lightered, 75,000 tons of cargo remain on board the Aframax to be transported up the river. This reduced load of cargo lessens the Aframax tanker's draft such that it can continue up the Delaware River to moor at the cargo discharge terminal.

Table 4 summarizes the values for an Aframax tanker and Lightering Vessel working together. It shows that when operated in a system where the Lightering Vessel combines with 122 Aframax tankers over one year to deliver 13,725,000 tons of cargo, 360,563 tons of CO_2 are generated. Aframax voyages are round trips therefore, ballast leg emissions are fully accounted for. While the Lightering Vessel when taken on its own achieves a poor CII grade due to its extremely short voyages, the overall system achieves an excellent CII grade.

Table 4.

Aframax & Lightering Vessel Working Together

	Aframax	Lightering Vessel
No. of Round Trips per Year	122[1]	122[2]
Nautical Miles per Trip	8,150[3]	130
Nautical Miles per Year	994,300	15,860
Cargo per Trip Pre-Lighter (tons)	112,500	-
Cargo per Trip Post-Lighter (tons)	75,000	37,500
Cargo Per Year (tons)	13,725,000	4,575,000
Fuel Consumption Per Year (tons)[4]	111,691	3,660
CO_2 Emissions Per Year (tons, each)[5]	348,835	11,734
CII Grade (2023)	A	E
CO_2 Emissions Per Year (tons, combined)	360,563	
CII Grade (combined, effective) (2023)	A	

Note: Corresponding footnotes are on following page.

1. This assumes numerous Aframax tankers collectively make 122 round trips to Delaware Bay. Two-thirds of them are assumed to come from West Africa and one-third from southern Mexico.
2. The same lightering vessel makes 122 round trips from the lightering area of Lower Delaware Bay to the Delaware River near Philadelphia.
3. Weighted average of two-thirds originating in West Africa and one-third in southern Mexico.
4. Assumes eco-speed for the Aframax at 12.5 knots in laden condition, 13.0 knots in ballast condition.
5. Assumes a Carbon Factor of 3.114 outside and 3.206 inside of the North American Emissions Control Area.

Under the IMO rules as they currently stand, the lightering vessel would be forced out of service within one year due to her poor CII grade. This is because the IMO rules do not recognize vessels as part of a combined system. The lightering vessel may only be considered on its own. This remains a key fault of the IMO metric in that its simplicity doesn't recognize combined logistics systems. Yet, an inability to conduct lightering operations would dramatically increase the amount of CO_2 emissions resulting from transporting and delivering the same quantity of cargo. Without a lightering vessel waiting for it at the destination, the typical Aframax tanker would have to "short-load," or load to far less than its maximum capacity, at the cargo origination point. This is so that on arrival at Delaware Bay she would be at a light enough draft to continue up the river and moor at the terminal. In this scenario it is assumed the Aframax Tanker loads only 75,000 tons of cargo versus 112,500 tons. However the vessel would consume only slightly less fuel in this loaded condition. And at this reduced capacity, 50% more tankers would be necessary to carry the same amount of cargo. Within the framework of the current rules this would be acceptable as each of those 61 additional tankers would likely score very good CII grades due to their long voyages and relatively short port time. These rules do not however take into account the potential significant amount of CO_2 emissions related to construction and maintenance of those additional vessels.

Table 5 summarizes these results. Those 183 Aframax tankers, or a smaller number of tankers making that many voyages, would emit a collective 513,319 tons of CO_2 to carry the same amount of cargo, a 42% increase as compared with the more efficient lightering delivery system. Voyages are round trips therefore, ballast leg emissions are fully accounted for.

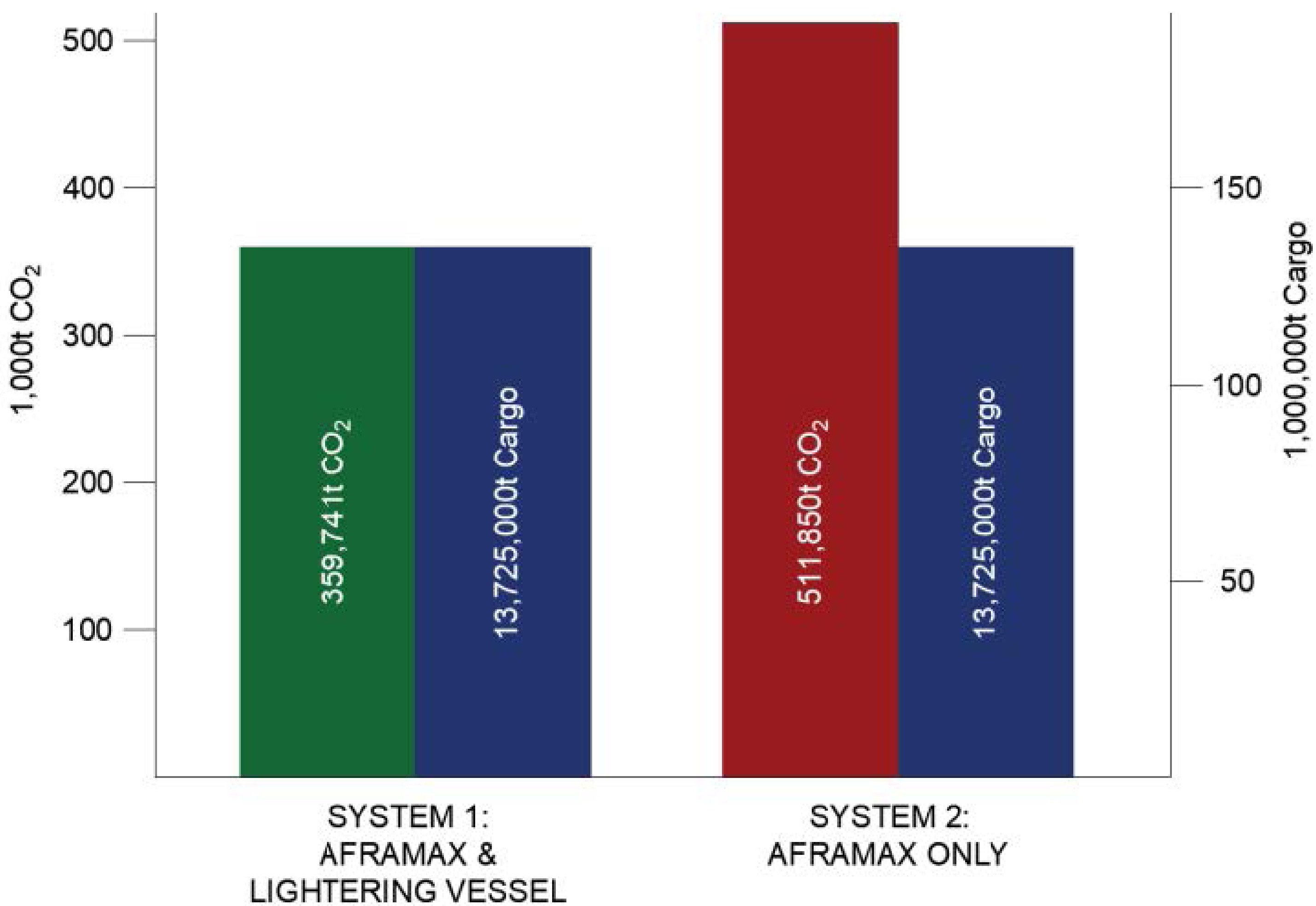
Table 5.
Aframax Only, Without The Benefit of the Lightering Vessel

	Aframax
No. of Round Trips	183
Nautical Miles per Trip	8,150
Nautical Miles per Year	1,491,450
Cargo per Trip (tons)	75,000
Cargo Per Year (tons)	13,725,000
Fuel Consumption Per Year (tons)	164,371
CO_2 Emissions Per Year (tons)	513,319
CII Grade (effective) (2023)	A

As shown in Table 5, 50% more Aframax tankers carrying less cargo on each voyage would still achieve a CII Grade of A. This is because the CII calculation does not take into account the lower amount of cargo actually carried. Instead, it only takes into account the rated deadweight capacity of the vessel which does not change if the vessel is short-loaded. This shows just one possible perverse outcome of the CII formula; a larger fleet of ships carrying the same cumulative amount of cargo can still achieve an excellent grade despite emitting 42% more CO_2.

In summary, while the lightering vessel achieves a poor CII grade due to her extremely short voyages and comparatively longer time in port, without it the overall CO_2 emissions of the system would be 42% higher.

Figure 10.
System 1 vs. System 2 CO_2 Emissions



OLD VERSUS NEW TONNAGE

An unstated intent of the new GHG-reduction regulations may be to incentivize replacement of older tonnage with newer, more efficient tonnage. On paper, many may view this as a guaranteed solid first step toward lower emissions where it is assumed that a state-of-the-art ship will always be rewarded with a higher CII grade than a similarly sized older vessel. However even a vessel of modern, efficient design will suffer low CII grades if it is engaged in a trade with short voyages or long waiting times.

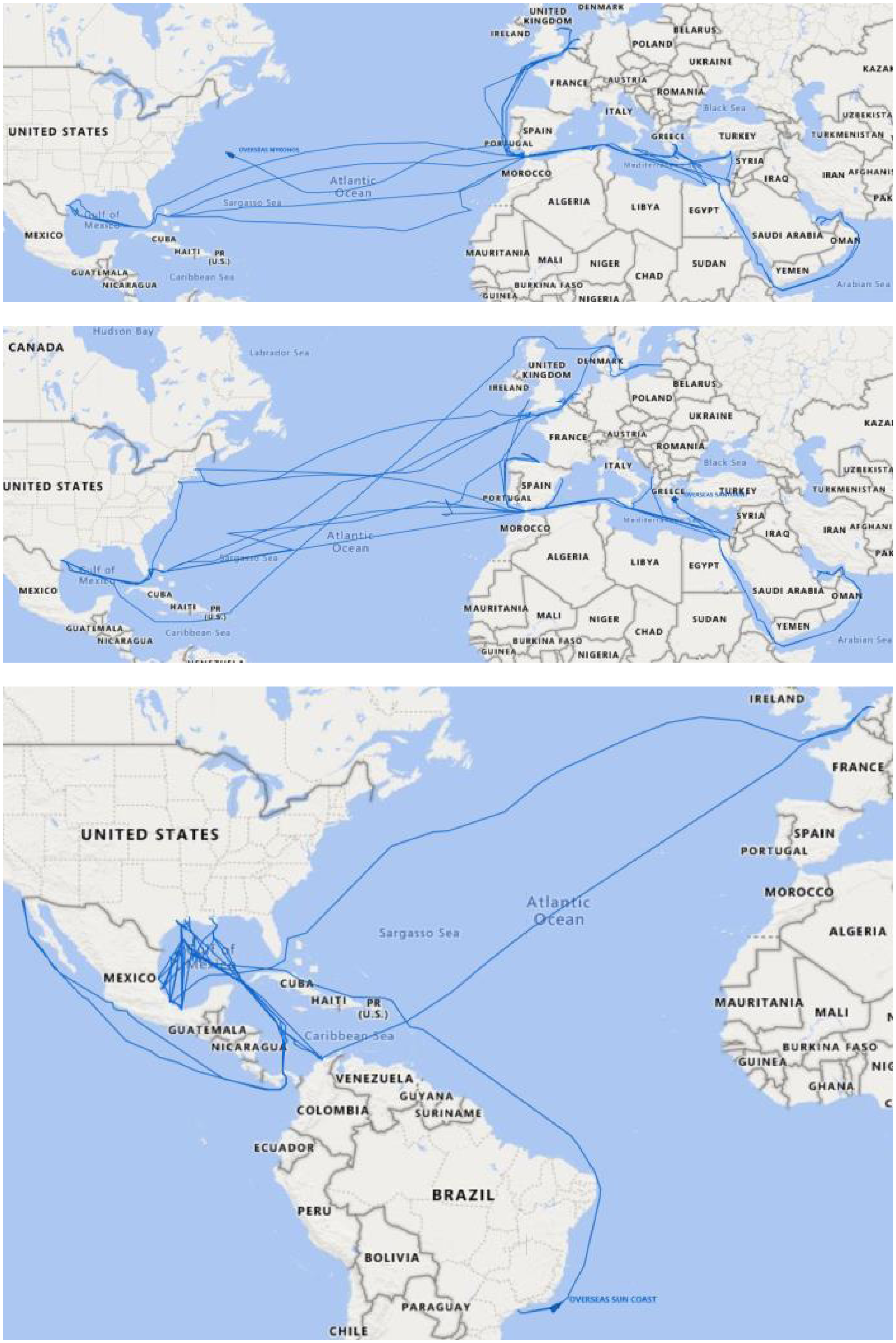
OSG has direct experience with operating older and newer tonnage side by side. *Tanker 14*, delivered from Hyundai Mipo Dockyard in 2019, is several design generations newer than *Tanker* 15 and *Tanker 16*, each of which were delivered by HMD in 2010. *Tanker 14* adds such fuel efficiency technology as a slimmer hull shape, a MAN B&W 'ultra-long stroke' engine, and a 17% larger diameter propeller turning at 32% fewer revolutions per minute for higher open water efficiency. OSG's experience is that *Tanker 14* averages approximately 25% lower fuel consumption, with a corresponding reduction in CO_2 emissions, at sea compared to its older tankers.

Despite its more advanced design, *Tanker 14* did not achieve a higher CII score in 2020 or 2021 than the older, less efficient *Tanker 15* and *Tanker 16*. The latter two vessels were able to match the newer vessel's CII score not because they have the technology fitted to be as fuel efficient on a per-mile basis, but rather because their trades are simply treated more favorably by the CII formula. With their greater commercial emphasis on transatlantic runs, *Tanker 15* and *Tanker 16* average 30-50% greater miles run than *Tanker 14* which is the primary factor in their CII scores being roughly equal.

The illustrations that follow show that *Tanker 15* and *Tanker 16* both made, on average, three to four transatlantic voyages and one long round trip voyage to the Persian Gulf per year compared to only one long voyage by *Tanker 14* during the period under review. *Tanker 14* conversely spent relatively more time making short voyages between ports in the Gulf of Mexico, resulting in shorter average voyage lengths, and multiple transits through the Panama Canal which often require lengthy wait times at anchor. *Tanker 15* and *Tanker 16* experienced a relatively higher number of days transiting (and corresponding miles run) and fewer port calls than *Tanker 14*. *Tanker 15*, for example, ran over 71,000 nautical miles in 2021 compared to only 45,000 by *Tanker 14*.

Figure 11.

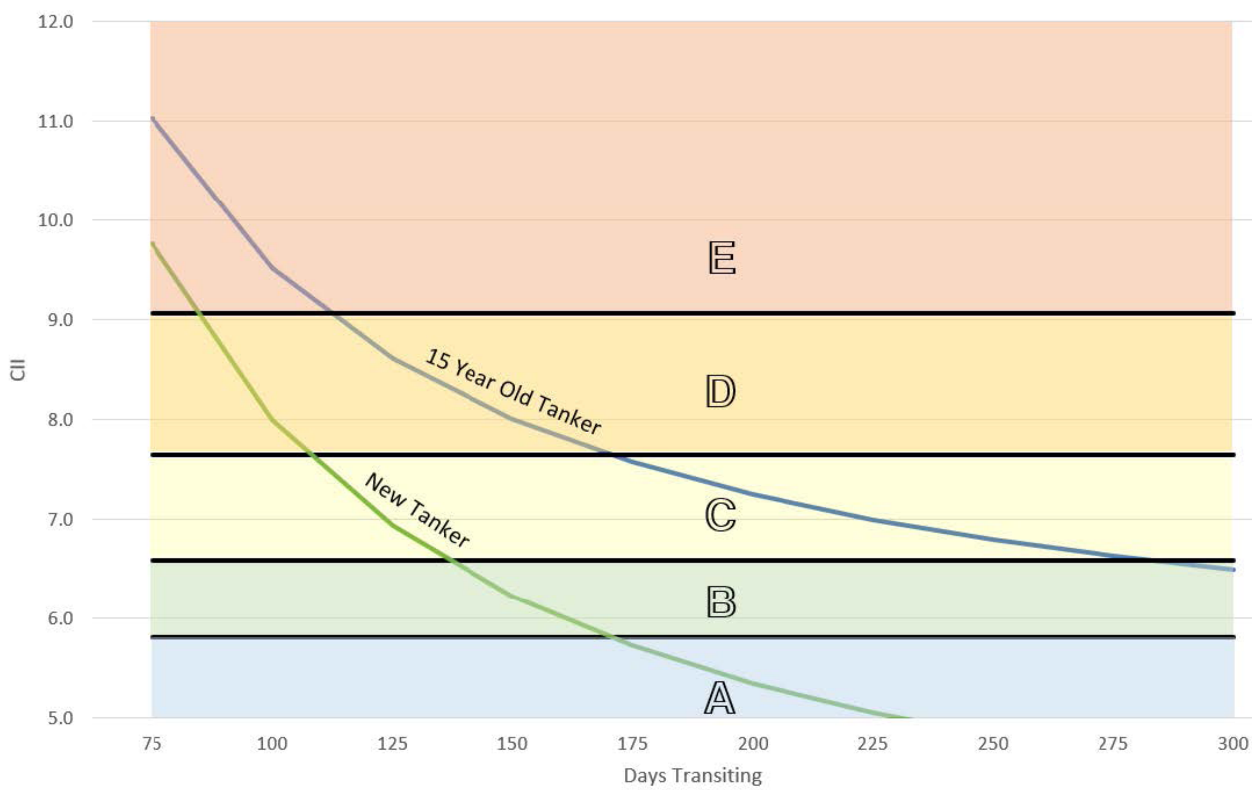
Typical Annual Trading Patterns of Tanker 15 (top), Tanker 16 (middle), and Tanker 14 (bottom)



A similar result would be likely even if an Owner were to order the absolute latest tanker design from Hyundai Mipo Dockyard. HMD advertises that its "New Std (7th Generation)" MR tanker achieves 19 tons per day consumption in its main engine with a rudder bulb.[5] Compared to approximately 26 tons per day in the main engine of OSG's 15-year-old tanker, this represents a significant 27% reduction in main engine fuel consumption. But assume for a moment that with the addition of more energy savings devices and the highest-performance hull antifoulant coating, an additional 5% reduction could be achieved for a total of 32% efficiency gain as compared to OSG's 15-year-old tanker. Some might assume that such a ship, representing the most technologically-advanced MR tanker commercially available today, would always achieve the highest CII grade. But a relatively simple calculation shows that is not necessarily the case and even this best-in-class ship is reasonably capable of receiving only a "D" grade.

Assume that the older ship consumes a total of 30 tons per day (including auxiliaries) at 14 knots but the state-of-the-art ship consumes only 20.4 tons per day at the same speed, achieving a 32% reduction in overall fuel consumption. Figure 12 shows that the new tanker will achieve a grade of "B" when underway half of the year (182 days), whereas the 15 year old tanker will achieve a grade of "D." This is to be expected. But what may not have been expected is that even the new tanker, if in a trade with very short runs and relatively longer periods in port or waiting at anchor, can receive a grade of "D" despite all of the latest technology incorporated into its design.

Figure 12.
CII vs Days Transiting, New Tanker vs 15 Year Old Tanker



5 Mipo MR Tanker Presentation, Initial Planning Dep't, May, 2021.

VESSELS ENGAGED IN SPECIALIZED TRADE

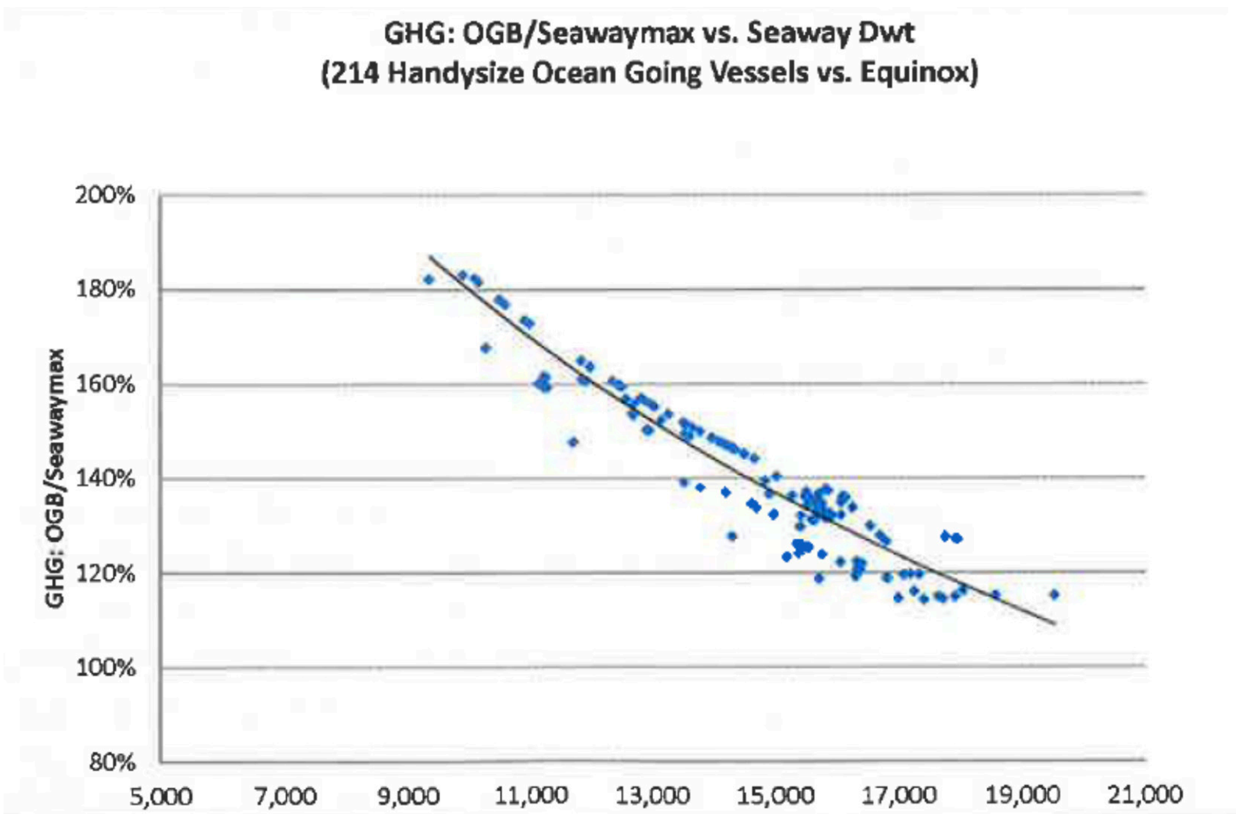
As the enforcement date for the IMO's EEXI and CII regulations is quickly approaching, it is important to examine how the global framework could expand to address vessel efficiency within specific regional trades. A number of individual governments have recently announced their commitment to minimize maritime emissions by 2050 and beyond. Vessels trading domestically and in inland waters will eventually need to meet set benchmarks for technical and operational efficiency. Where the IMO's EEDI, EEXI and CII indices are considered to be used, regulators need to closely examine regional fleet data to determine any necessary adjustments to the current calculation formulas.

Vessels trading in the U.S. Great Lakes are an example of unique design characteristics that were put in place to address restrictions of a specific geographical area. Great Lakes Seawaymax vessels transiting the St. Lawrence Seaway System aim to maximize their cargo carrying capacity within the waterways limitations by fuller hull forms, lower drafts and propeller geometries that perform poorly when compared to their IMO compliant ocean-going counterparts using the MARPOL Annex VI framework. However, in an assumed scenario where regulations would require the employment of IMO compliant ships in the specific region, the overall carbon intensity would increase significantly, also considering that the replacement vessels are much smaller in size. SNAME [8] has published the results of a relevant case study where a comparative analysis between a series of modern Seawaymax Lakers and a series of CII-compliant oceangoing bulkers (OGB) indicates the increase of GHG emissions and overall efficiency drop when the smaller conventional OGBs are considered. Table 6 and Figure 13 below, taken from the SNAME publication, provide a comprehensive summary of these conclusions.

Table 6.
Seawaymax vs CII- Compliant Oceangoing Bulkers (OGB)

	Seawaymax Laker	OGB	
# of Sisterships	5	15	12
Deadweight (mt)	35,900	18,315	16,213
Seaway deadweight (mt)	30,000	15,548	15,595
Trips Required	20	39	38
Observed CII	8.5	10.7	11.5
Required CII	7.0	10.7	11.5
Observed/Required	1.21	1	1
GHG Indication (t CO_2)	5,100,000	6,406,219	6,914,239
Relative Emissions (OGB/laker)	100%	126%	136%

Figure 13.
Comparative Emissions Between OGBs and Seawaymax



It is therefore imperative that regulations aiming to reduce the carbon intensity of commercial shipping activities, remain goal-based nature and take into account a range of operating profile characteristics when benchmarking the global fleet. Many times, these operating conditions, that in turn inform ship design criteria, are unique to local geographies. By deciding to apply a uniform approach, based only on the performance of conventional oceangoing vessel designs, ambitious decarbonization targets may become much harder to meet.

INCREASING CHARTERERS' RESPONSIBILITIES

There is some movement in the industry towards making Charterers more responsible for the CII grade issued to a vessel that results from the voyage orders they issue to that vessel. BIMCO, a membership-based non-governmental organization with over 1,900 members in more than 130 countries, recently adopted a charter party clause that would assign proper responsibility for achieving required CII scores. The clause recognizes that the Charterer's orders may need to be modified from time to time during the charter period in order to meet it. It would make the Charterer submit a written corrective action plan when the agreed-to CII score is not met.

The draft clause does not let Owners off the hook, and rightfully so. It would require both parties to work together in good faith to ensure the agreed-to CII score is met. It would also require the Owner to exercise due diligence in the daily operation of the vessel to minimize fuel consumption, through measures such as efficient voyage planning, trim optimization, and main and auxiliary engine operation.

The CII clause was adopted on November 17th 2022 on BIMCO's[6] website and is viewed as a positive first step in recognizing that even though compliance with MARPOL Annex VI is the Owner's obligation, the Charterer's actions can be instrumental to the vessel's achieved CII grade.

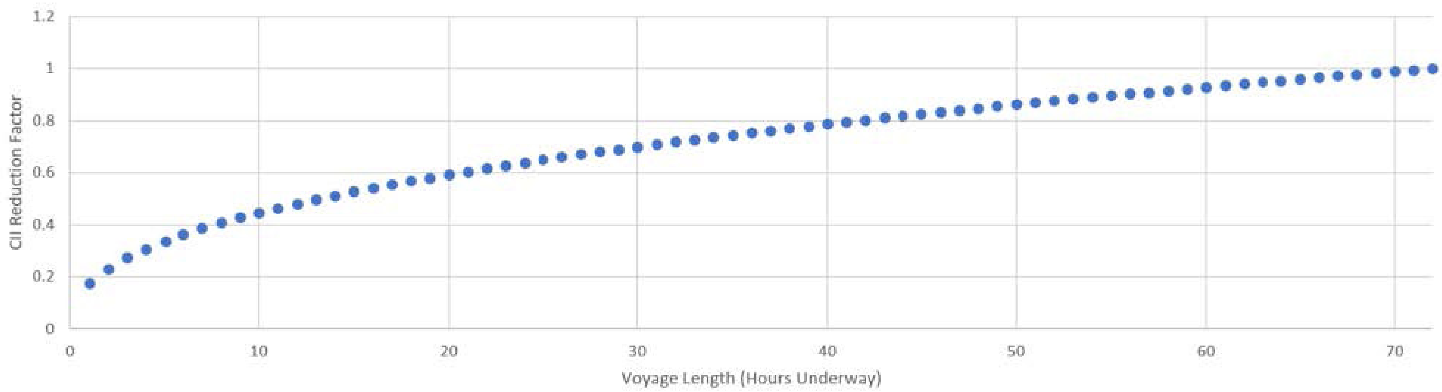
6 https://www.bimco.org/contracts-and-clauses/upcoming-contracts-and-clauses

CORRECTION FACTORS

As stated above, several correction factors are under consideration at the IMO level which would adjust CII scores for certain vessels in certain circumstances where it is acknowledged that the vessel is unfairly penalized by the CII calculation without it. One in particular that has the full support of the authors, and would correct some of the situations described earlier in this paper, is that submitted by Liberia to the IMO's Working Group on Reduction of GHG Emissions From Ships on 1 April 2022.[7] The proposed correction factor would reduce CO_2 emissions on any voyage where the total time under way is less than 72 hours. The applied correction factor would vary with the number of hours underway as shown in Figure 14.

Figure 14.

CII vs Days Transiting, New Tanker vs 15 Year Old Tanker



For example, a vessel on a voyage between the departure from one berth and the departure from the next berth, where the total time underway between berths is 40 hours, would be able to multiply the total CO_2 emitted over that voyage by a factor of 0.8. In other words, the CII calculated for that particular voyage would be reduced by 20% to put it on a level playing field with similar ships on longer voyages. The authors of the correction factor proposal included an example of a bulk carrier where out of 89 voyages conducted during the calendar year, 57 were "short voyages" with less than 72 hours underway. The overall annual CII was reduced by 5.8% as a result. For a vessel that is unfairly penalized with regard to CII because the charterer puts it in a trade with relatively short voyages, this correction factor could mean the difference between a "C" and a "D" grade.

This proposed correction factor would not, unfortunately, help a vessel with a voyage length of over 72 hours underway that is forced to sit at anchor for an extended period of time due to the charterer's requirements or while waiting for its next job. Such a vessel would still suffer a low CII score despite the waiting time being out of the Owner's control. The authors recommend another correction factor that applies a maximum to the number of days' worth of CO_2 emissions while waiting that apply to the CII calculation. For example, if a vessel sits at anchor waiting for the cargo terminal to be ready for ten days, perhaps only the first three days' worth of CO_2 emissions while at that anchorage should count towards the CII calculation for that voyage.

7 ISWG-GHG 12/2/6, CONSIDERATION OF ANY ISSUE ARISING FROM THE FINAL REPORT OF THE CORRESPONDENCE GROUP ON CARBON INTENSITY REDUCTION, CII correction factors for ships engaged in short voyages, Submitted by Liberia, 1 April 2022.

CONCLUSION

Existing contractual arrangements provide Charterers full discretion to determine the operating conditions under which a vessel is to perform a voyage; Charterers give orders which the vessel Owner is obliged to follow. The cases presented above demonstrate that the operational profiles dictated by the Charterer result in a residual carbon score, measured as a grade determined by a flawed CII equation, that remains with the vessel. The cases demonstrate how Charterer-determined vessel operations can overwhelm technical vessel attributes even for the most advanced energy efficient vessel. Furthermore, commercial models comprising of multiple vessels for cargo delivery, have proven efficient from a logistics perspective through the years while, indicating a much lower carbon intensity compared to a scenario where individual CII compliant vessels would service the same routes on their own. The ship Owner bears the consequences of decisions taken by the Charterer that are outside of his control or without reference to the technical capabilities of the vessel.

An improved mutual assumption of responsibility and obligation by both the Charterer and vessel Owner must find accommodation to incentivize the common goal of emission reduction more fairly. To accomplish this effort, both parties must have transparent negotiations under a new era of chartering contracts where environmental key performance indicators are shared amongst both parties.

Several organizations are providing the IMO MEPC committee with submittals that highlight many of these shortcomings and provide suggestions on how to merge real vessel operations for alignment with environmental metrics that reflect logistics.

Blue Sky Maritime Coalition welcomes feedback and communication regarding this position paper. Please send remarks to communications@bluesky-maritime.org.

REFERENCES

1. IMO Resolution 328(76) (Amendments to MARPOL Annex VI)

2. IMO Resolution 336(76) (CII Calculation, G1 Guidelines)

3. IMO Resolution 337(76) (CII Reference Lines, G2 Guidelines)

4. IMO Resolution 338(76) (CII Reduction Factors, G3 Guidelines)

5. IMO Resolution 339(76) (CII Ratings, G4 Guidelines)

6. IMO MEPC Submission, 78/7/11 ANNEX 1, CII Correction Factors and Voyage Exclusions, G5 Interim Guidelines)

7. ISWG-GHG 12/2/6, CONSIDERATION OF ANY ISSUE ARISING FROM THE FINAL REPORT OF THE CORRESPONDENCE GROUP ON CARBON INTENSITY REDUCTION, CII correction factors for ships engaged in short voyages, Submitted by Liberia, 1 April 2022.

8. SNAME, Marine Technology, Perverse Consequences (Energy Efficiency Regulations for Great Lakes Vessels), July 2022