INTERNATIONAL NAVIGATION ASSOCIATION
ENVIRONMENT COMMISSION

Report of the WORKING GROUP 136

SUSTAINABLE MARITIME NAVIGATION
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1. Background

1.1. Context

Our oceans, seas and estuaries are under increasing pressure from a variety of human activities. Important natural habitats such as salt marshes and mudflats, sand banks and reefs, along with dolphins and other marine mammals, fish, birds and invertebrates can be impacted by resource exploitation and other uses of the marine environment.

Whilst maritime navigation is not a consumptive use of marine resources, both shipping and development or maintenance of navigation-related infrastructure may influence the marine environment - whether as a result of discharges or emissions, noise, physical disturbance/modification or other activities especially new infrastructures building.

1.2. International organisations’ involvement

Waterborne trade is vital to the economic well-being of maritime nations. The ‘right of innocent passage’ is enshrined in UNCLOS (the United Nations Convention of the Law of the Sea), enabling commercial vessels to transit between countries.

A variety of other international Conventions and regional initiatives (such as the EU Maritime Strategy) aim to improve the management of activities such as navigation in the marine environment, whilst national laws protect and regulate activities in territorial waters.

1.3. Needs for a comprehensive overview

Each of these various organisations has a specific purpose (e.g. the International Convention for the Control and Management of Ballast Water aims to prevent the introduction of non-indigenous species, and MARPOL deals with various aspects of marine pollution).

However, it is sometimes difficult to see the ‘overall picture’ insofar as sustainable maritime navigation is concerned.

Considerations such as climate change and ecosystem-based management are further increasing the focus on delivering sustainable management of marine resources. The extension of existing ports, and the development of new ones to deal with this significant growth in traffic, has required the development of huge areas in coastal margins. This is a particularly serious issue because the corresponding spaces, including estuaries, marshes and coastal zones are often of high environmental value.

An important objective of this Working Group will therefore be to bring together, in an accessible and navigation-specific way, the concepts of integrated management, adaptability and sustainable use. In that prospect, a specific attention will be paid to air emissions by the port and shipping industry, not only in coastal areas but also during all the maritime transportation of goods or passengers.

The major aim of this working group will be to provide all necessary data for the assessment of the environmental performance or eco-efficiency of maritime navigation.
2. Subject fields

In a similar manner to the PIANC EnviCom Working Group 6 report on sustainable inland navigation, this Working Group will need to identify, assess and evaluate the role of navigation in the wider context of sustainability criteria.

Whilst it should acknowledge the relative benefits of waterborne transport when compared, for example, to road or air transport, it should highlight how navigation interacts with the various natural (physical and ecosystem) processes in the marine environment.

In exploring ways to deliver sustainable - but also safe and cost-effective - integrated navigation management (both operation and development) the group should inter alia consider the following:

- emissions to air (Ships and Ports Operation)
- discharges to water (Ships and Ports Operation)
- noise (Ships and Ports Operation)
- dangerous cargo handling and transportation
- ballast water exchange
- anti-fouling
- risk of collision/accidental spillages
- shipwrecking
- physical and ecological disturbance or modification including ship wash
- wetland disturbance (Port planning and works)
- hydro-morphological modification

Having described the key functions/needs of maritime navigation and how these interact with the marine environment, alternatives and their associated impacts should also be explored.

Taking into account the existing requirements of the various relevant international instruments, the Working Group will need to consider how to apply the ‘working with nature’ philosophy to strategic plans, project-specific assessments, routine operations and management, whilst also taking proper account of socio-economic factors.

Associated costs including environmental costs should also be considered. The importance of appropriate specifically-designed monitoring leading to adaptive management to provide continuous improvement should similarly be stressed.

A step-wise approach to decision making (similar to that developed for inland navigation in the WG6 report) might be developed. This could indicate what needs to be done to improve navigation sustainability, who might do it (i.e. the respective roles of the various actors), and how.

Good practice case studies should also be presented insofar as these contribute to the objective of providing clear practical and accessible advice and guidance to practitioners in the ports, shipping and wider navigation sector.

3. Working Group membership

Working Group members will need to represent the interests of a wide range of stakeholders: vessel owners and operators, port operators, regulators, engineers and environmental scientists, along with relevant international organisations (e.g. IMO, OSPAR, London Convention, European Commission, ESPO (European Sea Ports Organization), ECSA (European Community Ship owners’ Associations), and IAPH.
SUMMARY

Drivers for sustainable navigation

1. Global trade, and subsequently seaborne trade, are driven by the global economy. World gross domestic product has grown by more than 50% in the two last decades, while seaborne trade has increased about 80% over the same period. The economic crisis since the end of 2008 has disrupted this growth. Now the prospects seem again somehow more favourable, but there are still great uncertainties. The shipping industry has to adapt to economic changes. The global fleet tonnage has increased for decades. Another key feature is the explosive growth of the containerized shipping sector in recent decades. Due to an intense global competition, shipping activity has become more and more concentrated. The ships used on the main commercial lines are larger and larger. The ports follow the economic trends and provide the infrastructure and superstructures required by shipping companies. A number of new port facilities have been or are under development. Due to history and culture, shipping and land-based maritime activities make up two different worlds. The respective roles of all the different players in shipping activities should be kept in mind when developing recommendations for sustainable maritime transportation.

2. The report gives a large overview of international and regional regulations regarding shipping:
   - “Montego Bay” Convention on the Law of the Seas,
   - IMO conventions regarding ships safety and security
   - Specialized conventions on the protection of Marine environment (MARPOL, Oil pollution, Ballast water and sediments, London Convention, …)
   - Regional memoranda of Understanding on Port State Controls
   And:
   - Regional conventions for Marine Environment protection.

3. The report discusses the different sorts of economic incentives, (market instruments, either credit or benchmark based, port dues differentiation, subsidies provision). A number of dues differentiation and subsidy provision schemes do exist, but no important market instrument has been found implemented in the field of shipping.

Ships based sustainability issues

1. The report gives an overview of ship lifecycle issues, from design to operations to scrapping.
2. Air quality is one of the very major shipping sustainability issues: the GHG emissions from ships are 2.7 % of the world GHG emissions. A number of technologies exist to reduce them dramatically: use of cleaner fuels, improve hull and superstructure, improve propulsion, combustion efficiency, hull coatings and maintenance, operational measures, and slow steaming.
3. Water quality is tackled: ships are no more allowed to throw overboard their wastes and litter, but must take them ashore to appropriate port facilities.
4. Fouling required the use of toxic paints, that are quite harmful to the environment, and are now forbidden by regulations. New products and techniques are explored.
5. Invasive species can be spread over the world by ships. Measures have to be taken to combat this phenomenon.
6. Accidents at sea have disastrous impacts on the environment. A number of measures have been taken in the past and still have to be developed in the future.
Port based sustainability issues

1. **Methodologies.** The classical approaches for port projects are based on assessing the impacts on the environment and defining mitigation/compensation measures. A more proactive approach has been especially developed by PIANC: the *Working with Nature philosophy*. It consists of an integrated process, based on a good understanding of the environmental processes. It takes place early in the project lifecycle, in order to identify win-win solutions, acceptable by both the project proponents and the environment stakeholders.

2. **Hydrological, morphological, sedimentary** processes are particularly complex. Modelling techniques can help engineers understand them and test solutions in order to avoid or minimize adverse impacts. The specific PIANC reports on dredging are referenced.

3. Good *water quality* is vital to sustain marine life. Ships should no longer throw wastes at sea, but in the appropriate facilities provided by ports. The actual efficiency of the current implemented measures is checked from global and regional points of views. The possible measures for reception of waste generated by port activity are brought up.

4. The impacts of port development and operations on *habitats and biodiversity* can be huge. Due to the complexity of the ecological processes, a proper understanding of the potential effects on habitats and species is essential prior to undertaking port construction or development activities. Possible mitigation-compensation measures are many and various. The examples of Le Havre Ports 2000 and Rotterdam Maasklakte 2 projects are described.

5. Various sources contribute to the *pollution of air* from ports. Data from Ports of Charleston and Los Angeles/Long Beach ports are given. A large set of possible measures are brought out, through slowing the vessels’ speed when approaching the ports, using shore electricity while at berth, improving all devices and crafts (handling equipment, trucks, locomotives, harbour craft,...). Examples of port of Bristol (renewable energy generation), of San Pedro Bay Ports (global Clean Air Action Plan) are given, as well as the approach of the World Ports Climate Initiative.

6. 7. **Noise and visual aspects** are brought out.

8. 60% of mankind lives less than 100 km away from the coast. Planners have to deal with the competition of the *different human uses* of coastal zones. This requires both a good understanding and communication of the different communities involved.

9. The range of the causes of the *accidents in ports* is quite broad. They often include poor communication between participants, and insufficient training and crews.

Conclusion

As a conclusion, efforts should be carried on and strongly supported to:

- improve regulations at international and regional levels which are still a major necessity. The regulatory frameworks should be as simple, robust and consistent as possible. However no other instrument (economic incentive, contract or market instrument) has to be set aside. Individual imaginativeness and company initiatives are also to be encouraged.
- master GHG gas emissions from ships, which is still one of the main environmental impacts of maritime transport.
- mitigate the environmental footprint of ports and ports operators, but also ensure the sustainability of human uses of coastal land and waters.
- develop awareness, increase capacity, train and educate the next generation of maritime navigation operators and stakeholders.

Laying out our environment in a sustainable way requires that we *change our way of thinking*: adopt global and long-term views, involve all relevant bodies, use all available instruments in a proactive, transparent and pragmatic manner, and adopt the *Working with Nature* approach for all development projects.
INTRODUCTION

1.1. Setting the scene

1.1.1. The maritime environment and the seaborne trade

The marine and coastal environment provides many functions and services which are essential to human wellbeing; for example, food including fish and shellfish, atmospheric and climate regulation, nutrient cycling, pharmaceutical compounds derived from marine algae and invertebrates, flood attenuation, filtering of organic waste and so on (UNEP, 2006). However, this environment is also under increasing pressure, in part from the multitude of uses it supports.

Maritime navigation and navigation-related infrastructure are also vital to economic well-being, yet these activities can contribute to the pressures on marine ecosystems. Maritime navigation developments and activities are planned, regulated, managed and operated by a wide variety of different players.

Seaborne trade has doubled from 1988 to 2007; the trend accelerated since 2002. Since the last quarter of 2008, the economic-financial crisis has significantly impacted the world trade, and consequently seaborne trade growth. The prospects are now uncertain, but one can expect that the mid-term trend will be positive again.

It is clear that understanding and assessing the sustainability of navigation in the maritime environment therefore requires consideration of a wide range of activities and many environmental, social and economic factors.

1.1.2. What do we mean by ‘sustainable’?

Maritime transportation, the vehicle of a large part of the worldwide fluxes of goods is at the heart of the globalization phenomenon. The fortunes of the global maritime transportation sector are intimately interlinked with that of the global economy, its ups and its downs. Products these days are often assembled with the help of supply chains spanning the world. Even simple products can travel around the world when e.g. a particular step in the chain involves manual labour that is sourced from a particular country where this is relatively inexpensive. Emerging economies are growing fast on the basis of their ability to supply large quantities of their goods at competitive prices on the world market. The exploitation of competitive advantage can thus result in increasing flows of goods and an increased interdependence of economies.

In all this, the maritime transportation sector is a key player and the fact that more goods seem to undergo more and more transport is in itself seen as unsustainable by a part of the public.

Sustainable transportation should not endanger public health or ecosystems and should meet mobility needs consistent with:

(a) use of renewable resources at below their rates of regeneration and

(b) use of non-renewable resources at below the rates of development of renewable substitutes.

This provided a conservative benchmark view of what sustainable transport is all about which is still often put forward in the public debate.
1.1.3. Why do we say ‘A bird’s eye view’?

Any guidance on sustainable maritime navigation will necessarily cover a broad range of topics. In many cases, a great deal of detailed information already exists at the level of a particular activity or a particular environmental interest. However, relatively little guidance exists on how such activities and impacts interact - and without this type of awareness it can be difficult to maximize opportunities, minimize adverse impacts, and hence contribute to sustainability in the maritime environment.

This guidance document provides a high-level overview of a range of activities, their implications and potential interactions. It does not go into detail. Rather it is intended to help key players broaden their understanding of the environmental and social as well as economic consequences of commercial navigation activities in the maritime environment. By providing such a bird’s eye view, the report aims to enable these actors to recognize and take other interests and factors into account - thus giving them an opportunity to contribute to effective, sustainable operation, management and development. The intended audience for this guidance document includes:

- Professionals and senior managers working throughout the maritime transport chain
- National and international institutions, governments, administrations, regulators
- Port operators, designers and planners
- Non-governmental shipping and environmental organizations etc.
- Development banks, multi-laterals, and financiers

1.2. Scope and structure of the report

This Working Group report focuses on the activities of commercial navigation and its supporting infrastructure, viz:

- commercial shipping and navigation; trading ships: i.e. sustainability at sea
- Sea ports and port infrastructure: i.e. sustainability at the coast.

It does not cover issues associated with the sustainability of other activities, notably the activity of fishing vessels or recreational craft. Nor does it extend to consider other uses of the marine environment such as the extraction of marine minerals (i.e. aggregate dredging), oil and gas, or renewable energies). In its successive parts, this report analyzes sustainable maritime navigation from the two points of views of shipping and of shore infrastructure; and for both of them development and operations topics.

This report includes, before the two special chapters devoted to ships-based sustainability and port-based sustainability issues, an introductory chapter 1 and a common chapter 2 devoted to the drivers and the global management instruments of the maritime activity.
Chapter 2 first reminds the economic context of sea borne trade. It emphasizes that, due to history and culture, shipping and port-based maritime activities are two different but interacting fields. It describes the respective roles of the actors of shipping.

The second part of this chapter aims at helping the reader to find his way in the bundle of laws and regulations governing shipping and marine environment matters.

2.2.1 United Nations Conference on the Law of the Sea (UNCLOS), ‘Montego Bay Convention’, which is the wider one

2.2.2 International Maritime Organization (IMO) Conventions on ships security and safety, focused on ships matters

2.2.3 Specialized International Conventions on the Protection of Maritime Environment, focused on pollution from ships matters

2.2.4 Memoranda of Understanding on Port State Control, aiming at eradicating substandard ships through harmonized checking systems

2.2.5 Regional Conventions for Marine Environment Protection organizing the cooperation of their Parties to protect the marine environment from sea and land pollution sources.

The third part is a discussion on economic incentives available, besides regulations and controls, to encourage the best environmental practices.

Chapter 3 is devoted to ships-based sustainability issues at construction and operation stages: life cycle of vessels, impacts on air and water quality, fouling, invasive species, and accidents. For each of these items, it assesses the impacts and what has been done up until now for sustainability; then it describes the emerging ideas and forecasts, ongoing research and suggests a number of possible actions for ship design, construction and operations.

Chapter 4 is devoted to ports-based sustainability issues, at construction and operation stages. It begins by presenting methodological considerations in reference to the “Working with Nature” philosophy developed by PIANC since 2008. Then it assesses the situation and proposes environmental improvement tracks regarding port layout (hydrology, morphology, sedimentary), quality of water, habitats and biodiversity, quality of air, noise and vibrations, visual impacts, spatial context (other human uses, cities and ports, climate change) and ports security.

Chapter 5 concludes and gives some recommendations on regulation development and improvement, economic incentives use, research efforts on emissions from ships, on building capacity, education and training, an adoption of holistic, long-term views, adaptive, participative, transparent and pragmatic methods, using the Working with Nature philosophy.
2. DRIVERS and INSTRUMENTS

2.1. Meeting shipping growth in a sustainable manner

2.1.1. World trade and maritime transport development


During the decades 1990-2010, world Gross Domestic Product grew by nearly 60%, and more than 850% from 1950 to 2010 (*WTO International Trade statistics, 2011, table annex 1a*). This evolution is not uniform. It is stronger in emergent countries such as China and India than in developed countries.

Since 1950, the global trade exports volume has been multiplied by 30 (*WTO, 2012*). According to figure 2.1 below, there is a strong correlation between GDP and world merchandise volume trade.

![Figure 2.1. Evolution of world GDP and seaborne trade. Source: UNCTAD, 2011](image)
According to Mandryk (2009), 75% of world trade volume is transported by sea (59% in value).

Maritime transport is strongly correlated to world merchandise trade. Throughout the period from 1990 to 2010, it nearly doubled in volume; it reached 8879 million tons in 2011. In terms of ton-miles, it totalled 32 746 billion ton-miles in 2008, (Fearnleys Review estimation, quoted in UNCTAD, 2009).

Figure 2.2. Growth of international seaborne trade. Source: UNCTAD (2011)

World economy is more and more globalized. The relative weight of emerging countries has been growing and their share in seaborne trade has grown as well: in 2010, this share amounted to 60% of total goods loaded and 56% of goods unloaded.

At the end of 2008, the economic-financial crisis put a brake on the international trade growth. Seaborne trade fell 4.5% in 2009. Then the global economic situation turned around; in 2010, world GDP expanded by 3.5% and global merchandise exports by 14%. The economic upturn benefited mostly the dry bulk and container trade segments.

Meanwhile, some of the economic influence from the North and the West moved to the South and East. Trade patterns are expected to follow the same track.

This recent economic trend is expected to last next years, despite a number of uncertainties.
2.1.2. The merchant fleet

In January 2011, there were more than 100,000 seagoing commercial ships, with a combined tonnage of near 1 400 million dwt. (UNCTAD, 2011). As shows figure 2.3 below, the global capacity of this fleet has nearly doubled in thirty years to keep up with the growth in global trade. This development results mainly from the growth in ship sizes, but at different periods and different speeds.

The share of dry bulk carriers in the world fleet increases up to 38% in 2011.

During the seventies tankers up to five hundred thousand dwt appeared. This development was stopped in the middle of the decade by the second oil crisis. At the moment the share of oil tankers in the world fleet totals 34%; most of tankers belong to three classes, 10-20 thousand dwt, 50-100 thousand dwt, and 100-300 thousand dwt.

![Figure 2.3 Structure of the world merchant fleet (millions dwt) UNCTAD (2011)](image)

The main change for maritime transport of general cargo since 1960 has been the development of containerized shipping. During the last two decades, the tonnage of containerized goods grew 10% per year. The share of container vessels in the global fleet reached 13% in 2011. The size of container vessels has also grown dramatically. From 1987 to 2010, the mean capacity of container ships grew from 1155 to 2896 TEUs. Nowadays, containerships of more than 10 000 TEUs are common and operated by all major shipping companies. The largest container ships in service in early 2010 had a nominal capacity of 14770 TEUs, and a major company has given orders for 10 18 000 TEUs vessels to be delivered in 2013-2015. Any further significant growth of vessels sizes [beyond 18-22000 TEUs] would require massive port investments. Probably a plateau has been reached (UNCTAD, 2011, p39).
2.1.3. Ports and other main infrastructures

Ports have to face the evolution of economy, trade, seaborne trade, and fleet extent and characteristics. Table 2.1 below illustrates the growth of the number of very large ports over the last decade; this growth is expected to continue into the medium term.

<table>
<thead>
<tr>
<th>Number of major ports</th>
<th>2002</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>General traffic &gt; 60 Mt</td>
<td>46</td>
<td>59</td>
</tr>
<tr>
<td>Container traffic &gt; 2 MTEU</td>
<td>28</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 2.1 Number of major ports in the world Source AAPA (2010)

Due to competition between ports, the shipping companies are able to impose on the ports to comply with their infrastructure needs and requirements.

During the 1970-1980 decade, the ports were designed to service the largest tanker vessels. Channels were deepened, larger berths were built, and larger industrial areas were developed near the terminals. In that period the first container terminals were also built. The number and size of these kinds of facilities grew dramatically during the decade from 2000-2010. New channels have been dug or deepened, new berths and quays have been built, new surfaces have been applied to storage platforms, new cranes and gantries have been brought into service, specific intermodal and logistic facilities have been implemented.

These port developments have been particularly spectacular in Asia, where huge ports have been built, sometimes through expansion of existing facilities, sometimes from scratch. Due to the same pressure, the Suez and Panama canals are being improved, or are to be improved during the next few years. For example, without expansion the existing Panama Canal would no longer be able to serve 37% of the global container ship fleet. The Panama Canal expansion that is under way will allow 12 000 TEU vessels to use it.

2.1.4. Two different worlds interacting

For centuries, specific methods, tools, techniques have been used in shipping activity. Due to distance, isolation, and long periods of separation, the lifestyles, traditions and cultures of seafarers are different from those of people who choose to stay on land. International seaborne trade is highly competitive; it is organized worldwide and now thoroughly globalized. Freedom of navigation is a principle of customary international law and is acknowledged by the modern UNCLOS. However, ship operations can have very harmful consequences on foreign people and countries, and not just in the case of accidents. Remedying those consequences requires trans-national instruments. Since the sinking of the Titanic in 1912, a huge body of international agreements and conventions has been gradually implemented.

Port development and operations generally can impact national populations and land masses. They are managed according to national common practices and regulations. Another difference with shipping is the number of actors potentially involved in land-based maritime activity issues: local, national administrations and planners, port managers, private operators, all kind of stakeholders, lobbies, etc.

These distinctive features have to be taken into account. In the following sections, we think it useful to first remind the reader who the players are in the particular world of global shipping and what their respective roles are. Then we shall give an overview of the two main instruments available to insure maritime navigation sustainability: specific international regulations on maritime activity, and economic incentives.
2.1.5. Players in shipping activity

![Figure 2.1 Players in Shipping activity](image)

2.1.5.1. Operating Ships

There are two main organizations of sea trade:

- **tramping**, mainly devoted to bulk carrying. The operator has to find freight for each voyage.
- **line shipping**, mainly devoted to general cargo trade; today line shipping is mostly container shipping. The operator arranges regular calls in the different ports on a given range.

In both cases, shipping consists of three main businesses: build and **own**, technically **manage** (crews, bunker, maintain, drive), and commercially **operate** (charter ships, find cargo). Today, for a given fleet, those three functions can either be performed by a single company or distributed across several separate companies. The operator can charter vessels bare boat, for a given period, for a given voyage. It is important to know that the 100 top container shipping companies operate 4861 ships of which 2063 (42%) are owned and 2798 (58%) are chartered. [Alphaliner,3]

The operator concludes sea transport contracts with freight agents. He also deals with a number of technical partners such as ship yards for building and maintenance of their vessels, financial partners (banks), administrative partners (insurance companies: the high costs and risks of sea trade have led to a strong development of the maritime insurance business), brokers, and agents. The distribution of liabilities between the different parties in the different kinds of charter and sea transport contracts is complex and out of the scope of the present report. Nevertheless, one must remember that it is often difficult to identify them.
2.1.5.2. Flag states responsibilities and action

The regulations to be applied on board a given vessel for technical (e.g. building, fitting, maintaining ships), social (e.g. number, qualifications recruiting and working conditions of crews) administrative (e.g. fiscal) and other matters depend on the ship’s flag, i.e. the state she belongs to.

Registration conditions are specified by flag states. It is the flag state’s responsibility to check whether ships comply with international regulations on maritime security and safety, and on environment protection agreements to which they are parties. They also deliver the appropriate statutory navigation certificates. Some states delegate part of those responsibilities to Classification Societies.

For economic reasons, a number of owners and operators have registered their ships in countries where technical, labour and administrative standards are low (flags of convenience). This has sometimes resulted in the development of sub-standard vessels and subsequent accidents, spillages,…

2.1.5.3. The classification societies

In the mid 18th century, charterers and insurers were badly in need of better assessments of marine shipping risks. As a result, non-governmental companies known as classification societies were established to set technical standards for different classes of ships. Today, these groups conduct regular surveys of ships that are under construction, and these surveys are followed up with periodic inspections of these same vessels throughout their operational life. Class certificates are issued for vessels ensuring that they comply with the standards established for their respective class. Though these class certificates lack the legal backing of statutory permits, they are required by insurance companies and are therefore critical documents for any operator of oceangoing vessels.

There are about fifty classification societies in the world. Some 13 of the major ones class more than 90% of world tonnage and are members of International Association of Classification Societies.

2.1.5.4. Vetting inspections

Historically, shippers of oceangoing cargo such as large oil companies have required that the vessels transporting their goods be surveyed by vetting inspectors to ensure that their own technical and safety standards are properly fulfilled. Vetting inspectors also verify the presence on board of all required Classification certificates.

2.1.5.5. Port state controls

Sea accidents may cause considerable environmental damage to coastal countries. In a number of cases, accidents have resulted due to the inadequacy of controls in the flag states of the vessel involved. Consequently, international agreements (Memoranda of Understanding) have been set up at regional scales to improve the protection of coastal countries.

Under such agreements, ships can be inspected by Port State Control Officers (PSCO). Depending on the seriousness of the deficiencies found aboard, the PSCO may require that the infractions to be rectified (within a prescribed time, or before arrival to next call, or before leaving the port), that the ship be detained, and/or that the ship be blacklisted (see next sections) from future operations.
2.2. Maritime international laws and regulations

Since the beginning of the 20th century, sea hazards and disasters have led the international community to set up a great number of regulations, conventions, codes of conduct, etc., with safety issues being of foremost concern. At the end of the 1960s, oil spillages at sea brought environmental concerns to the forefront, and these became the basis for subsequent agreements.

The current such Conventions regarding shipping are discussed and implemented under the umbrella of the United Nations Organization and its subsidiary, namely the IMO. They are complemented by a number of multilateral agreements, dealing not only with shipping, but also more widely with the marine environment at the regional level.

These regulations are critical if maritime navigation (including land-based maritime activities) is to remain sustainable over the long-term; however, cumulatively, they form a very broad and complicated corpus. What we intend in this chapter is to provide some help to the reader to find his way through this large body of maritime regulations.

1. The chapter begins with a discussion of the UNCLOS, also known as “Montego Bay Convention”, has the broadest purview of all maritime regulations, and is referred to as the “Constitution of the seas”.

2. Next an important group of regulations established mainly within the IMO (and also in International Labour Organization, ILO) regarding ships security and safety are discussed:

- ships safety of navigation, with the Convention on the International Regulations on Preventing Collisions at Sea (COLREG 72).

- ships design and operations, with the International Convention on Safety Of Life At Sea, (SOLAS 74).

- ships operations with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW 95) and ILO International Convention on Marine Labour Standards.

- followed by some more specialized conventions.

3. Then we shall examine the other multilateral agreements made to protect the environment from pollution by ships. The main one is the International Convention on Prevention of Marine Pollution by Ships, MARPOL 73-78. There are also some Conventions made under IMO’s umbrella on different precise subjects (Pollution by oil, by other substances, anti-fouling, ballast water management, waste and other matter dumping at sea, recycling of ships, and removal of wrecks) There are also some other regulations on more particular environmental matters (e.g. antifouling and ship waste management).

4. Then we shall take a look at the agreements — Memoranda of Understanding — made by maritime authorities at regional levels in order to set up the checking of ship conditions regarding the above regulations, and consequently to eradicate sub-standard vessels.

5. Finally, a number of regional agreements aimed at organizing cooperation and marine environment protection between states are discussed.


It distinguishes (in parts I to XI) the following zones, some of them coming from previous agreements, some others (Archipelagic waters, economic exclusive zones, navigable straights, bottom of the sea) being new:

- The maritime areas annexed to land territories. Those areas cover inland waters (total sovereignty), territorial sea (maximal width 12 nautical miles; the coastal states are free to set laws, regulate use, and use any resource; “innocent passage” of foreign vessels allowed); contiguous zones (maximum width 24 nm, the coastal state enforces laws on pollution, taxation, customs, immigration), archipelagic waters (full sovereignty but “innocent passage” allowed) and international straights (border states may notably set up traffic separation schemes).

- The areas where the coastal state enforces law on economic matters: Exclusive Economic Zones (maximum width 200 miles) including seabed and water column. The other states have the same rights as in high sea regarding navigation, over flight, submarine pipes and cables lying, and continental shelf.

- High sea where UNCLOS establishes general obligation for safeguarding the marine environment and protecting freedom of scientific research, and creates an innovative legal regime for controlling mineral resources in deep seabed areas.

Part XII is devoted to the protection of the environment. It defines the responsibilities of states (both flag state and port state) regarding preservation of the sea, the adoption of international, regional and national regulations able to insure the protection of the marine environment, and the modes of application of those regulations.

It deals (parts XIII and XIV) with scientific research, development and marine technologies transfer.

Finally, part XV is devoted to disputes and their settlement. www.un.org/depts/los/convention_agreements/texts/unclos/closindx.htm

2.2.2. IMO conventions on ships security and safety.

The Intergovernmental Maritime Consultative Organization, which later became the International Maritime Organization currently includes 169 Members States and 3 Associated Members. It established a complete corpus of regulations, about all aspects of maritime life. This section deals with the agreements on ship designs and operations. It begins with the four “pillars” of IMO Conventions, then it quotes some more specific agreements, and then it explains the regional agreements made by maritime national authorities aimed at organizing the control of ships. www.imo.org/conventions

2.2.2.1. Convention on the International Regulations for Preventing Collisions (COLREG 72)

COLREG 72 applies to all sea-going ships, regardless of the specific waters in which they sail. It aims to set manoeuvring regulations for avoiding collisions based on the relative courses of ships, their manoeuvring ability and their propulsive means. It also standardizes navigation lights and marks.

These Regulations were adopted in 1972, and entered into force in 1977. COLREG 72 replaces an agreement adopted in 1960, i.e. the same year as the SOLAS Convention. An important innovation brought by COLREG 72 is the integration of regulations on traffic separation schemes. COLREG 72 has been amended at various times: 1981, 1987, 1989, 1993, 2001 and 2007.
2.2.2.2. **International Convention on Safety of Life at Sea. (SOLAS 74)**

The sinking of the Titanic in 1912 prompted the meeting of an important international conference on safety of life at sea. Five successive SOLAS Conventions have been adopted since this initial conference: in 1914, 1929, 1948, 1960 and most recently 1974.


It has been amended many times. It includes specific instruments worth some more comments:

**ISM Code.** This Code forms Chapter IX of the **SOLAS 74** Convention. It defines regulations on ship management aimed at maintaining the safety of ships operations, preventing injuries and human loss of life, and reducing **damages to the environment**. These regulations include regular audits on companies and ships by external certified bodies.

**ISPS Code.** This Code was established after 2001 September 11th terrorist attacks. It aims at improving and guaranteeing security of ships. It also provides for audits and internal/external controls, and certification by qualified bodies.

2.2.2.3. **IMO Standards on Training, Certification and Watchkeeping for Seafarers Convention (STCW 95) and ILO Conventions on Labour at Sea**

The **STCW 95 Convention** has been drawn up by a common IMO/ILO committee. It defines minimum standard skills for seafarers. A first version was adopted in 1978. It entered into force in 1984. Since then an important update has been performed, making it more precise and restrictive. The resulting agreement, **STCW 95 Convention**, states that:

- certificates delivered by foreign states must be agreed to by the flag state;
- the port state may control the application of manning rules, as well as qualifications and skills of seafarers;
- companies must implement quality standards for training, including external periodic assessment;
- the flag state must certify that standards are respected;
- companies are liable for qualification of their crews;
- Seafarers must keep on board their original certificates.

A new **Convention on maritime labour standards** has been adopted by ILO in 2006. Although it is not yet entered into force, it is important to quote it first because it gives important new protections for seafarers (minimum salaries, working conditions and hours, minimum age of employment, recruitment conditions, and health protections) and secondly because it is to collect, update and replace more than 65 international standards adopted since ILO creation in 1919.

IMO and ILO have also adopted a set of three non-mandatory guidelines to ensure that the rights of seafarers are respected. These are the **Guidelines on Fair Treatment of Seafarers in the Event of a Maritime Accident**, the **Guidelines on Ship owners’ Responsibilities in respect of Contractual Claims for Personal Injury to or Death of Seafarers** and the **Guidelines on Provision of Financial Security in Case of Abandonment of Seafarers**.

2.2.2.4. **Other specific conventions on safety and security of ships**

A number of other treaties relevant to sustainable maritime navigation issues warrant mention. They concern safety, operations, security and environment protection matters. The main ones are the following:
2.2.2.4.1. Load Line International Convention 66-88. This Convention aims at standardizing safety regulations about immersion of ships at sea. It was modified by a Protocol adopted in 1988 to harmonize provisions related to visits and certificates with the equivalent requirements in SOLAS 74 and MARPOL 73-78.

2.2.2.4.2. International Convention on Research and Rescue. (SAR 79). It aims at developing an international Search and Rescue plan. It entered into force in 1985.

2.2.2.4.3. Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SLUA 88). The purpose of this Convention is to ensure that appropriate action is taken against persons committing unlawful acts against ships, including seizure of ships by force, acts of violence against persons on board, and placing of devices likely to damage or destroy the ship. It entered into force in 1992. A Protocol extends the requirements to fixed platforms, and another (1995, not yet ratified) broadens the range of offences included in the Convention.

All these conventions can be found on IMO and ILO web sites: www.imo.org  www.ilo.org

2.2.3. Specialized international conventions on the protection of marine environment

2.2.3.1. International Convention for the Prevention of the Pollution from Ships (MARPOL 73-78)

MARPOL 73-78 is the main international convention covering prevention of the marine environment by ships, from operational and accidental causes. The first Convention (1973) was held in response to Torrey Canyon sinking (1967). This accident had shown that existing legal tools (Oilpol Convention, London, 1958) were not sufficient. Then after another series of tanker accidents, a new Protocol relating to the Convention was adopted in 1978. As the 1973 MARPOL Convention had not entered into force, the Convention and Protocol were integrated as the MARPOL 73-78 Convention. At the same time, new measures were adopted for tanker designs and operations and incorporated in a 1978 Protocol integrated in a standalone SOLAS 74 Protocol.

The resulting Convention entered into force in 1983. It includes provisions aimed at preventing pollution by oil, but also from a very wide range of sources, described in the current 6 annexes:

Annex 1 Regulation for the Prevention of Pollution by Oil.
Annex 2 Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk.
Annex 3 Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form.
Annex 4 Prevention of Pollution by Sewage from Ships.
Annex 5 Prevention of Pollution by Garbage from Ships.
Annex 6 Prevention from Air Pollution from Ships.

Prevention measures as adopted in IMO Conventions and namely MARPOL 73-78 cannot be expected to prevent all accidents. Therefore, specific Conventions have been established to prepare responses to pollution emergencies:

2.2.3.2. Conventions on Oil Pollution

2.2.3.2.1. International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC). The OPRC Convention was adopted in 1990; it is designed to help Governments combat major oil pollution incidents and to encourage States to develop and maintain an adequate ability to deal with oil pollution emergencies. It requires that ships and ports have oil pollution emergency plans and reporting procedures, but its main provisions apply to preparation measures such as pre-position of oil spill combating equipment, training and exercises, information exchange, organizational and technical co-operation, and research and development, all managed by Governments and public bodies.
2.2.3.2.2. **International Convention Relating to Intervention on the High Seas in Case of Oil Pollution casualties (INTERVENTION 69).** This Convention affirms the right of a coastal State to take such measures on the high sea as may be necessary to prevent, mitigate or eliminate danger to its coastline or related interests from pollution by oil or the threat thereof, following upon a maritime casualty. A protocol of 1973 extended the Convention to other substances in addition to oil.

2.2.3.2.3. **International Convention on Civil Liability for Oil Pollution Damage 1992.**

**International Convention on the Establishment of an International Fund for Oil Pollution Damage (1992 FUND Convention).** The liability and compensation regime was originally established by the 1969 Civil Liability Convention and 1971 Fund Convention. The 1992 agreements apply to all vessels carrying oil as a mass product (i.e. including empty tankers causing damage with bunker oil), and in economic exclusive zones of State parts to the Conventions.

2.2.3.3. **Protocol on Preparedness, Response and Cooperation to Pollution Incidents by Hazardous and Noxious Substances (HNS Protocol)**

Adopted in 2000 by IMO, it follows the principles of the OPRC Convention and extends it to substances other than oil.

2.2.3.4. **International Convention on the Control of Harmful anti-fouling Systems on Ships**

Prohibits the use of harmful organotins in anti-fouling paints and will establish a mechanism to prevent the future use of other harmful substances in anti-fouling systems. Entered into force 2008.

2.2.3.5. **International Convention for the Control of and Management of Ship’s Ballast Water an Sediments**

Parties undertake to minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ship’s ballast water and sediments. (Not yet entered into force)

2.2.3.6. **Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 72)**

**LONDON Convention 72** is one of the first global Conventions to protect the marine environment from human activities. Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollutions of the sea by dumping of waste and other matters. It covers dumping from ships, platforms and aircraft. It does not cover emissions from land based sources nor wastes coming from exploration and operations of seabed resources, nor storage of material in a purpose other than eliminating. It entered into force in 1975.

It includes 22 articles and 3 annexes. Annex 1 provides a list of wastes whose dumping is forbidden; annex 2 provides the list of materials whose dumping is submitted to a specific authorization; annex 3 defines the criteria for general dumping permits.

It was amended and replaced by a Protocol adopted in 1995, that introduces important modifications, such as "precaution" principle and "polluter pay" principle. It aims at a better protection from pollutions. The list of substances whose dumping is authorized is replaced by an 'inverse list' of substances whose dumping is authorized, with dumping of any others being forbidden. Annex 2 of the Protocol defines the rules for assessment of wastes, to which dumping of waste conditions, and authorizations delivered by parties to the Convention will have to comply with.

As of March 2006, the Convention included 81 parties. The 1995 Protocol has been ratified by 30 countries.
2.2.3.7. International Convention for the Safe and Environmentally Sound Recycling of Ships. (Hong Kong Convention 2009)

The text of the ship recycling Convention has been developed over the past three years, with input from IMO Member States and relevant non-governmental organizations, and in co-operation with the International Labour Organization and the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

Regulations in the new Convention cover: the design, construction, operation and preparation of ships so as to facilitate safe and environmentally sound recycling, without compromising the safety and operational efficiency of ships; the operation of ship recycling facilities in a safe and environmentally sound manner; and the establishment of an appropriate enforcement mechanism for ship recycling, incorporating certification and reporting requirements.

2.2.3.8. Nairobi International Convention on Removal of Wrecks 2007

This Convention provides a sound legal basis for coastal States to remove wrecks which pose a hazard to the safety of navigation or to the marine and coastal environments. It will make ship owners financially liable and require them to provide financial securities to cover the costs of wreck removal.

2.2.4. Memoranda of understanding on port state controls

The above international Conventions lay quite detailed regulations on ships, but the intended benefits of these can only be realized through proper enforcement.

This enforcement cannot be performed by the flag states only. For a given ship, the application of some provisions of the Conventions is enforced by the flag state authority. For example, flag state authorities set the periodic inspections to check for compliance for each vessel class, either on their own accord or via one of the various classification societies.

However, experience has shown that flag state controls have not been sufficient in many cases, and sub-standard ships have been allowed to keep sailing, resulting in environmental damages. As a result, compliance to the Conventions is increasingly checked by port state authorities. The efficiency of such checks is improved when organized on a regional basis, resulting in notable reductions in regulatory redundancy. A number of Memoranda of Understanding on Port State Controls in specific geographic regions have been implemented: MoU of Paris www.parismou.org, Tokyo (Asia) www.tokyo-mou.org, Indian Ocean www.iomou.org, Viñas del Mar www.acuerdolatino.int.ar, Caribbean www.abujamou.org, Riyadh www.riyadhmou.org, Mediterranean www.medmou.org. In the United States, Port state control is enforced by the U.S. Coast Guard.

Unlike the Conventions above, the Memoranda of Agreement are discussed by the different states Maritime authorities. They aim at eradicating sub-standard ships by means of a harmonized ship control system. The Memoranda are made on the same pattern. They refer to Conventions above (Load Lines 66, SOLAS 74, COLREG 72, MARPOL 73-78, STCW 78, and International Convention on Harmful Anti-fouling systems 2001). They define inspection procedures to check the validity of certificates. In the case of deficiencies which are clearly hazardous for safety, health or the environment, the port authority may detain the ship. Detention is lifted under repair conditions. Ships with non-cleared deficiencies can be banned from the ports of the MoU’s region.

According to Erika III package measures, the Paris MoU set a New Inspection Regime which entered into force on 2011 January 1st. Frequency of checks is determined from the ship’s “risk profile” (high risk, standard risk, low risk ship) depending on type, age, flag, class, company, number of previous detentions, and ongoing deficiencies. Other overriding factors are also considered (e.g. report from another state, sea accident, immersion of pollutant substances, dangerous manoeuvre, class suspension due to safety reason, unknown ship) and also unexpected factors (contravening to IMO recommendations, class suspension, ongoing deficiencies, previous detention, complaint, cargo problems, default of notification). Banishment rules are reinforced. The inspections are prepared according to call notification by ships. The aim is to inspect all ships calling in the region.
2.2.5. Regional Conventions for marine environment protection

In some 18 geographic areas, the States bordering the sea have decided to cooperate to protect the marine environment. This results in the development of studies to assess ecologic situations, to share information, to finalize coordinated action plans, to prepare responses organized at the regional level in case of accidents, and to provide training and communication.

These actions need legal instruments in order to be implemented. So a number of treaties, agreements, and Conventions have been finalized at the regional level in order to complement the international Conventions above. Their geographic areas of application are more limited, but the set of themes they speak of is wider. Those Conventions are the legal instruments to implement Action Plans finalized by State parties. They are discussed by special permanent Committees and secretariats.

As with the Conventions above, the Regional Conventions undergo frequent changes and revisions. They are generally complemented by specialized Protocols; they are amended, and sometimes deeply modified. They often refer to UNCLOS especially in Part XII and Article 197 on the global and regional cooperation for the protection and preservation of the marine environment.


Most of the Regional Conventions are developed under the United Nations Environment Program’s umbrella; 6 are directly administered by UNEP organizations, 7 by specific organisms. 5 Conventions are independent. Those approaches generally involve government bodies, but also GNOs and private sector representatives.

Below we provide two examples of such Conventions, and a general table of ongoing agreements of this kind:


  9 coastal states and the European Community are part of this Convention, which is the legal instrument to develop international cooperation regarding marine environment protection of the Baltic Sea. The general framework is the Baltic Sea Comprehensive Environment Action Programme. A first convention was signed in 1974, the current one in 1992.

  It refers to **Stockholm Declaration, London Convention 72, MARPOL 73/78, SOLAS, PARIS MoU, and OPRC**.

  The Convention is governed by the Helsinki Commission, or **HELCOM**. This Commission acts as the environment policy maker, information provider, supervisory and coordinating body.
<table>
<thead>
<tr>
<th>Region</th>
<th>Full name</th>
<th>Short name</th>
<th>Signed/ into force</th>
<th>Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antarctic</td>
<td>Prot. on Environmental Protection to the Antarctic Treaty</td>
<td>Madrid Protocol</td>
<td>1991</td>
<td>Independent</td>
</tr>
<tr>
<td>Arctic</td>
<td>No current convention</td>
<td></td>
<td></td>
<td>Independent</td>
</tr>
<tr>
<td>Baltic sea</td>
<td>Conv. on the protection of the Marine Environment of the Baltic Sea</td>
<td>Helsinki</td>
<td>1992/2000</td>
<td>Independent</td>
</tr>
<tr>
<td>Black Sea</td>
<td>Conv. on the Protection of the Black Sea against Pollution</td>
<td>Bucharest</td>
<td></td>
<td>Specific</td>
</tr>
<tr>
<td>Caribbean</td>
<td>Conv. for the Protection and Development of the Marine Environment of the Wider Caribbean Region</td>
<td>Cartagena</td>
<td>1983/1986</td>
<td>UNEP</td>
</tr>
<tr>
<td>Caspian sea</td>
<td><a href="http://www.tehranconvention.org/">www.tehranconvention.org/</a></td>
<td>Framework</td>
<td></td>
<td>Independent</td>
</tr>
<tr>
<td>East Asian Seas</td>
<td>No Current Convention</td>
<td></td>
<td></td>
<td>UNEP</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>Conv. for the Protection of Mediterranean Marine Environment and coastal regions</td>
<td>Barcelona</td>
<td>1995/2004</td>
<td>UNEP</td>
</tr>
<tr>
<td>North East Pacific</td>
<td>Conv. for cooperation in the protection and sustainable development of the marine and coastal environment of the North-East Pacific</td>
<td>Antigua</td>
<td>2002/</td>
<td>Specific</td>
</tr>
<tr>
<td>North West Pacific</td>
<td>No current Convention</td>
<td></td>
<td></td>
<td>UNEP</td>
</tr>
<tr>
<td>South Pacific</td>
<td>Conv. for the Protection of the Natural resources and Environment of the South Pacific region and related Protocols</td>
<td>Nouméa</td>
<td>1986/1990</td>
<td>Specific</td>
</tr>
<tr>
<td>Persian Gulf area</td>
<td>Regional Conv. for Co-operation on the Protection of the Marine Environment from Pollution</td>
<td>Kuwait</td>
<td>1978/1979</td>
<td>Specific</td>
</tr>
<tr>
<td>South Asian Sea</td>
<td>No current Convention</td>
<td></td>
<td></td>
<td>Specific</td>
</tr>
<tr>
<td>South East Pacific</td>
<td>Conv. for the Protection of the Marine Environment and Coastal zones of the South East Pacific</td>
<td>Lima</td>
<td>1981/1986</td>
<td>Specific</td>
</tr>
<tr>
<td>West and Central Africa</td>
<td>Conv. for Co-operation in the Protection of the Marine and Coastal Environment of the West and Central Africa</td>
<td>Abidjan</td>
<td>1981/1984</td>
<td>UNEP</td>
</tr>
</tbody>
</table>

Table 2.2 Regional conventions for marine environment protection
The Nairobi Convention provides a mechanism for regional cooperation, coordination and collaborative actions, and enables the Contracting Parties to harness resources and expertise from a wide range of stakeholders and interest groups towards solving interlinked problems of the coastal and marine environment. It plays a coordinating role in the implementation of a series of intervention projects developed under the New Partnership for Africa’s Development (NEPAD) environment initiative. The aim is to stem any further degradation of the marine environment and to reverse the degradation and destruction of critical habitats.

The Nairobi Convention is an important platform for dialogue between Governments and the civil society at the regional and national level. Partnerships between the Nairobi Convention and regional non-governmental organizations such as The World Conservation Union (IUCN) and Western Indian Ocean Marine Science Association (WIOMSA) have encouraged government focal points to work together with NGOs to share expertise and experience with an aim of stemming the multitude of problems associated with unplanned urbanization and poor regulatory regimes.

The Convention offers a legal framework and coordinates the efforts of the countries of the region to plan and develop programmes that strengthen their capacity to protect, manage and develop their coastal and marine environment sustainably. It also provides a forum for inter-governmental discussions that lead to better understanding of regional environmental problems and the strategies needed to address them; it develops and implements regional programmes and projects that address critical national and trans-boundary issues, and promotes sharing of information and experiences in the WIO region and with the rest of the world.

The Nairobi Convention is a partnership Convention. It recognizes that success in the protection, management, and development of the coastal and marine environment of the WIO region will depend on effective partnerships built on strategic linkages between governments, NGOs and the private sector.

An ecosystems approach to manage marine and coastal resources addresses the interconnectedness between land-based activities, fresh water systems and coastal and marine environments. The approach recognizes the effect of the environment on the resource being exploited and the effect of resource exploitation on the environment. This approach ensures that there is a balance between sustainable use and the fair and equitable sharing of the benefits arising out of the utilization of marine and coastal resources over time.

The two major ecosystems in the Western Indian Ocean (WIO) region, i.e. the Agulhas and Somalia Current Large Marine Ecosystems (LMEs), contain important critical habitats such as sea grass beds, coral reefs and mangrove forests. These habitats are areas of high diversity and are critical fish spawning and nursery areas that provide other vital ecological services, such as shoreline shelter from ocean swells.

The Global Environment Facility (GEF), with the support of the Contracting Parties to the Nairobi Convention and their development partners, have embraced the ecosystems approach and are investing over $78 million, between 2004 and 2012, to support LME projects in the Western Indian Ocean.
2.2.6. Other regional marine environmental protection initiatives

In addition to the Regional Seas Conventions discussed in Section 2.2.5, certain areas have additional initiatives designed to deliver the sustainable management of marine resources. For example, Member States of the European Union are obliged under the requirements of the Marine Strategy Framework Directive to achieve ‘Good Environmental Status’ (a measure of quality) by 2020, assuming the required measures are not disproportionately costly. Good Environmental Status will be determined with reference to a number of ‘descriptors’, many of which are common to the interests managed at the Regional Seas level:

- Biodiversity
- Non-indigenous species
- Fish populations
- Food webs
- Eutrophication
- Sea floor integrity
- Hydrographical conditions
- Contaminants
- Levels of contaminants in fish and seafood
- Marine litter
- Underwater noise and other forms of energy

The objectives of the Directive are to be achieved through a number of prescribed steps:

- An assessment of the current state of marine waters, to be completed by July 2012
- Agreement on a detailed description of what Good Environmental Status means and associated targets and indicators, to be reached by July 2012
- Monitoring programmes to measure progress toward Good Environmental Status, to be established by July 2014
- Programmes of measures for achieving Good Environmental Status, to be agreed by 2016
- Marine Strategies to be prepared for each Marine Region by 2018. These strategies must set out the measures required to protect the marine environment, prevent deterioration and, where possible, restore damaged marine ecosystems. The Directive also seeks to phase out marine pollution to protect the marine environment, human health, and sustainable use. Preparation of marine strategies will necessarily involve close collaboration between EU Member States.

In practical terms, some of the requirements of the Directive will be coordinated and delivered through the four relevant Regional Seas Conventions (OSPAR, HELCOM, Barcelona and Bucharest). However, an important additional consideration for EU Member States is the threat of legal action through the European Court of Justice if the various deadlines and deliverables are not met.

Sustainable marine management, a key objective of marine strategies, will necessarily involve all sectors. The Marine Strategy Framework Directive does not form a substitute but rather a complement to non-specifically marine environmental EC regulations. It explicitly refers to Birds Directive (1979), Habitats Directive (1992), and Water Framework Directive (2000), and it supports the positions taken by the Community in the context of the Convention on Biological Diversity. This publication can help those preparing marine strategies insofar as maritime navigation is concerned.

Table 2.3 illustrates some of the key conceptual linkages between the topics covered in this guidance document and delivery of the objectives of the Marine Strategy Framework Directive.
<table>
<thead>
<tr>
<th>Marine Strategy Framework Descriptor</th>
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Key:
* at the scale of relevance to the MSFD
Relevant Section numbers are shown in brackets e.g. (3.4)
Darker shading indicates potentially more significant effect of activity on Environmental Status
Box 2.1. Erika sinking

On 12 December 1999, oil tanker ERIKA, loaded with 37,000 tons of heavy oil, chartered by TOTAL, breaks in two parts and sinks 40 miles off Brittany coasts.

400 km of coast are spoiled. From June to September, 11,000 tons of oil are pumped off the wreck. This incident highlights first the problem of refuge places, but, overall, of liability issues between the captain, ship owner, charterer, carrier, classification society, flag and port state.

Court actions (ongoing appeal) lead among others to sentences to the charterers and the classification society, and to recognition of damage suffered by the environment.

After the incident, a great legislative work is performed at the European Community level, in order to improve maritime safety.

**Package 1:** entered into force in 2003: stepping up the port state controls, monitoring more strictly classification societies, and speeding up replacement of single-hull tankers with double-hull ones.

**Package 2:** introduction of a Community monitoring control and information system for maritime traffic, setting up of a compensation fund for oil pollution in European waters, and setting up of a European Maritime Safety Agency.

**Package 3:** approved 2009; reinforcement, amendment and addition of measures regarding Quality of European flags, Classification societies, Port State controls, Traffic Monitoring and Assistance to ships in distress, Accident Investigation and Protection of victims.
2.3. Economic Incentives

In addition to the usual regulatory ("Command and control") approach, different economic instruments are conceivable to stimulate innovation and reduction of shipping impacts on the environment. A number of examples of such approaches can be found, and most frequently the goal is reducing ships emissions to air; but economic incentives have also been used in other fields, such as waste management.

This section concerns both ship and port matters. How economic incentives work are first explained; then IMO’s and EU’s positions are presented; finally an overview on what is done at the national and port levels.

2.3.1. How do economic incentives work?

Detailed information on how those mechanisms work, discussion on their respective advantages and drawbacks, and examples of implementation can be found in a study performed by consultant NERA for EU (NERA, 2005), and in the two IMO’s reports on Green House Gas (2000 and 2009): The Swedish Ship Owner Association Emissions Trading Schemes in Europe for SO₂ & NOₓ including shipping study, 2006 gives also a clear and detailed description of Cap-and-trade mechanisms that they proposed to EU.

The present section is based on NERA (2005). This consultant describes four kinds of economic incentive mechanisms, of which two are market-based instruments:

- **Credit based approach.** Credit programs provide tradable “credits” to sources that voluntarily reduce emissions below their “business as usual” ("BAU") levels. These credits can then be traded and counted toward compliance by other sources that would face high costs or other difficulties in meeting their own emissions requirements.

- **Benchmark approach** In the approach considered here, vessels would have the option of joining a consortium that would voluntarily commit to achieving an average emissions rate, known as the benchmark. The specific proposal we consider allows for this program to be voluntary, i.e., ships could form consortia and trade among themselves to achieve the average rate (which would be below the “BAU regulatory case” to account for the cost savings that flexibility would provide and avoid environmental backsliding). Benchmarking emissions trading programs identify a specific emissions rate to apply to covered activities and require that the average emission rate (weighted by activity level) from these activities does not exceed the benchmark level. In contrast to a credit-based approach, there is no need to establish and certify a baseline emissions rate in the case of benchmarking, because the benchmark rate effectively serves as the baseline.

- **Port charges differentiation.** Ships complying with given technical and/or management criteria can be given rebates on ports charges. NERA quotes different examples, particularly Swedish ones.

- **Subsidies.** Environmental subsidies involve financial support by the government of environmentally desirable activities. The support can come in the form of grants, low-interest loans, favourable tax treatment, and other financial assistance to for products with desirable environmental characteristics.
2.3.2. IMO’s approach

In 1997, the *MARPOL Conference (resolution n°8 on CO₂ emission from ships)* invited IMO to undertake a study on GHG emissions from ships and to consider “feasible ...reduction strategies”. This study was completed in 2000. Then, in December 2003, the *IMO Assembly resolution A963* decided to develop actions aiming to identify priority to:

- Establish a GHG emission baseline
- Develop a methodology to describe the GHG efficiency of a ship in terms of a GHG index for that ship.
- Develop guidelines by which the GHG emission indexing scheme may be applied in practice.
- Evaluate technical, operational and market-based solutions.

As a follow-up to resolution A963, IMO's MEPC approved a “work plan to identify and develop the mechanisms needed to achieve the reduction of GHG emissions from international shipping”. This plan included an update of the previous study, which was completed in 2009. The Second Study on GHG includes a package of possible policy options aimed at reducing CO₂ emissions (CO₂ is regarded by IMO as the main air pollution source from ships):

- An Energy Efficiency Design Index (EEDI), ratio between the expected emissions from a ship and its transport capacity, and characterizing the environmental efficiency of new ships. Emission reductions would result in the implementation of a mandatory limit value, or in (mandatory or voluntary) reporting of the EEDI;
- An Energy Efficiency Operational Indicator (EEOI) ratio between the actual CO₂ emissions and its actual transport work (expressed for most ships, as their tonnage of cargo); it has to be calculated for each leg of voyage and periodically reported. Emission reductions would result in the implementation of a mandatory limit or in the (mandatory or voluntary) reporting of EEOI.
- A Ship Energy Efficiency Management Plan (SEEMP). It may be considered as an amplification of the ISM Code. It provides a possible mechanism, based on EEOI, for monitoring ship efficiency performance.
- An International Compensation Fund (IFC) based on a levy on marine bunkers. Emission reductions would result in the possible purchase of offsets from other industrial sectors than shipping, and in funding programs to improve the efficiency of the world fleet.
- A Market Emission Trading Scheme (METS). A cap on global maritime emissions would be set. Allowances would be initially allocated to ships (several possible options: auctioning based on former emissions or activity, on the basis of a benchmark,...) and then could be exchanged on the market. The METS can also be linked to other sectors’ trading schemes.

The two last options require a central organization to manage the scheme.

These different policies and market instruments are thoroughly assessed in the Second GHG Study. It concludes that both ICF and METS appear to be cost effective instruments with high environmental effectiveness.

This work resulted in a submission to the 15th session of the conference of the parties at UNFCC (Copenhagen Summit) in December 2009. In March 2010 MEPC 60 agreed that an expert group should be established to undertake a feasibility study and impact assessment of variations on the above mechanisms, as proposed by some IMO members.

In July 2011, MEPC 62 has adopted EEDI and SEMP policies, and other MARPOL-Annex VI amendments projects. EEDI and SEMP policies form the first binding instrument to be adopted since the Kyoto Protocol. MEPC 63 (February 2012) has adopted four additional Guideline documents; but there is no general agreement on marked-based measures, which have been postponed pending consensus.
2.3.3. European Union’s approach

In 2008 the EU leaders approved an ambitious plan aiming at reducing GHG global emissions by 2020 20% compared with 1990 levels.

As a cornerstone of this strategy EU had implemented (2005) an Emissions Trading Scheme for CO\textsubscript{2}. It is the first ETS of this scale. 12,000 factories and plants of main industrial sectors, responsible for about half of the EU’s emissions of CO\textsubscript{2}, are covered by the plan. The governments set limits on CO\textsubscript{2} emissions for each industry. Those who want to emit more than their quota have to buy spare permits from other more energy efficient companies.

As of January 2012 the transportation sector was not involved in the European Emissions Trade Scheme; however since then it has been extended to include air transport.

IMO’s future system for shipping could conceivably get connected to EU scheme. In 2011, EU leaders confirmed that should no satisfactory solution be found soon within IMO, then the EU would implement its own in 2012.

In March 2012, EU launched a public consultation on the extension of ETS to shipping. However it has already faced strong opposition from non-European countries to the enforcement of ETS for air transport activity. Therefore it is unlikely that ETS would be extended to shipping in the near term.

2.3.4. National and port authorities approaches

**Sweden:** Maritime fairways, navigational aids, ice breaking, piloting, and rescue operations are funded through fairway dues. The Swedish Maritime Administration (SMA), Swedish Ship Owners Associations, Swedish Ports and Stevedores Association agreed to implement measures to reduce ships emissions to air. In 1998, SMA created a differentiated fairway and port dues system, existing since 1998, aiming at reducing 75% NO\textsubscript{x} and SO\textsubscript{2} emissions within a few years. Half of the 50 major Swedish ports decided also to differentiate their port dues on the basis of environmental performance of ships. The system was revised in 2005. It was completed in 2000-2003 by grants from SMA to operators to enhance technical engines improvements on a number of ferries calling at Swedish ports. The rebates being weak, the fairways dues differentiation scheme is not regarded as very efficient in itself. (SMA 2007).

**Norway** has a long experience with environmental taxation. Bunker fuel used in Norway domestic trade is subject to a CO\textsubscript{2} tax and sulphur tax. (1991). More recently (2007), Norway created a NO\textsubscript{x} tax, and a NO\textsubscript{x} fund. The level of the tax is quite significant (2000€/t NO\textsubscript{x} in 2011) The enterprises affiliated to the fund pay less than the tax, and are entitled to get grants for reducing emissions technical measures. NO\textsubscript{x} reductions 2008-2011: 23 000 t (12% total Norway emissions) (Hoibye, 2011)

**The Green Award scheme** was initiated in 1994 by the port of Rotterdam. It is now managed by an independent Foundation. This entity works as a certification organism, auditing ships about requirements related to quality, safety, technical issues, crew and management, and environmental performance.

Certified ships are eligible to varying incentives, (harbour dues rebates…) in ports members, now about 35 ports in the Netherlands, Belgium, Canada, Lithuania, Latvia, Oman, New Zealand, and South Africa….

In 2011, the foundation decided to refer to IAPH and World Port Initiative’s Environmental Ship Index (ESI) as a criterion for environmental performance, the same for all ports in the scheme.

**The port of Vancouver** has an important differentiated harbour dues scheme: Blue Angel. It allows 4 port dues abatement levels from 0,094 $/t (basic), to 0,072 $/t (bronze), 0,061 $/t (silver) and 0,050 $/t (gold). Ships have to comply with some requirements including environmental designations by classification societies, green award, and existence of reducing harmful emissions technologies, nature and quality of bunker, use of alternative power at berth….
Los Angeles - Long Beach. The pervasiveness of air pollution problems in the Los Angeles metropolitan area, which has some of the worst air quality in the US, drove the authorities at various levels of government to implement numerous air quality measures. The ports of Los Angeles and of Long Beach set up their Clean Air Action Plan in 2006. Non-regulatory measures include the following:

- In 1993, South Coast Air Quality Management District implemented the “RECLAIM” program. This program (a “credit based” one in NERA terminology) applies to stationary sources. In 2001 it was expanded to include “captive” marine vessels (harbour craft, fishing vessels, operating exclusively within 25 miles of the district’s shoreline) over a four year experience. Participating ships have reduced NOx and SO2 emissions through engine improvements, and been allowed to emit reduction credits bought by participating stationary sources.

- Since 2001, both ports have participated in a very successful voluntary Vessel Speed Reduction (VSR) program: Ocean-going vessels were encouraged to reduce speeds down to 12 knots at a distance of 20 nautical miles from ports (extended to 40 n miles I, 2008). The incentives include reduced dockage rates and environmental recognition for operators who voluntarily reduce speed when arriving or departing. 90% compliance corresponds to 15% rebate. Individual ships can get a green flag award.

- The approach described by NERA (2005) regarding California Air Resources Board (CARB) policies, expected to form a “benchmark scheme” has not been implemented.

- In 2008-2009, both Port authorities have implemented Low Sulphur Vessel Main Engine Fuel Incentive Program to encourage ships using low-sulphur fuels when close to the ports. They funded the cost difference between heavy and low sulphur fuels, prior to adoption by CARB of new regulations requiring the use of low sulphur fuels within 24 miles of Californian coast.

Now an IMO-Marpol VI ECA has been implemented on US most coasts, that will enter into force in January 2012.

World Ports Climate Initiative (WPCI) includes more than 55 major world ports (including ports of LA-LB), aiming at improving their GHG emissions. (See Box 4.6). One of their chief actions is to develop an Environmental Ship Index (ESI). The ESI can be used by the ship owners and by the ports as a label of good performance, and also as a way to calculate rebates on harbour dues.

Other harbour due rebates systems is quoted (ports of Marieham, Turku, Clean Shipping project in Gothenburg). Some of them have been abandoned (Hamburg).

2.3.5. Commentary about economic incentives

Among the different economic instruments aimed at tackling vessels emissions to air, we find:

- A significant number of harbour dues differentiation schemes. The question is where the limits of such schemes are: to be efficient, they should be developed at a large scale, but is spreading possible, in the port competition contexts?

- Several subsidiarization operations, to help with technical engine improvements to limit NOx, SO2 and PM emissions. Those schemes can be efficient, but examples found show that the polluter-pays principle is not always complied with.

- Great things are expected of market-based instruments, but very few practical examples found.
3. SHIP-BASED SUSTAINABILITY ISSUES

3.1. Ships life cycle; “green” ships

Subsequent sections of this report specifically address the different impacts of shipping on the environment. A number of initiatives (e.g. “Green ships” approaches) are currently taken at various management levels (international organizations, states, industry, and ship owners,) to significantly reduce environmental impacts and to ensure a greater degree of sustainability for the shipping industry.

For example, efforts are currently underway in both the EU (EC Fifth Frame program on sustainable transportation and inter-modality) and the US (Society of Naval Architects and Engineers) to establish measures of environmental performance for ships to facilitate improvements in sustainability throughout a ship’s lifecycle. More recently, at the 15th United Nations Climate Change Conference (COP15) Dec. 7 – 18, 2010 representatives of the shipping industry discussed the technical and operational improvements in the global commercial shipping fleet necessary to reduce harmful emissions from world shipping (http://www.maritimereporter.com/en-US/News/Article/COP15-Discusses-Sustainability-in-Shipping/332715.aspx)

These approaches require global views on sustainability at all stages of ship life cycle, i.e.; design, construction, operation and maintenance, gravning/recycling/scrapping. General sustainability considerations for each of these four phases are outlined below:

Design:
- Design elements that improve fuel efficiency and/or use of renewable fuel sources (e.g., propulsion systems)
- Elements that reduce/eliminate harmful air and water emissions (e.g., propulsion, ballast water, and waste management systems)
- Incorporation of sustainable construction materials (e.g., environmentally friendly hull coatings)
- Elements that facilitate recycling of ship materials at the end of design life
- Elements that facilitate sustainable shore side operations (solid and liquid waste handling, shore side power, etc.)
- Electronic gear and intakes that minimize impacts on aquatic life
- Elements that minimize potential for spills/accidents
- Elements that reduce amount/frequency of maintenance

Construction:
- Use of sustainable materials (“green” solvents, lubricants, coolants, etc. and environmentally friendly hull coatings)
- Use of equipment and/or control processes that limit or eliminate releases to air and water during construction
- Equipment or practices that minimize or eliminate use of non-renewable resources during construction

Operation/maintenance:
- Waste reduction/management
- Fuel efficiency
- Emission reductions
- Ballast water management
- Practices and equipment to minimize risk of environmental release/accident
Recycling (scrapping):

- Management of hazardous materials
- Practices and/or use of equipment and materials that minimize or eliminate environmental releases during recycling.
- Equipment or practices that minimize or eliminate use of non-renewable resources during recycling.

For each phase of a ship’s design life, guidance is emerging to facilitate improved efficiencies, reduce environmental impacts, and contribute to overall sustainability. The “green passport” developed and adopted by the IMO under Assembly resolution No. A.962(23) requires an inventory of all hazardous materials onboard a vessel. This inventory is initially compiled during design and construction, maintained and updated during operation, and then utilized to facilitate the clean recycling of ship materials at the end of the design life.

### 3.2. Air Quality (MARPOL VI)

#### 3.2.1. Assessment

Gases and particles which are emitted by manufacturing and construction activities, means of conveyance (road and rail transports, aviation, shipping), electricity and heat production, and other uses are significant sources of pollution at the global level. Green House Gases (GHG), $\text{H}_2\text{O}$ vapour, $\text{CO}_2$, $\text{CH}_4$, $\text{N}_2\text{O}$, Fluoride gases) are regarded as partly responsible for climate change. Nitrogen and sulphur oxides ($\text{NO}_x$ and $\text{SO}_x$), are responsible for acid rain, and are also associated with particulate matter leading to health problems (lung illnesses, bronchitis) in many urban areas.

The shipping industry is not immune from these air quality issues, though compared to other modes of transportation, it is the least environmentally damaging in terms of transport capacity. Shipping contributes to the overall air quality problems encountered by populations in many coastal areas, and also to problems encountered by inland populations since the air pollutants can be carried hundredths of kilometres inland.

Figure 3.1 shows the share of international shipping in the global total anthropogenic emissions.

![Figure 3.1: Emissions of CO₂. From Second IMO GHG Study 2009](image-url)
Acknowledging the importance of controlling and reducing greenhouse gas emissions, in the year 2000 IMO launched a study on Greenhouse Gas (IMO, 2000) emissions from ships which was followed by the Second GHG Study, (IMO, 2009). According to the 2009 study international shipping was estimated to have emitted 870 million tons, or about 2.7% of the global emissions of CO₂ in the year 2007.

In the absence of global policies to control greenhouse gas emissions from international shipping, the emissions may increase by between 150 and 250% by the year 2050 due to the expected continued growth in international seaborne trade.

In 2050, the share of international shipping could increase by 12-18% of the global emissions required to achieve stabilization of CO₂ emissions by the year 2100. This figure is not sustainable.

Another indicator leads to the same conclusion: Corbett et al (2007), estimates that the world shipping fleet operations contribute heavily to premature mortality and health incidences, up to 60.000 deaths a year through particulate matters.

3.2.2. Regulatory framework

3.2.2.1. International framework

The main global initiative to prevent air pollution from ships is Annex VI to MARPOL 73/78. Annex VI contains specific regulations on preventing air pollution from ship; it entered into force on 15 May 2005 and has been ratified by 70 IMO member states representing 93.29% of world tonnage. In addition to basic quality requirements for fuel oil delivered and used onboard ships and specific recording requirements, Annex VI prescribes limiting values for ship’s emissions (SOₓ and NOₓ) in particular and prohibits deliberate emissions of ozone depleting substances. It contains provisions allowing for special "Sulphur Oxides Emissions Control Areas" (SECAs) to be established with more stringent control on sulphur emissions. Concerning SOₓ emissions, Annex VI prescribes a world-wide limiting value of 4.5% sulphur content and within SECAs a limiting value of 1.5% as yet. Compliance with these limiting values can be achieved by using appropriate fuel oil or alternatively by the employment of an exhaust gas cleaning system or by use of any other technological method to limit SOₓ emissions. So far the Baltic Sea and the North Sea are designated as SECAs (Baltic Sea in effect since 19 May 2006, North Sea in effect since 22 November 2007). Concerning NOₓ emissions, Annex VI prescribes specific limiting values (amount of emission in relation to rated engine speed) for the operation of each diesel engine. A mandatory NOₓ Technical Code, developed by IMO, defines how this is to be done. Concerning ozone depleting substances, Annex VI prohibits deliberate emissions of ozone depleting substances, which include halons and chlorofluorocarbons (CFCs). New installations containing ozone-depleting substances are prohibited on all ships, but new installations containing hydrochlorofluorocarbons (HCFCs) are permitted until 1 January 2020.

Within the revision process of MARPOL Annex VI the tightening of the limiting values was extensively discussed and decided. These discussions led to adaptation of the revised MARPOL Annex VI in October 2008 which will bring out a further and progressive reduction of ships emissions. The revised Annex VI extends the possibility for the designation of “Control Areas” with the creation of “Emissions Control Areas (ECAs)” which can be designated for SOₓ and PM, or NOₓ, or all three types of emissions from ships, subject to a proposal from a Party. On this basis the United States of America and Canada already proposed the designation of an ECA for specific portions of their coastal waters including parts of Hawaii for the control of NOₓ, SOₓ and Particulate Matter emissions. As related to SOₓ emissions, revised annex VI aims at the long-term changeover from heavy fuel oils to higher quality fuels and finally to distillates. A progressive reduction has been decided with the global sulphur cap reduced initially to 3.50% (from the current 4.50%), effective from 1 January 2012; then progressively to 0.50%, effective from 1 January 2020, subject to a feasibility review of the availability of the relevant fuel oil quality, to be completed no later than 2018. In the SECAs this process is even faster with a reduction to 1.0 % effective from 1 July 2010 to 0.1% as from 1 January 2015. NOₓ emissions generated by operation of diesel engines are supposed to be reduced within a 3 Tier system to about 80 % of the current standard (Tier I). This means that each diesel machine which is built and installed on board as from 01 January 2016 has to comply with the Tier III standard.
The Marine Environment Protection Committee (MEPC) of the IMO agreed (MEPC 59, July 2009) to a package of technical and operational measures to improve energy efficiency and reduce GHG emissions from international shipping: Energy Efficiency Design Index (EEDI), Ship Energy Efficiency Management Plan (SEEMP), and Energy Efficiency Operational Indicator (EEOI). In July 2011, MEPC 62 adopted amendments to MARPOL VI making EEDI mandatory for new ships and SEEMP for all ships. In February 2012, MEPC 63 adopted four subsequent important guidelines. These new regulations should enter into force on 1st January 2013. They are the first legally binding instrument on climate change to be adopted since the Kyoto Protocol. According to IMO, they are expected to lead to significant emissions reductions and cost savings (www.imo.org//technical-and-operational-measures. See also IMO (2009) and section 2.3.2).

3.2.2.2. Regional framework

- European Community: EC Sulphur Directive 2005/33 amending Directive 1999/32 restricts the use of fuel oil with a sulphur content of more than 0.1 % m/m for ships at berth of EU ports in general beginning January 2010.
- European Community: EC Commission Recommendation 2006/339/EC on the promotion of shore-side electricity for use by ships at berth in Community ports recommends to the Member States to consider the installation of said means.
- HELCOM: Recommendation for introducing economic incentive schemes as a possible complement to existing regulations to reduce emissions from ships in the Baltic Sea Area
- HELCOM: Evaluations to propose the designation of the Baltic Sea as NECA

3.2.2.3. National framework

- Germany: Environmental label scheme called “The Blue Angel”. The Blue Angel exists on Eco-friendly ship design and on Eco-friendly ship operation and has a primary focus to reduce emissions to air.

3.2.3. Technical Prospects

3.2.3.1. Overview

For decades Marine shipping has been known for using lower grade refinery products for propulsion and power generation. Although maritime transport is considered to be the cleanest transportation mode, the growing maritime trade, environmental awareness, and market competitiveness are driving this sector to search for more energy efficient and less polluting alternatives to be incorporated into ship design and operation and to make maritime transport more sustainable. Sustainability, efficiency, profitability and pollution prevention all go hand-in-hand. Efforts need to be strengthened to minimize wastage of resources and energy in the form of emissions, discharges, heat loss, and friction loss through innovative and technologically progressive design, operation, and maintenance of ships. Multi-pronged approaches are needed to make maritime navigation more sustainable. In spite of growth in shipping its environmental footprint needs reduction in the long run to meet environmental challenges in terms of reduction in emission of sulphur, GHG, soot, etc...Considerable efforts have been taken by different players in improving the ultimate ship design to maximize energy efficiency and reduce environmental footprints. Management alternatives such as incentives for greener technology or green operation, route planning, incentives modifications/retrofits, etc. are also required to improve overall environmental performance in a sustainable manner.

Revised MARPOL Annex VI (in force since May 2010) requires sulphur content ≤ 1 % or exhaust gas cleaning system with total emission of SO₂ ≤ 4 g SOx/kWh, which will be further restricted from Jan. 2015, requiring sulphur content ≤ 0.1% (or exhaust gas cleaning system with total emission of SO₂ ≤ 0.4 g SOx/kWh). Use of alternate cleaner fuel or an exhaust gas cleaning mechanism with adequate operational management will be able to meet the immediate challenges posed by this restriction. Carbon emission reduction along with growth in maritime transport can only be achieved by increasing energy efficiency and utilizing clean energy technology for the propulsion. Projected estimates suggest that significant reductions in air pollutant load due to shipping can be achieved by incorporating various compatible technologies at different stages of ship design, operations and maintenance.
Leading shipping players viz. Lloyd, Maersk, CMA CGM, MAN Diesel, APL and many more to name, have made notable contributions in evolving and experimenting with newer and more energy efficient technologies and management approaches. A high degree of coordination among engine manufactures, ship designers, auxiliary suppliers, operators, sailing professionals and regulators are required to effectively evaluate and implement alternative or control technologies.

Available solutions with potential for limiting emissions can be substituting sustainable energy sources, cleaner fuels, substituting better instrumentation and movable parts, and operational improvements to the existing system.

Challenges in terms of environmental sustainability can be addressed by adopting green technologies in constructing new ships and retrofitting existing ships with control equipments, suitable modifications, adopting best operating and maintenance practices to reduce energy loss and increase efficiency. Emission is nothing but energy loss in the form of gases, carbon, and un-burnt hydrocarbons. The quantum of energy loss from a specific point may vary significantly for a bulk carrier compared to a passenger ferry on account of speed, super structure, hull design, coating, propeller, engine type, etc., and depending on ship design and operations, the priority area for improvement may change. Fuel per tonne-mile can be significantly reduced by curving energy losses at various points in shipping operation. Existing shipping fleet can be made more environmentally friendly by employing various techno-managerial solutions. A few of them will be briefly discussed here.

### 3.2.3.2. Cleaner fuel Alternatives

Wind power, solar power, fuel cells, bio-fuel, Liquefied Natural Gas (LNG), emulsion diesel, etc. are fuels of the future. Wind and solar power, the most eco-friendly and non-exhaustible source of energy, have limitations of peak power fluctuations and can be utilized partially when backed by other clean-energy alternatives.

#### 3.2.3.2.1. LNG

LNG is emerging as one of the most promising fuels for the immediate future. A few ferry vessels and medium-sized cargo ships are successfully utilizing LNG, but use within the existing fleet is difficult because of the extensive modifications required to switch fuel types. Logistics support and an improved LNG bunkering network shall favour construction of LNG-fuelled container ships and tankers. Availability, cost, environmental suitability, and operating parameters all favour LNG as the main alternative to bunker fuel, but it does require higher space on board. LNG is characterized by a higher hydrogen-to-carbon ratio, absence of sulphur, and a relatively lower combustion temperature, thereby reducing emissions of CO\(_2\) (25%), NO\(_x\) (90%), particulates (99%), and SO\(_x\) (100%). However, due to a higher hydrogen-to-carbon ratio it will produce more methane, indirectly affecting the net benefit in controlling global warming. The 2\(^{nd}\) IMO GHG study (2009) estimates that due to methane, the net benefit of LNG in terms of green house gas emission will be limited by 15%. Technologies for reducing methane emission from LNG powered ships shall need to be explored to make LNG a real sustainable alternative fuel for future ships. In the first phase of development, LNG can be used for new coming ships for coastal shipping.

#### 3.2.3.2.2 Wind

Traditional sails, solid wing sails, towing kites, and Flettner-type rotors are some of the technologies available today to harness wind energy. Efficiency and power per unit area of sail varies with different technology and also with wind velocity. Technological improvements to harness wind energy by using the Towing-kite wind propulsion concept employed through ‘Skysails’ can save 10-35 % fuel and corresponding emission reductions. These are being used on a few medium-sized cargo vessels (“Beluga Skysails”, “Michael A” and “Theseus”) and fishing vessels (the ROS-171 “Maartje Theadora”). They give better (>5 times) propulsion power per unit area than the conventional sails. Skysails claim that 160 sq m of kite generates a traction force of 8 MT equivalent to 600-1000 kW of installed main engine power. The present system for cargo vessels can provide towing loads of 8 and 16 tons, whereas developmental programs are aiming for an effective load of 130 tons. The Technical University of Berlin study concluded that fuel savings were greater at low speed, varying from about 5% at 15 knots to about 20% at 10 knots (Clauss et al, 2007). More research & development is required to once again make wind a main power source to drive ships.
3.2.3.2.3. Solar power
Available solar-cell technology can meet only a fraction of the auxiliary power requirements of the ocean liners, due to space constraints on board and comparatively high power requirement. Solar power is of interest basically as a complementary source of energy. Technology has not been able to meet cost-efficiency criteria required for shipping. Initiatives to maximize solar power use in conjunction with wind have been tried in Solar Panel Sails and are being used successfully on catamaran type ‘Solar Sailor’ hybrid fuel passenger ferry vessels operated in Sydney Harbour, Honkong, and Shanghai. The return on extra cost is claimed to be 20% per annum with a 50% fuel saving and > 50% emission reduction. The technology is so far limited with few field trials with passenger ferries. Its power to withstand harsh climatic conditions encountered during voyages of an ocean liner is yet to be evaluated. Even with use in smaller vessels it will benefit the environment at the local level.

3.2.3.2.4. Fuel Cells
Fuel Cell technology is in the developing stage and its commercial use for maritime transport needs more advancement. Fuel cells produce electricity directly from a fuel by converting chemical energy stored in the fuel to electricity through a reaction with oxygen. Fuel cells are far more energy efficient than conventional combustion engines, thereby reducing energy loss, GHG emission, and increasing profitability in operation. Technological development for commercial exploitation may take approximately another 20 years with coordinated efforts. Fuel cells operating on different base fuels have different operating limitations, but the most successful have been hydrogen and LNG fuel cells. Marine applications with LNG can lead to 20-40% reductions in green house gas (GHG) emission (Fuel Cells technology in ships 2004). Utilization may be limited with stationary applications (on board power supply) in bigger ships and propulsion in smaller boats. So far it has been utilized in new ferries (FCS Alsterwasser, a 100 PAX capacity) and recreational boats (New Clermont, Bristol 22, etc.). The technical viability of fuel cells on cargo ships by has been showcased by installing a 320 kW LNG fuel cell for the 5900 dwt LNG-powered cargo vessel ‘Viking Lady’. This type of composition can eliminate problems with sulphur and soot emissions, and reduce carbon dioxide and nitrogen oxide emissions by more than 50%.

3.2.3.2.5 Nuclear Fuel
Ideally nuclear fuel is very environmentally friendly. Its use in commercial shipping with micro-nuclear onboard reactors is limited by various technical, safety, security, and operating cost reasons. Long journey periods, absence of adequate on-board security measures and threats from pirates are the main causes of concern. A few nuclear fuel propelled vessels have been tried in the past, especially for ice breakers, but these could not be operated for long periods because of various constraints. Nuclear fuel for merchant shipping is unlikely to take shape in near future.

3.2.3.2.6 Bio fuel
Bio fuel (bio-diesel) with refinement is technically feasible for shipping except for minor operational challenges associated with specific types of bio-fuel, but availability, cost, and other socioeconomic issues (mainly diverting grains away from human food chains) limit its widespread use. Technical acceptance in marine engines and potential pollution reductions are two key issues which will vary depending on the source of fuel and engine type. First-generation bio-fuels may potentially create maintenance troubles in marine engines due to bio fouling and clogging of filters. Refined or processed bio-fuels and bio-diesel may be an alternative to counter these problems. Second-generation (produced from non food items) bio fuels shall have more advantages over those of the first generation, but limited availability and cost become limiting factors for use of bio fuel for ships.

3.2.3.2.6 Emulsion Fuel
Emulsion fuel is an emulsion of 30% water and 70% fuel oil on a sub-micron level, which remains stable for very long periods. It is approximately 30% cheaper than the original fuel and approx 95% more efficient than the pre-processed oil. Having water molecules mixed in reduces soot, nitrogen oxides, and GHG, by more than 50% and sulphur emissions by 30%. Fuel saving, environment protection, and reduced maintenance are the key benefits of emulsion fuel. Individual emulsifying units can be installed on ships to produce emulsified fuel on board. This technology can be applied to diesel, bio-diesel, contaminated waste oil, and bunker oil.
3.2.3.3. Improved hull design

A considerable amount of energy is lost due to water resistance to the hull. A better designed hull that effectively reduces resistive force can save significant energy and operating costs. Energy loss in counteracting the friction force between the hull and water is estimated to be on the order of 16% for a medium size cargo vessel. Wave resistance offers large design potential. Moderate changes in lines can result in considerable changes in wave resistance. It is necessary to find an optimal hydrodynamic design for a hull to maximize energy saving. The water resistance is the main factor favoring fuel economy at slow speeds. IMO is focusing on an Energy Efficiency Design Index (EEDI) for new ships. After some future date every new ship will be required to show improvement in its EEDI over a baseline to be fixed appropriately considering all test and normal operational data and available technologies.

3.2.3.4. Improved superstructure design

Similarly air resistance posed by a ship’s superstructure can be managed to some extent through aerodynamic designing. Ships operating at higher speeds need a better aerodynamic concept for their superstructures.

3.2.3.5. Improved propulsion

The propeller transforms the power delivered from the main engine via the shaft into a thrust power to propel the ship. Typically, only 2/3 of the delivered power is converted into thrust power. A larger diameter propeller rotating at low speed produces higher efficiency. Energy efficiency can be further increased by enhancements like contra-rotating propellers, high-efficiency rudders, ducts, vane wheels, and asymmetric rudders. The savings through these enhancements may vary from 5-10%.

3.2.3.6. Enhancing Combustion Efficiency

Combustion efficiency and operating characteristics of an engine decides fuel saving and emission reduction. Emission reduction targets of Tier II engines (15–20% NOx from the current levels) can be met through modifications in the internal-combustion process. But for higher efficiency, integrated exhaust gas recirculation, catalytic converters, and auto engine tuning are a few common options. Different technologies and products are currently available in the market to utilize these options. NOx limit to Tier III engines (80% reduction from Tier I) can only be achieved by use of post-treatment catalytic conversion (reduction). Catalytic conversion technology is available for four-stroke engines; however, more R&D is required for large two-stroke engines. A better tuned engine will give maximum power with minimum fuel, thus providing better efficiency, fuel saving, and equivalent reductions in emission. Automated tuning systems continuously monitor the operating parameters and performance and control the fuel injection, pressure, and other control variables for optimization. These types of systems are techno-economically viable and commercially available and can reduce emission and fuel consumption between 1-3%.

3.2.3.6.1. Exhaust Gas Recirculation (EGR)

As the name suggests, part of the exhaust gas is diverted back into the air intake to the engine. This reduces the oxygen content of the air in the combustion chamber and also the combustion temperature by increasing the heat capacity due to the presence of exhaust gas. The lower combustion temperature and oxygen content in the combustion chamber results in reduced formation of NOx. EGR following turbocharger can better regulate quantity and heat capacity of air. Different green initiatives like ‘Green Ship of the Future’ and ‘Hercules-B’, have adopted EGR as an emission reduction method. EGR can be the best suited method for reducing NOx by 80% (Tier III) on a two-stroke low-speed engine with minimum deteriorations regarding specific fuel oil consumption (SFOC) penalty. MAN Diesel performed a test on their 4T50ME-X test engine. One of the results was an 87% NOx reduction obtained at 75% load with an SFOC penalty of 5 g/kWh and 80% NOx reduction at 75% load with SFOC penalty of only 2 g/kWh. However, the long-term effects of EGR on engine efficiency still need to be considered.
3.2.3.6.2. Waste Heat Recovery System
Exhaust gas just outside the engine has high heat content. This heat can be utilized in an exhaust gas boiler to produce steam which can be used to generate electricity through a steam turbine connected with a generator. The amount of heat trapped can be maximized with a multi-steam pressure system utilizing EGR for feed water heating. Alternatively, a smaller capacity gas turbine can be used to utilize energy available in the exhaust gas not used through turbocharger. This electricity can be used for onboard auxiliary systems, hostelling, etc. It reduces the total requirement of the heat to be generated by using fresh fuel, thus a fuel saving of amounts equivalent to a reduction of 10% each of SOx, NOx and CO2. Field trials have shown increases in 5-10% of the shaft power. Similar systems based on Organic Rankine Cycle (ORC) are commercially available, having benefits over steam systems in terms of reduced space requirements. The limitation in the long run may come due to the nature of the liquid used by ORC. Alternatives such as use of high-pressure CO2 as working fluid could become more viable options going forward.

3.2.3.6.3. Exhaust Gas cleaning
In order to achieve legal compliance pertaining to emission of SO2, flue gas scrubbing is another alternative for existing ships unable to adopt cleaner fuel or manage their emissions otherwise. Normal sea water as an absorbent in scrubbers has doubled the efficiency of brackish water. The SO2 absorption capacity increases with the salinity and alkalinity of sea water. However, the water quantity required to meet the desired efficiency is quite high, thereby losing significant energy fuel energy for scrubbing. A Man Diesel research team suggests that to meet emission limits of Sulphur Emission Control Areas (SECA), operating on 4.5% sulphur, a 66% cleaning efficiency requires a minimum water supply rate of 40–63kg/kWh.

3.2.3.7. Improved hull coatings and maintenance:
Friction resistance depends mainly on the wetted surface and net surface roughness of the hull. Ships with severe fouling may require twice the power as those with a smooth surface. Surface roughness and relative speed of the hull to water determines friction which varies over the hull surface (Faltinsen, 2005). Chemical composition of the coating and quality of application (surface preparation, coating methodology, layering, etc.) decides coating efficiency in terms of providing a smooth surface, reducing fouling, and corrosion prevention. An improved hull coating reduces energy loss by decreasing friction force, thus providing better energy efficiency and leading to reduced fuel consumption (2-5%). Silicone-based coatings create non-stick surfaces and provide a greater degree of friction reduction and improved protection from recurrent fouling. As time passes the roughness increases and fuel efficiency starts coming down. Regular hull maintenance (by underwater cleaning, or dry docking) and repetitive coating can provide a better sustained reduction in hull friction resistance. These two can be optimized based on operational environment and ship configuration. As fouling and rusting are governed by a number of techno-environmental parameters of the ship and operating waters, it is not easy to have a common schedule of maintenance but it can be done through visual inspection, test trials, etc. Mostly the bow area and air-water interface area of a ship typically gives the most significant information about hull fouling. Forthcoming air lubrication technology for reducing hull friction is under development and requires detailed techno-economic evaluation. The energy requirement for creation of an air film between the hull and water surface will have to be evaluated against the overall benefit through air lubrication.

3.2.3.8. Trim Optimization
To optimize fuel savings and environmental protection, hull resistance needs to be counteracted through control of the ship’s trim. With the proper trim, fuel consumption is minimized. At present it is typically managed manually, but computer controlled modules can deliver better efficiency and real-time correction based on online monitoring of resistive forces. The available technology considers draft, ballast tank conditions, hull resistance, and main engine models to find the optimal trim. Optimal values and suggestions regarding parameter adjustments are displayed. Suggestions contain current operational settings and indications of what could be gained by changing the parameters to other given values. Recently released software packages provide real-time responses to voyage conditions and can lead up to 5% fuel savings.
3.2.3.9. Slow steaming

Slow steaming (slowing of ship speed during voyage) reduces wastage of energy leading to fuel saving and emission reduction, without any significant technical drawbacks. However, slow steaming requires an increase in the number of vessels operating on a given line, which limits the environmental benefits from fuel savings. Slow steaming also increase the transit times, which could impact the overall demand for shipping. Nevertheless, all main container carriers currently use slow steaming, which can result in an energy saving of 19% on a ton-mile basis. (IMO, 2009)

These measures added together can achieve sustainability in terms of energy efficiency by 25 – 75% and corresponding emission reductions. (IMO, 2009)

3.3. Water quality (MARPOL I, II, IV, V)

3.3.1. Assessment

Emissions to Water fall within two major groups: Liquid Emissions and Litter Emissions. They are generally addressed as discharges of wastes which have been generated during the regular service of the ship. Within the liquid emissions category, a distinction can be made between sewage and grey water. Sewage is defined as drainage and other wastes from any form of toilets and urinals, drainage from medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs and scuppers located in such premises; drainage from spaces containing living animals or other waste waters when mixed with the drainages defined above – contaminated waste water (MARPOL IV reg 1.3). It is to be noted, that the term “grey water” is not an official term. From a general understanding it can be defined as water from swimming pools, laundries, dish washing, showers, cleaning, etc. In general it consists of all liquid emissions others than sewage, that is, non-contaminated waste water. Emissions to water from ships and associated effects on the marine environment are a global problem. In particular, the nutrient discharges from the sewage of passenger ships introduces pathogens and nutrients to the water and may contribute to poor water quality and associated effects on human health and marine ecosystems. This includes, especially in coastal areas, microbiological contamination of waters and the passing on of diseases to humans in contact with the water or through consumption of contaminated shellfish. Nutrients can enhance eutrophication, i.e. excessive growth of algae and associated adverse effects like oxygen depletion and then lead to obvious visual pollution. It also has a social and economic impact with regard to fishing, aquaculture, recreation and tourism.

Garbage is defined as all kinds of victual, domestic, and operational waste including tank washing and bilge water generated during the normal operation of a ship which is not covered by other Annexes. When garbage is not disposed of legally, it becomes litter. Pollution through litter especially with regard to plastic can have severe and long lasting impacts on the ecosystem and its visual pollution is evident. Fish and marine mammals may mistake plastic for food and they can also become trapped in plastic ropes, net bags, and other items.

3.3.2. Regulatory framework

3.3.2.1. International framework

The best know global initiative to prevent sewage pollution from ships is Annex VI to MARPOL 73/78. MARPOL Annex IV contains specific regulations for the prevention of pollution by sewage from ships, entered into force as from 27 September 2003 and has been ratified by 124 IMO member states representing 81.62% of world tonnage. MARPOL Annex IV prohibits ships from discharging sewage within a specified distance of the nearest land, unless they have in operation a sewage treatment plant which has to be approved in accordance with Guidelines on implementation of effluent standards and performance tests. Governments are required to ensure the provision of adequate reception facilities at ports and terminals for the reception of sewage. The discharge of untreated sewage when at a
distance equal to or greater than 12 nautical miles from the nearest land has to be done according to standards for the maximum rate of discharge of untreated sewage from holding tanks. It is to be noted that grey water doesn’t fall within the scope of MARPOL Annex IV and therefore is not yet dealt with on the global level.

The best know global initiative to prevent garbage pollution from ships is **Annex V to MARPOL 73/78**. MARPOL Annex V contains specific regulations for the prevention of pollution by garbage entered into force as 31 December 1988 and has been ratified by 139 IMO member states representing 97.18 % world tonnage. **MARPOL Annex V** prohibits the disposal of plastics anywhere into the sea and contains provisions allowing for “Special Areas” to be established with more stringent regulations. Currently 5 designated Special Areas are in effect (Baltic Sea since 1 October 1989, North Sea since 18 February 1991, Arctic Area since 17 March 1992, “Gulf” Area since 1 August 2008, Mediterranean Sea since 1 May 2009). Governments are required to ensure the provision of adequate reception facilities at ports and terminals for the reception of garbage.

### 3.3.2.2. Regional framework

- HELCOM: Recommendations for the establishment of a harmonized "no-special-fee" system for the operation of reception facilities in ports for ship-generated wastes covered by Annex IV (sewage) and Annex V (garbage) of MARPOL 73/78.
- HELCOM: Proposal to amend MARPOL Annex IV to include the possibility to establish Special Areas for the prevention of pollution by sewage and to designate the Baltic Sea as a Special Area under Annex IV.

### 3.3.2.3. National framework

- Germany: Environmental label scheme called “The Blue Angel”. The Blue Angel label applies to Eco-friendly ship design and on Eco-friendly ship operation and sets as well standards for sewage and garbage.

The issue of port waste reception facilities is addressed in section 4.3 (Port Matters).
3.4. Fouling

3.4.1. Assessment

Fouling phenomena have been observed for centuries. Fouling grows in subsurface waters on any kind of submerged structures, particularly on vessel hulls. Due to the abundance of bacteria in zoo and phyto plankton, bio fouling is very important in marine environments. It starts by a fast adsorption of organic fragments, giving a primary film. Then this film is colonized by bacteria and micro algae, forming a bio film. The macro organisms can come and stick to this structure. Fouling can clog hull water inlets and heat exchangers, increase hydrodynamic drag, lower ships manoeuvrability and increase fuel consumption, and require more dry docking time. So fouling is an important economic problem for ships.

Anti-fouling paints contain toxic substances to prevent aquatic organisms from settling on the hulls of ships. Those substances are gradually diffused in the water. Soluble matrix paints have been marketed since the second half of the 20th century. As the matrix gets dissolved, biocides are emitted. The efficiency duration of these paints is limited to 12-15 months. To extend this duration, non-soluble matrix paints that can last 2 years were developed, and these are convenient for fast ships or stationary vessels. Auto polishing paints, composed of acrylic copolymers with tributyltin oxides as biocides, are the most-recently developed. As these products are efficient (5 years efficiency duration) and inexpensive, their use has been widespread, with up to 70% of the commercial vessel market share in the 1970s.

Biocides in anti-fouling paints were mainly metals (copper, zinc) and in the 1960s-1970s Tributyltins and Tributyltins Oxydes. They are quite toxic. They can cause cancer and genetic mutations, weaken immunological defences, and alter reproduction of numerous species. They can get accumulated in living organisms, and persist for long times in the environment. The decline of several mammal species exposed to these substances has been observed. They can also be transported by the wind to the shore and inland. The most sensitive micro fauna can disappear and be replaced by more resistant species, but with harmful consequences to other species. The effects are observed during the operational life of the coatings, but also when they are applied or removed for maintenance, through washing of hulls and rain streaming.

3.4.2. Regulatory framework

3.4.2.1. Global level

Due to the growing concentrations of TBT and other toxic substances mainly in coastal and harbour waters, the problem of fouling was submitted to the IMO-MEPC in 1988. In 1990, IMO adopted a resolution recommending the adoption by governments of measures to eliminate anti-fouling paints containing TBT. In 1999, IMO adopted another resolution for developing an instrument, legally binding throughout the world, to address the harmful effects of anti-fouling systems used on ships. The resolution called for a global prohibition on the application of organotin compounds, which act as biocides in anti-fouling systems on ships, by 1 January 2003, and a complete prohibition by 1 January 2008. In October 2001, IMO adopted a new International Convention on the Control of Harmful Anti-fouling Systems on Ships (ASF Convention), which prohibits the application of anti-fouling paints containing organotins as of 1 January 2003 and active presence of those compounds on ships from 1 January 2008; it also establishes a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.

The ASF Convention was adopted 1 October 2001 and entered into force 17 September 2008. In March 2010, it was ratified by 42 countries representing 73% of world commercial tonnage. IMO developed some implementation guidelines:

- Survey and certification of anti-fouling systems on ships adopted by MEPC 48 on 11 October 2002, revised by MEPC 61 on 1 October 2010
- Brief sampling of anti-fouling systems on ships MEPC 49 on 18 July 2003
- Inspection of anti-fouling systems on ships adopted by MEPC 49 on 18 July 2003
3.4.2.2. Regional level

Before the ASF Convention transposition, the EU set a regulation (directive n°98/8/CE, 16 February 1998) to limit the authorized biocides and make compulsory administrative agreement of new products before they could be put on the market.

ASF Convention is transposed into EU regulations by Reg (EC) n° 782/2003, council Directive n°76/769/EEC (prohibits marketing and use of organotin compounds), and Commission Reg n°536/2008 (measures enabling ships flying a third party flag to demonstrate compliance)

3.4.3. New approaches for anti-fouling systems

The ban of TBT led to active research for new cost-efficient and environmentally acceptable solutions. Some of these approaches are described in the literature (Chambers & al, 2006, Almeida & al, 2007):

The required properties of an optimal anti-fouling coating (Chambers & al, 2006), besides being anti-corrosive, anti-fouling-efficient and environmentally acceptable, are that they be:
- economically viable, long life, compatible with underlying system, resistant to abrasion/biodegradation/erosion, efficient regardless of operational profile, smooth
- Non-toxic, not persistent, inexpensive, chemically stable, not a target for non specific species

Tin-free biocides systems. Heavy metals (copper and zinc) are still used as biocides. Booster co-
biocides are also used to improve the efficiency of copper. The binder can be a soluble matrix (controlled depletion paints), or a self-polishing copolymer.
The biocides are still toxic and persistent; they often impact non-targeted species; their toxicity can be magnified through bioaccumulation phenomena, which is still a concern; they are less efficient than TBT systems. So those solutions can be only interim ones.

Foul release approach. The smoothness of the coating prevents the organisms from sticking to the hull once the vessel moves beyond a given speed. This purely physical principle makes it more environmentally friendly than biocides; but it does not work when the vessel is at berth, which limits its efficiency and can lead to alien species transport issues. Some of the silicone oils and curing agents can contain TBT and be toxic, so those solutions cannot be universal.

Bio-mimetic approach. Diverse physical and chemical mechanisms that marine organisms use to protect their own surfaces have inspired designers.
A wealth of marine organisms liable to product secondary metabolites with chemical anti-fouling properties have been investigated and tested. The limits of these approaches are practical, and linked to the difficulty of finding broad spectrum efficient molecules, non toxic to non targeted organisms, and easy to produce.
Marine organisms also use physical mechanisms to protect themselves from fouling. Mammals and shark skin micro topography has been proven to play a role in the defence of these organisms against fouling. Those techniques are likely too specific.

At the moment, all those alternatives are either not efficient enough, or too expensive, or highly harmful to the environment, or too specific. Research must continue.
3.5. Invasive Species (ballast water, fouling)

3.5.1. Assessment

Aquatic species which are not part of the original ecosystem are considered to be non-native or non-indigenous. Increasing numbers of non-native species are being observed in the seas all around the world. Over 130 non-native aquatic species have been recorded in the Baltic Sea to date, and around 80 of these have established viably reproducing populations in some parts of the Baltic. Pacific Oyster in the North Sea, spread of shipworm in the Baltic Sea, Zebra mussels (Dreissena polymorpha) in the Great Lakes, Kappaphycus alvarezii in the Hawaii Islands and Gulf of Minnar, India are but a few examples. However, invasive species introduction cannot be completely attributed to shipping alone; there are other anthropogenic pathways also.

![Figure 3.2. HELCOM: Vectors of introduction of non-native species](image)

Of major concern are “Harmful Aquatic Organisms and Pathogens, meaning aquatic organisms or pathogens which, if introduced into the sea including estuaries, or into fresh water courses, may create hazards to the environment, human health, property or resources, impair biological diversity or interfere with other legitimate uses of such areas. This affects a variety of sectors with connections to the maritime environment (e.g. fisheries, tourism, maritime construction), even when the relationship is only indirect (e.g. clogging of cooling pipes of power plants). When species are introduced into a new ecosystem, they may disrupt the food chain and/or habitat, prey on certain vulnerable life stages of other organisms, or reshape the ecosystem completely by altering the defining conditions. Sometimes they can have a direct impact on human health.

Shipping contributes to the introduction of aquatic species to non-native environments by different pathways. One pathway is the ships’ ballast water and the sediments contained in the ballast water tanks. The ballast water that is loaded by ships to stabilize them often contains such organisms, e.g. small fishes, benthic organisms or plankton, or pathogenic bacteria, which are released into the environment when the ballast water is discharged. It is estimated that about 10 billion tons of ballast water are transferred globally each year. With continued growth of shipping traffic, the probability increases that such organisms survive the transport in ballast water. In this way, numerous invasive species have already established populations.

Bio-fouling on ships is another important vector for introduction of non-native species, as bio-microfilm favours the undesirable accumulation of aquatic microscopic organisms, spores, etc. on surfaces of structures immersed in or exposed to the aquatic environment. All ships have some degree of bio-fouling, even those which may have been recently cleaned or had a new application of anti-fouling coating.
Figure 3.3. HELCOM: The non-indigenous and cryptogenic species in different parts of the Baltic Sea

Economic impact of the introduction of non-native species:
- The cost of non-native species is not easily estimated and figures are scarce.
  - cost for Germany between 74 and 85 Million €, excluding unquantifiable costs such as impact on biodiversity according to the Initial Scoping Study on the Global Economic Impacts of Invasive Aquatic Species, Non-indigenous Species in German Coastal Waters, Stephan Gollasch, September 2004
  - The US EPA estimates that invasive species are responsible annually for damages of $100 billion in the U.S. alone (Cangelosi 2002-2003: 69).

3.5.2. Regulatory framework

3.5.2.1. Global framework

In 2004, IMO adopted the *International Convention for the Control and Management of Ships’ Ballast Water and Sediments (BWMC)*. To bring the Convention into force, 30 signatures are needed, representing at least 35% of the world’s tonnage. As of January 2010 the total number of parties to the Convention is 21, representing around 23% of global tonnage. When in force, the BWMC will require all ships to carry out ballast water management procedures to a given standard, to implement a Ballast Water and Sediments Management Plan and to carry a Ballast Water Record Book. Existing ships will be required to do the same, but after a phase-in period. The Convention also contains noteworthy provisions allowing member states to adopt stricter standards. The ballast water management procedure follows a Ballast Water Performance Standard (Regulation D-2 of the BWMC) which states that ships conducting ballast water management shall discharge less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension and less than 10 viable organisms per millilitre less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension; and discharge of the indicator microbes shall not exceed the specified concentrations. Already a number of ballast water management systems meeting this standard have been type approved. The Conventions sets as well the requirement for the ports and terminals where cleaning or repair of ballast tanks occurs, to provide adequate facilities for the reception of Sediments.

Acknowledging the importance of other introduction vectors of non-native aquatic species IMO has initiated the development of international measures for minimizing the translocation of non-native aquatic species through **bio-fouling** of ships. Currently best practice measures for minimizing the harmful effects of bio-fouling are developed and practical guidelines for the control and management of ships’ bio-fouling to minimize the transfer of invasive aquatic species are drafted (annex 2 of BLG 14/9). They’ll aim to provide a globally consistent approach to the management of bio-fouling. According to the draft, the ships’anti-fouling system should ensure that the ship is maintained in a clean state throughout the docking cycle, i.e. the total absence of visible macro fouling and to minimize the transfer of invasive aquatic species.
3.5.2.2. Regional framework


3.5.2.3. National framework

- Australia: Mandatory ballast water management requirements enforced under the Quarantine Act 1908.
- USA: US EPA’s Environmental Technology Verification (ETV) program
- USA: electric barriers in Chicago Sanitary and Ship Canal preventing entry of alien species to Great Lakes
- Germany: Environmental label scheme called “The Blue Angel”. The Blue Angel exists on Eco-friendly ship design and on Eco-friendly ship operation and sets as well standards for ballast water management.

3.5.3. Controlling Biological Pollution

Ballast water and hull fouling from marine shipping are primary vectors for intra-oceanic and interoceanic movement of non-native, harmful biological organisms, of which ballast water is the dominant mode. Although a fully-effective technological solution to on board ballast water treatment is still in its infancy, the ballast water exchange regime, an interim control measure, is likely to ease the ecological pressure on the Great Lakes and similar threatened aquatic ecosystems globally. Ballast water exchange has operational and net performance limitations. Elimination efficiency can vary from 50-99%. Cohen (1998), Parsons (1998), Wonham et al (2001), Mac Isaac et al (2002), Ruiz & Reid (2007), depending on operational conditions, thus leaving a substantial margin for harmful organisms to contaminate.

Altogether 25 different combinations of a few basic technologies are available, 17 of those are chemical-based and mostly found to be non-fully environmentally or economically acceptable because of their residual active ingredients, which may have negative impacts on the biodiversity of the water body receiving treated ballast water.

The future therefore lies in non-residual on board treatment of ballast water, which can kill or deactivate the organisms in the hold without any damage to external organisms in the receiving water body. Filtration, UV treatment, and ozonation are the potential technologies in this field. The main limitation of UV treatment is associated with the turbidity of the ballast water. Penetration of UV radiation of 270 nm (most effective in killing microbes) decreases with increases in turbidity. Also higher organisms are less susceptible to UV. Filtration or hydro cyclone followed by UV treatment has been tested and shown to be the better option. Another alternative combination is hydro cyclone followed by ozonation; however the ozonation chamber should be non-corrosive. Ozonation can be a well-suited method for in line treatment if applied to intake circuits.
Box 3.1. ALANG ships dismantling site

Everything on this earth dies after completing its life, and so it is with the ship. In the early 1980s, as European and other OECD countries grew more conscious of Environment, Health, and Safety (EHS) aspects, the dismantling costs of large oceangoing vessels began to escalate, leading to a migration of ship breaking operations to Asian countries. Availability of 7 m tidal difference and a long tidal gap, together with abundant labourers, low cost of dismantling, and nascent environmental regulation favoured this process at Alang. Situated on the western coast of the Gulf of Cambay in Bhavnagar district of Gujarat, INDIA, traceable through navigation chart 208 at Lat. 21°-21' N, Long 72°-12'E, it slowly became the favourite destination for ship recycling. Up to December 2009, a total of 5031 vessels from all corners of the world having a cumulative LDT of 35.95 million MT have been dismantled on 163 plots of 1350 sq m to 3600 sq. m and 10 plots of 600 sq. m (for VLCC). Everything that comes out of the vessels is recycled, even down to the nut-bolts.

Since this operation started initially in an uncontrolled/unregulated manner, concerns have been raised on the health and safety of the workers. Until the 1990s, EHS aspects were mostly compromised and ship owners took advantage of very little oversight. As the damages caused by the improperly regulated ship breaking became more widely known, labour unions, NGOs and regulatory authorities joined hand to strengthen the EHS conditions. The first five years of the 21st Century have witnessed a number of improvements in the overall EHS management scenario. Mechanisation processes, distribution of personal protection equipments to workers, and hazardous waste management initiatives have been visible in recent years.

A Treatment Storage and Disposal Facility (TSDF) to handle the wide range of hazardous wastes generated from ship breaking was commissioned at Alang in 2005. It consists of secured landfill cells with leachate sump and monitoring wells, having 43038 m³ designated space for asbestos and glass wool, 10212 m³ for other chemical waste, and 8723 m³ for contaminated municipal waste; and an incinerator for disposal of combustible hazardous wastes like paint, glass wool, thermocol, chemical & oil, rubber, PVC, canvas, resin, board, etc. The incinerated ash is disposed of in a secured landfill site. Improved EHS management requires mandatory prior decontamination of ships, de-gasification of tanks, and disclosure of hazardous inventory on board. Without these requirements satisfied, ships should not be allowed to beach for dismantling. However, enforcing these conditions can become difficult because of an absence of strong international coordination. India seeks international cooperation for decontamination of ships of their hazardous substances prior to export to India for breaking.

The high profile French air craft carrier **Clemenceau** was denied access to Alang by the Indian authorities in Jan, 2006 due to high amount of hazardous waste on board, and **Blue lady** (S S Norway) was held up due to non disclosure concerning the presence of radioactive substances on board. These are examples of awareness and actions, though not at appropriate times, that have grown in recent years. The changing face of Alang is an indication that owners of ships with hazardous material on board could face extreme difficulty in retiring those vessels. Future ships should therefore only have environmentally acceptable materials used during their construction.

### 3.6. Accidents at sea

#### 3.6.1. What has been done since Torrey Canyon and Amoco Cadiz?

The Torrey Canyon (1967) and Amoco Cadiz (1978) wrecks were the first major shipping environmental disasters. Since those accidents, much has been done to improve safety at sea. On top of new regulations, many improvements have been developed regarding design and operations of ships.
New regulations have been implemented regarding design, construction, equipments, training, controls, crews… ISM code entered into force in 2002 as a chapter of SOLAS 74; MARPOL 73-78 has been implemented, and a number of Conventions on the protection of the environment (see Ch. 2)

New equipment is available: Global maritime distress and safety systems, radiolocation and generalization of use of GPS for commercial shipping, electronic charts (ECDIS), Automatic Identification Systems (AIS; displays on radar screens the main identification features of neighbouring ships, for safety). Long Range Identification and Tracking (LRIT, 2009, gives ship position information to flag, coastal and destination port states, for security). New equipment is available: Global maritime distress and safety systems, radiolocation and generalization of use of GPS for commercial shipping, electronic charts (ECDIS), Automatic Identification Systems (AIS; displays on radar screens the main identification features of neighbouring ships, for safety). Long Range Identification and Tracking (LRIT, 2009, gives ship position information to flag, coastal and destination port states, for security).

Vessel Traffic Services (VTS) have been developed: they are marine traffic monitoring systems, using radar, and radio communication techniques (VHF), meteorological/nautical sensors, automatic identification systems. They are established by maritime or port authorities to control, manage traffic, and promote maritime safety, provide information to ship masters, in straights, fairways, port accesses, port basins. They are governed by SOLAS (ChV Reg 12) and IMO Guidelines for VTS (resolution A. 857, 1997 Nov 11th). A group of professional associations (International Maritime Pilots Association, International federation of Ship masters Association, International Harbour Masters Association, International Ports and Harbour Association, International Lighthouse Association), publishes a guide of World VTS.

UNCLOS says that states bordering straits may designate sea lanes and prescribe Traffic Separation Schemes (TSS) for navigation where necessary to promote the safe passage of ships. TSS projects are submitted for IMO agreement, and once accepted, described in charts and nautical documents. SOLAS gives general operation rules in the TSSs. Generally, Traffic Separation Schemes are monitored by VTS. The first Traffic Separation Scheme to have been implemented is Pas de Calais TSS in 1967. Since then a number of them have been developed: Ushant, Casquets, Finisterre Cape, Gibraltar straight, and Malacca strait.

3.6.2. Assessment and discussion

Accidents to ships, or accidents caused by ships, occur both while ships are under way, outside a port’s limits and also within a port’s limits: it is difficult to be precise about separating the two groups of accidents geographically. However, there are particular features of accidents occurring to ships underway that differ significantly from those which occur within a port. For example, once a ship is underway at sea, within the relevant regulatory framework, the ship’s crew must make their own decisions as to how navigate safely and may no longer have a harbour pilot(s) to advise them.

Separately, the ship is likely to be exposed to more onerous environmental conditions, for example wave conditions, when it is underway than when it is within the port limits. This means that the ship’s crew must place reliance on the integrity of the ship’s structure even if several incidents, for example those involving the container ship MSC Napoli and the tankers Prestige and Erika, demonstrate that this reliance can be misplaced. This section presents a discussion of accidents at sea: their typical causes and consequences and suggests possible mitigating measures.

Despite the introduction of IMO sponsored initiatives such as the International Safety Management Code, studies by organizations such as the International Union of Marine Insurance have found that while total ship losses declined between 1980 and 2007, serious ship losses increased to a peak around 2008 and then declined markedly by approximately 300%. Separate statistics show that for the period between 2005 and 2009, weather was the principal cause of total ship losses, followed by groundings and collisions.

Other causes of ship total losses were fire/explosion, hull damage, machinery, and “other.” To put the hull damage statistics in context, the MSC Napoli and the Erika accidents could be seen as being caused by hull damage although several other issues were also involved. The Exxon Valdez and Erika accidents led to banishment of single hull tankers. But Prestige was a double hull vessel, and her wreck resulted in a great environmental disaster as well. Hull rupture was caused by corrosion. This accident highlights that some structure improvements are relevant only when associated with sufficient maintenance.
The consequences of losses due to weather conditions, either total or partial, may be seen in the pollution of coastlines with corresponding significant ecological and socioeconomic impacts: for example impacts on fisheries and tourism. Groundings often also result in pollution of coastlines, either in the form of cargo spillage or loss of bunkers or both. Busy, constricted waterways such as the Malacca and Singapore Straits have been the scenes of serious ship to ship collisions, despite the introduction of IMO recognized traffic separation lanes.
Serious accident statistics from audits of the International Safety Management Code confirm that ship quality matters: the best 25% of all ships were involved in only 7% of all ship accidents while the worst 25% were involved in 51% of all accidents. The audits also confirmed that the best ships tended to be owned by large established companies while the worst ships were owned by small companies with apparently no established safety culture.

The above statistics mask several underlying themes. For example, Port State Control inspections, improved ship design (e.g. adoption of Common Structural Rules), and increased vetting of ships by charterers (e.g. using vetting and rating agencies such as Rightship) can all be seen to have resulted in significant improvements to ship quality or to have at least deterred or prevented lower quality ships from engaging in certain trades and/or entering ports in certain regions.

However, several other issues, principally human error, are likely to be contributing to the increasing trend of serious losses seen up to 2008. These are likely to include poorly trained crews, particularly in the context of the increasing complexity of bridge equipment, premature promotion of inexperienced officers, increased workload, and fatigue.

A United Kingdom Marine Accident Investigation Branch review of accidents, collisions, groundings, contacts, and near collisions involving ships over 500 GT between 1994 and 2003 revealed the following statistics:
• 65% of ships involved in accidents were not keeping a proper lookout;
• 33% of all accidents that occurred at night involved a single watch keeper on the bridge;
• On 19% of the ships involved in collisions, the bridge watch keeping officers were unaware of the other ship, until the collision took place, or until after the collision.

Accident investigation reports on recent ship-to-ship collisions have also highlighted the importance of bridge watch keepers having a common language, for example English, to communicate with each other as a potential ship-to-ship collision situation develops. Other factors in recent ship-to-ship collisions have included the reluctance of bridge watch keepers to alter engine settings because of a lack of knowledge.

Other apparent factors considered in recently investigated ship-to-ship collisions have included fatigue, the use of VHF radio for collision avoidance, and uncertainty about the safe speed to be selected in reduced visibility conditions.

Technology that is intended to make life easier for seafarers can also lead to accidents. For example, the mandatory carriage of electronic chart display equipment (ECDIS) by most ships should in principle improve safety, but in practice several recent incidents have indicated that crews have received little training in how to use the equipment effectively. A key feature of the ECDIS display is that the number and extent of the dangers, such as submerged shoals, displayed depend on the scale of the chart selected. This represents a major change to the way that a navigating officer is used to working: a correct scale paper chart shows all the relevant dangers at a glance. Review of recent accident investigation reports confirms that selection of an incorrect chart display has led to groundings even though ECDIS will provide a warning that a more appropriate scale should be selected.

The above discussion shows that the required technology is often available but human factors such as fatigue and/or complacency conspire to result in accidents. Shipping safety is reported to be improving but comparisons with the more regulated aviation sector do not appear to show maritime transport in a positive light. Few people would wish to travel on a passenger aircraft if they knew that the flight deck crew had only limited knowledge of how to operate the aircraft systems, including the engine controls.

Poor training is often compounded by the perceived lack of appeal of seafaring as a career choice. Again, comparisons with the aviation sector often do not show seafaring in a favourable light: flight crews are able to leave their aircraft for a hotel shortly after landing and are able to join an aircraft in the knowledge that it has largely been prepared for departure by others. Although improved training is likely to be an imperative for reducing accidents.
The figures below show that in spite of 2008 peak, the global trend is positive, and the measures adopted since 1967 rather efficient at least for oil spillages.

Figure 3.9 Statistics on great oil spillage accidents.

Figure 3.10 Number of oil spills >7 t versus global Oil traffic
The Malacca Strait extends between Port Kelang in Peninsular Malaysia and Singapore and is one of the most important shipping routes in the world: 76,381 vessels of 300 gross tons or more were reported to have transited through the Strait in 2008. This is the equivalent to approximately 209 ships a day, or approximately one ship transit every 6 to 7 minutes. Vessel transits through the Strait have increased steadily in the last decade as trade between East Asian economies, particularly China, and developed economies in Europe and North America has grown. Reflecting this established trade pattern, container ships are the most dominant users of the Strait. To support its growth in exports, China has also been a major importer of commodities in recent years and this has resulted in a significant increase in the number of bulk carriers using the Strait. Alongside this generally longer haul traffic, intra Asian trade has also grown significantly in the last decade.

The World Bank and the Maritime Institute of Malaysia predict that there will be approximately 122,500 transits through the Strait, equivalent to approximately one ship transit every four minutes, by approximately 2025.

A feature of the Strait is that it is a relatively high risk navigation route for larger ships because it is narrow and shallow in certain locations. The risks associated with the route are exemplified by the recent collision between the products tanker Formosa product Brick and the Panamax bulk carrier Ostende Max. The subsequent fire on the products tanker, which was carrying a cargo of naphtha, resulted in 9 members of the tanker’s crew losing their lives. A further potential hazard for transiting ships is that small vessels are reported to cross the Strait in an uncontrolled manner. Another important feature of the Strait is that it effectively represents a transit route through waters of the littoral states of Indonesia and Malaysia. Although both countries operate ports on the Strait, they suffer the consequences of any vessels collisions and cargo spillages.

In recognition of the particular challenges posed by commercial navigation through the Strait, several measures have been put in place to improve safety and minimize the risk of vessel collision and /or cargo spillage:

- an International Maritime Organization recognized traffic separation scheme has been introduced;
- a mandatory vessel reporting system, STRAITREP, originally proposed by Indonesia, Malaysia and Singapore has been introduced to complement the traffic separation scheme,
- Japan, through the Nippon Foundation, has funded the installation of aids to navigation through the Strait; and
- Regular Strait user meetings are held to provide the opportunities for areas of concern to be discussed.

It is generally recognized as a result of international cooperation that the above measures, resulting from international cooperation have resulted in improved navigational safety. However, further improvements are required and are planned.

1 Hand, M., article in Lloyds List, “Strait safety on the line”, 2 September 2009
Box 3.3. MSC NAPOLI’s sinking
An example of International Cooperation.

On 18th January 2007, container vessel MSC NAPOLI, loaded with 2318 containers, and sailing from Antwerp to Sines, 45 miles Southeast from the Lizard, sends out a distress message, reporting major structural damage.

The response was to be co-ordinated by French CROSS Corsen. In accordance with Anglo-French Joint Mancheplan, the maritime authorities confer and it is agreed that the most suitable port to take MSC NAPOLI is Portland. From that point forward the UK authorities drive the course of events.

Due to rough weather conditions, the vessel cannot be towed to the port and is beached on the Lyme Bay coast. Fuel oil is pumped out of the wreck and most of the containers are removed on a barge. Some of them fall to sea and go ashore. Some are ‘scavenged’.

The vessel is split in two parts with explosives. The main one is towed away to Dublin to be dismantled. The other part is removed later.

This incident highlights the importance of good international preparation; it is an example of an efficiently driven operation, in spite of very complex co-ordination between sea and shore operations. It shows the importance of good monitoring of the containers with dangerous goods.
4 PORT-BASED SUSTAINABILITY ISSUES

4.1 “Green ports”; methodologies

4.1.1 Understanding the environment and human uses

The usual approaches to improve infrastructure construction or operations consist of checking their different impacts on the environment, and then implementing mitigation, damage limitation, and compensation measures.

For several decades, environmental impact assessment (EIA) has played a major role in helping to reduce the environmental impacts of new port infrastructure development projects. More recently, many ports have introduced environmental management systems to help manage the impacts of ongoing activities and operations. A typical check list used is given in the document “Assessment of the Environmental Impact of Port Development”, by the UN (1992).

The following table, adapted from UN 1992 op cit., identifies at what stage of port development or operation such environmental or socio-cultural elements may be impacted. The impacts considered to be the most important are highlighted with a double tick.

<table>
<thead>
<tr>
<th></th>
<th>Location Of Port</th>
<th>Construction maintenance</th>
<th>Ship operations</th>
<th>Cargo operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrology and morphology</td>
<td>✓ ✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedimentology</td>
<td>✓</td>
<td>✓ ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water quality</td>
<td>✓</td>
<td>✓ ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Biological processes</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Air quality</td>
<td></td>
<td>✓ ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Noise and vibrations</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Visual impact, lighting</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Waste management</td>
<td></td>
<td>✓ ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Social and cultural aspects</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Security and safety</td>
<td></td>
<td>✓ ✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

4.1.2 Working with Nature Philosophy

Whilst Environmental Impact Assessment (EIA) has been used for decades, neither EIA nor consideration of related social matters typically commence until an initial design concept has been established. Opportunities may therefore be missed or sub-optimal solutions adopted.

Those working in the port and navigation sector have to face an ever-increasing pressure over the maritime environment due to growth of world population and its growing needs (notably efficient waterborne transport infrastructures), and climate change. And yet at the same time, aquatic ecosystems contribute significantly to human well-being. Therefore, approaches such as EIA, which rely on ‘damage limitation’ are not sustainable.

We therefore need to change our way of thinking. Let us remember that “sustainability” means simultaneous achievement of economic prosperity, environmental quality, and social responsibility objectives. To improve sustainability, it is necessary to start fully integrated approaches as soon as the objectives of the project are known and to achieve them by working with natural processes. This is the Working with Nature Philosophy, developed in PIANC Position Paper (2008):

**Working with Nature (WwN)** consists of “an integrated process” aiming “to identify and exploit win-win solutions which respect nature and are acceptable to both project proponents and environmental stakeholders. It is a philosophy which needs to be applied early in projects, when flexibility is still possible.”

WwN “sets out to identify ways of achieving the project objectives by working with natural processes to deliver environmental protection, restoration, and enhancement outcomes”. Fundamentally, WwN means doing things in a different order:

- establish project needs and objectives
- understand the environment
- make meaningful use of stakeholder engagement to identify possible win-win opportunities
- prepare initial project proposals/design to benefit navigation and nature

“We have achieved important advances in science, modelling, technology, natural systems understanding and prediction, dealing with uncertainty, and engaging stakeholders in contributing to sustainable outcomes.” Nevertheless further research (ecosystem dynamics, cause-and-effect relationships, data collection, modelling tools…) still needs to be carried out.

Regarding administrative procedures, a philosophy of “management” rather than of “control” is needed, and the cultural differences between engineers, planners, and politicians have to be addressed. A concerted and patient effort will be required to raise awareness of the concept of WwN and the benefits it offers, and to engage port and navigation authorities, project developers, local communities, and environmental stakeholders in the transition.

Adopting the WwN philosophy also means that parallels have to be established between new port project developments and more general processes that are increasingly implemented at local-regional levels (e.g. integrated coastal zone management approaches) involving views on the mid and long term future of entire coastal areas. (See section 4.8)
4.1.3. Stepwise approach to decision making

The following diagram highlights how adopting the WwN philosophy might look like in practical terms:

Figure 4.1. Working with Nature Philosophy. Step wise approach
4.1.4 A practical guide for a sustainable seaport

More information about port-base sustainability issues can be found in PIANC WG Report 150 ‘a practical guide for a sustainable seaport’. This report provides for each of the environmental themes a detailed overview of challenges and issues ports can be confronted with, as well as approaches on how these issues could be dealt with from the perspective of the different roles of a port authority. The report illustrates the driving forces for ports to become green ports.

4.2 Hydrology, morphology, sedimentary

4.2.1 Understanding the physical environment

Coastlines and estuaries are naturally dynamic. Morphological changes result from a number of physical factors: storms, waves, tides, currents, and river flow. They also depend on the nature and characteristics of the ground formations: obviously a rocky shore is more stable than a sandy one. So there are natural littoral drifts, erosion, and sediment deposition phenomena in the shore zone.

The development of ports can have significant impacts on morphology, hydrology, and sediment transport, for example due to construction of dykes, breakwaters and jetties, and the dredging of new channels. that can modify the distribution and intensity of the different hydrodynamic forces (mainly waves and currents). The extent of the affected areas depends on the nature of both the coastline and the driving forces. In some cases the impact on the littoral drift is very important, causing severe changes in erosion or accretion with potentially significant consequences up to more than one hundred kilometres.

Morphological evolution following infrastructure development can also lead to changes in seabed nature: for example a sandy area could become a mudflat or a beach located downstream of the littoral drift could get totally eroded because its supply of sand is blocked by the port infrastructure. Some of the very aims of port construction (e.g. provide a refuge for ships from waves and storms) are in contradiction to the preservation of natural sedimentary conditions: zones protected by dikes or breakwaters get less choppy, contributing to more sedimentation.

Estuaries are particularly sensitive because of the combination of river flow and sediment supply, sea waves, tides, and currents – sometimes leading to complex hydraulic and sedimentary dynamics. Port infrastructure can significantly modify tidal propagation conditions, with related impacts such as:

- propagation of tide upstream may become easier, so water levels, tide currents, tide range, water salinity, etc. may be modified
- mudflats and marshes may be drained, islands may be bent out of shape or get connected to the shore
- alteration of sedimentary conditions: tidal and river forces can be dramatically modified, leading for example to changes in fluid mud dynamics.

Compared to biodiversity and the protection of specific habitats and species, relatively few international or national regulations seek to manage impacts on hydrology or morphology – neither for their own sake nor because of their wider role in supporting other natural environment features.
4.2.2 Improving sustainability: mitigation, compensation and enhancement measures

Understanding the natural physical conditions (bathymetry, winds, storm surges, waves, currents, tides, salinity, temperatures…) in the area of the existing or future port is essential. Modern digital modelling tools are available to help engineers and planners understand and forecast existing hydrologic, morphologic and even sedimentary conditions and to test the effects of new port infrastructure implementation. These models can be used to check and test as many solutions as necessary to ensure that project proponents are fully aware of the different ways of managing potential port development problems.

When considering how to achieve port development and operations sustainability, much thought should be given not only to assessing new development proposals but also to reviewing existing infrastructure and activities. For example, in accordance with the EU Water Framework Directive, Member states (and hence port authorities in coastal waters) are invited to ensure whether all possible protection and enhancement measures are already set up in so-called ‘heavily modified water bodies’. The following list from the England and Wales Environment Agency describes some examples of the type of mitigation and enhancement measures that could potentially be applied retrospectively:

- manage navigation (e.g. use fluid mud navigation) to avoid need to dredge
- modify timing of dredging or disposal activities to avoid sensitive periods
- select dredging methods to minimise environmental damage
- prepare a dredging strategy
- Explore sediment management options (e.g. beneficial use of dredged material).

Adopting the Working with Nature philosophy should enable those promoting new port-related developments to identify options which make use of natural processes wherever practicable. However, in many cases, residual impacts on hydro-morphological processes might still be anticipated, and mitigation or compensation measures may need to be investigated. For example, if a new breakwater is to interrupt littoral drift, options for by-passing the accumulated sediment should be explored in order to avoid or minimise unacceptable impacts down drift. Modelling techniques can be used to help minimise impacts and assess mitigation options. In all cases, the objective should be to avoid residual adverse impacts through the adoption of mitigation measures. Where residual impacts cannot be avoided, compensatory measures should be designed and implemented. And in all cases opportunities for enhancement should be sought (e.g. even if erosion is caused by a new structure, can measures be set up as part of the new project to help stem erosion and promote accretion?)

4.3 Water quality

4.3.1 Understanding water quality

Good water quality is vital to sustain marine life. The aesthetic quality of water is also important, not least in areas accessible to the public. Shipping activity, port operations, and port development all have the potential to impact water quality. Measures may therefore be necessary to prevent deterioration in the chemical or ecological status of water, or to improve water quality if its status is currently unsatisfactory.

In addition to national environmental or marine government agencies, many port and harbour authorities monitor water quality in and around port areas. Some such monitoring is required to demonstrate compliance: Section 2.2 explains that water quality targets are often set under international or regional/national legislation. Sediment quality can also affect water quality if sediments are re-suspended into the water column – for example as a result of dredging or even vessel manoeuvring. A review of existing water and sediment quality data can help develop an understanding of the nature and extent of any contamination issues, including whether any problems are related to current sources of pollution or to historic (or legacy) activities. In some cases, measures to deal with specific problems may already be in place, in others additional management may be required.
Box 4.1. Dredging and sediment management

Sediments play a critical role as a natural source of material for beach and shoreline protection. They also provide nutrients and physical materials for creating and sustaining wetlands and coastal habitats. Unfortunately, sediments also serve as a vector and sink for contaminants in the environment, and accretion of sediments can negatively affect navigation and flood control. Each year, approximately a billion cubic meters of sediment is removed from waterways throughout the world not only to ensure safe navigation and maintain waterborne commerce, but also for environmental clean-up, habitat restoration, flood control and other purposes, at a cost between 15 to 30 billion dollars (US).

Sustainable sediment management is essential to ensure sustainable maritime navigation. Typically these sediments are managed on a project-by-project basis. Growth and development in communities adjacent to these waterways are often constrained by available resources (i.e., availability of land) in addition to environmental and societal concerns (i.e., contamination, loss of habitat, loss of green space). Because the resources available to manage problems and opportunities associated with sediments are constrained, conflicts and tradeoffs must be resolved in order to satisfy regional environmental and social objectives relevant to sediments. Increasingly there is a recognized need for more comprehensive, long-term solutions aimed at managing sediments at the basin scale.

Different authorities (federal, regional, port) often share dredging responsibility. For example in the US the Federal entity (i.e. US Army Corps of Engineers, USACE) maybe responsible for the main navigation channels, the Port for secondary and/or side channels, and either the Port or private lease holder for berths. Only through coordinated efforts of these various entities is safe navigation ensured.

In some instances the concept of long-term management strategies is codified as a requirement: the USACE requires Districts to develop Dredged Management Plans for major Ports. Additionally, Regional Sediment Management Plans (http://www.wes.army.mil/rsm/) have been developed by the USACE to accommodate coastal restoration and stabilization needs. The Europe-wide SedNet initiative similarly promotes the incorporation of sediment issues and knowledge into European strategies to support the achievement of a good environmental status and to develop new tools for sediment management.

Regional approaches to sediment management can also help to meet the objectives of wider marine protection initiatives such as the European Marine Strategy Framework Directive (MSFD). In the case of the latter, targets are set regarding both concentrations of marine contaminants and the integrity of the sea floor (ecology). Whereas most dredging and disposal operations will not – individually - be of concern at the ‘Regional Seas’ scale relevant to the MSFD, the possibility of significant ‘in combination’ effects also needs to be considered. Regional approaches can help both to set minimum standards for potentially damaging activities and to improve transparency such that well-regulated activities are recognised as such and are not wrongly implicated in causing problems.

PIANC has produced a number of technical reports on dredging and sediment management. PIANC report n°100 (2009) explains how to take into account environmental concerns at planning and design phases including organising Environmental Impact Assessment studies. It highlights ways to deal with risk in dredging projects; it describes the different dredging techniques available, and the possible dredged material placement options; it explains how to characterize sediments and to assess the project impacts on environment; it provides a toolbox for Management Practices and the processes to select appropriate measures addressing the risks of a given project; and lastly it provides recommendations on setting up monitoring programmes.

The management of highly contaminated material disposal sites is also described in EnviCom reports WG5 (2002) Environmental guidelines for confined disposal facilities for contaminated dredged material and n°109 (2009) on long term management of confined materials disposal facilities. Beneficial use alternatives such as those discussed in PIANC report n°104 (2009)are preferred when those alternatives are available and practical based on suitability of the material for a particular application and the cost/engineering feasibility associated with implementation of a particular alternative.

Other relevant PIANC reports are given in the references list at the end of this report.
Notwithstanding any specific problems, however, adopting good practice can help to improve the sustainability of ports operations, to ensure there is no (further) deterioration and to facilitate improvements in both chemical and ecological status.

The impacts of discharges of any kind to water from ships at sea have been described in Section 3.3.2. In this section we explain what can be done in ports to prevent problems associated with discharges from vessels as well as measures relevant to discharges to water coming from ports themselves. Taking measures to deal with individual point sources or to reduce local diffuse sources is also important to avoid contributing to cumulative failures which may be recorded at a larger scale under strategic initiatives such as the EU Marine Strategy Framework Directive. The latter also includes specific objectives with regard to marine litter (in terms of its impacts on the marine environment).

4.3.2 Potential effects on water quality associated with ship wastes

*MARPOL 73-78* provides the international framework on how pollution from ships, including garbage, should be regulated (in order to prevent ships discharging it illegally at sea). It requires that “adequate” facilities (including collection, storage, transfer and /or treatment services and facilities of sufficient capacity and type for all wastewater generated by vessels at the port in accordance with MARPOL and national regulations.) should be provided, and that using them should not cause “undue delays” to ships.

General guidance is provided in the *IMO’s Comprehensive Manual on Port Reception Facilities (2009).*

Oily waste and wastewater should be collected in barges, vehicles, or central collection systems and storage tanks. The capacity of oily waste collection should be established based on applicable MARPOL provisions.

Wastewater with noxious chemicals from bulk tank cleaning should be collected through appropriate onsite or off-site treatment prior to discharge. Incompatible substances should not be mixed in the collection system. Treatment methods should be established based on the effluent characteristics. Under *Annex II, Regulation 7 of MARPOL 73/78,* cargo hoses and piping systems receiving noxious liquid substances cannot be drained back into the ships. Passenger ships have often on board sewage treatment systems, but most ships rely on shore facilities to discharge sewage. So ports should also provide appropriate facilities for sewage.

Shipping generates not only liquid waste but also operational and domestic garbage. *MARPOL 73-78* confirms that ships may throw overboard bio-degradable wastes at least three miles offshore. Some areas such as English Channels and North Sea are regarded as special areas for garbage where disposal at sea is forbidden within twelve miles from land. So ports should provide garbage segregation and containment bins and organize treatment.

The treatment of the different kinds of waste collected in ports is dealt with according to regional/ national regulations. In EU, wastes reception facilities are regulated through *Directive 2000/59/EC on Port Reception Facilities (PRF).* This Directive transposes *MARPOL* into European regulations and makes provisions for, *inter alia:*

- ports to implement appropriate waste reception and handling plans, approved by member ports, and to report operations to state.
- states and ports to implement a cost recovery system, providing an incentive for ships not to discharge ship-generated waste at sea
- masters to notify the port of call of the ship’s intentions
- vessels to deliver all waste including cargo residues

*IFC Documents* (www.ifc.org/) also give recommendations on these subjects.
4.3.3 Port reception facilities evaluation

4.3.3.1 Global level

The provision of effective port reception facilities plays an important role in protecting water quality. **MARPOL 73-78** does not set prescriptive standards on Port Reception Facilities other than being “adequate”. IMO/MEPC meeting 83 (March 2000, item 44) requires that facilities should allow for the ultimate disposal of ships’ waste to take place in an environmentally appropriate way. They should:

- Fully meet the needs of the ships regularly using it
- Not provide mariners with a disincentive to use them
- Contribute to improve marine environment

Over 35 years, a number of difficulties in accepting and implementing waste reception facilities have been reported, as well as have inadequacies in the operations of the existing ones.

In order to improve the information about PRF, IMO/FSI decided in 2004 to implement a **Port Reception Facility Database (PRFD)**, as a module of its general database on shipping GISIS. The PRFD is updated by member states. It allows the public to locate all facilities in a given port, to search facilities by waste category in a given country, obtain contact information on the port or flag State authority responsible for handling reports on inadequacies of PRF, and on reported inadequacies themselves.

In October 2006, IMO/MEPC approved an Action Plan for tackling the alleged inadequacy of port reception facilities. Different measures have been taken:

- finalize notification form, waste delivery receipt
- finalize some improvements on PRFD
- identify no technical problems for ship to shore transfer
- work on ISO 21070 standards on garbage segregation bins and containers.
- suggest ISO to contribute a new standard for PRF design and operation

(Kind and amount of waste typically delivered in PRFs, number and type of ships frequenting a given port, methodology to determine capacity and technical abilities or PRFs)

- consider development of guidelines for regional arrangements for PRFs.
- decide upon Up-to-date Comprehensive Manual
- approve Guide to good practices (approved 2009)
- approve assistance and training program.

4.3.3.2 Regional level

In 2005, the European Commission started a broad evaluation of the implementation of the Directive, carried out by EMSA. The result of this work is reported in **EMSA Horizontal Assessment Report on Port Reception Facilities, (2010)**. It concludes that:

- provisions regarding PRF are not still fully implemented, mainly in smaller, fishing and recreational ports.
- there are still differences in implementation and application of cost recovery and fees systems in the different states, and even within states. This is a rather worrying concern, because it impacts the “level playing field” principle.
- there are information exchange problems regarding enforcement (masters’ calls notifications, port facilities and fees, inspections, waste volumes and flows.)

So whereas the Directive appears to have produced positive effects since its entry into force, a range of potential shortcomings is identified, confirming that the current system is not optimal and that all the waste and cargo residues are not collected. In order to optimize this situation, EU has launched (July-September 2011) a public consultation for a possible revision of the Directive.

4.3.4 Waste generated by port activity
In addition to providing and managing waste reception facilities, ports should also take appropriate measures to manage discharges, emissions, and losses of potentially polluting substances resulting from activities within and around the port. Effective management to prevent contaminants entering the water (rather than cleaning up afterwards) is not only important in ensuring sustainable operations, it is usually also the cheapest option. The most significant sources of wastewater effluents from port-based operations include discharges of sewage and storm water, and dry dock discharges of vessel cleaning wastewater. Sewage and wastewater discharges can contain high concentrations of organic matter (measured as biochemical oxygen demand (BOD) and enteric bacteria (e.g. Escherichia coli); storm water discharges can contain suspended solids and oil amongst other contaminants; and dry dock discharges can contain the biocide agents of anti-fouling paint residues.

Storm water and sewage from port-based operations, including hull cleaning activity, should be managed in line with relevant regional/national regulations relating to discharges to water. For example, IFC’s (www.ifc.org/) recommended measures specific to storm water and wastewater from port operations include:

- avoiding installation of storm drainage catch basins that discharge directly into surface waters without treatment;
- using containment basins and bunds in areas with a high risk of accidental releases of oil or hazardous materials (e.g. fuelling or fuel transfer locations);
- using oil/grit or oil/water separators in all run-off collection areas, and maintaining them regularly to keep them operational;
- installing filter mechanisms (e.g. draining swabs, filter berms, drainage inlet protection, sediment traps and sediment basins) to prevent sediment and particulates from reaching the surface water;

4.3.5 Potential opportunities associated with new developments

Capital works and new port developments including dredging as well as land-based construction activities have the potential to affect water quality. Sustainable development requires not only avoiding deterioration but also seeking opportunities for improving water quality and promoting functioning aquatic ecosystems. Care should therefore be taken during the feasibility and design processes for such works to avoid detrimental effects, including those associated with run-off, spills and other incidents, and any disturbance of (contaminated) sediments. The latter could not only lead to short term problems associated with raised turbidity levels but could also lead to long-term effects (for example associated with making contaminating substances bio-available).

Potential opportunities for enhancement associated with new developments can include options such as the use of sustainable drainage schemes designed to act as a sink to prevent contaminants from entering the water body and/or to provide grey water storage for appropriate use on site, or initiatives which promote important ecosystem services such as nutrient cycling.

4.4 Habitats, species and biodiversity

4.4.1 Understanding the natural environment

Port infrastructures are located at the interface between complex inland, coastal, and marine ecosystems. Those environments include wetlands, coastal areas, marshes, mangroves, estuaries, beaches, brackish waters, dunes, lagoons; and also fallow lands, meadows, woods, bush, open fields, natural or not, cultivated or not, but always with secondary biotopes.

Those areas can be split by ecological barriers into patchworks of different functional bodies. They provide habitats to a very large number of species including bacteria, phyto and zooplankton, insects and all kinds of invertebrates, shellfish, fish, wetland and land flora and fauna, settled and migrant birds, sea or land mammals (e.g. seals, chiropters, otters) Those places and species form ecosystems in which a wide variety of specific processes (e.g. food chains, life cycles, spawning beds), dictated by
a huge number of variables, are dynamically interacting. The marine ecosystems are often rich, always complex, most of the time fragile.

Port development and operations adversely affect the natural environment in many different ways, both directly and indirectly – for example physical modifications may lead to changes in erosion or accretion; or the re-suspension of (contaminated) sediments may affect water quality. Direct effects of port development can result from construction activities removing habitats, smothering (e.g. of seagrass or shellfish beds) may result from the deposition of suspended sediments; or species may be disturbed at sensitive times (e.g., breeding, overwintering, migration, etc.). Port operations can also affect the habitats and the species within: stress may be associated with lighting, noise, discharges, emissions and also maintenance activities such as dredging.

In addition to considering the potential implications of port operations and developments for habitats and species, increasing attention has been paid in recent years to the concept of ecosystem services. Ecosystem services (natural services which would otherwise have to be provided at sometimes significant economic costs) fall into four main categories:

- provisioning services (e.g. food, fuel, water, etc.)
- regulatory services (e.g. control of flooding, climate, carbon, disease)
- cultural (e.g. recreation, spiritual services)
- supporting services (e.g. nutrient cycling; crop pollination)

Port activities or developments which affect, for example, intertidal habitats therefore potentially also impact on the ability of that habitat to provide a service (e.g. as a fish nursery supporting a commercial fishery or in attenuating wave energy and thus reducing flood risk).

Due to the very complexity of those interactions, it is essential to get a very good understanding of the potential effects on habitats and species prior to undertaking port construction or development activities. This approach includes stock-making and map-making of the various vegetative and animal species, understanding of biological processes, and identification of annual biological cycles. In addition to carrying out seasonally-appropriate surveys and data collection, numerical modelling may be required to assist in predicting the nature and significance of possible impacts. After the construction phase, appropriate surveys must also be organised to monitor the changes in biotopes. Efforts must also be made to share knowledge.

Applying the stepwise multidisciplinary Working with Nature philosophy described in Section 4.1 should help to identify the best options to protect or even to improve the environment, and insure the sustainability of all aspects of the developments and operations of ports.

### 4.4.2 Regulatory framework

#### 4.4.2.1. Global level


The Convention on wetlands of international importance (RAMSAR Convention, 1971) aims at preserving the ecologic characteristics of the most important wetlands and at planning the sustainable management of all wetlands. As it includes marine wetlands, it is important even for port development and operations.
4.4.2.2 European Community, UK approaches

In 1993, the European Community signed the UN Convention on Biodiversity. In 1998, it worked out its first strategy on biodiversity (EU 2020 Biodiversity Strategy, 1998) clarified and developed by several subsequent Communications and Action Plans.

Planners and developers have also to deal with other general Directives and strategies such as Water framework strategy, and overall Birds Directive (1979) and Habitats, Flora and Fauna Directive (1992). Those two (important for port developers) Directives charge the members states to create a network of protected areas: Natura 2000.

The scope of the agreements above is wider than the marine biodiversity strategies. So the Community adopted the EU Marine Strategy Framework Directive, 2008, that sets objectives to ensure the protection of biodiversity and may extend into setting objectives relating to food-webs, seafloor integrity and non-indigenous species in marine environments. (See § 2.2.6). There are linkages with other European regional marine agreements (described in 2.2.5), and with the non-marine specialized Directives above.

The Biodiversity 2020: A strategy for England’s wildlife and ecosystem services, set by the United Kingdom Government is a good example of national implementation of global and regional strategies. It refers to Nagoya Protocol 2010, to the UE 2020 Biodiversity Strategy, and to the UK National Ecosystem Assessment, 2011. It aims at halting the loss of biodiversity, through a more integrated approach on land and at sea, involving people, reducing environmental pressures, improving knowledge. It establishes inter alia 10 marine management plans.

4.4.3 Good practice and examples

Applying WwN process to identify win-win responses to a given development or operational project, planners and operators will have to consider sets of alternative designs or processes. In each instance, they will have to answer the kind of questions asked in classical EIA processes.

They will try to:
- avoid the potential adverse environmental effects (displacing the project in place or time)
- If not possible, minimize or mitigate the impacts
- As a last resort, compensate for them

In any case, careful monitoring is necessary to assess the efficiency of the measures taken. Those programmes have to be agreed to by all partners. They also have to foresee regular reviews, in order to set proper remedial actions if the aims of mitigation and compensation measures are not being achieved.

Possible mitigation and compensation measures are many and varied. Several PIANC good practice reports (e.g. “Bird habitat management in ports and waterways” (2005), “Ecological and engineering guidelines for wetlands restoration in relation to the development, operation and maintenance of navigation infrastructures” (2003) or, regarding Natura 2000 issues, CETMEF Guide Cadre. (2012) provide guidance on mitigation, restoration, compensation or enhancement measures. Specific examples of such initiatives might include designing or modifying features to support certain types of intertidal, sub-tidal or supra-tidal habitat (mudflats, salt marshes, sand-dunes) or similar to support specific types of flora and fauna.

As there are an infinite number of possible environmental measures, it is not possible to provide general recommendations. Boxes 4.2 and 4.7 give examples of what has been done as part of the expansion plans for two large European ports.
The Port 2000 project, which began operations in March 2006, stemmed from the desire of the French Government to position Le Havre as a main gateway for the flows of containerised goods. The first phase provides four quay berths over a total length of 1.4 km. Six additional berths, providing 3.5 km of quay were constructed in 2009-10 according to the needs of the terminal operators. This large scale port operation also provided the opportunity to initiate environmental restoration of the Seine Estuary. With a budget of about € 50 million, this program is the product of the dialogue between the public, developers and environmental interests in the estuary. This cooperation is expected to continue and represents a major success for the Seine Estuary.

The measures initiated to date, involve the restoration of the mudflats and the creation of habitat for birds, in addition to many positive measures for the Nature Reserve, the development and the management of a preserved ecological area, the creation of an ecological beach, a fishing observatory and the related monitoring system, the environmental training and information, the transfer and safeguard of protected species as well as scientific monitoring.

Restoration of mudflats in the Seine Estuary (M€ 23)

At M€ 23 and over 100 ha of restored mudflats, this project represents the first of its kind for both a French as well as the first carried out in a Nature Reserve. For this to be successful, the principles of adaptive management were used. The construction work was gradual with first, the construction of the groin sub-base – with materials coming from dredging operations for purely port works- and only after one year of observations, the construction of the whole groin (see photo 1) and the channel dredging. All the work of creation of the environmental channel (see photo 2) was carried out between February 2005 and August 2005 with a dredger capable of beaching at low tide. This characteristic was particularly adapted to this work in shallow waters with emerging zones at low tide at the beginning of the work. The scientific monitoring set up for now more than 5 years since end of works shows that as expected more than 100 ha of intertidal mudflat has emerged.
Creation of resting places for birds (M€ 9).

The design of this area was achieved in a very proactive manner, including meetings between ornithologists, environmental and port structures specialists. With project need and objectives defined by ornithologists, the Port Authority engineers carried out studies including physical modelling which made it possible to improve the design both as regards the purely technical point of view and as regards the environmental purposes looked for.

The body of the islet was made up of sand and gravel materials (260,000 m³ coming from dredging operations for port works), protected on the most exposed parts, by a protection armour of 200 to 250 kg hard rock-fills. Access to this islet is of course forbidden except for ornithologists and biologists who exceptionnally come to carry out their follow-up studies ashore. Continuous monitoring, including a remote controlled camera has shown the efficiency of this birds island, with more than 50 different species using it as a resting place at high tide, some of them having even their nests on the island.
Conclusions

One of the major technical difficulties in Port 2000 has been the completion of the port works and the environmental works at the same time, all having to be studied, selected and implemented to work with, rather than against, the natural processes and so limit as much as possible the impact of the port works on the estuary environment and sedimentology. As the preliminary studies had largely proven that the scheduling of maritime works was of prime importance for the possible changes in the estuary sedimentology (during and even after the works), the phasing selected for the completion of breakwaters was studied by the selected group on a mathematical sedimentologic model to reduce to a minimum the effects of the construction works on the estuary environment. In addition to this phasing, the dredging of a trench (3.5 Mm$^3$) south of the structures was decided with the only purpose not to leave materials which otherwise would have been eroded, go and settle upstream in the estuary. Likewise, the structures were designed with the objective of re-using at a maximum the dredging materials by looking classically for the balance between earthmoving/back-fills on all the site (out of 60 Mm$^3$, only half was deposited at sea) but also with the design of breakwater with a sub-base made of gravels dredged on site for the creation of the navigation channel.

4.5 Air quality

4.5.1. Understanding air quality

Port-based emissions to air can include gaseous substances (e.g. greenhouse gases, NO$_x$, SO$_2$ and VOCs) and solid substances (e.g. dust as Total Suspended Particulate Matter (TSP) and PM$_{10}$). The release and interaction of these air polluting substances to the receiving atmosphere can contribute to various environmental and public health issues at the local, national, and global scales. Emissions can also affect ports’ sensitive cargoes, such as fugitive dust settling on cars awaiting export.

The most significant sources of air pollutants from port-based operations include combustion emissions from diesel engines and boilers. These sources are generally sub-divided into ocean going vessels (OGVs), harbour craft, cargo handling equipment, road transport / Heavy Duty Vehicles (HDVs), rail transport / locomotives and, in some studies, port construction projects. Port-based emissions from diesel combustion release greenhouse gases (i.e. CO$_2$ and CO) and a range of other key air pollutants (i.e. SO$_2$, NO$_x$, PM and VOCs).

Other port-based sources of air pollutants include dry bulk storage and handling (PM), fuel storage and transfer (VOCs), and onshore construction activities and vehicle traffic on unpaved roads (PM).

Box 4.3 Port of Bristol’s Renewable Energy Generation

Operational since 2007, the Port of Bristol has installed three 2MW wind turbines within an 8.5 hectares area of reclaimed port land. The turbines have a hub height of 79 metres and a rotor diameter of 83 metres. The associated works included installation of cabling, access ways and a control building. The project has a design life of 30 years.

The maximum renewable energy capacity of the wind turbines is rated up to 6MW, which equates to approximately 50% of the port’s electrical energy demand, or approximately 4670 homes, and saves more than 15,000 tonnes of carbon emissions (as CO$_2$) a year. Bristol was not the first port in the UK to install wind turbines; wind turbines were previously installed at the ports of Blythe (nine 0.3MW turbines) and Liverpool (six 0.6KW turbines).
4.5.2 Emissions from combustion sources

4.5.2.1 Assessment

The air pollutant contributions of port-based sources depend on the port’s mix of sources. Baseline monitoring data from the Port of Charleston ([Port of Charleston Baseline Air Inventory, 2005]) indicates that at this port ocean going vessels and heavy duty vehicles are the primary sources of NOx, CO, SO2 and PM10, with ocean going vessels being the dominant source of SO2 and PM10 and heavy duty vehicles being the dominant source of CO. Data from the Ports of Los Angeles and Long Beach ([The Port of Long Beach. 2005 air emissions Inventory]) are quite comparable. Accordingly, baseline monitoring is the only way to identify accurately the relative air pollutant contributions of individual ports.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Ocean Going Vessels</th>
<th>Harbour Craft</th>
<th>Cargo Handling Equipment</th>
<th>Heavy Duty Vehicles</th>
<th>Rail Locomotives</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>42.9</td>
<td>3.8</td>
<td>8.2</td>
<td>43.5</td>
<td>1.6</td>
</tr>
<tr>
<td>CO</td>
<td>18.0</td>
<td>3.2</td>
<td>14.8</td>
<td>63.2</td>
<td>0.8</td>
</tr>
<tr>
<td>SO2</td>
<td>92.9</td>
<td>0.6</td>
<td>3.1</td>
<td>3.1</td>
<td>0.3</td>
</tr>
<tr>
<td>PM10</td>
<td>60.6</td>
<td>1.6</td>
<td>9.4</td>
<td>27.8</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Table 4.2: Distribution of Air Pollutants from Port-based Sources (derived from Port of Charleston, [4.8], 2005)

4.5.2.2 Mitigating strategies and good practices

Emissions to air from diesel based combustion sources are believed to be the major contributor to adverse air quality conditions at ports and the surrounding areas. Recognising the need to proactively reduce the risk of port-based air emissions contributing to adverse environmental and public health conditions, the IAPH published its [Toolbox for Port Clean Air Programs [4.10], 2007]. This toolbox proposes strategies for reducing emissions to air from the key port-based diesel combustion sources including ocean going vessels, harbour craft, cargo handling equipment, heavy duty vehicles (trucks), light duty vehicles, locomotives and rail, and construction equipment. Each strategy is divided into a strategy, technical consideration, options for implementation, and pros and cons.

Other Recommendations are given by [IFC, Environmental health and safety guidelines, Ports, Harbors and Terminals, 2007]: A number of measures can be made to manage and reduce the emission of air pollutants from combustion sources within a port. Port operators can develop air quality management procedures applicable to ship operators, such as:

- navigation of port access areas at partial power, achieving full power only after leaving the port area;
- avoiding or limiting the practice of blowing soot from tubes or flues on steam boilers while in port or during unfavourable atmospheric conditions; and
- reducing shipboard power use during loading / unloading activities by requiring vessels to shut down power plants and use an onshore power supply if docked above a specified time threshold (see Box 4.4 on Alternative Maritime Power)

In addition, port operators can address local air quality concerns by developing air quality management procedures for application to land-based activities such as:

- designing (where practicable) port infrastructure to minimise travel distance between ships off-loading / on-loading facilities and cargo storage areas;
- keeping transfer equipment (e.g. cranes, forklifts, and trucks) in good working condition;
Upgrading the land vehicle fleet with less-polluting trucks and vehicles, and using alternative fuels and fuel mixtures.

- encouraging reduction in engine idling during on- and off-loading activities; and
- Planning cargo storage operations to avoid or minimise re-storage and reshuffling of cargoes.

Port operators can also use renewable energy production techniques for their own needs:

We give hereafter some examples of what can be done in this domain:

- the Port of Bristol has developed specific renewable energy production systems.
- a number of ports provide electrical energy from shore sources as an alternative to the use of the vessels’ engines when calling.
- the ports of San Pedro Bay (i.e. Los Angeles and Long Beach) have implemented a very comprehensive program aiming at reducing hardly the emissions to air from ships, harbour crafts, trucks, cranes, ...: The San Pedro Bay Ports Clean Air Action Plan (CAAP).

### Box 4.4. Alternative Maritime Power (“Cold ironing”)

**What is Alternative Maritime Power?**

Alternative maritime power – AMP (or “Onshore Power Supply”, or “Cold ironing”) is the process of providing vessels moored in port with electrical power from a shore-side source to serve cargo handling and hostelling requirements, and reduces or eliminates the emissions to air that would otherwise be caused by the need to use vessels’ main and/or auxiliary diesel engines as a power source for its onboard electrical generators.

**How effective is Alternative Maritime power?**

The efficacy of AMP is dependent on the compatibility of vessels and shore-side electrical sources in relation to various matters such as vessels’ electrical systems, connection and cabling, and load requirements. These issues are being resolved as AMP becomes more widely adopted. For example, the potential incompatibility of vessels’ electrical voltages, phases and frequencies with shore-side power sources is being addressed through the retrofitting of converters where vessels have sufficient space available onboard.

AMP appears to be well-suited to vessels that make frequent and regular visits to ports with shore-side electrical sources and, therefore, appears to favour container, cruise andreefer vessels over vessels that make infrequent and irregular visits that are short and/or have low power requirements, such as tankers, bulk cargo vessels and fast-turnaround ferries.

AMP also appears to be suited to vessels that do not rely on onboard machinery to unload cargoes. For example, it may not be suited to tankers that require their steam turbine pumps to unload their cargo and retrofitting to facilitate AMP would require a prohibitively expensive rebuild of machinery systems. AMP may be well suited to container vessels because, unlike tankers, they are loaded and unloaded by shore-side cranes rather than their own machinery.

The Port of Goteborg was the first in the world to adopt AMP. Calculations indicate that, if all vessels using its ro-ro terminal had access to the shore-side electricity which is supplied from a renewable energy source (i.e. wind power), then emissions of carbon dioxide would be reduced by 10 per cent and emissions of SOx and NOx would be reduced by 95 per cent (Rogalska, 2008).

More information can be found on: [www.onshorepowersupply.org](http://www.onshorepowersupply.org)
4.5.3 Emissions from Fuel Sources Transfer and storage (VOCs)

A number of measures can be taken to manage and reduce emission of air pollutants (i.e. VOCs) from fuel storage and transfer activities, including (derived from *IFC EHS guidelines, 2007*)

- selecting appropriate equipment such as the use of floating top storage tanks or vapour recovery systems for fuel storage, loading / offloading and fuelling activities (depending on the type of material to be stored); and
- Adopting management practices such as limiting or eliminating loading / unloading during poor air quality episodes or implementing tank and piping leak detection and repair programs.

Additional prevention and control recommendations for VOC emissions applicable to fuel storage and handling are provided in the *General EHS Guidelines* and the *EHS Guidelines for Crude Oil and Petroleum Product Terminals*. (www.ifc.org/)

Information can also be found on the relevant Best Available Techniques (BAT) Reference Documents (BREFs) on EC Joint Research Centre site:


4.5.3 Emissions from Dry Bulks; Construction; Traffic on unpaved roads (PM)

Dry bulks activities and, to a lesser extent, construction activities are ports’ major contributors of dust and associated PM emissions, although construction activities, if not properly dealt with. Key sources of fugitive dust emissions include wind erosion of stockpiled materials, handling and transport of materials and traffic on unpaved haul roads (particularly during construction projects). Emissions can be sizeable; for example, annual PM$_{10}$ emissions between 100 and 200 tonnes have been estimated for coal and iron ore activities at the Port of Rotterdam in 2005 and 2006 (*Vrins and van den Elshout, 2009*), and annual average TSP emissions of 872 tonnes and PM$_{10}$ emissions of 221 tonnes have been estimated for all activities at the Port of Mumbai (*Gupta et al, 2002*).

A number of design and control measures can be made (derived from *IFC EHS Guidelines, 2007*) to manage and reduce the emission of air pollutants (i.e. PM / dust) from dry bulks including:

- storing pulverized coal and pet-coke in silos;
- installing dust suppression mechanisms (e.g. water spray or covered storage areas);
- using telescoping chutes to eliminate the need for slingers;
- using vacuum collectors at dust-generating activities;
- using slurry transport, pneumatic or continuous screw conveyors, and covering other types of conveyors;
- minimising free fall of materials during handling operations;
- minimising dry cargo pile heights and containing piles with perimeter walls;
- removing materials from the bottom of piles to minimise dust re-suspension;
- ensuring hatches are covered when material handling is not being conducted;
- covering transport vehicles (e.g. with tarpaulins); and
- Regularly sweeping docks and handling areas, truck / rail storage areas, and paved roadway surfaces.

European BREF document on storage also covers emissions from dry bulks.

In the early 2000s, the South Coast Air Basin, (second largest urban area in the USA) had one of the worst air qualities in the US, representing a major public health concern. Air emissions from the Ports of Los Angeles (POLA) and of Long Beach (POLB) complex (40% of US container trade), have been identified as a significant source of air quality pollutants. (For example, port related SOx emissions were 45% of total in South Californian Coast Basin). As such, the POLA, POLB and South Coast Air Quality Management District worked together with state, California Air Resources Board, and the United States Environmental Protection Agency Region 9 in a proactive manner to develop what has been known as the Clean Air Action Plan (CAAP). The first version of the CAAP was adopted in November 2006 and updates were made in October 2010. The CAAP has served as a template for the development of air quality management plans for other regions in the United States as well as internationally. The goal of the CAAP is to support clean air quality and economic development, and to reduce human health risk associated with air quality pollutants specifically DPM, NOx, and SOx.

**Implementation strategies**

The air quality improvements are driven by state and federal regulations to fulfill an Emission Reduction Standard as well as the Human Health Risk Standard which represent a pollutant load reduction and the pollutants modeled risk to human health in nearby communities. The CAAP represents an adaptive and resilient program that integrates administrative processes, data evaluation, technological advancement, and interagency communication to improve air quality and maintain the ports mission and capacity to support the movement of goods. It uses different tools: tariffs changes, direct port and agencies targeted incentives, lease requirements: as short and long-term lease renewals occur, the CAAP provides administrative process and language to leases and enhance operational reduction, minimization, and treatment of air quality emissions consistent with the CAAP goal. The local state and federal agencies (SCAMD, CARB, US EPA) contribute allocations or grants to support the CAAP program. So as the ports develop and redevelop, the CAAP methods and strategies ensure that new and renewed operations at the ports meet the CAAP goal.

**Main measures**

**Heavy Vehicles/trucks.** A few examples of measures currently under implementation include the clean truck program under the Heavy Vehicle Measure. The aim was to convert trucks (16800 frequent callers) to lower emission, alternative fuel, or hybrid, or to ban/replace the older ones, in order that all trucks comply with the USEPA 2007 On-road Heavy Duty Vehicle Air Emission Standard in January 2012. This required coordination with repair facilities, integrated data and information streams from the trucking agencies (they were very resistant to sharing access to databases), air models, regulatory agency support, weather data, daily ground recordings, and terminals throughput to name a few. The ports developed the truck activity reporting system (TARS), which creates and updates a weekly dashboard for the port managers and technical staff according to each staff's need. Total estimated cost was $1.8 billion, public commitments $200 million.

**Cargo Handling Equipment:** The Plan sets environmental performance standards and measures to accelerate CHE fleet turnover, in compliance with CARB regulations

**Harbour craft:** The Plan encourages at repowering harbour crafts under Carl Moyer Program, use of shore power and engine replacement.

**Railroad locomotives:** The Plan points upgrading and replacement measures for locomotives and setting new standards on Port yards.

**Ocean Going Vessels.** This particular part of the Plan started before 2006. It aims at reducing transit and hostelling emissions through vessel speed reduction programs when approaching and leaving the ports (recognition and docking rebates), to allow vessels to use electricity from shore power facilities rather than diesel engines and generators while at berth, and other technologies.
Technology advancement program

New technologies are evaluated, demonstrated and integrated to the different control measures through a Technology Advancement Program where Ports, Agencies and tenants' initiatives are coordinated. The four main areas of research are:

- Specific Control Measure Requirements
- "Green-Container” Transport Systems
- Emerging Technology Testing
- Emissions Inventory Improvements

Results

The Ports measure and report the CAAP goal against cost of implementation to ensure the most efficient administration support of technology advancements, and improvements to air quality while maintaining cargo throughput.

The Plan was established for 5 years. Its progress has been constantly monitored. The two ports publish annual inventories on air emissions from port activity. The difference between 2010 and 2005 situations for main pollutants are the following (globalized for the two ports, and rounded):

DPM: -70%  NOx : -50%  SOx: -75%  CO² : -18%

So the goals as given in the 2006 documents are clearly reached.
Box 4.6. World Ports Climate Initiative

WPCI has been initiated in 2008 under the auspices of IAPH. It groups 55 major ports all over the world, aiming at reducing GHG emissions while continuing their role as transportation and economic centres. Detailed information is available on: www.wpci.nl    wpci.iaphworldports.org

Chief goals:

- Increase support for WPCI among the world’s ports
- Promote information sharing
- Establish a framework for CO₂ footprint inventory and management
- Establish Environmental Ship indexing and increase support for this measurement
- Organize global support for WPCI goals among regional and global organization

Main actions:

Carbon Footprint
WPCI has released *inter alia* a “Carbon foot printing Guidance document” serving as a reference for ports looking to develop or improve their GHG emissions inventories, and port related carbon emissions calculator models (“World Ports Climate Initiative Scope 1 &2 CO₂ Calculator”).

Onshore Power Supply
WPCI provides practical information about OPS, targeted particularly at port authorities, terminal operators and shipping companies.

Environmental Ship Index.
ESI aims at identifying ships performing better than international IMO’s standards, regarding NOx, SOx, particles emissions as well as CO₂ in the longer term. It is intended to be used in ports to reward participating ships, but also by shipping companies for their own promotion.

   The ESI bureau provides a specific web tool to establish each ship’s score receives Ships Self Declarations and informs the suppliers of the ESI of the results.

   This approach is totally voluntary.

Other Projects in progress:

WPCI manages thoughts and studies on the role of port authorities regarding Intermodal transport, on Lease agreement aiming at reducing GHG operators emissions, Cargo handling equipment improvements, and LNG fuelled vessels…

IAPH tool box

In prior years, IAPH developed a set of tool boxes (*Toolbox for Clean Air programs*, ...) to promote methods and techniques aiming at reducing emissions to air associated with local health impacts. With the increase concern for the effect of global climate change, this toolbox had to be expanded to include new tools focusing on the GHG mitigation. WPCI aims at providing these additional tools, as described above.
4.6 Noise and vibrations

The issue of noise in construction may be associated with:

- works using explosives (vibrations can be transmitted very far away)
- dredging (mainly bucket dredgers)
- piles and stacks driving

and at operation stage with:

- ships movements, for example in channels
- dredging
- ship engines at berth
- port cranes and gantries
- Port crafts (straddle carriers, trucks)

in densely populated areas.

Compared, for example, to biodiversity or water quality, relatively few international or national regulations seek to manage the impacts of noise and vibration on either human populations or wildlife species (birds, fish, cetaceans, etc.). The main regulations are often related to municipal framework.


Mitigation measures should be considered and might include low noise equipments, fences, limitation of working hours. It will be important to measure noise levels before and after port implementation.

4.7 Visual impacts

Ports increasingly face the challenge of minimizing the visual impacts that they have on adjacent communities. Impacts can range from sun light reflecting off the windscreens of cars in open storage areas to the way that large ship-to-shore gantry cranes dominate the skyline, particularly when the crane booms are in their raised position. Impacts can be a matter of individual perception: some observers may find that a skyline featuring large container ships and gantry cranes impressive while others may find large cruise ships a form of visual pollution.

One method of reducing the visual impact of container cranes is for the crane booms to be raised to 45º to the horizontal rather than raised to a near vertical position. This approach has been adopted by North American ports such as Los Angeles.

Separately, ports have investigated the impact of crane colours to establish whether softer colours, for example colours that merge with sky colours, can reduce the impacts which cranes may have on the skyline.

Lighting impacts, for example from floodlighting of container storage yards, can also often be a cause of concern. As a condition of planning permission for a new container terminal being granted, the Port of Felixstowe used earthworks bunds to shield to the container yards.
4.8 Spatial context management

4.8.1 Growing pressures

Coastal areas. More than 50% of the global population lives less than 60 km away from the coast (guidelines on ICZM, 1996). Due to the strong attraction of coastal regions, this trend is intended to continue in the future. The coastal areas support lots of activities including:

- agriculture, fisheries, shellfish farming and aquaculture,
- industry, and even heavy industry (resulting from possible connections with the transport networks), shipyards,
- mining, aggregate extraction
- land or waterborne transport infrastructure and operations
- social and urban development
- energy production
- recreational activities, tourism

Coastal areas are home to many forms of natural and human resources and cultural heritage, ranging from ancient times through current day. Users of these areas, new or established residents, farmers, fishermen, manufacturers, landowners, tourists, town citizens, all have their own legitimate claims and interests. But conflicts may (and do) arise among those users. The anthropic pressure is more and more intense on the coastal environment, leading to other conflicts among the users and the environment.

Cities and Ports. Recently, the development and improvement of ports have had a huge impact on coastal areas, including the growth in size of ships, the development of container terminals, the trend toward specialization of ports, the setting up of new facilities for logistics, all of these factors lead to isolate port functions from urban areas. This trend is emphasized by safety (industrial risks management) and security concerns (ISPS measures). The ports have transformed the flow of goods: on the maritime side the volumes are extensive, on the terrestrial side (short sea and inland navigation, road and rail networks), transport is more limited. As a result, the ports connect the transport chains. The servicing of rural areas is a major concern for ports. In order to optimize commercial offerings, some of the major shipping companies have developed hubs, which are completely disconnected from traditional shipping networks. Thus the ports expand further outside their original cities, and consequently use more coastal land.

The current drivers for coastal urban development are no longer the enhancement of maritime trade, but that of territorial attractiveness. As the ancient port facilities are no longer sufficient for current sea trade conditions, urban planners want to use those areas for urban development operations. Waterfront is often appropriated to cultural and recreational uses (historic centres, marinas,). This trend to separation is not absolute. Strong links still exist, shipping and trade tertiary activities are still located in the original port-cities. The need to connect with railway, road, and inland waterways networks sometimes leads to maintaining port cities maritime activities and infrastructures. Consequently they can contribute to keep maritime activity in some cities, notably in estuaries.

Climate change is another source of pressure on human/natural context in coastal areas (see PIANC TG3 report Climate change and Navigation (2008). Impacts may include:

- increases in CO₂ concentration,
- temperature fluctuations,
- rising sea levels expected to continue even after emissions are reduced,
- speed of winds, power of waves to increase,
- extreme meteorological events (storms, droughts, floods) to increase in both frequency and intensity,
- tide and surge propagation,
- ocean circulations, coastal and estuarine hydrodynamics to be altered,
- key ecological chemical parameters as salinity may be affected
- Arctic ice cover expansion is expected to be reduced;
Each of the changes mentioned will have significant impacts on populations, mainly in lower elevations. They will necessitate reinforcement of infrastructure, displacement of people and of existing infrastructures, for all kind of activities. They will also have to be considered in the future plans and projects.

Of course maritime navigation will also be impacted by these changes. Sector-by-sector actions can be designed and implemented to face this situation. However, the most relevant current responses are global approaches, integrating both sea and land aspects of those issues. There ports and shipping should be proactive stakeholders.

4.8.2 Modern Coastal and Marine Management instruments

Sector-by-sector measures do not take into account the strong interactions between human activities and the environment. Only global, multi-sectoral approaches, including the physical, ecological, socio-economic, and institutional aspects which involve all the concerned practitioners, decision-makers and stakeholders, are able to lead to proper arbitrations and solutions. In 1992 the Rio Earth Summit acknowledged this idea and recommended to develop “Integrated Coastal Zones Management” (ICZM) in its Agenda 21 (chapter 17).

The aim is to use and influence all public action instruments for specific policies (fisheries, agriculture, economic development), for town and country planning, for resource management (water, biologic resources, mining) for natural (species, habitats) and historical and cultural heritage, for management of natural risks and anticipating climate change. The approach aims to integrate temporal and spatial scales, the different sectors of human activity, the ecosystems, the different actors and institutions, the many relevant scientific disciplines. It aims to build capacity and share knowledge.

The principles of ICZM (as derived from EU 2002 Recommendation) are to:
- adopt a broad holistic perspective
- integrate local specificities
- use adaptive management
- work with natural processes
- take a long term view
- use participatory planning, involve all stakeholders
- ensure the support of all relevant bodies, at all levels (global, regional, national, sub-national, local) of governance
- use a combination of all available instruments (regulations, economic incentives, arrangements, research, technical solutions, training)

The geographic boundaries to be taken into account depends on the specific problems to solve, but must include both the terrestrial and marine components of the coastal zones. The approach is a long-term one. It requires
- a global governance of coastal areas, associating new regulations, policies and programme making, - accompanying measures and general dialogue involving all the actors;
- cooperative arrangements between the different levels of governance, in order to address key resource management issues;
- bottom-up approaches, rather than top-down ones;
- monitoring and management actions.

In that sense ICZM is a new, flexible and adaptive, way of exercising power. It involves a huge number of contributors, administrations and institutions.

There is generally a strong gap between terrestrial and marine laws, regulations and institutions that may slow progress on ICZM projects. Consequently ICZM is generally considered a slow, long term process.

**Marine Spatial Planning** focuses on the growing demand for sea and coastal space. It shares major points with ICZM, (main aims, methods, integration, adaptability, stakeholder's involvement ...).
It appeals to modern Geographic Information Systems. The UNESCO has published a Guide on Marine Spatial Planning, which refers to the following principles:

- Ecosystem-based
- Integrated across sectors and agencies, across different levels of governance
- Area-based.
- Strategic and anticipatory, focused on the long term
- Adaptive, capable of learning from experience
- Participatory;

There are some variants on the concept of MSP: Coastal and Marine Planning, Integrated Coastal and Marine Planning, Marine Spatial Zoning. Plan Coast European project has established a Handbook on Integrated Maritime Spatial Planning which clearly integrates sea and land issues. Those approaches are not contradictory to ICZM. They can be regarded as specific instruments or steps in ICZM processes.

4.8.3 Some examples

Hundredths of more or less ICZM-related initiatives have been set about throughout the world since Rio Summit. Here we can only cite some examples, which are significant of both the difficulties and promises of ICZM. Other ones can be found in Germany, Vietnam, the Netherlands and USA.

**Australia.** The Great Barrier Reef Park was created in 1975 and is regarded as one of the best examples of successful implementation of ICZM in the world. Australia established in 2006 a Implementation Plan for a national approach to ICZM focused on land and marine sources of pollution, climate change, invasive pest plants and animals, allocation and use of coastal resources, and capacity building.

**China** faces a tremendous development of its economy, particularly on its coastal regions. This evolution has had huge adverse impacts on the environment. Since the early 1990s, a model set of ICZM-inspired projects have been developed in Port city of Xiamen. In that period, GDP and population growth rates were more than 20% a year. Main impacts were linked to land reclamation projects achieved since the 1950s, waste disposal issues, water supply, aquaculture. One of the first actions in the ICZM approach was a detailed analysis of those impacts. Several governance measures have been taken, including a multi-sectoral coordination structure, a (local) legislative framework, a Marine Functional Zoning plan, a comprehensive marine economic development Plan, a marine environmental monitoring network, an improved financial mechanism for management-oriented scientific research, and a training centre for capacity building on coastal sustainable development issues. China has now implemented a national policy based on Marine Functional Zoning Planning.

**European Union** ICZM concerns have been discussed in EC for 4 decades. In 2002, the European Community adopted a (non binding) Recommendation on ICZM, which required the Member states to initiate a stocktaking exercise on ICZM, and to elaborate on existing national ICZM strategies. In 2006 the Member States were required to report to the EC on the implementation of the Recommendation. The results were a bit disappointing, as only 13 among 24 states had initiated ICZM or partially ICZM policies. The main identified reason of these difficulties is the strong gap between land and sea administrative structures, and ICZM is identified as a long term approach. Yet the Recommendation on ICZM has initiated what is considered an « irreversible process », and the efforts aiming at promoting ICZM must continue. Recent directives and communications (Green Paper 2006, Blue Book 2007, Water strategy framework Directive 2008) prescribe Marine Spatial Planning. A number of projects (OURCOAST, (sharing lessons from ICZM initiatives), ENCORA, (flood plain land use), and EUROSION (coastal erosion and climate change) are supported by UE.

In the **Mediterranean** region the 7th Protocol to Barcelona Convention on ICZM entered into force on 24 March 2011. It represents the first international binding instrument on ICZM. Spain, Slovenia, France and European Union are parties to this Protocol, and hence subject to ICZM binding regulations.

**United Kingdom:** In the late 1990s, the UK initiated a process of institutional devolvement to Scotland, Wales and Northern Ireland. This major change in governance has had a considerable
impact on coastal policies development and decision making. Nevertheless ICZM strategies pursuant to EU 2002 Recommendation started to be implemented. The ICZM Evaluation in 2007 asserted that 'one of the key obstacles to ICZM is the current strong legislative separation between land and sea-based activities'. After an extensive consultation and discussion phase, the UK Government published 'A strategy for promoting an integrated approach to the management of coastal areas in England' and then the Marine and Coastal Access Act 2009. The Act gives provisions to setting up a Marine Management Organisation, and introducing a (inter alia) Marine Planning System. This system includes a Marine Policy Statement (2011) which outlines UK wide policies for sustainable development in the marine areas. This document now provides a framework for the development of Marine Plans and making decisions affecting the marine area. It is focused on marine issues but it commits all UK administrations to cooperate to insure the consistency between land planning and marine planning. So the foundation work to achieve a fully integrated and holistic approach to the management of coastal areas in the UK is in place. However, a number of local initiatives have led to genuine ICZM coastal plans in the UK.

4.9 Port Safety

Broadly stated, accidents and cargo spillages within ports may involve ships, cargo handling, and/or other port equipment. Accidents involving ships may occur when the ship is manoeuvring or when the ship is already alongside a berth. For example, as a result of equipment failure on a ship, the ship may strike a container crane during a manoeuvring operation or alternatively a ship may already be moored alongside a berth and an equipment failure on the ship may result in a cargo spillage. Both of the above examples represent actual incidents—the first led to a fatality and the second resulted in an oil pollution event. Other incidents have involved the failure of port equipment such as quayside bollards leading to ships drifting away from their berth or container cranes collapsing onto ships.

Examples of accidents within ports investigated by the United Kingdom’s Marine Accident Investigation branch have included a ferry making contact with a ferry terminal link span, a tanker making contact with a terminal’s mooring structures, two ships making contact with each other within a confined port basin, a gas cloud escaping from a gas tanker alongside a terminal and cargo vapours being released during a ship to ship cargo transfer while the ships were alongside a terminal berth. The above examples illustrate how wide the range of accidents that can occur within ports. In contrast, when ships are at sea, weather conditions are the primary cause of the accident.

Review of recent ship handling accident investigations suggest several recurring themes, including inadequate passage plans, poor communication between crew members, lack of knowledge of the ship’s control systems, use of engine telegraph settings rather than VHF radio communications, and even improperly cleaned bridge windows. Review of recent cargo handling accident investigations again suggest several recurring themes, including overcomplicated communications, inadequate briefings and impulsive attempts to rescue crew members overcome by vapours in confined spaces. A particular potentially hazardous situation occurred in a North European terminal container stack when containers forming part of the deck stow collapsed overboard when the twist locks were released by the terminal operatives. Subsequent investigation established that although the containers were reported to be empty, they were actually heavily loaded.

A key concern of the seafarer is that he or she is often expected to operate in several roles at once, perhaps with one role to operate the ship while supervise cargo handling operations.

The above shortcomings are often not due to the lack of a regulatory framework: often crews are reported to work extended hours to address both regulatory and corporate procedures. Although the environmental benefits of transporting freight by water are generally widely accepted, the business model for some operators of small dry cargo ships, which often carry relatively low value cargoes which would otherwise need to be transported by road or rail, appears to rely on small crews working extended hours which may not be acceptable for other maritime transport modes or for example in the offshore energy sector. This will require consideration of how best to regulate maritime transport on varying scales.
Maasvlakte 2 concerns the extension of the Port of Rotterdam port, west of the Maasvlakte. With this extension of 2,000 hectares, the port of Rotterdam increases by 20%. On 1 September 2008 the project started after years of planning, discussions and protests. By 2013 the first enlargements should be operational. Maasvlakte 2 will have a depth of 20 meters and will give access to the latest generation of large containerships.

Maasvlakte 2 consists of new land to be gained from sea, immediately following the current Maasvlakte. Of the total area gained 1,000 hectares is reserved for port-related activity. The remaining space is needed for infrastructure (290 hectares), seawall (230 hectares) and waterways / harbors (510 hectares). The expansion of the port is part of the Project Main Port Development Rotterdam (PMR). PMR also includes the establishment of nature and recreation areas and several projects with aimed at improving the quality of life in the Rotterdam area.

At present approximately 40% of the land at Maasvlakte 2 has already been leased. In the first area that will be put into use, is a container terminal to be operated by RWG Ltd, which is a combination of stevedore DP World and four companies: New World Alliance (MOL, Hyundai and APL) and CMA CGM. Two other areas already leased will be operated by APM Terminals and Euromax. Companies with interest must demonstrate that their business operates in a sustainable manner. For example, reductions in hinterland transport by road and through rail and inland waterways. Emission of pollutants, chemical, noise or light, will also play a role in assessing and planning for future port customers. To secure accessibility for the port and also the city of Rotterdam, the Port Authority has taken measures to reduce the number of road vehicles permitted in Maasvlakte 2. The Port Authority has requested firm commitments from operators on the future use of alternatives such as rail (Betuweroute) and inland waterways. Maasvlakte 2 is located in a protected nature reserve. During the construction and operation of the new port area, efforts were made to minimize impacts on the environment. But the transformation of 2,000 hectares of seabed into a port will inevitably affect the plants and animals that live there. Therefore compensatory measures were undertaken. The compensation for the seabed removal was to establish a protection area southwest of the land reclamation in the North Sea. About 25,000 acres - more than ten times the area of the Maasvlakte 2 land reclamation – has been assigned as protected seabed, containing habitat for various species. Seabed fishing is prohibited here. In addition, new dunes along the coast North of Maasvlakte 2 will be erected. This area is being built to offset the effects on the dunes at Voorne. The new dunes at Hook of Holland will have an area of about 35 hectares.

Air pollution is a major problem in the Rijnmond region, there are many busy highways that deal with port traffic. The Maasvlakte 2 will contribute more polluting emissions from industry and traffic and without additional measures would lead to further reductions in regional air quality. Based on extensive research, including the Environmental Impact Assessment, a number of measures have been formulated. All partners within the PMR - State, County, city and Port Authority are in agreement to ensure that the measures are implemented on time (Air Agreement).
5. CONCLUSION

Despite the current economic crisis, the global economy is expected to continue growing. This will drive trade and then maritime transport, which is a critical component of the economy. This could result in additional environmental impacts, which would threaten sustainability. Estimating and improving the environmental footprint continues to be a major challenge for maritime transportation.

Maritime transport is composed of two different parts. International shipping has always been a specific activity: characterized by particular techniques and culture, strong competition with other (national and foreign) companies, working abroad, specific risks and regulations. It represents one of the very first operations to have been globalized for centuries. Port and land based maritime activity are governed by common practice and national laws.

Regulation of shipping operations, internationally, has been occurring since 1912 and has led to mitigation of some aspects of shipping. Since operational controls have been imposed, the number of accidents in dense maritime traffic zones has decreased dramatically. Technical and social conditions of operations have also been improved. Due to the development of port state controls, the number of sub standard ships has decreased. The number of great oil spillage accidents has decreased. These successes are the result of many factors, including regulations, increased awareness, innovation, new operational solutions, involvement of major ship owners have yet led to significant improvements in the environmental efficiency of shipping. A number of research avenues are open. One of the main impacts of shipping on the environment, GHG emissions, are being addressed and estimated. Despite this, significant improvements are still possible. Due to the general trends in global trade, reducing the absolute value of carbon is still a formidable challenge.

On land also, many issues have been identified and addressed. The development and operations of port have impacts on the coastal morphology, hydrodynamics, biological systems, to name a few areas. Here also, strong regulatory instruments have been developed, at global, regional, national and local levels. The port authorities themselves can, and do, make changes to their own equipment and facilities to mitigate their environmental footprint. Through economic or contract incentives they also can encourage ship or land operators to adopt more environmental friendly practices. Important successes have already been achieved with regard to public health, as well as sensitive or protected areas. International efforts have been launched for upgrading, harmonizing and coordinating these actions. A global approach can lead to the mitigation of the consequences of rapid economic development, and help to anticipate the consequences of a changing climate.

Recent changes in operations prove it is possible to improve the environmental footprint of maritime transport. However further work is needed for shipping and land-based activities together to address the challenge of sustainable maritime transport, and consequently, our global future. Continued support is needed for the efforts to:

- improve regulations at international and regional levels which are a major necessity. The regulatory frameworks should be as simple, robust and consistent as possible. However no other instrument (economic incentive, contract or market instrument) has to be compromised. Individual innovation and corporate initiatives are also to be encouraged.

- estimate GHG gas emissions from ships, which are still one of the main environmental impacts of maritime transport.

- mitigate the environmental footprint of ports and ports operators, but also ensure the sustainability of human uses of coastal land and waters.

- develop awareness, build capacity, emphasize training and education.

Considering our environment in a sustainable way require we change our way of thinking: adopt global and long term views, involve all stakeholders, use available technology in a proactive, transparent and pragmatic manner, and adopt Working with Nature approach for all development projects.
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<td>Acronym</td>
<td>Description</td>
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<tr>
<td>TBT</td>
<td>Tributyltins</td>
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<tr>
<td>UNCCC</td>
<td>United Nations Conference on Climate Change</td>
</tr>
<tr>
<td>UNCLOS</td>
<td>United Nations Conference on the Law Of the Sea</td>
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<tr>
<td>UNCTAD</td>
<td>United Nations Conference on Trade And Development</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<tr>
<td>SOLAS 74</td>
<td>Convention on Safety Of Life At Sea</td>
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<td>SSOA</td>
<td>Swedish Ship Owners Association</td>
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<tr>
<td>STCW 95</td>
<td>International Convention on Standards of Training, Certification and Watchkeeping for Seafarers</td>
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<td>USACE</td>
<td>United States Army Corps of Engineers</td>
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<tr>
<td>VSR</td>
<td>Vessel Speed Reduction</td>
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<tr>
<td>WPCI</td>
<td>World Port Climate Initiative</td>
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<td>WTO</td>
<td>World Trade Organization</td>
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