Speed Limits versus Slow Steaming

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1 Background

Recently, several entities have suggested using speed limits to regulate ship-borne CO2 emissions. Often these suggestions take the form of pointing that a "few" shipowners are slow-steaming which results in a massive savings in fuel per trip, so why not force all owners to these speeds? Often the distinction between slow steaming and a speed limit becomes blurred in these discussions.

The first thing we need to understand is that, given current bunker costs and market conditions, the implication that only a few owners have slowed down is, to put it as politely as possible, misleading. In fact, almost all ships have slowed down in response to skyrocketing fuel cost and weak spot rates, some ships much more than others.

Big tankers and bulk carriers have slowed down dramatically. Almost all big tankers and bulk carriers are steaming at average speeds of 11 or 12 knots — considerably less on the ballast leg. And they would do the same on the loaded legs if it were not for horribly inefficient C/P speeds. These C/P speeds force tanker owners to 13 or even 14 knots on loaded legs, when the fuel efficient market solution is 11 or 12 knots. As a result the owners, over slow-down on the ballast leg to 9 or 10 knots, when the fuel efficient solution is 12 or 13 knots. If C/P speeds were eliminated, tanker and bulker owners could provide the same amount of ton-miles with considerably less fuel. ***This important market imperfection should be the target of any rational regulation.*** See The Impact of Charter Party Speeds on CO2 emissions

In 2009, CE Delft published a study, claiming that, if tankers, bulk carriers, and containerships were to slow down to the extent necessary to bring surplus capacity back into the fleet emissions could be cut by 30%, implying that this was not happening. Guess what? They have slowed down and much more than CE Delft envisioned. Currently, there is nil tanker, bulk carrier, and containership lay up. Clarksons, Shipping Intelligence Weekly, 2011-06-03, estimates there are 0.2 mm tons of bulkers laid up out of 564.1 mm afloat and 2.6 mm tons of tankers (probably single hulls hoping for conversion) out of 440.1 mm tons afloat. Alphaline puts the "idle" container fleet at 0.2 MM TEU out of a total of 13 MM TEU. ***Essentially all the excess ton-miles have been absorbed in slow steaming.***

Most tanker and bulk carrier market analysts put the current excess ton-mile capacity in these sectors at somewhere around 25 to 30%. To absorb all this excess capacity by slow steaming would require an average fleet speed of about 11 knots.[1] Deep slow-steaming is pervasive in big tankers, bulk carriers, and on the boxship routes that don't involve perishable cargo.

Of course, some ships have not slowed down nearly this much. Ships carrying perishable cargos, or reefer cargos, or people who have to get to work in the morning have slowed down hardly at all, despite the gargantuan increase in fuel costs. I will argue below this is how it should be.

[1] A very small portion of the excess is absorbed in the form of extra-waitingtime for cargos.

2 Slow-steaming versus Speed Limits

Here is the crux of my argument.

Slow steaming and speed limits are two entirely different animals.

1. Slow steaming is the owners/charterers voluntary reaction to the current spot rate and fuel cost. When it's allowed to work, it is part of the competitive market process minimizing transportation costs for any given short-run ton-mile supply and demand situation.
2. A speed limit is something that's mandated from the outside. It is either ineffective or inefficient. If the voluntary slow-steaming speed is less than the mandated speed, the regulation does nothing. If the mandated speed is less than the voluntary speed, all sorts of horrible things happen. In the short run, we have shortages and an artificial spot rate boom. We respond by building more ships than we should, and these ships will be underpowered and unsafe.

Slow-steaming is good; speed limits are bad. If you want more slow-steaming, increase the cost of fuel. The best way to do that is with a carbon tax.

To make this argument, we need to go back to basics. When it comes to regulating ship-borne CO2 emissions, it all comes down to:

1. The atmosphere is a public good. It belongs to all of us.
2. As far as ships are concerned, we are giving away this public good. We are charging ships zero for the use of our atmosphere.
3. Unless we want to waste the planet's limited resources, we must cut back efficiently, that is, in the least costly way possible.
4. We need to balance the cost of pollution versus the cost of reducing pollution. If we charge each polluter the social cost of his pollution, then we will end up with the optimal amount of pollution and do it in the least costly way possible.

There are two key implications of these fundamental principles:

There is no requirement to reduce CO2 evenly.

Cariou found that when bunker prices skyrocketed in 2008 and box rates plummeted in 2009, containerships on the Asia to Europe route slowed down much more than containerships on the South America to Europe route. The reason was obvious. There is almost no perishable cargo going from Asia to Europe and little reefer cargo. 30% of the cargo from South America to Europe is perishable and another 30% is reefer. The cost to society of slow-steaming South America to Europe is much higher than the cost to society of slow-steaming Asia to Europe. What happened is exactly what should have happened, except neither trade was being charged for its use of the atmosphere. One size does not fit all.

The social cost of cutting back can vary not only by trade but also with time. The tanker and dry bulk markets offer dramatic examples. These markets cycle between boom and bust. In boom, when ships are scarce the value of a marginal ton-mile to society is an order of magnitude or more higher than in slumps when ships are in surplus, and this is reflected in the spot rate. ***To efficiently reduce emissions, ships should reduce speed far more in a slump than in a boom.***

There is a requirement to price CO2 evenly.

In the case of CO2 pollution, it is appropriate to assume that the social cost of each unit of CO2 is the same.[2] In such a case, each polluter must be charged the same price for his pollution. The obvious way to do this is with a tax. This eliminates the need for some regulator to guess how costly it is for each polluter to cut back. Those polluters for whom it is cheaper to cut back than pay the tax will cut back and those for whom it is cheaper to pay the tax than cut back will pay the tax.

Eventually, everybody gets to the point where the cost of cutting back one more unit is equal to the tax. At that point we will have reached the optimal level of pollution, and we will have done so efficiently.

[2] This is not necessarily true of all pollution. For example, the social cost of SO2 and NOx emissions depends on location, and in the case of NOx on local weather.

3 The Long Run Response

To see how a tax will work in practice, I will use the VLCC market as an example. The owner's response to changes in fuel costs takes place at two levels:

1. The long run response, changing his newbuilding specification to maximize the long-run return on investment given his current fuel cost expectations. This process operates over periods of decades.
2. The short-run response, adjusting his steaming speed to maximize his voyage earnings given the current spot rate and fuel cost. This can be done and is done on a weekly basis.

Let's start with the long-run response. Figure 1 compares the fuel consumption curves of three VLCC's.

2002 VLCC A good ship delivered in 2002. his ship was designed in 2000 when bunker prices were $100 to $150 per ton. It uses a cam shaft controlled engine which as built cannot run much below 50% (12 to 13 knots) for an extended period. This ship can be fitted with modifications to allow such operations and most owners of older VLCC's are investing in these modifications. But the low speed performance is limited by the mechanically controlled engine.

2011 VLCC A ship scheduled to be delivered this summer. This ship's specifications were fixed in 2009 when bunker prices were fluctuating around $400 per ton. This ship is fitted with an electronically controlled main engine and advanced waste heat recovery. This ship can slow steam down to less than 10 knots without difficulty.

The 2011 ship is full powered. Her installed power is slightly more than the old ship. EEDI had no influence on her design. In fact, a big, slow turning engine was essential to obtaining the improved fuel consumption. It allowed a more efficient prop and a lower Specific Fuel Consumption.

2013 VLCC The latest offering from the yard. This ship incorporates the advances of the 2011 ship plus a fancy turbocharger system, a pre-swirl device, and the very latest in propeller and hull design. This ship was designed in a $650 bunker price environment.

The 2013 ship uses exactly the same engine as the 2011 ship but it has been derated from 31,640 kW to 24,900, solely to improve the EEDI. This means the ship will be less valuable to the owner since it can make less money in booms. Owners are not fond of paying for power they can't use so many will opt instead for a smaller, less efficient engine. For the purposes of this analysis, we have assumed that EEDI is not imposed, and have not derated the engine.

Above 13 knots the 2011 ship consumes 10 to 15 TPD less than the 2002 at the same speed, and the 2013 ship is another 5 to 10 TPD lower. The fuel consumption curves tend to diverge as you move to lower and lower speeds. At 10 knots, the 2002 ship which was never intended to run at that speed, has almost twice the fuel consumption of the 2013 ship.

The overall ten year picture is one of considerable improvement, especially at the low speed end. Onwer are responding to the massive post-2005 jump in fuel costs, just about as fast as they can. Owners know how to run the numbers. When their fuel cost expectations change, their investment decisions change. And as long as we maintain competitive markets ***and properly charge them for pollution***, they will change in a way that minimizes the total cost of providing the transportation service including the cost of the pollution.

If owners knew that their future fuel costs were going to be say $150 higher as a result of a $50 per ton carbon tax, they would do whatever they can to maximize their profits at that higher cost.

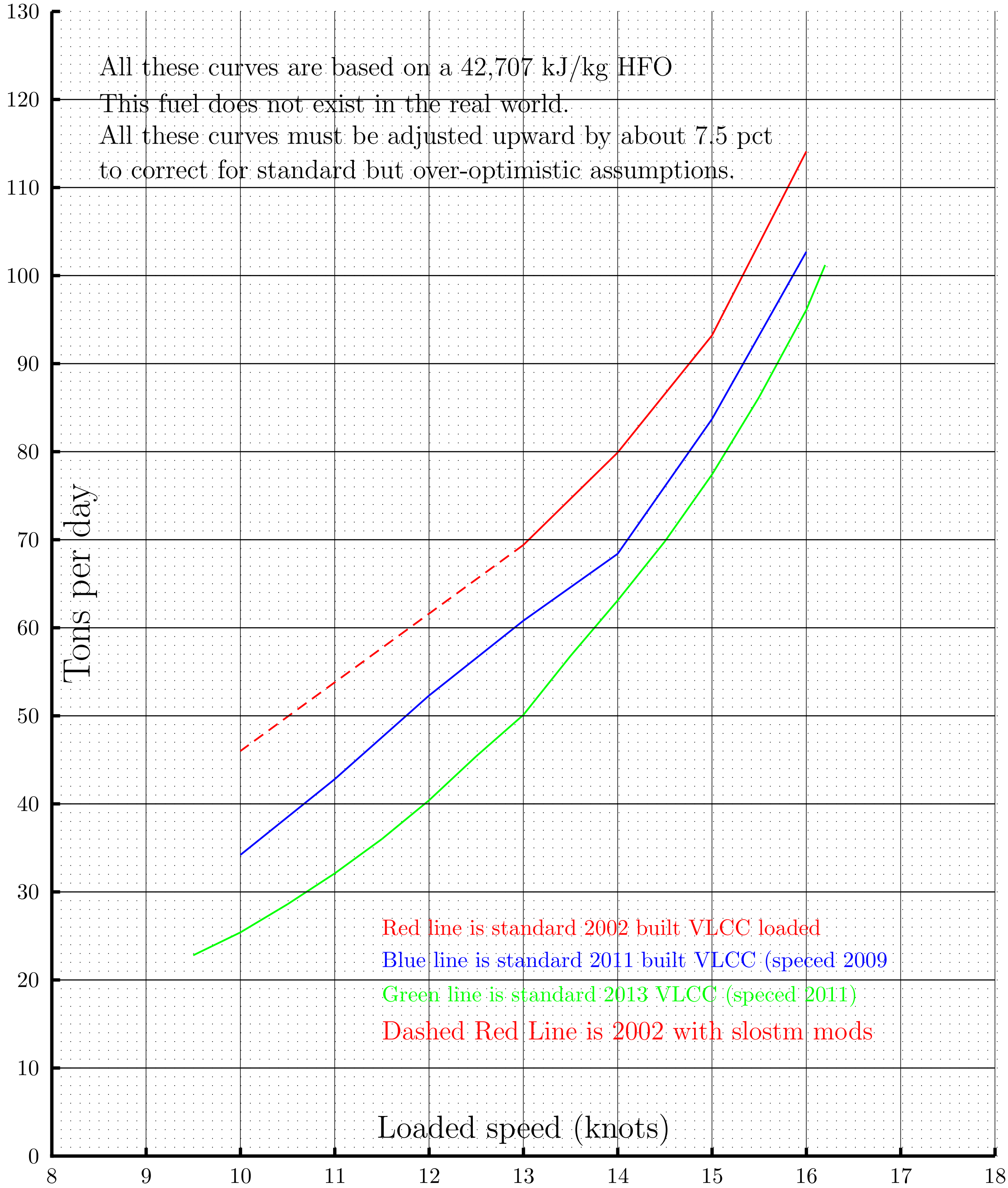

Figure 1: Comparison of 2002, 2011 and 2013 VLCC Loaded Fuel Consumption Curves

4 The Short Run Response

Figure 2 shows three different *slow-steaming curves.* A slow-steaming curve shows the average loaded/ballast speed an owner will use a function of the spot rate for a given fuel cost. In these curves, ***we have assumed that the owner is not forced to go faster than the economic level by a charterer dictated loaded speed.*** In other words, for any given spot rate and bunker prices. the owner picks the loaded and ballast speeds that will maximize his earnings per day. This will only happen if we find a way to force charterers to not impose C/P spds.

The curves shown are

1. for a fuel cost of $650 per ton, about the current market price
2. for a fuel cost of $800 per ton about the current price plus a $50 per ton CO2 tax.
3. for a fuel cost of $950 per ton about the current price plus a $100 per ton CO2 tax.

The horizontal portion of each curve to the left delineates the *layup* rate. Owners will not trade below this rate for any length of time, since they will lose less money by laying up.

For $650 bunker cost, our 2013 VLCC owner comes of layup at about WS31 at which point she is steaming as slow as she can, which for the purpose of this analysis we have assumed to be 9 knots loaded and 10 knots ballast. As rates improve, she will speed up, until at WS140 pretty much a full boom, she is going as fast as she can. The speed-up is a little jumpy because the software used only optimizes to the nearest half knot.

At $800 bunker costs, our owner comes out of layup at WS35. But now it takes higher rates to get her to speed up as she trades off the additional revenue from speeding up against the higher increased fuel costs. Once again the speed up is jumpy, but for some WS rates, the differential with $650 BFO is as much as 3 knots. Our VLCC owner facing this fuel cost will not go full speed until rates reach WS170, which is a full scale boom.

At $950 bunker costs, our owner comes out of layup at WS39. But now it takes still higher rates to get her to speed up. Despite having a very efficient ship, she will not be goingfull speed until rates are above WS200. Except at the very bottom and the very top of the curves, our owner will be steaming 2 to 3 knots slower at $950 bunkers than at $650.

In general, a given tax will slow a less fuel efficient ship more than a more fuel efficient ship. Of course, this is exactly what we want: the efficient ships going faster than the inefficient. ***One size does not fit all.***

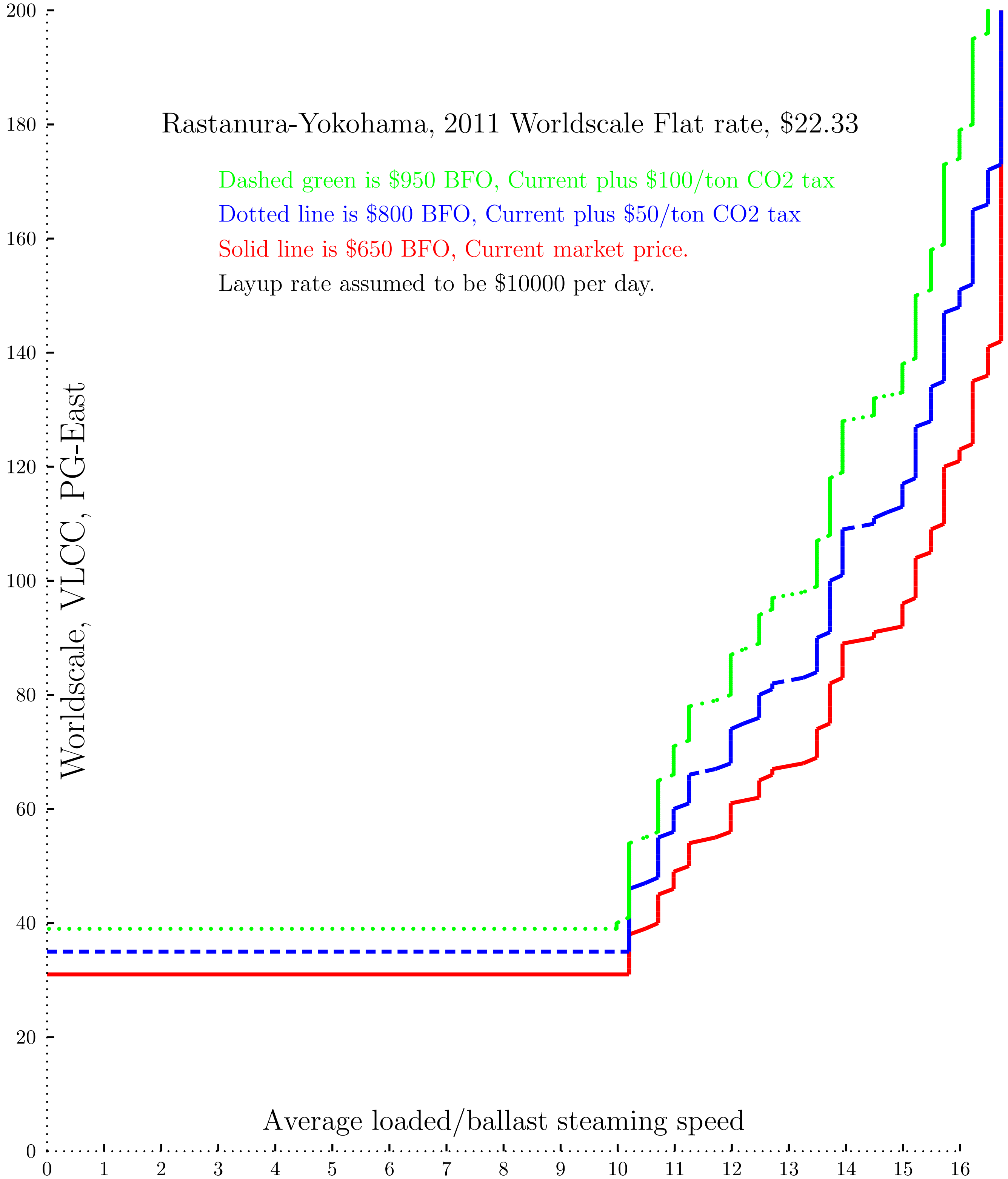

Figure 2: 2013 VLCC Slow steaming Curves

5 Implications for CO2 Emissions

The obvious question is what does this slow down means for CO2 emissions?

Tables 1, 2, and 3 show (a portion of) of the numbers upon which Figure 2 is based.[3]

Table 1: Slow-steaming curve for 2013 VLCC, BFO=$650

WS	AVESPD	BFO	TCE	DAYS	CARGO	BPD	C02/TPD
30	9.98	1550	11279	59.61	285919	34522	1.0348
40	10.20	1578	21851	58.39	285893	35236	1.0317
50	10.98	1742	32817	54.53	285851	37726	1.0641
60	11.98	2008	44438	50.31	285734	40877	1.1320
70	12.71	2219	57019	47.65	285611	43137	1.1852
80	13.72	2508	70774	44.46	285486	46215	1.2504
90	14.49	2776	84864	42.31	285419	48556	1.3175
100	15.22	3023	99989	40.46	285274	50743	1.3729
110	15.72	3216	115466	39.30	285190	52229	1.4189
120	15.72	3216	131246	39.30	285190	52229	1.4189
130	16.22	3436	147384	38.21	285097	53702	1.4742
140	16.49	3567	163725	37.65	285097	54492	1.5084
150	16.72	3681	180365	37.18	284991	55161	1.5378
160	16.72	3681	197031	37.18	284991	55161	1.5378
170	16.72	3681	213697	37.18	284991	55161	1.5378
180	16.72	3681	230363	37.18	284991	55161	1.5378
190	16.72	3681	247029	37.18	284991	55161	1.5378
200	16.72	3681	263695	37.18	284991	55161	1.5378

Table 2: Slow-steaming curve for 2013 VLCC, BFO=$800

WS	AVESPD	BFO	TCE	DAYS	CARGO	BPD	C02/TPD
30	9.98	1550	7383	59.61	285919	34522	1.0348
40	9.98	1550	17814	59.61	285919	34522	1.0348
50	10.20	1578	28450	58.39	285893	35236	1.0317
60	10.98	1742	39429	54.53	285851	37726	1.0641
70	11.25	1810	50946	53.34	285851	38567	1.0812
80	12.25	2086	63161	49.31	285734	41702	1.1527
90	13.49	2438	76387	45.15	285550	45518	1.2344
100	13.72	2508	90250	44.46	285486	46215	1.2504
110	14.49	2776	104375	42.31	285419	48556	1.3175
120	15.22	3023	119459	40.46	285274	50743	1.3729
130	15.49	3126	134858	39.83	285274	51548	1.3972
140	15.72	3216	150548	39.30	285190	52229	1.4189
150	15.99	3335	166399	38.71	285190	53026	1.4491
160	16.22	3436	182590	38.21	285097	53702	1.4742
170	16.49	3567	198926	37.65	285097	54492	1.5084
180	16.72	3681	215533	37.18	284991	55161	1.5378
190	16.72	3681	232199	37.18	284991	55161	1.5378
200	16.72	3681	248865	37.18	284991	55161	1.5378

In order to see what these differences mean for CO2 emissions, ***we must analyse the situation over an entire market cycle***. To do this we need a market rate profile. Figure 3 shows the VLCC rate profile used in this analysis. It is based on historical spot rate data for the 20 year period, 1989 to 2009. Over the very long run, spot rates must average the rate required to cover the fully built up cost of building and operating a VLCC. If rates averaged above this level, then there would be an inflow of capital into VLCC's. depressing rates. If rates averaged below this level, then there would be an outflow of capital from VLCC's, improving rates. And indeed the average of the VLCC rates over this 20 year is roughly the rate required to return an investor in VLCC's his opportunity cost of capital.

Given this profile, for each fuel cost,

1. We can easily compute the amount of time the ship will spend at each market rate.
2. From our slosteaming tables, we know the ship's speed and fuel consumpion at that rate, so it is straightforward to compute the cargo delivered and the fuel consumed, during the period that the market is at that rate.

[3] Actually, these tables have been shortened to show only every 10 Worldscale points.

Table 3: Slow-steaming curve for 2013 VLCC, BFO=$950

WS	AVESPD	BFO	TCE	DAYS	CARGO	BPD	C02/TPD
30	9.98	1550	3487	59.61	285919	34522	1.0348
40	9.98	1550	13918	59.61	285919	34522	1.0348
50	10.20	1578	24403	58.39	285893	35236	1.0317
60	10.20	1578	35049	58.39	285893	35236	1.0317
70	10.98	1742	46042	54.53	285851	37726	1.0641
80	11.25	1810	57517	53.34	285851	38567	1.0812
90	11.98	2008	69531	50.31	285734	40877	1.1320
100	12.71	2219	82170	47.65	285611	43137	1.1852
110	13.49	2438	95802	45.15	285550	45518	1.2344
120	13.72	2508	109727	44.46	285486	46215	1.2504
130	14.49	2776	123887	42.31	285419	48556	1.3175
140	15.22	3023	138929	40.46	285274	50743	1.3729
150	15.22	3023	154260	40.46	285274	50743	1.3729
160	15.72	3216	169850	39.30	285190	52229	1.4189
170	15.72	3216	185630	39.30	285190	52229	1.4189
180	16.22	3436	201572	38.21	285097	53702	1.4742
190	16.22	3436	217797	38.21	285097	53702	1.4742
200	16.49	3567	234127	37.65	285097	54492	1.5084

3. We simply add the cargo delivered and fuel burned in each such rate period over all the rates in market rate profile. The CO2 emissions per market cycle will be proportional to the total fuel burn.

One way to do this is to put the ship on a representative route in each of the three bunker cost situations.[4] In this case, we used RasTanura to Yokohama as our representative route. Table 4 summarizes the results

Table 4: Total fuel burn and cargo delivered over a five year market cycle

BFO Cost	Tons delivered	Fuel burn tons	Fuel tons/ton delivered	%reduction CO2
650	10,514,000	86,561	0.008233	0.0
800	9,995,000	76,047	0.007639	7.8
950	9,660,000	71,026	0.007353	12.0

In computing these numbers, we assumed a 5 year market cycle; but this is arbitary. We are really only interested in the ratio in the fourth column. Any other cycle length would lead to the same ratio.

For this ship, a $50 per ton CO2 tax, generates an 8% reduction in ship-borne CO2 for the same amount of cargo delivered over the market cycle. A $100 per ton CO2 tax generates a 12% reduction. The reduction in effectiveness as we increase the tax reflects increasing marginal cost to society as we cut back further and further.

It is important to recognize as a ship goes slower and slower the fuel consumption curves becomes flatter and flatter. Eventually you get to a point where a further decrease in steaming speed ***increases*** fuel and emissions for the same amount of cargo delivered. For our VLCC this occurs at about 10 knots, as can be seem by looking at the top of the leftmost column in the three tables. For ships with very large hotel loads, such as reefer vessels, this can occur at higher speeds.

It is much more important to recognize how we have accomplished this reduction. Our owner cuts back speed drastically in slumps and not at all in full booms. This is exactly what we want, for it allows us to avoid wastefully building a ship just to a handle a boom which occurs less than 10% of the time. ***A speed limit guarantees this sort of waste.***

Still more importantly, we have also given our owner an incentive to install lots of power, so she can maks lots of money in a boom. This means a large slow-turning engine and prop for better efficiency, far better heavy weather performance, far better reliability since the engine will spend more of its life at part-power, and most importantly a safer ship. ***We lose all of this with a speed limit.***

[4] This works for most tankers and bulk carrier sectors. For other types of ships, you will need multiple "representative" routes, possibly one for each trade.

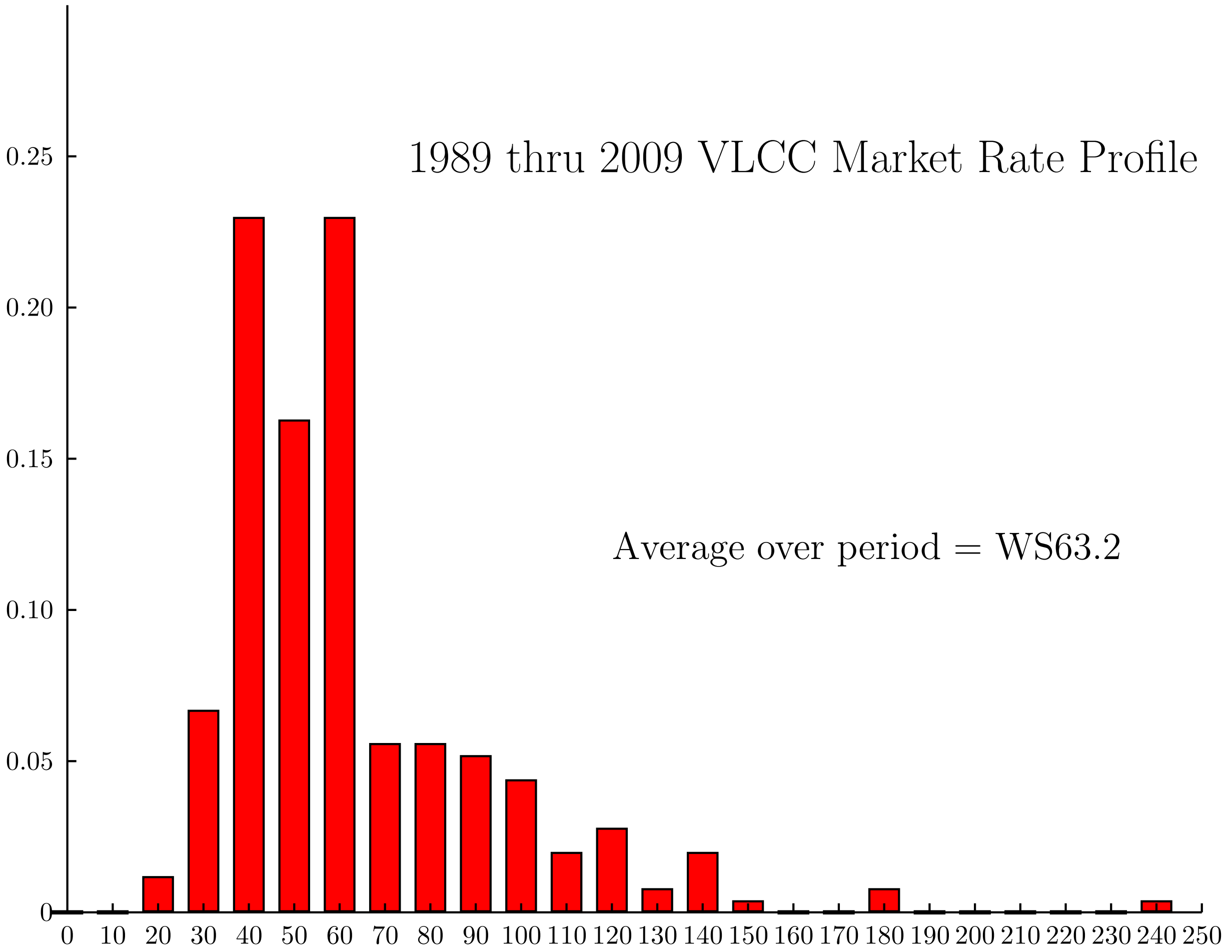

Figure 3: VLCC Market Rate Profile

6 Summary

Economic theory and common sense tell us that different ships should steam at different speeds. Despite what EEDI claims, small ships should steam more slowly than big ships carrying the same cargo. On average a ship carrying low value cargo should steam more slowly than a ship carrying high value cargo, which in turn should travel more slowly that a ship carrying perishable cargo, or simply people that have to be at work in the morning.

Moreover, the same ship should travel at different speeds depending on the momentary scarcity of that kind of ship. When a ship of a certain type is in surplus, the cost to society of that ship slowing down is far less than when when any such slow down would disrupt trade and create shortages.

But the cost to society of each unit of CO2 emitted into our atmosphere is the same. It does not depend on the type or size of ship. It does not depend on whether a particular market is in boom or slump.

If we charge owners the cost of their pollution, overall they will steam more slowly. But that slow down will be spread very unevenly over ship sectors and within each ship sector unevenly over time. This is precisely what we want if we wish to achieve any particular level of redcution without wasting the planet's precious resource.

The conclusion is obivous:

1. Speed limits are bad. They will be horribly inefficient.
2. Slow steaming is good. If you want more slow steaming, increase the owners' bunkers cost.