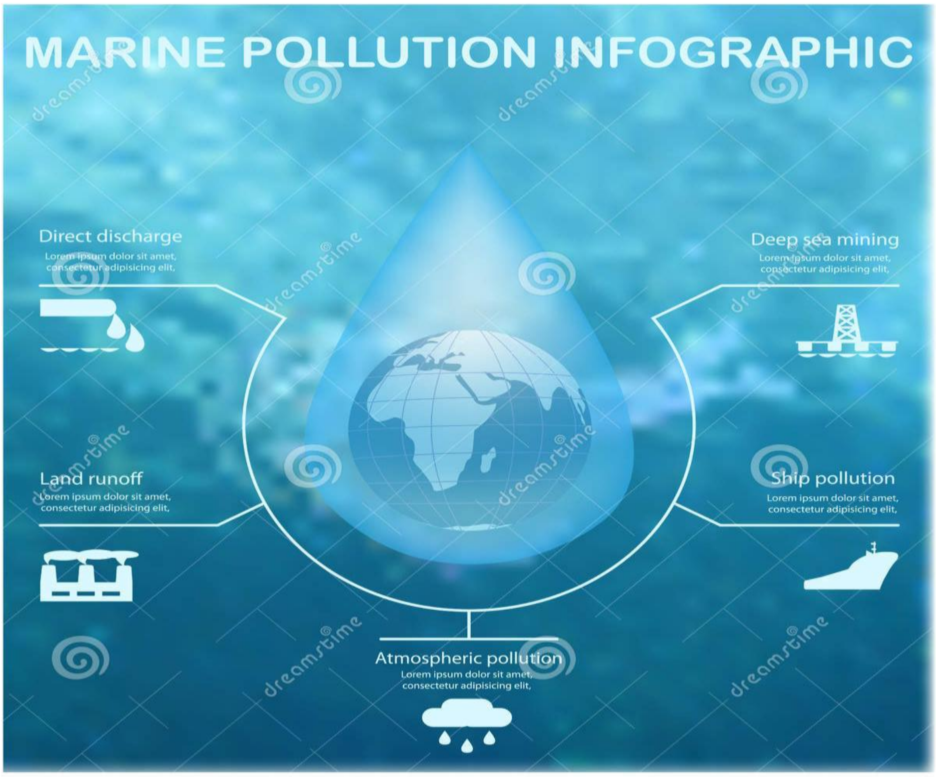
*ΑΚΑΔΗΜΙΑ ΕΜΠΟΡΙΚΟΥ ΝΑΥΤΙΚΟΥ ΜΑΚΕΔΟΝΙΑΣ*

*ΣΧΟΛΗ ΠΛΟΙΑΡΧΩΝ*

**ΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ**

# ΘΕΜΑ: MARINE POLLUTION AND POLLUTION PREVENTION

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**ΣΠΟΥΔΑΣΤΗΣ: ΜΙΧΑΗΛ-ΧΡΥΣΟΒΑΛΑΝΤΗΣ ΤΣΟΥΡΟΥΣ**

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***Α.Ε.Ν. ΜΑΚΕΔΟΝΙΑΣ***

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***MARINE POLLUTION AND POLLUTION PREVENTION***

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***Α.Γ.Μ: 3486***

Ημερομηνία ανάληψης της εργασίας:

Ημερομηνία παράδοσης της εργασίας:

| ***Α/Α*** | ***Ονοματεπώνυμο*** | ***Ειδικότης*** | ***Αξιολόγηση*** | ***Υπογραφή*** |
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# *ΠΕΡΙΕΧΟΜΕΝΑ*

# ΠΕΡΙΛΗΨΗ

Although marine pollution has a long history, significant international laws to counter it were only enacted in the twentieth century. Marine pollution was a concern during several United Nations Conferences on the Law of the Sea beginning in the 1950s. Most scientists believed that the oceans were so vast that they had unlimited ability to dilute, and thus render pollution harmless. Marine pollution occurs when harmful, or potentially harmful, effects result from the entry into the ocean of chemicals, particles, industrial, agricultural and residential waste, noise, or the spread of invasive organisms. Eighty percent of marine pollution comes from land. Air pollution is also a contributing factor by carrying off pesticides or dirt into the ocean. Land and air pollution have proven to be harmful to marine life and its habitats.

# Environmental impact of Shipping

The **environmental impact of shipping** includes greenhouse gas emissions, acoustic, and oil pollution. The International Maritime Organization (IMO) estimates that Carbon dioxide emissions from shipping were equal to 2.2% of the global human-made emissions in 2012 and expects them to rise by as much as 2 to 3 times by 2050 if no action is taken.

The First Intercessional Meeting of the IMO Working Group on Greenhouse Gas Emissions from Ships took place in Oslo, Norway on 23–27 June 2008. It was tasked with developing the technical basis for the reduction mechanisms that may form part of a future IMO regime to control greenhouse gas emissions from international shipping, and a draft of the actual reduction mechanisms themselves, for further consideration by IMO's Marine Environment Protection Committee (MEPC)

Ships can pollute waterways and oceans in many ways. Oil spills can have devastating effects. While being toxic to marine life, polycyclic aromatic hydrocarbons (PAHs), found in crude oil, are very difficult to clean up, and last for years in the sediment and marine environment.

Oil spills are probably the most emotive of marine pollution events. However, while a tanker wreck may result in extensive newspaper headlines, much of the oil in the world's seas comes from other smaller sources, such as tankers discharging ballast water from oil tanks used on return ships, leaking pipelines or engine oil disposed of down sewers.

Discharge of cargo residues from bulk carriers can pollute ports, waterways and oceans. In many instances vessels intentionally discharge illegal wastes despite foreign and domestic regulation prohibiting such actions. It has been estimated that container ships lose over 10,000 containers at sea each year (usually during storms). Ships also create noise pollution that disturbs natural wildlife, and water from ballast tanks can spread harmful algae and other invasive species.

Ballast water taken up at sea and released in port is a major source of unwanted exotic marine life. The invasive freshwater zebra mussels, native to the Black, Caspian and Azov seas, were probably transported to the Great Lakes via ballast water from a transoceanic vessel. Meinesz believes that one of the worst cases of a single invasive species causing harm to an ecosystem can be attributed to a seemingly harmless jellyfish. *Mnemiopsis leidyi*, a species of comb jellyfish that spread so it now inhabits estuaries in many parts of the world. It was first introduced in 1982, and thought to have been transported to the Black Sea in a ship's ballast water. The population of the jellyfish shot up exponentially and, by 1988, it was wreaking havoc upon the local fishing industry. "The anchovy catch fell from 204,000 tons in 1984 to 200 tons in 1993; sprat from 24,600 tons in 1984 to 12,000 tons in 1993; horse mackerel from 4,000 tons in 1984 to zero in 1993." Now that the jellyfish have exhausted the zooplankton, including fish larvae, their numbers have fallen dramatically, yet they continue to maintain a stranglehold on the ecosystem.

Invasive species can take over once occupied areas facilitate the spread of new diseases, introduce new genetic material, alter underwater seascapes and jeopardize the ability of native species to obtain food. Invasive species are responsible for about $138 billion annually in lost revenue and management costs in the US alone.

## Ways that ships can pollute the waterways and oceans are:

I. Ballast Water: Cruise ships, large tankers, and bulk cargo carriers use a huge amount of ballast water, which is often taken on in the coastal waters in one region after ships discharge wastewater or unload cargo, and discharged at the next port of call, wherever more cargo is loaded. Ballast water discharge typically contains a variety of biological materials, including plants, animals, viruses, and bacteria. These materials often include non-native, nuisance, invasive, exotic species that can cause extensive ecological and economic damage to aquatic ecosystems along with serious human health problems.

II. Sound Pollution: Noise pollution caused by shipping and other human enterprises has increased in recent history. The noise produced by ships can travel long distances, and marine species that may rely on sound for their orientation, communication, and feeding, can be harmed by this sound pollution. The Convention on the Conservation of Migratory Species has identified ocean noise as a potential threat to marine life. The disruption of whales' ability to communicate with one another is an extreme threat and is affecting their ability to survive. According to Discovery Channel's article on Sonic Sea Journeys Deep Into the Ocean, over the last century, extremely loud noise from commercial ships, oil and gas exploration, naval sonar exercises and other sources has transformed the ocean's delicate acoustic habitat, challenging the ability of whales and other marine life to prosper and ultimately to survive. Whales are starting to react to this in ways that are life-threatening. Kenneth C. Balcomb, a whale researcher and a former U.S Navy officer, states that the day March 15, 2000, is the day of infamy

III. Wildlife Collisions: Marine mammals, such as whales and manatees, risk being struck by ships, causing injury and death.

IV. Atmospheric Pollution: Exhaust gases from ships are considered to be a significant source of air pollution, both for conventional pollutants and greenhouse gases. There is a perception that cargo transport by ship is low in air pollutants, because for equal weight and distance it is the most efficient transport method, according to shipping researcher Amy Bows-Larkin. This is particularly true in comparison to air freight; however, because sea shipment accounts for far more annual tonnage and the distances are often large, shipping's emissions are globally substantial. A difficulty is that the year-on-year increasing amount shipping overwhelms gains in efficiency, such as from slow-steaming or the use of kites. The growth in tonne-kilometers of sea shipment has averaged 4 percent yearly since the 1990s. And it has grown by a factor of 5 since the 1970s. There are now over 100,000 transport ships at sea, of which about 6,000 are large container ships.

a. Conventional Pollutants: Air pollution from cruise ships is generated by diesel engines that burn high sulphur content fuel oil, also known as bunker oil, producing sulphur dioxide, nitrogen oxide and particulate, in addition to carbon monoxide, carbon dioxide, and hydrocarbons. Diesel exhaust has been classified by EPA as a likely human carcinogen. EPA recognizes that these emissions from marine diesel engines contribute to ozone and carbon monoxide non-attainment (i.e., failure to meet air quality standards), as well as adverse health effects associated with ambient concentrations of particulate matter and visibility, haze, acid deposition, and eutrophication and nitrification of water.

b. Greenhouse gas pollutants: As one way to reduce the impact of greenhouse gas emissions from shipping, vetting agency RightShip developed an online "Greenhouse Gas (GHG) Emissions Rating" as a systematic way for the industry to compare a ship's $CO_2$ emissions with peer vessels of a similar size and type. Based on the International Maritime Organisation's (IMO) Energy Efficiency Design Index (EEDI) that applies to ships built from 2013, RightShip's GHG Rating can also be applied to vessels built prior to 2013, allowing for effective vessel comparison across the world's fleet. The GHG Rating utilises an A to G scale, where A represents the most efficient ships. It measures the theoretical amount of carbon dioxide emitted per tonne nautical mile travelled, based on the design characteristics of the ship at time of build such as cargo carrying capacity, engine power and fuel consumption. Higher rated ships can deliver significantly lower $CO_2$ emissions across the voyage length, which means they also use less fuel and are cheaper to run.

c. Stress for Improvement: One source of environmental stresses on maritime vessels recently has come from states and localities, as they assess the contribution of commercial marine vessels to regional air quality problems when ships are docked at port. In 2005, MARPOL Annex VI came into force to combat this problem. As such cruise ships now employ CCTV monitoring on the smokestacks as well as recorded measuring via opacity meter while some are also using clean burning gas turbines for electrical loads and propulsion in sensitive areas.

V. Oil Spills: Most commonly associated with ship pollution are oil spills. While less frequent than the pollution that occurs from daily operations, oil spills have devastating effects. While being toxic to marine life, polycyclic aromatic hydrocarbons (PAHs), the components in crude oil, are very difficult to clean up, and last for years in the sediment and marine environment.

Marine species constantly exposed to PAHs can exhibit developmental problems, susceptibility to disease, and abnormal reproductive cycles.

VI. International Regulations: Some of the major international efforts in the form of treaties are the Marine Pollution Treaty, Honolulu, which deals with regulating marine pollution from ships, and the UN Convention on Law of the Sea, which deals with marine species and pollution. While plenty of local and international regulations have been introduced throughout maritime history, much of the current regulations are considered inadequate. "In general, the treaties tend to emphasize the technical features of safety and pollution control measures without going to the root causes of sub-standard shipping, the absence of incentives for compliance and the lack of enforceability of measures. The most common problems encountered with international shipping arise from paperwork errors and customs brokers not having the proper information about your items.

VII. Sewage: Sewage is Blackwater, wastewater from toilets and medical facilities, which can contain harmful bacteria, pathogens, viruses, intestinal parasites, and harmful nutrients. Discharges of untreated or inadequately treated sewage can cause bacterial and viral contamination of fisheries and shellfish beds, producing risks to public health. Nutrients in sewage, such as nitrogen and phosphorus, promote excessive algal blooms, which consumes oxygen in the water and can lead to fish kills and destruction of other aquatic life. Due to the environmental impact of shipping, and sewage in particular marpol annex IV was brought into force September 2003 strictly limiting untreated waste discharge. Modern cruise ships are most commonly installed with a membrane bioreactor type treatment plant for all blackwater and greywater, which produce near drinkable quality effluent to be re-used in the machinery spaces as technical water.

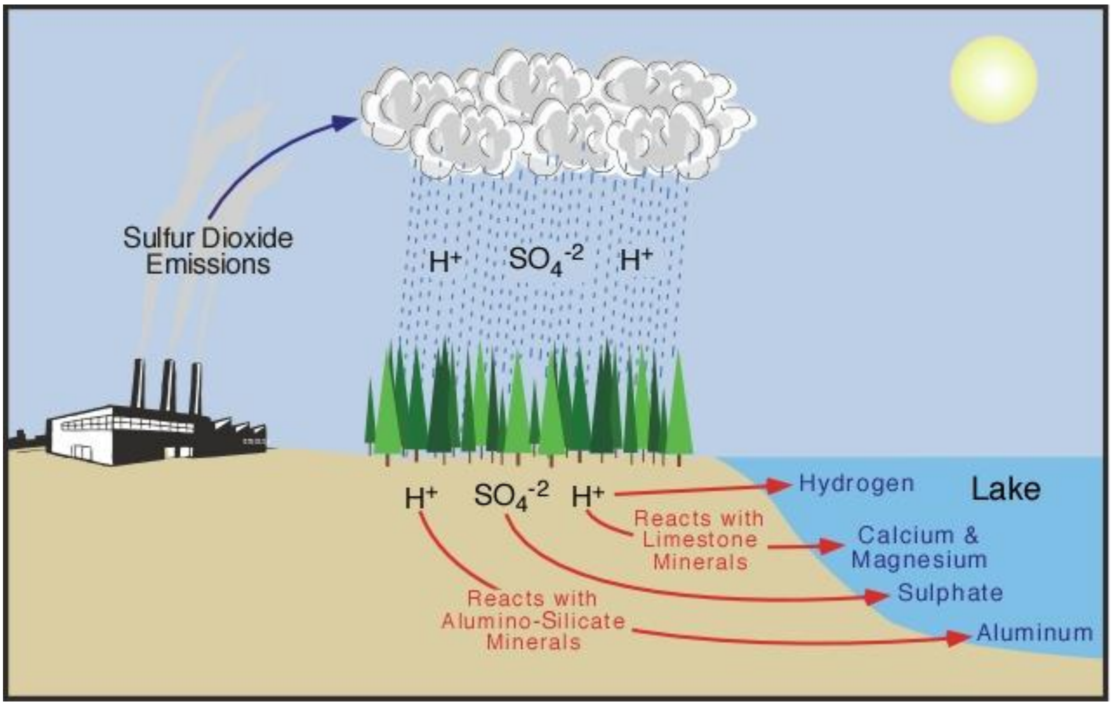
VIII. Cleaning: Greywater is wastewater from the sinks, showers, galleys, laundry, and cleaning activities aboard a ship. It can contain a variety of pollutant substances, including fecal coliforms, detergents, oil and grease, metals, organic compounds, petroleum hydrocarbons, nutrients, food waste, medical and dental waste. Sampling done by the EPA and the state of Alaska found that untreated greywater from cruise ships can contain pollutants at variable strengths and that it can contain levels of fecal coliform bacteria several times greater than is typically found in untreated domestic wastewater. Greywater has potential to cause adverse environmental effects because of concentrations of nutrients and other oxygen-demanding materials, in particular. Greywater is typically the largest source of liquid waste generated by cruise ships.

IX. Solid Waste: Solid waste generated on a ship includes glass, paper, cardboard, aluminium and steel cans, and plastics. It can be either non-hazardous or hazardous in nature. Solid waste that enters the ocean may become marine debris, and can then pose a threat to marine organisms, humans, coastal communities, and industries that utilize marine waters. Cruise ships typically manage solid waste by a combination of source reduction, waste minimization, and recycling. However, as much as 75 percent of solid waste is incinerated on board, and the ash typically is discharged at sea, although some is landed ashore for disposal or recycling. Marine mammals, fish, sea turtles, and birds can be injured or killed from entanglement with plastics and other solid waste that may be released or disposed off of cruise ships. Most cruise ship garbage is treated on board (incinerated, pulped, or ground up) for discharge overboard. When garbage must be off-loaded (for example, because glass and aluminium cannot be incinerated), cruise ships can put a strain on port reception facilities, which are rarely adequate to the task of serving a large passenger vessel.

X. Bilge Water: On a ship, oil often leaks from engine and machinery spaces or from engine maintenance activities and mixes with water in the bilge, the lowest part of the hull of the ship, but there is a filter to clean bilge water before being discharged. Oil, gasoline, and by-products from the biological breakdown of petroleum products can harm fish and wildlife and pose threats to human health if ingested. Oil in even minute concentrations can kill fish or have various sub-lethal chronic effects. Bilge water also may contain solid wastes and pollutants containing high levels of oxygen-demanding material, oil and other chemicals. To maintain ship stability and eliminate potentially hazardous conditions from oilvapors in these areas, the bilge spaces need to be flushed and periodically pumped dry. However, before a bilge can be cleared out and the water discharged, the oil that has been accumulated needs to be extracted from the bilge water, after which the extracted oil can be reused, incinerated, and/or offloaded in port. If a separator, which is normally used to extract the oil, is faulty or is deliberately bypassed, untreated oily bilge water could be discharged directly into the ocean, where it can damage marine life. A number of cruise lines have been charged with environmental violations related to this issue in recent years

# Types of Pollution

First type of pollution: Acidification (Dissolving $CO_2$ in seawater increases the hydrogen ion ($H^+$) concentration in the ocean, and thus decreases ocean pH).




The oceans are normally a natural carbon sink, absorbing carbon dioxide from the atmosphere. Because the levels of atmospheric carbon dioxide are increasing, the oceans are becoming more acidic. The potential consequences of ocean acidification are not fully understood, but there are concerns that structures made of calcium carbonate may become vulnerable to dissolution, affecting corals and the ability of shellfish to form shells.

Oceans and coastal ecosystems play an important role in the global carbon cycle and have removed about 25% of the carbon dioxide emitted by human activities between 2000 and 2007 and about half the anthropogenic $CO_2$ released since the start of the industrial revolution. Rising ocean temperatures and ocean acidification means that the capacity of the ocean carbon sink will gradually get weaker, giving rise to global concerns expressed in the Monaco and Manado Declarations.

A report from NOAA scientists published in the journal Science in May 2008 found that large amounts of relatively acidified water are upwelling to within four miles of the Pacific continental shelf area of North America. This area is a critical zone where most local marine life lives or is born. While the paper dealt only with areas from Vancouver to northern California, other continental shelf areas may be experiencing similar effects.

A related issue is the methane clathrate reservoirs found under sediments on the ocean floors. These trap large amounts of the greenhouse gas methane, which ocean warming has the potential to release. In 2004 the global inventory of ocean methane clathrates was estimated to occupy between one and five million cubic kilometres. If all these clathrates were to be spread uniformly across the ocean floor, this would translate to a thickness between three and fourteen metres. This estimate corresponds to 500–2500 gigatonnes carbon (Gt C), and can be compared with the 5000 Gt C estimated for all other fossil fuel reserves

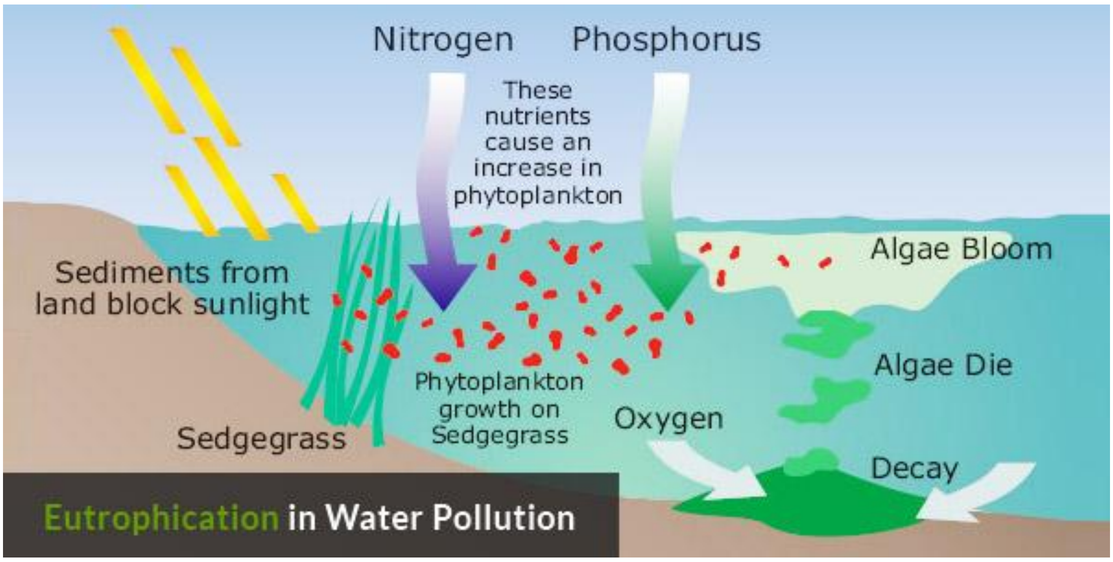
Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide ($CO_2$) from the atmosphere. Seawater is slightly basic (meaning pH > 7), and the process in question is a shift towards pH-neutral conditions rather than a transition to acidic conditions (pH < 7). Ocean alkalinity is not changed by the process, or may increase over long time periods due to carbonate dissolution. An estimated 30–40% of the carbon dioxide from human activity released into the atmosphere dissolves into oceans, rivers and lakes. To achieve chemical equilibrium, some of it reacts with the water to form carbonic acid. Some of these extra carbonic acid molecules react with a water molecule to give a bicarbonate ion and ahydronium ion, thus increasing ocean acidity ($H^+$ ion concentration). Between 1751 and 1996 surface ocean pH is estimated to have decreased from approximately 8.25 to 8.14, representing an increase of almost 35% in $H^+$ion concentration in the world's oceans. Earth System Models project that within the last decade ocean acidity exceeded historical analogs and in combination with other ocean biogeochemical changes could undermine the functioning of marine ecosystems and disrupt the provision of many goods and services associated with the ocean.

Increasing acidity is thought to have a range of potentially harmful consequences for marine organisms, such as depressing metabolic rates and immune responses in some organisms, and causing coral bleaching. By increasing the presence of free hydrogen ions, each molecule of carbonic acid that forms in the oceans ultimately results in the conversion of *two* carbonate ions into bicarbonate ions. This net decrease in the amount of carbonate ions available makes it more difficult for marine calcifying organisms, such as coral and some plankton, to form biogenic calcium carbonate, and such structures become vulnerable to dissolution. Ongoing acidification of the oceans threatens food chains connected with the oceans. As members of the InterAcademy Panel, 105 science academies have issued a statement on ocean acidification recommending that by 2050, global $CO_2$ emissions be reduced by at least 50% compared to the 1990 level.

While ongoing ocean acidification is anthropogenic in origin, it has occurred previously in Earth's history. The most notable example is the Paleocene-Eocene Thermal Maximum (PETM), which occurred approximately 56 million years ago. For reasons that are currently uncertain, massive amounts of carbon entered the ocean and atmosphere, and led to the dissolution of carbonate sediments in all ocean basins.

Ocean acidification has been called the "evil twin of global warming and "the other $CO_2$ problem.

Second type of pollution: Eutrophication (Eutrophication arises from the oversupply of nutrients, which leads to over growth of plants and algae. After such organisms die, the bacterial degradation of their biomass consumes the oxygen in the water, thereby creating the state of hypoxia).




**Eutrophication** (Greek: *eutrophia* (from *eu* "well"+ *trephein* "nourish".); German: *E utrophie*), or more precisely **hypertrophication**, is the depletion of oxygen in a water body, which kills aquatic animals. It is a response to the addition of excess nutrients, mainly phosphates, which induces explosive growth of plants and algae, the decaying of which consumes oxygen from the water. One example is the "bloom" or great increase of phytoplankton in a water body as a response to increased levels of nutrients. Eutrophication is almost always induced by the discharge of phosphate-containing detergents, fertilizers, or sewage, into an aquatic system.

Eutrophication is a common phenomenon in coastal waters. In contrast to freshwater systems, nitrogen is more commonly the key limiting nutrient of marine waters; thus, nitrogen levels have greater importance to understanding eutrophication problems in salt water. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where run-off enters a confined channel. Upwelling in coastal systems also promotes increased productivity by conveying deep, nutrient-rich waters to the surface, where the nutrients can be assimilated by algae.

The World Resources Institute has identified 375 hypoxic coastal zones in the world, concentrated in coastal areas in Western Europe, the Eastern and Southern coasts of the US, and East Asia, particularly Japan.

In addition to runoff from land, atmospheric fixed nitrogen can enter the open ocean. A study in 2008 found that this could account for around one third of the ocean's external (non-recycled) nitrogen supply, and up to 3% of the annual new marine biological production. It has been suggested that accumulating reactive nitrogen in the environment may prove as serious as putting carbon dioxide in the atmosphere.

Third type of pollution: Plastic debris (Ocean dumping. Marine debris, also known as marine litter, is human-created waste that has deliberately or accidentally been released in a lake, sea, ocean or waterway).


Floating oceanic debris tends to accumulate at the center of gyres and on coastlines, frequently washing aground, when it is known as *beach litter* or tidewrack. Deliberate disposal of wastes at sea is called *ocean dumping*. Naturally occurring debris, such as driftwood, are also present.

With the increasing use of plastic, human influence has become an issue as many types of plastics do not biodegrade. Waterborne plastic poses a serious threat to fish, seabirds, marine reptiles, and marine mammals, as well as to boats and coasts. Dumping, container spillages, litter washed into storm drains and waterways and wind-blown landfill waste all contribute to this problem.

Researchers classify debris as either land- or ocean-based; in 1991, the United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution estimated that up to 80% of the pollution was land-based. More recent studies have found that more than half of plastic debris found on Korean shores is ocean-based. A wide variety of anthropogenic artifacts can become marine debris; plastic bags, balloons, buoys, rope, medical waste, glass bottles and plastic bottles, cigarette stubs, cigarette lighters, beverage cans, polystyrene, lost fishing line and nets, and various wastes from cruise shipsand oil rigs are among the items commonly found to have washed ashore. Six pack rings, in particular, are considered emblematic of the problem. The US military used ocean dumping for unused weapons and bombs, including ordinary bombs, UXO, landmines and chemical weapons from at least 1919 until 1970. Millions of pounds of ordnance were disposed of in the Gulf of Mexico and off the coasts of at least 16 states, from New Jersey to Hawaii (although these, of course, do not wash up onshore, nor is the US the only country who has practiced this, safely dismantling and recycling explosives being a very dangerous and costly procedure).

Eighty percent of marine debris is plastic. Plastics accumulate because they typically do not biodegrade as many other substances do. They photodegrade on exposure to sunlight, although they do so only under dry conditions, as water inhibits photolysis. In a 2014 study using computers models, scientists from the group 5 Gyres, estimate 5.25 trillion pieces of plastic weighing 269,000 tons dispersed in oceans in similar amount in the Northern and Southern Hemispheres, and one-hundredth of them in particles in the scale of a sand-size.

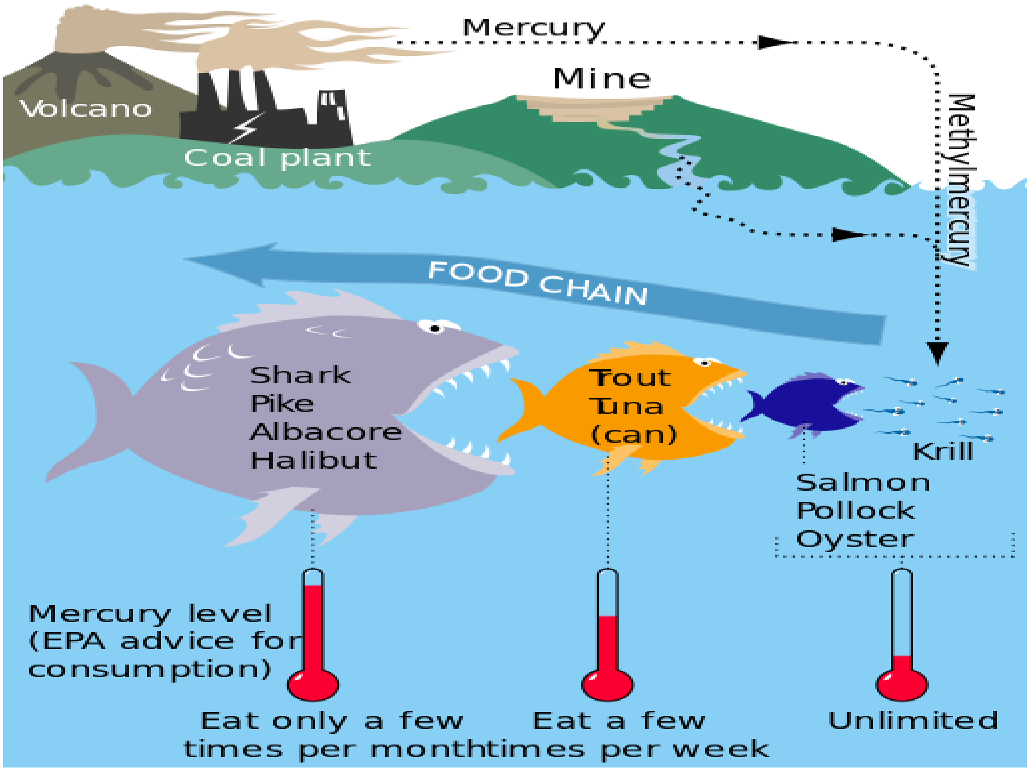
Many animals that live on or in the sea consume flotsam by mistake, as it often looks similar to their natural prey. Plastic debris, when bulky or tangled, is difficult to pass, and may become permanently lodged in the digestive tracts of these animals. Especially when evolutionary adaptions make it impossible for the likes of turtles to reject plastic bags, which resemble jellyfish when immersed in water, as they have a system in their throat to stop slippery foods from otherwise escaping. Thereby blocking the passage of food and causing death through starvation or infection.

Plastics accumulate because they don't biodegrade in the way many other substances do. They will photodegrade on exposure to the sun, but they do so properly only under dry conditions, and water inhibits this process. In marine environments, photodegraded plastic disintegrates into ever smaller pieces while remaining polymers, even down to the molecular level. When floating plastic particles photodegrade down to zooplankton sizes, jellyfish attempt to consume them, and in this way the plastic enters the ocean food chain. Many of these long-lasting pieces end up in the stomachs of marine birds and animals, including sea turtles, and black-footed albatross.

Plastic debris tends to accumulate at the centre of ocean gyres. In particular, the Great Pacific Garbage Patch has a very high level of plastic particulate suspended in the upper water column. In samples taken in 1999, the mass of plastic exceeded that of zooplankton (the dominant animal life in the area) by a factor of six. Midway Atoll, in common with all the Hawaiian Islands, receives substantial amounts of debris from the garbage patch. Ninety percent plastic, this debris accumulates on the beaches of Midway where it becomes a hazard to the bird population of the island. Midway Atoll is home to two-thirds (1.5 million) of the global population of Laysan albatross. Nearly all of these albatross have plastic in their digestive system and one-third of their chicks die.

Toxic additives used in the manufacture of plastic materials can leach out into their surroundings when exposed to water. Waterborne hydrophobic pollutants collect and magnify on the surface of plastic debris, thus making plastic far more deadly in the ocean than it would be on land. Hydrophobic contaminants are also known to bioaccumulate in fatty tissues,biomagnifying up the food chain and putting pressure on apex predators. Some plastic additives are known to disrupt the endocrine system when consumed, others can suppress the immune system or decrease reproductive rates. Floating debris can also absorb persistent organic pollutants from seawater, including PCBs, DDT and PAHs. Aside from toxic effects, when ingested some of these are mistaken by the animal brain for estradiol, causing hormone disruption in the affected wildlife.

Fourth type of pollution: Toxins ( Examples of persistent toxins are PCBs, DDT, TBT, pesticides, furans, dioxins, phenols and radioactive waste).

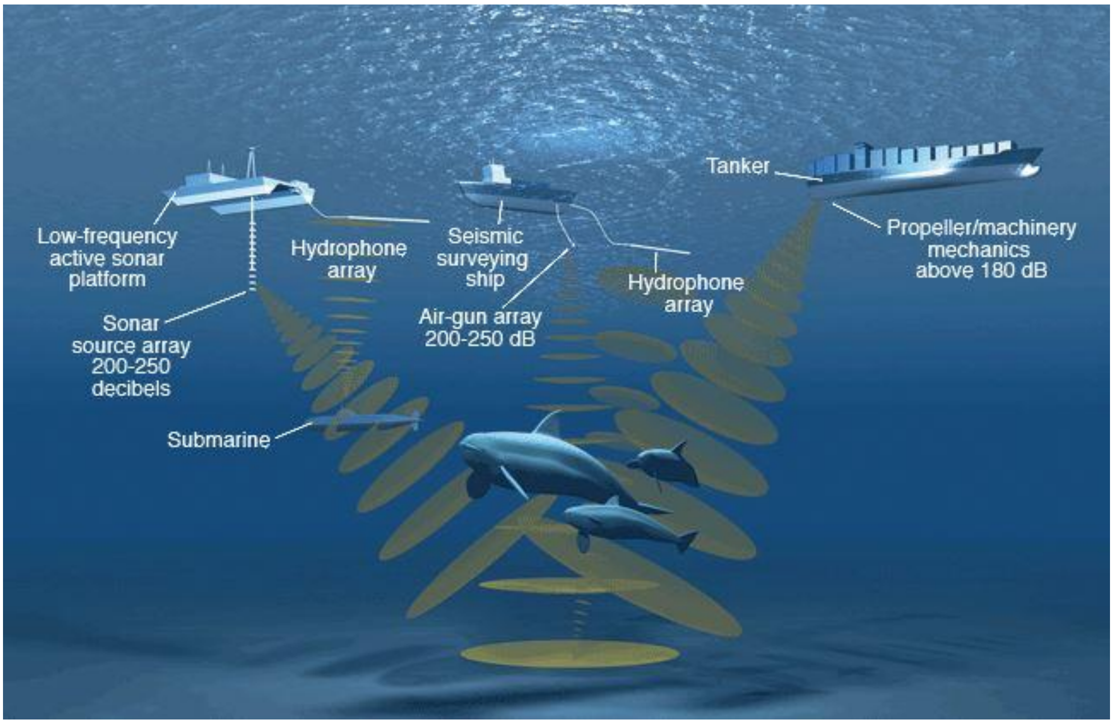



Apart from plastics, there are particular problems with other toxins that do not disintegrate rapidly in the marine environment. Heavy metals are metallic chemical elements that have a relatively high density and are toxic or poisonous at low concentrations. Examples are mercury, lead, nickel, arsenic and cadmium. Such toxins can accumulate in the tissues of many species of aquatic life in a process called bioaccumulation. They are also known to accumulate in benthic environments, such as estuaries and bay muds: a geological record of human activities of the last century.

Fish and shellfish concentrate mercury in their bodies, often in the form of methylmercury, a highly toxic organic compound of mercury. Fish products have been shown to contain varying amounts of heavy metals, particularlymercury and fat-soluble pollutants from water pollution. Species of fish that are long-lived and high on the food chain, such as marlin, tuna, shark, swordfish, king mackerel, tilefish (Gulf of Mexico), and northern pike, contain higher concentrations of mercury than others.

Mercury is known to bioaccumulate in humans, so bioaccumulation in seafood carries over into human populations, where it can result in mercury poisoning. Mercury is dangerous to both natural ecosystems and humans because it is a metal known to be highly toxic, especially due to its ability to damage the central nervous system. In human-controlled ecosystems of fish, usually done for market production of wanted seafoodspecies, mercury clearly rises through the food chain via fish consuming small plankton, as well as through non-food sources such as underwater sediment. This mercury grows in concentration within the bodies of fish and can be measured in the tissues of selected species

Fifth type of pollution: Underwater noise (Active sonar, the transmission equipment used on some ships to assist with navigation, is detrimental to the health and livelihood of some marine animals).




Marine life can be susceptible to noise or the sound pollution from sources such as passing ships, oil exploration seismic surveys, and naval low-frequency active sonar. Sound travels more rapidly and over larger distances in the sea than in the atmosphere. Marine animals, such as cetaceans, often have weak eyesight, and live in a world largely defined by acoustic information. This applies also too many deeper sea fish, who live in a world of darkness. Between 1950 and 1975, ambient noise at one location in the Pacific Ocean increased by about ten decibels (that is a tenfold increase in intensity).

Noise also makes species communicate louder, which is called the Lombard vocal response. Whale songs are longer when submarine-detectors are on. If creatures don't "speak" loud enough, their voice can be masked by anthropogenic sounds. These unheard voices might be warnings, finding of prey, or preparations of net-bubbling. When one species begins speaking louder, it will mask other species voices, causing the whole ecosystem to eventually speak louder.

According to the oceanographer Sylvia Earle, "Undersea noise pollution is like the death of a thousand cuts. Each sound in itself may not be a matter of critical concern, but taken all together, the noise from shipping, seismic surveys, and military activity is creating a totally different environment than existed even 50 years ago. That high level of noise is bound to have a hard, sweeping impact on life in the sea

Research has recently shown that beaked and blue whales are sensitive to mid-frequency active sonar and move rapidly away from the source of the sonar, a response that disrupts their feeding and can cause mass strandings. Some marine animals, such as whales and dolphins, use echolocation or "biosonar" systems to locate predators and prey. It is conjectured that active sonar transmitters could confuse these animals and interfere with basic biological functions such as feeding and mating. Study has shown whales experience decompression sickness, a disease that forces nitrogen into gas bubbles in the tissues and is caused by rapid and prolonged surfacing. Although whales were originally thought to be immune to this disease, sonar has been implicated in causing behavioural changes that can lead to decompression sickness.

# Preventing/Reducing Marine Pollution as per IMO

## 1. MARPOL

In 1973, IMO adopted the International Convention for the Prevention of Pollution from Ships, now known universally as MARPOL, which has been amended by the Protocols of 1978 and 1997 and kept updated with relevant amendments. The MARPOL Convention addresses pollution from ships by oil; by noxious liquid substances carried in bulk; harmful substances carried by sea in packaged form; sewage, garbage; and the prevention of air pollution from ships. MARPOL has greatly contributed to a significant decrease in pollution from international shipping and applies to 99% of the world's merchant tonnage.

**List of the MARPOL 73/78 Annexes**

| | |
|---|---|
| Annex I | prevention of pollution by oil & oily water |
| Annex II | control of pollution by noxious liquid substances in bulk |
| Annex III | prevention of pollution by harmful substances carried by sea in packaged form |
| Annex IV | pollution by sewage from ships |
| Annex V | pollution by garbage from ships |
| Annex VI | Prevention of air pollution from ships |

**MARPOL Annex I – Prevention of Pollution by Oil:** Measures introduced by IMO have helped ensure that the majority of oil tankers are safely built and operated and are constructed to reduce the amount of oil spilled in the event of an accident. Operational pollution, such as from routine tank cleaning operations, has also been cut. The operational and construction regulations introduced by MARPOL, which entered into force in 1983, have been a success, with statistics from reputable industry and independent bodies showing that these regulations, along with other safety-related regulations such as the introduction of mandatory traffic separation schemes and international standards for seafarer training, have been instrumental in the continuous decline of accidental oil pollution that has taken place over the last 30 years. The MARPOL convention, in 1983, introduced a number of radical new concepts, such as a requirement for new oil tankers to be fitted with segregated ballast tanks, so as to obviate the need to carry ballast water in cargo tanks. This was superseded by the requirement for oil tankers delivered from 1996 onwards to be fitted with a double hull. The protection of the marine environment was thus greatly enhanced. As far as operational oil pollution is concerned, the many innovations introduced by MARPOL on allowable discharges of bilge water through the oily water separator (with the well-known 15ppm standard), or oily waters from the cargo tanks, through the oil discharge and monitoring system, have contributed greatly to a noticeable decrease in the pollution of the world's seas, though it is fair to recognise that a greater effort to impose compliance must be carried out.

SOPEP stands for Ship oil pollution emergency plan and as per the MARPOL 73/78 requirement under Annex I, all ships with 400 GT and above must carry an oil prevention plan as per the norms and guidelines laid down by International Maritime Organization under MEPC (Marine Environmental Protection Committee) act. Master of the ship is the overall in charge of the SOPEP of the ship, along with the chief officer as subordinate in charge for implementation of SOPEP on board. SOPEP also describes the plan for the master, officer and the crew of the ship to tackle various oil spill scenario that can occur on a ship. For oil tankers, action plan widens regarding the cargo handling and cargo tanks containing huge quantities of oil.
SOPEP contains the following things:

- The action plan contains duty of each crew member at the time of spill, including emergency muster and actions.
- SOPEP contains the general information about the ship and the owner of the ship etc.
- Steps and procedure to contain the discharge of oil into the sea using SOPEP equipments.
- On board Reporting procedure and requirement in case of oil spill is described.
- Authorities to contact and reporting requirements in case of oil spill are listed in SOPEP. Authorities like port state control, oil clean up team etc are to be notified.

- SOPEP includes drawing of various fuel lines, along with other oil lines on board vessel with positioning of vents, save all trays etc.
- General arrangement of ship is also listed in SOPEP, which includes location of all the oil tanks with capacity, content etc.
- The location of the SOPEP locker and contents of the locker with a list of inventory.

**MARPOL Annex II - Carriage of noxious liquid substances in bulk:** Carriage of chemicals in bulk is covered by regulations in SOLAS Chapter VII - Carriage of dangerous goods and MARPOL Annex II - Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. Both Conventions require chemical tankers built after 1 July 1986 to comply with the International Bulk Chemical Code (IBC Code), which sets out the international standards for the safe carriage, in bulk by sea, of dangerous chemicals and noxious liquid substances. The Code prescribes the design and a construction standard of ships involved in the transport of bulk liquid chemicals and identifies the equipment to be carried to minimize the risks to the ship, its crew and to the environment, with regard to the nature of the products carried. The IBC Code sets out a list chemicals and their hazards, and identifies both the ship type required to carry that product and the environmental hazard rating.

MARPOL Annex II Regulations for the control of pollution by noxious liquid substances in bulk sets out a pollution categorization system for noxious and liquid substances. The four categories are:

- Category X: Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a major hazard to either marine resources or human health and, therefore, justify the prohibition of the discharge into the marine environment;
- Category Y: Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify a limitation on the quality and quantity of the discharge into the marine environment;
- Category Z: Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a minor hazard to either marine resources or human health and therefore justify less stringent restrictions on the quality and quantity of the discharge into the marine environment; and

- Other Substances: substances which have been evaluated and found to fall outside Category X, Y or Z because they are considered to present no harm to marine resources, human health, amenities or other legitimate uses of the sea when discharged into the sea from tank cleaning of deballasting operations. The discharge of bilge or ballast water or other residues or mixtures containing these substances are not subject to any requirements of MARPOL Annex II.

**MARPOL Annex III - Chemicals carried in packaged form:** Chemicals which are carried in packaged form, in solid form or in bulk are regulated by Part A of SOLAS Chapter VII - Carriage of dangerous goods, which includes provisions for the classification, packing, marking, labelling and placarding, documentation and stowage of dangerous goods. MARPOL Annex III also sets out regulations for the prevention of pollution by harmful substances in packaged form and includes general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications for preventing pollution by harmful substances. For the purpose of Annex III, "harmful substances" are those identified as "marine pollutants" in the IMDG Code. Both SOLAS and MARPOL refer to the International Maritime Dangerous Goods (IMDG) Code, which was developed by IMO as a uniform international code for the transport of dangerous goods by sea

The International Maritime Dangerous Goods (IMDG) Code was adopted in 1965 as per the SOLAS (Safety for Life at Sea) Convention of 1960. The **IMDG Code** was formed to prevent all types of pollutions at sea. The code also ensures that the goods transported through marine transport are packaged in such a way that they can be safely transported. The **dangerous goods code** is a uniform code. This means that the code is applicable for all cargo-carrying ships around the world. Shipping dangerous goods is very tricky. This is why in order to avoid complications and problems while categorising the aspect and level of danger, there is a set of classification of the dangerous goods. There are nine categories in which the dangerous goods are classified. The same can be explained as follows:


- **Class 1: Explosives**

Subclass 1.1: Explosives with a mass explosion hazard

Consists of explosives that have a mass explosion hazard. A mass explosion is one which affects almost the entire load instantaneously.

Subclass 1.2: Explosives with a severe projection hazard

Consists of explosives that have a projection hazard but not a mass explosion hazard.

Subclass 1.3: Explosives with a fire

Consists of explosives that have a fire hazard and either a minor blast hazard or a minor projection hazard or both but not a mass explosion hazard.

Subclass 1.4: Minor fire or projection hazard

Consists of explosives that present a minor explosion hazard. The explosive effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire must not cause virtually instantaneous explosion of almost the entire contents of the package.

Subclass 1.5: An insensitive substance with a mass explosion hazard

Consists of very insensitive explosives with a mass explosion hazard (explosion similar to 1.1). This division is comprised of substances which have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport.

Subclass 1.6: Extremely insensitive articles
Consists of extremely insensitive articles which do not have a mass explosive hazard. This division is comprised of articles which contain only extremely insensitive detonating substances and which demonstrate a negligible probability of accidental initiation or propagation.

- **Class 2 :Gases**

Subclass 2.1: Flammable Gas
Gases which ignite on contact with an ignition source, such as acetylene and hydrogen. Flammable gas gas means any material which is ignitable at 101.3 kPa (14.7 psi) when in a mixture of 13 percent or less by volume with air, or has a flammable range at 101.3 kPa (14.7 psi) with air of at least 12 percent regardless of the lower limit.

Subclass 2.2: Non-Flammable Gases
Gases which are neither flammable nor poisonous. Includes the cryogenic gases/liquids (temperatures of below -100°C) used for cryopreservation and rocket fuels. This division includes compressed gas, liquefied gas, pressurized cryogenic gas, compressed gas in solution, asphyxiant gas and oxidizing gas. A non-flammable, non-poisonous compressed gas means any material which exerts in the packaging an absolute pressure of 280 kPa (40.6 psia) or greater at 20°C (68°F), and does not meet the definition of Division 2.1 or 2.3.

Subclass 2.3: Poisonous Gases
Gases liable to cause death or serious injury to human health if inhaled. Gas poisonous by inhalation means a material which is a gas at 20°C or less and a pressure of 101.3 kPa (a material which has a boiling point of 20°C or less at 101.3kPa (14.7 psi)) which is known to be so toxic to humans as to pose a hazard to health during transportation, or in the absence f adequate data on human toxicity, is presumed to be toxic to humans because when tested on laboratory animals it has an LC50 value of not more than 5000 ml/m3.

- **Class 3:Flammable Liquids**

A flammable liquid means a liquid which may catch fire easily or any mixture having one or more components with any flash point. As example: acetone, diesel, gasoline, kerosene, oil etc. There is strongly recommended for transportation at or above its flash point in a bulk packaging. There are three main groups of flammable liquid.

I. Low flash point - liquids with flash point below -18°C
II. Intermediate flash point - liquids with flash point from -18°C. up to +23°C
III. High flash point group - liquids with flash point from +23°C

- **Class 4:Flammable solids or substances**

Subclass 4.1: Flammable solids
Solid substances that are easily ignited. Self-reactive materials, which are thermally unstable and that can undergo a strongly exothermic decomposition even without participation of air. Readily combustible solids that can cause a fire through friction and show a burning rate faster than 2.2 mm (0.087 inches) per second, or metal powders that can be ignited and react over the whole length of a sample in 10 minutes or less.

Subclass 4.2: Spontaneously combustible solids
Solid substances that ignite spontaneously. Spontaneously combustible material is a pyrophoric material, which is a liquid or solid that can ignite within five minutes after coming in contact with air or a self-heating material that when in contact with air and without an energy supply is liable to self-heat.

Subclass 4.3: Dangerous when wet
Solid substances that emit a flammable gas when wet. Dangerous when wet material is a material that when it makes contact with water is liable to become spontaneously flammable or give off flammable or toxic gas at a rate greater than 1 L per kilogram of the material per hour.

- **Class 5: Oxidizing substances and organic peroxides**

Subclass 5.1: Oxidizing agent
Oxidizing agent means a material that may, generally by yielding oxygen, cause or enhance the combustion of other materials.

Subclass 5.2: Organic peroxide oxidizing agent
Organic peroxide means any organic compound containing oxygen in the bivalent structure and which may be considered a derivative of hydrogen peroxide, where one or more of the hydrogen atoms have been replaced by organic radicals.

- **Class 6:Toxic and infectious substances**

Subclass 6.1: Poison

Toxic substances which are able to cause death or serious hazard to humans health during transportation.

Subclass 6.2: Biohazard

Infectious Substance material is known to contain or suspected of containing a pathogen. Infectious substances are substances which are known or are reasonably expected to contain pathogens. Pathogens are defined as micro-organisms (including bacteria, viruses, rickettsiae, parasites, fungi) and other agents such as prions, which can cause disease in humans or animals.

- **Class 7:Radioactive substances**

Radioactive substances comprise substances or a combination of substances which emit ionizing radiation

- **Class 8:Corrosive substances**

Corrosive materials mean a liquid or solid that causes full thickness destruction of human skin at the site of contact within a specified period of time. A liquid that has a severe corrosion rate on steel or aluminium is also a corrosive material.

- **Class 9: Miscellaneous dangerous substances and articles**

A material which presents a hazard during transportation but which does not meet the definition of any other hazard class. This class includes: any material which has an anesthetic, noxious or other similar property which could cause extreme annoyance or discomfort to a flight crew member so as to prevent the correct performance of assigned duties or material for an elevated temperature material, a hazardous substance, a hazardous waste, or a marine pollutant.

**MARPOL Annex IV - Prevention of Pollution by Sewage from Ships:** Annex IV contains a set of regulations regarding the discharge of sewage into the sea from ships, including regulations regarding the ships' equipment and systems for the control of sewage discharge, the provision of port reception facilities for sewage, and requirements for survey and certification. It is generally considered that on the high seas, the oceans are capable of assimilating and dealing with raw sewage through natural bacterial action. Therefore, the regulations in Annex IV of MARPOL prohibit the discharge of sewage into the sea within a specified distance from the nearest land, unless otherwise provided. Governments are required to ensure the provision of adequate reception facilities at ports and terminals for the reception of sewage, without causing delay to ships. The Annex entered into force on 27 September 2003. A revised Annex IV was adopted on 1 April 2004 and entered into force on 1 August 2005. The revised Annex applies to new ships engaged in international voyages of 400 gross tonnage and above or which are certified to carry more than 15 persons. Existing ships are required to comply with the provisions of the revised Annex IV five years after the date of entry into force of Annex IV, namely since 27 September 2008. The Annex requires ships to be equipped with either an approved sewage treatment plant or an approved sewage comminuting and disinfecting system or a sewage holding tank. The discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land. Sewage which is not comminuted or disinfected may be discharged at a distance of more than 12 nautical miles from the nearest land, and the rate of discharge of untreated sewage shall be approved by the Administration. The MEPC also adopted a standard for the maximum rate of discharge of untreated sewage from holding tanks at a distance of more than 12 nautical miles from the nearest land.

**MARPOL Annex V - Prevention of Pollution by Garbage from Ships:** The MARPOL Convention seeks to eliminate and reduce the amount of garbage being discharged into the sea from ships. Unless expressly provided otherwise, Annex V applies to all ships, which means all vessels of any type whatsoever operating in the marine environment, from merchant ships to fixed or floating platforms to non-commercial ships like pleasure crafts and yachts. Although the Annex is optional1, it did receive a sufficient number of ratifications to enable entry into force on 31 December 1988. The original version of Annex V prohibited the disposal of plastics anywhere into the sea, and severely restricted discharges of other garbage from ships in coastal waters and “Special Areas”. The revised Annex V now generally prohibits the discharge of all garbage into the sea, except as provided otherwise in regulations 4, 5, and 6 of the Annex, which are related to food waste, cargo residues, cleaning agents and additives and animal carcasses. An overview of the revised MARPOL Annex V discharge provisions can be accessed here. Exceptions with respect to the safety of a ship and those on board and accidental loss are contained in regulation 7 of Annex V. Under the revised MARPOL Annex V, garbage includes all kinds of food, domestic and operational waste, all plastics, cargo residues, incinerator ashes, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship and liable to be disposed of continuously or periodically. Garbage does not include fresh fish and parts thereof generated as a result of fishing activities undertaken during the voyage, or as a result of aquaculture activities. The effectiveness of ships to comply with the discharge requirements of MARPOL depends largely upon the availability of adequate port reception facilities, especially within special areas. Hence, the Annex also obliges Governments to ensure the provision of adequate reception facilities at ports and terminals for the reception of garbage without causing undue delay to ships, and according to the needs of the ships using them.

**MARPOL Annex VI - Prevention of air pollution from Ships:** In 1997, a new annex was added to the International Convention for the Prevention of Pollution from Ships (MARPOL). The regulations for the Prevention of Air Pollution from Ships (Annex VI) seek to minimize airborne emissions from ships (SOx, NOx, ODS, VOC shipboard incineration) and their contribution to local and global air pollution and environmental problems. Annex VI entered into force on 19 May 2005 and a revised Annex VI with significantly tightened emissions limits was adopted in October 2008 which entered into force on 1 July 2010.

In Annex I Prevention of pollution by oil, Annex II Control of pollution by noxious liquid substances, Annex IV Prevention of pollution by sewage from ships and Annex V Prevention of pollution by garbage from ships, MARPOL defines certain sea areas as "**special areas**" in which, for technical reasons relating to their oceanographical and ecological condition and to their sea traffic, the adoption of special mandatory methods for the prevention of sea pollution is required. Under the Convention, these special areas are provided with a higher level of protection than other areas of the sea. Annex VI Regulations for the Prevention of Air Pollution from Ships establishes certain sulphur oxide (SOx) Emission Control Areas with more stringent controls on sulphur emissions and nitrogen oxides (NOx) Emission Control Areas for Tier III NOx emission standards.

**Annex I Oil:** Mediterranean Sea, Baltic Sea, Black Sea, Red Sea, "Gulfs" area, Gulf of Aden, Antarctic area, North West European Waters, Oman area of the Arabian Sea, Southern South African waters.

**Annex II Noxious Liquid Substances**: Antarctic area.

**Annex IV Sewage**: Baltic Sea.

**Annex V Garbage**: North Sea, Mediterranean Sea, Baltic Sea, Black Sea, Red Sea, "Gulfs" area, Antarctic area (south of latitude 60 degrees south), Wider Caribbean region including the Gulf of Mexico and the Caribbean Sea.

**Annex VI Prevention of air pollution by ships (Emission Control Areas):** Baltic Sea (SOx), North Sea (SOx), North American ECA (SOx and PM), United States Caribbean Sea ECA (SOx and PM)

A **Particularly Sensitive Sea Area (PSSA)** is an area that needs special protection through action by IMO because of its significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities. The criteria for the identification of particularly sensitive sea areas and the criteria for the designation of special areas are not mutually exclusive. In many cases a Particularly Sensitive Sea Area may be identified within a Special Area and vice versa.

The following PSSAS have been designated:

- The Great Barrier Reef, Australia (designated a PSSA in 1990)
- The Sabana-Camagüey Archipelago in Cuba (1997)
- Malpelo Island, Colombia (2002)
- The sea around the Florida Keys, United States (2002)
- The Wadden Sea, Denmark, Germany, Netherlands (2002)
- Paracas National Reserve, Peru (2003)
- Western European Waters (2004)
- Extension of the existing Great Barrier Reef PSSA to include the Torres Strait (proposed by Australia and Papua New Guinea) (2005)
- Canary Islands, Spain (2005)
- The Galapagos Archipelago, Ecuador (2005)
- The Baltic Sea area, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden (2005)
- The Papahānaumokuākea Marine National Monument, United States (2007)
- The Strait of Bonifacio, France and Italy (2011)
- The Saba Bank, in the North-eastern Caribbean area of the Kingdom of the Netherlands (2012)
- Extension of Great Barrier Reef and Torres Strait to encompass the south-west part of the Coral Sea (2015)
- The Jomard Entrance, Papua New Guinea (2016)

**Sulphur Emission Control Areas (SECAs)** or **Emission Control Areas (ECAs)** are sea areas in which stricter controls were established to minimize airborne emissions (SOx, NOx, ODS, VOC) from ships as defined by Annex VI of the 1997 MARPOL Protocol which came into effect in May 2005. Annex VI contains provisions for two sets of emission and fuel quality requirements regarding SOx and PM, or NOx, a global requirement and more stringent controls in special Emission Control Areas (ECA). These regulations stemmed from concerns about the contribution of the shipping industry to "local and global air pollution and environmental problems." By July 2010 a revised more stringent Annex VI was enforced with significantly tightened emissions limits. As of 2011 there were four existing ECAs: the Baltic Sea, the North Sea,[4] the North American ECA, including most of US and Canadian coast and the US Caribbean ECA. Also other areas may be added via protocol defined in Annex VI. ECAs with nitrogen oxides thresholds are denoted as Nitrogen Oxide Emission Control Areas (NECAs).

As of 2011 there were four existing ECAs: the Baltic Sea, the North Sea, the North American ECA, including most of US and Canadian coast and the US Caribbean ECA

## 2. Pollution Preparedness and Response

Good prevention initiatives can go a long way in reducing the risk of pollution from ships. However, in spite of best efforts, spills will inevitably occur. When this happens, it is necessary to ensure that effective preparedness measures are in place that will ensure a timely and coordinated response to limit the adverse consequences of pollution incidents involving oil and hazardous and noxious substances (HNS). The International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 (OPRC 90) is the international instrument that provides a framework designed to facilitate international co-operation and mutual assistance in preparing for and responding to major oil pollution incidents and requires States to plan and prepare by developing national systems for pollution response in their respective countries, and by maintaining adequate capacity and resources to address oil pollution emergencies.

## 3. Ballast Water Management

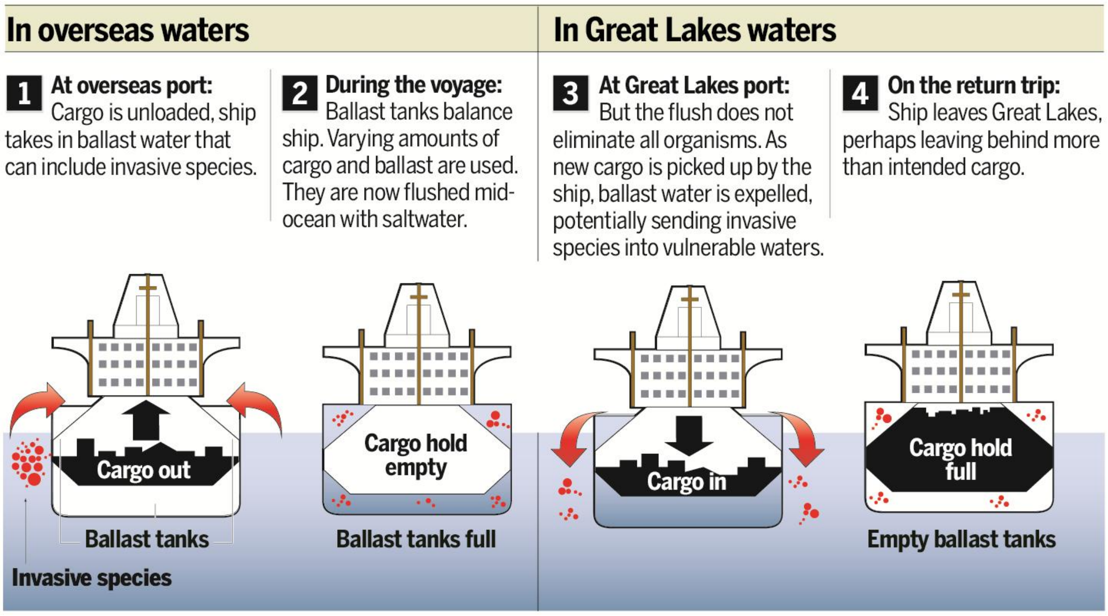
What is ballast water: Ballast water is used to stabilise vessels and maintain their structural integrity. Typically ballast water is pumped in to special tanks while cargo is being unloaded, and discharged while cargo is being taken on board. Safety, weather conditions, the ship's load, and the route taken are the primary factors that determine how much ballast water is taken on board a vessel for a particular voyage. More ballast is necessary for ships to sit lower in the water during stormy weather to avoid bottom impact from waves. Ballast water is also adjusted so as to balance the ship as it consumes fuel during a long voyage.

What is ballast water treatment: Ballast water treatment is the process of treating ballast water in order to actively remove, kill and /or inactivate organisms prior to discharge. Ballast water treatment is different from the older process of ballast water exchange, which involved completely flushing the ballast water tanks during voyages in open water with sufficient water depth and distance from shore.

Why is ballast water treatment needed: Ballast water taken on in one ecological zone and released into another can introduce invasive and nuisance aquatic species that may have detrimental impacts on the biodiversity, economy or human health of the receiving community and may in time become a serious threat to the environment. Bio-invasion is one of the four greatest threats to the world's oceans today, alongside land-based sources of marine pollution, the over exploitation of living marine resources and the physical alteration and destruction of marine habitats. More than 90 per cent of global trade is carried by sea, and each year transfers of up to 12 billion tonnes of ballast water take place around the world. In order to reduce the incidence of bio-invasions, ballast water treatment reduces or renders inactive 99.9% of the living organisms in the ballast water.

What is included in the type approval process: Technologies developed for ballast water treatment are subject to approval through specific processes and testing guidelines designed to ensure that such technologies meet the relevant standards. The approval consists of both land-based testing of a production model to prove that the discharge standards are met, and shipboard testing to prove that the system works in service.

How can the transport of small organisms evolve into such huge problems: There are thousands of marine species that can be carried in ships' ballast water; basically anything that is small enough to pass through a ship's ballast water intake ports and pumps. The problem is compounded by the fact that virtually all marine species have life cycles that include a planktonic stage or stages. Even species in which the adults are unlikely to be taken on in ballast water, for example because they are too large or live attached to the seabed, may be transferred in ballast water during their planktonic phase. The biodiversity, large numbers and prevalence of a planktonic phase for most species, are the primary factors that significantly increase the risk of bio-invasion via ballast water transfer.




A number of factors are taken into account for choosing a ballast water treatment system for a ship. Some of the main factors taken into consideration are:

- Effectiveness on ballast water organisms
- Environment-friendliness
- Safety of the crew
- Cost effectiveness
- Ease of installation and operation
- Space availability on board

The main types of ballast water treatment technologies available in the market are:

1. Filtration Systems (physical): Physical separation or filtrations systems are used to separate marine organisms and suspended solid materials from the ballast water using sedimentation or surface filtration systems. The suspended/filtered solids and waste (backwashing) water from the filtration process is either discharged in the area from where the ballast is taken or further treated on board ships before discharging.
2. Chemical Disinfection (oxidizing and non-oxidizing biocides): Biocides (Oxidizing and non-oxidizing) are disinfectants which have been tested to potentially remove invasive organisms from ballast water. Biocides removes or inactivates marine organisms in the ballast water. However, it is to note that the biocides used for ballast water disinfectant purpose must be effective on marine organisms and also readily degradable or removable to prevent discharge water from becoming toxic in nature.
   On the basis of their functions, biocides are mainly divided into two types:
   - Oxidizing

- Non-Oxidizing

Oxidizing biocides: Oxidizing biocides are general disinfectants such as chlorine, bromine, and iodine used to inactivate organisms in the ballast water. This type of disinfectants act by destroying organic structures of the microorganisms such as cell membrane or nucleic acids.

Non-oxidizing biocides: Non-oxidizing biocides are a type of disinfectants which when used interfere with reproductive, neural or metabolic functions of the organisms.

3. Ultra-violet treatment: Ultraviolet ballast water treatment method consists of UV lamps which surround a chamber through which the ballast water is allowed to pass. The UV lamps (Amalgam lamps) produce ultraviolet rays which acts on the DNA of the organisms and make them harmless and prevent their reproduction. This method has been successfully used globally for water filtration purpose and is effective against a broad range of organisms.
4. Deoxygenation treatment: As the name suggests, the deoxygenation ballast treatment method involves purging/removing of oxygen from the ballast water tanks to make the organisms asphyxiated. This is usually done by injecting nitrogen or any other inert gas in the space above the water level in the ballast tanks.
5. Heat (thermal treatment): This treatment involves heating the ballast water to reach a temperature that will kill the organisms. A separate heating system can be utilized to heat the ballast water in the tanks or the ballast water can be used to cool the ship’s engine, thus disinfecting the organisms from the heat acquired from the engine. However, such treatment can take a lot of time before the organisms become inactive and would also increase the corrosion in the tanks.
6. Acoustic (cavitation treatment): Ultrasonic energy is used to produce high energy ultrasound to kill the cells of the organisms in ballast water. Such high pressure ballast water cavitation techniques are generally used in combination with other systems.
7. Electric pulse/pulse plasma systems: The electric pulse /plasma for ballast water treatment is still in the development stage. In this system, short bursts of energy are used to kill the organisms in ballast water.

   In the pulse electric field technology, two metal electrodes are used to produce energy pulse in the ballast water at very high power density and pressure. This energy kills the organisms in the water.

   In electric plasma technology, high energy pulse is supplied to a mechanism placed in the ballast water, generating a plasma arc and thus killing the organisms.

   Both these methods are said to have almost the same effect on the organisms.
8. Magnetic Field Treatment: The magnetic field treatment uses the coagulation technology. Magnetic powder is mixed with the coagulants and added to the ballast water. This leads to the formation of magnetic flocs which includes

marine organisms. Magnetic Discs are used to separate these magnetic flocks from the water.

## 4. Anti-fouling systems

The International Convention on the Control of Harmful Anti-fouling Systems on Ships, which was adopted on 5 October 2001, will prohibit the use of harmful organotin compounds in anti-fouling paints used on ships and will establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems. The Convention entered into force on 17 September 2008. Under the terms of the Convention, Parties to the Convention are required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party. Annex I attached to the Convention states that by an effective date of 1 January 2003, all ships shall not apply or re-apply organotins compounds which act as biocides in anti-fouling systems, and by 1 January 2008 (effective date), ships either:

(a) shall not bear such compounds on their hulls or external parts or surfaces; or

(b) shall bear a coating that forms a barrier to such compounds leaching from the underlying non-compliant anti-fouling systems.

This applies to all ships (except fixed and floating platforms, floating storage units (FSUs), and floating production storage and off-loading units (FPSOs) that have been constructed prior to 1 January 2003 and that have not been in dry-dock on or after 1 January 2003. Ships of above 400 gross tonnage and above engaged in international voyages (excluding fixed or floating platforms, FSUs and FPSOs) will be required to undergo an initial survey before the ship is put into service or before the International Anti-fouling System Certificate is issued for the first time; and a survey when the anti-fouling systems are changed or replaced.

## 5. Ship Recycling

When ships reach the end of their working lives, recycling is the most environmentally friendly way to dispose of them. Many of the components and virtually all of the steel are re-used in the countries where the ships are recycled, into new ships, in agriculture, in hospitals, at homes, and in other products. However, there are concerns about environmental and working conditions in ship recycling yards. In May 2009, IMO adopted the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 (the Hong Kong Convention). The new Convention balances safety and environmental concerns with the commercial realities of seaborne trade and the ship recycling industry. Following the adoption of the Convention, Member States of IMO will need:

- to initiate work to accede to the Convention at the earliest possible opportunity so as to expedite its entry into force;
- to initiate action to provide technical assistance to requesting countries without awaiting the Convention's entry into force; and
- to initiate action, as may be necessary, to ensure the effective implementation and proper enforcement of the Convention when it comes into force.

Currently IMO is working on the development and adoption of guidelines associated with the Hong Kong Convention. Six guidelines are envisaged by the Convention. The "guidelines on the development of the Inventory of Hazardous Materials" and the "guidelines for the development of the Ship Recycling Plan" have already been adopted. The remaining guidelines are expected to be finalized and adopted during 2012.

## 6. Reception facilities

IMO has recognized that provision of reception facilities is crucial for effective MARPOL implementation, and the Marine Environment Protection Committee (MEPC) has strongly encouraged Member States, particularly those Parties to MARPOL as port States, to fulfil their treaty obligations on providing adequate reception facilities. In March 2006, MEPC 54 emphasized the importance of adequate reception facilities in the chain of implementation of MARPOL, and stated that the policy of "zero tolerance of illegal discharges from ships" could only be effectively enforced when there were adequate reception facilities in ports. Therefore the Committee urged all Parties to MARPOL, particularly port States, to fulfil their treaty obligations to provide reception facilities for wastes generated during the normal operation of ships. The Committee also agreed to develop a port reception facility database (PRFD) as a module of the IMO Global Integrated Shipping Information System (GISIS). The PRFD was designed to allow Member States to update the Database via a log-in password, and to allow the public to access all the information in the Database on a view-only basis. The Database went live to the public on 1 March 2006.

# ΒΙΒΛΙΟΓΡΑΦΕΙΑ


1.1.1 Article: Ship pollution

1.1.2 Article: Ocean acidification

1.1.3 Article: Eutrophication

1.1.4 Article: Marine debris

1.1.5 Article: Mercury in fish

1.1.6 Article: Marine mammals and sonar

http://www.damengreen.com/en/bwt#regulations

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