GLOBAL MARITIME ENVIRONMENTAL CONGRESS
SMM Hamburg,
7th September 2010

"How shipping has changed the world & the social impact of shipping"

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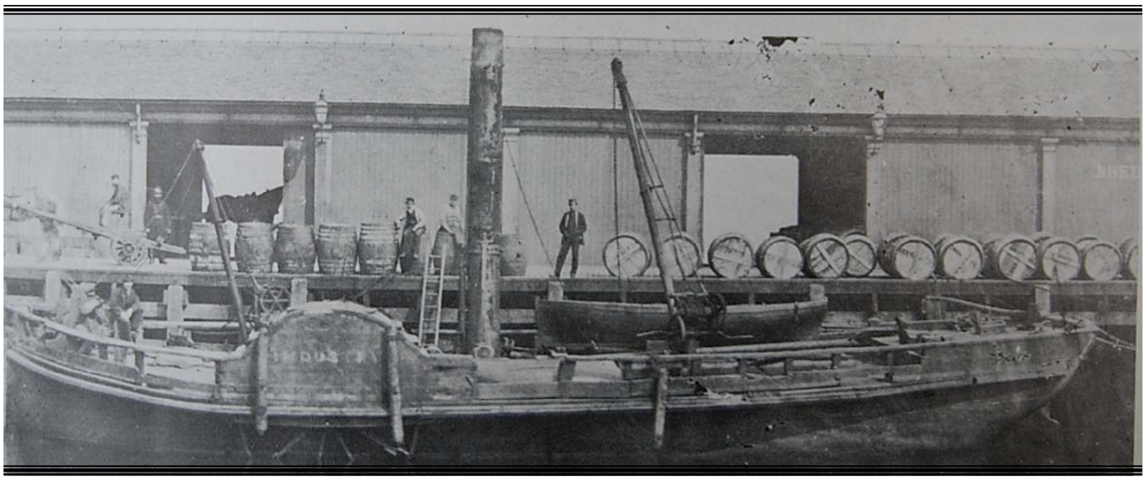


Figure 1: The past…The "Industry", a Clyde tug built in 1814, was one of the first commercial steam ships, photographed here in the early 1860s. These ships pioneered the great sea transport revolution.

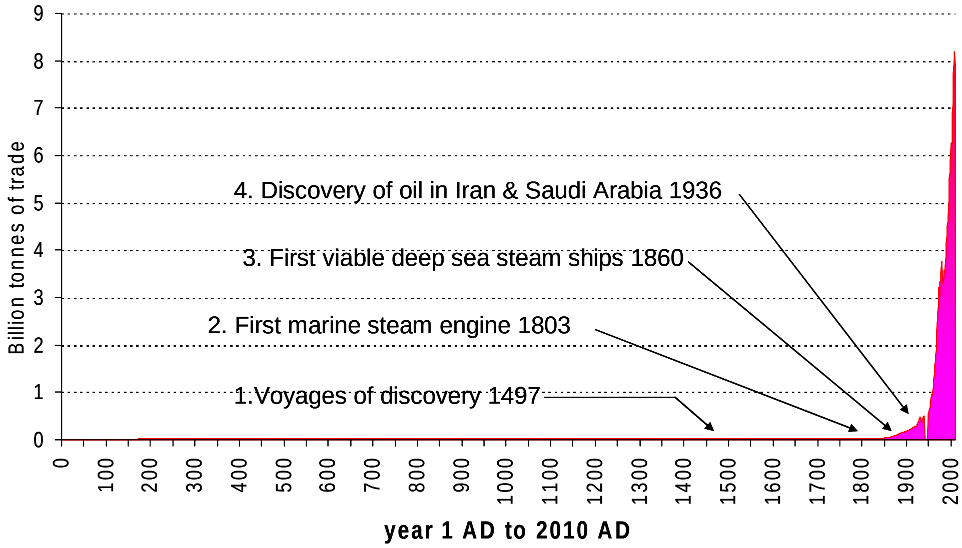
Mr. Chairman, Ladies and Gentlemen, it is a pleasure to be invited to address you at this prestigious event.

As the Chairman has reminded us, we have a serious task at hand. Today we must advance the debate on how the shipping industry should deal with the environmental crisis. SMM is the ideal venue for doing this. Senior executives from shipyards, equipment manufacturers, information suppliers and of course shipowners are gathered to promote the technical excellence of their product. What better opportunity to discuss what the problems really are; what the options are for resolving them and from a practical viewpoint, what is possible?

1. Shipping's central role in economic development

Shipping has a 5000 year documented history, but during the last two centuries sea transport has acquired a special place through its central role in the globalization of the world economy and this is where I want to concentrate. Until 1840 virtually all merchant ships were built from wood and powered by the wind. During the early 18th century the sailing ships used in foreign trade were typically 100-300 tons burthen, whilst East

Figure 1: Sea trade over 2000 years showing impact of fossil fuels



Indiamen, the elite of maritime transport, were 400-600 tons. Sizes crept up during the century and by 1770 vessels of 500 tons were widely used, but the limitations of wood as a structural material made further increases difficult[i].

There were also many technical improvements, some of which are outlined in Table 1. Navigation equipment became more accurate (the compass; the back staff; the chronometer) and more accurate charts which meant that inter-regional navigation was no longer a voyage into the unknown. There were also developments on the commercial front, especially in Europe where the first maritime newspaper (Lloyds List) was established at the end of the 17th century and by the 18th century there was a well-established insurance market, plus ship brokers and commercial procedures for trade

But despite all these improvements sailing ships were too small and slow to move cargo economically in very large volumes[ii]. The problems were the structural limitations of wood and the lack of an independent energy source. In the late 18th century Europe relied for energy on animals (about 40 million horses and oxen), wood and water wheels (about 500,000). Wood and water supplies were too limited to support sustained economic growth[iii]. Total energy consumption was estimated as about 12.6 megawatts. The arrival of the practical technology for using the energy in fossil fuels solved both problems.

2. Fossil fuels and the mechanization of sea transport

When steam ships able to burn fossil fuels arrived in the early 19th century the result was stunning. Since the 1840s the volume of cargo moved by sea has increased by a factor of 400 (that is to say we transport 400 times as much cargo today as we did then) to 8 billion tonnes in 2009 (see Figure 1 below). Today we transport 1.2 tonnes of cargo each year for every person on the globe[iv]. For rich countries such as the European Union, imports are closer to 3 tonnes per capita.

Table 1: Development of marine transport technology 5000 BC to the present

	1	2	3	3	4	5	6	7
Date	**Primary Energy Source**	**Hull Materials**	**Hull Construction**	**Main Engine**	**Propulsion unit**	**Navigation technology**	**Inland Transport System**	**Shipping System**
5000BC	Muscle	Wood	pegs		Oars	Astro	Road	Tramp
		nails	nails					
	Wind	rope	rope		Sail			
		oakum				Compass		
		pitch				Backstaff (1)		
						Chronometer (2)		
1780		copper	fasteners					
		sheath						
1833	Coal	Iron		steam 1	Paddle		Canals	
			rivets					Liner
			caulking	steam 2	Screw		Rail	Tramp
1870		Steel	Wire	steam 3		Sextant (3)		Passenger
							Truck	
		Aluminium		Turbine				
		GRP				Radio	Air	
1913	Oil			Diesel				
		SPC	welding					
1950	(Nuclear)					Radar		
								Bulk
	(LNG)							Container
						Satellite		Specialized
2000								

Notes

1. Backstaff which relied on the shadow cast by the sun, was developed in 1720
2. Chronometer developed by John Harrison 1759
3. Sextant developed about 1870 as improvement of Hadley's backstaff. Allowed accurate measurements from heaving deck of a ship at sea.

Thanks to coal, then oil, today's transport costs are so low that the markets for materials and products are truly global. Distance and quantity are not a problem. In 2008 maritime nations imported 2.7 billion tons of energy commodities (oil, coal and gas); 500 million tons of agricultural product (grain, fertilizer sugars are etc); 1 billion tons of raw-materials and products for the metals industry; and another billion tons of minor bulk commodities including forest products, bulk minerals and chemicals. Finally there is a billion tonnes of manufactures and semi manufactures, including the machinery, spare parts and consumer society needed to keep the wheels of modern society turning.

But developing the technology to burn fossil fuels was slow, tedious and littered with commercial disasters. In fact it took well over a century for steam ships to drive sailing ships from the sea[1]. The pace was slow because the early steam engines were far too large and inefficient to be fitted into a ship. It was not until the end of the 18th century

[1] The last commercial sailing ships were probably the Pamir and the Passat which made their final voyages in 1948/9, owned by Edgar Erikson, son of Gustav who died in the previous year

that boiler technology had improved enough for engineers to experiment with steam boats burning coal. Probably the first was the *Charlotte Dundas* which in March 1803 pulled two barges against the wind along a canal in Scotland. One of the earliest photographic records of a steam ship is of the PS *Industry* built in 1814 (see Figure 1 which is a photo of the ship taken at the end of its life in the early 1860s). Its was a steam tug working on the river Clyde. But as steam engines became more efficient and shipbuilders learnt how to exploit their potential, they helped to create a whole new world.

The steam ships with iron or steel hulls which started to appear after 1840 were initially not so different in size and speed from the sailing ships they replaced, mainly less than 1000 gross tons. The difference was that their potential was vastly greater. As the 19th century progressed they became bigger, faster and massively more efficient at moving cargo[v]. The ability to sail on the tide, to schedule, and maintain a consistent speed, initially five to eight knots, was a genuine revolution and by the 1860s a steamship could complete the Edinburgh round trip mentioned above in 5 days.

As marine engineering improved so did speed, size and operating expense. The fastest ships in the fleet increased from 7 knots in 1833 to 23 knots in 1914. Size increases were equally dramatic. At the beginning of the period the average sailing ship was 300 to 1000 tonnes. Today the average bulk carrier is 45,000 tonnes and the biggest are over 300,000 dwt. Efficiency also improved thanks to automation and fossil fuels and today a large bulk carrier requires a crew of around 20, compared with a crew of 25-35 on a late 19th century sailing ship with only 5% of the cargo deadweight[vi] . Finally, the productivity of the fleet quadrupled.

Steam technology peaked out in the 1940s, and its place was taken by diesel engines using oil. A renewed upswing in the global economy during the 1950s and 1960s allowed shipping companies to exploit the potential of the diesel engine and new shipbuilding techniques which had been developed during the Second World War. A decade of innovation followed, during which passenger liners mutated into cruise liners and many specialized ship designs were successfully developed including vehicle carriers, forest products carriers, chemical parcel tankers, boom discharging bulk carriers, ro-ros and, of course, the containership.

All this was achieved with progressively less fuel. Since 1855 fuel consumption has been reduced by 97% from 199 pounds of fuel per 000 cargo tonne miles in 1855 to 9.5 per 000 tonmiles (Figure 3).

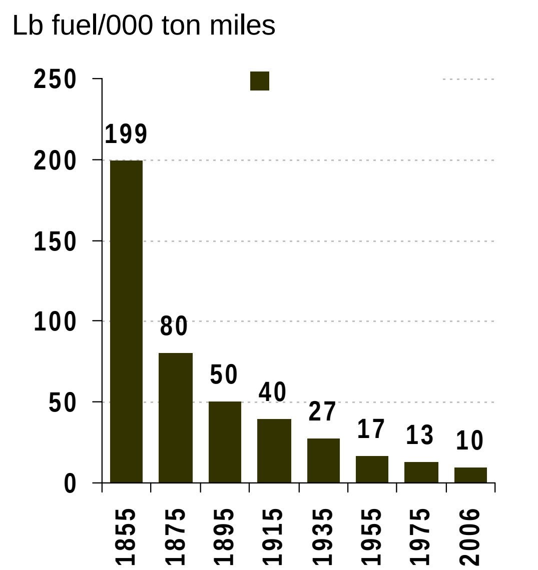
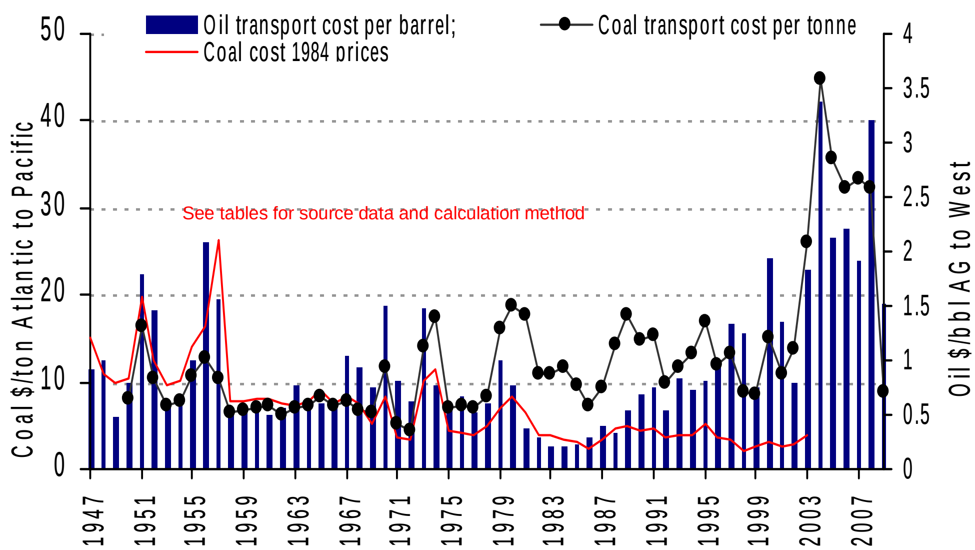


Figure 3: efficiency of merchant ships

Finally we must mention the sophisticated international market for sea transport. Sea trade is complex, with a fleet of 80,000 ships serving thousands of ports and millions of potential trade routes. This trade is managed through a market driven system which ruthlessly drives down transport costs. With few barriers, this remains one of the few examples of the classical economist's "perfect competition" model at work. This market based system, combined with improved technology, and meant that over a period of fifty years transport costs for key commodities such as coal and oil hardly increased (see Figure 4).

Figure 4: The cost of sea transport of coal and oil 1947-2010



Note: the transport costs shown in this graph are based on prevailing spot rates for the average vessel size used on the transport date. The tankers increased from 17,000 dwt to 280,000 dwt and the dry vessel from about 10,000 dwt to 150,000 dwt. The costs shown are at market prices, and are not deflated for inflation. The sharp rise in costs at the end of the period are due to the shipping market boom 2003-8

3. The evolution of ships and shipping systems

Some examples show how far technology has come (series of ship comparisons):

a. Bulk carriers: (John Bowes to Brasil Maru). We start out with the John Bowes 650 dwt built in 1852 and generally considered the first modern bulk carrier. Today the average bulk carrier is 50,000 dwt and the largest are 300,000 dwt.

b. Tankers (Glukauf to Knock Nevis): the first purpose built tanker was the Gluckauf a 3,000 dwt vessel built in 1886. It had a steam engine with two masts. The biggest modern tanker was 550,000 dwt, though this was not a great success commercially.

c. Containerships (Agamemnon to the Emma Maersk): The Agamemnon delivered in 1865 to Alfred Holt is one of the first modern cargo liners. With capacity of 2,280 gt, a steam engine, a propeller and a speed of 10 knots this was a state of the art cargo liner built for the Europe to China trade. Its modern counterpart is the Emma Maersk 170,000 gt and an engine of 110,000 HP. Just to put that in context, the engine weighs 2,300 tonnes, the size of the Agamemnon's total cargo capacity. The diversity of the modern containership's cargo is illustrated by the example in the text box.

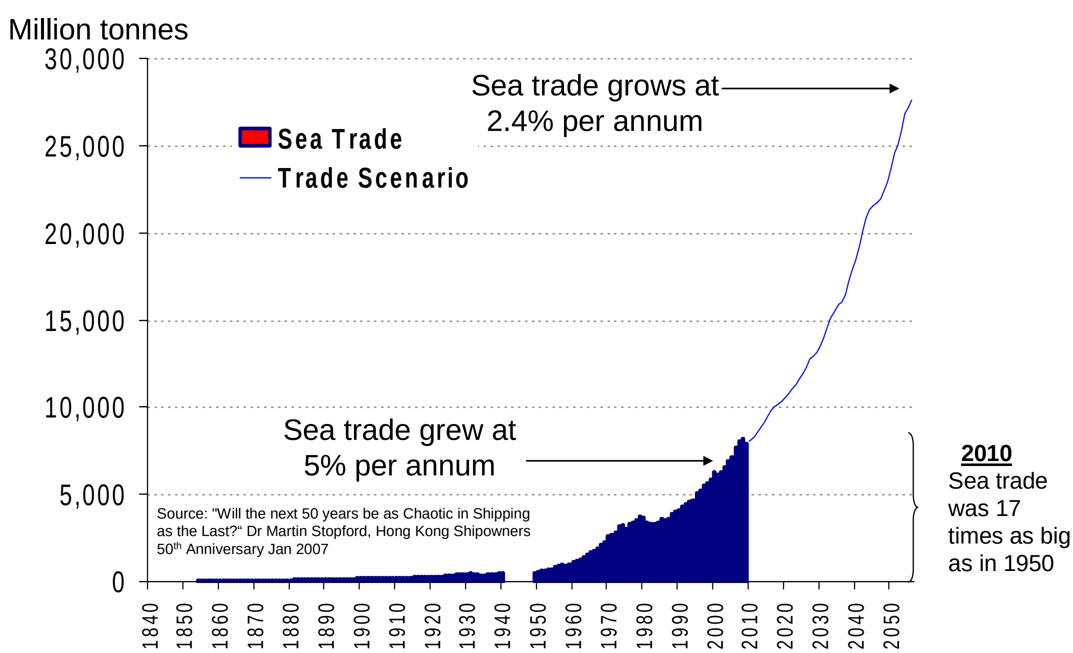
The result of the increase in size and improvements in efficiency is that the cost of freight has fallen and world trade is global. If shipping stopped for 3 months, so would modern life as we know it.

4. The Next Fifty years

So what happens next? Over the last 150 years by providing cheap, reliable and efficient transport the shipping industry has helped turn the world into a single market place. It does not matter where companies produce their raw materials and goods, they can be delivered to market for just a few dollars. As a result today the world is well along the road to an economically integrated global economy (maybe 60% there is my guess) and shipping has played a crucial and highly effective part in the process. Billions have benefited from the massive productivity improvements achieved by bulk, specialized and container shipping, especially in the last 60 years.

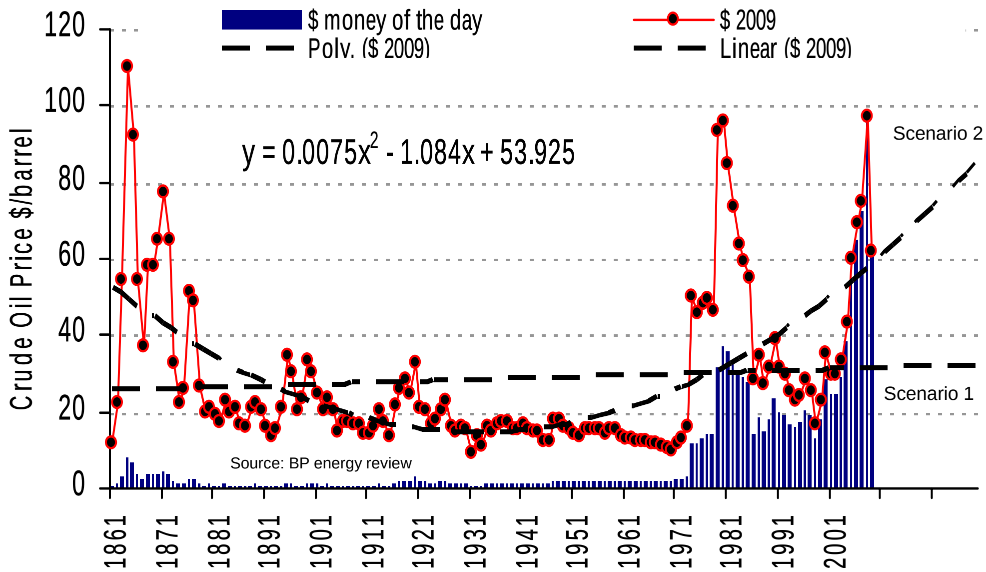
But billions more expect to benefit in future. If the trade growth trend of the last 150 years continues, by 2060 the 8 billion tonnes of cargo will have grown to 23 billion tonnes, and unless we do something about it that will expand the shipping carbon footprint by 300% (see Figure 5).

Figure 5: Sea Trade 1840-2010 & extrapolation to 2060



But this is not the only problem. Today the shipping industry faces a potentially very different scenario from the last fifty years. Even without this growth, the industry is facing a series of economic and regulatory challenges to the basic energy systems on which the modern shipping industry relies.

Figure 6: The cost of crude oil



1. **<u>The cost of fossil fuels</u>**, upon which the sea transport revolution was built, is escalating. Oil has risen in price from $2 a barrel in the 1960s to close to $100 a barrel today. With "peak oil" in prospect and literally billions of new consumers flooding into the world's markets through the development of India, China, South America and others, we must assume this trend will continue as fossil fuels becomes more scarce. Figure 6 shows two diverse scenarios in relation to past trends.
2. **<u>The side-effects of fossil fuel consumption</u>** by ships are no longer accepted by local communities who are becoming concerned about the health risk of pollution caused by merchant ships in their coastal waters and ports. This has reached the stage of class actions and environmentally protected zones.
3. **<u>Climate change</u>**: scientists are making a compelling case that fossil fuels are driving climate change, the consequences of which we do not fully understand. Regulators accept this case.

I have described in this paper the lengthy gestation period for the technology needed to burn fossil fuels efficiently in seagoing ships. Looking back the change seems inevitable – it was just a matter of time – but at the time it was a long and tedious business. Today the case for replacing them looks equally inevitable but we must not expect miracles. Nor must we expect fossil fuels to suddenly disappear.

5. Conclusions

In this paper my aim has been to step far enough back from the day-to-day preoccupations of exhaust scrubbing; ballast water and propeller tuning to see the very big picture the shipping industry faces. I have suggested that over 5000 years shipping has indeed changed world, but its cameo role only started in the mid-19th century when fossil fuels became available. Before that the best efforts of shipbuilders and seafarers were frustrated by lack of a reliable energy source.

With the arrival of coal and oil the way was opened to providing sea transport on a vastly greater scale than previously. The shipping industry rose to the occasion, producing ships which were 97 per cent more efficient than the early prototypes and the volume of cargo surged from 20 million tons to 8 billion tons. That is where we are today, but, I have suggested, there are further challenges ahead. Globalization is far from complete, and if the process carries on as it has in the last century, in 50 years' time industry could be faced with moving three-times as much cargo as at present.

Today the shipping industry is "hooked on oil" and this fundamental energy source is under attack from several directions.

The first is the speed with which the oil is being depleted. New oil supplies are harder to find, more expensive to develop, and there are many more consumers who want to make use of them. So prices are on an upward trend. Existing energy sources getting more expensive and as this develops, it will change the economic framework within which marine engineers make their technical decisions about what is or is not economic.

The other major problem is that fossil fuels are contributing to global warming and regulators are determined to reduce the carbon footprint of the shipping industry. With the prospect of a 300 per cent increase in cargo, it is difficult to see how that could be achieved without radical thinking.

But radical thinking has to start somewhere. I have argued that in the past new technology has taken many years to get established in shipping - driving sailing ships from sea took the better part of the century. So do not expect immediate results. If you believe my arguments, a start must be made.

We have some radical fuel options ahead, including LNG and LPG, both of which a much cleaner than oil. Then there is nuclear power and fuel cells. Finally the possibility of harnessing the wind, but hopefully not a return to the galley is which was so popular with the Romans!

It is not my job to tell you which of these is appropriate, or how. All I can tell you is that we are coming to a turning-point. The economic and regulatory framework are gradually changing and some thing has to give. It is our job to find a way to make it happen. That's what we paid for. But we can be reasonably certain that there is a long hill to climb. Let's get busy.

The conclusion is that, as always, we must use our ingenuity to address the challenges as best we can. Whether this is defending the old way like Gustav Erikson did so resolutely or blazing a new trail is up to us. We get paid to use our judgment and take risks, whether this applies to the use of new energy sources like nuclear propulsion; natural gas; or radically new logistics systems we cannot be sure.

Figure 7: The "Emma Maersk", an 11,000 TEU containership delivered in 2006 with a gross tonnage of 170,000 and 110,000 HP motor

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2,380 words

Questions

1. Today sea trade is 8 billion tonnes. In 2060 will sea trade be a) 5 billion tones b) 15 billion tones c) 25 billion tones.
2. Are we at another turning point for the propulsive power source for merchant shipping?
3. In 2050 will the price of a barrel of oil be a) Under $100 b) $100-200 c) Over $200 (all in 2010 prices)
4. What will be the major power source in 2060 a) oil b) coal c) nuclear d) LNG e) fuel cells?
5. Today the average deep sea merchant ship is 40,000 dwt. In 2060 will it be a) 40,000 dwt b) 50,000 dwt, c) Over 60,000 dwt

[i] Over the previous centuries naval architects had also become more adept at fine-tuning the designs for efficient cargo transport - the Dutch flyte and the sophisticated ships of the East India Company are examples.
[ii] For exampleon the round trip from London to Edinburgh, described by Adam Smith in 1778, the journey time was 6 weeks , averaging only 1 mile an hour.
[iii] Getting wood was a massive problem and constraint on development. Boat building devastated forests and "every fleet, in no matter what country, required for its construction the destruction of enormous expanses of forests" (Braudel p363).
[iv] This is a 2009 figure. In 1840 it was 20kg per capita

[v] Getting wood was a massive problem and constraint on development. Boat building devastated forests and “every fleet, in no matter what country, required for its construction the destruction of enormous expanses of forests” (Braudel p363).

[vi] The Balcuttha built 1886 by Charles Connell, Glasgow for the Horn trade had a complex square-rigging system with 25 sails altogether; it took a crew of 26 to handle it