The Hong Kong Maritime Museum

The Environmental Impacts of Shipping: A Primer

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Introduction

In many ways, a large ocean-going vessel can be compared to a small town in an isolated location: it must have its own power supply, water, food and shelter for the crew. Like any small town, it will produce its own garbage and sewage. Unlike a town, however, the ship will also need an engine powerful enough to move it around the world and will contain large covered spaces where cargo is carried and tanks for fuel and ballast water.

It is generally accepted that more than 90% of global trade is carried by sea, by more than 95,000 ships.[1] Commercial ships have an average age of 21 years[2] and provide employment for 1,647,500 seafarers [3] of which 774,000 are officers and 873,500 are ratings.[4]

Shipping companies are under intense commercial pressure to keep costs to a minimum and have adopted a number of strategies to achieve this. In recent years' ships have become much bigger carrying more cargo, gaining economies of scale. And, as the largest cost of running a ship is the cost of fuel, many measures have been adopted to minimize it. Some have been driven by legislation and others by selecting more efficient hulls, propellers and engines.

For thousands of years' ships were made from timber and powered by sails and by themselves were almost pollution free. The only source of pollution would have been when ships sank and were carrying cargo that caused some pollution, but as they were small the environmental impact was minimal. This changed when ships started to be made from steel at the end of the 19th century and were driven by steam engines and not sails. The average size ship rapidly increased in size and coupled with the rise of the world trade an increasing variety of commodities were carried. The growth of shipping has closely tracked the growth of world GDP. From 1980 to 2019 the volume of cargo shipped per year increased from 4 billion tonnes to 11 billion tonnes.[5] The result, even with economies of scale, has been a large increase in the number and size of ships to meet the cargo demand. With larger ships come larger engines.

Today, the largest container vessel is capable of carrying more than 23,750 TEU (twenty-foot equivalent units), has a deadweight, (weight of cargo, fuel & stores), of 224,999dwt, is 384m long 61.5m wide and has a draft of 26m. The Times newspaper reported that MV Gulsun, delivered in June 2019, owned by the Mediterranean Shipping Company, MSC, has the capacity to carry 8.35 million microwave ovens or 2.94 million washing machines. She is powered by single, direct drive, reversible, 2 stroke diesel engine of 75,000kw, weighing 1,600tonnes, with a fuel consumption of 260tonnes/day at 25kts, full power.[6] To save fuel, the most expensive cost of operating a ship, it is expected the ship will operate most of her time at her most economical speed of 14.5kts. Averaging 280 days per year at sea at 14.5kts, with 85 days in port, MV Gulsun will consume about 35,000tonnes of fuel per year, 100 tonnes/day at sea for propulsion and about 15tonnes per day per year for electrical power. MSC claims that fully loaded the ship has the lowest carbon footprint by design of any container ship, at 7.49 grams of CO_2 emissions to move one ton of cargo one nautical mile.

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[1] ***UN TDC Review of Marine Transport 2019 Cpt 2 p28***

[2] ***Ibid***

[3] **International Chamber of Shipping 2019 Shipping Facts**

[4] **Ibid**

[5] ***UN TDC Review of Marine Transport 2019 Fig 1.1 Page 5***

[6] ***The Motorship Article 10th June 2019 New MSC 23,0000 UCLS***

The environmental impacts of transporting goods by sea are in three major areas:

Sea Pollution

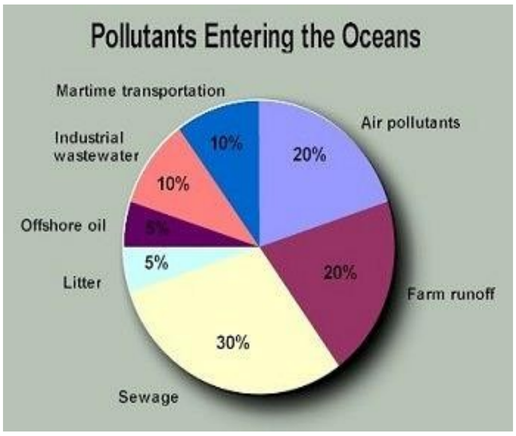
Air Pollution

Land Pollution

These are discussed in detail in the following sections.

Sea Pollution

Contrary to popular belief, the majority of pollution in our seas and oceans does not come from ships but from the land, as shown in Table 1,[7] with most ocean pollutants coming from sewage outfalls and agricultural or industrial runoff. Even marine litter comes mostly from ashore. However, shipping is considered to be directly responsible for about 10% of the pollutants entering the sea and also contributes to air pollution and some marine litter.



Nick Mallos, Director of the Trash Free Seas Program at Ocean Conservancy, a non-profit environmental advocacy group, estimates that between 600,000 to 800,000 metric tons of fishing gear is abandoned or lost during storms each year in the oceans. Another 8 million metric tons of plastic waste, including plastic bottles, bags, toys and other items, flow annually into the ocean from beaches, rivers and creeks, according to experts.[8]

The European Environment Agency estimates that around 20% of marine litter comes from shipping activities.[9] Estimates by the Marine Conservation Society in 2019 estimated that 15% comes from commercial fishing vessels and around 3.3% from international shipping.[10]

Even though shipping is not the major contributor of ocean pollution, there is no room for complacency and a number of steps have been taken to reduce the impact of ships on the marine environment. These preventive measures are discussed below: -

Hull Antifouling Prevention

Fouling of ships hulls has been and continues to be a serious problem for ships sailing the high seas, particularly in tropical waters. Whereas, ships that are confined to freshwater lakes and rivers have almost no fouling problems. The sea is full of marine life and a ships underwater hull is an attractive platform which attracts marine growth of slime, weed, worms and barnacles. The wooden hulls of sailing ships needed to be cleaned every year to prevent tube worms and barnacles boring into the wooden planks, causing leaks and roughness, creating friction and slowing the ship down. Various methods have been used over 1000's of years to try to prevent marine fouling and prolong the need for docking to clean the hull.

The Greeks and Romans used pitch, arsenic and sulphur but also tried out lead sheets nailed on with copper nails. Although these were quite effective, they were very heavy and often fell off. As shipping developed all manner of concoctions were tried, mixtures of tax, wax and seal oil with a copper mix of cement and or powdered iron were often pasted onto the underwater parts. However, none were very

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[7] **Blueplanet education water-pollution**

[8] ***Fishing Nets Lost at Sea news 2019-06***

[9] **EU Report litter-in-our-seas**

[10] **UK Coastal Clean Up Report 2019**

effective. In the 18th century as ships spent more time in hot climates, particularly Britain's Royal Navy, they started experimenting with copper sheets nailed to the underwater hull. While the copper was very effective at preventing marine fouling, and maintaining good speeds, it was very expensive and caused rapid corrosion of the iron bolts holding the hull planks to the frame; due, at the time, to the unknown effect of electrolysis. Eventually, in the late 18th century a practical solution was found using copper zinc bolts to secure the wooden planks to the frames and by placing thick paper between the copper plates and wooden planks. This proved so effective that the entire fleet of the Royal Navy, more than 100 wooden sailing vessels, were copper sheathed, between 1758 and 1780. This extended their lives and saved the exchequer and whole forests of oak trees from being chopped down to build replacement ships. The owners of commercial wooden hulled merchant sailing ships took note and soon followed.[11] Copper sheathed ships could trade for up to 5years between dockings and didn't lose speed which was a remarkable change and for commercial ships often offset the high capital expenditure. One of the most famous copper sheathed ships was the tea clipper, *Cutty Sark,* which is preserved at Greenwich in London. She and other tea clippers raced from China to London in the mid 19th Century averaging daily speeds of 17kts, which for large square-rigged sailing ships was remarkable. This wouldn't have been possible without smooth hulls created by copper sheets.

When larger iron, and eventually steel ships, replaced wooden hulled ships in the late 19th century it proved too expensive and technically difficult to continue sheathing them with copper plates. The answer was to paint the hulls with copper and lead based paints; "Red Lead", became a favorite but unfortunately this didn't last nearly as long as copper sheathing. To maintain hulls in a fouling free condition ships needed to be docked annually for repainting, which was expensive. There was continual antifouling paint development from the late 19th century onwards, to try to extend the dry-docking periods, but even by the 1950's ships could barely last 2 years between dockings before heavy marine fouling took hold. A breakthrough occurred in the 1960's when chemists in Britain developed a reliable new antifouling paint based on self-polishing, fouling release technology, using tributyltin (TBT). This organotin compound was very effective against marine growth such as barnacles, algae, tubeworms and sponges etc. and by the mid 1970's finally enabled ships to operate fouling free for up to 5years, similar the copper sheathed ships 150years earlier. Unfortunately, by the late 1970s it was found that TBT was very harmful to the marine environment and could persist in water and sediments for many years, killing sea life and possibly even entering the food chain. Among other things TBT was shown to cause shell deformations in oysters, sex changes in whelks and genetic problems in other marine species. The International Maritime Organisation (IMO), the body which regulates international shipping, decreed in 2001 that TBT paint could not be applied to any ship after January 2003 and would be completely prohibited from being on any ship by January 2008.[12]

After TBT was banned in early 2000, marine paint companies quickly developed new copper-based TBT-free self-polishing copolymer antifouling paints, which still allowed 5-year docking intervals. However, by 2010 it was recognized that leaching of copper into the sea by thousands of large ships was creating another marine pollution problem, requiring non copper-based paints. The paint companies set about developing these. One of the most promising is a non-self-polishing, silicon based, super smooth paint, similar to Teflon, impregnated with various enzymes, that prevent any marine fouling attaching itself to the paint. However, it is very expensive and only lasts about 3 years before slime build up starts. This has to be removed by underwater hull wiping but this also tends to remove paint as well, as the silicon paints are soft. Harder super smooth paints are now being developed to avoid this problem and to resist tug and berthing damage. However, more changes will be needed as the IMO is now looking into pollution caused by plastic based, self-polishing paints and non-polishing soft silicon super smooth paints. Plastic based paints will probably be banned within the next few years. [13]

A great deal of research is currently underway to find replacements, super smooth, or self-polishing, water based, non-plastic paints that still prevent any buildup of marine pollution while underway no matter the ships speed and also while the ship is stationary at anchor or at a berth.

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[11] **Antifouling Technology, past, present and future**

[12] **Ibid**

[13] **Ibid**

Ballast Water and the Transference of Invasive Species

To keep ships stable and prevent them from capsizing, the majority of the weight in every ship must be as low down as possible. When ships are fully loaded, the weight of the cargo is normally sufficient to maintain stability, but when the cargo is discharged it must be replaced by some other weight. From the Greeks to the Victorians the most common ballast used was stones. It was laborious work to fill up the bottom of the ship with them and also to remove them when the ship arrived in port to load cargo. With the advent of much larger iron and eventually steel ships with mechanically driven pumps it became possible to replace stones with water. Sea or river water was pumped into the bottom tanks as ballast in port, after discharging cargo, and on arrival at the discharge port was pumped out as cargo was loaded, keeping the ship stable at all times.

Ballast water illustration - source IMO

For many years, this was thought to be a very good system: sea water is free and it is entirely natural, so it was considered to be harmless in environmental terms.

Unfortunately, the system turned out to be quite harmful in certain circumstances because sea water contains many living organisms, which, although they may be benign in the areas where they originate, can do serious harm if they are pumped out in different locations with no natural predators. Unwanted organisms may include marine and freshwater fish larvae, small fish, crustaceans, algae, invertebrates and even viruses and bacteria.

When discharged in a new area, these so-called invasive species may breed rapidly and have a very harmful effect on the local environment. Some recorded cases include:[14]

- The North American comb jellyfish. When introduced into the waters of the Black Sea in the late 1980s this jellyfish virtually wiped out local stocks of anchovy and sprat. It has now spread to the Caspian Sea, North Sea and Baltic Sea;
- The red mysid shrimp is native to fresh and brackish waters around the Black Sea and the Caspian, yet it arrived in the Great Lakes in 2006 and rapidly invaded all the lakes and the St. Lawrence Seaway. The shrimp has a voracious appetite for zooplankton and algae, so experts fear it will oust many local species as it spreads through the region;
- The Chinese mitten crab has spread to estuaries and rivers bordering the North Sea, Baltic Sea and both coasts of North America altering habitats and causing erosion due to its extensive burrowing, as well as clogging industrial water systems. The economic impact on Germany alone is thought to be €80 million since the crabs arrived in 2007;
- A serious outbreak of cholera in Peru in 1991 was believed to have been partly caused by a waterborne strain from Asia, introduced by ships when they pumped their ballast water into Peruvian harbours before deep sea ballast water exchange became the norm. This strain is believed to have mixed with a land-based strain introduced from Africa by laborers. More than 10,000 people died in the outbreak.[15]

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[14] **Silent Invasion - Spread of invasive Species by Ballast Water**

[15] **Evolution of Cholera Pandemic 1991 Lantin America**

To counter these harmful effects, responsible shipowners in the mid 1990's started to exchange their ballast water in mid ocean, before arriving in the next port, so water from one coastal area was not carried to another. Unfortunately, this method is not 100% effective and many organisms still survived the ballast transfer, as it is very difficult to pump out all ballast water. Also, often there is some mud buildup in the ballast tanks which provides a good breeding ground.

In 2004, to prevent the migration of invasive species, the IMO drafted a *Convention on the Control and Management of Ships' Ballast Water* which required ocean-going ships to fit approved types of ballast water treatment apparatus. The idea was these devices would clean the incoming ballast water removing all species. Shipping nations were initially reluctant to approve the convention as there was no proven effective ballast water treatment technology at the time. However, after 4 years of discussion the *Ballast Water Convention* was finally approved in October 2008. The convention approved the use of chemical, electrical or thermal treatment to destroy invasive organisms. Although, similar equipment was used on land in sewage and water treatment plants, the technology was not readily adaptable for marine purposes. Because of this it took another 11 years before the new convention was finally approved on 8th September 2017. The new convention required all ships to adopt the following ballast water treatment systems.

D-1 standard, requiring ships to fully exchange their ballast water in open seas, away from coastal waters. Ideally, this meant at least 200 nautical miles from land and in water at least 200 meters deep. Deep ocean water has fewer marine organisms than shallow coastal waters, by following this procedure ships will be less likely to introduce potentially harmful species when they release the ballast water in port. Because of the known issues of water retention and mud, the preferred method of ballast water exchange in deep water is to flush water through the tanks, overflowing them on deck, but this requires strengthened air pipes due to the high pressures involved with the overflow process.

D-2 standard, was the specified output standard for Ballast Water Treatment System, BWTS, and specified the maximum number of viable organisms allowed to be discharged, including a specified indicator of microbes harmful to human health. New ships built after 8th September 2017 needed to meet the *D-2 standard*, while existing ships needed to meet the *D-1 standard* until the renewal of the ships International Oil Pollution Prevention Certificate, (IOPPC), which occurs every five years. On renewal, existing ships would be required to install a BWTS, to meet the D2 standard. This meant that all ships would be fitted with a BWTS by 8th September 2022.

Unfortunately, the United States, USA, caused a major disruption to the plans of the IMO by declaring in 2015 that ships that called at ports in the USA, after 1st January 2016, needed to have their BWTS approved by the US Coast Guard, USCG. The standards the USCG applied were much higher than the *IMO D2 standard*. Because the USA is a very important port of call for many ships, this resulted in the IMO declaring a 2-year delay in the introduction of the *D2 standard* so they could adopt similar standards to the USA. The requirement for ships to meet new the *D2 standard* was pushed back to 8th September 2019 for new builds and 8th September 2024 for existing ships.

Shipowners who went ahead and installed a BWTS before they were required have been given grandfather rights by the IMO to keep the system Unfortunately the USA has not accepted this idea. After a certain date, depending upon when installed, they insist ships upgrade to a USA approved BWTS, or to the new *IMO D2 standard*.

In practice, it has proved quite difficult at times for the BWTS to work as designed, due to aquatic overloading, heavy sediments or brackish water, so although the migration of species around the world in ballast water has been largely eliminated it is unlikely to ever reach perfection.

Bio Fouling Prevention

Once the Ballast Water convention was approved in 2008, IMO started work on producing guidelines for the prevention of species migration on ships hulls and underwater appendages. The new guidelines were eventually produced in 2011. At present only New Zealand and California are applying IMO Bio Fouling Guidelines, but other countries are expected to follow over the next few years.

It is well known that the largest expenditure of operating any ship is the cost of fuel. Also, as there is a cubed root relationship between speed and power, any fouling on a ship's hull increases resistance, resulting in either a very major reduction of speed or greatly increased fuel consumption. Because of this, shipowners try to keep ships hulls free of fouling by applying good quality antifouling paints that prevent fouling for a given time, based on the ships speed and number of days at sea.

Modern antifouling paints generally work well, provided the ship keeps moving and abides by the paint plan for the designed speeds and days at sea. However, when a ship deviates from the designed paint plan, going faster or slower, spending longer at anchor or trading to different parts of the world than planned, the antifouling effect is compromised and is not so effective. This is especially so when ships spend weeks at anchor in warm tropical seas waiting to load or discharge cargo.

In such conditions, with no water flowing across the hull, polishing the antifouling paint and releasing the biocides, marine fouling can quickly build up on the hull and in many niche crevices. Typical hull marine fouling starts as slime, followed by weed, worms, mussels and lastly barnacles.

In niche areas where waterflow is minimal, even while underway, unused sea chests, thruster tunnels, under bilge keels and on tops of rudders, more aggressive marine organisms can grow and nurture wider marine eco systems. Regardless of where the fouling is, if it is not removed, transfer of marine life from one part of the world can still occur.

Common Invasive Species migrating via ships hulls and niche areas			
Name	Native to	Introduced to	Impact
Asian paddle crab *Charybdis japonica*	Ranges from the North-west Pacific (China, Japan, Korea) to the east Asian Seas (Thailand, Malaysia)	New Zealand; detected but not established in Australia	May carry the White Spot Syndrome virus which can affect crustacean mariculture. Can affect biodiversity through either predation or by indirectly altering trophic levels.
Colonial tunicate *Didemnum vexillum*	North-west Pacific	North-east and north-west Atlantic, north-east Pacific, New Zealand	This species is an aggressive invader and is able to reproduce sexually or asexually. Fragments of the species are able to disperse, reproduce, reattach and thrive. This species fouls hydrotechnical constructions, ships, aquaculture infrastructure and cultured molluscs. It affects the biodiversity of existing communities as it outcompetes for habitat or simply grows over or smothers existing species.
North Pacific seastar *Asterias amurensis*	North-west Pacific	North-east Pacific, Southern Australia	This species is a voracious carnivorous feeder. They are prolific breeders and are able to quickly establish large populations in new areas. The species is a serious pest to native species, such as the endangered spotted handfish (*Brachionichthys hirsutus*), as the seastar preys on the fish's egg masses.
Asian green mussel *Perna viridis*	Persian Gulf through to the Philippines East Asian eastern China	The Caribbean, South Atlantic, South Pacific; detected in far North Queensland, Australia but not established	Tolerates wide fluctuations of salinity and temperature and reaches high densities. This species fouls hydrotechnical constructions, ships and aquaculture infrastructure. It affects the biodiversity of existing communities and can alter trophic levels.

Common Invasive Species migrating via ships hulls and niche areas – Continued			
Name	**Native to**	**Introduced to**	**Impact**
Black striped mussel *Mytilopsis sallei*	North-west Atlantic, the Caribbean and South Atlantic	India, East Asian Seas (Malaysia, Singapore), South Pacific, North-west Pacific (Japan, Taiwan, Hong Kong); was detected in Darwin, Australia but eradicated.	Tolerates wide fluctuations of salinity and temperature. Highly fecund, grows and reaches maturity rapidly. This species is capable of forming dense aggregations, impacting biodiversity as they exclude most other species. The fouling of hydrotechnical constructions, ships and aquaculture infrastructure with this species causes corrosion, technical problems and loss of efficiency.
European fan worm *Sabella spallanzanii*	North-east Atlantic, Mediterranean	South-west Atlantic, Southern Australia, New Zealand, North-west Pacific	This species is highly fecund and is able to form mat-like, dense populations on the seafloor. The species can tolerate wide ranges in salinity and successfully fouls artificial structures such as hydrotechnical constructions, vessels and aquaculture infrastructure. The species competes with native filter-feeding organisms for habitat and food. It is possible that dense formations alter water flow, sediment stability and bacterial communities due to their efficiency filtering particulate matter from the water column.
Bay barnacle *Amphibalanus improvisus*	Thought to be the east coast of North-east and North-west Atlantic	South-west Atlantic, Caribbean Sea, Atlantic, Baltic Sea, Black Sea, Caspian Sea, North-west Pacific, East Asia Seas; detected but not established in Australia and New Zealand	This species is fast growing and gregarious. It has high reproductive potential; being able to re-produce sexually and asexually. Tolerates wide fluctuations of salinity and temperature. The fouling of hydrotechnical constructions, ships and aquaculture infrastructure with this species causes corrosion, technical problems and loss of efficiency.
Wakame seaweed *Undaria pinnatifida*	North-west Pacific	Mediterranean, North-east Atlantic, South-west Atlantic, North-east Pacific, South-east Australia, New Zealand	This species is able to rapidly colonise temperate regions; it can colonise any hard surface and is therefore able to foul hydrotechnical constructions, ships and aquaculture infrastructure. Able to affect biodiversity, change community structures and alter trophic levels.
European shore crab *Carcinus maenas*	North-east Atlantic, The Baltic Sea	West Africa (Mauritania to South Africa), Mediterranean, North-west Atlantic (Delaware to Nova Scotia), South-west Atlantic (Panama to Argentina), East Africa (Red Sea to South Africa; including Madagascar), North-west Pacific (Japan), North-east Pacific (South-east Alaska to California), East Asian Seas (Burma), Central Indian Ocean (Sri Lanka), South Pacific, South-eastern Australia	The adult specimens of this species are able to withstand wide ranging temperature and salinity fluctuations. It is able to reside in damp air exposed environments for up to 10 days and tolerate up to 3 months of starvation. However, when able to feed, this species is a voracious predator, preying on molluscs and other crustaceans, including commercially important species. Apart from impacting on native species through predation, this species disrupts existing community structures through competition (habitat and food) and behavioural activities (burrowing).

Removing marine fouling requires powerful hull scrubbers. These are generally driven by hydraulics and guided around the hull by divers. In the last few years ports have woken up to the bio damage to the local environment that can occur if fouling collection systems are not used. New systems that can capture the marine fouling, preventing it being released into the sea, are now required for ships being cleaned in most ports or near coastal waters. Also, the use of divers makes cleaning very expensive and cleaning can only be carried out in daylight hours. Robotic cleaning systems, which can operate without diver’s, day and night, and also capture the marine debris are currently being developed. The demand for robotic hull and propeller cleaning is expected to grow strongly in the coming years.

IMO is being urged to make the guidelines mandatory. It is anticipated that a Bio Fouling Convention maybe agreed by 2022 but it is unlikely to become mandatory worldwide before 2027.

MARPOL – Marine Pollution

Oil pollution from ships has decreased dramatically since the 1970's, a factor generally associated with a series of major tanker accidents and high-profile pollution incidents leading the IMO to introduce the first convention on the prevention of pollution from ships in 1973. Another convention was introduced in 1978 on Tanker Safety and Pollution Prevention which absorbed the 1973 convention and was then absorbed into a new convention called MARPOL73/78, which came into effect in 1983[16].

In addition, the safety failings uncovered by the Sheen enquiry into the *Herald of Free Enterprise* tragedy in the English Channel on 6th March 1987, causing 193 deaths, led to the introduction of the International Safety Management Code (ISM Code) in 1994[17]. The ISM Code has been incorporated into the International Convention for the Safety of Life at Sea 1974 (SOLAS). It provides an international standard for the safe management and operation of ships and for pollution prevention. To comply with the Code, ocean-going ships must have a working Safety Management System, (SMS), and must be able to demonstrate its effectiveness.

Along with these robust regulations, there have been advances in technology. For example, marine salvage companies have to devised safe methods of removing oil from ships which sink, even in deep water. Despite these improvements, accidents still happen, and quantities of oil are still spilled at sea every year. That said, the situation has improved dramatically in recent decades. Unfortunately, many of the regulations do not apply to local craft, small fishing vessels or leisure craft, so there are still many vessels which pose a risk to the environment.

In 1993 a UN body, the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) estimated that 2.3 million tonnes of oil was being spilled into the world's oceans every year. However, 50% of that came from land-based sources, 13% from atmospheric fallout, 11% from natural seepage with 24% from shipping.[18]

Ten years later, a detailed study revealed that the majority of oil in US and international waters came from natural seepage and runoff from land-based sources.[19] Even oil contamination and spills from leisure craft are considered to be more abundant than spills from ocean-going vessels. Spillage from ocean-going vessels in US waters declined significantly in the 1990s, to a point where they represented less than 2% of petroleum discharges. At the same time, oil production increased from 7 million tonnes per day in 1970 to 12.8 million tonnes per day in 2019[20], with significantly higher volumes of oil being transported by sea. The success has been due to the robust application of MARPOL and the ISM Code.

MARPOL has been expanded to 6 annexes which cover pollution of the sea in many forms.

MARPOL Annex I

MARPOL Annex I is considered to be the most important of the international marine environmental legislation acts and now contains 39 regulations, 7 chapters and 5 appendixes and continues to be updated on a regular basis.

It was developed to minimize all forms of oil pollution of the oceans and controls the dumping of oil and oily sludge. The ship is also required keep detailed records of every action taken dealing with all marine

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16 The History of Marpol

17 History of the SOLAS_Convention

18 Oil Tanker Spill Statistics 2019

19 Petroleum Seep

20 World Oil Production

pollution. These records are inspected by PSC on every ship visit and large fines imposed for any violations.

The first half of Annex I deals with oil pollution in the machinery spaces and how to separate it from bilge water. New equipment and technology which was developed to prevent the discharge of any oil into the sea with bilge water such as:

• Oily Water Separators (OWS).

The function of oily water separator is to separate oil particles from the water to be discharged overboard from engine room or cargo hold bilges, oil tanks and oil contaminated spaces. As per the regulation, the oil content in the water processed from the OWS must be less than 15 parts per million of oil.

• Oil Content Meters (OCM).

The OCM continuously monitors how much oil is in the water that is pumped out of the OWS. The OCM will not allow the oil concentration of the exiting water to be above the MARPOL standard of 15 ppm.

Also, the regulations covered disposal of oily waste and other contaminants ashore:-

• Port reception facilities.

International shipping ports are required to provide environmental collection services for ships to disposal ashore oily mixtures, and garbage generated that cannot be dealt with onboard or discharged directly to the ocean. According to MARPOL 73/78 they must be collected by the Port reception facilities all around the world. The Port reception facility must be able to receive dirty oil and other contaminants, and also provide quick and efficient services.

The second half of Annex I has more to do with cleaning of tanks and cargo areas. Technology that has greatly helped improve efficiency and environmental protection in these areas is :-

• Oil Discharge Monitoring Equipment (ODME).

Oil Discharge Monitoring Equipment (ODME) is based on a measurement of oil content in the ballast and slop water, to measure conformance with regulations. The apparatus is equipped with a GPS, data recording functionality, an oil content meter and a flow meter. By use of data interpretation, a computing unit will be able to allow the discharge to continue or it will stop it using a control valve on deck with recirculation back to the tank.

There have been regular major updates to MARPOL : -

1984 Amendments – Covered strengthening of oil tankers to prevent them being easily damaged.

1991 Amendments – Required all ships to carry oil spill prevention plans (SOPEP) and equipment.

1992 Amendments – Required all new tankers delivered after 1996, over 5000dwt, to be double hull.

1994 Amendments – Extended SOLAS Port Sate Control, PSC, inspections to MARPOL requirements.

1997 Amendments – New intact stability requirements required for all newly built oil tankers.

2017 Amendments – Redesign of oil sludge piping to prevent cross contamination with bilge system.

Noxious Liquid Substances in Bulk – MARPOL Annex II

MARPOL Annex II covers pollution of the sea by noxious liquid substances and entered force in April 1987. The annex covers the many chemicals that are transported by sea in chemical tankers as cargo. These have been categorized into the IBC/BCH codes covering 100's of chemicals that can only be discharged to shore reception facilities. Chemical carriers are required to have tank cleaning systems that retain chemical residues onboard for discharge to shore reception facilities. After tank cleaning only very minute quantities of any remaining residues containing chemical pollutants are permitted to be discharged 12 miles from the nearest land with stricter limits in 'special sea areas.

Prevention of Pollution by Harmful substances in Package Form - MARPOL Annex III

MARPOL Annex III entered force in July 1992 and covers pollution of the sea by ships carrying harmful goods in package form, identified by the International Dangerous Goods Code, IMDG. Shippers are required to declare the contents of all goods shipped by sea and the IMDG Code provides a guide for shippers on how declare their goods and also how to pack them for a sea voyage. Shipowners receiving such information know where to safely stow the IMDG cargo so that no harm will occur to the ship or cargo. Incorrectly declared IMDG cargo does occur and can be very dangerous for the ship, crew and sea and has been the cause of many container ship fires. IMDG cargo is usually charged at a higher freight rate than non IMDG cargo.

Sewage – (Black Water) - MARPOL Annex IV

MARPOL Annex IV covers the discharge of sewage, which is now prohibited within 12 miles of the nearest land, except under the following conditions:

- The sewage is comminuted and disinfected using an approved system and discharged not less than four miles from the nearest land. It must be discharged gradually while the ship is sailing at a speed greater than four knots; and
- The ship has an approved sewage treatment plant which does not produce visible floating solids or discolouration of the surrounding water.

Sewage pollution is still a major problem as left untreated it can cause serious health problems, but the vast majority enters our oceans from the land. For example, 80% of urban sewage discharged into the Mediterranean Sea is untreated. [21]

Once again, the regulations apply only to ocean-going vessels. Small vessels under 400grt eg, ferries, tugs and yachts may still be contributing to sewage pollution in harbours and near beaches. However, the leisure market is growing rapidly, and many countries now require new ferries and yachts to have holding tanks so sewage can be collected and pumped ashore for environmental disposal. However, the vast majority of yachts, launches and small ferries worldwide may still be pumping untreated sewage straight into the sea in port and close to land.

Passenger ships create the most sewage output. The largest passenger ships now have 6000 passengers and 3000 crew. However, these ships have very sophisticated vacuum sewage plants which use very little water. The sewage residue after treatment is contained in large holding tanks while the ship is in port and only discharged to sea as per the regulations above but even when discharged over 4 miles from land in inland seas, Baltic Sea, Black Sea, Red Sea, Canadian, Norwegian and Alaskan inside passages due to the very large volumes this can still create environmental hazards. A study into the sewage discharge from large cruise ships is currently underway by NGO's

[21] WWF Ocean Pollution

Greywater Discharge - currently not covered by MARPOL

Greywater is water discharge from other all other sources, showers, washing basins, laundries, galley etc. This water is currently discharged overboard with no treatment on most cargo vessels. However, ports and countries with inland protected waters, the Baltic sea, Black sea, Red Sea and Canadian, Alaskan and Norwegian inside passages, now require passenger ships to contain Greywater onboard in large holding tanks for disposal at sea over 12 miles from land and outside the inland sea areas. But for other ships the discharge of greywater is unregulated. This is most likely to change as the amount of shipping is increasing and ports and coastal areas cannot withstand the high levels of grey water discharged. A study into the issues involved is currently underway at the IMO. New regulations to control Greywater are expected in the near future.

Garbage MARPOL Annex V

How ships treat their garbage is governed by Annex V of the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL). A revised Annex V entered force in January 2013 which totally prohibits the disposal of plastics anywhere in the sea and severely restricts discharges of other garbage from ships into coastal waters and Special Areas, unless explicitly permitted by the Annex. A summary of the requirements is shown in the Table 1. The “Special Areas” zones are shown in Table 2.

Table 1

Type of garbage	Ships outside special areas	Ships within special areas	Offshore platforms (more than 12 nm from land) and all ships within 500 m of such platforms
Food waste comminuted or ground	**Discharge permitted** ≥3 nm from the nearest land, en route and as far as practicable	**Discharge permitted** ≥12 nm from the nearest land, en route and as far as practicable	**Discharge permitted**
Food waste not comminuted or ground	**Discharge permitted** ≥12 nm from the nearest land, en route and as far as practicable	**Discharge prohibited**	**Discharge prohibited**
Cargo residues[1] not contained in wash water	**Discharge permitted** ≥12 nm from the nearest land, en route and as far as practicable	**Discharge prohibited**	**Discharge prohibited**
Cargo residues[1] contained in wash water		**Discharge permitted** ≥12 nm from the nearest land, en route, as far as practicable and subject to two additional conditions[2]	**Discharge prohibited**
Cleaning agents and additives[1] contained in cargo hold wash water	**Discharge permitted**	**Discharge permitted** ≥12 nm from the nearest land, en route, as far as practicable and subject to two additional conditions[2]	**Discharge prohibited**
Cleaning agents and additives[1] in deck and external surfaces wash water		**Discharge permitted**	**Discharge prohibited**
Carcasses of animals carried on board as cargo and which died during the voyage	**Discharge permitted** as far from the nearest land as possible and en route	**Discharge prohibited**	**Discharge prohibited**
All other garbage including plastics, synthetic ropes, fishing gear, plastic garbage bags, incinerator ashes, clinkers, cooking oil, floating dunnage, lining and packing materials, paper, rags, glass, metal, bottles, crockery and similar refuse	**Discharge prohibited**	**Discharge prohibited**	**Discharge prohibited**
Mixed garbage	When garbage is mixed with or contaminated by other substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply		

1)These substances must not be harmful to the marine environment.

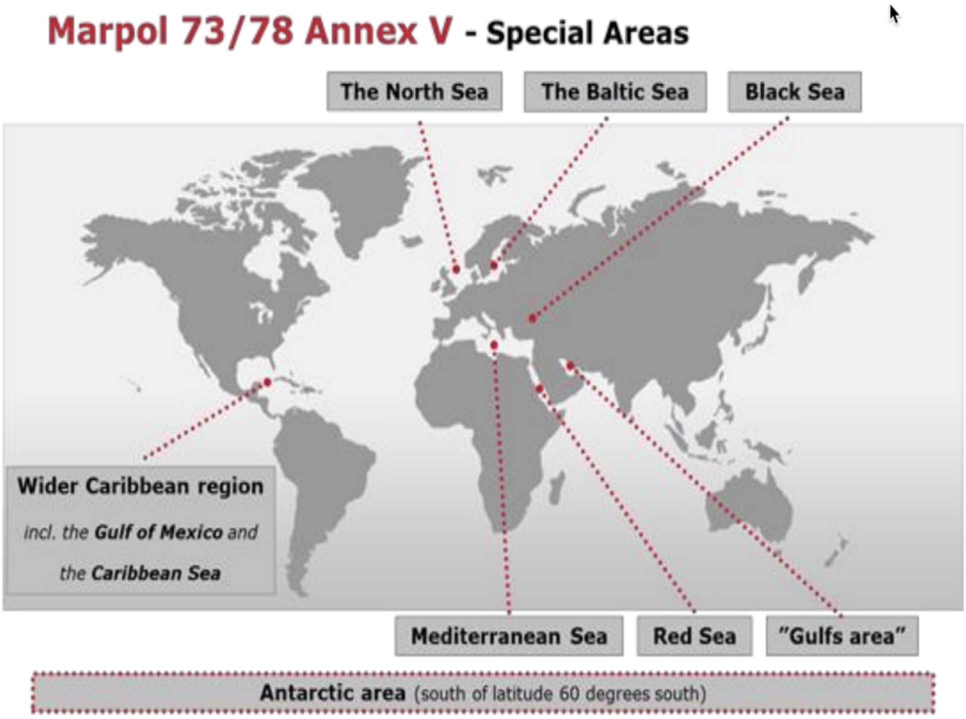
2) Discharge shall only be allowed if:

(a) **both the port of departure and the next port of destination are within the special area and the ship will not transit outside the special area between these ports (regulation 6.1.2.2);**

and

(b) **if no adequate reception facilities are available at those ports (regulation 6.1.2.3)**

Table 2



The new Annex V is comprehensive and prohibits the discharge of most floating waste such as plastics and rope, and any chemicals which are harmful to the marine environment. Ships are required to keep garbage on board, for discharge to proper reception facilities at the next port. In addition, every ocean-going ship must have a Garbage Management Plan and every kilogram of garbage must be fully accounted for.

Unfortunately, there are two major problems with Annex V. The first is that IMO regulates shipping, but it cannot regulate ports. Consequently, many ports do not have proper reception facilities and some refuse to accept certain types garbage from ships or any at all. If a ship cannot dispose of its garbage there is a real danger that the accumulated waste will pose a health hazard to the crew. The second problem is that IMO regulations do not apply to vessels under 400grt which includes most fishing boats, local ferries, coasters, tugs, and pleasure boats, yachts etc.

Nonetheless, most ships do their best to comply with the regulations, although they are often frustrated by the lack of proper reception facilities in some ports. Overall, the figures quoted earlier of 18% for oceanic litter pollution seem reasonable. The latest statistics are that ocean-going ships over 400grt are responsible for no more than 2% of marine litter with 16% coming from fishing vessels, lost fishing nets and long lines. Certainly, the results of studies by the UK Marine Conservation Society, 2019 Beach Clean Report[22] would seem to support this conclusion.

The IMO now have a major task force investigating and reporting back to MEPC on the extent of plastic litter pollution from ships. They have identified two areas that need urgent action, loss of fishing gear and use and disposal of single use plastics.

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[22] UK Beach Clean Report 2019

Air Pollution – MARPOL Annex VI

It is well recognized that shipping goods by sea is the most carbon efficient mode of transport. Moving 1ton of cargo in a container 1km produces only 10 grams of CO_2 compared to rail which produces 21 grams, by truck, 59 grams and by air 470 grams. Because shipping by sea is so efficient and low cost, 90% of goods moved around the world are shipped by sea. Shipping goods by rail used twice the GHG per ton mile and by truck six times and by air 47 times.

The amount of goods moved by sea has tracked global GDP for many years and continues to do so. To cope with the increasing amount of cargo more ships have been built, but in line with the free market and economies of scale they have also increased in size. Ships have become larger and larger over time which in turn has resulted in increased air pollution from, sulphur dioxide, SOx, nitrous oxide, NOx, and particulates, PM's, all of which are harmful to health. In 2019 shipping accounted for 13% of world SOx emissions and 15% of NOx.[23]

Also, because of world trade patterns, 70% of all ship emissions take place within 400 kilometers of land with 85% of all emissions released in the northern hemisphere. People living close to major shipping routes or ports are particularly vulnerable to the harmful health effects of SOx and NOx and PM's.

The seeds of air pollution were planted when shipping changed from sail to steam power in the late 19th century. Steam ships were initially powered by coal fired boilers driving triple expansion steam engines and later stream turbines; however, the ships were small and overall air pollution was negligible compared to industry on land. When diesel engines became large enough to propel an ocean-going ship, they quickly replaced the coal fired steamships, as oil requires only 40% of the space for the same amount of energy as coal and weighs less. For the same size ship a diesel powered one compared to a coal power had much more cargo space and available weight. Also, oil could be quickly pumped onboard, so ships could spend longer at sea and less time in port. This made diesel powered ships much more profitable than coal fired ones. The first diesel-powered commercial vessel was *Selandia*,[24] launched in 1911 by Burmeiser & Wain for the East Asiatic Company. She served the route from Copenhagen to Bangkok for many years and was so effective and profitable that other owners were soon scrambling to build diesel-powered ships of their own.

At first diesel engines only burnt clean diesel fuel but even in the early days it was recognized that diesel engines could be adapted to burn almost anything, including the heavy oil sludge which remained at the end of the oil refining process.

It was not until the 1950s that ships diesel engines were built to use heavy residual high sulphur fuel oils that also contained significant amounts of ash, vanadium, cat fines and water. These fuels came from the bottom of the refining process and were a waste product that was sold very cheaply compared to the residual diesel oils previously used. To burn the heavy fuels, they first needed to be heated up and purified to remove the ash, vanadium, cat fines and water but the purifiers could not remove the SOx, NOx or reduce the particulates.[25]

The second half of the 20th century saw a massive increase in world trade as it tracked world GDP, coupled with a corresponding increase in the size of the world fleet and ship sizes. There was also a growing sense of alarm over the worsening state of the environment from industry ashore and from shipping. Many countries started introducing legislation in the 1970's to steadily curb air pollution from

[23] **Shipping Emissions how it is tackling its problem head on**

[24] **MS Selandia - Wekipedia**

[25] **Wikipedia- Diesel Exhaust Particulars**

SOx, NOx and PM's as they had noticed the serious health effects.

With land generated air pollution falling significantly by the late 1990's the effects of ships air pollution became noticeable.

Because of the large increase in the number and sizes of ships from the early 1970's to the late 1990's the air pollution from ships became a very major issue, particularly when the ships were in port or sailing close to land. People became increasingly concerned about atmospheric pollution and about the effects of vessel emissions on human health. The IMO responded with legislation, but implementation was slow.

The IMO established its first policy on Air Pollution from Ships in a new Annex VI in the 1997 Marine Environmental Protection Committee, MEPC, conference but this did not become effective until 2005. The lengthy delay was because of IMO's unique ratification system of requiring a certain percentage of ships and number of countries before new conventions are implemented which is to ensure a level playing field.

Annex VI became effective in 2005 after 15 countries and 50% of the worlds gross tonnage had ratified the new convention. Annex VI set new ships emissions limits for all IMO contracting countries ships for SOx, NOx, PM's and Volatile organic compounds VOC's. It also established requirements for discharges from exhaust gas cleaning systems, incinerators, fuel oil quality, for offshore platforms and drilling rigs and for the establishment of Sulphur Emission control Areas, SECA's [26]

Sulphur Dioxide – (SOx) MARPOL Regulation 14 Annex VI

In 2008 IMO agreed finally to regulate the global sulphur percentage in ships fuel oil from 1st January 2012 from 4.5% to 3.5% but left open the timing to switch to 0.5% sulphur fuel to the outcome of a fuel availability study, to either 1st Jan 2020 or 1st Jan 2025. The 2nd IMO initiated fuel study, completed in 2016, forecast sufficient 0.5% fuel being available in 2020. With this confirmed, IMO agreed to adopt the 1st January 2020 as the implementation date. This was ratified at MEPC70 in Oct 2016, resulting in the biggest fuel change ever recorded on a single day. On the 1st January 2020 an estimated 58,000 ships switched from 3.5% to 0.5% sulphur fuel but around 7,000 ships were able to carry on burning the cheaper 3.5% sulphur fuel as they were fitted with exhaust gas scrubbers which removed the excess sulphur. [27] As a comparison it took 10years for unleaded petrol for cars to be implemented worldwide, which proved that international shipping could respond quickly when properly prepared.

The economics of scrubbers has changed considerably in less than 6mths. In January 2020 the differential fuel price between the cheaper 3.5% fuel and 0.5% sulphur fuel was around USD300/ton enabling large ships to payback the cost of the scrubber in 8-12mths and then turn in a good profit. But, by April 2020 the differential price had reduced to only USD35/ton. The other difficulty for the scrubber fitted ships was that only a few major bunker ports stocked the high sulphur fuel. Due to the uneconomic outlook for scrubbers it is unlikely that many more will be installed. The switch to low sulphur fuel has significantly improved the air quality in many populated coastal and port areas. It is estimated that between 250,000 and 450,000 early deaths, and many more hospitalization cases of asthma and bronchitis will be prevented each year .[28]

Well before the action being taken by the IMO in 2008 to reduce the damaging effects of sulphur dioxide on humans the city of Los Angles had initiated a study themselves. They had noticed higher death and hospitalization rates of people living around the twin ports of Los Angeles and Long Beach. Their study brought to global attention the health risks between high rates of SOx produced by ships emissions in port, burning 3.5% sulphur fuel, 35,000ppm, and people living close by. This was similar to the detrimental effects on people who lived near busy roads which resulted in the fuel for petrol and diesel vehicles being lowered to around 10ppm of sulphur in the late 1990's.

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[26] SOx Emission Control Areas (SECAs).

[27] IMO Sulphur Limits - Environment Regulation-14

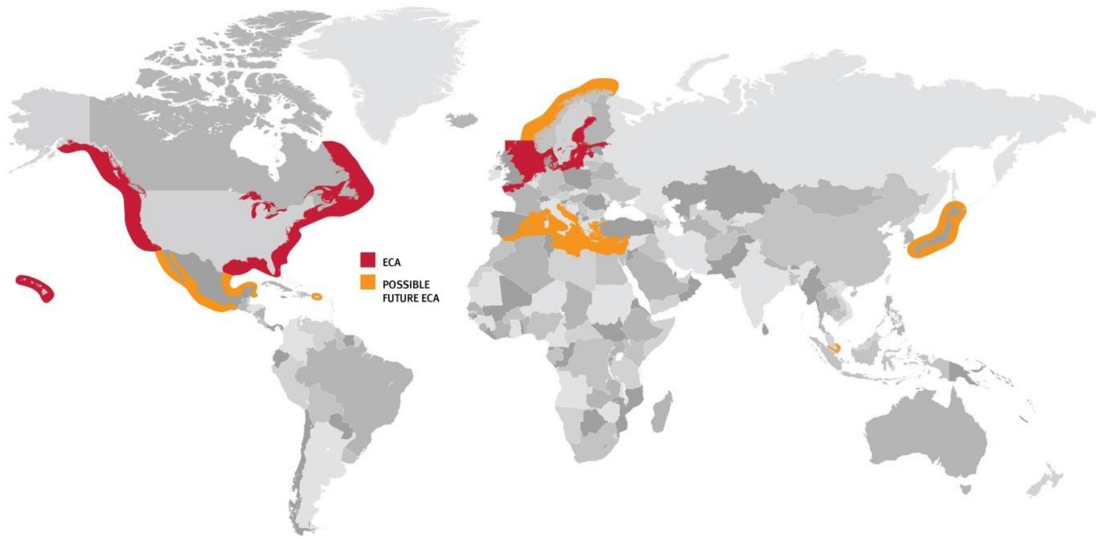
[28] **EU Report on Clean Air In Ports**

Civic Exchange in Hong Kong picked up on the Los Angles study in 2005 as they thought the effect might be similar in Hong Kong, due to the very high throughput of container ships at Kwai Chung. They initiated a major study, initially engaging with government and universities. It was soon clear that people in Hong Kong, living close to the container port, were suffering from similar health problems. After producing a report of the problem in 2007, engagement with the shipping community started. This eventually led to the launch in October 2010 of a voluntary scheme, *The Fairwinds Charter*,[29] supported by 18 leading container shipping companies who all agree to operate their ships at berth on 0.5% sulphur fuel, 5,000 ppm, thereby considerably lowering the sulphur dioxide air emissions around the port. It is estimated that this has saved around 100 deaths per year and many 1000's of hospital stays. In July 2015 the HK Government enacted legislation to make it mandatory to use 0.5.% sulphur fuel, 5,000ppm, at berth for all vessels. China soon picked up on the impressive results in Hong Kong and the various studies by Civic Exchange, Universities and Government and enacted its own DECA Scheme in December 2015.

At time that *The Fairwinds Charter* was introduced in 2010 the IMO also initiated stringent SECA's requirements. From 1st July 2010 all ships sailing in SECA areas were required to change over from 3.5% sulphur fuel to 1.0%. Then from 1st January 2016 it was dropped to 0.1% sulphur, 1,000 ppm, *see table below*. It was at this time that the IMO also approved the use of exhaust gas scrubber units to clean the exhaust gas, provided the air emission were the same or better than ships using the low sulphur fuel, and the waste discharge into the sea met stringent regulations. Many ships operating inside the SECA areas adopted this idea so they could continue to use the cheaper 3.5% sulphur fuel.

In 2011 there were four existing SECAs; the Baltic Sea, the North Sea, most of the US and Canadian coast and the US Caribbean as shown in the Red areas below. As of mid 2020 the future ECA areas shown in Yellow have not yet been introduced. In December 2015 China declared key areas in the Gulf of Bohai, and the Yangtze and Peal River Deltas environmental controlled area, DECA's[30] where ships must use 0.5% sulphur from 1st January 2017 when berthed at major ports, and from 1st January 2019 when entering the DECA area. In 2018 China extended the DECA areas to cover its entire coastline up to 12nm offshore. Although, China did not strictly meet the IMO ECA regulations this did not stop them improving the environment for their citizens.

SECA Areas



SECA Zones and Limits

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[29] [Hong Kong - Fair Winds Charter Report 2018](#)

[30] [China DCA Reulations 2019](#)

Sulphur Limits in SECA Zones	mass/mass
SECA Sulphur limit before 1 July 2010	1.50% m/m
between 1 July 2010 and 1 January 2015	1.00% m/m
after 1 January 2015	0.10% m/m

Nitrogen Dioxide – (NOx) Regulation 13 Annex VI [31]

At the same time that the SOx regulations were ratified in 2005, new NOx emission control requirements were also implemented worldwide, for all marine diesel engine over 130 kW output power. Three stages were introduced, occurring on different dates, based on the ship's date of construction. There requirements are quite technical and are based on engines speeds, RPM. Most deep-sea ships have slow speed 2 stoke diesel engines and based on engines up to 130rpm the following regulations apply: -

Tier 1 - at 17g NOx/kWh, applies to ships engines of ships with keels laid from 1st January 2000

Tier 2 - at 14.4g NOx/kWh, applies to ships engines of ships with keels laid from 1st January 2008

Tier 3 - at 3.4g NOx/kWh, applies to ships engines of ships with keels laid from 1st January 2016

Tiers 1 and 2 apply worldwide and are met by making technical adjustments to the engines, which also result in a small increase in fuel consumption of 1.5 to 3%. The adjustments are irreversible and are documented in the engine technical code.

Tier 3 applied from 1st January 2016 to all ships operating in the ECA Zone of the USA but from 1st January 2021 it also applies to all ships operating in the ECA zones of the Baltic and North Sea. Tier 3 can only be achieved by installing a special device to remove the NOx from the exhaust gas. There are generally 2 types applied on ships today.

A) Selective Catalytic Converter, SCR.[32]

The SCR is located in the hot exhaust gas stream and is made up of titanium dioxide blocks with holes to allow the exhaust gas to pass. Urea is injected into the exhaust gas before the SCR. The Urea is converted to ammonia in the SCR and reacts with the NOx to form nitrogen and water thereby lowering

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[31] IMO Environment Pollution Prevention NOx Air Pollution - Reg-13

[32] MAN SCR Technology Paper

the NOx by 90%. Similar devices are used on land to reduce NOx in diesel engines used in buses, trucks and cars.

B) Exhaust Gas Recirculation, EGR.[33]

The EGR is mounted on the engine and reduces the NOx by recirculation. Part of the exhaust gas is recirculated and mixes with the incoming air which reduces the nitrogen level of the air injected into the engine for combustion. Because the exhaust gas is hot and corrosive, as it still contains sulphur and also contains and lot of abrasive particles the EGR needs scrubbing filters and coolers and non-corrosive material to clean up the exhaust gas before it is mixed with the incoming scavenge air. The EGR can also act as a basic SOx scrubber as well. The EGR is a complex piece of engineering which only works on large slow speed diesel engines.

Particulate Reduction, PM's [34]

It is a well know that diesel engines produce a lot of particulates. The sizes are classified as PM10,10um or PM2.5, 2.5um. These are Nano size but the smaller they are the worse the damage. The small ones PM2.5 penetrate deep into lungs and are very detrimental to human health. However, to date nothing has been achieved on controlling the PM's in the atmosphere. The only way to reduce them is to ensure the engines are running very efficiently as filtering them out is impossible as they are so small. It has been found in some port areas of the world that the PM's from ships produce up to 20% of the PM's found in the surrounding city.

Land Pollution - Black Carbon (BC)[35]

Black Carbon is caused by particle emissions from combustion in diesel engines and has harmful effects on global warming and melting of snow and ice in the polar regions. Shipping is believed to contribute to between 1-2% of Black Carbon emitted worldwide but up to 50% of BC in the Artic due to the amount of shipping in the area and because most shipping is powered by diesel engines. The particles of black carbon rise high in the air and are brought down to earth in rain and snow showers with the latter falling onto snow and ice of the Artic and Greenland ice sheets, darkening them and accelerating melting. The IMO is currently looking into this issue and considering how best to reduce the back carbon.[36] Also, there is now agreement at IMO that a ban on the use of heavy fuels in the Artic is needed to reduce the effects of oil pollution from any casualty and also BC emissions. Ships are also being encouraged to slow down as they burn much less fuel and produce much less BC, a 10% drop in speed lowers the fuel consumption by 27% and a corresponding amount of BC. Also, if ships switch over from burning oil-based fuels to clean LNG the BC is reduced by about 95%.

Climate Change – Reductions of Green House Gases, (GHG), CO_2.

In 2019 approximately 65,000 ships sailing worldwide, over 500grt, consumed about 300m tonnes of fossil fuel creating about 1,000m tonnes of CO_2 per year, 2.7% of the worlds CO_2, slightly more than Germany at 2.6%,

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[33] MAN SCR Technology Paper

[34] DNV-GL-Brochure, Particulates and Black-Carbon Paper -2016 06.pdf

[35] DNV-GL-Brochure, Particulates and Black-Carbon Paper -2016 06.pdf

[36] IMO PPR7 Protecting the Artic

Talks regarding regulation of CO2 emissions in shipping date all the way back to 1997 but stalled repeatedly. Finally, after a lot of external pressure for shipping to adopt effective Green House Gas (GHG) regulations, (shipping and airlines were not included in the Paris Climate change agreement), the IMO, at it 72nd session of MEPC in April 2018, agreed to an initial strategy for reducing greenhouse gas emissions.[37]

What was finally agreed on was the following: -

Vison

The IMO remains committed to reducing GHG emissions from international shipping as a matter of urgency and aims to phase them out as soon as possible this century.

Levels of Ambition

1. Carbon intensity of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) of new ships

To review, with the aim to strengthen, the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship as appropriate.

2. Carbon Intensity of Shipping to Decline

To reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008.

3. GHG Emissions from International Shipping to Peak and then Decline.

GHG emissions from international shipping to peak as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050, compared to 2008, whilst pursuing efforts towards phasing them out as called for in the vision

The vision confirms IMO's commitment to reducing GHG emissions from international shipping and, as a matter of urgency, aims to phase them out as soon as possible this century.

Energy Efficiency Design Index, EEDI [38]

The EEDI, regulation 21 of MARPOL Annex VI, was the first GHG improvement introduced for shipping. It became mandatory for all new buildings from 1st January 2013.

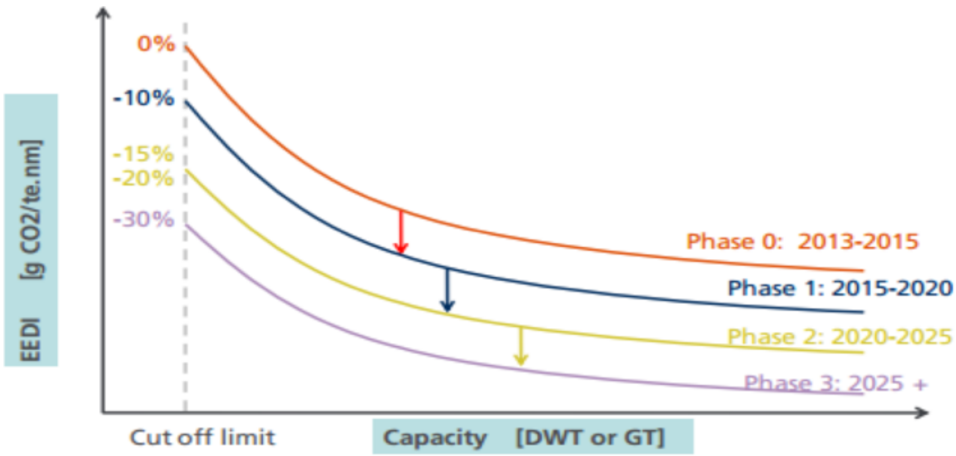
The EEDI requires a minimum energy efficiency level per capacity mile (e.g., tonne mile) for different ship types and size segments. It is expected to stimulate continued innovation and technical development of all the components influencing the fuel efficiency of a ship from its design phase. As long as the required energy efficiency level is attained, ship designers and builders are free to use the most cost-efficient solutions for the ship to comply with the regulations. The EEDI provides a specific figure for an individual ship design, expressed in grams of carbon dioxide (CO2) per ship's capacity-mile (the smaller the EEDI the more energy efficient ship design) and is calculated by a formula based on the technical design parameters for a given ship. The initial regulation specified 3 EEDI phases increasing by 10% every 5 years as shown in the diagram below. In 2020 ships are required to meet phase 2. Phase 3 is being introduced early for containerships, roro's, gas carriers and passenger ships in 2022 instead of in 2025 when it will be also be introduced for Tankers and Bulkcarriers. Phase

[37] briefing 06/2018.

[38] **IMO Environment EEDI and EEOI Operational-Measures**

4 is now being discussed and likely to be adopted although introduction dates have not been decided yet.

Diagram of EEDI Curves that newbuild ships need to meet



Ship Energy Efficiency Management Plan (SEEMP) and Energy Efficiency Operational Indicator (EEOI) [39]

The SEEMP is an operational measure that establishes a mechanism for shipping companies to improve the energy efficiency of a ship in a cost-effective manner over time. It was introduced in 2018 as requirement for all ships over 400grt and although it is endorsed by the ships class society, at present no annual survey is required. There are plans to introduce a super SEEMP in 2023, part of the short-term measures, which would be surveyed annually. The idea of the super SEEMP is to use it to monitor the efficiency of a ship, forcing ships to maintain clean hulls and propellers and the engines and machinery in good operational order. Without actively monitoring a ships performance ships lose efficiency as they age. Active management of the super SEEMP aims to stop the loss of performance and excessive fuel consumption and hence higher GHG over time. As machinery wears it will be necessary to install efficiency improvers to counter any fall off in efficiency.

Ships are also required to adopt an EEOI but like the current SEEMP this is not a mandatory requirement at the moment. The EEOI was developed by the IMO in order for ships and shipping companies to monitor carbon emissions of there shipping activities. The EEOI is the total carbon emission in a given time factor per unit of revenue tonne-miles. Variations in the index are mainly caused by three factors: the technical efficiency of the ship, the amount if cargo transported per unit or time and variations in speed. As the EEOI is an aggregate number of all it is difficult to fully identify the influence of individual factors. There are plans at IMO to strengthen the EEOI by making it mandatory from 2023 and part of the ships certification and more clearly identifying the factors and possibly including a clear carbon index which the ship must adhere to.

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[39] IMO Environment EEDI and EEOI Operational-Measures

EU MRV and IMO DSC Regulation [40]

Both regulations were in introduced to obtain bottom up fuel consumption data of international shipping and thereby the GHG emissions compared with the top down method used previously. The EU MRV Regulation (EU) 2015/757 on “monitoring, reporting and verification of carbon dioxide emissions from maritime transport” required all ships calling into EU ports from 1st January 2018 to report fuel consumption from the last port. The International Maritime Organization (IMO) adopted a mandatory Fuel Oil Data Collection System (DCS) for international shipping, requiring ships of 5,000 gross tonnage or above to start collecting and reporting data to an IMO database from 1st January 2019.
Both the EU and the IMO have clear ambitions to reduce GHG emissions from ships. The plan is to establish a standard for each ship type from which future GHG reduction regulations can be built. The major difference between the two systems is the EU system, which only focuses on ships trading to and within the EU, also collects cargo deadweight and publishes the data. Shipping companies are not happy about this, claiming it provides competitive data to rivals. The IMO DSC system covers emissions globally and only requires data on fuel consumption and does not publish individual ships data.

The Future

The IMO has laid out a road map, firstly to reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030 and pursuing efforts towards 70% by 2050, compared to 2008. And secondly, for GHG emissions from international shipping to peak as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050, compared to 2008, whilst pursuing efforts towards phasing them out as called for in the vision.

While the EEDI, EEOI, SEEMP, MRV and DSC are all helpful, applying them will not enable shipping to even meet the first GHG goal. The only way forward for shipping to achieve the goals set by the IMO is to change to new green fuels which is a major challenge. Switching fuels will be very expensive as it requires a worldwide bunkering system and compatible propulsion and power systems which can burn the new fuels. It is generally not economic to convert engines burning fuel oil to burn green fuels. Thus, new ships with new engines will be needed to meet the requirements.

At present LNG is the only slightly green fuel that is becoming available worldwide. LNG has some advantages, zero sulphur dioxide, SOx, and Nitrogen Dioxide, NOx, and very low particulates, plus around 10% lower CO_2 compared to fuel oil. However, the problem with LNG is that most engines cannot burn LNG without some methane slip. Methane is 30 times worse than CO_2, altougth does not last as long.

Future Green fuels that are being considered are Hydrogen, Ammonia, green Methanol and other Bio or Synthetic fuels. However, to obtain them in a green way requires large amounts of sustainable power. Also, they need to be stored and distributed in a sustainable and safe manner. All have disadvantages of one kind or another. There is no easy solution, but one certainty is that the 2 stoke diesel engine can be converted to burn all the new green fuels so will most likely continue to be used for main propulsion rather than using fuel cells.

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[40] DNVGL Insights to EU-MRV-and-IMO-DCS

Conclusions

Shipping has always been regarded as the cheapest and most environmentally friendly way to move people and goods, but over the years it has been a major contributor to both ocean and atmospheric pollution. Nonetheless, most pollution enters our seas and oceans from the land, not from ships.

In recent years there have been concerted efforts to address this situation and reduce the impact of shipping on the environment. Meanwhile, legislation is slow to catch up with industry best practices.

Ship owners and operators generally have no objection to being more environmentally friendly. Indeed, most would be delighted to see cleaner seas and less polluted air. All the industry asks is that regulations apply to all, creating a level playing field: unscrupulous shipowners should not benefit at the expense of more responsible companies.

Governments and the IMO need to enforce fair and effective legislation, people ashore need to accept the additional costs of carrying the world's goods in a less damaging manner, and there needs to be sufficient supplies of acceptable fuels and that any residues are dealt with in a proper manner.

Meanwhile, more attention must be paid to local shipping and leisure craft. These sectors are expanding rapidly and unless controlled, we may face a situation where the reduction of emissions by ocean-going vessels is matched by a corresponding increase from local craft.

Shipping has come a long way in the last 50 years in reducing air and sea pollution, yet the biggest challenges lie ahead and if the IMO visons are to be achieved on time it will require a huge effort from the entire marine industry over the next 10-15years. Based on past practice, when set a target, shipping has generally stepped up to meet it.

Martin Cresswell, July 2020