MARINE ENVIRONMENTAL AWARENESS (IMO Model Course 1.38)

In accordance with the STCW 78 Convention, as amended

INTRODUCTION

Part A: Course framework

Scope

This course covers the awareness on the prevention of pollution on board the vessel and laws concerning pollution. Individual topics include MARPOL, US and state/local laws, criminal liabilities on violation of laws, documentation and record keeping, pollution and the marine environment, and the EPA's Vessel General Permit computer based training.

Course Framework

This knowledge and understanding shall include, but is not limited to the following topics:

- concept of sustainable shipping
- complexity and diversity of the marine environment
- impact of shipping on the environment
- role of regulations, procedures and technical installations to protect the environment
- marine environmental awareness, personal responsibility
- role of human element to prevent pollution, proactive measures.
- updating with new MARPOL regulations

Those who have successfully completed the course shall demonstrate the intention to:

- fully observe procedures for monitoring ship-board operations and ensure compliance with requirements for environmental protection
- act to ensure that the positive environmental reputation of shipping is maintained.

General objectives

Those who have successfully completed the course will be able to demonstrate knowledge and understanding of the importance of preventing pollution to the (marine) environment.
This course is based on IMO Model course 1.38

Entry standards

The course is designed for officers and officers in charge of a navigational or an engineering watch.

Course certificate

On suscessful completion of the course appropiate documenatry evidence is required to be issued to the trainee.

Course intake limitations

The maximum number of trainees attending each session will be 20 persons.

Target audience

Sea staff and shore staff
of maritime businesses who wish to:

- work on their environmental performance by investing in the human element
- examine how economic and ecological sustainability can go hand in hand
- invest in environmental awareness training as part of the implementation of an Environmental Management System (such as ISO 14001)

Why this course?

Shipping has great potential to be a clean mode of transport. Besides regulations, technical installations and operational procedures, sustainable shipping and protection of the marine ecosystem require the competence of maritime personnel. The IMO, aware of the importance of this 'human element', added the involvement of seafarers in the 'prevention of pollution' to the STCW Code requirements (2010 Manilla amendments).

Summarised course objectives

Those who have successfully completed the course will be able to demonstrate knowledge and understanding of the importance of preventing pollution to the (marine) environment.
Those who have successfully completed the course shall demonstrate the intention to:

- fully observe procedures for monitoring ship-board operations and ensure compliance with requirements for environmental protection
- act to ensure that the positive environmental reputation of shipping is maintained

Staff requirements

The instructor in charge shall have had training and /or equivalent knowledge in the subject matter of this course, including but not limited to sustainable shipping, the marine evironment, impact of shipping on the environment, and role of regulations, procedures, technical installations and the human element in protecting the environement.

Teaching facilities and equipment

The facilities should include additional rooms for break-out discussion groups, as well as the usual equipment such as overhead projection, interactive whiteboard, flip charts and access to computer terminals. Learning materials should include Marine Environmental Awareness materials, including computer based training presentations and hard copy handouts, together with internet access and access to relevant library books and other publications.

Teaching aids

A1 Facilitator manual
A2 Assessment and evaluation

Bibliography

The following suggested textbooks and websites are recommended for developing knowledge and understanding of environmental awareness.

- Model Course 1.38

Part B: Course outline and timetable

Course outline

Subject area and topics	Hours (film/lecture)	Workshop
1 Introduction **1 Introduction** 1.1. Introduction 1.2. General objectives 1.3. Global context 1.4. Climate change 1.5. Sustainable shipping 1.6. Course overview 1.7. Opinions **2 Marine environment** 2.1. Importance of the oceans 2.2. Role of the oceans in human life 2.3. Marine ecology – the basics 2.4. Open ocean and coastal seas 2.5. Regional marine areas	0.5 1	1
3 Discharges to the Sea 3.1. Environmental impact of oil, chemicals, sewage and solid waste 3.2. Pollution prevention measures	2.5	
4 Emissions to air, greenhouse gases 4.1. Environmental impact of emissions of greenhouse gases 4.2. Pollution prevention measures	.75	
5 Introduction of invasive species 5.1. Environmental impact of transfer of species 5.2. Pollution prevention measures	1.0	

6 Other impacts to the marine environment 6.1. Environmental impact of underwater noise 6.2. Environmental impact of antifouling paint **7 Emissions to air and other pollutants** 7.1. Environmental impact of engine emissions (SOx, NOx, PM) 7.2. Other air pollutants from ships 7.3. Pollution prevention measures	1.0 .75	 1.5
8 Personal involvement 8.1. Personal behavior 8.2. Personal responsibility 8.3. Officer responsibility		2
Subtotal	**7.5**	**4.5**
Total	**12HOURS**	

Course Timetable

The following timetable for a 12 hour course should be considered indicative and adjusted in accordance with the needs of course participants.

Days	Day 1 – (5.75 Hours) Day 2 – (6.25 Hours)
Day 1 **(5.75 Hours)**	**1.Introduction** • Introduction • General objectives • Global context • Climate change • Sustainable shipping • Course overview • Opinions **2. Marine environment** • Importance of the oceans • Role of the oceans in human life • Marine ecology – the basics • Open ocean and coastal seas **3. Discharges to the Sea** • Environmental impact of oil, chemicals, sewage and solid waste Pollution prevention measures **4.Emissions to air, greenhouse gases** • Environmental impact of emissions of greenhouse gases • Pollution prevention measures

Day 2-**(6.25 Hours)**

5. Introduction of invasive species

- Environmental impact of transfer of species
- Pollution prevention measures

6. Other impacts to the marine environment

- Environmental impact of underwater noise
- Environmental impact of antifouling paint

7. Emissions to air and other pollutants

- Environmental impact of engine emissions (SOx, NOx, PM)
- Other air pollutants from ships
- Pollution prevention measures

8 . Personal involvement

- Personal behavior
- Personal responsibility
- Officer responsibility

Part C: Detailed teaching programme

Learning objectives

The detailed teaching programme has been written in learning objective format in which the objective describes what the learner should do to demonstrate that knowledge has been transferred and environmental awareness has been achieved.

Knowledge, understanding and proficiency		IMO Referenc	Textbooks, Bibliography	Teaching Aid
1.	• **Introduction** • Introduction • General objectives • Global context • Climate change • Sustainable shipping • Course overview • Opinions			
2.	• **Marine environment** • Importance of the oceans • Role of the oceans in human life • Marine ecology – the basics • Open ocean and coastal seas • Regional marine áreas			
3.	• **Discharges to the Sea** • Environmental impact of oil, chemicals, sewage and solid waste • Pollution prevention measures			
4.	• **Emissions to air, greenhouse gases** • Environmental impact of emissions of greenhouse gases • Pollution prevention measures			

Knowledge, understanding and proficiency		IMO Referenc	Textbooks, Bibliography	Teaching Aid
5.	• **Introduction of invasive species** • Environmental impact of transfer of species • Pollution prevention measures			
6	• **Other impacts to the marine environment** • Environmental impact of underwater noise • Environmental impact of antifouling paint			
7	• **Emissions to air and other pollutants** • Environmental impact of engine emissions (SOx, NOx, PM) • Other air pollutants from ships • Pollution prevention measures			
8	• **Personal involvement** • Personal behavior • Personal responsibility • Officer responsibility			

1. INTRODUCTION

1.1. General

Marine environmental awareness represents the contribution of the human element to the prevention of pollution. Therefore, marine environmental awareness training brings together two important aspects of modern shipping:

- care for the marine environment and the
- importance of human performance.

The IMO Strategic Plan for the Organization for the six-year period 2010 to 2015 (A.1011(26)) seeks to enhance the environmental conscience of the shipping industry:

"The mission of the International Maritime Organization (IMO) as a United Nations specialized agency is to promote safe, secure, environmentally sound, efficient and sustainable shipping through cooperation"

The enhancement of a sustainable environmental policy for the shipping industry remains a high profile matter. The heightened concern at the impact of global shipping activities on the environment has given further impetus to efforts by the Organization to develop sustainable and environmentally conscious means of preventing pollution from ships, such as those aimed at reducing atmospheric pollution and addressing climate change and global warming; ensuring the preservation of aquatic systems; and preventing the introduction of harmful and polluting substances from ships into the marine environment.

The Strategic Plan also addresses human performance: "As IMO strives for full compliance with its instruments, their effectiveness will come under scrutiny with each incident resulting from human error. The challenge for IMO is to place increased emphasis on the contribution of the human element to safer, more secure and environmentally friendly shipping and continuously to improve measures aimed at enhancing human performance in the maritime industry".

IMO identified strategic directions (SD) for the Organization and states in strategic direction 7.4: "IMO will focus on reducing and eliminating any adverse impact by shipping on the environment by increasing the emphasis on the role of the human element in environmentally sound shipping.

This is exactly what this marine environmental awareness course aims to do. Marine

environmental awareness training offers knowledge of the importance and diversity of the marine environment as well as understanding and awareness of the impacts of shipping activities on the (marine) environment. It offers insight into the background of IMO regulations and enhances compliance. The training also stimulates personal responsibility to use solutions that contribute to environmentally sound shipping.

1.2. General objectives

Those who have successfully completed the course will be able to demonstrate knowledge and understanding of the importance of preventing pollution to the (marine) environment.

This knowledge and understanding shall include, but is not limited to the following topics:

- concept of sustainable shipping
- complexity and diversity of the marine environment
- impact of shipping on the environment
- role of regulations, procedures and technical installations to protect the environment
- marine environmental awareness, personal responsibility
- role of human element to prevent pollution, proactive measures.

Those who have successfully completed the course shall demonstrate the intention to:

- fully observe procedures for monitoring ship-board operations and ensure compliance with requirements for environmental protection
- act to ensure that the positive environmental reputation of shipping is maintained.

1.3. Global Context

Shipping is responsible for the transportation of approximately 90% of world trade and is also one of the most environmentally benign forms of transportation when considering goods transported on a tonne mile basis. However ships continue to be large producers of CO_2, SOx, and NOx emissions. Other pollutants such as wastes, persistent chemicals from anti-fouling, cleaning agents and lubricants are associated with the shipping industry to the potential detriment of the marine environment despite the growing awareness of environmental issues and corporate social responsibility with regards to shipping and the environment.

Seaborne trade continues to expand, bringing benefits for consumers across the world through low and decreasing freight costs. Thanks to the growing efficiency of shipping as a mode of transport and increased economic liberalization, the prospects for the industry's further growth continue to be strong. There are around 50,000 merchant ships trading internationally, transporting every kind of cargo.

1.4. Climate Change

In the climate change debate shipping should be regarded as the best available solution to the global need for transportation. Shipping is the most energy efficient mode of transport and the backbone of global trade. Seen in light of the enormous volume of goods carried by ships, the CO2 emissions from shipping are small. The reason for this is that for many decades shipping - even without specific regulation on this issue - has had a strong market driven incentive to focus on reduction of fuel consumption.

However the Shipping Industry fully acknowledges the need for further reduction of air emissions from shipping in terms of emissions per unit of transport work, in particular in view of the projected growth in world trade and thus seaborne transportation, and is of the opinion that the way to achieve environmental protection must be found in a holistic manner. To be successful, such an approach should take into consideration the availability of technology to reduce emissions, the need to encourage innovation and the economics of world trade. Reducing pollutants such as SOx and NOx may have a negative effect on CO2 emissions. A holistic approach to air emissions is therefore necessary to ensure an overall environmental improvement in the long term.

Global warming is, by definition, a global problem and shipping is the most global of all industries. The demand for sea transportation determines the volume of shipping and is therefore the key factor that influences the overall Green House Gas (GHG) emissions from shipping. Many independent studies have been carried out to assess the total CO2 emissions from shipping.

1.5. Sustainable or shipping

1.5.1. Definition of Sustainability

Defining sustainability is not straight forward but it is important for this project to establish a shared understanding of what is meant by the term, particularly when moving forward with a shipping framework that is entirely focused on the issue.

In 1987 the World Commission on Environment and Development developed a definition of sustainability that was subsequently incorporated into the Brundtland report (1987). It stated that:

“Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Although this definition is widely accepted, the term sustainability is not limited to one concise definition. However in the context of sustainable development, three key areas emerge, which are identified by the pillars of sustainability and include:

1. the environment,
2. the economics and
3. the society

This is often illustrated as the three P's: People, Planet and Profit. Sustainable shipping is then a balance between economic interests and preservation of the environment.

The concept of environmentally sound shipping is part of sustainable shipping. Legislation, technical installations and procedures are designed to prevent pollution from ships and minimize the impact of shipping to the environment. These can only be effective if people, the human element, have the right competences and attitude to comply with regulations and procedures and to use the technical installations in the proper way.

1.5.2. Sustainable development policies and ideals

Sustainable transport is recognized as one of the biggest challenges of the 21st century. It is recognized that whilst shipping is relatively safe and clean, compared with other transport modes, the industry does have a significant impact on the environment.

As shipping is a global industry the impacts of increasing pollution and illegal discharges are felt world-wide. However shipping is subject to less stringent environmental demands than those placed on land-based transportation and business. The precautionary principle, sustainable development policies and ideals, greater public concern about global environmental issues and pressure from other sectors all serve to reinforce the need for the industry to behave in a more sustainable manner.

To an extent this is being achieved through the Marine Environmental Protection Committee (MEPC) of the IMO using legislative instruments, codes and guidance1. In general, therefore, significant progress has been made in terms of effective environmental management, with the consensus of the wider shipping industry, but much of it is reactive and based on a command and control philosophy.

1.6. Course overview

The aim of the course is to make trainees aware of their role:

- Marine environmental awareness represents the contribution of the human element to the pollution prevention. Therefore, marine environmental awareness training brings together two important aspects of modern shipping, care for the marine environment and the importance of human performance;
- Marine environmental awareness training offers knowledge of the importance and diversity of the marine environment and understanding and awareness of the impacts of shipping activities on the (marine) environment. It offers insight in the background of IMO regulations and enhances compliance. The training stimulates personal responsibility to use solutions that contribute to environmentally sound shipping.

1.7 Opinions

2. MARINE ENVIRONMENT

2.1. Importance of the Oceans

Marine environmental awareness starts with a (personal) connection with the marine environment.

People on board ships use our seas and oceans to get from one place to the other or to transport goods around the globe. But the sea is much more. The sea holds vast amounts of life, regulates our climate, and produces 50% of the oxygen we breathe and huge amounts of fish we eat. The sea is worth getting to know in general, but especially because it is the working environment of seafarers. Therefore, they have a special relationship with and responsibility for the sea.

A basic understanding of "how the sea works" is essential in understanding the environmental impacts of shipping on the marine environment. In addition, it will also help to understand the backgrounds of environmental regulations, like the regulations set out in MARPOL and other relevant IMO conventions.

2.2. Role of the oceans in human life

Over 70% of the world's surface is covered with water – seas and oceans. On average, oceans are about 3,700 metres (12,237 feet) deep. They play a very important role for life on earth.

Oceans provide food for people worldwide. For example, fish consumption is the most important source of protein for most Asians and for 1 out of 5 Africans. In addition, over 200 million people worldwide work in the fishing industry.

Oceans affect global weather and climate by absorbing, storing, and transporting massive amounts of sun heat. Ocean currents regulate the global climate by transporting and redistributing heat across the globe.

In addition, oceans absorb large quantities of carbon dioxide (CO_2) from the air and may form a buffer for the effects of human-induced global warming. Furthermore, together with rain forests, tiny algae in the oceans produce large quantities of oxygen (O_2) that people breathe.

Besides being ecologically important, oceans and coasts are economically important for the food industry and tourism. The oceans are also a major source of fossil fuels, providing 50% of the natural gas, and 30% of the crude oil we use worldwide. Furthermore, about 90% of all world trade takes place by ships sailing across the oceans.

2.3. Marine ecology – the basics

2.3.1. Algae form the basis (primary production)

Microscopic cells of green plants (algae) are at the basis of almost all sea-life. These single celled plants are part of the plankton in the sea. Plankton is like a soup of microscopic organisms that drift along with the sea currents. The plankton algae are therefore called "phytoplankton" (phyto = plant).

These small algae are the primary producers in the sea, transforming carbon dioxide and water into glucose (sugar) by using sunlight. This process is called photosynthesis. It has oxygen as a by-product. In addition to glucose, primary producers build other substances such as proteins and fats.

2.3.2. Marine food chains

The substances generated by phytoplankton are passed on to other marine animals in the food chain. In a food chain, plants are consumed by plant-eating organisms (herbivores), which in turn are consumed by animal-eating organisms (carnivores).

A simple marine food chain starts with phytoplankton, which is eaten by microscopic animals called zooplankton (animal plankton). Zooplankton in turn is eaten by small fish, such as sardines, that filter the plankton. Larger fish, such as tuna, consume these small fish. In this example, tuna are the predators at the top of the food chain.

Energy can also be transferred from phytoplankton to large predators via benthos; organisms living at or near the sea floor. For instance, mussels or worms filter zooplankton out of the seawater. These mussels or worms (benthic organisms) are in turn eaten by small fish, which are eaten by bigger fish, etc.

2.3.3. The 10 per cent rule

Organisms use a large part of their energy for basic life processes, such as basic cellular processes, movement, breathing, eating and reproduction. About 90% of the energy of the ingested food is used up to fuel such processes, or lost in the form of heat. Only 10% of the energy gained from food is used to grow: to gain biomass. When an animal is eaten, it is the organic material from this 10% weight
gain that is passed on to the next level in the food chain. Hence, as a rule, only 10% of the energy is passed on from one level in the food chain to the next. This means that in every step in the food chain, 90% of the energy is lost.

This 10 per cent rule means that you need quite a lot of algae at the base of the food chain to produce one big tuna at the top of the food chain. Let's imagine the following food chain: phytoplankton – copepods (zooplankton) – small fish – tuna. To produce 1 kilo of tuna, it takes 10 kilos small fish to feed the tuna, which takes
100 kilos of copepods to feed the small fish, and finally 1,000 kilos of phytoplankton

to feed the copepods.

Because of this energy loss, food chains are in fact like pyramids. Many small organisms at the base of the food chain feed fewer large animals at the top.

2.3.4. Bacteria make food chains circular

Food chains actually are not a straight line; they are circular, because nutrients are recycled. Here, bacteria play an important role. At every level of the food chain, waste is produced, such as faeces and dead organisms. Bacteria break down the waste produced in the food chain, by which nutrients and carbon are released and can re-enter the food chain via the primary producers. Large amounts of bacteria are needed to get this job done. One ml of seawater contains over 1 million bacteria.

2.3.5. The role of viruses in marine food chains

There are even more viruses than bacteria in the sea. These viruses also play an important role in the recycling of nutrients. That is because most marine viruses are pathogens of bacteria, phytoplankton and zooplankton. After viruses kill these organisms, bacteria break down the dead tissues, releasing nutrients and carbon that can be re-used.

2.3.6. Food chains connected in food web

All the food chains in the sea are connected with each other in more complex food webs. After all, most organisms eat more than one type of food and can be eaten by more than one type of predator.

When one species becomes more or less abundant due to whatever reason, this is likely to have an effect on the abundance of other species in the food web.

2.4. Open ocean and coastal seas

The sea consists of areas with very different characteristics. The oceans can roughly be divided into open oceans and coastal seas.
The coastal ocean is the shallow (<200 m) sea area above the continental shelf. These waters contain many nutrients, due to run-off from rivers. The open ocean is relatively deep – on average 3.5 km. It is a nutrient-poor environment.

Besides availability of nutrients, there are also physical differences between open oceans and coastal seas, such as penetration of sunlight, temperature, salinity, and mixing of water layers. This ensures that the living conditions for marine life in open oceans are very different compared to coastal areas. The different characteristics lead to differences between open oceans and coastal seas when considering (1) types of plankton, (2) levels of primary production, and (3) lengths of food chains.

2.4.1. Phytoplankton types

For phytoplankton to grow, sunlight and nutrients are essential.

In open oceans, where nutrient-levels are low and where there is little movement and transfer of water between deeper and shallower water levels, plankton is small and round. Only the very small phytoplankton cells can survive in these nutrient-poor and stable waters. Being small means being light, meaning that the risk of sinking to deeper, darker waters where no sunlight penetrates is minimized.

In coastal areas, where nutrient-levels are higher and where water layers are relatively well mixed, plankton is large and has more complex shapes. To prevent being eaten, they often have an external skeleton made of glass, sometimes with large spines. Since the water in a coastal area is turbulent, the heavier cells that sink to the bottom have a big chance to reach the surface again along with the water movement, where they receive enough sunlight to grow.

2.4.2. Primary production levels

Coastal areas have very good conditions for phytoplankton growth, including abundance of nutrients. This results in relatively high levels of primary production. Open oceans have relatively low levels of primary production, because of the limited availability of nutrients, such as nitrates, but also due to the lack of microelements, such as iron.

2.4.3. Food chain lengths

In coastal areas, where phytoplankton is relatively large, and primary production is relatively high, food chains basically have four levels. In the open ocean, plankton is much smaller, and therefore the animals that eat this phytoplankton are smaller as well. Therefore, the food chains are generally longer in open oceans, with around six levels.

This means that in an open ocean area, more phytoplankton is needed to produce the same amount of predatory fish at the top of the food chain, when compared to coastal areas. As a result, in coastal areas more fish (in kilograms – biomass) can be found compared to open ocean areas.

2.5. Regional marine areas

A regional marine area can be, for instance, a tropical marine area (with mangroves, sea grass beds, and coral reefs), a rocky shoreline, or a local intertidal wetland or estuary.

2.5.1. Particularly Sensitive Sea Areas (PSSAs)

The International Maritime Organization (IMO) has two instruments to protect sea areas from shipping activities: PSSAs (Particularly Sensitive Sea Areas) and Special Areas. The latter are always coupled to MARPOL Annexes. Below, the focus is on PSSAs.

A PSSA is a marine area that needs special protection because it has important ecological, social, cultural, economic, scientific or educational characteristics, which may be vulnerable to damage by international shipping activities. PSSAs are established by the IMO. When an area is approved as a PSSA, specific measures must be used to control the maritime activities in that area. Such measures can be routing measures, mandatory piloting, reporting systems, speed restrictions, and strict application of MARPOL discharge and equipment requirements for ships, such as oil tankers.

PSSAs are different from other marine protected areas (MPAs) because PSSAs only protect the marine environment against shipping activities. Other MPAs can, for instance, also protect against impacts from fishing or other industries.

Worldwide, 12 PSSAs have been designated since 1990. They are listed on the IMO website.

SUMMING UP

The sea is not only a blue highway, but is teeming with life. The sea is not a uniform mass of water with the same species and amounts of organisms everywhere. Coastal areas are very different from open ocean areas, for instance because of differences in the availability of nutrients needed for the production of marine life. But in almost all marine areas, phytoplankton are at the base of the food web, energy is transferred to predators at higher levels in food chains or food pyramids, and viruses and bacteria ensure that nutrients and carbon are recycled.

It is the microscopically small organisms (plankton, viruses and bacteria) that are crucial for the more visible life in the sea, such as fish and marine mammals. Because food chains are interconnected in more complex food webs, many organisms are interlinked. When one marine organism decreases or increases in abundance by human or natural causes, this will have an effect on other organisms in the same food web.

3. DISCHARGES TO THE SEA

3.1. Environmental challenges for the shipping industry

The following environmental challenges are faced by the shipping industry:

3.1.1. Discharges to the sea – oil

Oil and oil products play an important role in modern society. During production, transport and use, oil may enter the marine environment. Oil in the sea is perceived by society as a major environmental problem.

The exact impacts from an oil spill depend on a number of factors. These include:

- the type and amount of oil and its behavior once spilled;
- weather conditions and season; the effectiveness of the clean-up response;
- the biological and economic characteristics of the area and their sensitivity to oil pollution.

Ecological impacts of oil include toxic effects on zooplankton, fouling of the plumage of birds and the fur of mammals, tainting of shellfish and oiling of coastal habitat such as beaches, mangroves and tidal areas. Economic effects include cleanup cost and damage to fisheries and the tourism industry.

Despite the publicity that oil spills always attract, only a small fraction of the oil entering the sea comes from tanker accidents. Routine shipping operations contribute three times as much to the input of oil to the marine environment as accidental pollution. Other major contributors are natural seeps and land-based sources. Since 1979, the amount of oil entering the sea as a result of shipping operations has declined dramatically, due to safer shipping operations, design improvements and regulations.

IMO regulations for the prevention of pollution of oil from ships can be found in MARPOL Annex I. Instructors are encouraged to discuss oil pollution prevention measures (e.g., oil-water separators, incinerators, vapor recovery and port reception facilities).

3.1.2. Discharges to the sea – chemicals

Chemicals are everywhere, naturally occurring or synthesized by humans. Chemicals are transported by ships as bulk products (in chemical tankers, bulk carriers or gas tankers) or in packaged form, for example on container ships. In 2000, approximately 120 million tons of chemicals were transported in bulk at sea.

If a chemical has one or more of the following properties, it is likely to be considered a
Hazardous or Noxious Substance:

- Flammable
- Explosive
- Toxic
- Corrosive
- Reactive.

To judge the effect of a spill, it is important to understand the behaviour and "fate" of the spilled chemical. The fate is determined by several physical and chemical characteristics such as the properties of volatility and solubility. Chemical substances can be divided in four main groups:

- Chemicals that evaporate – evaporators/gases
- Chemicals that float – floaters
- Chemicals that dissolve – dissolvers
- Chemicals that sink – sinkers.

In the environment, chemicals can reduce the ability of humans and other organisms to reproduce, grow, feed or otherwise function optimally. There is still little knowledge about the impact of the most widely used chemicals and their cocktail-like combinations on human health and the environment. Relatively few organic pollutants are fully understood or even identified today. The effects of a chemical spilled into the marine environment depend on a number of factors like the toxicity of the material, the quantities involved and the sensitivity of the organisms to the particular chemical.

Instructors should addresses acute and chronic toxicity on marine organisms, bioaccumulation, biodegradation, health effects on humans, effects on marine wildlife, benthic habitats and marine resources.

IMO regulations for the prevention of pollution by noxious and harmful substances can be found in MARPOL Annex II (noxious liquid substances carried in bulk) and Annex III (harmful substances in packaged form). Instructors are encouraged to discuss pollution prevention measures (e.g., efficient stripping, use of biodegradable chemicals and inert gas generators).

3.1.3. Discharges to the sea – sewage

Sanitary waste or sewage from shipping consists of black water (waste from toilets) and grey water (water from sinks, showers and on- board cleaning and flushing water from kitchen spaces).

Sanitary waste contains many nutrients such as nitrogen and phosphorus. Discharge of sewage adds extra nutrients to the sea, which may cause excessive growth of some algae (algae blooms). When these algae blooms die, a significant amount of oxygen will be withdrawn from the water, as the algae are decomposed by bacteria. Consequently, the oxygen concentration will quickly decrease. Such an oxygen shortage can lead to death of benthic organisms (animals living at or near the sea floor) and fishes.

Discharging sanitary waste in the sea can cause local environmental problems. Sewage discharges in the open ocean are rarely problematic. Coastal areas are more vulnerable, especially when the water temperature is relatively high (such as the Mediterranean and Black Sea as well as enclosed bays), the water contains less oxygen and in case of low currents and turbulence.
Other problems may arise when sewage contains pathogens and cleaning chemicals. Sewage is a major issue for two types of ships; cruise ships and livestock carriers. These
ships produce large amounts of sewage. IMO regulations for the prevention of pollution by sewage from ships can be found in MARPOL Annex IV.

3.1.4. Discharges to the sea – solid waste

When solid waste ends up in the marine environment, it is described as marine litter. This includes all man-made objects that do not naturally occur in the marine and coastal environment. Marine litter consists mostly of very slow degradable waste items, such as plastics, polystyrene, and metal. In many regions, plastics constitute the majority (up to 90 per cent) of the total amount of marine litter.

Marine litter includes items that are discarded directly into the sea (thrown or lost), brought to the sea indirectly by rivers, or left by people on beaches and shores. Marine litter is found everywhere in the marine environment, all around the world. It is a truly global problem. The litter soiling our beaches is only part of the problem. There are enormous rotating pools of garbage in the middle of the Pacific Ocean. One of the three known mid-ocean pools of garbage is estimated to be the size of the continent of Europe. These gyres contain large plastic items, but also huge amounts of tiny plastic particles that are much less visible. In some areas, plastic is six times as abundant as plankton. Besides on beaches and in the water column, litter is found on the sea floor.

Entanglement and ingestion are the two primary kinds of direct damage to wildlife:

- Entanglement means that an animal becomes encircled or ensnared by litter. This may happen accidentally or because the animal is attracted to litter out of curiosity or when in search of food or shelter. Entanglement can impede natural behaviour in all sorts of ways and can eventually lead to death;

- Ingestion occurs when animals swallow litter items. Generally, animals swallow litter items because they resemble their natural prey. Typical examples of such food mix-ups are when turtles eat plastic bags (mistaking them for jellyfish), and when birds feed plastic pellets to their young (mistaking them for fish eggs). Ingestion can lead to malnutrition or starvation. The swallowed litter items can accumulate in the digestive tract and make the animal feel "full", while the litter has no nutritional value.

The marine environment now also contains a vast quantity of tiny pieces of plastic smaller than 5 millimetres in diameter. Called microplastics, much of this material is microscopic in size. As small animals at the base of the food chain ingest microplastics, the toxic chemicals in plastic enter the food chain. These chemicals interact with numerous biological processes, and may eventually pose risks for humans eating contaminated marine organisms.

Marine litter also causes serious damage to people, property and livelihood and has significant economic repercussions on coastal and fishing communities. Adverse impacts include damage to fishing vessels and gear, safety risks at sea, damage to power stations, contamination of beaches and clean up cost.

Shipping is one of the contributors to the marine litter problem. Instructors are encouraged to discuss the contribution of shipping and personal experiences with waste treatment onboard of ships with the trainees.

IMO regulations for the prevention of pollution by garbage from ships can be found in MARPOL Annex V. Instructors are encouraged to discuss pollution prevention measures (e.g., minimizing packaging, compacters, incinerators, separate waste collection on board, and port reception facilities).

4. EMISSIONS TO AIR, GREENHOUSE GASES

4.1. Environmental impact of emissions of greenhouse gases

Climate change is a pressing issue on political agendas and the media are full of it. Climate change has been investigated by scientists for decades, of which the last two decades by The Intergovernmental Panel on Climate Change (IPCC). The IPCC defines climate change as: "any change in climate over time, whether due to natural variability or as a result of human activity".

The sun warms the Earth's surface and atmosphere. Some of the sunlight striking the earth is absorbed and converted to infrared radiation (heat), which warms the surface.

The surface also emits this infrared radiation back to the atmosphere. Greenhouse gases (GHGs) like carbon dioxide, methane, and nitrous oxide in the atmosphere trap this infrared radiation like the glass walls of a greenhouse. This process warms the atmosphere and is called the "greenhouse effect". Without the natural greenhouse effect, life on Earth as we know it would not be possible. The average world temperature would be -18°C, rather than +15°C which is the current average.

Greenhouse gases are produced by natural processes, such as volcano eruptions, natural forest fires, and decaying plants and trees. Since the beginning of industrialization around 1750, humans have also started producing GHG. Some examples of human activities producing GHG are combustion of fossil fuels (by cars, airplanes, ships, etc.), electricity and heat production, and agriculture. Since the beginning of industrialization, concentrations of GHG in the atmosphere have notably increased. This enhances the natural greenhouse effect. Of all greenhouse gases produced by humans, CO2 is the most influential.

During the past century, scientists have also measured that, on average and worldwide, global air and ocean temperatures are rising, snow and ice are melting, and sea levels are rising. According to the IPCC, anthropogenic (human) greenhouse gases have very likely caused most of these changes over the last 50 years. The IPCC-report states that it is very likely that the observed change in world temperatures is not only due to natural processes.

There is scientific consensus about the causes and occurrence of climate change. But the future effects, consequences and developments of climate change are much more difficult to predict and subject to many uncertainties. That's due to the complexity of processes in the Earth's climate system. Nonetheless, some predicted effects include sea level rise, loss of biodiversity, increase of human diseases, damage to coral reefs and unpredictable weather patterns.

When considering total shipping emissions worldwide, CO2 is the most important greenhouse gas. The main source of CO2 produced by shipping is exhaust gases from the burning of fuel in main and auxiliary engines. In 2007, international shipping was responsible for 2.7% of the global anthropogenic CO2 emissions worldwide. When considering the fact that 90% of all the worlds' products are transported by sea, this is a relative low contribution.

However, this relatively low contribution might change in the future. World trade is expected to grow, and so is the shipping sector. Moreover, shipping emissions of CO2 are not regulated at the moment and many other sources are. If land based sources cut emissions and shipping doesn't, the relative contribution of shipping will grow.

4.2. Pollution prevention measures

Future regulations regarding CO2 are being discussed at the IMO.

5. INTRODUCTION OF INVASIVE SPECIES

5.1. Environmental impact of transfer of species

Shipping transfers approximately 3 to 5 billion tons of ballast water each year. A potentially serious environmental problem arises when this ballast water contains marine life.

It is estimated that yearly at least 7,000 different species are being carried in ships' ballast tanks around the world. Basically anything that is small enough to pass through a ship's intake ports and pumps can be found in ballast water. These include bacteria and other microbes, small invertebrates and the eggs, cysts and larvae of various species.

The vast majority of marine species carried in ballast water do not survive the journey, as the ballasting and de-ballasting cycle and the environment inside ballast tanks can be too hostile for an organism to survive. However, when they do survive, an introduced species may become invasive, out-competing native species and multiply into pests because they have no natural enemies. As a result, whole ecosystems are being changed drastically.

For instance in the USA, the European Zebra Mussel has grown aggressively in o ver 40% of the internal waterways and may have required between US$750 million and US$1 billion in expenditure on control measures between 1989 and 2000. In the Black Sea, the North American jellyfish has on occasion reached densities of 1 kg of biomass per m3. It has depleted native plankton stocks to such an extent that it has contributed to the collapse of entire Black Sea commercial fisheries.

In several countries, introduced, microscopic, "red tide" algae (toxic dinoflagellates) have been absorbed by filter-feeding shellfish, such as oysters. When eaten by humans, these contaminated shellfish can cause paralysis and even death.

There are hundreds of other examples of catastrophic introductions around the world, causing severe human health, economic and/or ecological impacts in their host environments. The impacts of invasive marine species are often irreversible!

5.2. Pollution prevention measures

IMO regulations with regards to the introduction of invasive species through ballast water can be found in the International Convention for the Control and Management of Ships' Ballast Water and Sediments. This convention will enter into force 12 months after ratification by 30 States, representing 35 per cent of world merchant shipping tonnage.

In addition to invasive species introduction through ballast water, "biofouling" is a growing vector of transfer of harmful aquatic species around the worlds' oceans and coastal areas. Organisms can be transferred attached to the outside structures from a vessel, like sticking to the ships' hull. Transported amounts up to 90 tons of bio-fouling on the hull of one vessel have been reported. In some sea areas, the amount of introduced species by bio-fouling outnumbers the amount introduced by ballast water.

6. OTHER IMPACTS TO THE MARINE ENVIRONMENT

6.1. Environmental impact of underwater noise

In an underwater world where vision is limited, many animals use sound to communicate, to navigate or to sense the marine environment around them. Human activities also create sounds that can have a negative impact on marine mammals, fish and invertebrates. Human produced sounds cause problems when:

- the background noise becomes too loud;
- the frequency of the sounds overlaps with the sounds that the marine animals must use.

Most research on the effects of noise on marine animals has been done with whales and dolphins (cetaceans). Human-produced noise has the potential to disturb behaviour and/or interfere with vital biological functions of cetaceans:

- Human-generated noise can drown biologically important sounds (masking), making them undetectable by whales and dolphins;
- Noise may cause a threshold shift, a change in the ability of an animal to hear.

Once a threshold shift occurs, a sound will have to be much louder for the animal to be able to hear it.

Whales and dolphins have been shown to change their behaviour in response to noise. Also, the level of underwater noise may influence the collision rate between vessels and marine mammals.

Noise has been recognized by IMO as an environmental issue to be discussed, but noise pollution by ships is not regulated.

6.2. Environmental impact of Anti-fouling paint

All underwater structures are subject to "fouling". Microorganisms, algae, and/or animals will grow on these structures. For ships this has direct consequences, because high levels of fouling can reduce the performance of the vessel and increase the use of fuel. In order to minimize the impacts of fouling, ship's hulls are protected by antifouling coatings.

Many types of coatings, however, have been found to cause chemical pollution and toxic effects for marine organisms. For decades, Tributyltin (TBT) was the most commonly used anti-fouling agent. TBT caused defective shell growth in oysters and the development of male characteristics in female genitalia in the dog whelk.

The International Convention on the Control of Harmful Anti-fouling Systems on Ships prohibits the use of harmful organotins (like TBT) in anti-fouling paints used on ships and aims to prevent the use of other harmful substances in anti- fouling systems. Instructors are encouraged to discuss alternative anti-fouling systems (e.g., copper based antifouling, silicone-based non-stick coating).

7. EMISSIONS TO AIR AND OTHER POLLUTANTS

7.1. Environmental impact of engine emissions (SOx, NOx, PM)

Other than greenhouse gases, the main polluting substances in air emissions from ships are sulphur oxides (SO_2 and SO_3), nitrogen oxides (NOx), particulate matter (PM), Volatile Organic Compounds (VOCs) and ozone depleting substances (ODS, like HCFCs). These substances contribute to acidification problems, ambient air quality which may lead to health problems for humans and to depletion of the ozone layer.

7.2. Other air pollutants from ships

Acidification is caused by different pollutants. Nitrogen oxides (NOx), sulphur oxides (SOx) and ammonia (NH_3) increase the acidity of water and soil. This is caused by rain, snow or hail (wet deposition) and by direct exchange of gases from the atmosphere to land (dry deposition). Acidification causes a variety of ecological and other damage.

Air pollution is a severe threat to ambient air quality, and consequently, human health:

- At ground level, ozone is a pollutant with harms human health, and it is one of the main components of smog. It results from reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Exposure to high levels of ozone results in chest tightness, coughing and wheezing. Ozone also causes agricultural crop loss and significant leaf damage in many crops, plants, and trees;

- Particulate matter (PM) represents a wide variety of very small particles. PM smaller than 10 micrometres (µm) penetrates our lung cells when we breathe, and causes health problems. Health effects include increased mortality and a higher frequency of heart and lung diseases.

Shipping is becoming a major – and in some areas in the world the biggest – contributor to air pollution problems.

7.3. Pollution prevention measures

IMO regulations for the prevention of air pollution from ships can be found in MARPOL Annex VI. Instructors are encouraged to discuss pollution prevention measures like exhaust cleaning systems (e.g., sea or fresh water scrubbers, selective catalytic reactors) or other adequate means of emission reduction (e.g., change of ship or propeller design, use of low sulphur or alternative fuels).

8. PERSONAL INVOLVEMENT (See Workshop 6)

9. WORKSHOP 1 – Personal Opinion

This workshop is set up early in the course program to establish a starting point and assess the current knowledge of the trainees about the environmental impacts of shipping. It invites the trainees to become actively involved in the course and a feeling of ownership of the course content. It also enables trainees to relate their ideas and opinions to the ideas and opinions of other trainees.

Trainees will have prior knowledge, ideas or experience with environmental aspects of shipping. In this workshop, trainees are asked to share this knowledge and their opinions about different aspects of the relationship between shipping and the environment.

Trainees are divided in small groups of 4-8 participants and given an assignment. Different types of assignments can be used. One that works very well is asking the groups to make a list of the top-five environmental challenges for shipping and explain their respective importance.

All groups present their results in a plenary session, so all trainees are aware of the results of the other groups. The plenary session gives instructors the chance to ask questions when things are not clear and to point out common themes between the groups.

Instructors are encouraged to give trainees the chance to voice their opinions and to listen to the opinions of others. At this point in the course, little attention should be given to the correctness of arguments. It is important for the trainees to feel that their opinions and ideas are important, so they are more likely to share their opinions, thoughts and feelings during the rest of the course. The instructor should listen closely to the groups and the plenary presentations, because it will give him or her information about the current knowledge and awareness of the trainees. This will enable the instructor to emphasize certain information in his lectures later.

WORKSHOP 2 - Reputation of shipping workshop

Instructors should emphasize that sustainable development or sustainable shipping is more than taking care of the environmental (Planet P). A sector like shipping also has to be aware of the social part of sustainability (People P).

The people P stands for care for human capital. The human capital has two levels: (1) the workers in the business and (2) the broader community in which the company conducts its business:

- The people P is about fair salaries for workers, a safe working environment and tolerable working hours. When working conditions are bad, or perceived as being bad, it might be hard to get enough people to work for a company;

- The people P relationship with community and society is less direct. Society related aspects of sustainable development are described as "acceptance by society" which can be a license to operate. A sustainable company or sector will have the (indirect) support from the society. When companies or business sectors lose the support from society, and for example people stop buying products out of protest, the sustainability of a company or sector is at stake.

Maritime transport is essential to the world's economy as over 90% of the world's trade is carried by sea. Given that the bulk of this trade consists of commodities such as grain and oil, this leads to the inescapable conclusion that, without shipping, half the world would starve and the other half would freeze. Shipping is the lynchpin of the global economy.

Shipping provides a vital service, on which the entire global economy depends. Shipping is one of the least environmentally damaging forms of commercial transport. Where it competes directly with other means of transport, shipping remains by far the most energy efficient.

Logically, in the light of the facts, one would surely expect the public image of shipping to be a favourable one. And yet, this is not the case. The contribution made by the shipping industry – and in particular by those who work hard, both on board ships and ashore, to make it safer and more environmentally friendly – is greatly undervalued by the public at large.

In this workshop, instructors should start with an introduction of the People P, the importance of shipping and the problems with the image of shipping. After this, instructors should ask trainees to think about the difference between the image of shipping/seafarers (how others think about us or the shipping sector) and their identity (how seafarers think about themselves or the shipping sector). The trainees should be encouraged to think about the causes of this difference (why do we have this image), the consequences (how can a good image be helpful?), and ways to improve the image or to ensure that the image more closely resembles the identity of seafarers or the shipping sector as a whole.

After the results are presented in a plenary session, the instructor should lead a plenary discussion about this subject. He or she needs to make sure that all trainees can voice their opinions. After a summary of the results, the discussion should focus on the reasons and consequences of the difference in image and identity.

Reasons might be:

- Media?
- Environmental groups?
- Movies?
- Lack of (positive) information about shipping?
- Old culture, habits from the past?
- Behaviour of seafarers now?

When possible it is valuable to exchange ideas on solutions – how can this image be changed?

WORKSHOP 3 - Pollution prevention measures workshop

The instructor should remind trainees that legislation, technical installations and procedures are designed to prevent pollution from ships and minimize the impact of shipping to the environment. Remind the trainees that several examples of solutions have been addressed in this course. In the lectures, the connection between the environmental challenges and possible solutions has been discussed.

Environmentally sound shipping can be achieved if all these solutions are effective and used to their potential. For this, the role of people is important. People are essential to make regulations and procedures work and to invest in and use technical installations in the proper way.

This workshop is designed to help trainees develop an understanding of solutions for the environmental challenges the shipping industry faces and identify responsibilities for these solutions.

Trainees are divided up in small groups (4-8 participants) and given an assignment.

Groups should identify solutions (regulations, technical installations, procedures) for one or more of the environmental challenges. Trainees should be encouraged to think about the effectiveness of these solutions. In addition, groups should identify who is responsible for the different solutions (IMO, ship owners, captain, officers, crew, government, the trainees themselves). It might be an interesting addition to encourage groups to come up with "new", creative, even futuristic solutions such as fuel cells or solar power.

All groups present their results in a plenary session; so all trainees hear the results of the other groups. The plenary session gives instructors the chance to ask questions and to address common themes.

WORKSHOP 4 - Personal involvement and personal responsibilities workshop

The instructor should connect this final workshop to the outcome of the pollution prevention workshop. Where some solutions can be expected from other people or institutions like IMO and the ship owners, it should be made clear that every individual can play a positive role in achieving environmentally responsible shipping.

The final workshop of this course is designed to encourage trainees to show personal involvement and express a sense of personal responsibility.

In this workshop, trainees should work in teams of two or three trainees with the assignment to identify their personal role in the prevention of pollution from shipping. Instructors should encourage trainees to exchange opinions and to express personal ideas about how they can play a positive role – what can they do to contribute to environmentally responsible shipping and to ensure a positive reputation for shipping. Ask the trainees to be as specific as possible, and let them use examples.

Secondly, as (future) officers, trainees should identify the tasks of the crew they will be leading on board. Teams of trainees should be asked to think about ways to "stimulate and motivate" their crew to do the right thing – how would you do that as an officer?

After the assignment, the instructor should lead a plenary discussion about different approaches to "convince" the crew. Trainees should be aware of different possibilities and (when possible) experience different ways of leading crew to do the right thing:

- Leading by example (show how it is done)
- Hierarchical (I am your boss and I say so …)
- Mentoring (I will show you how it is done and why …)
- Appeal to a sense of pride (pride to be a seaman, a professional …)
- Personal (I have seen the effects of oil in the environment and I would like you to …)
- Educational (These pictures show the effects of plastics, so please think twice …)
- **Punishment (Do it again and …).**

WORKSHOP 5 – Video BBC Worldwide-IMO production "Invaders from the Sea"

Discuss the principles and effectiveness of mid ocean exchange and (a selection of) ballast water treatment systems.

Discuss the environmental impact of transfer of species

- Describe the impact of the introduction of invasive species
- Define the term invasive species
- Describe the transfer of species through ballast water
- Describe problems associated with the introduction of alien species
- Give an example of the ecological impact of invasive species
- Give an example of the economic impact of invasive species
- Give an example of the impact of invasive species on human health

WORKSHOP 6 - Personal involvement

1. **Personal behaviour**
   - Describe the role of personal behaviour for pollution prevention
   - Recognize the importance of officer and crew behavior for pollution prevention
   - Give one example where proper behaviour contributes significantly to pollution prevention

2. **Personal responsibility**
   - Recognize his/her personal responsibility towards the environment
   - Describe his/her (future) responsibilities with regard to environmental care in shipping
   - List five actions he/she (can) take to ensure compliance with requirements

3. **Officer responsibility**
   - Be aware of his/her (future) position as an officer as an example for the rest of the crew
   - Recognize the influence he/she has on the environmental behaviour of ratings
   - Recognize the need to motivate the crew to commit themselves to their tasks and to further improve competence, attitudes and motivation of individuals at all levels, as stated in the ISM Code
   - Identify one action he/she can take to ensure better compliance by ratings