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Impact of Maritime Transportation on Environment- A Review**Emil Mathew***

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Abstract:

Liberalisation policies adopted by a large number of countries, implementation of technological innovations with developments in communication networks and continuous reduction in transport costs led to the growth of international transportation of goods over the last 50 to 60 years. Being looked upon as a less polluting and cost efficient mode of transportation, shipping has received wide acceptance due to its economies of scale. Higher and persistent growth prospects of maritime transportation calls for an examination into its environmental externalities. The present paper examines the adverse effects of maritime transportation on environment, that is, on the externalities of transporting cargoes using water mode of transportation. This review carried out on the recent literature on externalities of maritime transportation suggests that appropriate policies may be adopted to address the issue at national and international levels without which international trade may be hampered.

Keywords: International Trade, Maritime Trade, Environment, Economic Development, Shipping

Introduction

Recent developments in the sphere of globalisation can be attributed to liberalisation of international trade, rise of new consumer markets, technological developments in the field of telecommunications and decrease in transaction costs (van Veen-Groot and Nijkamp 1999). Many scholars have examined inter-linkage between international trade as a promoter of

economic development and its effects on environmental quality. Some of them (Bhagwati 1993, Grossman and Krueger 1993) are highly optimistic about such a linkage by stating that trade acts as a catalyst to achieve better environmental quality, whereas the environmentalists (Nijkamp et al 1998, Daly 1993, Lofdahl 1998) are quite pessimistic on such a stand. The supporters of free trade argue that a 'U' shaped environmental Kuznet's curve indicates a

reduction in environmental quality as the trade improves and it enhances environmental quality as trade induced growth proceeds further. Thus advocates of free trade argue that the potentials of the country to invest on cleaner environment increases as the trade advances. Regarding the environmental consequences of growth, Tucker (1995) stated that such a 'U' shaped Kuznet's curve is applicable only in case of certain short term environmental problems emanate from local smoke pollution, SO_2 , contaminated water, sulphur or particulate matter, whereas environmental problems having a long lasting effects on the economy such as accumulation of stocks of waste and emission of GHGs, primarily, CO_2 indicate that environmental degradation is an increasing function of economic development.

Veen-Groot and Nijkamp (1999) had identified four effects of globalisation in the economy and they are scale effects, structural effects, technological effects and product effects having both beneficial and detrimental effects on the environment. They argued that there is a tendency on the part of the trade partners to choose environmentally sound methods of production as the trade grows by volume and value. Scale effects indicate that though

countries adopt a growth oriented trade policy in the initial stages of trade, gradually, there will be a shift towards production of environmentally benign products. By technological effects, it is meant that innovations may be carried out to invent more environmentally sound production techniques and hence, it is believed that the technological progress is likely to bring about resource saving and pollution reduction. For example, a positive environmental effect is said to be implemented in the transportation sector, if a newly efficient transport technology replaces a polluting alternative. However, according to Johnstone (1995) as the economies are moving towards increased global production, further economic progress generates irreversible environmental degradation, as majority of the developing countries have not yet reached the turning point of the inverted 'U' shaped curve (Frankel 2009). Structural effects of globalisation refer to the overall effects of trade due to changes in the composition and location of production and consumption activities. Moreover, it is argued that wide variations in environmental policies between trading partners lead to environmental problems (Anderson 1993), as environmentally hostile production

policies may be carried out in poorer countries in a competitive bid to achieve economic development. A change in the product mix may induce the trading partners to shift the composition of the products and the services that they offer.

A remarkable participation of both developed and developing countries with trade in a wide spectrum of consumables are visible in the international arena since the second half of the 20th century (Stopford 2009). A number of factors including reduction in the costs of transportation and telecommunication and the interlinkage of various modes of transportation contributed positively towards implementation of policies of trade liberalisation. Environmental effects of such a large-scale trade was often debated and discussed by a number of economists and environmentalists on grounds of production and consumption. The trade related concerns raised by environmentalists are: (1) domestic environmental effects caused by the consumption of imported products, (2) foreign environmental effects caused by production of goods for export and (3) environmental effects of transport movements for international trade (van Veen-Groot and Nijkamp 1999). A large number of scholars have addressed first two

aspects of international trade, however, studies addressing the environmental impact of international trade movements are relatively scanty.

Liberalisation induced changes in the scale of production, technology, structure and product mix are visible in the case of transportation sector too. Some of these changes can have positive effects on the environment, whereas others have negative or damaging effects on the environment. Technological innovations in the international trade include improvement of existing transport modes, development of new modes of transportation, efficiency in the management of transport and development of alternative fuels (Hummels 2007). These innovations have generated diverse impact on the environment. According to Gwilliam and Geerlings (1994) cost efficient technologies developed in the liberalised period, instead of producing a lower impact on fuel consumption, promote longer trips due to fuel efficiency, which might encourage travellers to prefer longer distance, and hence, the total travelled distance increases. Moreover, a cost efficient product mix may induce the customers to choose environmentally damaging modes of transportation like air, if the product has low

volume and high value (Nijkamp et al 1998). Liberalisation induced changes taken place in the transportation sector has resulted in the creation of both benefits as well as costs on the environment. If appropriate environmental policies are designed to suit the goals of economic growth and environmental protection, environmental quality could have been enhanced. Otherwise, it is likely to result in further and remarkable degradation of environment, as we are expecting an increasing trend in trade in the future.

The present paper written in the background of international trade tries to look into the environmental externalities of international maritime transportation. Being a mode of transportation that handles more than 80 per cent of the trade volume (UNCTAD 2015), an examination into the maritime transport, its composition, changing trade patterns and types of vessels used for transportation given in the second section of the paper provides an insight into the nature of global maritime transportation. Considered to be a mode of transportation with relatively less environmental externalities, maritime transportation requires a closer examination as it handles huge volume of international trade. The relative importance of maritime transportation over and above other modes

of transportation with lesser taxing on the environment is discussed in the third part. This is followed by an examination into various types of maritime environmental externalities presented in the fourth section. As distinct from the existing literature focussed on one or the other externality of maritime transportation, the present paper provides a broader overview of varied types of maritime environmental externalities. Fifth section deals with environmental regulations put forth by international agencies in order to ensure safety of sea and protection of the maritime environment. This is followed by a number of technical and operational suggestions provided at the end, to protect and improve the maritime environment without adversely affecting the international trade.

2. Relevance of Maritime Trade

Transportation is considered to be one of the four cornerstones of globalisation along with communication, international standardisation and trade liberalisation (Kumar and Hoffman 2002). The enormous growth in the volume of international trade in the second half of the twentieth century materialised with the support of transportation networks. The transport sector had undergone systematic and time bound improvements, which contributed in

accelerating the liberalisation process, and liberalisation in turn contributed towards demand for cost efficient and time saving transportation mechanisms. In the era of globalisation, maritime transportation facilitated the movement of large scale agricultural products harvested in one continent, shipped to another one for intermediate processing, later on, transported to a third continent for final assembling and then delivered to the market. The global freight movements consist of the transport modes such as ocean and coastal routes, inland waterways, railways, roads and air. Almost all modes of transportation experienced significant transformations since second half of the last century and for carrying out international trade, especially, trade with non-adjacent partners; nations relied on sea and air modes. Relatively high valued less volume goods are carried by air whereas bulk commodities like oil and petroleum products, iron ore, coal and grains are shipped via ocean. International maritime transportation is considered to be complementing other modes of transportation and it is quite useful in the movement of intercontinental containerised cargoes and for liquid and dry bulk cargoes such as oil and grain (Corbett et al 2008). Bulk cargoes constitute majority of the

international trade when measured in terms of weight but they are relatively less when measured in value terms as high value cargoes are transported in containers (Hummels 2007).

Global technological advancements produced significant improvements in maritime sector too. Larger container vessels brought down per unit cost of international transportation through the operation of economies of scale. The studies have proved that the transformations have made the maritime transportation cheaper over time and made it comparatively a cost efficient mode of transport. The technological innovations in terms of introduction of containerships, large size vessels with potentials of economies of scale, and faster ships have brought down the sea transportation cost per tonne-km (OECD 2008). The impact of these new developments are visible more in bringing the direct costs down, however, its effects in lowering the indirect costs are meagre. Since the vessels are likely to spend more idle time at ports waiting for loading and unloading, the indirect costs of serving them at ports appeared to be higher. Because of this reason, it is argued that smaller ships are most cost efficient over short distances and

larger ships are more cost efficient over long distances (Hummels 2001).

With the incentive to reduce cost and to improve the vessel performance, a number of innovations had been taken up in the last century and one among them is the switch in the fuel or energy to oil from coal (Stopford 2009). Engine efficiency too underwent improvements and it increased from 35 per cent to 40 per cent in 1975 to more than 20 per cent in 2004 (Corbett 2004). According to Corbett and Winebrake (2008) fuel cost alone constitutes between 20 per cent and 60 per cent of the overall shipping costs. Therefore, operators have a strong economic motivation to operate ships efficiently and to employ propulsion technologies that reduce fuel consumption per cargo ton-km. A study on the impact of transport cost on trade by Behar and Venables (2010) points out that reduction in transport cost had produced significant impact on an increase in trade. According to them, a fall in fuel cost, a fall in trade cost relative to the value of goods shipped and a quality improvement (speed and reliability) in transport services made available through technical advancements gave a positive impetus to the growth of trade. Quicker transport allowed in-time delivery of goods and similar management techniques that came to be operated in an

international level through production networks. Corbett and Winebrake (2008) identified some of the important determinants of maritime transport costs such as time spent in getting the goods to the market, trade imbalances, volume of trade, port infrastructure, competition among carriers, risk and fuel prices.

Can we really believe that the maritime transportation cost had fallen in the era of globalisation and technological advancement? Transportation cost measured in cost per kilogram of merchandise had fallen over the years, consequent to the adoption of advanced technologies. However, *advalorem* equivalent of transportation costs, that is, the one which expressed transportation cost as a percent of the value of the goods had not fallen much as there is an increase in the composition of value added goods (OECD 2008). The product mix of international trade had undergone a change over a period of time. In contrast to the trade that had taken place in earlier periods that are mostly in raw materials, in the containerised era, most of the cargoes assumed the status of value added and manufactured commodities. It is proved that these manufactured goods have become lighter over time as trade consists of more and more of processed foods, light

manufacturers and thereby increasing price per weight of goods. Transport costs as percentage of total value of the goods had fallen only slightly in the 25 years between 1980 and 2005. In 1980, maritime trade cost accounted for about 8 per cent of the final value of goods, where as the corresponding figure is 6 percent in 2005. The share of transport cost as a per cent of the value of commodities traded vary across countries, and in the case of certain under developed countries such as Guam, Nauru, Christmas Islands, Togo, Guinea, Tonga, Sierra Leone, and Pitcairn, maritime transport costs represent insurmountable barriers to conduct international trade (OECD 2008).

Though there is a wide acceptance for maritime transport that carries huge volume of goods, air mode received relative importance in the recent past. Air transport is preferred to ocean transport especially for long distance shipments. As the level of air transport costs drop, relative to the level of ocean transport, the long distance transport by air becomes relatively more attractive (Harrigan 2005). According to Hummels (2007), advancements in technology have propelled a sharp decline in costs, average revenue per ton km shipped dropped by 92 percent between 1955 and 2004. Moreover, shippers have expressed their willingness to

pay for speedy air shipping relative to slow ocean shipping. In the context of increasing income levels, consumers expressed their willingness to pay for air transport, as it constitutes a lower share of the value of the product. Though there is a growing dependence on air transport for high valued commodities, the role of the maritime transport is unquestionably accepted on account of movements of large volume of cargoes. It still enjoys a considerable share of the international transportation, as a huge volume of cargo is shipped by sea.

3. Structure, Trends and Nature of Maritime Transport

The maritime trade had undergone significant changes in liberalisation period, mostly in terms of the composition or structure of commodities traded, participating nations, and composition of vessels used for carrying cargo. Most of the developed and developing nations have unanimously accepted the importance of liberalisation of trade and accordingly adopted measures for free trade in order to reap the benefits of comparative cost advantages in international trade. They export commodities having comparative cost advantages and import those commodities having comparative cost disadvantages. In the liberalised era, international trade

opened avenues for developing nations to increase national income and this is reflected in the growth rate of GDP. An examination into the rate of growth of GDP and exports indicates that the fluctuations in the annual growth rate of global exports are higher compared to that of growth in global GDP. The annual growth rate of global exports and GDP from 2004 to 2014 is given in the Table 1.

The global annual growth rate in exports, an indicator of world trade, is higher than the rate of growth in the global GDP over the years. Both the exports and GDP had fallen in 2009, followed by the global recession of 2008. Except 2009, in all the years, the annual growth rate of world exports is higher than the global GDP growth. As the trade progresses with liberalised policies implemented through various regional and international trade agreements, the composition of the exports and imports of developed and developing countries underwent a transformation. The Table 2 gives an indication of the increased participation on the part of the developing countries in the world trade.

With the implementation of liberalised policies since 1970s, and improvements in the standard of living of the people, the purchasing patterns of the developing

nations underwent a transformation. This is reflected in an increase in per cent of unloaded goods of developing countries over the years. A reduction in the unloaded cargo for developed nations does not indicate that the volume of unloaded cargo had fallen and it indicates just a reduction in the share of unloaded cargo. Moreover, volume of commodities imported by developing countries increased enormously over this period (UNCTAD 2015). The expanding demand for international trade coupled with a reduction in cost efficient means of production contributed to an ever-increasing demand for merchandise trade. It also reflects the differences in countries' economic structures, composition of trade, urbanisation and level of development, levels of integration into global trading networks and supply chains. The seaborne trade was carried by different types of vessels based on the type of the cargo they handled. The composition of the cargo calls for the requirement of specialised vessels with which the trade can be carried out. The change in the composition of the cargo can be seen in Table 3 and the structure of the seaborne trade in 2014 is given in Chart 1.

There has been a continuous growth in international seaborne trade since 1980 and

this is true with all the four components of cargo, namely, containers, dry cargo, five major bulks and oil and gas over the years except 2009 and there has been a change in the composition of the cargo. The share of container trade and five major bulk (iron ore, grain, coal, bauxite/ alumina and phosphate rock) increased over the years, whereas the share of dry cargo and oil and gas decreased regardless of the increase in the volume of all the four components. An increasing preference for manufactured and value added goods made a shift towards containerisation. The rate of growth in five major bulks, basically raw materials for manufacturing goods indicate the demand of cargo for productive purposes. Though there is a reduction in the share of oil and gas and other dry cargo, there has been a significant increase in the volume over the years. The structure of the international seaborne trade in 2014 is given in Chart 1.

Maritime transport enjoys a major share of the international modes of transportation with over 80 per cent of the world merchandise (UNCTAD 2015). It has played a major role in the international sphere of trade and globalisation. It includes a number of auxiliary services, besides maritime transportation, having a bearing on the economic activities such as marine

equipment manufacturing, maritime auxiliary services fisheries, tourism, offshore energy sector and marine based industry such as ship building and ship demolition. Thus, it points towards the need for developing a matured and suitable maritime transport system, with transport infrastructure and services that are safe, reliable, affordable, fuel efficient, and environmentally friendly.

4. Composition of World Fleet

An examination into the composition of the cargo throws light upon the need for ensuring services of specialised vessels to meet the diverse cargo handled in the maritime transportation. Compared to the previous year, world fleet grew by 3.5 per cent in 2015 and it consisted of the world's commercial fleet of 89,464 vessels with a tonnage of 1.75 billion dwt (UNCTAD 2015). The distribution of the world fleet in dwt across different categories of vessels in 2014 and 2015 is given in Table 4.

Table 4 shows that in terms dwt, vessels carrying dry bulk and containers increased over the years, whereas share of oil tankers and general cargo decreased over the years. The world fleet by principal vessel types over 1980-2015 indicates the changes that had taken place in the product mix/ structure

of the goods demanded by the people in the globalisation era.

Containerisation as a technological development received wide appreciation and popularity during the period of liberalisation, which was in fact helpful in transporting manufactured and value added products, consequent to liberalisation.

5. Externalities of International Transportation

As discussed in the first section, the supporters of trade may concentrate on sustainable economic development without losing international environmental quality. The environmentalists concerned about growing environmental adversities of trade focussed on its indirect environmental effects either in production or in consumption of commodities. Very few studies have looked into the environmental impacts while transporting commodities between nations and most of these studies have focussed on one or the other negative externalities without carrying out a comprehensive analysis on the diverse environmental externalities in totality. Some of these studies have focussed either on costs involved in air pollution (Gallagher and Taylor 2003; Corbett and Fischbeck 2000; Saxe and Larsen 2004), or oil spillage or invasive species (ITOPF 2016, Oceana

2008, SPC 2012; Jiang et al 2012; Sakellariadou 2013) and the methodologies for calculating the cost too vary from one study to another. Some of them have adopted a bottom up approach, whereas others have adopted a top down approach. Assessing an accurate measure of total externalities while transporting the commodities is a major challenge; however, estimation has to be carried out if the costs are to be internalised. The economic costs of international transportation are in the form of health care costs, damage to ecosystems due to acid rain and the effects of global climate change. When the harmful emissions from the ships are not priced, there is a chance that the cost of the emissions is transferred on to the third parties other than the manufactures and the producers of the commodity (Pindyck and Rubinfeld 2008). International organisations like International Maritime Organisation (IMO) have convened a number of conventions to provide solutions to reduce the emissions of shipping and to improve the environmental performance of new and existing ships (IMO 2008; UNCTAD 2015). If the emissions are not priced, there will not be any incentive for the shipping firms to deploy emission reduction technologies or mitigate environmental externalities.

Various studies conducted on the relative importance of the different modes of transportation indicate that shipping is more environmentally friendly or less damaging and cost efficient (Psaraftis and Christos 2009; World Shipping Council 2009). Transportation cost per unit of commodities by sea is cheaper due to economies of scale, fuel efficiency and less congestion. Moreover, negative environmental effects in terms of pollutants emitted onto the atmosphere are also relatively less under maritime transportation compared to other modes of transportation. A comparative study on the external costs of short sea shipping and road transport in Taiwan indicates that short sea shipping is relatively environmentally friendly compared to truck transport (Lee et al 2010). Denisis (2009) justified the superiority of intermodal short sea shipping in terms of lower external costs compared to the all truck transportation. Addressing GHG emissions remains an urgent imperative to ensure manageable global warming levels, the effects of global warming are already felt in developed countries and measures have been taken by them to address that. However, in the race of competition to grab the fruits of economic growth, the poor countries are not giving adequate attention to the future prospects of

environmental degradation by neglecting the immediate requirements of the time. Compared to richer nations, the adaptability of the poorer countries to the devastations of environmental damages is relatively less.

Corbett and Winebrake (2008) classified environmental effects of maritime transportation into two broad categories as episodic environmental events and routine environmental events and some of them are vessel based and whereas others are port based in nature. According to them, episodic pollution discharges are addressed by international conventions and national regulations. They prohibit the pollution episodes from occurring and design systems that are safer to confine activities that produce discharges. Routine pollution releases are activities necessary for the safe operation of the vessel whether at sea or in port.

The most important direct environmental impacts caused by transport are emissions released into the air and water was noise and trembling. Some studies stated that the quantity of emissions released by the vessels depends on the amount of fuel consumed in the voyage. Transport emissions into air are the externalities due to carbon dioxide (CO_2), Nitrogen oxide (NO_x), Sulphur oxides (SO_x), Particles (PM), Carbon

monoxide (CO), Hydrocarbon (HC). The main causes of climate change are green house gases (GHGs). Carbon dioxide is the most common GHGs responsible for the global warming caused by human beings. Climate change exerts consequences on economic and natural systems in addition to human health including rising temperatures and it may result in shifting rainfall; patterns, melting glaciers and snow, rising global average sea level, more frequent and intense extreme weather events. Another major GHG contributor is black carbon which forms as a result of the incomplete combustion of fossil fuels, biofuels, and biomass. One of the primary sources of black carbon is diesel engine emissions. Black carbon causes global warming, because it is strongly light absorbing and warms up the air (SPC 2012). Table 7 shows a comparative analysis of CO₂ emissions, one of the important GHGs, by different modes of transport.

The CO₂ emissions discharged into the atmosphere to carry one tonne of cargo/km are considered to be the lowest in case of ships. On the other hand, air transport has recorded the highest CO₂ emissions and it calls for immediate action, as there is a growing preference on the part of the people to choose air transportation in the recent

past. Besides the advantages of having a lower transportation costs, seaborne transport is environmentally beneficial with lower CO₂ emissions. Though shipping is considered to be environmentally friendly, considering the increasing trend in the volume of commodities handled by them, there is a need to look into the CO₂ emissions by ships, as it is an important contributor to the GHG emissions. The shipping CO₂ emissions compared with global CO₂ emissions given in Table 8.

CO₂ emissions from global shipping in 2012 is estimated at 2.6 per cent by third IMO GHG study (IMO 2014). The contribution of shipping to the global emission is relatively low, but considering the huge volume of goods transported by sea with its future growth prospects, the emission is likely to grow in alarming rates, if left unregulated. Forecasting estimates that carbon emissions from international shipping could increase between 50 and 250 per cent by 2050, depending on economic growth and global energy demand (UNCTAD 2015).

International organisations like IMO have devised measures to reduce the emissions of shipping and to improve the environmental performance of new and existing ships (IMO, 2008). If the emissions are not priced,

there will not be any incentive for the shipping firms to deploy emission reduction technologies or mitigate environmental externalities. Several studies have found that the levels of emissions from the ship depends on the type of vessel, year built, deadweight tonnage, average cargo payload per laden trip, engine type, horse power, speed, time in port for loading and discharging, fuel type used at sea and port, total fuel consumption at sea and at port, and operation of engines (Entec 2005; Jiang Liping et al and Psaraftis and Christos 2009). An important factor influencing CO₂ emissions from shipping is the type of the vessels and Chart 2 illustrates emissions varied on account of types of ships used for transportation.

As mentioned in Chart 2, emissions vary based on the type of the ships, and hence, the vessels should not be considered as a homogeneous category. Specialised vessels are utilised for the transportation of specialised cargo. The volume of the container cargo, oil and gas and bulk cargo is increasing over the years and is likely to increase in future. Linking the volume with the CO₂ emissions from vessel types indicates that the an increase in the demand for certain specialised cargoes is likely to increase international CO₂ emission levels

and therefore, it points towards the voluminous emissions that the seaborne trade can discharge into the atmosphere on account of a shift in the composition of cargo in the recent past.

According to Berechman and Tseng (2012), a study conducted on the port of Kaohsiung (Taiwan), tankers have the largest negative externalities, followed by container ships and bulk carriers. Some of the studies established a direct linkage between environmental externalities and trade liberalisation. Certain studies have examined externalities associated with a number of air pollutants, besides CO₂ emissions. Two studies on the environmental externalities of North American Free Trade Agreement (NAFTA) found that free trade agreement led to an increase in the levels of pollution in those areas adjacent to port. In the first study, it is found that NAFTA had contributed to air pollution in five key transportation corridors that link North American commerce. Such pollution is estimated to be 3 to 11 per cent of all mobile source nitrous oxide (NO_x) emissions in those regions and 5 to 16 per cent of all particulate matter emissions (Consulting 2001).

In a study carried out by Corbett in 2003, highlighted the environmental emissions of

shipping and revealed shipping accounts for 14 per cent of NO_x emissions from all global fossil fuels and 16 per cent of sulphur from all petroleum fuels. Shipping has emerged as an unregulated source of air pollutants and in US alone, shipping accounts for 4 per cent of transportation related to NO_x emissions and 8 per cent of sulphur dioxide emissions (Corbett and Fishbeck 2000 and EPA 2000). A study carried out by EPA shows that marine diesel engines entering California and Texas account for 15 per cent and 17 per cent of NO_x emissions on summer days in these busiest ports of the USA (EPA 2000).

Another study (NACEC 2000) indicates that increased trade led to the introduction of alien invasive species which decreased the biological diversity that cost North America millions of dollars. An important dimension to the marine externalities is the introduction of invasive species from the transfer of ballast water. Native species can be transported by ships many thousands of miles and then be released into non-native waters. The non-native species can act as an invasive one and can endanger the biodiversity of the seawater and a positive correlation between non-native invasive species and sea-borne trade has already been established. Shipping is likely to be a danger

to marine mammals as they get struck by vessels (SPC 2012). According to Corbett, the number of vessels striking large whales worldwide has increased three fold since 1970s in accordance with an increase in the number, size and speed of the vessel in the world fleet (Corbett 2008).

An auxiliary business associated with shipping having environmental externalities is the scrapping of ships. Those who argue for scrapping assert that it is environmentally friendly as it reduces the oversupply of emission tonnage, and it encourages the modernisation of fleet as vessels demolished tend to be less fuel efficient and more detrimental to environment as far as emissions are concerned. South Asian countries such as India, Bangladesh, China and Pakistan together account for more than 90 per cent of global ship-breaking business. It is highly specialised and within the demolition, majority of container ships are demolished in India whereas Bangladesh and China specialise in dry bulk carriers and Pakistan in oil tankers. However, ship breaking has environmental consequences and it is done under harmful circumstances without adequate safety measures (UNCTAD 2015) and the abundant supply of labour in these developing countries are over exploited as

they are often underpaid and most of them work under risky circumstances without adequate protective gears.

Another important externality is oil spill and it can adversely affect the biodiversity of the seawater. Spills from vessels are generally categorised into sizes of less than 7 tonnes, 7-700 tonnes and more than 700 tonnes. Small and medium sized spill occurred during loading/ unloading, bunkering, while under operations such as ballasting, deballasting, tank cleaning and when the vessel is underway. The primary causes for large spills are allusions/ collisions/ groundings, hull failures, equipment failures, fire and explosion, heavy water damage and human error. Small and medium sized spills account for 95 per cent of all the accidents recorded and 29 to 40 per cent occurred during loading and unloading operations at ports and terminals. There has been a significant reduction in the oil spilt over the years and is given in Table 9.

Statistics on oil spill shows reduction in the number of recorded spills over the years due to the efforts taken by international organisations. This is an appreciating one, considering an increase in the maritime transportation over the years. However, there may be unrecorded instances with

smaller spills and its total volume due to such spills also needs to be brought under control.

6. Environmental Regulations on Maritime Transportation

The United Nations Convention on the Law of the Sea (UNCLOS) 1982 provides the rights and responsibilities of nations in their use of oceans and the regulations of shipping. Safety and environmental standards may be adopted by the states either individually through national legislations or collectively through conventions and other instruments negotiated at international organisations or regionally. The provisions of UNCLOS are supplemented by a number of conventions and other legal instruments negotiated and adopted by IMO and the International Labour Organisation (ILO) which deals with a wide range of safety, environmental and seafarers' issues. Main conventions that establish mandatory rules and regulations include Safety of Life at Sea (SOLAS), MARPOL (International Convention for the Prevention of Pollution from Ships) and the Maritime Labour Convention.

In 2014, maritime trade is carried by world fleet of 1,04,000 sea going merchant ships of more than 100 GT (UNCTAD 2015). Combustion of the fossil fuel used by the

engines of the vessels produce GHG and non GHG emissions into the atmosphere. GHG emissions have long lasting side effects through global climate change and environmental risks. Non GHG emissions have short term ill effects such as biological, social and economic implications. Among the GHG emissions, it is to be cautious about the alarming levels of growth of carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydro-fluorocarbons (HFCs), Perfluorooctanesulphonate (PFCs) and Sulphur hexafluoride (SF_6). It is reported that 1050 million tonnes of CO_2 is emitted by the ships in 2007 formed 3 per cent of the world CO_2 emissions, which doubled that of 1990 levels. Carbon dioxide is the most important GHG both in terms of quantity and global warming potential. Depending on the future economic and energy related developments, maritime CO_2 emissions are projected to increase by 50 to 250 per cent by 2050. Annual aggregated emissions of CH_4 , N_2O , and HFCs represent 21 million tonnes of CO_2 equivalent. However, emissions of PFCs and SF_6 are negligible. Among the noted non GHG emissions are Sulphur Oxides (SO_x), Nitrogen Oxides (NO_x), and Particular Matter (PM).

Four policy mechanisms have been suggested by regulatory organisations like International Maritime Organisation and European Union to address the ever increasing levels of air pollution emissions; emission trading, financial incentives or taxes, emission reporting/ monitoring obligations and energy efficiency/ emission standards. Shipping emissions from the air can be addressed at various levels depending upon the relative cost involved at each of these operations. In order to reduce exhaust emissions measures can be taken either before the combustion process (fuel oil treatment and fuel oil modification), during combustion process (reduce formation of air pollutants in combustion process) or through after treatment of exhaust gases. The fuel consumption and emissions may also be reduced by improved technical conditions (eg. Antifouling systems, engine efficiency), operational means (eg, reduced speed, weather routing), alternate fuels (eg LNG), alternate propulsion systems (eg fuel cells, skysails) (Eyring et al 2005, Tronstad and Enderson 2006 and Enderson et. al 2007). The list of technologies to be adopted for selected pollutant reductions is given in Table 10.

With regard to marine environmental protection, the main convention is

MARPOL, which aims at the prevention of pollution of the marine environment by ships from operational or accidental causes; six technical annexes specifically deal with prevention and control of pollution by oil (Annexure I); noxious liquid substances carried in bulk (Annexure II); harmful substances carried by sea in packaged form (Annexure III); sewage from ships (Annexure IV); garbage from ships (Annexure V); and air pollution from ships (Annexure VI). To ensure environmental protection and to foster the sustainable development of shipping in polar waters, both in the Arctic and the Antarctic, Guidelines for ships operating in Arctic ice covered waters is issued. Moreover, from time to time, modifications are done to the existing clause to make it stringent and more environmental friendly.

7. Concluding Suggestions

The discussions in the previous sections brought out that there is an ever increasing demand for maritime trade and consequent to that, there is an increase in demand for shipping in the future as well. Unlike the externality studies that focussed either on production or on consumption this paper examined the environmental externalities of trade associated with maritime transportation. Hence, it argues that the trade

generated international development should be materialised not at the cost of the environment through air pollution, water pollution, sewage disposal, noise pollution and the like.

Jiang L et al (2012) argued that in the context of environmental externalities, the regulations insisted the ship owners to invest on costly technologies, i.e., seawater scrubbing, to bring down environmental pollution. Such a beneficial investment on the society would result in a redistribution of cost from ship owners on to the end users of the product, which ultimately make the maritime transportation relatively expensive compared to other modes of transportation. It may distort the competitive advantage enjoyed by maritime transportation and likely to shift the preference in favour of road and rail modes of transportation and thereby, create an uneven level playing field among the transportation modes. There is a change in the preference pattern of the people to shift to air mode of transportation for low volume high value products, since transportation cost by air has recorded a cost reduction over a period of time, but it has been done at the cost of environmental degradation.

Market based mechanisms and emission-trading schemes are the two approaches to

bring down the levels of pollution and the effectiveness in implementing them will vary. The implementation of market based mechanisms may not be effective in reducing the pollution as there is a growing demand for shipping from all the quarters and goods will continue to be moved regardless of the additional charges. This consequently will result in an increase in the cost of transportation of goods by sea and will finally be passed on to the final consumers of the product.

Emission trading scheme (ETS) is another mechanism. However a number of prerequisites such as standardisation of ship designs and involvement of shipowners, ship operators, charterer, cargo owner and cargo receiver across countries are required for making its administration implementable. Since more than 75 per cent of the world fleet are handled by bulk carriers, tankers and general cargo ships without any uniformity on the structural, operational and contractual complexities, it is doubtful how effectively the tramp shipping can be brought under emission trading scheme. Moreover, this scheme appeared to be unsuitable and ineffective for shipping industry, if third parties outside the maritime

sector such as financial institutions and/ or futures trading houses were permitted to engage in emission trading process. ETS is aimed at creating certain incentive among the shipping companies to undertake innovations and technological improvements to develop ship and engine design, but most of them do not possess adequate resources.

It is a need of the time to put a check on the growing levels of pollution. The emission from the ships cannot be considered as a homogeneous category as we have diverse categories of vessels with varied levels of pollutions. It may not be feasible to establish a single mechanism to monitor different types of pollution, though it is desirable to institute so. However, there should be a pollution abatement policy for specified categories of the ships worldwide, as the externalities of pollution are global rather than region specific. The failure to do so would result in large-scale degradation of the environment, which is already under tremendous strain. The path of development and increased global trade cannot happen at the cost of environment and there is a need to find a path leading to sustainable development without impinging much on the volume of trade.

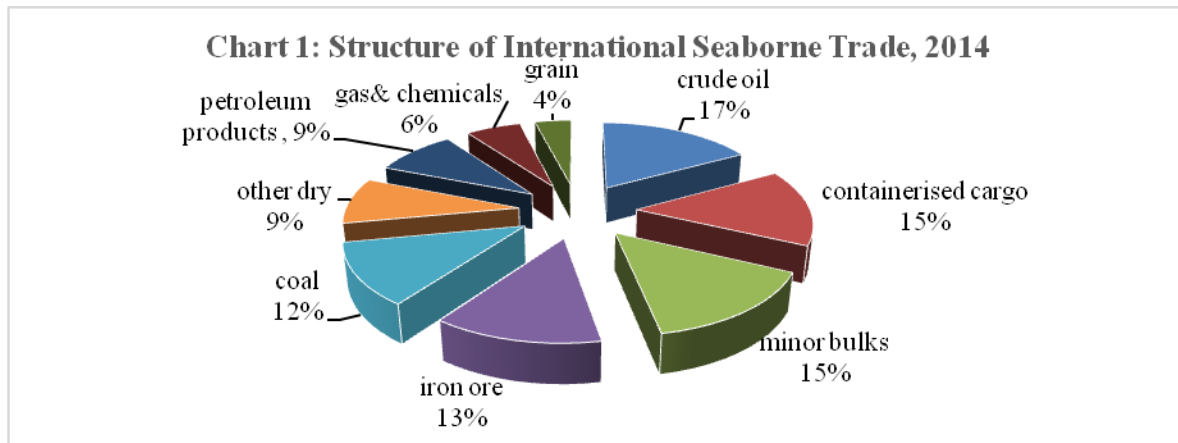
References:

1. Anderson K. (1993) *Economic Growth, Environmental Issues and Trade*. CEPR Discussion Paper No. 830, London: Centre for Economic Policy Research.
2. Behar Alberto and Anthony J. Venables (2010) 'Transport Costs and International Trade', in André de Palma, Robin Lindsey, Emile Quinet and Roger Vickerman. Edward Elgar (ed.) *Handbook of Transport Economics*. Cheltenham: Edward Elgar, pp. 97-115.http://works.bepress.com/alberto_behar/17
3. Berechman J. and Tseng P.H.(2012) Estimating the Environmental Costs of Port Related Emissions: The Case of Kaohsiung. *Transport Research Part D: Transport and Environment*, 17 (1): pp 35-38
4. Bhagwati, J.(1993).The Case for Free Trade. *Scientific American*, 269 (November):pp 42-49.
5. Consulting I. (2001). North American Free Trade and Transportation Corridors: Environmental Impacts and Mitigation Strategies, Paper prepared for North American Commission for Environmental Cooperation
6. Corbett J. J. and James Winebrake(2008)The Impacts of Globalisation on International Maritime Transport Activity: Past Trends and Future Prospects. Guadalajara, Mexico: Global Forum on Transport and Environment in a Globalising World, 10-12 November 2008.
7. Corbett J. J., and Fischbeck, P.S.(2000) Emissions from Waterborne Commerce Vessels in United States Continental and Inland Waterways,*Environmental Science & Technology*, 34 (15): pp 3254-3260
8. Daly H. E. (1993) The Perils of Free Trade. *Scientific American*, 269 (November): pp 50-57.
9. DenisisA. (2009) An Economic Feasibility Study of Short Sea Shipping including the Estimation of Externalities with Fuzzy Logic. PhD Thesis, University of Michigan.
10. Endersonet.al. (2007) A Historical Construction of Ships' Fuel Consumption and Emissions. *Journal of Geophysical Research D*, 112 (12) D12301.
11. Entec UK Limited (2005) European Commission Directorate General Environment Service Contract on Ship Emissions: Assignment Abatement, and market based Instruments. Task 2b-NOx Abatement. Final Report. Cheshire: Entec UK Limited.
12. EPA(2000) National Air Quality and Emissions Trends Report. Washington DC: Environmental Protection Agency: Table A-8.

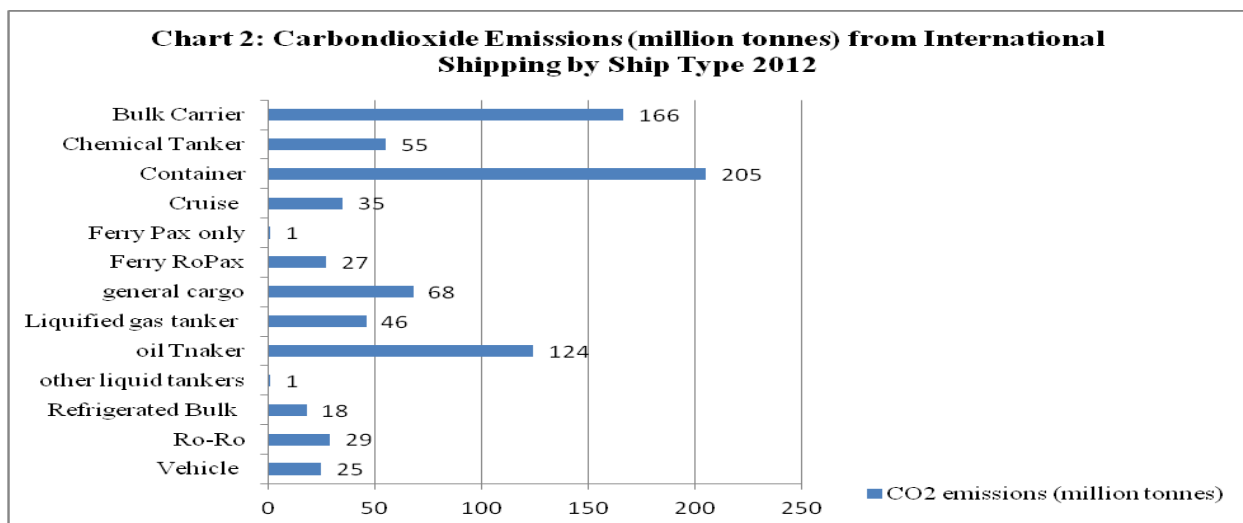
13. Eyring K. et. al. (2005) Emissions from International Shipping:1. The Last 50 Years. *Journal of Geophysical Research- Atmospheres*, 110 (D17) D 17305.
14. Frankel J.(2009) Environmental Effects of International Trade: Export Report No. 31 to Sweden's Globalisation Council, <https://www.hks.harvard.edu/fs/jfrankel/Swenvirinlaga31proofs.pdf>
15. Gallagher K.P., and Robin Taylor (2003) International Trade and Air Pollution: The Economic Costs of Air Emissions from Waterborne Commerce Vessels in the United States, Working Paper No. 03-08. Tufts University: Global Development and Environment Institute.
16. Grossman G. M., and A. B. Krueger(1993)'Environmental Impacts of a North American Free Trade Agreement', in P. M. Gargered (ed.) *The Mexico- US Free Trade Agreement*, pp 13-56. Cambridge, MA: MIT Press
17. Gwilliam K. M., and Geerlings H.(1994) New Technologies and their Potential to Reduce the Environmental Impact of Transportation. *Transport Research Part A: Policy and Practice*, 28A (4): pp 307-319.
18. Harrigan J.(2005) Airplanes and Comparative Advantage. National Bureau of Economic Research Working Paper 11688.
19. Hummels David, 2001. Toward a Geography of Trade Cost, Purdue University, September 2001.
20. Hummels D. (2007). Transportation Costs and International Trade in the Second Era of Globalisation. *Journal of Economic Perspectives*, 21 (3), pp.131-154.
21. IMO (2008) Revised MARPOL Annex V: Regulations for the Prevention of Air Pollution from Ships and NOx technical code London: IMO Marine Environmental Protection Committee (MEPC)
22. IMO(2015) Third IMO GHG Study 2014, International Maritime Organisation, Micropress Printers UK
23. ITOPF (2016) Oil Tanker Spill Tanker 2015, The International Tanker Owners Pollution Federation Limited, http://www.itopf.com/fileadmin/data/Documents/Company_Lit/Oil_Spill_Stats_2016.pdf
24. Jhonstone N.(1995) Trade Liberalisation, Economic Specialisation and the Environment, *Ecological Economics*, 14: pp 165-173.

25. Jiang, L., Kronbak, J., and Christensen, L. (2012). External costs of maritime shipping: A voyage-based methodology. Working Paper. Esbjerg, Denmark: Unit for Maritime Research, Department of Environmental and Business Economics, University of Southern Denmark.
26. Kumar S. and Jan Hoffman (2002) 'Globalisation: The Maritime Nexus', in *The Handbook of Maritime Economics and Business*, Costas Th. Grammenos (ed.), London: Informa.
27. Lee, P.T., Hu., K.C., and Chen T.(2010) External Costs of Domestic Container Transportation: Short Sea Shipping versus Trucking in Taiwan. *Transport Reviews*, 30 (3): pp 315-35.
28. Lofdahl C. L., (1998) On the Environmental Externalities of Global Trade. *International Political Science Review*, 19 (4): pp 339-355.
29. Nijkamp, P., Rienstra, S. A., and Vleugel, J.M. (1998) *Transportation Planning and the Future*. Chichester: John Wiley.
30. NACEC (2000) North American Agenda for Action: 2001-2003, A Three Year Program Plan for the North American Commission for Environmental Cooperation, http://www.cec.org/sites/default/files/documents/operational_plans/2379_operationalplan01-03_en.pdf
31. Oceana (2008) Shipping Impacts on Climate: A Source with Solutions, http://www.cleanshipping.org/download/Oceana_Shipping_Report1.pdf
32. OECD(2008) Clarifying Trade Costs in Maritime Transport, Working Party of the Trade Committee, Trade and Agriculture Directorate, TAD/TC/WP (2008) 10, Organisation for Economic Cooperation and Development
33. Pindyck R. S. and Rubinfeld, D.L. (2008) *Microeconomics*. London: Prentice Hall.
34. Psaraftis H. N. and Christos A. K. (2009) **CO₂** Emission Statistics for the World Commercial Fleet, *WMU Journal of Maritime Affairs*, 8 (1): pp 1-25.
35. Sakellariadou Fani(2013) Evaluation of Anthropogenic Pollution in Harbour Areas, *International Journal of Maritime, Trade and Economic Issues*, 1(1): pp 59-66.
36. Saxe, H. and Larsen, T. (2004) Air Pollution from ships in three Danish Ports. *Atmospheric Environment*, 38 (24): pp 4057-4067.
37. SPC (2012) Transport and the Environment 2012.Finland: Shortsea Promotion Centre. <http://www.utu.fi/fi/yksikot/mkk/spc/Documents/Environment.pdf>

38. Stopford M. (2009) *Maritime Economics* (3rd Edition). London: Routledge.
39. Tucker M. (1995) Carbon dioxide Emissions and Global GDP, *Ecological Economics*. 15 (3): pp 215-23.
40. UNCTAD (2015) Review of Maritime Transport, 2015. New York and Geneva: United Nations Conference on Tariff and Trade. http://unctad.org/en/PublicationsLibrary/rmt2015_en.pdf
41. VanVeen-Groot, Danielle B and Peter Nijkamp(1999) Globalisation, Transport and the Environment : New Perspectives for Ecological Economics. *Ecological Economics*, 31: pp 331-346.
42. World Shipping Council (2009) The Liner Shipping Industry and Carbon Emissions Policy, http://www.worldshipping.org/pdf/liner_shipping_co2emissions_policy_september.pdf



Source: UNCTAD, Review of Maritime Transport 2015



Source: IMO 2015, Third IMO GHG Study 2014

Table 1: Global Annual Growth Rate in GDP and Exports (2004-2014)

Year	Growth in GDP	Growth in Exports
2004	4.1	10.0
2005	3.6	6.5
2006	4.1	8.5
2007	3.9	6.5
2008	1.5	2.0
2009	-2.1	-12.0
2010	4.1	14.0
2011	2.8	5.5
2012	2.2	2.5
2013	2.4	3.0
2014	2.5	2.5

Source: World Trade Organisation: International Trade Statistics 2015

Table 2: Participation of Countries in World Seaborne Trade (in percent)

Years	Developing countries		Developed countries	
	Loaded goods	Unloaded goods	Loaded goods	Unloaded goods
1970	63	18	37	82
1980	58	26	42	74
1990	51	29	49	71
2000	53	37	47	63
2005	56	41	44	59
2006	63	46	37	54
2007	62	50	38	50
2008	62	51	38	49
2009	61	56	39	44
2010	60	56	40	44
2011	60	57	40	43
2012	60	58	40	42
2013	61	60	39	40
2014	60	61	40	39

Source: UNCTAD, Review of Maritime Transport 2015

Table 3: International Seaborne Trade, selected years (millions of tons loaded)

Years	Container	Other dry cargo	Five major bulks	Oil and gas	Total
1980	102(2.75)	1123 (30.32)	608 (16.41)	1871 (50.51)	3704
1985	152 (4.56)	819 (24.59)	900 (27.03)	1459 (43.81)	3330
1990	234 (5.84)	1031 (25.72)	988 (24.65)	1755 (43.79)	4008
1995	371 (7.98)	1125 (24.19)	1105 (23.76)	2050 (44.08)	4651
2000	598 (9.99)	1928 (32.21)	1295 (21.64)	2163 (36.15)	5984
2005	969 (13.63)	2009 (28.26)	1709 (24.04)	2422 (34.07)	7109
2006	1076 (13.97)	2112 (27.43)	1814 (23.56)	2698 (35.04)	7700
2007	1193 (14.89)	2141 (26.73)	1953 (24.38)	2747 (34.29)	8011
2008	1249 (15.18)	2173 (26.41)	2065 (25.09)	2742 (33.32)	8229
2009	1127 (14.34)	2004 (25.49)	2085 (26.52)	2642 (33.61)	7861

2010	1280 (15.22)	2022 (24.05)	2335 (27.77)	2772 (32.96)	8409
2011	1393 (15.86)	2112 (24.04)	2486 (28.30)	2794 (31.80)	8785
2012	1464 (15.92)	2150 (23.38)	2742 (29.81)	2841 (30.89)	9197
2013	1544 (16.22)	2218 (23.31)	2923 (30.71)	2829 (29.73)	9517
2014	1631 (16.57)	2272 (23.09)	3112 (31.62)	2826 (28.72)	9841

Note: Five major bulks consists of iron ore, grain, coal, bauxite/ alumina and phosphate rock

Source: UNCTAD, Review of Maritime Transport 2015

**Table 4: World Fleet by Principal Vessel Types 2014-2015
(thousands of dwt; percent share in brackets)**

Principal types	2014	2015
Oil tankers	482447 (28.5)	489388 (28)
Bulk carriers	728322 (43.1)	760468 (43.5)
General cargo ships	77507 (4.6)	76731 (4.4)
Container ships	215880 (12.8)	227741 (13)
Other types	185306 (11)	194893 (11.1)
World Total	1689462 (100)	1749222(100)

Source: UNCTAD, Review of Maritime Transport 2015

Table 5: World Feet by Principal Vessel Types 1980-2015(percent share of dwt)

Years	Oil tanker	Dry bulk	General cargo	Container	Other types
1980	49.7	27.2	17.0	1.6	4.5
1990	37.4	35.6	15.6	3.9	7.5
2000	35.4	34.6	12.7	8.0	9.3
2010	35.3	35.8	8.5	13.3	7.1
2015	28.0	43.5	4.4	13.0	11.1

Note: Other types include gas carriers, chemical tankers, ferries, passenger ships

Source: UNCTAD, Review of Maritime Transport 2015

Table 6: Overview of Types of Ocean Shipping Pollution

Episodic environmental events	Routine environmental events
Vessel based	
Oil spills	Engine air emissions
Ocean dumping	Invasive species introductions (ballast water/ hull fouling)
Sewage discharges	Hull coating toxics releases
Oily waste water	Under water noise
Vessel collisions	
Ship strikes with marine life	
Port based	
Dredging	Storm water run off
Port expansion	Vessel wake erosion
Ship construction, breaking	Cargo handling air emissions

Source: Corbett and Winebrake (2008)

Table 7: Grams of CO₂ to carry one tonne of cargo one km

Vessel types	Grams
Ship (container – 10,000)	10
Rail (diesel train)	21
Truck (tractor/ trailer)	59
Air (freight)	470

Source: World Shipping Council 2009, Data provided by Network of Transport and the Environment

Table 8: Shipping Emissions Compared with Global CO₂ (values in million tonnes CO₂)

Year	Global CO ₂	Total shipping	Per cent of the global
2007	31409	1100	3.5
2008	32204	1135	3.5
2009	32047	978	3.1
2010	33612	915	2.7
2011	34723	1022	2.9
2012	35640	938	2.6
Average	33273	1015	3.1

Source: Third IMO GHG Study 2014

Table 9: Number of oil spills over the years

Years	7-700 tonnes	More than 700 tonnes
1970-79	543 (39.8)	245 (53.38)
1980-89	360 (26.4)	94 (20.48)
1990-99	281 (20.60)	77 (16.78)
2000-09	149 (10.92)	32 (6.96)
2010-15	31 (2.28)	11 (2.40)
Total	1364	459

Source: ITOPIF 2016, Oil spill statistics

Table 10: List of Technologies for Selected Pollutant Reductions

Stage	Control of technology	Target pollutant
Pre-combustion	Fuel water emulsification	NO _x
	Humid air motor	NO _x
	Combustion air saturation system	NO _x
In-engine	After cooler upgrades	NO _x
	Engine derating	NO _x
	Injection timing delay	NO _x
	Engine efficiency improvements	NO _x , SO _x , PM, CO ₂
Post-engine	Selective catalytic reduction	NO _x
	Seawater Scrubbing	SO _x
	Diesel Particulate filters	PM
	Diesel oxidation catalysts	PM
Vessel designs	Hull form	CO ₂ , energy ratio pollutants
	Propeller	CO ₂ , energy ratio pollutants

Source: Corbett and Winebrake (2008)