CRITICAL ANALYSIS OF SHIPPING ENVIRONMENTAL LEGISLATION

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A simple idea underpins science: "Trust, but verify"

(The Economist Oct 19-25, 2013)

This presentation is mostly about verification of the effectiveness of regulatory proposals

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“Everything should be made as simple as possible, but not simpler.”

“Any intelligent fool can make things bigger, more complex and more violent. It takes a touch of genius - and a lot of courage - to move in the opposite direction.”

Albert Einstein

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Shipping serves over 90% of world trade

In view of the importance of shipping to globalization, world growth and prosperity, **all shipping related legislation must be accompanied by a rigorous Cost-Benefit analysis.**

A lot of existing and proposed shipping environmental legislations would not pass such a test.

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Shipping is the most environmentally friendly form of transport. International shipping has been estimated to have emitted in 2007 only 2.7% of the world's CO_2 emissions while serving over 90% of world trade. Even this estimation may be too high.

Ships emit 3.13 tons of CO_2 for every ton of fuel oil bunker. Ship consumption changes approximately with the cube of the speed. So will their emissions. Fuel emissions, other than CO_2, vary with the quality of fuel supplied.

Shipping contributes only 12% of marine pollution.

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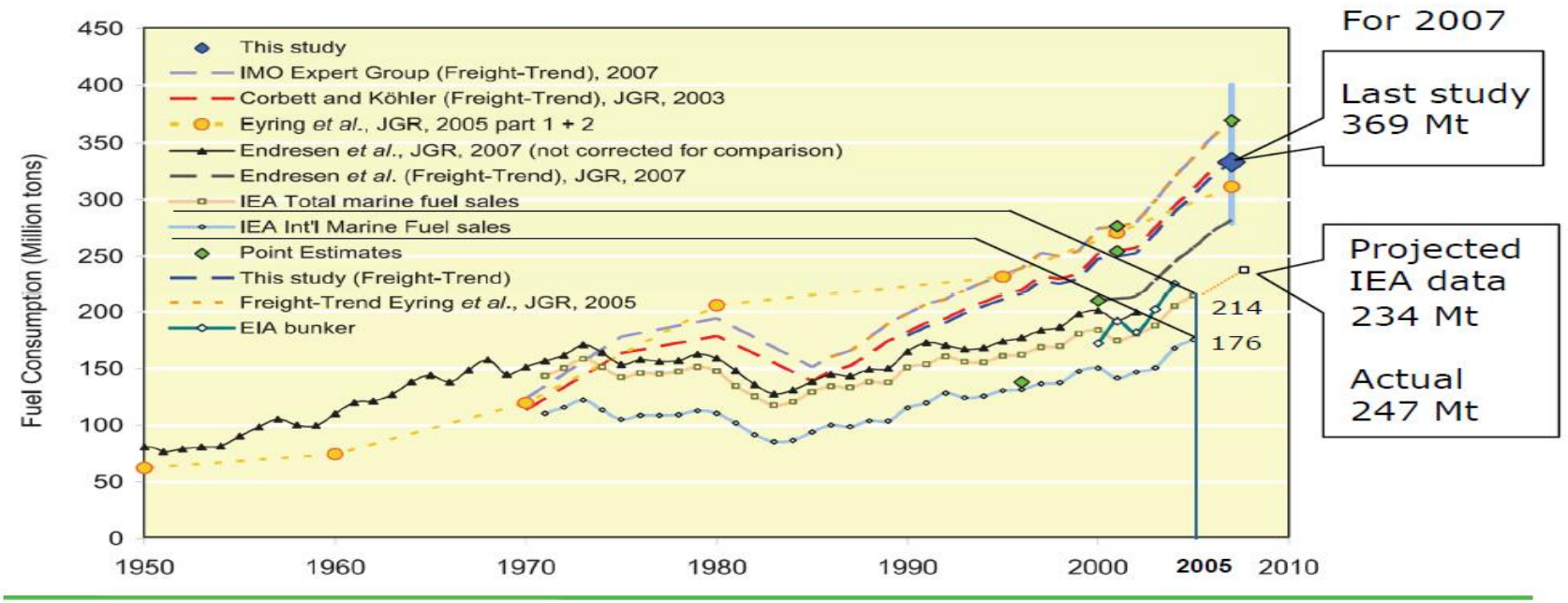
IEA statistics much lower than estimates based on activity based, bottom-up approach



Source: IMO, Second IMO GHG study, 2009, p.175.

Question: Where does the 50% more fuel above the IEA estimates made by expert "studies" come from? To be credible, studies based on simulations and assumptions must identify rogue oil wells and refineries to explain their discrepancy. "Leakage" from more expensive (taxed) products sold ashore subsequently to be on sold to tax free shipping make no financial sense.

If anything "leakage" from bunkers allocated to be sold to shipping but sold to on land consumers is not only probable but well documented. Therefore even the IEA estimates, as well as bunker receipts, very probably OVERSTATE ship consumption .

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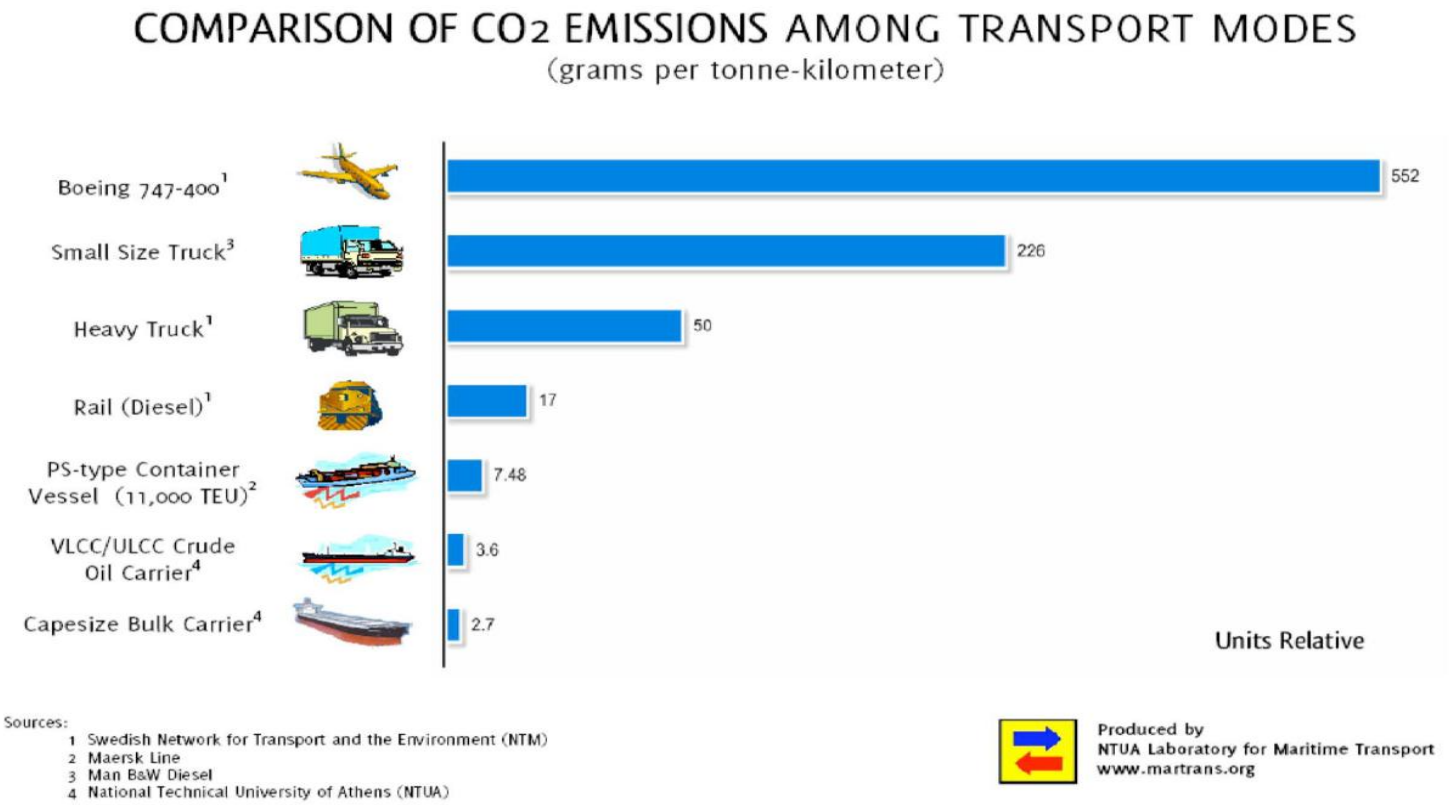

A Boeing 747-400 burns 204 times more fuel per tonne-km than a Cape size bulk carrier

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Shipping conforms to:

The laws of nature, which are well thought through and Consistent.

A robust legal environment tested over centuries.

Manmade regulations which, not being as inspired, some times create more problems than they solve despite the fact that knowledge and experience is ever expanding.

This presentation is mostly about the latter

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1: BUNKER QUALITY

IMO Regulation 14 ANNEX VI– MARPOL, limits sulfur contents in ECAs to 0.10%, from 1/1/2015. Global sulfur content must be reduced from 3.50% at present to 0.50% from 2020 onwards.

This regulation reduces the cooling effect of ship emissions therefore it does not achieve the primary environmental goal of: reducing global warming.

Low sulfur fuel should be used only in ECAs. SOx emissions are harmless if emitted outside ECAs and away from populated coasts since they have a short lifetime.

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Does Regulation 14-ANNEX VI-MARPOL reduce the rate of global warming?

NO

Aerosols such as sulfates and soot are man made and **last only a few days. Clouds grow on aerosols. Rain comes from low flying clouds** which also **reflect sunlight** but **let heat through.** This cools the atmosphere (The Economist October 5-11, 2013).

ENVIRONMENTAL Science & Technology-Viewpoint article titled "Shipping Emissions: From Cooling to Warming of Climate and Reducing Impacts on Health by: Jan Fuglestvedt, Terje Berntsen, Veronika Eyring, Ivar Isaksen, David S.Lee, Robert Sausen, which states:

"…ship emissions of sulfur dioxide (SO_2) cause cooling through effects on atmospheric particles and clouds, while nitrogen oxides (NOx) increase the levels of the greenhouse gas (GHG) ozone (O_3) and reduce the GHG methane (CH_4) causing warming and cooling, respectively." (Methane is a GHG 23 times more potent than CO_2)

According to the authors: **"The long term warming due to CO_2 will lead to a switch from net cooling to net warming after ~ 350 y. With the reduced SO_2 emissions the net temperature effect switches to warming much earlier after ~ 70 y."**

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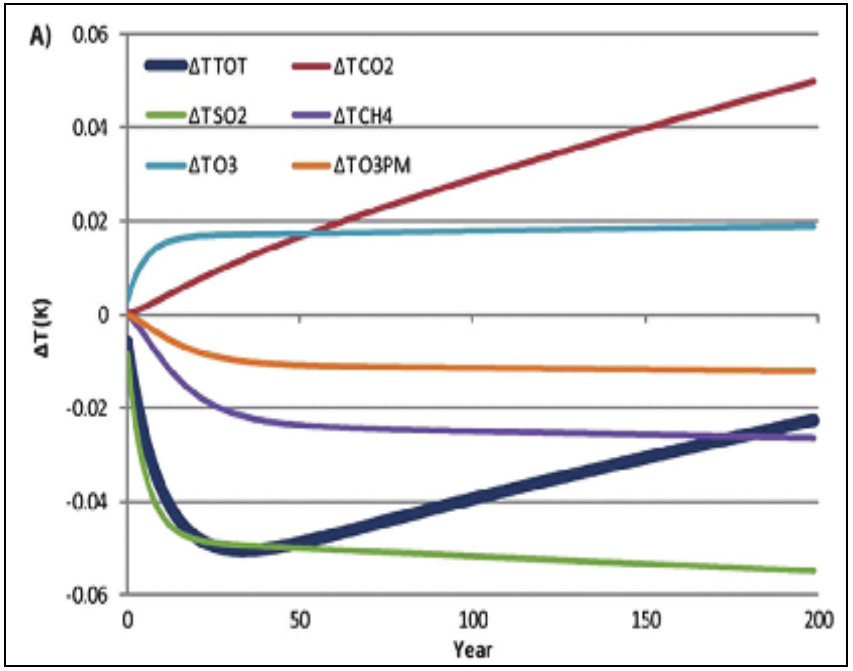

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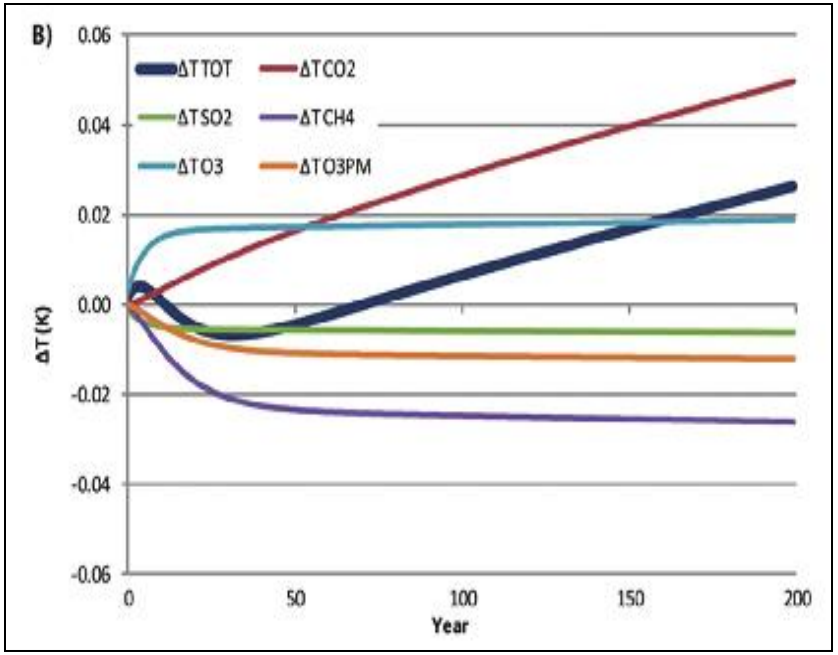

Global mean temperature changes due to emissions of CO2 and SO2 and NO*x*-induced changes in O3, CH4, and O3PM (the latter being the primary mode ozone controlled by CH4), and the total temperature change (Δ*T* TOT). Plotted are (A) the response to a scenario with all emissions kept constant at year 2000 levels and (B) the responses to a scenario with SO2 emissions reduced by 90% with all other emissions at year 2000 levels.

It seems shipping legislation has a tendency to <u>increase</u> global warming!

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Arctic melt is "economic time bomb"

Costs to world estimated at $60 trillion (FT July 25th, 2013)

The Arctic has been melting twice as fast as the rest of the world. This will "…hasten thawing of permafrost beneath the East Siberian Sea off northern Russia believed to contain vast deposits of methane…a greenhouse gas some 20 times more potent than carbon dioxide…" (research is published in the Nature science journal).

Arctic ice regulates "…ocean currents and the climate. As it melts it is likely to cause changes that will damage crops, flood properties and wreck infrastructure around the world, according to research by academics at the UK's University of Cambridge and Erasmus University Rotterdam in the Netherlands."

NOx reduces methane life time. Is it wise to reduce it? **NO**

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Reduction of SOx increases severe hurricane activity

The **U.K. Met Office** paper "Aerosols implicated as a prime driver of twenthieth-century North Atlantic climate variability", September 2011, **clearly indicates that the reduction in sulfur aerosols over the Atlantic Ocean has increased water temperature, increasing the severity of hurricane activity, Sahel and Amazon droughts and have variously influenced the whole planet**.

Reducing the sulfur content of bunker fuels outside SECAs will exacerbate the problem.

From the above, it could be said that presently enacted regulations represent inadvertent geo-engineering increasing violent weather patterns.

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To create low sulfur fuel you emit more CO_2

IPIECA submission to IMO (BLG 11/5/14, 9th February 2007) which states:

"Recent studies suggest a net increase in CO_2 emissions (for the production of low sulfur distillates) equivalent to about **15%** of current refinery emissions." **Thus increasing global warming**.

Low sulfur fuel is also more expensive, promoting modal shift to more polluting forms of transport.

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Is low sulfur fuel safe? NO

Demand for more low-sulfur fuel for use in Emissions Control Areas (ECAs) will add to bunker quality risks, according to Gunnar Kjeldsen head of DNV Petroleum Services (DNVPS) in Fujairah. (Source: Seatrade Global and Lloyd's List Sept 23, 2013)

Engine damages exceeding $1 m have been recorded from excessive engine wear caused by "cat" fines (catalytic fines) in fuel oil. "Cat" fines are used to convert large hydrocarbon molecules into lots of smaller molecules in order to create fuels like diesel from crude oil through catalytic cracking. Production in the refineries may lead to "cat" fines concentrations in the fuels. This creates **disparity between the quality of the fuel recommended by engine manufacturers, therefore required for ship engines, and that provided by refineries**. **This is dangerous for safe navigation.** **Refineries remain reluctant to absorb the costs involved in supplying safe fuel at the recommended low sulfur level.**

Legislators would not let such problems occur to aviation fuel. If they want ships to burn low sulfur fuel, **they should insist that refineries produce fuel that is up to the specifications of the engine makers so that it is safe for use.**

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2:BALLAST WATER TREATMENT

(It is being legislated in order to stop the proliferation of Non Indigenous Species)

Ocean currents move thousands of trillions of tons of sea water yearly, also transporting living species worldwide. These stay and multiply where conditions are favorable.

It is estimated that the Gulf Stream gradually increases from 30 Sv* in the Florida current to a maximum of 150 Sv* South of Newfoundland. The Antarctic Circumpolar is about 125 Sv*.

These currents transport between **9.4×10^{14} to 4.7×10^{15} cubic meters** of water per year,

Bulk carriers and tankers transport only about **4×10^{9} (4 billion) cubic meters of water** per year. **Nearly a million times less than sea currents.**

(*) 1 Sv (Sverdrup)=1 million cubic meters/second

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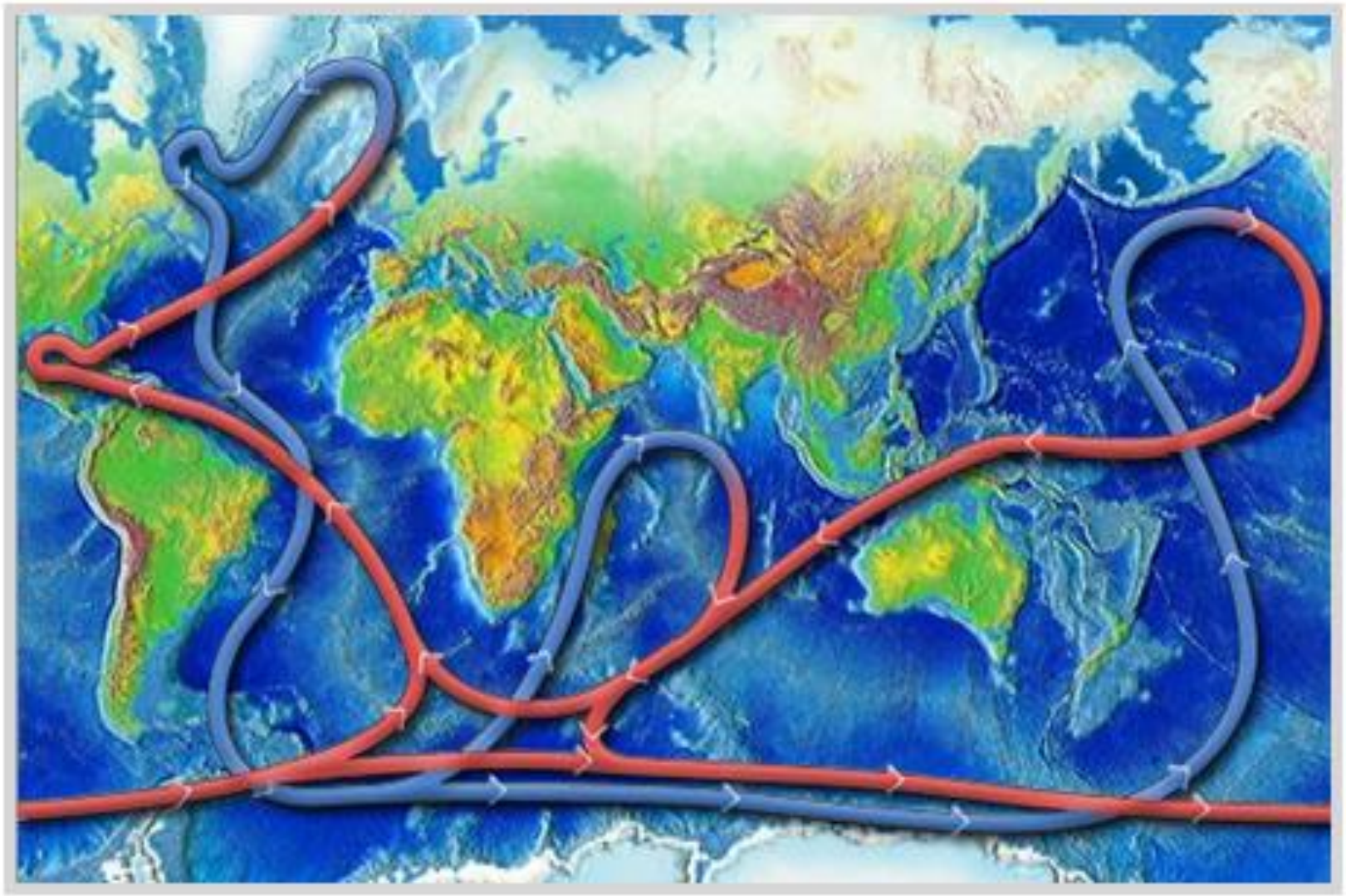
The Global Conveyor Belt



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Ocean currents transport sea life
(NOAA)*

"Currents are important in marine ecosystems because they redistribute water, heat, nutrients, and oxygen about the ocean. **At the same time, currents inevitably sweep over and carry off living organisms.**"

"Although many sea creatures are powerful, efficient swimmers, **many others are ungainly or even immobile**. **For these animals, currents could offer a free ride**. **Corals and sponges**, for instance, are attached to the bottom as adults, but when they reproduce, **they release volumes of planktonic larvae into the water column. These tiny creatures are free to "go with the flow" and could be carried long distances**. This could allow individuals to escape overpopulated areas with too much competition for resources, and allow the species **to spread into and colonize new habitat."**

"Once the juveniles settle down, currents will continue to bring other plankton and organic debris their way, providing a steady supply of food."

(*) National Oceanic & Atmospheric Administration (U.S. Dept. of Commerce)

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An ineffective and costly regulation

Water ballast carried and deposited worldwide by bulk carriers and tankers is additional to the very much larger volumes transported by sea currents. These transport methods have already created large colonies of **"Non Aboriginal Species"** worldwide. Much like Dutch-Americans, German-Americans, Greek-Americans, European-Americans and others, sea life has migrated over the years in sea currents and ships' ballast water and is already established where it ended up and has been multiplying for "generations". **Therefore these species have already become "naturalized" to those environments and by now have become "Indigenous".**

It is already well known that in the last decades the **Mediterranean** already has fish and other sea life that was unknown before. By **2000** more than **300** new fish species entered the **Mediterranean**. It is now estimated that a new species is found every **10 days!**

The costs of fitting ballast water management systems are exorbitant . The end result will be minimal. The cost effectiveness of the measure is very small and will produce no perceptible result.

Ballast water exchanges in deep water have proved effective and are adequate.

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3:BUREAUCRATS' CONCEPT OF HOW SHIPPING OPERATES IS FLAWED

Second IMO GHG Study 2009, paragraph 5.25, page 47 says:

"…and it is particularly important that they do not have incentives to contribute to inefficient behavior. As an example of the latter, ship upgrades and major maintenance activities depend on the high-level strategies of the operating companies. In cases where ships are operated by a different company than the commercial operator, **the technical operator may tend to minimize time in dry dock (to minimize off-hire cost) and other maintenance costs (e.g., painting costs) while at the same time handing the fuel bill to the commercial operator**."

This statement in the Study is incorrect and misleading.

Each ship is evaluated by the time charterer based on the speed and consumption warranties given by the shipowner and is **offered a daily rate for a specific trip or period on this basis.**

The higher the consumption the lower the T/C rate *ceteris paribus*. **The more energy efficient ship will potentially command a higher T/C rate.**

No commercial operator will accept practices leading to inflated fuel bills above the ship's speed/consumption warranties. **The commercial operator will successfully recoup ship overconsumption or underperformance even through legal means.**

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4: ENERGY EFFICIENCY "BACK TO THE FUTURE?"

The **EEDI** is the Energy Efficiency Design Index. Its purpose is to promote the **design** of energy efficient ships. **That means improved Hulls (the platform) and of course Machinery and Propellers.** The simplified formula is as follows:

The formula → $$\frac{P \cdot SFC \cdot C_f}{dw \cdot v} = EEDI \leq a \cdot dw^{-c}$$ ← the reference line

As formulated (at a V equivalent to P at 75% MCR) it has a bias to reduce power rather than improve the design. All it will succeed in doing will be to build ships travelling at **World War II** speeds. This will increase transit time from Brazil to China from about **34.5 days** at **13.5 kn** to about **49 days** at **9.5 kn**!! **Crews will suffer**, interest and inventory **costs will rise**, more ships will be built and market **fluctuations will be more violent**, for lack of the elasticity derived from being able to steam through a greater speed range.

It would have been better to compare ship designs at certain speeds (precedent: the automotive industry has a well defined cycle applicable to all automobiles). Greece has stated that **speed, being the result of both engine power and ship proper hull design**, is the measure to focus on and not just the power.

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The databases that produced the regressions which formulate the reference line are plagued with inconsistencies:

Table from IMO MEPC 62/5/6 of May 5, 2011 submitted by Greece

MO/YEAR	YARD	DWT (Ton)	Engine (HP)	Speed (kn)	EST EEDI
Feb-95	YARD 1	68519	9799	15.00	3.388 (3.730)
Jun-94	YARD 1	68621	9800	13.90	3.652 (4.019)
Jul-81	YARD 2	65337	15200	15.50	5.334 (5.871)
Jul-81	YARD 2	65020	15202	16.80	4.946 (5.444)
Aug-99	YARD 3	73725	10261	14.00	3.533 (3.889)
Sep-99	YARD 3	73659	10261	15.50	3.194 (3.516)

The above 3 pairs of 2 sister ships built by the same yard within a few months of each other have 8%-10% differences in EEDI.

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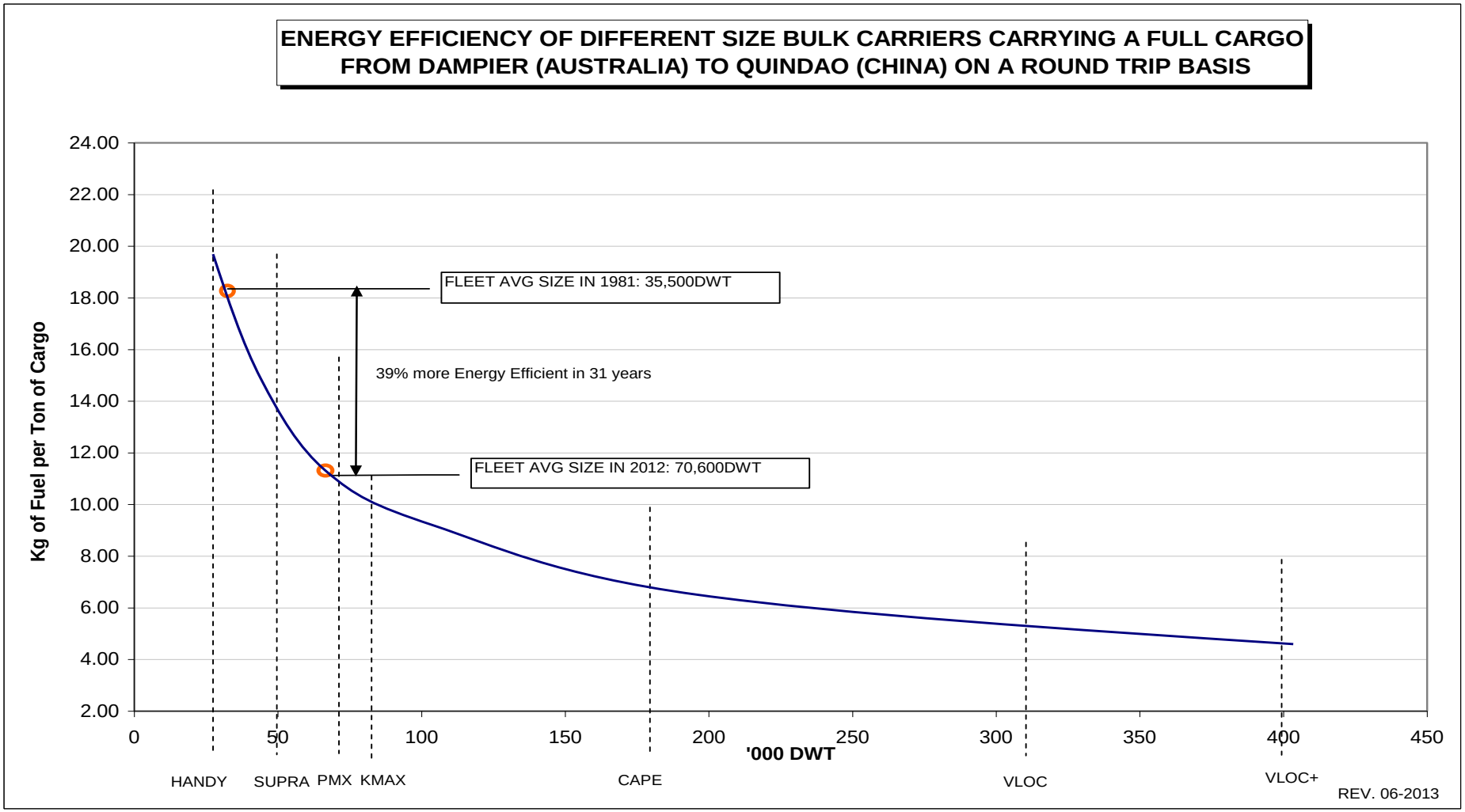
5: LARGE SHIPS ARE MORE ENERGY EFFICIENT. OVER THE LAST 31 YEARS ENERGY EFFICIENCY OF THE DRY BULK FLEET IMPROVED 39% FROM THE INCREASE IN SHIP SIZE ALONE



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6: ESTIMATING EMISSIONS AND RATING EXISTING SHIPS - (MRV AND U.S. PROPOSALS)

Trade expands in line with the world economy therefore ship emissions will always increase *ceteris paribus.*

Ships operate in an environment producing many variables most of which are not controlled by the shipowner. All affect speed, resistance and consumption. These are:

-**Condition of load**: full load, part load, light ballast, heavy ballast , trim etc., which create greater or lesser resistance and powering requirements.
-**Consumption and emissions vary with speed**. The speed at which profit is maximized varies with the ratio of freight rate to bunker price if there are no other constrains. It also varies with weather conditions.
-**Water surface currents:** Over the year they may vary from **1kn to 3 kn on the prevalent axis.**
-**Wind speed and direction**
-**Hull and propeller fouling**
-**Hull deformation/damages/groundings**

No amount of data analysis can be meaningful when trying to assess the recorded speed and consumption of about 50.000 ships, operating with the above variables, particularly if one tries to take averages over extended periods. Even identical sister ships in different trades and trading areas have recorded different consumptions.

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A practical suggestion

All owners create **warranted time charter speed and consumption descriptions** for their ships **at various speeds and conditions of load** which they update from time to time based on the ship's observed performance.

Charterers monitor a ship's speed/consumption performance daily using routing companies. This way they calculate overconsumption or underperformance, if any.

Since these speed and consumption descriptions are legally binding there is no reason to ask for third party verifications. A ship's recent speed and consumption warranties **are known on the market and verified by the fact that both owners and charterers accept them**.

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Survivability and maneuvering requirements

With the EEDI as formulated, minimum powering requirements should be established for each ship.

Criteria:
The IMO minimum speed requirement for maneuvering in heavy weather, works out from about 7 kn for Handysize ships to about 10 knots for Capesize ships. **From studies carried out at NTUA for 5 ships, present powering is marginal particularly so for the smaller ships. Any reduction will create underpowered ships which will need to follow longer, fair weather routes thus causing more emissions.**

The IMO Stability Code Severe Wind criterion requires testing in winds of 26m/sec plus gusts (10+B and 8 m waves).

October 2013 UK wind speeds of 31.1 m/sec (70 mph) and gusts 44.0 m/sec (99 mph)
Denmark 52.8 m/sec (190 km/hr)
October 1987 UK wind speeds of 51.1 m/sec (115 mph)
Top wind speeds Hurricanes: Katrina 2005 sustained 77.8 m/sec, gusts 95.6 m/sec
Sandy 2012 sustained 41.7 m/sec, gusts 62.1 m/sec

Ships often meet such weather conditions and must survive.

Any powering requirements to meet lesser weather conditions would result in the ship grounding in an upright position in bad weather!

MEPC 64 and MSF Dec 2012 decided on: 19m/sec (8 Beaufort and 6 m waves
MEPC 64 May 2013 reduced the above to: 15.7m/sec and 4 m waves for ships <200m and
19.0m/sec and 5.5 waves for ships >250m !!

In view of the above does this represent safe thinking? NO

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Distances as per OCEAN PASSAGES OF THE WORLD, Hydrographic Department, Admiralty, (London 1950)

San Francisco to Yokohama

MODERATE POWERED STEAMERS

June to September	4535 miles
October to May	4840 miles

LOW POWERED STEAMERS

All seasons	4840 miles

Increase in voyage length 6.70%

Rio De Janeiro to Cape Town

MODERATE POWERED STEAMERS

All seasons	3310 miles

LOW POWERED STEAMERS

All seasons	3510 miles

Increase in voyage length 6.04%

Sunda Strait to Aden

MODERATE POWERED STEAMERS

May to September	3820 miles

LOW POWERED STEAMERS

April to June	4145 miles
September to October	4145 miles
July to August	4000 miles

Increase in voyage length 8.51%

New York to Gibraltar

MODERATE POWERED STEAMERS

July 1st to April 10th	3.180 miles
April 11th to June 30th	3.185 miles

LOW POWERED STEAMERS

October to April	3.645 miles
May to September	3.360 miles

Increase in voyage length 14.60%

Rio de La Plata to Cape Town

MODERATE POWERED STEAMERS

All season	3590 miles

LOW POWERED STEAMERS

All seasons	3650 miles

Increase in voyage length 1.67%

Over the last 60 years weather patterns have deteriorated. The necessary deviations for the Low Powered Steamers, in all probability, have increased causing higher CO_2 emissions.

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7: SHIPPING REACTS TO COST INPUTS AND PROFITABILITY CRITERIA

To improve shipping's already **very good environmental performance** we must think clearly, **free of ideological constraints** and **avoid meaningless, unnecessary complications.**

Ships trade at the speed at which they maximize earnings for any given freight rate and bunker price. Ship emissions vary with the cube (or more) of the speed. **Ships operate in an environment producing many variables most of which are not controlled by the shipowner. All affect speed, resistance and consumption.**

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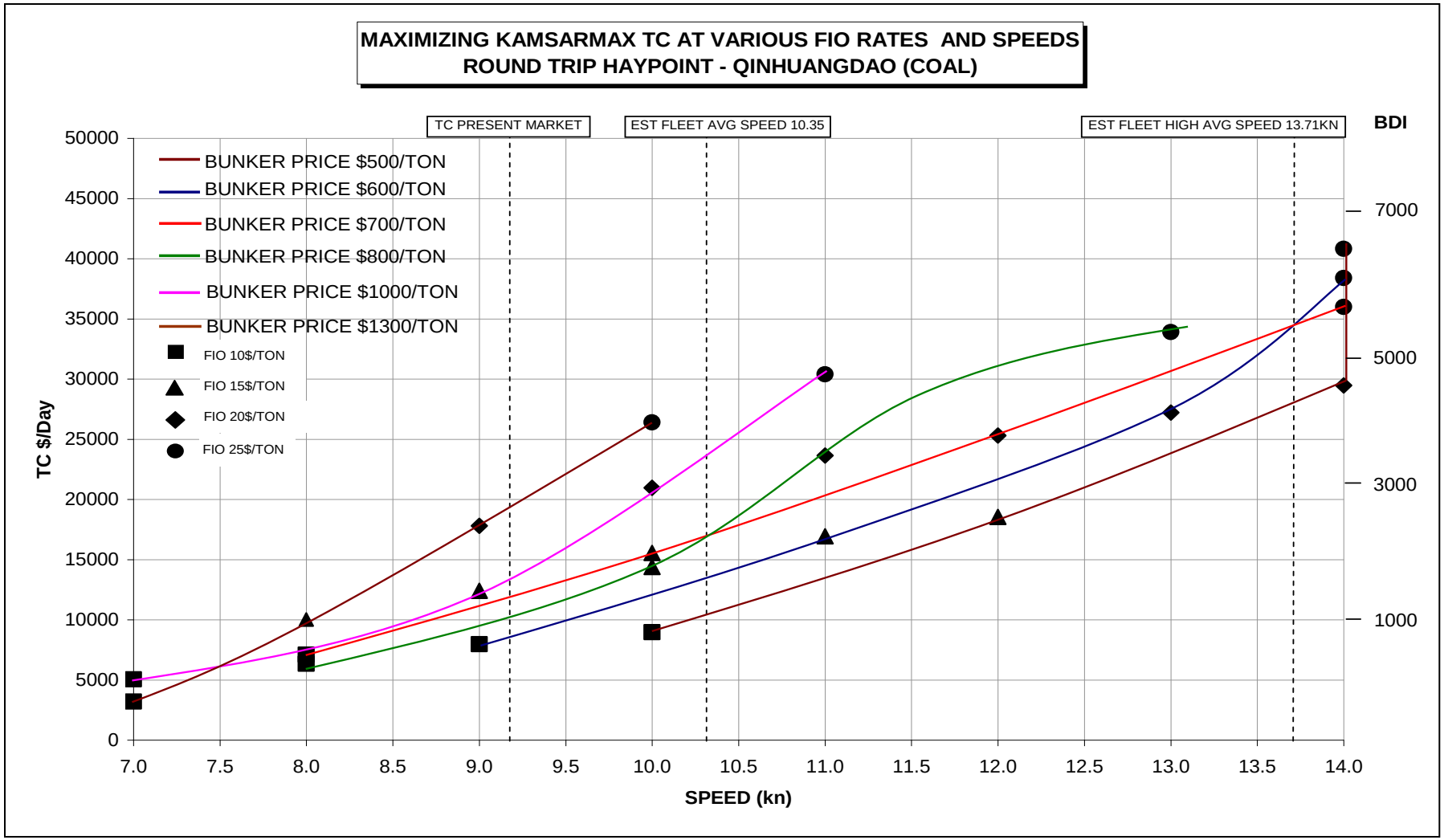

Simulation for other trips show similar results

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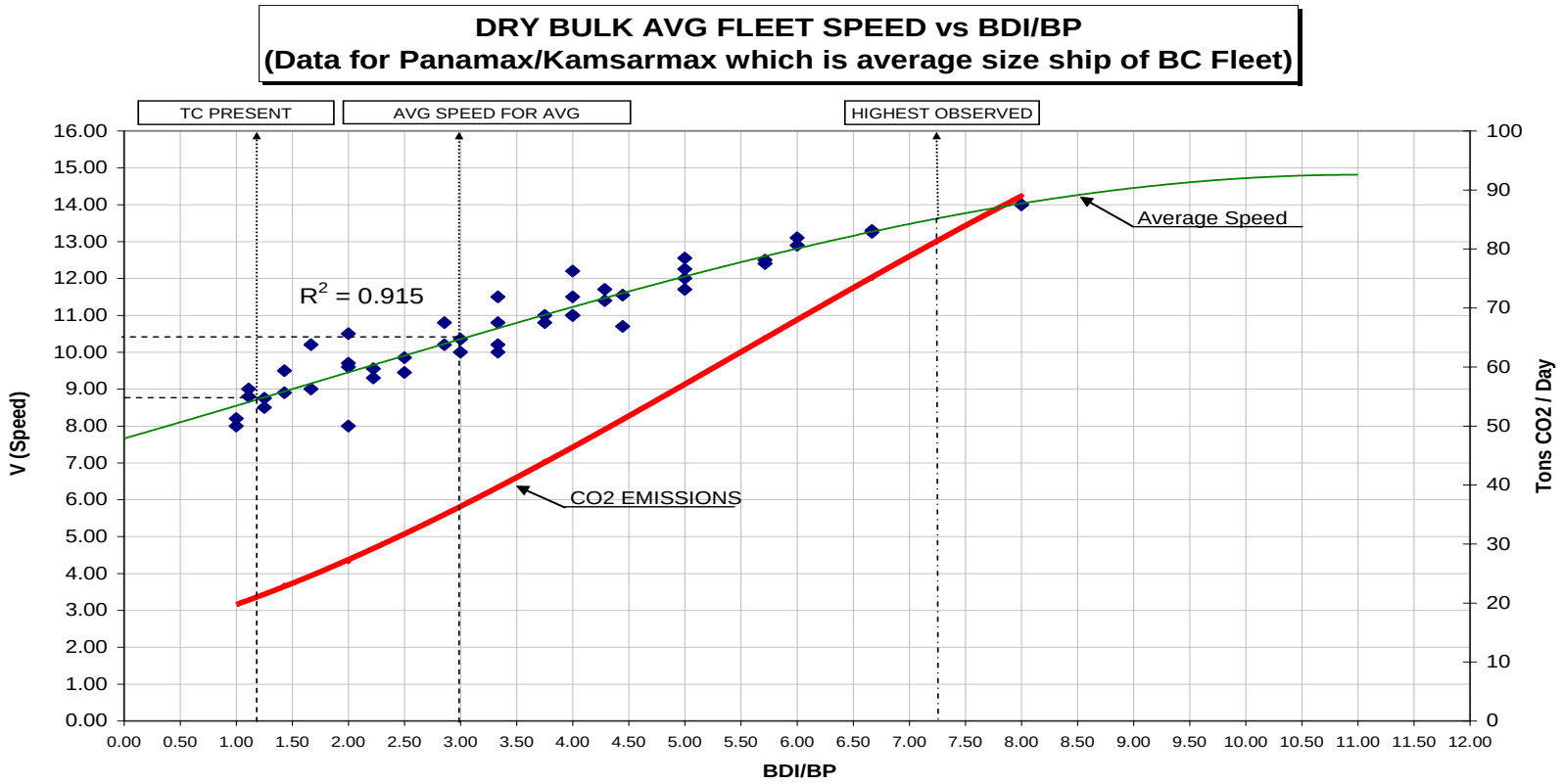

Ships will proceed at the speed at which they maximize earnings. This speed is a function of the ratio of the freight market to the bunker price.

The above shows that increasing the bunker price will predictably reduce the fleet's profitable operating speed, therefore its emissions.

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8: GLOBALIZATION, THE COST OF FUEL AND THE PRICE OF CARBON

The price of HFO presently fluctuates around **$600/ton**. Going forward it is more likely to increase than decrease. **To this one must also estimate a price for carbon emissions** which is presently being discussed in the form of a Market Based Mechanism (MBM). This will influence trade and globalization.

According to **IMO MBI study** "International Shipping & Market Based Instruments 2009" co-authored by the University of Cambridge, UK, Cambridge Econometrics (CE), UK, MARINTEK, Norway, Manchester Metropolitan University, UK, Deutsches Zentrum für Luft und Raumfahrt e.V. (DLR), Germany, **the price of carbon adjusted to represent tons of fuel** is estimated to be **$177/ton in 2020** and **$3,229 in 2050.**

A **$100/ton** increase in price of fuel would increase the round trip cost of freight in a Cape size bulk carrier **from Brazil to China by $2.27** or about **10%** of present rates. It will increase the cost of freight **from Australia to China at normal speed by $0.71** also about **10%**. **If the price of fuel increases with the price of carbon by $1,000/ton (est in 2030) this will double present freight rates and greatly reduce ship trading speeds. It will also reverse globalization.**

Without improvements in ship hull design a much a higher total fuel cost will change sourcing, slow or possibly even reverse globalization thus increasing costs to the society. This will slow world growth, trade and prosperity.

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Comments on market based mechanisms

They are mostly complicated, unworkable and have little to do with shipping reality.

The average loaded trading speed of the bulk carrier fleet in **2012/13** appears to be about **21.2%** lower than that of **2007. The number of loaded voyages completed per ship appears to be 27.1% less.** These factors indicate that the reduction in emission per ship is **over 50%. Because of these fluctuations, trying to create data bases and benchmarks for average yearly ship emissions etc., is an exercise in futility.**

The Levy is the only Market Based Mechanism (MBM) which is directly and identifiably applicable to the cost of fuel for any trip **and creates a bias to slower steaming without affecting the ship's powering requirements and safety.** Systems that rely on average yearly emissions such as the ETS and others fail to capture this.

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Advantages of a bunker levy

A bunker Levy alone could act as both:

- A ship design improvement mechanism, and
- An automatic speed regulating mechanism

It would do this while reducing emissions, increasing ship profitability, eliminating unnecessary complexities and uncertainty.

A bunker Levy will not create underpowered ships.

Because of its simplicity the Levy is also **2 to 5 times more cost efficient from ETS** (USA CBO) thus increasing environmental benefits at a lower overall cost to society.

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Concluding remarks

- **An EEDI pegged to a certain speed** for different ship types (dry bulk, tanker, container) is a better guide to designers to produce a real eco ship which is safe and has enough power to **prosecute the shortest possible voyages**. Longer voyages will invariably consume more fuel.

- **Ship speed and consumption descriptions clearly identify a ship's energy efficiency.**

- **IEA data and/or bunker delivery notes give a clear indication of shipping's bunker consumption and emissions** which may be higher than the actual consumption because of "leakage".

- **Low sulfur fuel for worldwide trading is unnecessary**, it increases transport cost, it induces global warming and as presently refined is unsuitable for ship engines with dangerous safety implications.

- If an MBM is considered necessary the **Carbon Levy is the most appropriate and most cost efficient method** to reduce CO_2 emissions from shipping because it induces a bias for slower steaming without improving safety.

Too much time and money has already been spent to do the obvious.

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Both emissions and the world transport system are very complex. Their interaction is obviously even more complicated.

Governments should carefully study the repercussions of their regulations before they inflict irreversible damage to society through inappropriate legislation. Our society has developed substantial analytical capabilities to help guide us.

Regulations should be supported by facts not feelings

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ATTEMPTS TO DATE ARE NOT IMPRESSIVE

THE ENVIRONMENT CAN'T WAIT

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Ship emissions cool the atmosphere because of SOx, NOx, PM etc., but:

- SOx and NOx cause health problems in populated areas and Acid rain, if emitted close to shore. Legislation should protect sensitive areas but should not apply worldwide, so that the cooling effect of ship emissions continues. **On the other hand:**
- Making low sulfur fuel increases refinery emissions by about 15% (IMO-BLG 11/5/14 9/2/07 by IPIECA)
- Reducing engine NOx increases CO_2 production by about 5% or more

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Thank you

G.A.Gratsos