IDENTIFICATION AND SELECTION OF ENVIRONMENTAL PERFORMANCE INDICATORS (EPIs) FOR USE IN THE MANAGEMENT OF EUROPEAN SEAPORTS

A thesis submitted for the degree of Master of Philosophy (MPhil) in Cardiff University

by Martí Puig Duran

School of Earth and Ocean Sciences

Cardiff University

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Abstract

Environmental Performance Indicators (EPIs), the information tools that summarise data on complex environmental issues to show overall status and trends, are becoming increasingly significant as port authorities come under more pressure to demonstrate compliance with legislation and to justify their credentials or licence to operate.

Environmental Performance Indicators can be particularly useful both to the authority and to a wide range of stakeholders in providing evidence of progress and the achievement of environmental objectives. In addition, the use of effective EPIs may contribute to cost and risk reduction, review of the effectiveness of an authority's Environmental Management System, and act as an early warning system.

The thesis identifies a comprehensive inventory of existing Environmental Performance Indicators in use in the seaport sector for monitoring performance of operational (e.g. dust, noise, dredging, waste), managerial (e.g. certification, compliance, complaints) and environmental condition (e.g. air, water, soil, sediment and ecosystems). Specific examples are given of practicable, informative, and representative indicators of port-specific issues. These indicators have been filtered against specific criteria and have been assessed and evaluated by port stakeholders in order to obtain a final set of indicators suitable to be implemented at EU level.

A user friendly tool has been developed specifically to assist port authorities in calculating and reporting the proposed indicators. European port authorities were encouraged to adopt this tool as a part of their environmental management and to provide data on their environmental performance. The results confirm the general feasibility and acceptability of the proposed indicators and provide a benchmark performance of the European port sector. The thesis demonstrates that a culture of monitoring and reporting environmental indicators is in place and the sector could readily be encouraged to populate the proposed European Port Observatory with meaningful EPI data.

Acknowledgements

I would like to express my gratitude to all those who contributed to the completion of this thesis. My deepest gratitude goes to Dr Chris Wooldridge not only for his valuable advice and leadership, but also for his friendly and fraternal relationship that he has given me during all my studies in Cardiff. Thank you Chris for all what I have learned inside and outside the university. I would also like to thank my second supervisor Dr Hance Smith for his strategic vision and interesting suggestions and recommendations. I acknowledge with grateful thanks the School of Earth and Ocean Sciences for the use of the research facilities.

This thesis would not have been the same without the valuable contribution of the European Sea Ports Organisation (ESPO) Secretariat, particularly from Patrick Verhoeven, ESPO Secretary General, for his enthusiasm and encouragement towards the development of the PPRISM research project, and Martina Fontanet and Dr Antonis Michail, ESPO Policy Advisors, for their continued support and efforts in coordinating the research project. I also give thanks to the PPRISM project partners for their advice and passionate research discussions, and to all the contributing ESPO ports for providing input data, assessments on the indicators and feedback on the tool. I cannot omit the contribution from members of the British Ports Association (BPA), and especially from David Whitehead OBE, Director, for his willingness to collaborate in several workshops and research exercises.

Many thanks to my office colleague Paul Evans who made the daily research life more enjoyable and pleasant, and a special acknowledgement to Dr Rosa Mari Darbra for her continued interest and kind support from the department of Chemical Engineering in the Polytechnic University of Catalonia. Finally, my thanks and love to my family for their encouragement and for always being near in my heart despite the 1500 kilometres which separate us.

Studying and living in Cardiff has been a unique and enriching experience for me. I have met students from all over the world, formed friendships, and we have shared unforgettable moments together.

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Abbreviations

AAPA	American Association of Port Authorities
AGP	Algal Growth Potential
BOD	Biochemical Oxygen Demand
BPA	British Ports Association
CFCs	Chlorofluorocarbons
CN	Cyanogen Compounds
COD	Chemical Oxygen Demand
DEFRA	Department for Environment, Food and Rural Affairs
DG TREN	Directorate-General for Mobility and Transport
DO	Dissolved Oxygen
EC	European Commission
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
EPI	Environmental Performance Indicators
ESPO	European Sea Ports Organisation
FEPORT	Federation of European Private Ports Operators
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
IMO	International Maritime Organisation
ISO	International Organisation for Standardisation
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas (propane)
ODS	Ozone-Depleting Substances

OECD	Organisation for Economic Co-operation and Development.
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated biphenyls
PERS	Port Environmental Review System
PFCs	Perfluorocarbons
POM	Particulate Organic Matter
PPRISM	Port Performance Indicators: Selection and Measurement
PPRN	Port Performance Research Network
SDM	Self-Diagnosis Method
SEA	Significant Environmental Aspect
SOM	Soil Organic Matter
SOSEA	Strategic Overview of Significant Environmental Aspects
SPM	Suspended Particulate Matter
SWOT	Strengths Weaknesses Opportunities Threats
TDS	Total Dissolved Solids
TEU	Twenty-food Equivalent Unit
TOC	Total Organic Carbon
TOD	Total Oxygen Demand
TSS	Total Suspended Solid
UNCTAD	United Nations Conference on Trade and Development
UNFCC	United Nations Frame-work Convention on Climate Change
VOC	Volatile Organic Compounds
WPCI	World Ports Climate Initiative

1 Introduction

1.1 The need for the research

Economic growth has resulted in the marked expansion of international trade. As a result, worldwide maritime cargo throughput has increased rapidly in most of the ports to the point that port facilities have needed to be expanded. Simultaneously, larger and more specialized vessels have been introduced to take advantage of economies of scale and to minimize costs. Consequently, new or improved quays, deeper channels and modern cargo handling facilities have been required (United Nations, 1992a).

Although it is acknowledged that the expansion of port facilities and their associated operations can contribute significantly to the growth of maritime transport and economic development, it may also create adverse impacts on the environment. Port operations and activities may impact on air, water, soil and sediment affecting both the terrestrial and marine environments. Port development and operation should, therefore, be planned and executed with careful consideration of their environmental impacts.

As environmental awareness is increasing throughout society, effective environmental management is essential if stakeholders are to continue their support for port operations and development (EC PPRISM, 2010). In order to deliver compliance, environmental protection and sustainable development, effective port environmental management needs to take into account the potential impacts on the environment, mitigating options, methods of prediction, information on environmental indicators, and legislation and regulations.

Ports are complex organisations from all points of view: economically, socially, geographically, and administratively because of the range of interests and responsibilities of the parties involved. In order to evaluate environmental performance of port authorities and to track progress towards continuous improvement, relevant Environmental Performance Indicators (EPIs) may be utilised so that port authorities can demonstrate compliance and continuous improvement with substantive evidence from science-based, quantifiable measures.

The European Sea Ports Organisation (ESPO) and Ecoports Foundation launched in February 2009 the 'ESPO / Ecoports Port Environmental Review 2009'. 122 ports from 20 European Maritime States participated in this survey. This review revealed that 60% of the respondent ports have identified environmental indicators to monitor trends in environmental performance (ESPO, 2010). Nevertheless, when they were asked to name the environmental indicators used, the responses provided more than 100 different indicators. Current Environmental Management Systems, such as the Port Environmental Review System (PERS), the Eco-Management and Audit Scheme (EMAS) Regulation and the International Organisation for Standardisation (ISO) 14001 require an explicit commitment to continuous improvement of environmental performance, though there is no obligation to use any specific indicator.

This means that although ports are becoming increasingly aware of the benefits of using environmental indicators there is not a common approach as to which indicators to adopt. This thesis compiles a list of selected science-based, practicable, informative, measurable, and representative EPIs which port managers would be able to implement in their port, along with a tool that would facilitate their calculation and reporting.

1.2 Aim and objectives

The general aim of this thesis is to review and research appropriate Environmental Performance Indicators (EPIs) and to provide tools for their implementation. In order to attain the aim of this study, the following specific research objectives were established:

- Identify and select key Environmental Performance Indicators (EPIs) for sustainable port development in European Ports. These indicators have to be assessed and accepted by the port community.
- Deliver science-based tools and methodologies for the effective application of selected EPIs in port environmental management. Ports would be able to assess their own performance and to provide data about the sector.
- Make a contribution towards the development of the proposed European Sea Port Organisation's Observatory.

1.3 Research hypotheses

A research hypothesis is a statement or theory to be proved or disproved by reference to evidence or facts (Chambers 21st Century Dictionary, 2010). In this study, the hypotheses to be tested by research are:

i) Sustainable development of port area operations requires appropriate EPIs for purposes of compliance, cost and risk reduction, reputation management and continuous improvement of environmental quality.

ii) There are a range of potential EPIs that may be integrated into programmes to deliver effective Environmental Management System (EMS).

iii) The culture and practice of identifying, monitoring and reporting Environmental Performance Indicators is already established within the port sector.

1.4 Research methodology

The research pathway determines the main processes needed to carry out the research. It is presented as a list of consecutive steps, where for the fulfilment of each one, the completion of the previous one is required. The realisation of these tasks will lead to the achievement of the mentioned objectives. The research methodology of this research is composed of six main actions:

i) Introduce the relationship between ports and environment in Chapter 2. Section 2.2 examines the current importance of the shipping industry and the port sector. The top environmental priorities of the European port sector are identified and the variations over time are analysed in Section 2.3. Major driving forces for change (Section 2.4) considers some of the major international and European legislation that port environmental managers are obliged to comply with, relevant port organisations involved in promoting environmental awareness and collaborative research and development projects aimed at developing practical tools and methodologies for the improvement of the environmental performance of the port sector.

ii) Compile a comprehensive inventory of existing Environmental Performance Indicators currently in use by the port sector, categorising each indicator according to its type of EPI and reported in Chapter 3. The indicators were identified mainly from reports and reviews from port authorities. The concept of Environmental Performance Indicators (EPIs), their roles and characteristics are introduced in Section 3.1 and Section 3.2.

iii) Screen and filter the inventory of indicators in order to obtain a set of effective key Environmental Performance Indicators. The research methodology included 'theoretical' assessments against specified criteria and 'practical' assessments from port stakeholders. The criteria are specified in Section 4.1 and several information sources were combined in order to consider the following criteria: policy relevant, informative, measurable, representative and practical. In order to evaluate the proposed indicators in terms of feasibility of data collection and stakeholders' acceptance, several assessments were conducted among port stakeholders and the results are presented in Section 4.3.

iv) Define and describe the final set of EPIs' characteristics and the justification for their selection, which is explained in Section 4.4.

v) Develop a tool for the effective calculation and reporting of the proposed indicators. Encourage the use and implementation of the tool among European ports. Analyse and interpret the quantitative and qualitative results of the input data provided by ports. Feedback from port professionals would provide the opportunity to enhance further and update the tool. The EPI Tool is described in Section 5.1 and it is included in the Appendix X.

vi) Assess best practices in calculating and reporting selected port indicators through website research and provides recommendations (in Section 5.3) for the creation a future European Port Observatory.

The data and information were obtained from a wide range of different sources from both academic (such as books, articles and port publications) and industry (such as port visits and feedback from port professionals) in order to obtain a deeper understanding of the research topic. Major inputs include the following sources:

- Literature review from scientific articles, books and websites in order to gain background information about the relationship between ports and the environment.
- European research projects related to ports and environment such as ECO-information (1997-1999, 4th FP), ECOPORTS (2002-2005, 5th FP), PEARL (2005-2008, 6th FP) and PPRISM (2010-2011, DG TREN) were analysed in order to discover the progress made in recent years by the port sector.
- Port publications such as annual environmental reports or bulletins are a key source to investigate the physical, chemical and biological EPIs that are currently in use in the port sector. Port authorities tend to report their performance in order to demonstrate their commitment towards the environment.
- Participation in, and personal contributions to international conferences such as the 5th Annual Conference on Ports and the Environment held in Stockholm (Sweden) in February 2010, the Energy for Green Ports and GreenPort Logistics Conference 2011 held in Venice (Italy) in February 2011 and the European Sea Ports Conference 2011 held in Limassol (Cyprus) in May 2011 provided helpful opportunities for data-gathering, feedback and assessment from port professionals, and an insight into current practices.
- Workshops with port associations such as the British Ports Association (BPA) Environmental Contacts Meeting held in Cardiff in June 2011 and the 8th Port Performance Research Network (PPRN) workshop held in July 2010 in Lisbon (Portugal) provided critical appraisal through interaction and discussions with port members and such views made a significant contribution to this study.
- Active participation within the EC PPRISM Project (http://pprism.espo.be/) as Research Assistant provided both academic and professional contacts that were most beneficial for purposes of evaluation and validation. Five categories of port performance indicators were researched. The PPRISM network of research partners provided an overall view of Port Performance Indicators and their interrelations.

- The selected indicators were assessed internally by the Sustainable Development Committee members of the European Sea Ports Organization (ESPO) and externally by a wide range of port stakeholders. External assessments were obtained from a freely available on-line survey and the participation in the British Ports Association Conference 2010 held in Torquay (UK) in October 2010, and in the Clean Shipping Project Conference held in Stockholm (Sweden) in November 2010.
- Port visits and field investigations have contributed to discovering first – hand which indicators are used and how to implement, calculate, and report them. The visited ports have been the Port of Milford Haven (UK) and the Port of Venice (Italy).
- Finally, some factual data about the proposed indicators was obtained from the responses of the (PPRISM) pilot ports. A total of 47 European ports participated in the pilot providing information on their operational performance and environmental management.

During the period of study for the thesis, the author was employed as a Research Assistant on the E.C. 'Port PeRformance Indicators: Selection and Measurement' (PPRISM) Project with specific responsibilities for project management, data collection, and contributions to partner meetings, conference presentations, analysis and report writing. Working as part of the Marine and Coastal Environment Research Group (MACE) in the School of Earth and Ocean Sciences, Cardiff University, and as a contributor to the international project partnership, the author of the thesis had specific responsibilities for delivering the Environmental Performance Indicators (EPIs) and associated research material according to contract. Except where otherwise stated, the author personally: i) compiled the data base, assessment tables and performance trends, ii) structured the research protocols necessary to obtain relevant data and information from port sector professionals, iii) developed the EPI reporting tool, iv) configured the assessment and Pilot project responses, and v) analysed all assessment and validation results, and vi) contributed directly to the specification for the final dashboard. Collaboration with project partners and Cardiff University colleagues is acknowledged in appropriate sections.

PPRISM project was coordinated by the European Sea Ports Organization (ESPO) and it was supported by the Directorate-General for Mobility and Transport (DG TREN) of the European Commission (EC) with the project number 500363. Experience and responsibilities as a Research Assistant for the Project provided insight and understanding of the practical aspects of implementation of EPIs.

The project involved five academic partners namely the Institute of Transport and Maritime Management Antwerp (ITMMA) from the University of Antwerp (UA); the Vrije Universiteit Brussel (VUB); the School of Earth and Ocean Sciences from Cardiff University (CU); the Technical University of Eindhoven (TUe); and the Department of Shipping, Trade and Transport of the University of the Aegean. Each partner was responsible for research in a category of indicators, covering market trends and structure, socio-economic impact, environmental performance, logistic chain & operational performance and governance. These five categories were identified based on the experience of the partners in previous research projects as well as meetings of the ESPO technical committees.

The ESPO technical committees have participated actively throughout the project by assessing the suitability of potential indicators to be implemented across European ports. ESPO has encouraged its port members to participate in the Port Pilot, providing information on the proposed indicators.

1.5 Organisational structure of the thesis

The above-mentioned tasks identified in the research methodology have been classified into six chapters, which are specified in the following paragraphs.

Chapter One introduces the need for the research, the aim and objectives of this study, the research hypotheses, the methodology, and the organisational structure of this thesis.

Chapter Two is entitled 'Ports and the environment' and it is a review of the literature, which has been conducted along three main lines of inquiry: i) the strategic role of ports, ii) the environmental impacts of ports activities, and iii) the driving forces for environmental action. This section considers the importance of the environment in the port sector, the progress made in the recent years, the most relevant projects and initiatives that have been carried out, and the well-established tools and methodologies existing in the port sector. The aim of this chapter is to provide with some background about the research topic, including definitions and examples.

Chapter Three presents the concept of Environmental Performance Indicators. It describes their characteristics, their role and use, the importance for the port sector, the users, the types of EPIs, and their strengths and weaknesses. In addition, it identifies a comprehensive inventory of existing Environmental Performance Indicators in use in the seaport sector. The indicators are grouped under the three different types of EPIs: Management Performance Indicators, Operational Performance Indicators and Environmental Condition Indicators. Finally, the chapter describes the interaction of environmental indicators with other categories of port performance indicators.

Chapter Four provides a selection and description of key EPIs. Initially, the chapter presents the criteria that effective indicators should meet. The indicators identified in chapter three have been screened and filtered against the specific criteria in order to obtain a set of relevant, measurable, informative, representative and practical indicators. The proposed indicators were assessed by internal and external stakeholders, in terms of its acceptance and feasibility, proving recommendations and amending them. The final set of indicators is described and justified at the end of this chapter.

Chapter Five delivers a science-based tool for the effective application of selected EPIs in port environmental management. This EPI Tool has been developed specifically to assist port authorities in calculating and reporting selected Environmental Performance Indicators (EPIs). The chapter describes the tool and analyses and interprets the data obtained from its application to some pilot ports. It contains a GAP and a SWOT analysis of the results. This chapter also includes a proposal for a future European Port Observatory based on current examples of best practice on management and operational indicators, obtained from a website research.

Finally, **Chapter Six** provides conclusions and recommendations for further research. The benefits of the adoption and application of EPIs to the European Commission, ESPO, Port Associations and port authorities are explained in the context of monitoring and reporting of significant trends.

2 Ports and the environment

2.1 Introduction

This section is a review of literature written in the field of ports and environment. The chapter in divided into three main sections: i) the strategic role of ports which explains the importance of the shipping industry and the port sector and describes the concept, evolution and types of ports; ii) a definition of the following concepts: environmental impacts, environmental issues and environmental aspects with examples of them; and iii) the driving forces for environmental port action, which examine the actual regulatory framework, the existing port organisations and associations, and the collaborative research projects that have been undertaken.

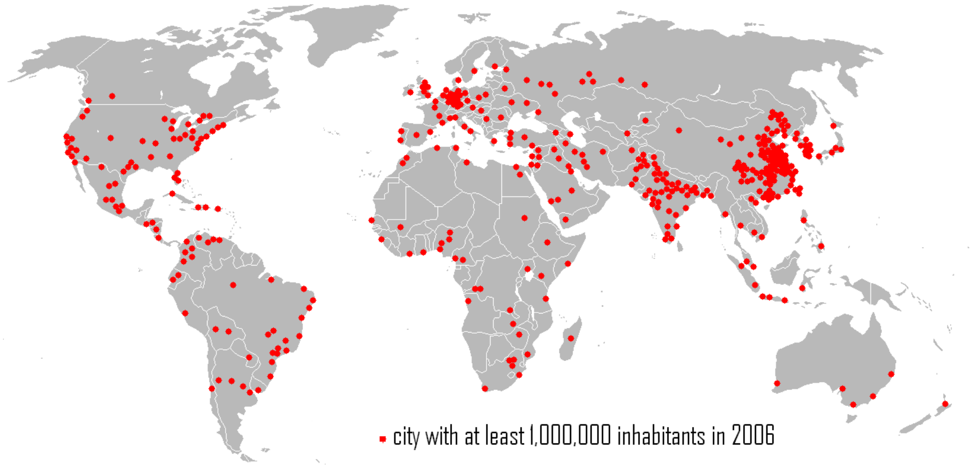
The purpose of this chapter is to outline the relationship between ports and environment and to provide an insight into previous research in this field. In order to identify and select efficient Environmental Performance Indicators (EPIs) for sustainable port development, it is essential that this previous background information is studied.

2.2 Strategic role of ports

2.2.1 The shipping industry and the port sector

The world’s population has just reached 7 billion (United Nations, 2011). Current projections show a continued increase of population with expecting to reach between 8 and 11 billion in the year 2050 (United Nations, 2009). As shown in Figure 2.1, more than 50% of the world population lives close to the coast, of which more than 300 million inhabit the coastal urban cities (Chua, 1999).

Figure 2.1: Urban Areas with at least one million inhabitants in 2006.



Source: City Mayors Statistics, 2010.

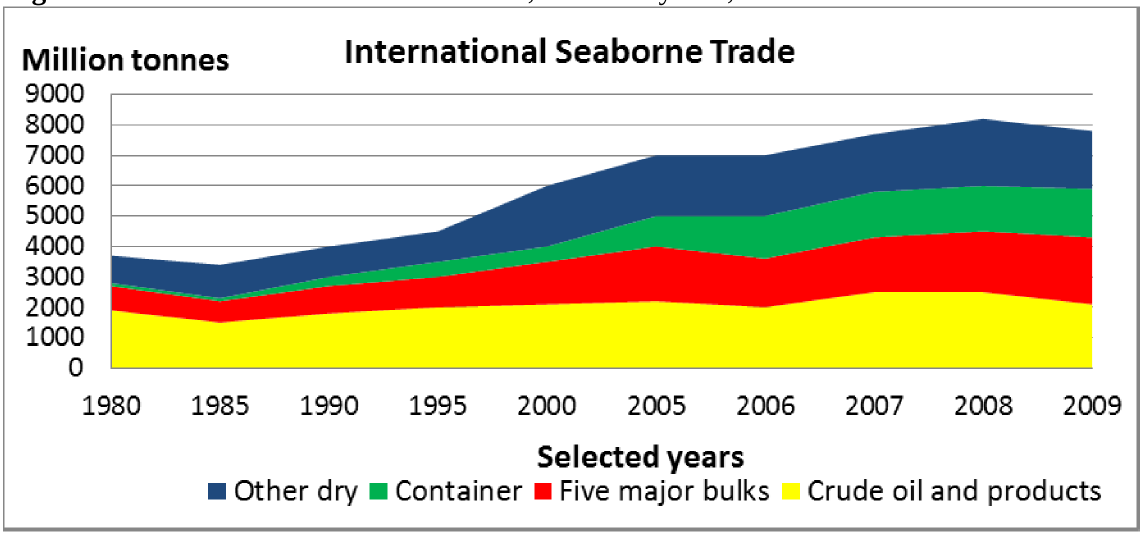
Shipping is vital to the global economy with around 90% of world trade being carried by the international shipping industry. Without shipping, the import and export of goods on the scale necessary for the modern world would not be possible. There are over 50,000 merchant ships trading internationally, transporting every kind of cargo, such as raw materials and commodities, finished goods, food or fuel (Shipping Facts, 2011). According to the World Port Ranking 2009 carried out by the American Association of Port Authorities (AAPA), the world's busiest ports are the Port of Shanghai (China) in terms of total cargo throughput and the Port of Singapore (Singapore) in terms of container traffic.

There are more than 1,200 ports along the 100,000 kilometres of coastline in Europe, providing more than half a million direct and indirect jobs (European Commission, 2011). In 2009, the total weight of goods handled in ports of the 22 European Union maritime Member States was estimated at 3.4 billion tonnes. By type of goods, liquid bulk (which include petroleum products) accounted for 42 % of the total cargo handled, followed by dry bulk (23 %) and containers (18 %). Rotterdam, Antwerp and Hamburg –all located on the North Sea coast– maintained their positions as the three largest EU ports in terms of both gross weight of goods and volume of containers handled. The number of passengers passing through EU ports in 2009 was estimated at 403 million, being Italy (23 %), Greece (22 %) and Denmark (11 %) the three leading sea passenger transport countries (European Commission, 2010).

The importance of the shipping industry is even stronger in the UK, where 97% of all the goods entering and leaving the UK (by tonnage) do it through sea ports (Chaplin, 2011). As an island nation that depends on shipping, the existence of ports is crucial. Shipping is an economic generator for the UK and, despite the recession, this sector has continued growing in the UK, earning more than £1million every hour of every day (British Shipping, 2011). Furthermore, shipping continues to be a major provider of jobs, directly employing more than 117,000 people in the UK (Oxford Economics, 2011). In fact, United Kingdom had in 2009 the highest share (15 %) of goods handled in EU ports, followed by Italy and the Netherlands (European Commission, 2010).

However, following the global financial crisis of late 2008, the year 2009 recorded the largest drop in global output since the 1930s, falling by 4.5% (see Figure 2.2). In 2009, international total goods loaded amounted to 7.8 billion tons, down from 8.2 billion tons recorded in 2008 (United Nations, 2010). Freight handling in EU ports fell by more than 12 % in 2009, after almost a decade of continuous growth (European Commission, 2010).

Figure 2.2: International seaborne trade, selected years, millions of tonnes loaded.



Source: Adapted from United Nations, 2010.

Dry bulk cargo is simply cargo that is transported unpacked in large quantities. The category 'five major bulks' shown in figure 2 include iron ore, grain, coal, phosphates, and bauxite. The category 'other dry' covers many other commodities, being the most important steel products, steel scrap, cement, gypsum, non-ferrous metal ores, sugar, salt, sulphur, forest products, wood chips and chemicals. Crude oil and petroleum products are the main liquid bulk components, along with chemicals, vegetable oils, fruit juices and wine.

2.2.2 Port definition

Before examining ports' activities and their environmental impacts, a definition of what is understood by 'port' should be established. The Oxford Dictionary defines a port as "a town or city with a harbour or access to navigable water where ships load and unload" (Concise Oxford English Dictionary, 2008).

However, this definition is not precise enough to accurately define today's ports. The European Sea Ports Organisation (ESPO), which represents port authorities, port associations and port administrations and its mission is to influence public policy in the EU in order to achieve a safe, efficient and environmentally sustainable European port sector (ESPO, 2012), proposed a more detailed definition: "a port may be understood to be an area of land and water made up of such improvement works and equipment as to permit, principally, the reception of ships, their loading and unloading, the storage of goods, the receipt and delivery of these goods by inland transport and can also include the activities of business linked to sea transport" (Mokkhavas, 2002).

This definition is more comprehensive because it stresses that a port is not merely an organization that provides a single service, but instead many different activities are performed simultaneously within the 'port area'. Therefore, an organisation that ensures the proper use of common facilities provides port services and guarantees safe maritime access for ships is needed, which is called Port Authority.

The port area is comprised of water and land areas. Water areas include safe access routes for ships and areas for ships to be safely anchored and berthed. Land areas include facilities for the loading and unloading, transportation and storage of goods, and the embarking and disembarking of passengers.

This means that to fully understand the environmental impact of a port, land transport from / to the port as well as other auxiliary professions located near the port must also be considered. In fact, one of the challenges facing port managers is determining the exact scope and degree of responsibility for responding to environmental problems and impacts.

2.2.3 Port evolution

The concept of port has evolved from being a simple shelter for ships, to a sea / land (ship / port) interface, to a logistic platform, and, finally, to an instrument of prosperity for the population because they may contribute to the creation of wealthy areas around its installations such as industrial zones, cargo storage, trading activities or urban development (Mokkhavas, 2002). Since the Second World War, ports have been going through an evolution which the United Nations Conference on Trade and Development (UNCTAD) has referred to as generations.

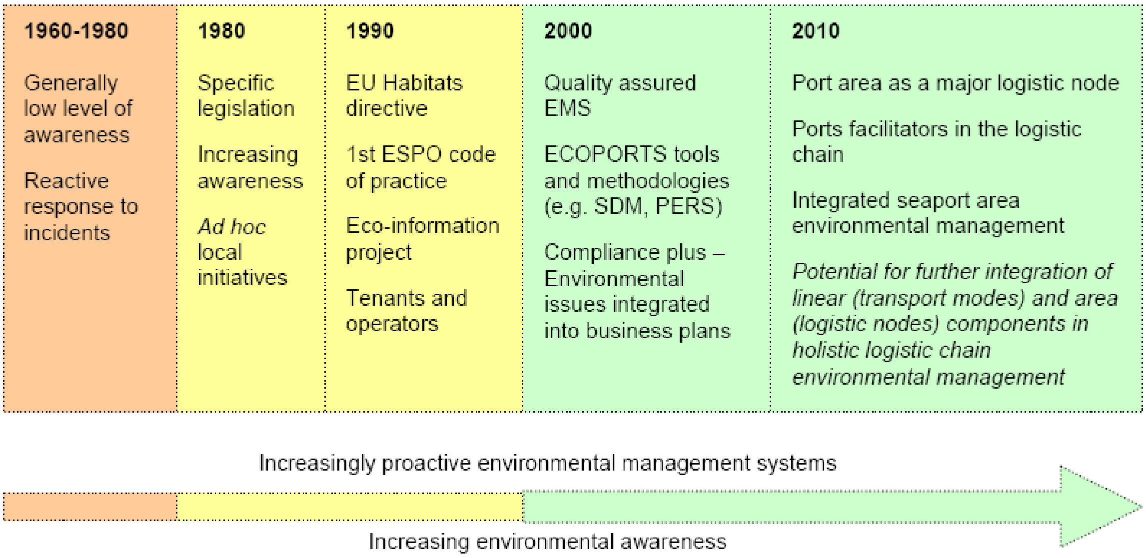
The first generation was based on ports traditional activities: cargo loading / unloading and storage, and giving safe shelter; aids to navigation, mooring and berthing for the ships (United Nations, 1992b). Port authorities were isolated from each other and from the municipality. There was no link between ports and other transport and trade activities. This generation, in which bulk cargo was the dominant type of traffic, lasted until 1960 (Mokkhavas, 2002).

The second generation was born from the increase of the vessel sizes, the considerable importation of raw materials in developed countries and the beginning of the logistics concept. With industries using the raw materials (e.g. steel factories, oil refineries, wood procession, flour mills, and aluminium) and cargo imported (e.g. re-packing, marking, long term storage); a hinterland service area was developed. The port authority was less isolated and the decisions were taken jointly with the main users (e.g. ship owners, shippers, freight forwarders) and with the industries installed in the port area (United Nations, 1992b). Port Authority and municipality and/or local administrative authorities kept frequent relations; they were more dependent from each other: local employment, income taxes, land and energy availability, and favourable environment for investors. Concerning the environment, port authorities generally had a low level of environmental awareness and their response to incidents was merely reactive (see Figure 2.3). Finally, from a marketing point of view, the users were considered clients and their claims or requirements were cautiously taken into account (Mokkhavas, 2002).

The third generation was born from the development of containerisation, the implementation of intermodal transport and globalisation of the economy in the 1980's. While in the first two generations ports supplied infrastructure, in the third generation ports provided services to cope with the demands from the ship-owners and shippers. Because of the development of land transport networks, the competition between ports grew rapidly and ports had to develop services to attract shippers and offer attractive conditions for new investors, such as brokering, storage, new technologies, engineering, and management training (Mokkhavas, 2002). Environmental awareness increased among port authorities thanks to not only the publication of specific legislation, such as the Habitats Directive (1992), but also with the development of collaborative research projects, such as the ECO-Information project (1997 – 1999) (see Table App.3 and Table App.7).

According to the UNCTAD Secretariat (1999), in 2000 a new generation appeared. The fourth generation of port consists of a "network of physically separated ports (terminals) linked through common operators or through a common administration" (United Nations, 1999). Advances in communications and information technology allow terminal operators to increase their productivity through better planning and reduced time of cargo in the port. Examples of the fourth generation ports are terminals linked through common international operators and shipping lines, which operate dozens of terminals around the world (United Nations, 1999). Port authorities have become familiarised with components of Environmental Management Systems (EMS) and the sector has adopted the well-established methodologies for port environmental management, such as the Self Diagnosis Methodology (SDM) or the Port Environmental Review System (PERS) (see Figure 2.3).

Figure 2.3: Evolution of the environmental management in ports



Source: Ecoports Foundation, 2010.

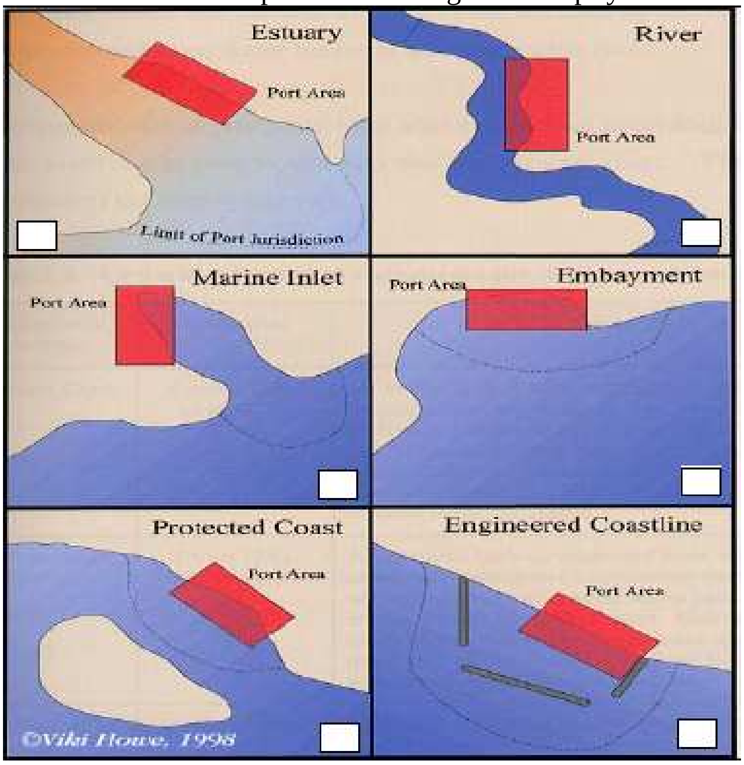
2.2.4 Types of ports

Ports are complex organisations in which several factors are involved. Ports may be categorised from different points of view: its specific location, its size, its commercial profile, its ownership, its administration, or its organizational mode.

As far as the size is concerned, the European Sea Ports Organisation has classified ports in four categories, depending on their annual total cargo throughput. Small ports are considered to have less than 1 million tonnes handled; medium ports between 1 and 10 million tonnes, large ports between 10 and 25 million and very large ports with more than 25 million tonnes handled annually. Other measures of the size of a port are the annual number of passengers or the annual TEU (Twenty-food Equivalent Unit, a measure of the ship containers) handled.

According to its physical surroundings, a port may be situated in an estuary, a river, a marine inlet, an embayment, a protected coast or an engineered coastline. These possibilities are schematised in Figure 2.4.

Figure 2.4: Classification of ports according to their physical surroundings.



Source: European Sea Ports Organisation, 2009.

Regarding their commercial profile, ports may generally be divided into two types: cargo and cruise. Ports may handle mainly one particular type of cargo or numerous cargoes. The main cargoes are: standard-sized shipping containers carried by container ships; dry bulk cargo such as coal or grain carried by bulk carriers; liquid bulk such as chemicals or petroleum products carried by tankers; and roll-on/roll-off including automobiles and trucks. Cruise ships are passenger ships used for pleasure voyages which may include leisure facilities such as swimming pools, cinemas and gyms. Ferries usually perform short journeys for a mix of passengers, cars and commercial vehicles.

According to their ownership, a port authority may be owned by a private owner or by a public entity. If it belongs to a public entity, it may be controlled by the national government, the regional government, or the municipal government.

In public ports, depending on their administration, a port authority may be managed by a non-autonomous public entity (i.e. an administrative department of the government); a commercialised public entity (i.e. a separate legal entity from the government but without sharing capital); or a corporatized public entity (i.e. a separate legal entity from the government with capital owned partly or fully by the government).

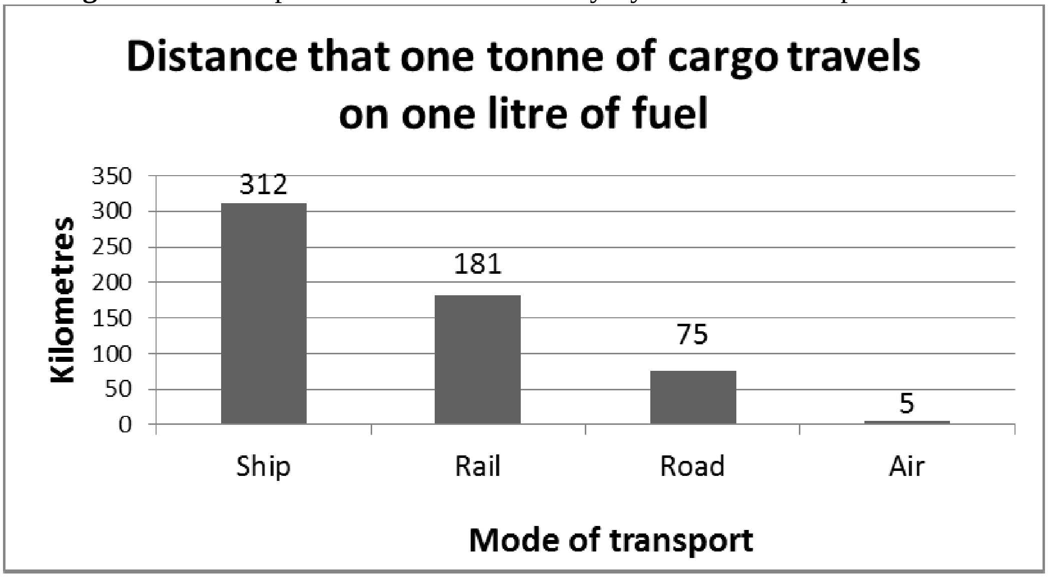
Finally, ports may have different organizational modes, depending on the role that the port authority assumes. According to Juhel (1997), there are three categories: landlord port in which the port authority only owns and manages the port infrastructure; tool port in which the port authority owns not only the port infrastructure but also the port superstructure (i.e. buildings) and equipments (i.e. cranes); and service port in which the port authority is responsible for the port as a whole: they own the infra- and superstructures and they also employ personnel to provide services.

2.2.5 The benefits of the shipping industry

Compared to highway, railway and air transportation, water transportation presents more advantage in transporting goods. The main strengths of marine transport are: i) it is an economical mode of transportation having less energy consumption; ii) it is environmentally friendly producing fewer exhaust emissions; and iii) it is a safe transportation method having less frequency of accidents.

In terms of energy efficiency, shipping is the clear leader compared to other transport modes. Figure 2.5 draws a comparison of the distance in kilometres that one tonne of cargo travels on one litre of fuel, and the fact is that the marine mode can move a tonne of cargo much further with a single litre of fuel.

Figure 2.5: Comparison of fuel efficiency by different transport modes.

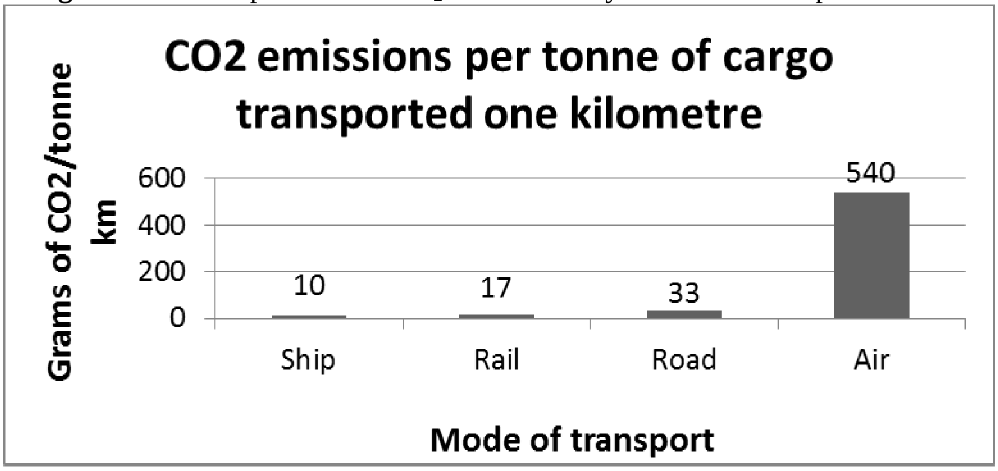


Source: Adapted from St. Lawrence Seaway, 2011.

The recent rapid increase in the price of oil has meant that fuel costs now account for up to 50% of operating costs in some sectors and trades (Shipping Facts, 2011). Ship owners, therefore, have a strong incentive to reduce their fuel consumption, and the industry has also made efforts to increase fuel efficiency as a way of reducing shipping's environmental impact, such as continuing developments in engines, hull and propeller design and the use of larger ships.

The shipping industry is a relatively small contributor to the total volume of atmospheric emissions compared to road vehicles and air transportation. In terms of CO_2 emissions per tonne of cargo transported one mile, shipping is recognised as the most efficient form of commercial transport, as shown in Figure 2.6. However, the large scale of the industry means that it is, nevertheless, a significant contributor to the world's total greenhouse gas emissions, around 3% of total global CO_2 emissions (Shipping Facts, 2011).

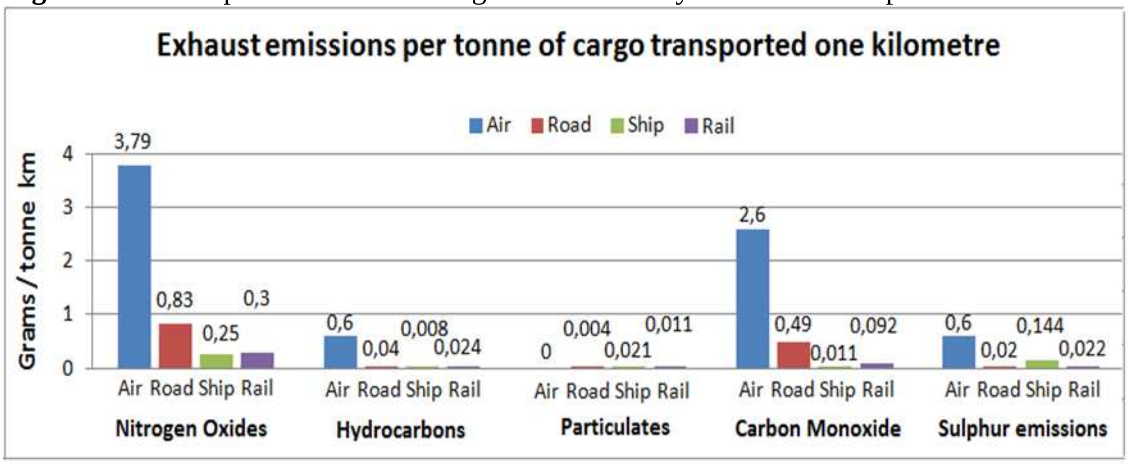
Figure 2.6: Comparison of CO_2 emissions by different transport modes.



Source: Adapted from Shipping Facts, 2011 and St. Lawrence Seaway, 2011.

Figure 2.7 shows a comparison of the main exhaust gas emissions, namely nitrogen oxides (NOx), hydrocarbons, particulates, carbon monoxide (CO), and sulphur emissions (SOx) by different transport modes.

Figure 2.7: Comparison of exhaust gas emissions by different transport modes.

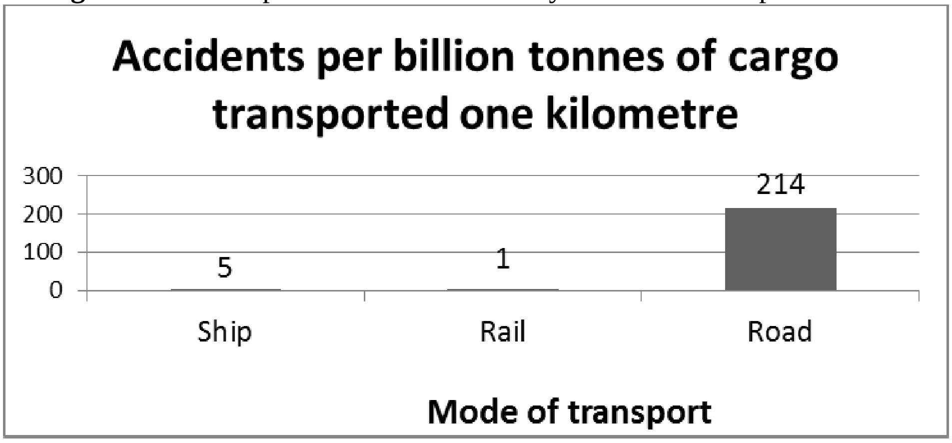


Source: Adapted from Shipping Facts, 2011and and St. Lawrence Seaway, 2011.

Overall, air freight tends to be most polluting mode of transport, followed by road transportation. Ships perform well especially in NO_x, hydrocarbons and CO emissions. The sulphur content of fuel oil supplied to ships by the oil companies is relatively high; therefore, the fuel quality should be improved. The industry has also been exploring other possible solutions, such as the use of alternative fuels.

The marine mode of transportation compares very favourably when it comes to safety, having less injures per billion tonnes of cargo transported one kilometre. Although accident definitions and reporting criteria may differ from mode of transport, it is possible to estimate the standardised frequencies of accidents and their consequences in terms of deaths and injuries, as shown in Figure 2.8.

Figure 2.8: Comparison of accidents by different transport modes.



Source: Adapted from Lawson, 2007.

Some other advantages of the maritime transport are the existence of large capacity vessels that can transport large amount of oil, containers or bulk cargo; and its flexibility and versatility because there are ships with sizes and types suitable for all kind of cargo, such as LNG tankers, refrigerated cargo, bulk carriers, ro-ro, among others. The traffic congestion is another element that should be taken into account because it involves delays in shipments, increased greenhouse gas emissions, higher air contamination, and increased noise. Shipping helps to reduce traffic congestion, because to carry the same amount of cargo on land, the equivalent of 25.000 tonnes of cargo, 870 large trucks or 225 rail cars would be needed (St Lawrence Seaway, 2011).

2.3 Environmental impacts, aspects and issues

These three concepts: environmental impacts, aspects and issues are strongly related to each other and it is worth examining their definition and providing examples in order to clarify their meaning.

According to the ISO 14001 (1996), an environmental aspect is defined as an element of the port authority’s activities, products or services that can interact with the environment. A Significant Environmental Aspect (SEA) is an environmental aspect that has or can have a significant impact on the environment.

There are several factors to consider when developing the criteria of what is considered significant. The significance of an environmental aspect can be based on specific legal requirements (if the port does not comply with regulations of a specific aspect), local concern (if the port has complains from stakeholders on a specific aspect), or global concern (aspects that can affect the environment harmfully at a global scale, such as global warming). Methodologies currently used by port authorities are the Strategic Overview of Significant Environmental Aspects (Darbra *et al.*, 2005), process flow diagrams, interviews, peer evaluation, or independent audits.

Therefore, each port should determine its Significant Environmental Aspects in order to focus its time and efforts on those issues with major potential for environmental impact, providing the greatest assurance that the environment will be protected and also encouraging an efficient and cost-effective use of resources. The Guidelines for Self Diagnosis Method (EcoPorts Foundation, 2004) defined twelve Significant Environmental Aspects, which are presented in Table 2.1:

Table 2.1: Significant Environmental Aspects

Significant Environmental Aspect (SEA)
Emissions to air
Discharges to water
Emissions to soil
Emissions to sediments
Noise
Waste production
Changes in terrestrial habitats
Changes in marine ecosystems
Odour
Resource consumption
Port development (land)
Port development (sea)

Source: EcoPorts Foundation, 2004

An environmental issue is a point or matter of discussion, debate, or dispute of an organisation’s environmental aspect (ISO 14001, 1996).

European ports revealed their environmental priority issues in the 'ESPO / Ecoports Port Environmental Review 2009' where they were asked to rank their Top 10 issues by preference out of 35 different environmental issues proposed. The results are presented in Table 2.2, together with the ones from the similar exercises that took place in 1996 and 2004 so that the variations over time are demonstrated. 122 ESPO members participated in the 2009 survey and the full list of respondent ports is provided in Appendix I.

Table 2.2: Top 10 environmental priorities of the European Port Sector over time

	1996	2004	2009
1	Port Development (water)	Garbage / Port waste	Noise
2	Water quality	Dredging: operations	Air quality
3	Dredging disposal	Dredging disposal	Garbage / Port waste
4	Dredging: operations	Dust	Dredging: operations
5	Dust	Noise	Dredging: disposal
6	Port Development (land)	Air quality	Relationship with local community
7	Contaminated land	Hazardous cargo	Energy consumption
8	Habitat loss / degradation	Bunkering	Dust
9	Traffic volume	Port Development (land)	Port Development (water)
10	Industrial effluent	Ship discharge (bilge)	Port Development (land)

Source: European Sea Ports Organisation, 2009.

Six new main issues appeared in 2004 compared to 1996: Garbage / port waste; noise; air quality; hazardous cargo; bunkering; and ship discharge (bilge). The two main problems related with water disappeared in 2004 and, instead of this, garbage / port waste became the main environmental issue. In 2009, there was a change in the top positions where noise pollution and air quality were pointed out as the current top environmental priorities by the European port sector as a whole, followed by garbage and dredging operations and disposal.

The two new entries in the 2009 top 10 were relationship with local community and energy consumption. Non-renewable energy consumption (such as coal, gas and oil) is a global problem with two main impacts, on one hand because its consumption produces carbon dioxide and other pollutants which create impacts in the environment; and on the other hand, it is a finite resource and a substitute should be found. Relationship with local community problems could be caused by social, political, economic and environmental reasons. Some environmental issues, namely dredging operations, dredging disposal, dust and port expansion, appear consistently within the top 10 of priorities in Europe in the last 15 years.

One of the main reasons for these changes is the implementation of EU Directives, such as the Port Waste Reception Facilities (2000/59/EC) affecting the garbage / port waste problem; the Habitats Directive (1992/43/EEC) impacting on dredging operation, dredging disposal and port development; and the Noise Directive (2002/49/EC) affecting noise concerns.

Any kind of economic and industrial activity has a certain impact on nature. Port and harbour activities are not an exception and they may produce significant impacts on many environmental resources. An environmental impact is any change to the environment, whether adverse or beneficial, wholly or partially resulting from the Port Authority's activities, products or services (ISO 14001, 1996).

Many authors have investigated the environmental impacts of port activities. For instance, the report 'Assessment of the Environmental Impact of Port Development' (United Nations, 1992a) categorises the impacts into three types: port location, port construction and port operation. Trozzi and Vaccaro (2000) make a distinction between the impacts produced by ships calling at ports and the ones generated on-land. The recent report 'Environmental impacts of international shipping' (Organisation for Economic Co-operation and Development, 2011) focused just on the main environmental concerns such as exhaust emissions and energy use. In the next chapter, port impacts are analysed and classified depending on which Significant Environmental Aspect (SEA) is affected.

2.4 Driving forces for change

There are several driving forces for change in modern port practices and they include multiple and interacting pressures that shape a port's response to environmental matters. Although it is widely agreed that the main driving force for change is legislation, other reasons include complaints, costs and political issues. New challenges imposed by environmental legislation specific to port operations have obliged port environmental managers to comply with environmental legislation and to deal with the practical considerations of implementing several International Conventions, European Directives and National Acts relating to environmental protection and sustainable development.

Several organisations, associations, and port agencies around the world have introduced legal instruments, codes of practice, policies and strategies in order to assist port managers to deliver compliance with legislation and to implement best practices in environmental management. These organisations, in association with port partners and universities, jointly sponsored by the EU and port members, have undertaken several collaborative research and development projects aimed at developing practical tools and methodologies for the improvement of the environmental performance of the port sector.

This section provides a summary of some of the major international and European legislation along with selected examples of other national provision. It is followed by a description of some of the most relevant port organisations involved in promoting environmental awareness and examples of relevant research projects carried out in Europe.

2.4.1 Legislation

Increasingly, modern society is regulated in all spheres and at all levels of activity by local, regional, national, and international laws and rules. Despite the development of voluntary or self-regulatory mechanisms such as sector codes and management systems, public law -the law developed by governments- is a major driving force for change affecting behaviour in all sectors.

Determining the applicable legislation is a complicated task for port managers. On one hand, ports, as the point of intersection between land and water, are subject to a complex regime of legislation requirements relating to both terrestrial and marine environmental protection. On the other hand, the legal issues applicable to each individual port may differ depending on a range of factors, such as its shipping traffic or its relative location to sensitive local land or water areas.

The following tables present the name, the acronym and the year of the latest publication of the major international and European legislation which have been considered significant in terms of the environmental management of ports. The description of each specific regulation is provided in Appendix II.

International level

The industrial revolution of the eighteenth and nineteenth centuries and the expansion in international trade resulted in the adoption of a number of international treaties related to shipping. International co-operation continued in the twentieth century, with the adoption of more internationally-developed treaties (IMO, 2011).

The International Maritime Organisation (IMO) is the specialized agency with responsibility for the environment, safety, and security of shipping. IMO is responsible for nearly 50 international conventions and agreements that affect ports and has adopted numerous protocols and amendments. Although international law does not usually regulate the port directly, governments have to assume obligations to implement international conventions in the ports under their jurisdiction. Table 2.3 lists the nine conventions which have been selected as the most important environmental conventions.

Table 2.3: International environmental conventions affecting ports

Name	Acronym	Year
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties	INTERVENTION	1969
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	London Convention	1972
International Convention for the Safety of Life at Sea	SOLAS	1974
International Convention for the Prevention of Pollution from Ships	MARPOL	1973/1978
International Convention on Standards of Training, Certification and Watchkeeping	STCW	1978
International Convention on Oil Pollution Preparedness, Response and Co-operation	OPRC	1990
International Convention on the Control of Harmful Anti-fouling Systems on Ships	AFS	2001
International Convention for the Control and	BWM	2004

Management of Ships' Ballast Water and Sediments		
International Convention for the Safe and Environmentally Sound Recycling of Ships	Hong Kong Convention	2009

Source: Adapted from International Marine Organisation, 2011

When IMO was created in 1958, several important international conventions had already been developed, such as the International Convention for the Safety of Life at Sea (SOLAS) in 1948 or the International Convention for the Prevention of Pollution of the Sea by Oil of 1954. IMO was made responsible to keep these conventions up to date and to develop new conventions whenever needed. The table demonstrates that new environmental conventions have entered into force or have been amended when technologies or techniques have required it. For example, the SOLAS Convention was amended six times after it entered into force in 1965: in 1966, 1967, 1968, 1969, 1971 and 1973. In 1974 a completely new convention was adopted incorporating all these amendments.

European Union level

In the European Community environmental matters are dealt with through European Directives. A Directive obliges Member States to achieve a specified result within a certain period of time but generally allows the member to determine the method and form of law by which this result is achieved. It can be distinguished from regulations, which apply directly to members and mean that all members are regulated in the same way.

Legislation considers all the environmental effects of the activities undertaken not only by the Port Authority itself but also by the industries located in the port because their actions affect the port area as a whole. Therefore, port administrations should stimulate and promote environmentally friendly behaviour among all port stakeholders. The main European environmental Directives affecting ports are presented in Table 2.4:

Table 2.4: European Environmental Directives affecting ports

Name	Reference	Year
Conservation of Wild Birds Directive (BIRDS)	1979/409/EEC	1979
Environmental Impact Assessment (EIA) Directive	1985/337/EEC	1985
Conservation of Natural Habitats and of Wild Flora and Fauna Directive (HABITATS)	1992/43/EEC	1992
Volatile Organic Compound (VOC) Emissions Directive	1994/63/EC	1994
Ambient Air Quality Assessment and Management Directive (Air Quality)	1996/62/EC	1996
Integrated Pollution Prevention and Control (IPPC) Directive	1996/61/EC	1996
Waste Incineration Plants Directive (WIPD) Directive	2000/76/EC	2000
Framework for Community action in the field of water policy (Water Framework Directive)	2000/60/EC	2000
Port reception facilities for ship-generated waste and cargo residues Directive	2000/59/EC	2000
Large Combustion Plants Directive (LCP) Directive	2001/80/EC	2001
Strategic Environmental Assessment (SEA) Directive	2001/42/EC	2001
Assessment and Management of environmental Noise (Noise Directive)	2002/49/EC	2002
Community vessel traffic monitoring and information system Directive	2002/59/EC	2002
Public Access Environmental Information Directive	2003/04 EC	2003
Environmental liability with regard to the prevention and remedying of environmental damage (Environmental Liability Directive)	2004/35/EC	2004

Source: Adapted from EUR-Lex Access to European Union Law, 2011

The above-mentioned Directives demonstrate that there is a wide range of environmental issues being affected by legislative and regulatory pressures. For example, the requirements of a series of Directives may affect port development, such as the Environmental Impact Assessment (EIA), the Strategic Environmental Assessment (SEA), and the Conservation of Wild Birds Directive. The designation of protected areas under the Conservation of Natural Habitats and of Wild Flora and Fauna Directive poses limitations on both dredging and disposal of dredged material. The Directive Assessment and Management of environmental Noise may require carrying out port noise maps, action plans for its management and noise reductions if necessary. The Water Framework Directive and the Ambient Air Quality Assessment and Management Directive set the basic principles of the water and air strategy of the

European Union. The Public Access Environmental Information Directive obliges port authorities to possess and update environmental information relevant to their activities and make this information publicly available.

There are several other regional legal arrangements that impact on European ports bordering the marine area with which the conventions are concerned. These include the OSPAR Convention (combined Oslo and Paris Convention) regulating activities in the North-East Atlantic, the Bucharest Convention for the Black Sea area, the Helsinki Convention regulating the Baltic Sea area and the Barcelona Convention regulating the Mediterranean Sea area.

National level - United Kingdom case study

Determining the national laws that are applicable in each port is a task that should be undertaken by local legal experts in cooperation with the relevant environmental regulatory agency. Usually, in the EU the content and objectives of national or local laws are determined by EU Directives.

Table 2.5 provides examples of the broad range of national environmental legislation affecting ports. It is drawn from the national law of the United Kingdom (UK) as a case study; however, this is a typical list that may be found in most countries.

Table 2.5: Examples of National legislation affecting ports

Air Quality Standards	Buildings Regulations	Clean Air Act
Planning and Compensation Act	Health and Safety at Work Act	Environmental Protection Act
Food Safety Act	Harbour Act	Merchant Shipping Act
Environmental Act	Litter Act	Noise Act
Water Resources Act	Waste Regulations	Wildlife and Countryside Act
Transport and Public Works Act	Town and Council Planning	Waste Management and Licensing Regulations

Source: Associated British Ports, 2011

Ports still face difficulties in implementing environmental legislation. The last ‘ESPO / EcoPorts Port Environmental Review’ (ESPO, 2009) investigated the factors which cause difficulties in the implementation of environmental legislation in European ports.

The review revealed that an 86.6% of the respondent ports still experience some difficulties and that the main challenges are the following:

Table 2.6: Factors which difficult the implementation of environmental management

Factor	Number of ports	Percentage
Number of authorities / stakeholders	44	16.9
No problems	35	13.4
Expense	32	12.3
Awareness of good practice	26	10.0
Priority/status given to environment	25	9.6
Identifying authority responsible	22	8.4
Information about legislation	19	7.3
Provision of guidance	15	5.7
Changes in national standards	15	5.7
Lack of trained personnel	11	4.2
Provision of training	9	3.4
Others	8	3.1

Source: European Sea Ports Organisation, 2009

It is interesting to note that 44 ports out of 122 cited number of authorities / stakeholders as a difficulty, with this being their most serious concern. The second factor is expense, followed by awareness of good practice and priority / status given to environment. This means that the major difficulties in implementing environmental legislation are predominantly caused by political and economic reasons.

2.4.2 Associations

Several national, regional and international organisations, associations, and port agencies around the world have introduced legal instruments, policies and strategies in order to regulate the environmental management of ports, to share information and provide adequate measures to avoid the adverse impacts of climate change and further marine environmental degradation.

In the following section, a list of relevant organisations willing to promote the environmental awareness among ports is provided. Although the research project is especially focused on a European level, shipping implies a worldwide approach so international organisations are included. Obviously, these are just examples of proactive associations; yet there are dozens or even hundreds of port associations around the world. A more comprehensive explanation of each association, along with some actions carried out towards the environment, is provided in Appendix III.

Table 2.7: Examples of port associations

Name
Ports Australia
British Ports Association (BPA)
Associated British Ports (ABP)
European Sea Ports Organisation (ESPO)
EcoPorts Foundation (EPF)
American Association of Port Authorities
California Association of Port Authorities
Baltic Ports Organisation
Port Management Association of Eastern and Southern Africa
European Federation of Inland Ports
North Adriatic Ports Association
International Maritime Organisation
International Association Cities and Ports
GreenPort Journal
International Association of Ports and Harbours
World Port Climate Initiative

Source: Port associations' websites, 2011

These examples of associations include national organisations, such as the British Ports Association (BPA) or the Associated British Ports (ABP) that represent the interests of, and promote environmental awareness amongst, its members; regional organisations that represent port authorities of countries geographically proximate to each other, such as the European Sea Ports Organisation (ESPO); and international associations such as the International Maritime Organisation (IMO) or the International Association of Cities and Ports (IACP).

Since February 2011, EcoPorts has been integrated within the structure of ESPO and the EcoPorts tools SDM and PERS are available to the broad ESPO membership. A New online system (www.ecoports.com) has been created, updating and re-launching SDM and PERS as part of the ESPO services. Figure 2.9 shows a screenshot of the new EcoPorts website.

Figure 2.9: Screenshot of the new EcoPorts on-line system.

Source: EcoPorts Foundation, 2011.

2.4.3 Research projects

Further to the commitment at the policy level, through the ESPO Codes of Practice and Environmental Reviews, the EU port sector has undertaken several research projects aimed at developing practical tools and methodologies especially designed to assist port managers to deliver compliance with legislation and to implement best practices in environmental management (Wooldridge and Stojanovic, 2004). In the following table major collaborative research projects are presented together with their acronyms and the dates of the projects being undertaken. They are listed in chronological order. Further information of each project is provided in Appendix IV.

Table 2.8: Examples of research projects

Project Name	Acronym	Years
Environmental Challenges for European Port Authorities	ECEPA	1995 - 1996
Methodologies for estimating air pollutant emissions from transport	MEET	1996 – 1997
MARPOL rules and ship generated waste	EMARC	1996 – 1997
ECO-Information in European ports	ECO-Information	1997-1999
Harbours - Silting and Environmental Sedimentology	H-SENSE	1998 – 2001
Towards an Environmentally Friendly Port Community	ECOPORT	1998 – 2000
Automatic Tool for Environmental Diagnosis	HADA	2002 – 2005
Port Environmental Indicator System	INDAPORT	2002 – 2003
Information exchange and impact assessment for	ECOPORTS	2002 – 2005

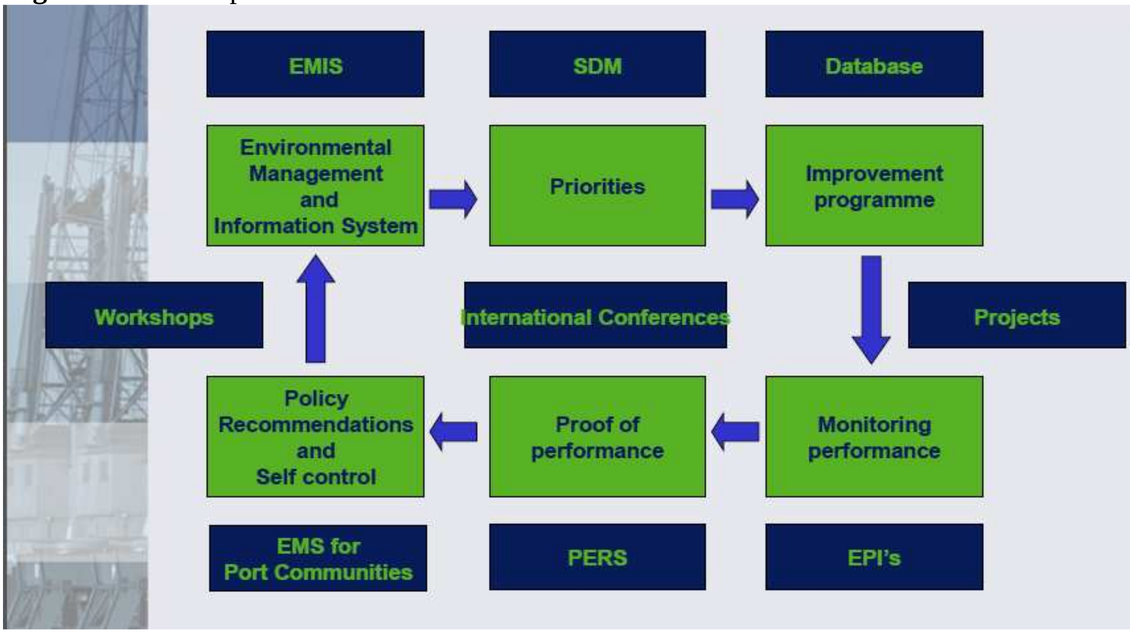
enhanced environmental conscious operations in European ports and terminals		
Environmental Integration for Ports and Cities	SIMPYC	2004 – 2008
Noise Management in European Ports	NoMEPorts	2005-2008
Port Environmental Information Collector	PEARL	2005-2008
Regeneration of Port-Cities: Elefsina Bay 2020	ELEFSINA	2005 – 2009
Risk Management Systems for Dangerous Goods Transport in Mediterranean Area	MADAMA	2006 – 2008
Effective Operation in Ports	EFFORTS	2006 – 2009
Clean Shipping Project for sustainable shipping	Clean Shipping	2007 – 2012
Energy Efficiency criteria at Port Container Terminals	EFICONT	2008 - 2011
Mediterranean Ports’ Contribution to Climate Change Mitigation	CLIMEPORT	2009 – 2012
Shared strategies and actions for strengthening at maritime and logistics sectors in the Mediterranean	SECURMET	2009 – 2012
Port Performance Indicators: Selection and Measurement	PPRISM	2010-2011
Sustainable management for European local Ports	SuPorts	2010 - 2012

Source: Research projects’ websites, 2011

Table 2.8 demonstrates that a wide range of research projects concerning ports and the environment has been undertaken in the last 17 years, led by port authorities with the collaboration of research institutes, universities, and environmental experts. It also demonstrates the priority issues that have existed during the respective periods.

These research projects have been a catalyst for action in port environmental management and provided tools for the improvement of the environmental performance. For example, a benchmark project was the ECOPORTS Project (2002-2005) which contributed to the development of significant outcomes. The products of the project were an Environmental Management and Information System (EMIS), a training system, a Decision-Support System (DSS), a Strategic Overview of Significant Environmental Aspects (SOSEA), a Self Diagnosis Method (SDM), and a Port Environmental Review System (PERS). These tools, represented in their network context in Figure 2.10, continue to be available for use by port authorities after the end of the project. The project also developed an extended network of port authorities which continues to interact and exchange best practice information.

Figure 2.10: Ecoports Tools



Source: Ecoports Foundation, 2010.

2.5 Conclusions

The policies, practices and characteristics of the port sector, established in Chapter 2, have been confirmed and validated by the results of the research programme. The significance of ports to the global economy remains paramount, as does the role of ports within the Logistic Chain. The pressure from an ever-widening range of stakeholders prompts the sector to actively demonstrate its environmental performance through the transparent declaration of indicators related to both environmental condition and to efficacy of the management process itself.

The sector's pro-active stance on standards provides evidence-based confirmation of the significance attached to environmental issues. The research results clarify the extent to which environmental performance is embedded in the culture of both sector and individual authority, with extensive references and experience readily demonstrated throughout the network. The initial profile of the port sector assisted in setting the context for the evolving nature of environmental management in this key area of marine operations.

Analysis of the sector's history in terms of environmental policy development, involvement in research and development projects, the implementation of training programmes, and the specification and endorsement of standards, confirms the change in culture and the evolution of the sector's policy. The initial concerns for conservation and environmental protection have rapidly been expanded to include demonstrable compliance with legislation, and more recently, the drive to achieve sustainable development through cost and risk reduction.

As with port development *per se*, the growth of port environmental management is a complex of phased evolution, issue-driven catalysts, and planned initiatives, reactive measures to incidents and legislation, and on-going policies to deliver sustainable development in the context of the socio-economic circumstances of the global economy, national objectives and local circumstances. Performance indicators are likely to continue to become even more significant components of a port's profile given the status of the environmental imperative and the interest by insurance companies of the port's environmental performance, along with the heightened expectations of increasingly well-informed society.

3 Environmental Performance Indicators (EPIs)

3.1 Concept, role and users of EPIs

An Environmental Performance Indicator (EPI) is defined as “an information tool that summarises data on complex environmental issues to show overall status and trends of those issues” (United Nations, 1997).

Indicators are developed and used predominantly to highlight the performance of a biological, physical, chemical, environmental, economic or social system (Jakobsen, 2008). In the case of environment, EPIs concern an organisation’s impacts on living and non-living natural systems, including ecosystems, air, water, soil and sediment.

There are several reasons why the use of indicators is important. Firstly, indicators provide simplified data that clearly show not only how an individual port is performing, but also assesses the national and regional benchmark performance of the port sector (EPCEM, 2003). The second reason is that indicators monitor progress and provide a picture of trends and changes over time. They measure the extent to which environmental goals are being achieved (EPCEM, 2003) and provide a firm basis for future targets and improvements (Dantes, 2003). Thirdly, they have a key role in providing early-warning information, capable of serving as a signal in case the situation is getting worse, indicating risk before serious harm has occurred. In addition, environmental indicators may be used as a powerful tool to raise public awareness on environmental issues. Providing information on driving forces, impacts and policy responses is a common strategy to strengthen public support for policy measures (Bosch *et al*., 1999).

Indicators can be quantitative such as distance, weight, and amount; or qualitative such as type, colour, and presence or absence of something (EPCEM, 2003). They may be grouped (with or without weighting) into what is called indices or indexes. Often, these indices or indexes are useful in conveying complicated information in a simple, straightforward manner (Jakobsen, 2008). An example is ‘The UK Customer Satisfaction Index (UKCSI)’ which is an indicator that measures the satisfaction of consumers across the UK economy, based on the responses of 26,000 adults (UKCSI, 2011).

Nowadays, indicators are widely used worldwide by scientists, governments, private-sector companies, public entities and the general public. However, it was not until the early 1990's when international organisations, such as the Organisation for Economic Co-operation and Development (OECD), the World Health Organisation (WHO), the World Bank or the United Nations Environment Programme (UNEP), began to promote the monitoring and reporting of environmental indicators. Examples of initial guidelines, technical papers or reports edited by these organisations were: 'Environmental indicators. A preliminary set' (OECD, 1991), 'Scanning the Global Environment: A framework and methodology for integrated environmental reporting and assessment' (UNEP, 1995) and 'Performance Monitoring Indicators Handbook' (World Bank, 1996). Subsequent improved editions of these documents have since been published.

For the port sector, potential users of environmental indicators include a wide range of stakeholders. A port stakeholder is defined as any individual or group having an interest or being affected by port activities (Notteboom and Winkelmans, 2002). Port stakeholders may be very varied and involve a wide range of interested parties. Notteboom and Winkelmans (2002) identified four main stakeholder groups in a port community, all them potential users of indicators: i) internal stakeholders, which belong to the Port Authority organization such as port managers, employees, public relations, board of directors, and unions; ii) external stakeholders, which include companies and industries that invest in the port area such as customers, terminal operators, shipping agencies, chemical companies or shipping repair; iii) public policy and legislation stakeholders, including departments responsible for transport, economic and environmental affairs on a local, regional, national and supranational level; and iv) community stakeholders, which consist of civil society organizations such as NGOs, local inhabitants, the press, environmentalist groups, and other non-market players. Apart from these mentioned stakeholders, other users of indicators include auditors (PERS, EMAS, and ISO), banks, insurance companies, ESPO, and port national organisations.

ESPO has continuously encouraged its members to identify Environmental Performance Indicators relevant to their major environmental issues in order to facilitate monitoring of their environmental performance. It was initially suggested in the ESPO Code of Practice 1994, the first European ports' code of practice of its kind, where it described the role of management in promoting sustainable development and it was followed by a number of operational recommendations including environmental monitoring. It was reaffirmed in the ESPO Environmental Review 2001, being one of six recommendations. Finally, the new Environmental Code of Practice 2003 reiterated the importance of identifying EPIs and carrying out environmental monitoring. The Code set out 10 recommendations which the EU port sector was encouraged to follow, being one "to promote monitoring, based on environmental performance indicators, in order to measure objectively identifiable progress in environmental port practices" (ESPO, 2003).

In addition, indicators are being used by multi-national agencies such as the Commission for Environmental Cooperation of North America (CEC) and the European Environment Agency (EEA); and national as well as municipal agencies. Examples of publications from national organisations containing indicators are 'UK Biodiversity Indicators in Your Pocket 2010' (Department for Environment, Food and Rural Affairs DEFRA, 2010); 'Environmental Performance Indicators Guideline for Organisations' (Ministry of Environment, Japan Government, 2003); or 'Summary of Proposed Indicators for Terrestrial and Freshwater Biodiversity' (Ministry for the Environment of New Zealand, 1999).

3.2 Strengths and weaknesses of EPIs

As stated above, adopting the culture of using and reporting environmental indicators brings benefits and added value to individual ports, national ports associations, ESPO, the European Commission and other stakeholders. In spite of this, and although indicators are widely used in a large range of different sectors and are generally regarded as being useful in assessing environmental information and solving environmental problems, they do have challenges and limitations. Table 3.1 summarises the major strengths that the use of indicators brings to the Port Authority and the weaknesses that indicators have.

Table 3.1: Strengths and challenges of EPIs

STRENGTHS	WEAKNESSES
Compliance with legislation: indicators may provide an appropriate response to legislative and regulatory pressures.	**Simplicity:** indicators are simplifications of observations and sometimes they cannot describe all aspects of every environment.
Cost and risk reduction: indicators may identify environmental risks and help to reduce costs (e.g. energy efficiency).	**Sensitivity:** some indicators may be sensitive to short-term environmental changes.
Sustainable development: indicators may contribute to the continual minimization of environmental impacts; to a better management of environmental issues and to raise staff awareness.	**Data availability:** sometimes the information for best indicators is not available, that makes data less representative.
Market opportunity: indicators may be helpful to meet customer demands, improve relations with customers and they may give a marketing advantage.	**Feasibility**: Although quantitative indicators usually are more representative than qualitative, they tend to be more demanding in terms of time and costs
Positive image: using indicators may show transparency of actions, improve stakeholder relationships and increase confidence of investors, shareholders, banks and insurers.	**Interpretation:** some indicators may be interpreted in different ways, depending on the conditions of the environment.

Source: Adapted from EPCEM, 2003

3.3 Types of EPIs

According to ISO 14031: Environmental Performance Evaluation (1999); there are three categories of Environmental Performance Indicators. The standard distinguishes between Management Performance Indicators (MPI) which “provide information about the management efforts that influence the environmental performance of the port”; Operational Performance Indicators (OPI) which “provide information about the environmental performance of the port’s operations”; and Environmental Condition Indicators (ECI) which “provide information about the condition of the environment”. All these three categories are explained in further detail in the following section.

3.4 Identification of EPIs

A comprehensive list of existing environmental performance indicators has been compiled. This inventory of indicators is a collection of those currently in use or identified as being potentially appropriate from academic and industrial sources. In order to provide an exhaustive database of possibilities, this selection has been based on a wide range of literature review and the identification of current industrial / sector best practice.

The main sources investigated were environmental reports and reviews from port authorities across the world. Usually, when a Port Authority makes efforts towards the environment, they are keen to show these efforts and publish their performance for their stakeholders. Most of the port authorities that publish an Environmental Report make it publicly available in their website and they tend to update it annually. The Self Diagnosis Method (Darbra *et al.*, 2004), a tool that assesses port environmental performance, has provided current examples of qualitative management indicators.

It is worth pointing out that in the 'ESPO / EcoPorts Port Environmental Review 2009' questionnaire it was asked, for the first time in this questionnaire, if the Port Authority had identified environmental indicators to monitor trends in environmental performance, and if so, to name the indicators used. This allowed the researchers to have feedback from 122 European ports on port environmental indicators. These indicators have been incorporated in this thesis, but keeping the individual sources anonymous. In addition, legislation has been taken into account. Research into EC Directives provided further indicators (along with limit values) that have been included in the report. In addition, the European Eco-Management and Audit Scheme (EMAS) also suggests the inclusion of environmental indicators.

In March 2010, the Finnish Ports Association and EcoPorts Foundation carried out a joint workshop entitled 'Environmental Performance Indicators for Planning and Operation' in which there was a working session to identify and discuss the appropriateness of EPIs. Another source of information has been research projects that were previously carried out. Particularly relevant research projects have been the 'EPCEM Environmental Performance Indicators in European Ports' Project in 2003 and

2005, both commissioned by ECOPORTS; and the 'Port Environmental Indicator System (INDAPORT)' coordinated by Valencia Port Authority in 2002.

The indicators identified have been grouped into the three types of environmental indicators detailed previously (see Section '3.3 Types of EPIs'). At the same time, each type includes several sub-categories, specified in Table 3.2. The numbers in brackets show the number of indicators that are included in each sub-category. A total of 304 environmental indicators have been identified as indicators already in use or with potential for use within the sector. In the following paragraphs, each sub-category is described; mentioning the sources, potential consequences and possible measures against adverse effects of the associated environmental impacts. Finally, a list of proposed indicators is presented for each sub-category.

Table 3.2: Categories and sub-categories of Environmental Performance Indicators

Management Performance Indicators (128)	**Operational Performance Indicators (80)**	**Environmental Condition Indicators (96)**
Environmental Management System (5)	Resources consumption (14)	Air quality (12)
Environmental policy (11)	Carbon Footprint (10)	Water quality (26)
Objectives and targets (8)	Noise (13)	Soil quality (10)
Environmental Monitoring Programme (6)	Waste management (28)	Sediments quality (20)
Significant Environmental Aspects (3)	Port development (15)	Ecosystems and habitats (20)
Management organisation & personnel (6)		Odour (8)
Environmental Training & Awareness (15)		
Environmental Communication (15)		
Emergency planning & response (23)		
Environmental audit (5)		
Environmental legislation (8)		
Environmental complaints (8)		
Environmental budget (11)		
Other management indicators (4)		

Management Performance indicators may be allocated into 14 sub-categories all related to the efforts made by the Port Authority towards the implementation of an effective environmental management within the organisation. Most of the sub-categories are the components required in the establishment of an Environmental Management System. Other sub-categories are derived from the sections present in the Self Diagnosis Method.

Operational indicators include a total of 80 indicators, divided into 5 sub-categories. These categories are regarded as Significant Environmental Aspects (SEA) by the Self Diagnosis Method. These indicators concentrate on the aspects associated with the Port Authority's operations, including activities, products and services. They are divided in input indicators, such as resources consumption; and output indicators, such as waste production, Carbon Footprint, or noise. Port development indicators are also included in operational indicators and they relate to operations carried out at sea, on land or both.

The last category is the condition indicators which give information on the quality and state of the environment. These indicators analyse the quality of the air, water, soil and sediment. It also includes ecosystems and habitats indicators that show the status and the trends in specific flora and fauna species. Odour is regarded as a Significant Environmental Aspect (SEA) so it has been considered as a separate aspect in this category.

3.4.1 Management Performance Indicators

Environmental Management Indicators are seen as qualitative measures of a Port Authority's capability to deliver environmental protection and sustainability, and as an effective way in which to demonstrate an Authority's credentials, competences and programmes to manage a wide range of environmental issues. It may be argued that such an approach provides an overall synthesis of environmental management benchmark performance and is based on the established auditing approach that if a company can demonstrate its ability to deal with extreme, severe environmental issues (such as oil spills or capital dredging), then it is more than likely to have the capacity to control relatively minor issues such as what happens to its office light bulbs and empty toner cartridges.

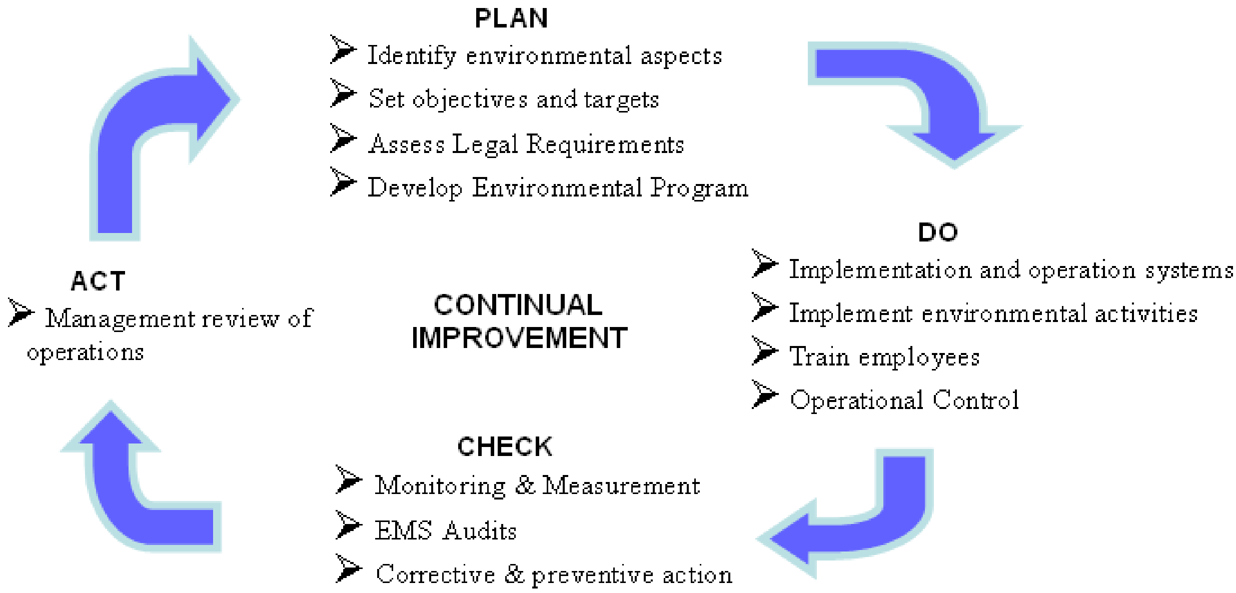
As it can be seen in Table 3.2, there are 14 different sub-categories for environmental management, all related to terminology recognised in international environmental standards, accounting up to 128 environmental management indicators. Most of them are qualitative indicators, which are presented in a Yes / No response format; and a few are quantitative indicators, which require a number or a percentage. Each sub-category and its corresponding indicators are presented in the following paragraphs. The suggested indicators have been identified from officially published indicators or from own research. The information source is mentioned next to each indicator, specifying SDM if it is derived from the Self Diagnosis Method, ESPO if it is from the ESPO/EcoPorts Port Environmental Review 2009 or OR if it comes from own research.

Environmental Management System

An Environmental Management System (EMS) is a set of management processes and procedures that allow an organisation to analyse, control, and reduce the environmental impact of its activities, products and services and operate with greater efficiency and control (Peer Center, 2011).

An EMS follows an established Plan-Do-Check-Act management system cycle (Figure 3.1) for continual improvement of the environmental performance. These steps are repeated over and over again so that the last step, conducting a management review, leads to new ideas and recommendations that then become the starting point for renewed management commitment to the environmental policy.

Figure 3.1: Environmental Management System cycle



Source: Adapted from Bull, T. *et al.*, 2007.

There are three main standards with respect to Environmental Management Systems for the port sector within Europe: ISO 14001, PERS and EMAS; all three widely recognised and implemented among the sector. ISO 14001 was developed by the International Organisation for Standardisation (ISO) in September 1996. It belongs to a set of ISO 14000 norms based on a voluntary approach to environmental regulation. Secondly, PERS stands for Port Environmental Review System, and it is the only port-sector specific environmental management standard developed by ports and for ports. PERS can be considered as the first step towards an EMS because it incorporates the main generic requirements of recognised environmental management standards, and its implementation can be independently certified by Lloyd's Register on behalf of ESPO. Finally, the EU Eco-Management and Audit Scheme (EMAS) has been available for participation by companies since 1995, and although it was originally restricted to companies in industrial sectors, since 2001 EMAS has been open to all economic sectors, including public and private services operating in the European Union and the European Economic Area (EEA). The latest revision (EMAS III) came into effect on January 2010.

Environmental Performance Indicators are an essential component of an Environmental Management System because they play a key role in fulfilling many requirements of an EMS. The requirements needed to establish and maintain an EMS are categorised into the Plan-Do-Check-Act model mentioned above. Table 3.3 presents the structure of ISO 14001, EMAS and PERS following their original format.

Table 3.3: Comparison of the ISO 14001, PERS and EMAS structure

	ISO 14001 Clause	EMAS Steps	PERS requirement
PLAN	N/A	N/A	1.0 Port Profile
PLAN	4.2 Environmental Policy	1. Environmental Policy	1.1 Policy statement
PLAN	4.3.1 Environmental aspects	2. Initial environmental review	1.2 Environmental aspects and legal requirements
PLAN	4.3.2 Legal and other requirements	3. Legal and other requirements	1.2 Environmental aspects and legal requirements
PLAN	4.3.3 Objectives and targets	4. Objectives and targets	1.1 Policy statement
PLAN	4.3.4 Environmental Management Programme	5. Environmental management programme	1.4 Conformity review
DO	4.4.1 Structure and responsibility	6. Structure and responsibility	1.3 Responsibilities and resources
DO	4.4..2 Training, awareness and competence	7. Training, awareness and competence	1.1 Policy statement
DO	4.4.3 Communication	8. Communication 18. Environmental reporting with verified information	1.5 Environmental Report
DO	4.4.4 EMS documentation	9. EMS documentation	1.2 Environmental aspects and legal requirement
DO	4.4.5 Document control	10. Document control	1.2 Environmental aspects and legal requirement
DO	4.4.6 Operational control	11. Operational control	1.4 Conformity review
DO	4.4.7 Emergency preparedness and response	12. Emergency preparedness and response	1.2 Environmental aspects and legal requirement
CHECK	4.5.1 Monitoring and measurement	13. Monitoring and measurement	1.2 Environmental aspects and legal requirement
CHECK	4.5.2 Non-conformance and corrective and preventive action	14. Non-conformance and corrective and preventive action	1.4 Conformity review
CHECK	4.5.3 Records	15. Records management	N/A
CHECK	4.5.4 EMS Audit	16. Internal audit 19. Independent validation of EMS	1.1 Policy statement
ACT	4.6 Management Review	17.Management review	1.4 Conformity review
ACT	N/A[1]	N/A	1.6 Best practices

[1] N/A stands for Not Applicable

As is shown in Table 3.3, although ISO 14001 and EMAS have a similar structure, EMAS is more demanding that ISO 14001 in some issues. For example, EMAS requires an initial environmental review (step 2) whereas in ISO 14001 it is just recommended. Furthermore, EMAS needs to have an independent validation of the EMS (step 19) while in ISO 14001 with an internal audit it is sufficient. The frequency of EMS audits in ISO 14001 is not specified, whereas EMAS obliges a port to have an EMS audit at least every three years. PERS is structured in six requirements and most of the ISO 14001 clauses are included within these six requirements. Apart from that, PERS has a section for the port profile (general information on legal status, geographical characteristics and commercial activities of the port) and another for best practices (requirement 1.6) where ports can introduce their solutions to environmental challenges.

The European port sector can demonstrate progress in developing and implementing EMS as a tool to assist it in fulfilling their environmental responsibilities and duties. As reported by the 'ESPO / Ecoports Port Environmental Review 2009', 48% of the respondent ports have a form of Environmental Management System, 30% being certified by ISO 14001 and 17% certified by Ecoports PERS. Progress achieved can be easily demonstrated when compared with the same exercise in 2004 where only 21% of the respondent ports had an EMS. In fact, according to Dr Antonis Michail, ESPO Policy Advisor and EcoPorts coordinator, since EcoPorts has been integrated within the structure of ESPO in February 2011, 35 new ports have registered with the network and 16 new Self Diagnosis Methods have been completed (Michail, 2011).

This commitment towards the continuous improvement of the environmental management programme of ports was exemplified at the ESPO Conference 2011 when the ports of Bremen / Bremerhaven and Thessaloniki were awarded with the Port Environmental Review System (PERS) certificate. Mrs. Bettina Linkogel on behalf of Bremen / Bremerhaven ports, Head of Section within the Ministry of Economic Affairs and Ports, thanked all her colleagues who worked towards the implementation of PERS, and she highlighted the added value of PERS that clearly defines and documents environmental responsibilities in a structured and consistent way. Mrs. Linkogel added "To our ports this certificate will be an incentive to go further on the path of sustainability and to increase the environmental performance" (B Linkogel, *pers comm.*, 5 May 2011).

Within the sub-category Environmental Management System, five indicators have been identified. There are three qualitative indicators (questions) that are taken from the 'ESPO / Ecoports Port Environmental Review 2009' and two quantitative indicators which provide further information on the EMS certifications of the port.

Table 3.4: Environmental Management System Indicators

Indicator	Source
Does the Port Authority have an Environmental Management System (EMS)?	ESPO
Number and type of EMS certifications	OR
Year(s) of certification	OR
Has the port completed the environmental review Self Diagnosis Method?	ESPO
Have any customers requested that the port to be EMS certified?	ESPO

Environmental Policy

An Environmental Policy is a declaration of the Port Authority's public intentions and principles, which aim to prevent, reduce, or mitigate harmful effects on nature and natural resources caused by human action (McCormick, 2001). The policy provides a framework for action and for setting its environmental objectives and targets (ISO, 1996) and it should contain specific commitments to compliance, continual improvement and prevention of pollution. Although an appropriate environmental policy should reflect the most relevant environmental impacts of the port's activities, products and services, usually it does not indicate the specific indicators used.

The Environmental Policy represents a tangible demonstration of commitment, and it should be accepted and signed by the highest level of management. Whenever new management is appointed, the policy should be reviewed and re-issued or otherwise formally re-affirmed.

The policy must be documented and should be regularly reviewed and rewritten, as necessary, to reflect changes in activities or services. The policy should be concise, avoiding generic language, and actively distributed to all employees, preferably through multiple mechanisms. The policy should be publicized in newsletters; discussed in mandatory employee orientation training; and included on the agenda of staff meetings, as appropriate. Finally, the policy should be available to the public (e.g. via bulletin boards or public websites).

Table 3.5 presents the management indicators that refer to Environmental Policy. They consist of a set of questions regarding the existence of an Environmental Policy, its contents, its scope and its diffusion. Most of them (the first 9 indicators of the Table 3.5) appear in the Self Diagnosis Method and the last two indicators are questions from the ESPO Environmental Review 2009.

Table 3.5: Environmental Policy indicators

Indicator	Source
Does the port have an Environmental Policy?	SDM
Is the policy signed by Chief Executive / Senior Management?	SDM
Is the policy communicated to all relevant stakeholders?	SDM
Is the policy communicated to all employees?	SDM
Is the policy publicly available on the port's website?	SDM
Does the policy include reference to major objectives?	SDM
Does the policy include reference to publication of an Environmental Report?	SDM
Does the policy include reference to the identification and control of the port's Significant Environmental Aspects?	SDM
Does the policy include reference to introduction / maintenance of an Environmental Management System?	SDM
Does the policy aim to improve environmental standards beyond those required by legislation?	ESPO
Does the policy include reference to ESPO Code of Practice (2003)?	ESPO

Objectives and targets

An objective is an overall environmental goal that a Port Authority sets itself to achieve, whereas a target is a detailed performance guideline, quantified where possible, that needs to be set and met in order to achieve those objectives (ISO, 1996). For example, an objective could be 'better management for water runoff', and a target 'to reduce the amount of water used by 20% by 2012'.

Environmental indicators play a key role in setting objectives because its targets should be measurable in order to enable ports to track their performance. Although objectives should be challenging, they have to be attainable and with financial sense. Objectives should be consistent with the environmental policy and related to the Significant Environmental Aspects described.

Out of the eight objectives and targets indicators, the first four presented in Table 3.6 are elements of the Self Diagnosis Method, while the other four are obtained from the own research.

Table 3.6: Objectives and targets indicators

Indicator	Source
Has the port defined objectives for environmental improvement?	SDM
Has the port defined targets for its objectives?	SDM
Have the objectives and targets been communicated?	SDM
Does the port have quantitative objectives?	SDM
Number of environmental objectives and targets defined	OR
Number of environmental objectives and targets achieved	OR
Percentage of environmental targets achieved	OR
Have management programmes and action plans been prepared to achieve each objective?	OR

Environmental Monitoring Programme

Port authorities should establish and maintain procedures to monitor and measure, on a regular basis, the key characteristics of their operations and activities that can have a significant impact on the environment (ISO, 1996). Monitoring is an activity involving repeated observation, according to a pre-determined schedule, of one or more elements of the environment to detect their status and trends (EcoPorts Foundation, 2004).

An Environmental Monitoring Programme consists of a repeated periodic observation and measurement of selected parameters, allowing a port to establish the current status and trends of environmental quality and being an essential tool to track its environmental performance. In the category of Environmental Condition Indicators, the chemical, physical and biological indicators used to monitor air, water, soil and sediment quality are examined; however, it is worth pointing out some indicators that may demonstrate the commitment of a Port Authority towards its monitoring programme. These indicators, presented in Table 3.7, can be used in parallel with the results from monitoring.

Table 3.7: Environmental Monitoring Programme indicators

Indicator	Source
Does the port have an environmental monitoring programme?	SDM
Has the port identified environmental indicators to monitor trends in environmental performance?	ESPO
Number of environmental parameters monitored	OR
Frequency of monitoring each parameter	OR
Number of monitoring locations for each parameter	OR
Number of days in a year that the limit value has been exceeded for each parameter	OR

Significant Environmental Aspects (SEA)

These indicators refer to the existence of a clearly defined list of Significant Environmental Aspects, whether it considers activities of tenants and operators, and the number of SEA identified, mentioned in Table 3.8. These indicators are relevant to demonstrate awareness and action taken to control impacts. A comprehensive definition, importance and examples of SEA are provided in Section 2.3.

The two qualitative indicators, presented in Table 3.8, are asked in the Self Diagnosis Method and the quantitative indicator is derived from the own research.

Table 3.8: Significant Environmental Aspects indicators

Indicator	Source
Does the port have an inventory of Significant Environmental Aspects?	SDM
Does the inventory consider aspects from the activities of tenants and operators?	SDM
Number of Significant Environmental Aspects identified	OR

Management organisation & personnel

The commitment of all employees is required in order to guarantee effective environmental management. Therefore, environmental liabilities should not be confined only to the environmental department, but it also includes other areas of the Port Authority, such as operational management. The roles and responsibilities of the personnel should be established, documented and communicated.

This commitment should start at the highest level of management. Top management should establish and accept an Environmental Policy and designate an environmental manager responsible for dealing with environmental issues. This manager should be responsible for coordinating environmental management throughout the port, responding to internal and external enquiries, ensuring compliance with environmental policy, having responsibility for implementation / maintenance of an EMS, and monitoring current environmental issues and legislation.

The indicators proposed in this sub-category (listed in Table 3.9) are mainly related to the responsibilities of the environmental management representative and the environmental responsibilities of key personnel. While the four qualitative indicators are derived from the Self Diagnosis Method, the other two quantitative indicators are derived from the own research.

Table 3.9: Management organisation & personnel indicators

Indicator	Source
Does the port have a representative responsible for managing environmental issues?	SDM
Are the environmental responsibilities of this representative documented?	SDM
Are all personnel aware of the responsibilities and authority of this representative?	SDM
Are the environmental responsibilities of other key personnel documented?	SDM
Number of levels of management with specific environmental responsibilities	OR
Number of employees who have requirements of professional competence on environmental matters in their jobs	OR

Environmental Training and Awareness

The Manpower Services Commission (1981) defined training as “a planned process to modify attitude, knowledge or skill behaviour through a learning experience to achieve effective performance in any activity or range of activities. Its purpose, in the work situation, is to develop the abilities of the individual and to satisfy current and future needs of the organisation”.

Implementing a training programme and awareness-raising activities deliver continuous improvement in environmental performance because they provide employees with the skills to do their work more efficiently, make them more aware of their roles and responsibilities and stimulate people to develop new ideas through consultation and discussion. ISO (1996) states that top management should determine the level of experience, competence and training necessary to ensure the capability of personnel, especially those carrying out specialised tasks.

Environmental Training indicators (presented in Table 3.10) focus on the existence of environmental training for port employees and the main characteristics of this training, such as its suitability, number of hours invested, the frequency, among others. It also includes four indicators on Environmental Awareness.

Table 3.10: Environmental Training and Awareness indicators

Indicator	Source
Does the Port Authority have an environmental training programme for its employees?	SDM
Is the environmental training fitted to employees’ activities and responsibilities?	SDM
Have all the personnel whose work may create an impact on the environment received appropriate training?	OR
Are environmental issues included in induction programmes for new employees?	SDM
Has the Port Authority established procedures for identifying training needs?	OR
Annual number of environmental training courses for port employees	OR
Number of port employees trained in environmental issues	OR
Annual number of hours invested on environmental training for port employees	OR
Frequency of environmental training sessions for port employees	OR

Percentage of port employees that have received environmental training	OR
Number of trained people working with hazardous cargo	OR
Are all employees aware of the importance of compliance with environmental policy?	SDM
Are all employees aware of the potential environmental impacts of their work activities?	SDM
Are all employees aware of their responsibility to conform to the environmental policy and management objectives?	SDM
Are all employees aware of the objectives, actions and programmes carried out by the port in order to improve its environmental performance?	SDM

Environmental Communication

Environmental Communication implies both internal and external communication. Internal communication helps to keep employees updated with the progress being made towards the environment, and external communication helps to ensure that stakeholders are kept informed of the port's environmental progress.

An Environmental Report gives information about the environmental activities, achievements and results that a Port Authority has carried out throughout the preceding year. Although producing an Environmental Report implies investing time, effort and budget, it is widely acknowledged that reporting the environmental performance of a company is an excellent opportunity not only to improve its reputation by demonstrating transparency, responsibility and good management but also to identify the Port Authority's environmental impacts, to set up objectives and targets, to identify ways to reduce costs and risks and to discover opportunities for improvement.

It may be considered that making an Environmental Report public helps a port authority to facilitate communication and build trust with a wide variety of stakeholders, such as current and prospective employees; port tenants and operators; customers; shareholders and funders, including bankers, investors and insurers; government, including regulators, local and planning authorities. It also allows the port to demonstrate improvements in the environmental performance to pressure groups, including academics, NGOs and the media; and the local community and neighbours. Identifying the key stakeholders of the port is helpful to know where to focus the efforts.

In recent years, the use of sustainability reporting among ports has grown significantly. According to the 'ESPO / Ecoports Port Environmental Review 2009', 43% of the respondent ports publish an annual report or review. Compared with the same exercise in 2004, the progress achieved is demonstrated, having increased 12% since then (ESPO, 2010). In fact, promoting environmental reporting among the EU port sector is one of the 'Ten Commandments' of the ESPO Environmental Policy Code (European Sea Port Organisation, 2003).

Data on Environmental Performance Indicators being monitored by a Port Authority is the most relevant contribution to an Environmental Report because they provide a clear and meaningful picture of the Port Authority's environmental performance. EPIs may be reported in absolute data, which is in absolute units of measurement such as tonnes or cubic metres; normalised data which relates two absolute figures such as the proportion of recycled waste to total waste or total CO_2 emissions per tonnes of cargo handled; and finally, trend data, which presents data over a number of years, such as total water consumption for each year from 2005-2010.

Apart from EPIs data, other contents that a comprehensive Environmental Report should include are the Chief Executive Officer's (CEO) statement, the Port Authority's Environmental Policy; a profile of the port specifying the size, location and its main operations and functions; a description of any recognised standard of Environmental Management System used in the port; a summary of the key environmental impacts of the port's activities; objectives for improvement and explanation of progress made towards targets; environmental best practices and initiatives implemented; future projects, and finally, a report on legal compliance, being mentioned if the organisation has been prosecuted for any environmental offence in the reporting period and explaining the actions taken to make it less likely to happen again.

As far as the methods to report are concerned, there are three common ways to report. The first option is to publish a stand-alone environmental hard-copy report. The main advantages are that it may be more easily disseminated to a target audience. On the other hand, the disadvantages are that it is difficult to serve the needs of all audiences in one document, and it is more expensive to print. The second option is to incorporate it as an environmental section in the annual report of the Port Authority. In this case, the strengths are that the links between environmental and other financial and management concerns are emphasised, and that it may be cheaper to publish than a separate report. The weaknesses are that this alternative is not focused on specific stakeholders, and it will probably be less comprehensive than the first option. The third option is to have a web-based report; the positive points are that it saves on publishing costs, it is environmentally-friendly, it may have a wider audience (including international), and it could be updated if needed. The main disadvantage is that not all interested stakeholders may have access to the Internet.

Table 3.11 details the proposed environmental communication indicators. These include quantitative and qualitative indicators concerning internal and external communication.

Table 3.11: Environmental communication indicators

Indicator	Source
Does the port publish a publicly available Environmental Report?	SDM
Does the port publish factual data by which the public can assess the trend of its environmental performance?	ESPO
Are there procedures to communicate environmental information internally between the key environmental personnel?	SDM
Are there procedures to exchange port environmental information with stakeholders including external parties?	SDM
Are there procedures to consult with the Local Community on the port's environmental programme?	ESPO
Frequency of meetings and consultations with external stakeholders	OR
Frequency of internal meetings with key environmental personnel	OR
Annual number of environmental publications published	OR
Annual number of press articles published concerning environment	OR
Does the port website show environmental information?	ESPO
Number of hours invested on environmental presentations given to stakeholders or interest groups	OR
Annual number of national and international conferences organized by the Port Authority	OR
Annual number of congresses and conferences attended by port employees concerning environment	OR
Number of universities and research institutes co-operating with the port in the field of environment	OR
Annual number of groups and students visiting the port for environmental	OR

education purposes	

Emergency planning and response

An Emergency Response Plan is a “document that identifies potential emergencies, assesses their probable effects and details step-by-step procedures to follow in case of emergencies” (Business Dictionary, 2011). Emergencies can arise from many causes, for example fire, explosion, collision, flooding, spillage, or leakage (EcoPorts Foundation, 2004).

Port authorities should identify possible accidents and emergency situations that are likely to happen and the manner in which to respond to them. Preventive and mitigation actions also should be carried out by the Port Authority to make the environmental impacts associated with them less severe. The emergency preparedness and response procedures should be reviewed and revised regularly, especially after the occurrence of accidents and emergency situations. The indicators of emergency planning and response are focused on the existence and content of an Emergency Response Plan, and the number and nature of accidents occurred and are listed in Table 3.12.

Table 3.12: Emergency planning and response indicators

Indicator	Source
Does the port have an Emergency Response Plan?	SDM
Does the Emergency Response Plan include the potential environmental consequences and actions to be taken in the event of explosion, fire, floods, oil/chemical spill, and shipping accident?	SDM
Does the Emergency Response Plan specify the responsibility and role of each body: Port Authority, tenants and operators, ship agents, and external agencies?	SDM
Does the port have an Emergency Response Plan specially designed for handling hazardous cargo?	OR
Does the port have a Cargo Handling Plan?	OR
Does the port have an Oil Spill Response Plan?	OR
Annual number of environmental accidents reported	OR
Average response time in case of environmental accidents	OR
Average response and correction time in case of environmental accidents	OR
Maximum response time in case of environmental accidents	OR
Number of bunkering related pollution accidents	OR

Number of vessel related pollution accidents	OR
Number of cargo related pollution accidents	OR
Total number and volume of oil and chemical spills	OR
Annual number of emergency drills	OR
Frequency of safety equipment revisions	OR
Number of environmental inspections	OR
Does the port have a representative responsible for managing safety issues?	OR
Are the responsibilities of this representative documented?	OR
Are all personnel familiarised with safety regulations?	OR
Has the Port Authority carried out an Environmental Risk Assessment during the last 5 years?	ESPO
Amount of annual hazardous cargo handled	OR
Number of Seveso II sites (sites containing large quantities of dangerous substances defined by the Directive 2003/105/EC)	OR

Environmental Audit

Environmental auditing has been defined as "a management tool comprising a systematic, documented, periodic and objective evaluation of the performance of the organisation, management system and processes designed to protect the environment with the aim of facilitating management control of practices that may have an impact on the environment, and assessing compliance with company policies" (Council of the European Communities, 1993).

There are many types of audits that can be carried out by companies, either internally or with the assistance of a third-party, being the most common ones: an Environmental Compliance Audit consisting of checks against environmental legislation and company policy; an EMS Gap Analysis which is a self-evaluation, usually a series of questions or a checklist, that helps ports to compare its current environmental management practices against a standard EMS model; and an Internal EMS Audit which evaluates periodically (usually annually) how well the EMS is performing in terms of meeting its regulatory requirements and its EMS goals.

Environmental audits are conducted to assess performance against a set of requirements or targets related to specific issues; to evaluate compliance with environmental legislation and corporate policies; and to measure performance against the requirements of an environmental management system standard. If these requirements are not met, the audit identifies non-nonconformities and therefore, corrective actions should be taken to address this undesirable situation.

Five indicators have been identified concerning Environmental Audits, listed in Table 3.13. Only the first one is qualitative (Yes/No format) and it is obtained from the SDM, the rest are from the own research.

Table 3.13: Environmental audit indicators

Indicator	Source
Has an environmental audit been conducted?	SDM
Number of environmental audits conducted	OR
Number of nonconformities found in environmental audits	OR
Number of nonconformities addressed	OR
Time spent on addressing nonconformities	OR

Environmental legislation

As mentioned in Section 2.4, there are legal requirements that may apply to port operations, including international, regional, national and local laws and regulations. Additionally, there are other requirements to which the port may have to subscribe to such as corporate policies, port association's standards or any other voluntary provisions. EPIs are crucial to obtain data that may demonstrate that the port complies with legislation.

An inventory of legislation is a list of legislation and regulations relevant to the port's liabilities and responsibilities. Port authorities should identify and have access to legal and other requirements to which the organisation subscribes, that are applicable to the environmental aspects of its activities (ISO, 1996). The indicators referring to environmental legislation are introduced in Table 3.14.

Table 3.14: Environmental legislation indicators

Indicator	Source
Does the port have an inventory of relevant environmental legislation and regulations related to its liabilities and responsibilities?	SDM
Are there procedures to maintain and update the inventory?	SDM

Are there methods to deal with non-compliance with internal and external standards?	OR
Number of prosecutions received for non-compliance with environmental legislation	OR
Number of fines received for non-compliance with environmental legislation	OR
Percentage of compliance with environmental legal requirements	OR
Total number of environmental licenses obtained	OR
Total number of environmental licenses withdrawn or refused	OR

Environmental complaints

An environmental complaint is a documented critical observation or query about the Port Authority’s environmental aspects, policy, management system or performance, from interested parties requesting a response or remedial action (Vacman Cleaning, 2005).

Environmental complaints, as stated by Dasgupta and Wheeler (1997), not only provide useful information, but also they are an important way for community participation. The information gathered from port employees’ and local community’ complaints have the potential to reveal some of the most problematic environmental issues of the Port Authority. Environmental complaints indicators (Table 3.15) are based on the number of complaints received and the response action taken to them.

Table 3.15: Environmental complaints indicators

Indicator	Source
Total annual number of environmental complaints received	OR
Annual number of environmental complaints received from NGOs	OR
Annual number of environmental complaints received from people working in port area	OR
Annual number of environmental complaints received from the Local Community	OR
Annual number of environmental complaints received from Port Authority’ employees	OR
Total annual number of environmental complaints investigated	OR
Annual number of environmental complaints resolved where no further action was necessary	OR
Annual number of environmental complaints resolved where further action was necessary	OR

Environmental budget

The environmental budget is the amount of money allocated to the protection of the environment. The indicators concerning environmental budget are significant because they provide information about the priority given and the economic efforts made by the Port Authority towards the environment.

The environmental budget indicators, listed in Table 3.16, offer the possibility to specify in which environmental protection components the funding has been allocated. The percentage of total budget allocated to environmental protection helps to clearly identify the priority given to the environment.

Table 3.16: Environmental budget indicators

Indicator	Source
Does the port have a budget specifically for environmental protection?	SDM
Amount of funding allocated to environmental training of employees	OR
Amount of funding allocated to control environmental impacts	OR
Amount of funding allocated to emergency response and prevention	OR
Amount of funding allocated to environmental monitoring	OR
Amount of funding allocated to stakeholder engagement and outreach activities	OR
Amount of funding allocated to environmental reporting	OR
Amount of funding allocated to biodiversity protection	OR
Total annual budget allocated to environmental protection	OR
Percentage of total budget allocated to environmental protection	OR
Percentage change of environmental budget compared to the previous year	OR

Other environmental management indicators

There are four environmental management indicators that are not included in any of the above-mentioned management components. These indicators are listed in Table 3.17:

Table 3.17: Other environmental management indicators

Indicator	Source
Are copies of ESPO Environmental Review (2001) available in the port?	ESPO
Are there procedures to involve all port users in the development of the environmental programme?	ESPO
Number of pollution prevention initiatives implemented	OR
Number of pollution reduction solutions implemented	OR

3.4.2 Operational Performance Indicators

Operational Performance Indicators take into account the aspects related to an organisation's operations, including activities, products or services (ISO, 1999). They concentrate on planning, controlling and monitoring the environmental impacts of the organisation's operations. Operational performance indicators are also a tool for communicating environmental data through environmental reports or environmental statements. By integrating cost aspects into them, they represent a basis for environmental cost management (European Commission, 2003).

Operational Performance Indicators include input indicators such as raw materials, energy and water consumption, and output indicators such as Carbon Footprint, noise, or waste management (European Commission, 2003). Port development operations are also included in this category. Each sub-category and its indicators are introduced in the following paragraphs:

Resource consumption

Resource consumption includes natural resources' consumption such as water or raw materials and non-renewable energy consumption such as fossil fuels (coal, petroleum and natural gas) (EcoPorts Foundation, 2004).

The combustion of fossil fuels on site includes stationary sources such as operational machines, cranes, heating or cooling; and mobile sources essentially company-owned vehicles such as cars or vessels. The consumption of electricity, which is largely generated from fossil fuels (Electric Power Research Institute, 2011), comprises electricity used for harbour lightning and port buildings' heating and lightning. It also includes electricity usage from cranes, lighthouses, or for other purposes.

The burning of fossil fuels creates emissions of carbon dioxide (CO_2), which is the greenhouse gas (GHG) that contributes most to the global warming (Kiehl and Trenberth, 1997) causing a rise in the average surface temperature of the Earth, which is one of the most serious aspects of climate change. The combustion of fossil fuels also generates sulphuric, carbonic, and nitric acids, which fall to the Earth as acid rain, impacting on both natural areas and built environment (Twerefou, 2009). The consumption of fossil fuels also contributes to the exhaustion of non-renewable resources.

To reduce CO_2 emissions, non-renewable energy demand needs to be lowered. To do so, efficient energy management is a key strategy and it could be achieved through redesigning processes, changing employees' behaviour and converting to greener technology. Replacing fossil fuel energy sources with renewable ones is another strategy to reduce carbon emissions and it also may decrease the Port Authority's future dependency on non-renewable energy sources. For instance, ports located in windy areas may invest in wind-power; in locations where solar radiation is regularly distributed over the months of the year, solar energy may be used as a supplement to the production of fossil-based electricity (OECD, 2011). Resource consumption indicators consist of three qualitative indicators and eleven quantitative indicators, and most of them are related to energy demands. They are presented in Table 3.18.

Table 3.18: Resource consumption indicators

Indicator	Source
Total annual energy consumption by energy source	OR
Percentage of energy sources of the total energy consumption	OR
Does the port have a programme to increase energy efficiency?	ESPO
Number of energy-efficiency initiatives implemented	OR
Amount of energy saved due to energy-efficiency improvements	OR
Does the port produce any form of renewable energy?	ESPO
Does the port provide shore-side electricity at any of its berths?	ESPO
Number of vessels using shore-side electricity	OR
Percentage of low consumption lights compared to total number of lights	OR
Total annual renewable energy consumption	OR
Percentage of renewable energy per total energy consumed	OR
Total annual water consumption	OR
Total annual water recycled and reused	OR
Percentage of water recycled per total water consumption	OR

Carbon Footprint

The Carbon Footprint is a measure of the total amount of greenhouse gas (GHG) emissions that is directly and indirectly caused by an activity (Carbon Trust, 2010). A Carbon Footprint accounts for all six Kyoto GHG emissions: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) (Carbon Trust, 2010). Carbon dioxide emissions are governed by the United Nations Frame-work Convention on Climate Change (UNFCC) and the subsequent Kyoto Protocol (IISD, 2009). As a result, different national and international regulations and incentive systems (such as trading climate certificates) aim to control the volume and reward the reduction of greenhouse gas emissions.

Although the Carbon Footprint is strongly related to the environmental aspect ‘resource consumption’ explained above, it has been considered as a separated sub-category of Operational Performance Indicators because the emissions of the greenhouse gas (GHG) are an output of the ports’ operations and not an input like ‘resource consumption’. This indicator is not categorised into the Environmental Condition Indicators of ‘air quality’ because Carbon Footprint calculates the tonnes of CO_2 that have been emitted to the atmosphere and also because it is not an indicator of the current concentration of CO_2 in the port environment.

An increasing number of port authorities are committing themselves to calculating, quantifying and reporting their Carbon Footprint in order to identify their key emission sources and to discover opportunities to reduce their emissions. Reducing an organisation’s Carbon Footprint may result in cost savings and could lead to competitive advantages and market differentiation.

Table 3.19 identifies Carbon Footprint indicators; some of them are qualitative (e.g. existence of a Carbon Footprint measurement) or quantitative (e.g. GHG emissions). Ideally, the GHG emissions should be reported in a standardised common ground, either annual million tonnes of cargo handled, annual thousand TEUs or annual million passengers because it would facilitate the analysis of the trends year-by-year in the Carbon Footprint of an individual port and its contribution to the port sector.

Table 3.19: Carbon Footprint indicators

Indicator	Source
Does the port measure or estimate its Carbon Footprint?	ESPO
Does the port take measures to reduce its Carbon Footprint?	ESPO
Total annual greenhouse gas (GHG) emissions (Carbon Footprint)	OR
Annual greenhouse gas (GHG) emissions from direct emissions (scope 1)	OR
Annual greenhouse gas emissions (GHG) from energy indirect emissions (scope 2)	OR
Annual greenhouse gas emissions (GHG) from other indirect emissions (scope 3)	OR
Percentage of each scope contributing to the total emissions	OR
Percentage of annual changes in greenhouse gas (GHG) emissions	OR
Kilometres driven by port vehicles	OR
Number of initiatives implemented to reduce greenhouse gas emissions	OR

Noise

According to the Self Diagnosis Method (EcoPorts Foundation, 2004), noise is defined as unwanted sound. Noise is generated mainly by mechanical and industrial activities carried out in a port.

Noise in ports tends to be generated by ship traffic, road traffic and cargo operations. The main noise sources in a ship are the propulsion machinery, the auxiliary engines, the propeller and the heating, ventilation and air condition systems (Trozzi and Vaccaro, 2000). Road traffic includes passenger cars, trucks and heavy vehicles. Cargo operations refer to noise from machinery such as quay-crane, pumps, among others (Trozzi and Vaccaro, 2000).

Noise may cause nuisances among employees, wildlife and local people, interfering with their sleep, communication and privacy. It may create stress, reduce working efficiency and, on top of that, high levels of noise may lead to hearing loss. Therefore, noise may constitute an occupational hazard, result in complaints and be considered a public offence under the law (EcoPorts Foundation, 2004). The extent to which noise from harbour activities is perceived as a nuisance depends on the sound pressure, the frequency and the distance to local communities (OECD, 2011).

Noise pollution has become an increasingly significant environmental issue for many port authorities. In the ‘ESPO/Ecoports Port Environmental Review 2009’, port managers identified noise as the current top environmental priority of the sector (see table 2). As a consequence, measures to address noise pollution should be taken by port authorities. Adopting low noise equipment, installing sound insulation fences or limiting working hours may contribute to reduce considerably the noise produced. The Noise Management in European Ports (NoMEPorts) research project (2005-2008) contributed to the definition of a common harmonized noise management approach with the development of a Good Practice Guide on Port Area Noise Mapping and Management (NoMEPorts, 2008).

Noise indicators, presented in Table 3.20, consider aspects such as the levels of noise, compliance with legislation, and the measures adopted to reduce noise levels.

Table 3.20: Noise indicators

Indicator	Source
Level of noise in terminals and industrial areas Lden (overall day-evening-night)	OR
Level of noise in terminals and industrial areas Lday (7:00 – 19:00 hrs)	OR
Level of noise in terminals and industrial areas Levening (19:00-23:00 hrs)	OR
Level of noise in terminals and industrial areas Lnight (23:00 – 7:00 hrs)	OR
Average noise exposure during an 8-hour working day	OR
Maximum level of noise in terminals and industrial areas L_{MAX}	OR
Frequency of noise measurements	OR
Existence of a noise-zoning map	OR
Frequency of verification of the noise-zoning map	OR
Compliance with limits at day, evening, and night time for noise level	OR
Number of measures implemented to reduce noise levels	OR
Annual number of noise complaints	OR
Number of local residents affected by noise from port area operations	OR

Waste management

The Self Diagnosis Method (EcoPorts Foundation, 2004) defines waste as any substance, either liquid or solid, that the holder intends to or is required to discard. Waste may originate from ships, port industries, Port Authority or construction works.

In order to prevent and minimise pollution from ships and to successfully control their discharges, ports are requested to supply sufficient reception facilities to receive residues and oily mixtures generated from ship operations according to provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL Protocol, 1973/78). The MARPOL Protocol currently includes six technical annexes that provide guidance on the products that are requested to be stored in the port and not dumped at sea: oil (annex I), noxious liquid substances in bulk (annex II), harmful substances (annex III), sewage (annex IV), and Garbage (annex V). Annex VI (prevention of air pollution from ships) set limits on sulphur oxide and nitrogen oxide emissions as well as particulate matter and prohibit deliberate emissions of ozone depleting substances.

The Port Authority and industries located in the port area can separate the waste according to what is being recycled: solid waste such as paper, plastic or glass; non-hazardous industrial waste such as scrap metal, wood, electronic waste or oil filters; and hazardous waste such as ink cartridges, fluorescents, used oil or batteries.

Discharges and spills of wastes may degrade water quality causing problems such as oil pollution, floating garbage, odour or unsanitary conditions. Disposal of dredged material on land may cause destruction of plants, loss of vegetation, and odour and unsightly view to the local community (EcoPorts Foundation, 2004). Table 3.21 introduces waste indicators.

Table 3.21: Waste management indicators

Indicator	Source
Total annual port waste collected by type	OR
Annual amount of port solid waste recycled	OR
Annual amount of port liquid waste recycled	OR
Annual amount of port non-hazardous industrial waste recycled	OR
Annual amount of port hazardous waste recycled	OR
Percentage of each above-mentioned waste type	OR
Existence of separate containers for the collection of port waste	OR
Percentage of disposal methods of port waste: landfill, incineration, recycling, and compost	OR
Hazardous waste eliminated by pollution prevention	OR

Annual amount of oil collected and recycled	OR
Percentage of waste handled per total cargo handled	OR
Number of operations with high levels of waste (>0,19% of total cargo handling)	OR
Number of port stakeholders with a Waste Management Plan	OR
Frequency of cleaning the port area	OR
Time spent on litter collection	OR
Annual amount of ship waste MARPOL Annex I (oil) collected	OR
Annual amount of ship waste MARPOL Annex II (noxious liquid substances carried in bulk) collected	OR
Annual amount of ship waste MARPOL Annex III (harmful substances) collected	OR
Annual amount of ship waste MARPOL Annex IV (sewage) collected	OR
Annual amount of ship waste MARPOL Annex V (garbage) collected	OR
Annual total amount of ship waste collected in ship waste reception facilities (Annexes of Marpol convention)	OR
Existence of ship waste reception facilities	OR
Total annual amount of ship waste collected	OR
Number of initiatives implemented to reduce, recycle or reuse waste	OR
Existence of a system to jointly collect and manage the waste from ships and port area	OR
Existence of a waste water treatment plant	OR
Existence of an oil spillage treatment plant	OR
Annual cost of waste treatment	OR

Port development

The increase in maritime transport around the world has required the development of ports with the construction of deeper channels and new docks. On land, the lack of space and the increasing number of industries located in port areas may create the need to expand the port towards the surroundings (EcoPorts Foundation, 2004). The Self Diagnosis Method considers that the port development activities carried out on land are a different aspect from the activities carried out at sea because may affect different ports. However, some port development indicators are common in both aspects, so they are compiled in a combined list in Table 3.22.

i) Land

The occupation of the terrestrial space may generate several environmental consequences, such as the destruction of natural areas, disturbances to flora and fauna and nuisances to the nearby community due to land-based traffic, noise produced by port operations or lighting used during night operations (EcoPorts Foundation, 2004).

The landscape may be transformed into an artificial scene of industrialisation, which may give an unpleasant impression of the port facilities. In order to mitigate the adverse effects of port development, appropriate location of the port expansion should be found. Moreover, the creation of a green belt zone around the port may give a more pleasant view (United Nations, 1992a).

ii) Sea

The main port development activity carried out in port waters is generally considered to be dredging. Dredging consists of removing a certain amount of sediment from the bottom of the sea in order to keep the navigation depth of a waterway (maintenance dredging), make it deeper (capital dredging), sell the material (commercial dredging) or to improve the environmental quality of a waterway (remedial dredging). In the UK, approximately 40 million tonnes of dredged material are annually disposed of to the marine environment at estuarine and offshore sites, being about 80% of the material arises from maintenance dredging (Cefas, 2011).

Dredging operation and dredging disposal constitutes one of the most important issues in coastal zone management and its environmental impacts are unavoidable, affecting either positively or negatively. According to Paipai (2009), dredging activities may impact on four main categories: i) physical environment: changes in bathymetry (underwater depth), hydrography (tidal flow, currents, velocity, and waves), sediment transportation (deposition or erosion), elimination of contaminated sediments; ii) biological environment: disturbances to benthic habitats, increase in turbidity, re-suspension of contaminants that may lead to a loss of fishery resources; iii) economy: promotion of fisheries and fishing industries, tourism, local agriculture; and iv) socio-political: increase in the quality of life (from increased local trade traffic), recreational activities, land/seascape features, environmental awareness and training.

Before dredging, surveys of sediment contamination should be undertaken and the dredging method should be carefully selected in order to minimise the dispersal of re-suspended sediments. The impact of dredging on current flow may be addressed by current flow simulations. Typical measures against beach erosion are construction of sea walls, offshore breakwaters and periodical beach nourishment (United Nations, 1992a). When it comes to the disposal of dredged material, it should be considered the 'beneficial use' options that this material may offer in providing environmental, economic or social benefits. Existing beneficial uses of dredged material may be classified in three categories: i) agricultural / product uses (e.g. aquaculture, construction materials, or topsoil); ii) engineered uses (e.g. beach nourishment, embankments creation, land improvement and shore protection); iii) environmental enhancement (e.g. fish and wildlife habitats, fisheries improvement or wetland restoration) (USACE, 2011). The ESPO Code of Practice on Birds and Habitats Directive include recommendations on dredging operations and disposal of dredged material.

Port development indicators, presented in Table 3.22, mainly concern dredging operations (seven indicators) and dredging disposal (five indicators). However, the list also includes three qualitative questions about port development planning, common to land and sea.

Table 3.22: Port development indicators

Indicator	Source
Has the Port Authority carried out an Environmental Impact Assessment (EIA) during the last 5 years?	ESPO
Is the port involved with other organisations in the development of coastal or estuary management plans?	ESPO
Has the Port Authority experienced, or does it anticipate any restrictions on development / expansion due to environmental planning controls?	ESPO
Annual quantity or volume of dredged sediment	OR
Annual amount of time and money spent on dredging activities	OR
Frequency of dredging	OR
Dredging efficiency: quantity of dredged sediment divided by fuel consumption	OR
Number of research projects undertaken to evaluate both the short and the long term effects of dredging	OR

Number of measures implemented to reduce negative ecological effects of dredging	OR
Number of turtles harmed by dredging	OR
Beneficial use of dredged material (definition and description of practices)	OR
Percentage of dredged sediment going to beneficial use	OR
Existence of facilities for the treatment and cleaning of the dredged sediments	OR
Number of researchers and projects carried out concerning dredging disposal	OR
Number of environmental licenses withdrawn or refused for dredging disposal	OR

3.4.3 Environmental Condition Indicators

Environmental Condition Indicators provide information about the condition of the environment. This information may help port environmental managers to better recognise the potential impacts of the Port Authority’s activities, products or services that may interact with the environment, and consequently, assist in the planning and implementation of environmental performance evaluation.

According to the ‘ESPO / Ecoports Port Environmental Review 2009’, 77% of the respondent ports carry out environmental monitoring in their port, being the highest positive response answer of the whole questionnaire. In fact, in the same questionnaire in 2004 this percentage was 65%, and in 1996 it was 53%. This may be considered as a marked progress. It may reasonably be argued that the port sector has established the culture of using Environmental Condition Indicators to monitor the state of the environment and to ensure sustained environmental quality across the port.

This section investigates the existing indicators regarding the condition of the environment which are categorised as air quality, water quality, soil quality, sediment quality, ecosystems and habitats, and odour indicators. Nevertheless, the results of these indicators should not be considered in isolation but should be taken into account along with the results of the management monitoring indicators, such as the frequency of monitoring, the number of monitoring locations or the number of days that the limit value has been exceeded.

Emissions to air

Air quality is defined as “a measure of the condition of air relative to the requirements of one or more biotic species or to any human need or purpose” (Johnson *et al*., 1997). In order to characterize the quality of the air at a given location, government agencies use the Air Quality Indices (AQI), which are numbers calculated from the existing concentration of pollutants. There is not a standardised protocol to calculate these indices and therefore, each country may not necessarily account for the same contaminants.

In recent years, air quality has turned out to be a main environmental priority for port authorities being rated as the second highest environmental concern for European ports in the ‘ESPO / Ecoports Port Environmental Review 2009’ (see Table 2.2). In fact, in this review air quality was considered to be the major concern for large ports (10-25 million tonnes handled) and for very large ports (> 25 million tonnes handled). The increasing importance of this issue is demonstrated when it is compared with the same exercise in 2004 where it was ranked 6^{th}. In the questionnaire from 1996, it did not appear.

Air emissions include substances, material and energy escaping to the atmosphere. These pollutants may originate from different sources located either at sea or on land. Ships are the main source of air emissions at sea, producing gasses, smoke, soot and fumes. In manoeuvring and berthing, typical pollutants generated by ships are NO_2 and SO_2, which may affect air pollution in the hinterland. On land, major sources of air pollution could be emissions of dust from bulk cargo handling, and emissions of combustion gasses from port and passenger car traffic, heavy vehicle traffic as well as cargo handling equipment.

The main consequence of the presence of these products in the atmosphere and their interaction is the creation of air pollution which may affect the local climate, building structures, the weather, the health of humans and wildlife, and the global environment mainly reflected in global warming and the depletion of the ozone layer. Dust can constitute visual, physical, chemical, or health hazards for employees or the public (EcoPorts Foundation, 2004). Accidental leakage of gases may cause problems such as toxic material emission, explosions, fumes, odours and hazardous air emissions (United Nations, 1992a). In loading and unloading petroleum products, volatile organic compounds (VOC) emissions are produced (Trozzi and Vaccaro, 2000).

Monitoring air quality is a highly recommended measure in order to avoid unacceptable levels of air pollution inside the port area. Nevertheless, due to the fact that port industries can release various kinds of gases and can be major sources of air pollution and odours, measures to prevent and minimise them should be implemented. Dust emissions could be reduced by covers, screens, enclosures, sprinkling water or other similar methods (United Nations, 1992a). Another solution may be the promotion of the consumption of fuel of improved quality, which performs better in reducing exhaust emissions. The World Ports Climate Initiative (WPCI) has developed projects which aim to improve local air quality in ports, in particular, the Environmental Ship Index and the Onshore Power Supply (WPCI, 2012). In fact, although the use of shore-side electricity would have the advantage of reducing several negative impacts simultaneously such as SO_x, NO_x, CO_2, and noise (OECD, 2011), the fact that the electricity system varies between countries in terms of voltage and frequency prevents the broader use of this methodology. Apart from these, several port authorities have introduced docking fees reduction to vessels that comply with a voluntary speed limit in the Port Authority's waters as a way to reduce ships' emissions (OECD, 2011).

In order to regulate global emissions from ships, the International Maritime Organization (IMO) expanded the MARPOL Convention Annex VI called the Prevention of Air Pollution from Ships that entered into force in May 2005 aimed at progressively reducing the global sulphur emissions from ships. Some options to comply with MARPOL Convention include switching to cleaner distillate fuel or to alternative fuels, improving the energy efficiency of ship movement or switching to advanced propulsion technologies (Moon, 2011). At a European level, as explained in Section 2.4, the Ambient Air Quality Assessment and Management Directive 96/62/EC lays down the basic principles of a strategy for establishing quality objectives for ambient air, drawing up common methods and criteria for assessing air quality and obtaining and disseminate information on air quality.

Although typical indicators of air quality are sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO) and suspended particulate matter (SPM), there are other specific air quality indicators that can be monitored in port areas. Short explanations of these indicators are listed in Table 3.23.

Table 3.23: Air quality indicators

Indicator	Description
Ammonia (NH_3)	It is widely used in a variety of manufacturing processes, but is mostly used as a fertilizer. Ammonia vapour is an irritant to the eyes and the respiratory tract.
Carbon monoxide (CO)	Formed as a result of incomplete combustion of oil products in air. It has a harmful effect on respiratory processes.
Dust	Dust levels refer to the amount of fine powder or other particles greater than 10 µm in the atmosphere. It may originate from open deposit of ore and other dry bulk cargoes, construction works and road traffic. Dust particles can affect local air and water quality.
Halogenated compounds	Compounds such as organo-chlorides and fluorides may be generated by specific industrial process. Traditionally, chlorofluorocarbons (CFCs) have been used extensively in last five or six decades as refrigerants. However, they are being phased out because it has been proved that CFCs are ozone-depleting substances (ODS) and they contribute to the formation of the ozone hole in the upper atmosphere (Khemani, 2010).
Hydrocarbon (HC)	Principal emission source are leakage from oil storage/handling facilities and volatilization from oily products and organic solvent.
Metals and their compounds	Metals such as lead, cadmium and cooper associate with particulates and are released into the air during combustion and volatilisation processes. The may be often toxic and bio-accumulatory.
Nitrogen oxides (NO_x)	Nitrous oxide (NO) and nitrogen dioxides (NO_2) are formed through direct combination of nitrogen and oxygen in air during combustion. They may cause respiratory problems and play an important role in photochemical reactions.
Photochemical oxidant (Ox)	This is a measure of any chemical which enters into oxidation reactions between nitrogen oxides and hydrocarbons in the presence of light, such as the ozone (O_3). They may affect respiratory organs and local air quality.
Sulphur oxides (SO_x)	Sulphur dioxide (SO_2) and sulphur trioxide (SO_3) are the main indicators oil combustion. Their concentrations depend on the

	sulphur content of the oil. Usually coexisting with suspended particulate matter and causing respiratory problems and acid deposition in the atmosphere.
Suspended particulate matter (SPM)	This is a measure of the amount of soot from combustion processes or dust sources. It generally concerns particulates with a diameter of 10 μm or less. Depending on the particulate type, they can create respiratory problems, smothering and smog.
Volatile Organic Compounds (VOCs)	Vapours produced by the volatilisation of low boiling point liquids, released by storage venting, spilling or traffic. The vapours are generally toxic if inhaled, damaging respiratory organs.
Other harmful air pollutants	The following substances generated with industrial activities may have adverse effects on life and the living environment: hydrogen fluoride (HF), hydrogen cyanide (HCN), formaldehyde (HCHO), methanol (CH_3OH), hydrogen sulphide (H_2S), hydrogen phosphide (PH_3), hydrogen chloride (HCl), nitrogen dioxide (NO_2), acrolein (CH_2CHCHO), sulphur dioxide (SO_2), chlorine (Cl_2), carbon disulphide (CS_2), benzene (C_6H_6), pyridine (C_5H_5N), phenol (C_6H_5OH), sulphuric acid (H_2SO_4) including sulphur trioxide (SO_3), silicon fluoride (SiF_4), phosgene ($COCl_2$), selenium dioxide (SeO_2), Chlorosulphonic acid (HSO_3Cl), yellow phosphorus (P_4), phosphorus trichloride (PCl_3), Bromine (Br_2), nickel carbonyl ($Ni(CO)_4$), phosphorus pentachloride (PCl_5) and mercaptan (C_nH_mSH).

Source: Adapted from United Nations (1992a) and Ontario (2011)

Water quality indicators

The term water quality is used to describe the condition of the water, including its chemical, physical and biological characteristics (Diersing, 2009). As in the case of air emissions, the sources of water discharges may be located at sea or on land. Possible sources of water pollution from ships are accidental spills or deliberate discharges of bilge water (oils and hydrocarbons discharged into the water), ballast water (invasive aquatic species that may displace native species and disrupt the balance of the marine ecosystem), sewage, chemical substances, lubricants, fuels, oily wastes and garbage (Trozzi and Vaccaro, 2000). On land, runoff from raw material storage, spills from bulk cargo handling, and wind-blown dust are possible sources of port water contamination. Construction works such as dredging, sand compaction, pile driving and deposition of rubble may cause a re-suspension of sediments and turbid water (United Nations, 1992a).

The major consequence of this kind of pollution is the creation of potential harmful effects on the health of humans and wildlife, the environment, fisheries and recreational pursuits (EcoPorts Foundation, 2004). Re-suspension of sediments in water leads to an increase in the level of suspended solids (SS) and in the concentration of organic matter, possibly to toxic or harmful levels. It also reduces sunlight penetration (United Nations, 1992a).

Monitoring water quality in port areas is essential to ensure that the water does not pose a health risk for humans and it is not a threat to marine ecosystem. Good water quality means that the area has a low level of contaminants which may be harmful to human health and has a good physical and chemical balance to sustain a healthy ecosystem. Nevertheless, some measures to address the discharges to water should be implemented. Ports should provide reception facilities for proper control of liquid ship waste. Although accidental spills are unavoidable, some actions could be prepared in view to minimise the spill dispersal, such as owning recovery vessels, having oil fences, and using treatment chemicals (OECD, 2011). Proper contingency plans and a prompt reporting system are keys to prevent oil dispersal. Periodical clean-up of floating wastes is also necessary for preservation of port water quality. Measures against runoff are mainly focussed on reducing the influence of wind and rain, such as covering raw material storage areas, sprinkling water on raw material except anti-humid materials like grains or cement, and providing special equipment for cargo handling and transport.

In addition, to prevent the spread of harmful aquatic organisms in ballast water, Trozzi and Vaccaro (2000) suggest “exchanging the ballast water in Deep Ocean where there is less marine life and where organisms are less likely to survive”. Other options proposed by them include “various treatments of the ballast water, such as filtration, thermo, chemical or radiation, to kill the living organisms”. In 2004, the International Maritime Organisation adopted the International Convention for the Control and Management of Ships’ Ballast Water in order to prevent, reduce and eliminate the transfer of harmful aquatic organisms from ship’s ballast water. However, this convention is not yet in force because it has not been ratified by at least 30 States, which represent 35% of world merchant shipping tonnage (International Maritime Organisation, 2011).

Water quality is usually referenced to a set of standards against which compliance can be assessed. The required quality of water depends on what the use to which the water is to be put. The Water Framework Directive 2000/60/EC concerns water resources management for Member States and it covers all types and uses of water, including surface water, groundwater, transitional and coastal waters. In England and Wales water quality is regulated under the ‘Water Supply (Water Quality) Regulations 2000’. In some ports and harbours, the water quality is measured by the Port Authority itself whereas in other authorities it is carried out by an outside consultant or agency in order to show transparency.

Table 3.24 presents a list of typical environmental indicators of water quality at sea along with a short description of their characteristics. Major indicators of water quality are Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), the degree of acid / alkaline (pH), coliform bacteria and oil content.

Table 3.24: Water quality indicators

Water quality indicator	Description
Algal Growth Potential (AGP)	An indicator of eutrophication obtained with a bioassay test which investigates the primary productivity of phytoplankton using water sampled from the study area.
Anthropogenic debris	Includes a host of man-made solids ranging from plastic bottles to polystyrene foam and fish netting. Much of the material is non-biodegradable and persistent in the environment. It is aesthetically unpleasant and can warm wildlife.
Biochemical Oxygen Demand (BOD)	The rate of oxygen consumption by organisms during the decomposition (respiration) of organic matter, expressed as grams oxygen per cubic metre of water. BOD during five days under 20°C is called BOD_5. It is a principal indicator of eutrophication.
Chemical Oxygen Demand (COD)	This is the amount of oxygen required to oxidise the organic and inorganic compounds in water. It is an indicator of potential low oxygen levels and eutrophication.

Halogen content	A measure of the fluorine (F), chlorine (Cl), bromine (Br), iodine (I), or astatine (At), by mass, of sea water, expressed as milligrams per litre.
Chlorophyll-a	A type of chlorophyll present in all type of algae, providing indication of the total algal biomass. Essential for the conversion of sunlight, carbon dioxide, and water to sugar and oxygen. Sugar is then converted to starch, proteins, fats and other organic molecules.
Complex organics	Complex organic pollutants such as furans, dioxins, PCBs and chlorinated pesticides require laboratory analysis. Many are non-biodegradable, persistent and can bioaccumulate in ecosystems.
Conductivity	This measures the concentration of soluble salts in water. From this, sea water salinity is derived. It indicates different water masses, which will have different environmental properties.
Dissolved Oxygen (DO)	The concentration of oxygen dissolved in water. An indicator of critical importance to survival of aquatic organisms. It decreases with organic matter decomposition and increases with photosynthesis.
Ecological studies (e.g. fauna and flora sampling, species diversity studies, benthic observation).	A measure of the biological or ecological changes in the environment as a result of habitat loss, contamination, or alteration. They are explained in further detail in the Section *Ecosystems and habitats indicators* of this chapter.
Heavy Metals	A measure of the concentration of the various metal ions in a sample, such as copper, lead, cadmium or chromium. Metal ions become bio-available to organisms, which may accumulate them and lead to the food chain. They are explained in further detail in Table 3.27.
Inorganic ions (nutrients)	A measure of the concentrations of various inorganic ions such as cyanides, phosphates or nitrates. They may be toxic (cyanides) or nutrients salts for growth of aquatic plants (nitrates and phosphates). The latter play an important role to increase the biomass of plankton and can lead to eutrophication.
Microbiology (Coliform Bacteria)	The number of Coliform bacteria such as *Escherichia coli* in water, expressed as most probable number in 100 ml (MPN/100ml). This indicates the possibly of faecal contamination by sewage. Although *E. coli* itself may not cause illness, other bacteria and viruses present will. They are a risk to human health and to other wildlife.
Oil content (Hydrocarbons)	A measure of the amount of oil in the water column or a sediment sample, normally expressed as milligrams of normal-hexane extracts per litre. Usually caused by a damaged oil tanker,

	oil spill from ships (bilge water, oily ballast water, etc.) and other facilities on land. Oil can have toxic effects as well as endangering wildlife by adhesion.
pH	A measure of the acidity or alkalinity of a sample by measuring the amount of hydrogen ions present. It ranges from very acid (pH 1) to very alkaline (pH14). pH 7 is neutral and most waters range between 6 and 9. It varies with photosynthetic activity and generation of organic acid and hydrogen sulphide, as well as man-made impacts.
Redox Potential	This is a measure of the oxidation / reduction state of a water sample. It is closely linked to the concentration of certain ions. It influences the solubility of certain metals.
Water salinity	Measures the saltiness or dissolved salt content of a body of water. It is a general term used to describe the levels of different salts such as sodium chloride, magnesium and calcium sulphates, and bicarbonates.
Specific simple organics	A measure of the concentrations of specific organic pollutants such as phenols and formaldehydes. Such pollutants have varying effects on different organisms but in certain cases are very toxic.
Surfactants	A measure of the amount of froth or foam on the surface of the water. It can be cause by detergents from effluent discharges or naturally by algae. These may be toxic or have a fertilising effect, leading to eutrophication.
Total Organic Carbon (TOC)	The amount of carbon contained in organic matter (dissolved organic matter, organic debris and plankton) in water. It is an indicator of organic pollution such as sewage or fishery waste.
Total Oxygen Demand (TOD)	An indicator of the total oxygen consumption in water, which can detect the oxygen consumption by nitrogen compounds that are ignored in measurements of BOD or COD.
Total Dissolved Solids (TDS)	A measure of the amount of particles and salts which have dissolved in a sample of water. There is a direct relationship with conductivity because they both measure dissolved organic compounds.
Total Suspended Solid (TSS)	A measure of the amount of particles and salts which have not dissolved in the water. They reduce light penetration in the water column and can cause clogging of respiratory and feeding organs.
Water transparency / Turbidity	Turbidity is a measure of the cloudiness of a liquid caused by fine suspended particles, bubbles, silt and organic matter such as microbes. It affects light transmission and consequently

	photosynthetic activity. It is a measure of cloudy effluents.
Water Colour	A basic measurement of the abnormal change in the colour of water. Related to natural and anthropogenic releases. Can be indicative of industrial effluent discharges.
Water Temperature	A basic indicator influencing the activity of enzyme and consequently the metabolic rate of organisms and also influencing the properties of other parameters such as chemical solubility.

Sources: adapted from United Nations (1992a) and Regional Aquatics Monitoring Programme (2005)

Emissions to soil

This Significant Environmental Aspect considers the emissions to the soil, ground or land that are released by port industrial activities. These emissions include liquid contaminants, solid bulk, residues or wastes (EcoPorts Foundation, 2004).

There are three main sources of soil pollution in the port area. The first is accidental discharges of oil in operations on terminals and fuel deposits. The second sources are spills of dust spread during the handling (transportation between quay and storage area). Finally, leaks from on-land vehicle and equipment fuelling may introduce petroleum hydrocarbons into the soil (Paipai, 1999).

The main consequence of emissions to the soil is the contamination of the surrounding land and groundwater. Land contamination may reduce land value, prevent future development and be an environmental or health hazard (EcoPorts Foundation, 2004). Groundwater contamination may affect plants and organisms living there and usually it not only affects individual species, but also the natural biological communities. In order to minimise the pollution from port operations, Trozzi and Vaccaro (2000) proposed producing a guideline containing recommendations on handling and storage methods according to each type of bulk product.

Table 3.25 presents a list of selected indicators that are often used in assessing soil quality. There are three main categories of soil indicators: i) chemical indicators that provide information about plant health; the nutritional requirements of plant and soil animal communities; and levels of soil contaminants (Soil quality, 2011). Examples of chemical indicators include electrical conductivity, soil pH, macronutrients, or organic contaminants; ii) physical indicators that provide information on soil hydrologic characteristics, such as water entry and retention (Soil quality, 2011). Examples include water content, soil porosity or bulk density; and iii) biological indicators that provide information on organic matter component in soil, such as Soil Organic Matter, Particulate Organic Matter, or Total Organic Carbon.

Table 3.25: Soil quality indicators

Indicator	Description
Electrical conductivity	Electrical conductivity is the most common measure of soil salinity and is indicative of the ability to carry an electric current. Salinity is a soil property referring to the amount of soluble salt in the soil. It is generally a problem of arid and semiarid regions
Soil pH	Soil pH refers to the degree of soil acidity or alkalinity by measuring the amount of hydrogen ions present in the soil solution. It ranges from very acid (pH 1) to very alkaline (pH14). Soil pH affects the soil's physical, chemical, and biological properties and processes, as well as plant growth. The nutrition, growth, and yields of most crops decrease where pH is low and increase as pH rises to an optimum level (between 6 and 7.5)
Organic contaminants	Concentrations of different organic chemicals in soil are found by using gas chromatography (GC)
Macronutrients	Macronutrients are essential elements used by plants in relatively large amounts for plant growth. The major macronutrients are nitrogen (N), phosphorous (P), and potassium (K). Calcium (Ca), magnesium (Mg), and sulfur (S) are also macronutrients. All six nutrients are important constituents in soil that promote plant growth.
Water content	Water content is defined as the ratio of the weight of water to the weight of solids in a given volume of soil. It gives information on the wetness of a soil and it is necessary for successful plant growth, as it provides the medium to transport soluble nutrients to the plant roots. If water content of a soil is too low, the plants may not receive adequate nutrients or water, possibly compromising their survival.
Soil porosity	Soil porosity refers to that part of a soil volume that is not occupied by soil particles or organic matter. Pore spaces are filled with air, other gases, or water. Large pores allow the ready movement of air and the drainage of water. They are also large enough to accommodate plant roots and the wide range of tiny animals that inhabit the soil. Large pore spaces permit fast infiltration and

	percolation of water through a soil.
Bulk Density	Bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. Bulk density is typically expressed in g/cm^3.
Soil Organic Matter	Soil organic matter (SOM) is the organic matter component of soil. It can be divided into three general pools: living biomass of microorganisms, fresh and partially decomposed residues, and humus: the well-decomposed organic matter and highly stable organic material.
Particulate organic matter	Particulate organic matter (POM) fraction comprises all Soil Organic Matter (SOM) particles less than 2 mm and greater than 0.053 mm in size. It is a source of food/energy for microorganisms and soil animals as well as nutrients for plant growth.
Total organic carbon	Total organic carbon (TOC) is the carbon (C) stored in soil organic matter (SOM). Organic carbon (OC) enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms, and soil biota. SOC is one of the most important constituents of the soil due to its capacity to affect plant growth as both a source of energy and a trigger for nutrient availability through mineralization

Source: Ecosystem restoration (2004) and Soil Quality (2011)

Sediment quality indicators

Sediments are fragmented materials that originate from erosion of rocks and are transported by, suspended in, or deposited by water (United States Environmental Protection Agency, 2011a). Sediment emissions include any kind of liquid discharge such as fuel, or solid product such as waste, that reaches the bottom of the sea (EcoPorts Foundation, 2004). Some of these pollutants were released into the environment a long time ago, such as the pesticide DDT and the industrial chemicals known as polychlorinated biphenyls (PCBs), which persist long time in the environment. Alternatively, other contaminants enter into waters every day; some come from industrial and municipal waste discharges while others come from polluted runoff in urban and agricultural areas (United States Environmental Protection Agency, 2011b).

Sediment pollution may pose a serious threat to marine ecosystems. The benthic environment, which includes worms, crustaceans, and insect larvae that inhabit the bottom of a water body, may be affected by sediment pollution to the point that it can kill them, reducing the food available to larger animals such as fish. When larger animals feed on contaminated benthic organisms; the toxins are transmitted to their bodies. As a result, fish and shellfish, as well as benthic organisms, may be affected by contaminated sediments. Some species may develop health problems and some may die, reducing the biodiversity of the area. Contaminated sediments do not necessarily remain at the bottom of a water body. When the water is agitated due to, for example, storm waves or a ship's propeller, sediment may be re-suspended exposing the toxic contaminants to all the animals of the water column. The risk comes to human health when humans eat fish with bio-accumulated toxins. Possible long-term effects of eating contaminated fish include cancer and neurological defects (United States Environmental Protection Agency, 2011b).

The main measure to prevent bottom contamination is, first of all, avoiding discharges with contaminants to water. A common way to remove contaminated sediments is undertaking dredging activities, usually carried out in a port to maintain its navigation channels. However, these activities may impact significantly on the environment as explained before in port development activities. A proper disposal of dredged material is critical in preserving the environment and monitoring surveys should be carried out in dredged sediments in order to guarantee that they do not pose any risk to the environment.

Table 3.26: Sediment quality indicators

Indicator	Description
Cyanogen compounds (CN)	They include highly toxic substances which may cause the death of aquatic animals.
Nutrients	It includes phosphorous and nitrogen compounds such as ammonia. Elevated levels of phosphorous can promote the unwanted growth of algae. This can lead to the amount of oxygen in the water being lowered when the algae die and decay. High concentrations of ammonia can be toxic to benthic organisms.
Halogenated Hydrocarbons or **Persistent Organics**	A group of chemicals which are very resistant to decay. DDT and PCBs are in this category. PCBs are toxic and stable compounds. They were extensively used in electrical fittings and paints and although they are no longer manufactured, they are extremely persistent. They may be

	eaten by aquatic animals and enter to the food chain.
Polycyclic Aromatic Hydrocarbons (PAHs)	Polycyclic aromatic hydrocarbons (PAHs) are compounds associated with petroleum products deposits such as bitumen and with combustion and decay of organic compounds. They are of concern due to their toxicity to aquatic organisms and humans. Concentrations of hydrocarbons in sediment can be measured on the basis of size (e.g., number of carbon atoms) or by compound type. Certain PAH compounds are indicative of specific sources; for example, dibenzothiophene molecules are associated with bitumen, while retene is generated through the decomposition of plant materials.
Heavy Metals	Such as iron, manganese, lead and cadmium. Metals vary in their ability to absorb to mineral particles and organic matter within the sediments. They are explained in further detail in Table 3.27.
Particle size	Examining the physical characteristics of sediments can provide information about the potential for sediment to adsorb chemicals of interest. According to the International Society of Soil Science, sediment samples are categorised according to its particle size range (mm) into clay (<0.002), silt (0.002-0.06), and sand (0.06 – 2) (Paripovic, 2011)
Amount of organic matter	Measured by COD, BOD or TOC. They are explained in Table 3.24

Source: adapted from United Nations (1992a), Regional Aquatics Monitoring Programme (2005) and United States Environmental Protection Agency (2011c)

Heavy metal contaminants may be found either in water or sediment samples. The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations (Lenntech, 2011). According to Duffus (2001), the oldest scientific use of the term found in the English literature, is in Bjerrum's Inorganic Chemistry (1936), which classifies heavy metals as those metals with elemental densities above 7 g/cm^3. Although some heavy metals are essential to maintain the metabolism of the human body, at higher concentrations they can lead to poisoning (Lenntech, 2011). Heavy metal poisoning could result, for instance, from drinking water contamination (e.g. lead pipes), high ambient air concentrations near emission sources or intake via the food chain.

As it is mentioned in Table 3.24, heavy metals are dangerous because they tend to bio-accumulate, increasing the concentration of a chemical in a biological organism over time. There are 23 heavy metals known and the main ones are presented in Table 3.27 along with a description of them.

Table 3.27: Heavy metal indicators

Indicator	Description
Alkylmercury (R-Hg)	Organic compound of alkyl and mercury. Virulently toxic. Used principally in manufacturing pesticides.
Arsenic (As)	Used mainly in manufacturing insecticides, rodenticide and medicines. Exposure to inorganic arsenic can cause various health effects, such as irritation of the stomach and intestines, decreased production of red and white blood cells, skin changes and lung irritation.
Antimony (Sb)	A metal used in the compound antimony trioxide, a flame retardant. It can also be found in batteries, pigments, ceramics and glass. Exposure to high levels of antimony may cause nausea, vomiting and diarrhea.
Cadmium (Cd)	A metallic element, often used in the plating of iron, steel and other metals. It is also used in industries of ceramics, cosmetics mines and refineries of zinc and lead. Cadmium is bio-persistent and, once absorbed by an organism, remains resident for many years. In humans, long-term exposure is associated with renal dysfunction. High exposure can lead to obstructive lung disease and has been linked to lung cancer. Cadmium may also produce bone defects (osteomalacia, osteoporosis) in humans and animals.
Chromium (VI) (Cr^{6+})	Chromium is used in metal alloys and pigments for paints, cement, paper, rubber, and other materials. Low-level exposure can irritate the skin and cause ulceration. Long-term exposure can cause kidney and liver damage, and damage too circulatory and nerve tissue. Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium.
Copper (Cu)	A metallic element used mainly in making alloys and in electric wiring. Copper is an essential substance to human life, but in high doses it can cause anemia, liver and kidney damage, and stomach and intestinal irritation. Copper normally occurs in drinking water from copper pipes, as well as from additives designed to control algal growth.
Iron (Fe)	A metallic element, essential to biological life and an essential part of human diet.
Lead (Pb)	Used principally in alloys in pipes, cable sheaths, batteries type metal and shields against radioactivity. In humans exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or

	chronic damage to the nervous system.
Manganese (Mn)	A metallic element, essential to biological life, used mainly in making steel.
Nickel (Ni)	Small amounts of nickel are needed by the human body to produce red blood cells, however, in excessive amounts can become toxic, causing decreased body weight, heart and liver damage and skin irritation.
Selenium (Se)	Selenium is needed by humans and other animals in small amounts, but in larger amounts can cause damage to the nervous system, fatigue, and irritability. Selenium accumulates in living tissue, causing high selenium content in fish and other organisms, and causing greater health problems in human over a lifetime of overexposure.
Thallium (Tl)	Thallium and its compounds are toxic and should be handled carefully. Due to accumulation of thallium in the bodies of humans, chronic effects consist, such as tiredness, headaches, and depressions, lack of appetite, leg pains, hair loss and disturbances of the sight. It is not applied widely by humans, merely as rat poison and as a substance in electro-technical and chemical industries.
Total mercury (T - Hg)	Mercury is a toxic substance which has no known function in human biochemistry or physiology and does not occur naturally in living organisms. It includes R-Hg and inorganic mercury. Inorganic mercury poisoning is associated with tremors, gingivitis and/or minor psychological changes, together with spontaneous abortion and congenital malformation. The usage of mercury is widespread in industrial processes and in various products (e.g. batteries, lamps and thermometers). It is also widely used in dentistry as an amalgam for fillings and by the pharmaceutical industry. Concern over mercury in the environment arises from the extremely toxic forms in which mercury can occur.
Zinc (Zn)	A metallic trace element, principally used for galvanizing iron and in the preparation of certain alloys. Zinc is a trace element that is essential for human health. When people absorb too little zinc they can experience a loss of appetite, decreased sense of taste and smell, slow wound healing and skin sores. Although humans can handle proportionally large concentrations of zinc, too much zinc can still cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anaemia. Very high levels of zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis.

Sources: adapted from United Nations (1992a) and Lenntech (2011)

Ecosystems and habitats

According to ISO 14031 guidelines (1999), ecosystems and habitat indicators are categorised as Environmental Condition Indicators. Before analysing in detail the specific indicators of ecosystems and habitats, it is convenient to look at the definition of these terms. An ecosystem is a "biological environment consisting of all the organisms living in a particular area, as well as all the nonliving components of the environment with which the organisms interact, such as air, soil, water and sunlight" (Campbell, 2009); whereas a habitat is "an area that is inhabited by a particular species of animal, plant or other type of organism" (Abercrombie *et al.*, 1966).

With these definitions in mind, the following paragraphs present the sources of the impacts, the analysis of their possible consequences on the environment, some measures against adverse effects and finally the proposed indicators. Flora and fauna indicators may show changes in aspects of biodiversity such as the population size of significant species or the area of land managed for wildlife. The effects that are caused on the environment may not be the same for terrestrial and marine ecosystems, and this is the reason why they are studied separately. However, they share common biodiversity indicators so that they are listed together.

i) Terrestrial ecosystems

The coastal ecosystem provides an extraordinary biodiversity of plants and animals. For this reason, the surrounding terrestrial areas of some ports have become conservation or protected areas, including flora and fauna such as mangroves, wetlands, woodlands, wildlife corridors and Natura 2000 sites (EcoPorts Foundation, 2004).

Port activities may disturb the habitat of these species and their natural behaviour. Dust dispersion on land may cover plants and change terrestrial habitat, being exacerbated if toxic or harmful substances are included in the emissions (United Nations, 1992a). Litter can also be hazardous to wildlife.

The governments of the European Communities adopted the Habitats Directive in 1992, which complemented the Birds Directive adopted in 1979, aiming to protect the most seriously threatened habitats and species across Europe. In order to provide port authorities with recommendations and guidance on this directive, the European Sea Ports Organisation (ESPO) presented the ESPO Code of Practice on the Birds and Habitats Directive in 2007.

ii) Marine ecosystems

Marine ecosystems are also considered important for their diversity of flora and fauna. Marine ecology includes aquatic fauna and flora composed of a large number of species of bacteria, phytoplankton, zooplankton, benthonic organisms, coral, seaweed, shellfish, fish and other aquatic biota (United Nations, 1992a).

Some port activities, such as dredging, shipping or bunkering, are regarded as having a potential influence on marine ecosystems. Leakage of oils and oily wastes from ships and cargo handling may directly cause damage to fishery resources, aquatic biota and coastal habitat. Biodegradation of oil generates polymerized oil particles and toxic aromatic fractions, which indirectly cause damage to bottom biota and habitats (United Nations, 1992a).

As a result of these impacts, marine ecosystems may be damaged, ranging from disturbances to organisms living there to their death. Deterioration of water quality usually gives rise to changes in aquatic biota: a decrease in the variety of different species and an increase in the quantity of one or two specific species. Further deterioration may lead to the destruction of all kinds of aquatic biota (United Nations, 1992a). Wastes may cause terrestrial and marine habitats to become entangled in plastics, nets and packing material. Furthermore, certain marine species mistake plastic bags for food and ingest them (Paipai, 1999).

Careful surveys of the specific marine and coastal ecology of an area is essential for appropriate planning of construction works, dredging, and disposal of dredged material (United Nations, 1992a). As it has been mentioned in the previous aspect, the EC Habitats Directive has also established some regulations for the conservation of important species and marine sites.

Twenty ecosystems and habitats indicators are presented in this document (Table 3.28), grouped under four main areas: three indicators concern designated protected areas and habitats; 13 indicators deal with the status and trends of species, including marine and terrestrial flora and fauna; three indicators care about the threats to biodiversity; and one indicator focuses on public awareness and participation.

Table 3.28: Ecosystems and habitats indicators

Is the port located in, or does it contain a designated protected area?
Area of land and water owned, leased, or managed within designated protected areas
Number of habitats protected or restored
Percentage of algae coverage at particular sites
Percentage of change in the size of algae blooms at particular sites
Other aquatic flora monitoring: quantity and variety of aquatic flora species
Plant diversity: number of plant species per survey plot in arable land, woodland and grassland, and boundary habitats
Area of mangroves (various kinds of trees that grow in saline coastal sediment habitats)
Benthic fauna monitoring: quantity and variety of benthic fauna found in sediments samples within the seabed
Trawling monitoring: quantity and variety of fish, crustaceans and other species which live on the seabed and within the water column
Marine ecosystem integrity: percentage of large fish (equal to or larger than 40 cm)
Annual number of fish deaths in a specific watercourse
Birds monitoring: quantity and variety of farmland birds, woodland birds, water and wetland birds, and seabirds
Butterflies monitoring: quantity and variety of generalists (wider countryside) and specialists species of butterflies
Population of a specific animal species within a defined area
Number of International Union for the Conservation of Nature and Natural Resources (IUCN) Red List species and national conservation list species with habitats in port areas
Change of species diversity at particular sites
Area of sensitive habitats exceeding critical loads for acidification and eutrophication
Number of widely established (more than 50 per cent) invasive species in freshwater, marine and terrestrial environments
Amount of time that people spend volunteering in biodiversity conservation

Odour

Odour may be defined as any kind of release of substances which produce an unpleasant smell. Although some researchers may consider odours as a type of air emission, the Self Diagnosis Method (EcoPorts Foundation, 2004) considers odours as a separate category due to the peculiarity of this problem in the ports.

Some port activities, particularly cargo handling, cargo storage, and waste management may be sources of unpleasant odours. The situation may be aggravated if the port area includes industries such as fisheries or chemical plants. The Section 'emissions to air' provides more information about the sources of the impacts, consequences and measures against adverse effects.

Table 3.29 lists typical substances that generate offensive odour, along with their molecular formula, a short description of their characteristics and their likely sources.

Table 3.29: Odour indicators

Substance	Molecular Formula	Odour characteristics	Likely sources
Acetaldehyde	CH_3CHO	Irritating odour like ether	Acetaldehyde, acetic acid, tobacco and fertilizer manufacturing. Meat and fish processing.
Ammonia	NH_3	Irritation odour	Fertilizer manufacturing. Meat and fish processing. Livestock.
Hydrogen sulphide	H_2S	Putrid smell of eggs	Starch and medicine manufacturing. Oil refinery. Refuse disposal plants. Sewage treatment plants.
Methyl disulphide	$(CH_3)_2S_2$	Putrid smell of cabbages	Medicine manufacturing. Oil refinery. Refuse disposal plants. Sewage treatment plants.
Methyl mercaptan	CH_3SH	Putrid smell of onions	Starch and medicine manufacturing. Oil refinery. Refuse disposal plants. Sewage treatment plants.
Methyl sulphide	$(CH_3)_2S$	Putrid smell of cabbages	Starch and medicine manufacturing. Oil refinery. Refuse disposal plants. Sewage treatment plants.
Styrene	$C_5H_5CH_2CH$	Offensive odour of solvents	Styrene, polystyrene, fibre-reinforced plastic and plywood manufacturing.
Trimethylamine	$(CH_3)_3N$	Putrid smell of fish	Fertilizer manufacturing. Meat and fish processing. Livestock. Canning factories of fish.

Source: adapted from United Nations (1992a)

3.4.4 Other Port Performance Indicators (PPIS) that may interact with EPIs

It may reasonably be suggested that there are inherent interrelationships between Environmental Performance Indicators and other categories of Port Performance Indicators where the same performance indicator may well apply to considerations of cost, efficiency, sustainability and even governance. Specific indicators for any one issue, such as energy, may well apply to several other facets of the overall management task. For example, the annual amount of energy consumed may be a reflection of cost efficiency, operational procedures, environmental impact and policy of governance.

Within the PPRISM Project, port indicators are categorised into the following five categories: market trends and structure, socio-economic impact, environmental performance, logistic chain & operational performance and governance, each category being investigated by a different University (research partner). Each partner proposed a set of relevant indicators to be implemented at EU level being assessed and accepted by port stakeholders.

The interrelations between EPIs and the indicators proposed by other categories of Port Performance Indicators have been studied. The outcomes of this study prove that the indicators that have strongest interrelations with the environment are from the category 'Market Trends and Structure' with the selection of seven indicators. The study also considers one indicator from the proposed in the category 'Socio-economic Impact' and four from the category of 'Governance'. Any indicator from 'Logistic Chain & Operational Performance' has been selected. Table 3.30 reveals the name of the selected indicators along with a description of them.

Table 3.30: Other Port Performance Indicators that interact with EPIs

Maritime Traffic: the sum of different types of seaborne cargo handled at the sea interface area of the port over a stated period of time.
Vessel Traffic: the sum of the number of incoming/outgoing cargo vessels over a stated period of time
Call Size: the ratio between the cargo Maritime Traffic of a port and the vessel capacity calling at the port by cargo type over a stated period of time
Average Vessel Size: the ratio between the total capacity of the vessels that call at the port and the number of those vessels over a stated period of time
Degree of Containerization: the ratio between the containerized cargo and the general or unitised maritime traffic
Modal Split: the ration of the total volumes of cargo handled per mode by the sum of cargo handled by the port over a stated period of time
TEU throughput per Hectare: the total TEU handled at the port per gross hectare of container terminal surface over stated period of time
Training per FTE (Full time equivalent): acquisition of knowledge, skills, and competencies for each port worker as a result of the teaching of vocational or practical skills and knowledge that relate to specific useful competencies.
Reporting Corporate Social Responsibility: it measures the extent that port authorities undertake and reports activities in a way that enhances Corporate Responsibility
Levels of Safety: it expresses the safety and security conditions found in a port
Extent of Performance Management: it measures the extent that port authorities use comprehensive performance measurement systems in order to measure their own overall performance.
Extent of Performance Measurement: it measures the extent that port authorities measure their performance in 6 distinctive fields.

Indicators on market trends and structure contribute to a better understanding of the dynamics and trends in the port industry because they are based on the total cargo throughput and its types, the number of passengers and the number of vessels coming and leaving the port over a stated period of time. These indicators have a direct effect on the state of the environment: the more movement of vessels and cargo handling, the more air emissions, and possibly more waste production and resources consumption.

Socio-economic impact indicators are important indicators to convince stakeholders of the necessity of port development and operations in their region or country. The indicator selected from socio-economic impact category is ‘training per full time equivalent'. This indicator may be related to environmental indicators if the training programme includes environmental issues. Environmental training is crucial to encourage employees to develop awareness and best practice and it is one of the components selected in Environmental Management Indicators.

Governance category includes four indicators with interrelations with the environment. The first one is 'reporting Corporate Social Responsibility' and it has been selected because Corporate Responsibility encourages a positive impact through its activities on the environment, customers, employees, and communities following ethical standards. Environmental reporting is another component of environmental management. The second selected governance indicator is 'levels of safety' because EPIs should be considered within the emerging integration of Safety, Health and Environmental issues at operational and planning levels (the SHE approach). In fact, 'Emergency planning and response' indicators are already considered within Environmental Management Indicators in this thesis. Finally, there are two more indicators 'the extent of performance management' and 'the extent of performance measurement' that indicate the extent to which port authorities measure their own overall performance in different fields, being one of them the environment.

3.5 Conclusions

Research on port environmental reports, best practices, and information from ESPO environmental reviews contributed to the identification of more than 300 indicators that are already in use in some ports and that have the potential for use in other ports. All the proposed indicators are real (existing) so that it proves that indicators are already in place and take part in the daily environmental management. The broad variety of indicators, classified into 25 sub-categories, also demonstrates the diversity of the sector in terms of needs, activities, responsibilities and priorities.

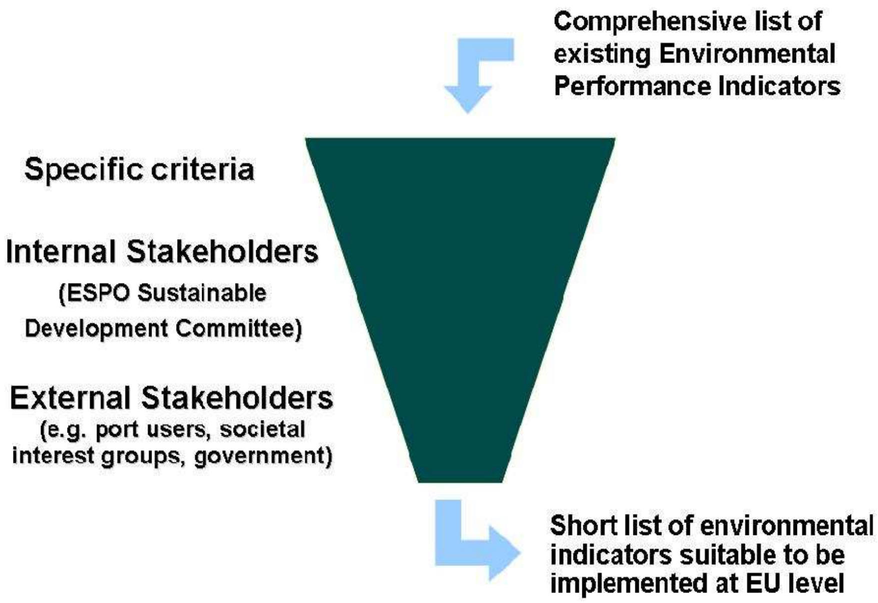
This extensive list of indicators may be helpful to provide port environmental managers with a broader understanding of the indicators that can be applied for monitoring, evaluating and improving the environmental performance of their organisation. However, this set of indicators is not a closed-list and it should be updated in accordance with new legislation and with changes in the port environmental management, such as new personnel or new technological improvements. The proposed set is in close connection with port's environmental targets; if targets change, it is necessary to re-define the selected EPIs according to these new targets.

This inventory of indicators can be considered as a valuable first step towards the development of a final set of EPIs that could be applied to evaluate the environmental performance of the European ports, investigated in chapter four of this thesis.

4 Selection and description of potential EPIs

In this chapter, the indicators identified in chapter three have been evaluated, screened and filtered. This involves 'theoretical' assessments against specified criteria and 'practical' assessments from internal and external port stakeholders with the aim of obtaining a final set of effective environmental indicators that comply with the selection criteria and that satisfy the stakeholders' requirements and expectations. Figure 4.1 shows schematically the multi-stage evaluation process followed starting from the comprehensive list of existing EPIs and resulting in the short list of indicators proposed for implementation at EU level. These selected indicators are described and justified at the end of this chapter.

Figure 4.1: Environmental indicators assessment methodology



4.1 Criteria for selecting indicators

It is necessary to define general criteria for the selection of indicators. Due to the fact that data from indicators should inform managers, policy-makers and society about the current conditions of the environment; management programmes should be scientifically supportable, relevant, accurate and useful (Verfaillie and Bidwell, 2000), and the criteria selected should guarantee these qualities. The data from indicators also should assess the efficacy of the appropriate policies.

A wide range of researchers, organisations, agencies and public bodies have carried out several studies for the purpose of identifying appropriate criteria by which to select the most appropriate indicators. In this thesis, four main references which had reported their criteria for the selection of indicators, were used as a baseline, and were combined to obtain a final set of criteria presented in Table 4.1. These four sources are: i) EPCEM Research Project (2005); ii) Environmental indicators (Jakobsen, 2008); iii) DANTES Project (2003); and iv) criteria presented by Diego Teurelincx, Secretary General of the Federation of European Private Ports Operators (FEPORT), at the ESPO Conference 2011 in Limassol.

Table 4.1: Criteria for selecting best indicators

Criteria	Characteristics
Policy relevant	Indicators monitor the key outcomes of environmental legislation and measure progress towards policy goals. They provide information to an appropriate level for policy decision-making.
Informative	Indicators supply information about a system's status and trends over time. Furthermore, they have an early warning role in order to indicate risk before serious harm has occurred. They are based on international standards and are normalized when it is possible. Indicators must be reliable so that the information provided can be trusted.
Measurable	Indicators should be based on readily available data or made available at a reasonable cost / benefit ratio. They may be updated at regular intervals in accordance with reliable procedures and they should be sensitive to environmental changes. Data collection should not be misleading.
Representative	Indicators provide a clear picture of environmental conditions and pressures on the environment. They are accessible and publicly available. The collection of information should serve a purpose, which can be clearly and un-mistakenly identified.
Practical	Indicators should require a limited number of parameters to be established. They should be simple to monitor and easy to interpret, even by people who are not experts.

Issues of reliability and confidence attached to the selection and use of indicators were discussed with representatives from the port sector. The challenge of defining absolute criteria based on statistical data, the value judgements sometimes applied by individuals, the varying circumstances across port sector practice, and the personal interpretation placed on some indicators in terms of experience all influenced perceptions as to reliability and confidence. The sector itself is currently taking a pragmatic and practicable approach as it seeks to encourage and develop a culture of monitoring and reporting, hence, initial acceptability and feasibility are seen as stepping stones towards more refined measures of reliability and confidence. The proposed Dashboard will establish baseline data and facilitate future benchmarking. This exercise will in turn produce feedback for successive refining of selection criteria and contribute useful information concerning reliability and confidence if data in the longer term. This approach has been recognised by ESPO.

In a practical way, in order to assess each indicator with the above-mentioned criteria, each criterion has been summarised with a question. Indicators were examined according to the questions; so that a positive answer (‘yes’) denotes compliance with the specific criterion:

1. **Policy relevant:** Does the indicator reflect the aims of the environmental policy, objectives and targets and the environmental legislation?

2. **Informative:** Does the indicator provide information about the status and trends of the port environmental performance over time?

3. **Measurable:** Does the indicator use measurable and/or readily available data?

4. **Representative:** Does the indicator provide a clear picture of environmental conditions and pressures on the environment?

5. **Practical:** Is the indicator straightforward to monitor?

4.2 Theoretical screening – Academic

Through successive phases, the inventory of existing indicators has been screened and filtered against the specified criteria. Each indicator, from the preliminary list of 304 collected EPIs, was reviewed and assessed as being of high significance and recommended for acceptance (15 indicators); medium significance and recommended for potential application (22 indicators); or low significance and recommended for rejection (267 indicators).

The template of all indicators containing the compliance with the criteria and its significance is detailed in Appendix V of this document (page 188). Any anomaly found in the methodology for the selection of the significance is explained in the tables provided in Appendix V. There have been a total of 37 resulting indicators regarded as being of high and medium significance and they are presented in Table 4.2, Table 4.3, and Table 4.4 for management, operational and conditional indicators, respectively.

Management Performance Indicators

From the initial collection of 128 indicators categorised as Management Performance Indicators, the analysis concluded with a list of four high significant and seven medium significant indicators. The selection of indicators represents the major components of an Environmental Management Programme.

Table 4.2: High and medium significant management indicators

Indicator	HIGH	MEDIUM
Number and type of EMS certifications	√	
Existence of an Environmental Policy		√
Percentage of environmental targets achieved		√
Existence of an Environmental Monitoring Programme	√	
Number of Significant Environmental Aspects identified	√	
Percentage of port employees that have received environmental training		√
Annual number of environmental accidents reported		√
Total number and volume of oil and chemical spills		√
Number of environmental audits conducted		√
Number of prosecutions received for non-compliance with environmental legislation	√	
Total annual number of environmental complaints received		√

Operational Performance Indicators

Out of the 80 existing operational indicators, 12 were categorised as being of high and medium significance. Mainly, the environmental issues concerned were energy consumption, noise and port waste.

Table 4.3: High and medium significance of operational indicators

Indicator	HIGH	MEDIUM
Total annual energy consumption by energy source	√	
Amount of energy saved due to energy-efficiency improvements		√
Percentage of renewable energy per total energy consumed	√	
Total water consumption		√
Percentage of water recycled per total water consumption		√
Total annual greenhouse gas (GHG) emissions (Carbon Footprint)	√	
Percentage of annual changes in greenhouse gas (GHG) emissions (Carbon Footprint)		√
Level of noise in terminals and industrial areas Lden (overall day-evening-night)	√	
Compliance with limits at day, evening, and night time for noise level	√	
Total annual port waste collected by type		√
Percentage of disposal methods of port waste: landfill, incineration, recycling, and compost		√
Percentage of dredged sediment going to beneficial use		√

Environmental Condition Indicators

Finally, after the screening process, 14 condition indicators resulted in being of high and medium significance, introduced in Table 4.4. Most of the indicators refer to air, water and sediment quality and ecosystems and habitats indicators.

Table 4.4: High and medium significance of condition indicators

Indicator	HIGH	MEDIUM
Concentration of air pollutants: NOx, SOx, PM10, VOCs, CO, O	√	
Quantity of anthropogenic debris collected		√
Biolchemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)	√	
Microbiology (Coliform Bacteria)	√	
Water Salinity	√	
Water transparency / turbidity	√	
Water Temperature	√	
Sediment quality: concentration of nutrients		√
Percentage of algae coverage at particular sites		√
Other aquatic flora monitoring: quantity and variety of aquatic flora species		√
Benthic fauna monitoring: quantity and variety of benthic fauna found in sediments samples within the seabed		√
Trawling monitoring: quantity and variety of fish, crustaceans and other species which live on the seabed and within the water column		√
Birds monitoring: quantity and variety of farmland birds, woodland birds, water and wetland birds, and seabirds		√
Change of species diversity at particular sites		√

The list of 37 high and medium significant indicators had to be further reduced to a shorter list of indicators, listed in the following Table 4.5. On one hand, three high significant indicators were selected from the Management Performance Indicators category, rejecting only one high significant indicator, namely the number of prosecutions. On the other hand, from the Operational Performance Indicators, it was selected one indicator of each subcategory, specifically energy consumption, Carbon Footprint, water consumption and port waste. Although noise indicators were categorised as high significant, they were excluded from the final list because noise monitoring is not a common practice throughout European ports and they may appear a highly-demanding indicator for some European sea ports.

These indicators reflect the majority of the port activities and affect the largest number of port authorities. This was the first proposal of indicators to be assessed by port stakeholders; however, the number and designation of the EPIs was subject to change as the programme evolved.

Table 4.5: Initial selection of EPIs

Indicator
Number of EMS certifications
Existence of an Environmental Monitoring Programme
Existence of an inventory of Significant Environmental Aspects
Total annual energy consumption by energy source
Total water consumption
Total annual greenhouse gas (GHG) emissions (Carbon Footprint)
Total annual port waste collected by type

This initial selection of environmental indicators included three management indicators and four operational indicators. Environmental Condition Indicators, such as air and water quality or noise, were excluded from this list because they were considered to be 'site-specific' indicators and their suitability should be decided by each individual port according to their own characteristics, needs and priorities; therefore, they were deemed as not to be recommended for use within the European port sector as a whole based on ESPO's specification for its planned Observatory.

The ecosystems and habitats indicators were also ruled out because of the difficulties in identifying EPIs suitable to the European ecosystems as a whole. Nevertheless, the implementation of an EMS may indicate that such EPIs have been considered accordingly.

4.3 Stakeholders' assessment

As part of the PPRISM project and this particular research pathway, the selected indicators were assessed in order to find out their appropriateness as an EPI. To do so, they were evaluated in terms of two parameters: the acceptance of each indicator by the stakeholders and the feasibility of the data collection for each specific indicator.

Several assessments were conducted, involving different stakeholders. Some were based on 'internal stakeholders' assessments in which members of the ESPO Sustainable Development (SD) Committee (representing European port authorities) participated and others focussed on the ‘external stakeholders’ assessments which included any other companies, organizations and individuals being directly related with ports (experts representing different interested parties such as ports, port users, societal interests, and government).

4.3.1 Internal stakeholders’ assessments

The assessments from the ‘internal stakeholders’ followed the Delphi methodology, an iterative multistage process designed to combine opinion into group consensus (McKenna, 1994). The Delphi methodology is considered to be one of the most appropriate methodologies for quantitative and qualitative assessments in cases of physical interactions between researchers and groups of stakeholders. In total, there have been two internal stakeholders’ evaluations: the first one celebrated on September 2010 which provided an initial insight into the indicators likely to be accepted, modified, deleted or added as new ones; and the second one on December 2010 which confirmed the final selection of indicators.

This evaluation method comprises several steps. Firstly, the aims and the scope of the project were presented to the participants of the workshop; then, each selected indicator was presented in detail including its definition, general purpose, calculation formula and units of measurement. After the presentation of each indicator committee members were asked to assess quantitatively - on a five point scale - each EPI based on sixteen different questions linked to the feasibility and acceptance of the indicators through filling in the assessment survey (see Appendix VI: Assessment Form, page 200). Following the quantitative assessments, members were requested to provide qualitative information, in order to better understand the actual viewpoints of the indicators. At this stage, the question asked of them was ‘Why did you assess each indicator in the way you did?’ Participants were divided into working groups of five or six members and they made statements and comments on the feasibility, acceptance and appropriateness of each EPI lead by an academic researcher. The groups were formed so that geographical representation of different areas in Europe was ensured within each. Finally, the qualitative results of the exercise were presented in a plenary session.

Stakeholders were encouraged to further comment on these results and to propose new indicators.

First internal stakeholders' assessment

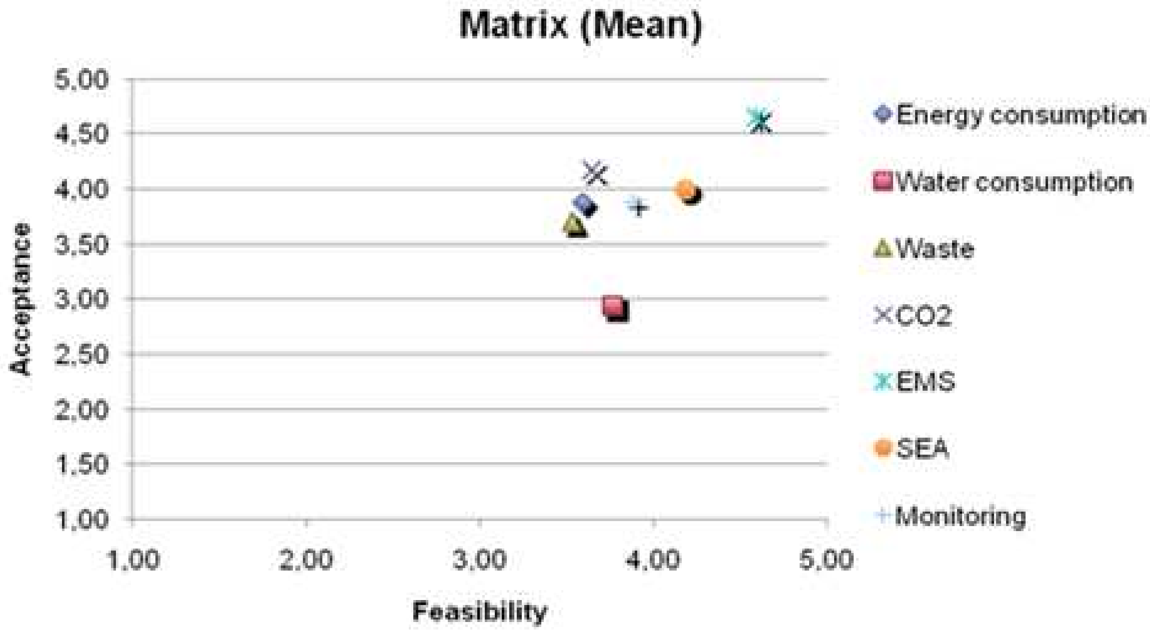
The first assessment was held in Brussels (Belgium) on the 28th September 2010, and it was attended by 17 members of the ESPO Sustainable Development Committee. The fact that this Committee meets regularly on a periodic basis provided an excellent opportunity for the interactive assessments between the stakeholders and the academic partners. The initial selection of seven indicators was assessed, following the multistage process above-mentioned. Table 4.6 shows the mean of results of the nine questions about the stakeholders' acceptance, the mean of the results of the seven questions about the implementation feasibility, and the overall results obtained. Figure 4.2 provides a matrix of the acceptance and feasibility of the seven indicators assessed in the First ESPO SD Committee Members. These results are rated on a 1 – 5 scale where 1 is least likely and 5 is most likely.

Table 4.6: First ESPO SD Committee Members assessment results (mean)

Indicator	Acceptance (Mean)	Feasibility (Mean)	Overall (Mean)
Environmental Management System	4.3	4.3	4.3
Environmental Monitoring Programme	3.7	3.6	3.6
Significant Environmental Aspects	3.6	4.0	3.8
Total energy consumption	3.6	3.2	3.4
Total water consumption	2.8	3.6	3.2
Carbon Footprint	4.0	3.2	3.6
Total port waste collected	3.5	3.5	3.5

The indicator with highest score is the existence of an Environmental Management System, in terms of both acceptance and feasibility (4.3). It is interesting to note that the indicators that need calculations tend to have their acceptance higher than their feasibility, such as the Carbon Footprint or the total energy consumption; while in the managerial indicators these two parameters are relatively similar. Inversely, although stakeholders tend to recognise that the water consumption indicator is a practical and measurable indicator, assessed with a reasonably high feasibility (3.6); they tend to consider this indicator as the one with the lowest acceptance (2.8).

Figure 4.2: Matrix of 1st ESPO SD Committee Members assessment results (mean)



In order to further interpret the previous results, the Standard Deviations (St. Dev.) of the means have been calculated. The standard deviation measures the spread or dispersion around the mean (or average) of a data set. A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data points are spread out over a large range of values (Sharif, [No date]). Standard deviation is expressed in the same units as the original data.

Table 4.7: First ESPO SD Committee Members assessment results (St. Dev.)

Indicator	Acceptance (St. Dev.)	Feasibility (St. Dev.)	Overall (St. Dev.)
Environmental Management System	0.26	0.23	0.24
Environmental Monitoring Programme	0.36	0.24	0.31
Significant Environmental Aspects	0.34	0.19	0.32
Total energy consumption	0.23	0.31	0.32
Total water consumption	0.37	0.38	0.52
Carbon Footprint	0.4	0.24	0.51
Total port waste collected	0.18	0.23	0.20

Table 4.7 shows that the highest standard deviation is in the total water consumption indicator. It means that there is a greater divergence of opinion concerning this indicator. Although the acceptance of water consumption was assessed as the lowest mean (2.8) in Table 4.6, the high standard deviation of water consumption proves that in fact it may be a priority issue for several ports throughout Europe. The lowest standard deviation is located in the existence of an Environmental Management System and in the total port waste collected, both with a high mean of acceptance and feasibility (4.3 and 3.5 respectively), what it also demonstrates that those indicators are broadly accepted by stakeholders.

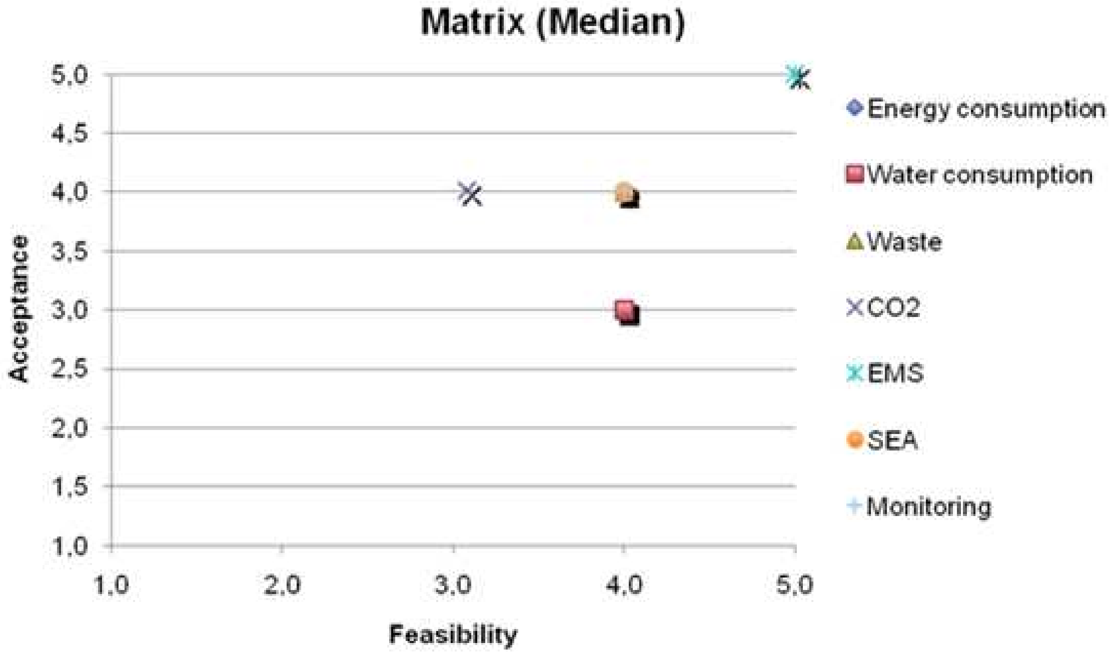
Finally, the third statistical analysis of the results is through the calculation of the median. The median is described as the numerical value separating the higher half of a sample from the lower half. The median of a finite list of numbers can be found by arranging all the observations from lowest value to highest value and picking the middle one. The results of the median for each suggested indicator are presented in Table 4.8, and almost all the indicators have a median of a 4 (out of 5) , except from the feasibility of Carbon Footprint and the acceptance of water consumption which is a 3, and the EMS which is an impressive median of 5. Table 4.3 provides a matrix with the mean results of the stakeholder’s acceptance and feasibility of data collection.

Table 4.8: First ESPO SD Committee Members assessment results (median)

Indicator	Acceptance (Median)	Feasibility (Median)	Overall (Median)
Environmental Management System	5	5	5
Environmental Monitoring Programme	4	4	4
Significant Environmental Aspects	4	4	4
Total energy consumption	4	4	4
Total water consumption	3	4	3
Carbon Footprint	4	3	4
Total port waste collected	4	4	4

Almost all the indicators have a median of a 4 (out of 5), except from the feasibility of Carbon Footprint and the acceptance of water consumption which is a 3, and the EMS which is an impressive median of 5.

Figure 4.3: Matrix of 1st ESPO SD Committee Members assessment results (median)



Apart from the quantitative results of this first assessment that appeared to be fairly well rated, the qualitative results and the discussions with Committee Members provided further advice on the enhancement of the original list of proposed EPIs. Members' views indicated that:

- Environmental Management Indicators were considered to be meaningful components because they demonstrate competence and ability to deal with a range of issues. It was suggested that an index (with weighting) could be created which included basic YES / NO responses to a range of environmental components. The three management indicators were accepted and six new environmental indicators were suggested (see Table 4.9).
- The indicator 'total energy consumption' could be integrated into the Carbon Footprint indicator since these calculations already require input from energy consumption issues.
- Carbon Footprint was seen as a high profile indicator and it was suggested to be retained in the proposed list. However, Committee members expressed the need to develop a consistent and practical calculation method that port authorities

could apply consistently over time and obtain meaningful trends of this indicator.

- The indicator ‘amount of waste produced’ should indicate the type and amount of waste collected and recycled within the port area (excluding ship waste, already regulated by MARPOL Convention) as well as the percentage of recycled waste. It was proposed to modify the name of the indicator to ‘waste management’.
- Although ‘water consumption’ was not rated as a high priority issue by some stakeholders, it was retained within the proposed indicators because on the one hand it was assessed as a high feasible indicator in terms of data collection, obtaining input data directly from water meters and water bills; and on the other hand, it can demonstrate commitment to reduce and willingness to manage this natural resource (For several ports throughout Europe it is in fact a priority issue).
- Quantified EPIs, namely Carbon Footprint, waste management and water consumption, should not only include data from the Port Authority but also from the whole port area if the data is available.
- Calculations and reporting of quantified environmental indicators should be modified to a common ground, normalized for annual cargo handled, annual TEUs transported or annual passengers embarked and disembarked if this is possible.
- Trends and patterns over time based on consistent reporting may be considered more significant than absolute values given the challenges of standardisation and the diversity of port profiles.

The feedback from the ESPO Sustainable Development (SD) committee was extremely significant for the evaluation of EPIs due to that fact that its members represent the views of the European port authorities and they retain a high expertise in relevant port environmental issues. Their recommendations for improvement are highlighted in Table 4.9, where each indicator is categorised as ‘accepted’, ‘modified’, ‘deleted’ or ‘new’, according to the suggestions above-mentioned.

Table 4.9: Modifications of indicators from the first SD Committee assessment

Indicator	Accepted	Modified	Deleted	New
Existence of an Environmental Management System		√		
Existence of Environmental Monitoring Programme	√			
Existence of an inventory of Significant Environmental Aspects	√			
Existence of Environmental Policy				√
Reference to ESPO Code of Practice in Port Policy				√
Existence of an inventory of environmental legislation				√
Existence of Objectives and Targets				√
Existence of Environmental Training				√
Existence of Environmental Report				√
Total Energy Consumption			√	
Carbon Footprint	√			
Waste management		√		
Water consumption	√			

Second internal stakeholders' assessment

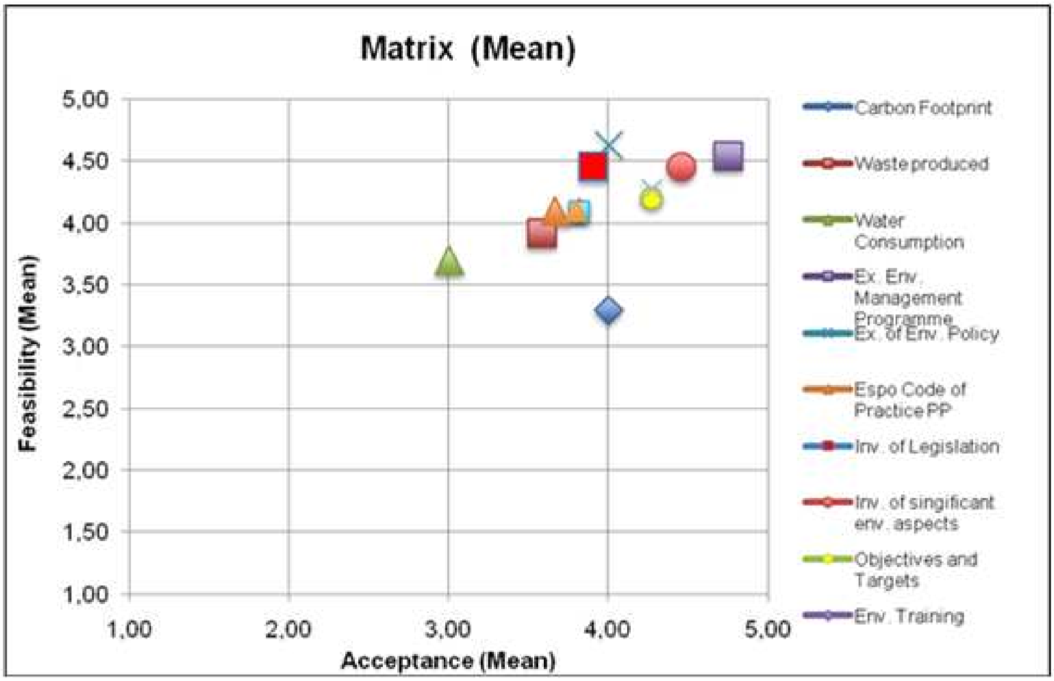
After the modifications and improvements proposed in the first assessment, a second evaluation from the ESPO Sustainable Committee Members took place. In this case, it was not possible to carry out the assessments during a Technical Committee meeting so the questionnaires were sent electronically to them along with the description of the modified and the new indicators. All responses were compiled by the 13th of December 2010.

The quantitative and qualitative results of the second round, received from 11 respondents served to prove the acceptance and the feasibility of the indicators. Again, indicators were evaluated in a 1 to 5 scale and the results of the mean are shown in Table 4.10 and represented in Figure 4.4.

Table 4.10: Second ESPO SD Committee Members assessment results (mean)

Indicator	Acceptance (Mean)	Feasibility (Mean)	Overall (Mean)
Environmental Management System	4.8	4.5	4.6
Environmental Monitoring Programme	3.8	4.1	4.0
Inventory of Significant Environmental Aspects	4.5	4.5	4.5
Environmental Policy	4.0	4.6	4.3
ESPO Code of Practice	3.7	4.1	3.9
Inventory of environmental legislation	3.9	4.5	4.2
Objectives and Targets	4.3	4.2	4.2
Environmental Training	3.8	4.1	4.0
Environmental Report	4.3	4.3	4.3
Carbon Footprint	4.0	3.3	3.7
Waste management	3.6	3.9	3.8
Water consumption	3.0	3.7	3.4

Figure 4.4: Matrix of 2nd ESPO SD Committee Members assessment results (mean)



The results follow the same pattern as the first assessment, with the existence of an Environmental Management System and an inventory of Significant Environmental Aspects achieving the highest score in management indicators, and Carbon Footprint and waste management in operational indicators. The table shows that all the six accepted and modified indicators obtained a higher rating in the second assessment compared to the first one, which shows that the amendments were satisfactory and well-received by stakeholders. In addition, all the six new management indicators received a feedback of 4 or more, except the reference to the ESPO Code of Practice which was a 3.9.

Following the same statistical analysis of the first ESPO SD Committee, the standard deviations of the mean have been calculated and are shown in Table 4.11.

Table 4.11: Second ESPO SD Committee Members assessment results (St. Dev.)

Indicator	Acceptance (St. Dev.)	Feasibility (St. Dev.)	Overall (St. Dev.)
Environmental Management System	0.32	0.60	0.45
Environmental Monitoring Programme	0.17	0.21	0.19
Inventory of Significant Environmental Aspects	0.20	0.26	0.23
Environmental Policy	0.35	0.58	0.52
ESPO Code of Practice	0.46	0.46	0.48
Inventory of environmental legislation	0.32	0.37	0.55
Objectives and Targets	0.19	0.37	0.28
Environmental Training	0.26	0.77	0.52
Environmental Report	0.15	0.39	0.27
Carbon Footprint	0.36	0.48	0.59
Waste management	0.35	0.41	0.38
Water consumption	0.27	0.42	0.42

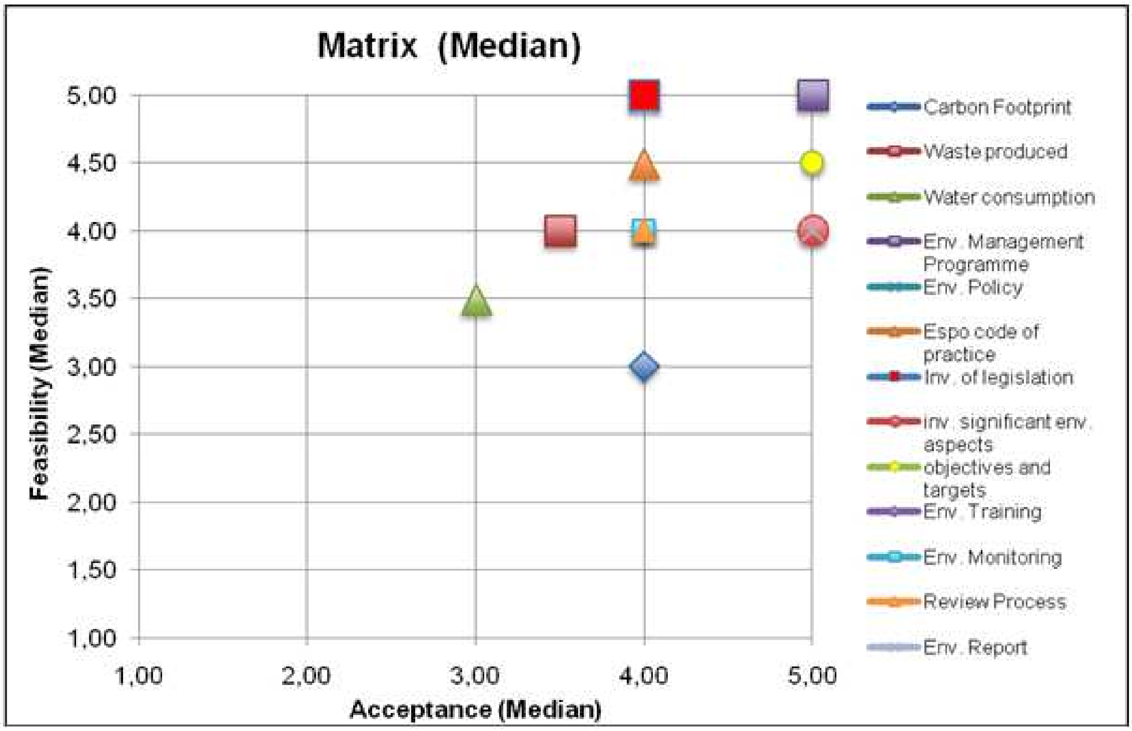
These results show the dispersion around the mean. Carbon Footprint remains as the indicator with the higher Standard deviation; however, Environmental Training and Environmental Legislation also create discrepancies between port stakeholders. In the second ESPO SD Committee Members assessment, the existence of an Environmental Monitoring Programme is the indicator that attracted greatest consensus of support among members being indicator with the lowest standard deviation value.

Finally, Table 4.12 and Figure 4.5 provide the medians of the second internal stakeholders' assessment.

Table 4.12: Second ESPO SD Committee Members assessment results (median)

Indicator	Acceptance (Median)	Feasibility (Median)	Overall (Median)
Environmental Management System	5	5	5
Environmental Monitoring Programme	4	4	4
Inventory of Significant Environmental Aspects	5	4	4
Environmental Policy	4	5	4
ESPO Code of Practice	4	4.5	4
Inventory of environmental legislation	4	5	4
Objectives and Targets	5	4.5	4
Environmental Training	4	4	4
Environmental Report	5	4	4
Carbon Footprint	4	3	3
Waste management	3.5	4	3.5
Water consumption	3	3.5	3.5

Figure 4.5: Matrix of 2nd ESPO SD Committee Members assessment results (median)



These median results are similar to the ones from the first internal assessment, having the existence of an EMS the top indicator with a median of 5, and the three operational indicators (Carbon Footprint, waste management and water consumption) the bottom ones with a median of 3 and 3.5 respectively.

4.3.2 External stakeholders' assessments

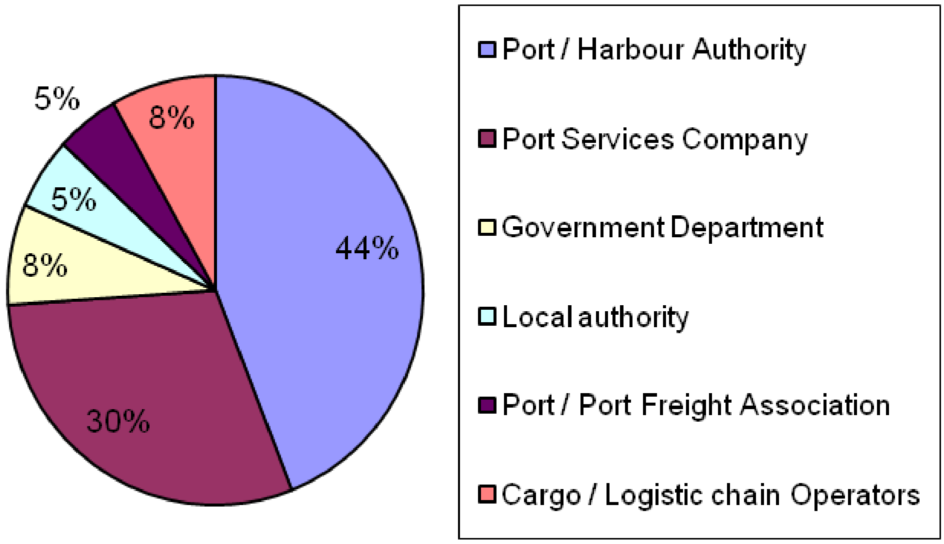
It was considered that these internal assessments would be unrepresentative without integrating the respective views of 'external stakeholders' on the feasibility and acceptance of the selected indicators. This is because i) the data needed in most of the proposed EPIs does not derive purely from port authorities as it also involves a number of external stakeholders (such as terminal operators or ship owners), and ii) it is worth taking into account their opinions because the external stakeholders will be directly or indirectly, affected by the final selection of indicators.

The external stakeholders' assessments included feedback from the participants of an international conference, a national ports organisation conference, an on-line questionnaire, and the comments and advice received from a port operator company.

The international conference was organised by the Clean Baltic Sea Shipping Project and it was held in Stockholm (Sweden) in November 2010. The environmental indicators were assessed by 33 individuals, including researchers (4), government members (3), port managers (17), consultants (4), and a port operator (1). The questionnaire used in this assessment is included in Appendix VII (page 201).

The proposed indicators were also presented and evaluated in the British Ports Association (BPA) Conference 2010, held in Torquay (UK) in October 2010. A total of 114 individuals attended this national ports organisation conference whereby they gave their opinion regarding the suitability of the selected environmental indicators and provided new indicators for consideration. A template of the assessment form is included in Appendix VIII (page 202). In the Figure 4.6 the respondents have been categorised into 6 different groups: Port / Harbour Authority, Port Services Company, Government department, local authority, Port / Port Freight Association, and Cargo / Logistics chain operators.

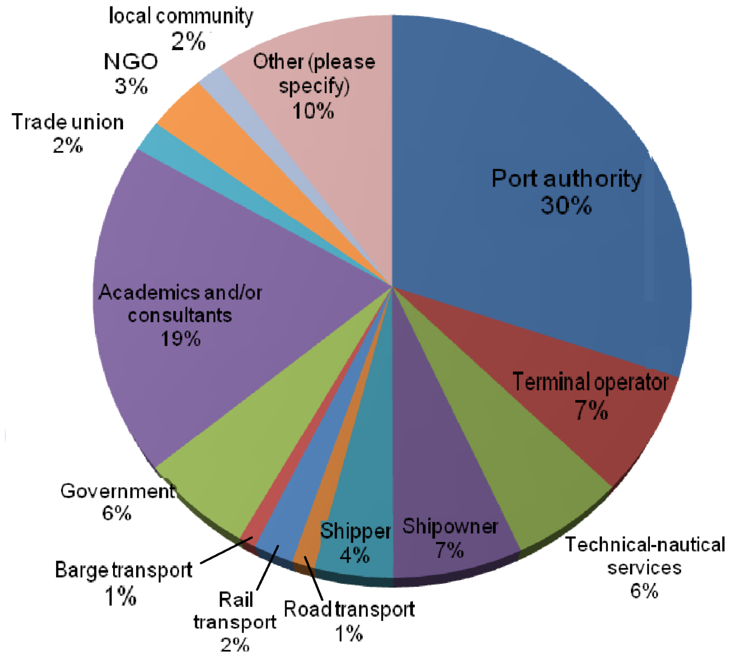
Figure 4.6: Breakdown of the BPA Conference 2010 respondents



Another procedure to obtain stakeholders' assessments was an on-line survey, which provided individuals or interested parties with the opportunity to assess the indicators that were under examination. This questionnaire was freely available and was not restricted to the respondents. This survey lasted available four months, starting on the 2nd February 2011 and finishing on the 13th May 2011 and obtained feedback from 114 participants. It was advertised via ESPO newsletters, specialised media, and through personal networks. Although all responses were answered anonymously, the job position of each respondent was requested in order to gain an understanding of their field of expertise. It was also asked whether the respondent was working or residing in one of the EU Member States. In terms of the content of the survey, each indicator was presented, detailing a definition, a description, and a calculation formula. It was followed by the question 'Do you think that the indicator "X" is acceptable and feasible?' and giving six response options, ranging from strongly agree (5) to strongly disagree (1) or 'No Opinion'. The vast majority of the responders (86%) was working and / or residing in a European Union member state, whereas the remaining 14% was located in a different country.

Figure 4.7 evidences the variety in the respondents categorising them in 13 different groups of stakeholders. A copy of the questions asked in the on-line survey is provided in Appendix IX (page 203).

Figure 4.7: Breakdown of the on-line survey respondents



In April 2011, a final evaluation took place. In this case, advice was requested from Hutchison Port Holdings (HPH), a leading port investor, developer and operator that has interests in 51 ports covering 25 countries throughout Asia, the Middle East, Africa, Europe, the Americas and Australasia. This company provided guidance and specific comments on several indicators.

The following table shows the summary overview of the assessment results from both internal and external stakeholders. The results displayed are the mean of the acceptance and feasibility, rated from 1 (least likely) to 5 (most likely). The number of respondents in each assessment is provided within the brackets. Successive evaluations are presented in chronological order so that the evolution of the assessments can be assessed through time. It should be noted that in assessments carried out by the 1st ESPO SD Committee and in the BPA Conference, there were fewer management indicators evaluated because those components had not yet been identified for further scrutiny. Although the two ESPO Sustainable Development Committee assessments have fewer feedback respondents in number compared with the rest of the assessments, they may be considered the most significant because they included the views of the European Port Authorities' representatives. Also, they are the most comprehensive assessments with a total 16 questions about the feasibility and acceptance of the indicators (see Appendix VI: Assessment Form).

The indicators are presented into two groups of EPIs, i) management indicators and ii) operational indicators.

Table 4.13: Overall results of internal and external stakeholders' assessments

	1st ESPO SD Committee (17)	**BPA Conference (114)**	**Clean Shipping Project (33)**	**2nd ESPO SD Committee (11)**	**On-line survey (114)**	**Overall (289)**
Management indicators						
Environmental Management System	4.3	4.0	4.6	4.6	3.9	**4.3**
Monitoring programme	3.7	3.9	4.4	4.0	4.0	**4.0**
Inventory of Significant Environmental Aspects	3.8	-	3.7	4.5	3.9	**4.0**
Environmental Policy	-	-	4.5	4.3	4.0	**4.3**
ESPO Code of Practice	-	-	3.8	3.9	3.7	**3.8**
Inventory of environmental legislation	-	-	3.6	4.2	3.8	**3.9**
Objectives and Targets	-	-	4.3	4.2	3.9	**4.1**
Environmental Training	-	-	4.1	4.0	3.9	**4.0**
Environmental Report	-	3.9	4.3	4.3	3.8	**4.1**
Operational indicators						
Carbon Footprint	3.7	3.4	3.9	3.7	3.7	**3.7**
Waste management	3.5	4.0	3.8	3.8	3.6	**3.7**
Water consumption	3.1	3.6	2.9	3.4	3.4	**3.3**

It may reasonably be proposed that the assessments have been broad-based, statistically significant in number, and useful in confirming the acceptance and feasibility of selected EPIs. The scores of each EPI are generally consistent with each successive assessment exercise to the extent that it is suggested that the chosen EPIs satisfy the port sector's expectations and there is every prospect that appropriate data could be compiled or calculated by respondent ports. With 289 different assessment respondents, it may be argued that the average scores reported confirm widespread acceptance. The EPIs have already been scrutinized by a genuinely representative cross-section of the sector's stakeholders, including port authorities' employees, consultants, academics, terminal operators, ship owners, governmental agents, people working within the area of technical-nautical services, shippers, rail transport, trade unions, local communities adjacent to a port, barge transport and road transport. Although the on-line survey had 114 responses, it is worth pointing out that a 14% of the participants were working and/or residing outside the European Union; while all the other assessments were from members of European countries, with a high contribution from British ports.

It is worth pointing out that the existence of an Environmental Management System and an Environmental Policy obtained an impressive overall score of 4.3, followed by the definition of Objectives and Targets (4.1) and publishing an Environmental Report (4.1). Concerning operational indicators, both Carbon Footprint and port waste management retain its significance as a high-profile issue with a score of 3.7 out of 5.

4.4 Description of potential indicators

Successive phases of research, assessments and evaluations led to the achievement of a final set of indicators which comprises of two types of EPIs:

i) A qualitative measure of a Port Authority's ability to deliver compliance and effective environmental protection for the wide range of existing or potential issues that may affect the port. These indicators are named Consolidated Environmental Management Indicators and are composed by nine components of environmental management.

ii) A calculated and quantified measure of the actual impact related to specific aspects, composed by three operational indications, namely Carbon Footprint, waste management and water consumption.

4.4.1 Management Performance Indicators

Nine Environmental Management Indicators have been selected and, although at first sight the checklist it may appear demanding in terms of data input, the response required is YES or NO, with the option of requesting additional detail in certain key components, such as Environmental Monitoring or Significant Environmental Aspects, which provide issue specific information related to the major issues faced by the ports and their activities and operations carried out.

A final index is calculated on the basis of specific weighting applied to the significance attached to key components of environmental management that demonstrates that useful indices could be created for purposes of baseline and benchmark performance. The initial weightings were derived from the assessment of port and marine-related professionals and then the consolidated value was derived on the basis of the Self Diagnosis Method (SDM) experience that links with the port sector's own standard of environmental management, the Port Environmental Review System (PERS).

The questions asked in calculating the index are all related to terminology and components recognised in environmental standards, and they are fairly well known and well-established within the port sector through the application of such environmental management tools and standards as the Self Diagnosis Method (SDM), Port Environmental Review System (PERS) and ISO 14001. In fact, most of these indicators are required in order to qualify for an Environmental Management System (EMS) standard certificate. The recommended components support the ESPO Code of Practice, and an auditor or reviewer would expect to see them present in any meaningful environmental management programme.

Table 4.14 Weighting of the Consolidated Environmental Management Indicators

Environmental Management Indicator	Weighting
Environmental Management System	1
Environmental Monitoring Programme	1.25
Inventory of Significant Environmental Aspects	1.5
Environmental Policy	1.5
ESPO Code of Practice	0.5
Inventory of environmental legislation	1.5
Objectives and Targets	1
Environmental Training	0.75
Environmental Report	1

The weightings of the consolidated environmental management indicators (Table 4.14) were derived from the protocols applied to the review procedure for the EcoPorts Self-Diagnosis Method (SDM). The components were established during research for the EC Eco-Information project fifteen years ago during collaboration between the port sector and Lloyd's Register Quality Assurance (LRQA), and have since been adopted to become part of the standard review procedure for the European Sea Ports Organization's (ESPO) tools and methods for port environmental management.

The rationale for the weighting follows established audit practice as applied, for example, to ISO 14001. With the objective of delivering compliance with legislative and regulatory requirements, it is recognized that the Environmental Policy statement (1.5) drives the whole system and that the Inventories of Significant Environmental Aspects (1.5) and environmental legislation (1.5) are the key components that an auditor would expect to find in place. Monitoring (1.25) of both environmental condition and management performance is recognized as being essential to deliver evidence of effectiveness of the EMS. In assessing benchmark performance and tracking progress for the sector as a whole, and the performance of the individual Port Authority, the presence or absence of an EMS (1.0), identification of Objectives and Targets (1.0), and publishing an Environmental Report (1.0) are graded as positive attributes in the development and implementation of an environmental programme. The latter indicator is recommended by ESPO and an auditor would expect an authority to adopt the sector's own policy-making body's recommendations. Environmental Training (0.75) is widely recognized by industry as being one of the most effective mechanisms for implementing and maintaining environmental management systems to high standards of delivery, and so ESPO recognizes the component as a positive indicator of a port authority's programme. Reference to the ESPO Code of Practice (0.5) is seen as an indicator of awareness of the sector's major environmental policies, and as with publishing a report; an auditor would expect reference to this component.

The weightings adopted are in line with the current practice of the port sector's GAP and SWOT analysis for the SDM, reflect the priority attributed to components in the audit trail, and are effective measures of trends of management performance.

The port sector has cooperated over 15 years in supplying data of this nature to successive EcoPorts and ESPO surveys and reviews, and these benchmark performance indicators have been widely published and presented on behalf of the sector. Confidentiality is well established between port authorities, trade organizations and academia. The following paragraphs justify the selection of each particular component and summarise the strengths and weaknesses that stakeholders reported in their evaluations.

Environmental Management System

An Environmental Management System is a structured and systematic methodology of the Authority's management programme that demonstrates capability, functional organization and activities specifically designed to deliver continuous improvement of environmental quality and compliance with legislation.

Stakeholders approved this indicator by rating it with the highest overall score. Strengths in selecting this indicator are based on the methodologies and standards that are already in place and many port authorities have familiarised themselves with it.

Environmental Monitoring Programme

A monitoring programme consists of a repeated periodic observation and measurement of selected parameters that allows ports to establish their current status and trends of the environmental quality.

This is a potentially useful EPI that gives the opportunity to list the parameters and issues being addressed. It relates to SEAs and has the potential to provide further quantified detail. This could be an iterative process starting with YES/NO in terms monitoring activity and progressing in stages to the identification and detailing of the monitoring programme and its results. Indeed, the value as an indicator depends on the contents of the monitoring programme and whether the results of it lead to further actions.

Inventory of Significant Environmental Aspects

This indicator addresses the existence of a clearly defined list of Significant Environmental Aspects, that are activities, products, and services that have direct or indirect impact on the environment (ISO, 1996).

Identifying the Significant Environmental Aspects allows a port to focus its time and efforts on those issues with major potential for environmental impact. To demonstrate awareness of and action taken to control impacts, the Significant Environmental Aspects (SEAs) should be reflected on the Environmental Policy and appropriate control of the aspects should be implemented within the environmental management programme.

Environmental policy

An environmental policy is a declaration of the Port Authority's public intentions and principles in relation to its overall environmental performance, which gives a framework for action and for setting its environmental objectives and targets. It is based on a list of actions or principles which aim to prevent, reduce, or mitigate harmful effects on nature and natural resources caused by humans.

Both internal and external stakeholder's assessments confirmed the value of this as a significant EPI scoring the highest punctuation as well. This component is a fundamental and a preliminary question in the Self Diagnosis Method.

ESPO Code of Practice in port policy

The European Sea Ports Organisation (ESPO) Code of Practice represents the sector's strategic view on environmental liabilities and responsibilities, and provides guidelines on best practice. The first ESPO Code was published in 1994 and it was updated in 2003 taking into consideration the policy and practice evolutions. In addition, ESPO published the Code of practice on the Birds and Habitats Directives in 2006 and the ESPO Code of Practice on Societal Integration of Ports in 2010.

The inclusion of the Code of Practice in the port policy would be indicative of a well-informed and pro-active organisation. It should be stressed that an environmental reviewer or auditor would expect to see adoption and implementation of the sector's Code of Practice.

Inventory of Legislation

The inventory of legislation is a list of the legislation and regulations relevant to the port's liabilities and responsibilities. Identifying the relevant environmental legislation to which the Authority must comply is seen critically important in terms of demonstrating compliance. How can any organization declare itself to be in compliance if it is not aware of the legislation and regulations that are in place?

Objectives and targets

As mentioned in Chapter 3, an objective is an overall environmental goal that a Port Authority sets itself to achieve, whereas a target is a detailed performance guideline, quantified where possible, that needs to be set and met in order to achieve those objectives (ISO, 1996).

Setting and achieving environmental objectives and targets is seen as a major contribution to guarantee continuous improvement of the environmental performance. This results in cost and risk reduction, and it may also be considered a strategic procedure whereby a planned pathway can be followed.

Environmental Training

This indicator aims to establish a variety of programmes where positive and on-going environmental training and awareness-raising activities is carried out.

It may be suggested that environmental training remains one of the most cost-effective techniques for raising employee awareness and best practice, and it is often indicative of a pro-active response to the implementation of an EMS. Training is generally widespread throughout the sector particularly with respect to Health and Safety issues.

Environmental Report

An Environmental Report gives information about the environmental activities, achievements and results that the Port Authority has carried out throughout the preceding year.

The existence of an Environmental Report, whether on a website and/or as a hard copy, is generally indicative of demonstrable competence and activity in the area of environmental management, demonstrates action to range of stakeholders and is recommended by ESPO Code of Practice.

4.4.2 Operational Performance Indicators

Several projects and standards agree in recognising Carbon Footprint, Waste Management and Water Consumption as the main operational indicators that all organisations should calculate and report. Examples of these projects and standards are the ‘Demonstrate and Assess New Tools for Environmental Sustainability’ (DANTES Project, 2003), and the European Eco-Management and Audit Scheme (European Commission, 2012).

Discussions with stakeholders suggested that calculations and reporting of quantified EPIs may be acceptable if clear, concise and standardised methodologies were available. In addition, calculation, compilation and reporting of EPIs must be user-friendly and should not involve undue time or cost. The characteristics of these three indictors are explained as follows:

Carbon Footprint

This Environmental Performance Indicator retains its significance as a high-profile issue and is likely to emerge as an even stronger consideration in terms of legislation and planning. As Carbon Footprint is a useful synthesis of energy use, emissions and impact, this could be considered as a major EPI that the sector adopts as a quantified measure.

The challenge is to establish a common approach or protocol within the port sector which should be consistent in its calculation. With this knowledge, trends and patterns would be meaningful over time. Although it is a potentially demanding calculation, there are several existing and well recognised online carbon calculation models, namely The Carbon Neutral Company, C Level, Pure Trust and National Energy Foundation (NEF). Furthermore, there is evidence of very successful application of appropriate methodologies by ports, such as the EC Climeport Project or the World Ports Climate Initiative which created an online Carbon Footprint calculator. As part of the PPRISM research project, a user-friendly methodology has been compiled from the best examples of existing models and it has already been tested and completed by some ESPO and BPA members.

If the calculations are made for the Port Authority only, these could still be standardised against the total cargo handled (or equivalent). The initial effort should be to encourage ports to adopt a culture of reporting the major components of Carbon Footprint. In the first instance, ports could calculate from invoices for their own consumption only. A second model would be to work in collaboration with selected, major operators/tenants that together produce, for example, 80% approximately of total Carbon Footprint for the port area (again, standardised to annual cargo handled). Another option would be for a port to calculate for whole port area as some ports already so, such as the Port of Antwerp.

Waste Management

Waste management is a potentially complex issue in terms of the range of material and substances that may be defined as waste within any port area. However, it is increasingly significant and consistently reported as being a high priority issue by many port authorities. This EPI gives the opportunity for port authorities to demonstrate control over an issue that can be sensitive locally. There may be scope for ports to report best practice for the port area and to quantify selected components of waste management and percentage recycling.

Water Consumption

The total volume of water consumption may be used as an indicator of sustainability in the context of a particularly sensitive resource. Although it is not seen as a high priority issue by some northern and western European port representatives, it is a consideration in other parts of the EU and adjoining countries. To the wider community, water is certainly a significant issue and the EU Water Framework Directive gives prominence to the wide range of aspects involved. It may be worth considering total water consumption as an EPI because:

i) It can readily be measured from metering and bills to give quantified result.

ii) It can be used to demonstrate reduction in resource use given appropriate action and standardisation.

iii) Ease of reporting demonstrates willingness of sector to manage an increasingly valuable/scarce resource.

iv) Water consumption calculation assists in developing a culture of EPI reporting and it is a sensitive issue for the sector in several areas of Europe.

4.4.3 Environmental Condition Indicators

Bearing in mind the truism that ‘each port is unique’ in terms of its environmental regime, the permissible levels of pollution in port environments may vary from port to port and from member state to member state, according to their specific legislation, the requirements of the local community, and the port location relative to other geographic features.

Whilst ports are strongly recommended to carry out environmental monitoring within the port area (ESPO, 2003), it should not be considered to create a standardised list of Environmental Condition Indicators recommended for use in all European ports since the types of pollution sources of one port are not necessarily the same for another port. Each port should use the condition indicators that are most appropriate to monitor the impacts of their activities, and that is why no environmental condition indicator was proposed for inclusion in the final set.

In addition, taking into account the prerequisite of selecting feasible, measurable and practical indicators, it may be suggested that accurate measurement and calculation of condition indicators is a specialist and high-cost exercise that in some ports would be beyond their resources or be inappropriate in terms of their priorities of monitoring. Proposing highly demanding indicators would not encourage widespread culture of EPI monitoring and reporting.

The Consolidated Environmental Management Indicators proposed and explained above encourage the development and implementation of a monitoring strategy that should encourage port-specific EPIs to be adopted as necessary.

5 EPI Tool

5.1 Description

As part of this thesis, an EPI Tool was developed and delivered within the PPRISM Research Project as a user-friendly methodology to assist port authorities in calculating and reporting the selected Environmental Performance Indicators (EPIs): Carbon Footprint, Water Consumption and components of Port Waste Management. The tool also incorporates a checklist (YES/NO response) to the nine Consolidated Environmental Management Indicators, where a final index is calculated on the basis of the specific weighting presented in Table 4.14

This science-based tool has been specifically designed to facilitate the calculation and reporting of the selected EPIs by acting as:

1) A guideline: it includes a justification of the selected indicators and instructions for use.

2) A calculating methodology in itself: only data input is required; the tool does the calculations immediately 'at the touch-of-a-button'.

3) A reporting approach: it includes an instantaneous summary of calculations and it produces graphics automatically, readily adapted to be included in an Environmental Report.

The tool, which is in a Microsoft Excel format, is composed of six independent sections. Although ports are encouraged to complete all six sections, they have the choice to fill in only the sections that they prefer or for which data is available. However, completing as much of the tool as possible would:

i) Be a proactive environmental activity worthy of reporting as part of their environmental and sustainability endeavours.

ii) Establish useful baseline data that can be built upon if they adopt the tool.

iii) Provide the port sector with (anonymous) environmental performance data.

The complete EPI Tool is included in Appendix X (page 205). The following paragraphs explain the characteristics each section:

1) PORT PROFILE (page 205)

Ports are asked to complete characteristics and components of their performance, such as the annual cargo handled, annual TEUs, annual passengers or the square meters of the port area, which are requested to assist in further interpretation of the results. The contact details (name and contact e-mail) and the job position of the respondent are also required, along with the year to which the data refers, in order to be able to identify trends and progress from periodic application of the tool. Ports are advised that all data provided will be treated in strict confidence.

2) CONSOLIDATED ENVIRONMENTAL MANAGEMENT INDICATORS (page 205)

Ports are asked if their environmental management programme includes or makes reference to each of the nine Consolidated Environmental Management Indicators. For affirmative responses, ports have to tick (☑) this component. Each indicator has a specific weighting and, depending on the answers, the tool will provide a final index, up to 10 points. Ports can easily track their environmental management performance by completing this checklist on a regular basis. If progress is made, their final score will be increased.

3) CARBON FOOTPRINT (page 206)

Respondents are asked to enter the period that covers the data being entered for this Carbon Footprint calculation, either monthly, quarterly or annually. It is pointed out that this period should be the same for all the scopes (detailed below).

Ports are required to select one option concerning the input data, which may apply to any of the following three factors:

i) Facilities exclusively under the operational control of Port Authority.

ii) Areas and facilities managed by major operators and tenants (Includes data for i) above). The criteria for identifying 'major' operators or tenants may be defined by the Port Authority on the basis of local knowledge of their apparent or monitored impacts. For example, input may reflect data from the top 20% of tenants that produce 80% of total emissions (if this information is known). If not, the Authority may select those with the presumed highest impact – the actual number may not necessarily be critical as long as the same companies are selected year-on-year. This approach will still yield a trend from the starting baseline.

iii) The whole port area (Including data for i) and ii) above).

Respondents are asked to enter the units consumed (e.g. litres, KWh, tonnes, km) in the coloured boxes headed ‘Activity Data’. According to GHG Protocol (Carbon Trust, 2010), emission sources are divided into three different scopes:

- **Scope 1:** Direct emissions resulting from fossil fuels combustions on site. These include stationary sources (operational machines and cranes, heating or cooling) and mobile sources (company owned vehicles such as cars or vessels). In stationary sources, the activity data can be introduced in different units, usually either tonnes or KWh. In mobile sources, the activity data can be either in litres consumed or km driven.
- **Scope 2:** Indirect emissions for consumption of electricity imported to the site. It includes electricity used for harbour lightning, and for the heating and lightning of the building. It also includes electricity usage by cranes, lighthouses, or electricity usage for other purposes.
- **Scope 3:** Any other indirect emissions from sources not directly controlled by the organisation, for example, employee business travel and employee commuting.

All Scope 1 and Scope 2 emissions should be included, but the authority can choose which Scope 3 emissions to include, if any, because it is considered as ‘voluntary’ by the GHG Protocol.

The Emission Factors (kg CO_2e per unit consumed) of this tool are based on data published by DEFRA - Department of Environment, Food and Rural Affairs of British Government in 2009 (DEFRA, 2009). The Emission Factor for electricity differs in each country because it is based on its grid average mix of different types of generation. As the country of the respondent port is asked in the port profile information, the tool identifies the actual Emission Factor of the country and calculates the GHG emissions for electricity consumption accordingly.

The program calculates the GHG emissions from the input of activity data of each port. The results are given in tonnes of carbon dioxide equivalent (CO_2e). This measure is used to compare the emissions from the greenhouse gases based on their Global Warming Potential (GWP). CO_2e emissions are calculated by multiplying the emissions of each of the six greenhouse gases (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6)) by its 100-year Global Warming Potential (GWP). On completion of the input of data, users of the tool will find the overall result expressed in tons CO_2e/selected calculation period (month / quarter / year).

Once the data has been introduced, the model creates a graphic that shows the percentage of each scope. This is helpful in identifying which scope contributes the most to the GHG emissions. The graphic is readily adapted for incorporation into to the port's Environmental Report.

For purposes of benchmarking, due to the many variables involved, the total Carbon Footprint emissions should be standardised to a common factor. Using the data introduced in the port profile section, the tool directly standardises the Carbon Footprint results.

The Carbon Footprint tool takes the same approach as several existing and well recognised online carbon calculation models, namely The Carbon Neutral Company (http://www.carbonneutral.com/carbon-calculators/), C Level (http://www.clevel.co.uk/businesscalc), Pure Trust (http://www.puretrust.org.uk/page.jsp?id=104) and National Energy Foundation (http://www.nef.org.uk/greencompany/co2calculator.htm). Nevertheless, the EPI Tool does not require connexion to the Internet to work because it is presented in a Microsoft Excel format, which can be helpful when the Internet connexion is restricted.

4) PORT WASTE MANAGEMENT (page 208)

The Authority is asked to provide input data about recycled and non-recycled waste. The waste typology is classified in five categories: solid waste, liquid waste, non-hazardous industrial waste, hazardous waste and non-recycled waste. Each category already includes examples of waste that are commonly recycled; however, suggestion boxes are also given in order to specify any other recycled waste. Solid waste is composed of organic waste, cupboard and paper, plastic and glass. Liquid waste includes grey water, black water and ballast water. Common examples of non-hazardous industrial waste are scrap metal, wood, remains of nets, electronic waste, aerosols, oil filters or floating debris. Hazardous waste consist basically of ink cartridges, used oil, fluorescents, and alkaline and button batteries.

With the input data, the program calculates the total amount of collected and recycled waste, and the percentage of overall recycling. Although input data may be entered in kg, tonnes, litres or units of waste per annum, depending on the port's accounting method, the final output is given in tonnes per year. This is done using conversion units and density values, wherever it is possible. Similarly to the Carbon Footprint indicator, a graphic is created with each percentage of recycled waste.

5) WATER CONSUMPTION (page 211)

Consumption data can be introduced either in litres or cubic metres depending on which unit is more convenient for the port; however, the final value of water consumption is given in cubic metres. Following the stakeholders' recommendations, input data may be categorised as drinking water or non-drinking water according to the source or the nature of the water.

The tool gives the opportunity to report only the Port Authority's water consumption or the whole port area, if the data is available. Examples of typical water usages for each case are provided. Major uses of Port Authority water consumption are buildings and irrigation. For the port area, water is mainly used for cleaning the common areas, for supply to vessels, and third parties consumption. Again, blank spaces are provided in order to specify other usages.

The EPI Tool gives a summary of the total drinking and non-drinking water consumption of the Port Authority and the whole port area. A graphic with the water usages is provided and it is readily available for reporting purposes.

6) OVERALL RESULTS (page 212)

The final section of the tool is a summary of the results. It compiles the results obtained in each section and displays them in absolute value and the standardised results against annual cargo, annual TEUs, annual passengers and port area. Port authorities are encouraged to adopt this tool as a procedure to calculate and report periodically selected EPIs because it establishes a consistent approach for submitting data and information and calculating the results.

7) FEEDBACK ASSESSMENT (OPTIONAL) (page 213)

Users are encouraged to provide feedback on the practicability of the EPI Tool in terms of time and effort invested in completing it, ease of understanding, and general user-friendliness. There is a scale from 1 to 5 where ports can evaluate these above measures (where 1=least and 5=most), and a suggestion box where respondents can add further comments. All comments and suggestions are taken into account to improve particular aspects of the tool.

The tool was introduced to port authorities in conjunction with a 'Step-by-step guide to the PPRISM tool for Environmental Performance Indicators', a schematic plan designed to help in the understanding and use of the EPI Tool. This guide is appended in Appendix XI (page 214).

5.2 Assessment and validation

The EPI Tool was used and accessed by members of ESPO, providing them with explanations and guidance for use, and encouraging the adoption of the tool within their Port Authority as a methodology to calculate and report selected environmental indicators.

The objectives of completing this tool were i) to validate the feasibility of the proposed Environmental Performance Indicators; ii) to demonstrate whether the proposed EPIs are currently implemented and used by the sector; iii) identify difficulties in the calculation of the indicators; and iv) obtain feedback and results to improve and update the tool.

The tool was explained to the participants of the British Ports Association (BPA) Environmental Contacts Meeting, a workshop held in Cardiff in June 2011 where more than 20 BPA members attended the meeting. Members shared opinions about their experience in using Environmental Performance Indicators in their port, the challenges of particular indicators and how the tool could be improved. In addition, through the ESPO Secretariat, the EPI Tool was also sent electronically to all ESPO Members. A total number of 47 port authorities completed at least one section of the tool and provided data on environmental indicators. The input of the ESPO Members in terms of data, assessment and feedback has been a substantive base for the further evaluation of EPIs.

The results obtained were analysed by means of a GAP and a SWOT analysis. The GAP analysis compares actual performance with the expected responses. Out of the four independent sections that were available to be completed, the GAP analysis provides a quick assessment of the current sections that were answered. If the section was completed, it has been selected with a '√' in Table 5.1. 'Number completed' in the right-hand column represents the total number of EPIs answered by each respondent port.

The names of the ports are listed by coded reference in order to guarantee the anonymity of the ports and confidentiality of data. With the aim of determining to what extent the responses were representative of the sector, respondent ports were classified into four size categories as previously recognised by ESPO in its periodic Environmental Reviews: A (< 1 million tonnes), B (1 - 10 million tonnes), C (10 - 25 million tonnes) and D (>25 million tonnes). The countries of the respondent ports are also displayed in the table to show the representative coverage of the sample.

Table 5.1: GAP Analysis of EPI Tool responses

Code	Size	Country	Carbon Footprint	Waste Management	Water consumption	Management indicators	Number completed
P1	C	Slovenia	√	√	√	√	4
P2	D	Spain	√	√	√	√	4
P3	D	Netherlands	√	√		√	3
P4	D	Romania	√	√	√	√	4
P5	D	Netherlands	√			√	2
P6	D	Latvia	√	√	√	√	4
P7	B	Portugal	√	√	√	√	4
P8	B	Italy			√		1
P9	D	Italy			√	√	2
P10	D	Ireland	√	√	√	√	4
P11	D	Germany	√		√	√	3
P12	C	Germany	√	√	√	√	4
P13	D	France	√	√	√	√	4
P14	A	Croatia	√		√	√	3
P15	D	Belgium	√		√	√	3
P16	B	Albania	√	√		√	3
P17	C	Croatia	√		√	√	3
P18	B	Finland	√	√	√	√	4
P19	D	France	√	√	√	√	4
P20	D	France	√	√		√	3
P21	D	Germany	√	√	√	√	4
P22	C	Greece				√	1
P23	C	Italy		√	√	√	3
P24	C	Italy		√		√	2
P25	B	Italy	√		√	√	3
P26	D	Malta		√		√	2
P27	D	Netherlands				√	1
P28	B	Portugal	√		√	√	3
P29	D	Spain	√	√	√	√	4
P30	D	Spain	√	√	√	√	4
P31	B	Sweden	√	√	√	√	4
P32	B	Croatia	√	√	√	√	4
P33	D	Estonia	√		√	√	3
P34	C	Finland	√	√	√	√	4
P35	B	Finland	√	√	√	√	4
P36	B	Germany		√	√		2
P37	A	Greece		√	√	√	3
P38	A	Greece				√	1
P39	B	Ireland	√	√		√	3
P40	D	Sweden	√			√	2

Code	Size	Country	Carbon Footprint	Waste Management	Water consumption	Management indicators	Number completed
P41	B	UK		√		√	2
P42	B	Norway	√			√	2
P43	D	France	√	√	√	√	4
P44	C	Denmark	√	√	√		3
P45	B	Denmark		√	√	√	3
P46	D	Lithuania	√		√	√	3
P47	C	UK	√	√		√	3
		Total ports	35	31	33	44	
		Percentage	74.5%	66%	70.2%	93.6%	

The majority of ports completed most of the sections proposed: 18 ports answered all four EPIs and 17 ports completed three EPIs. Given the pressure on port professionals to respond to so many requests for information from a wide range of interested bodies, the geographical and numerical responses are considered satisfactory and encouraging.

Out of a total of 47 ports that contributed to the provision of input data:

- 35 ports provided data on their Carbon Footprint (74.5%)
- 31 ports provided data on their waste management (66%)
- 33 ports provided data on their water consumption (70.2%)
- 44 ports provided data on their environmental management (93.6%)

The total number of respondents may reasonably be claimed as a representative profile of ports actively involved in EPI monitoring. Concerning the size of the respondent ports:

- 3 are Small ports handling less than 1 million tonnes annually (6.4%)
- 14 are Medium ports handling between 1 and 10 million tonnes annually (29.8%)
- 9 are Large ports handling between 10 and 25 million tonnes annually (19.1%)
- 21 are Very Large ports handling more than 25 million tonnes annually (44.7%)

Very Large ports dominate the feedback but it is suggested that this reflects the resources available and the priorities given to the issue of performance indicators. The overall findings are in line with the previous 289 feedback responses from the various internal and external stakeholder assessments, which confirmed the general feasibility and acceptability of the proposed indicators.

The SWOT analysis is a method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats of a system. Table 5.2 presents the SWOT analysis of the responses of the EPI Tool. The characteristics of each component are:

- Strengths – existing good or best practices and favourable elements.
- Weaknesses – elements that should be avoided or addressed as matters of urgency, and that may put the Authority at disadvantage.
- Opportunities – components that have potential for improvement and that could readily be addressed.
- Threats – areas that could be subject to legal action, prosecution, or considered a fundamental flaw in the management response option.

Table 5.2: SWOT analysis of the EPI Tool responses

STRENGTHS	WEAKNESSES
- Representative coverage of the sector, based on responses from 23 different European maritime states - Responses include results from each of the 4 categories of size of port as recognised by ESPO - Wide-range of statistical data and quantitative information of actual calculations of EPIs - Confirmation of the established acceptance and implementation of the proposed EPIs - Additional research confirms that many	- In some instances, the request for EPI data may not have reached the appropriate contact or representative. Some port authorities with a known pro-active record of environmental achievement, apparently did not respond on EPIs - Priorities, communication and issues of time may have been significant in the response. - The recurring tenet that 'each port is unique' continues to complicate the methodology and strategy accorded to specific EPI monitoring

ports have monitored EPIs for several years and the culture of reporting is established within the sector, and baseline performance and trends are already noticeable	- Standardisation or normalization of input data continues to be a challenge in terms of input
OPPORTUNITIES	**THREATS**
- Feedback comments from port professionals provide the opportunity to enhance further and update the EPI Tool -The EPI TOOL provided the opportunity for calculating these EPIs for the first time as they had not previously been calculated by some ports.	- Although a sample response of 47 ports has merit, the extent to which it represents a sector of some 1200 European ports may be questioned

All comments provided by the respondent ports have been analysed and classified into three categories of response: i) for information / no action; ii) follow-up direct with port / feedback to port; and iii) accept and incorporate into recommendations. The statistical data and quantitative results as well as the comments from feedback are provided in Appendix XII (page 215).

The data and information derived from the pilot responses were accepted in good faith in this first instance of requesting direct and professional application of the EPI Tool. No verification, auditing or review was carried out. However, detailed study of the feedback comments and assessments suggest that the procedures for using the tool were pursued according to the guidelines issued as part of the EPI Tool.

There are major variations in the quantities, volumes and amount of detail provided by the respondent ports. This would reflect the naturally expected differences in the local circumstances, managerial organization and activity profile of the individual ports. However, it can reasonably be argued that the results obtained have followed a consistent methodology applied by different ports.

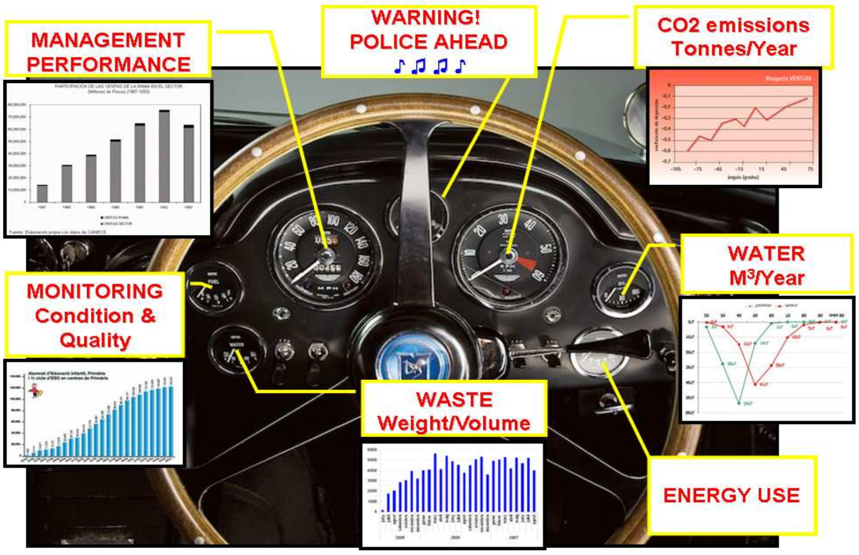
5.3 European Port Observatory

The PPRISM research project was also tasked with populating the proposed Port Observatory shortly to be commissioned by ESPO in response to the interest by the European Commission in seeking evidence of the extent to which EC Directives are being implemented. In this section, the concept of a European Port Observatory is defined and a concrete proposal for its implementation is provided.

The European Port Observatory aims to provide insight into the overall performance of the European port sector, involving the five categories of indicators included in the PPRISM research project. The observatory will tackle this goal by collecting periodical data on performance indicators from European ports. However, the Observatory will only give information on the overall performance of the European port sector through trends over time, and will not provide data on the performance of individual ports or terminals.

The development of the observatory may be seen as the creation of a ‘dashboard’ of the port sector performance, demonstrating the sector’s commitment to transparency, compliance and self-improvement. Figure 5.1 draws the similarity between a car dashboard and the proposed observatory. In the same way that while driving a car the driver wants to be sure that there is sufficient fuel, similarly, it is important to know that speed limit is not being exceeded. The Observatory provides, at-a-glance, the sector’s progress and achievements and could act as an early-warning indicator.

Figure 5.1: European Port Observatory Dashboard



Contributing to the observatory is also thought to be useful for individual ports because it brings them the chance to report in indicators that respond to port stakeholders' concerns, they are kept updated with the sector's progress and they are able to benchmark their performance against the EU average. In addition, their contribution may be helpful to increase their international reputation and prestige.

The responses to the pilot exercise of 74.5% for Carbon Footprint, 66% for waste management, 70.2% for water consumption and 93.6% for environmental management (see Table 5.1) demonstrate the sector's readiness and willingness to submit data related to the proposed EPIs. It is suggested that the data should be collected using the EPI Tool in order to provide a consistent calculation approach and reporting format.

Four major groups have been considered as the most relevant parties involved in the observatory: i) the ESPO Secretariat, which will manage and coordinate the development of the European Port Observatory, ii) the Scientific Advisory Committee (SAC) which consists of the academic partners involved in PPRISM and is responsible for analysing the input data, providing scientific advice and publishing the report progress, iii) The Steering Committee (STEC) that includes ESPO Technical Committees and representatives of the European Commission has the role of guiding and overseeing the Observatory's progress and performance, iv) The Forum of Contributing Ports that is a platform composed by ports that submit data to the observatory, and it aims to ensure that their concerns and suggestions are taken into account.

Bearing in mind the need for realistic, practicable and pragmatic management response options, it is recommended to submit data and information on an annual basis. Yearly reporting of monitoring results may be deemed sufficient for meaningful trends to be reported. The first contribution is expected to be presented at the ESPO Conference in Sopot (Poland) in May 2012, based on the PPRISM pilot results and data obtained from the public domain. In the second year of the observatory (2013) a publication on analysis and trends of the performance of the EU port sector will be released, developed by the Scientific Advisory Committee. It is proposed that, after 2014, the observatory will additionally take the form of a publicly available dashboard uploaded in the ESPO website, which is meant to be updated periodically.

The observatory results should be based on a sample of ports as representative as possible in order to encourage the culture of monitoring throughout the sector. Consistency of participating ports year-on-year would be the ideal. The development of the dashboard should be a phased exercise starting from first principles based on the pilot experience and evolving to a longer-term complexity as the sector gains and exchanges experience. Periods of consolidation will build confidence and produce meaningful benchmark performance indices.

The expected users of the outputs of the observatory include several parties, such as the contributing ports (ports that have provided data to the observatory), members of ESPO, national and European policy-makers, academic researchers and other users including media, consultants, and port stakeholders. Depending on the role of each interested party, the annual publications will either be free or subject to a fee.

The culture and practice of identifying, monitoring and reporting Environmental Performance Indicators is reasonably widely established within European ports with sufficient examples of existing good practice being reported for several years. A research focussed on existing experience and examples of monitoring and reporting indicators within the sector has been carried out in order to demonstrate the potential for delivering a representative dashboard of European port sector environmental performance. This section analyses the selected indicators through website research, identifying examples of best practice on management and operational indicators.

Management Performance Indicators

In Europe, the reporting of Environmental Management components has been well-established within the sector for 16 years through the EcoPorts/ESPO network. However, the benchmark performance of EPIs is not widely established outside Europe. A search through 125 websites of international port authorities (excluding Europe) was made in order to investigate aspects of their port environmental performance.

Although the aim was to research on the nine management indicators proposed, some certain key components were unlikely to be found in this research, and therefore, these indicators were replaced by others more likely to be analysed in a website research such as the existence of a separate environmental section in the website or whether the Environmental Policy is made available to the public.

Recognising that there is a wide range of ports throughout the sector, ports were selected that were representative of the different sizes and commercial profiles. 25 websites per continent were investigated, providing a total of 125 port authorities for analysis. North and Latin America were treated as different continents. Table 5.3 presents the overall results of each question per each continent in percentage of existence (‘yes’) and non-existence (‘no’). The table also includes the results from the ‘ESPO / EcoPorts Port Environmental Review 2009’ (122 European port authorities) and from the 28 British ports that participated in the ESPO questionnaire. Appendix XIII (page 228) provides a list of the international participant ports along with their size and the results of each question.

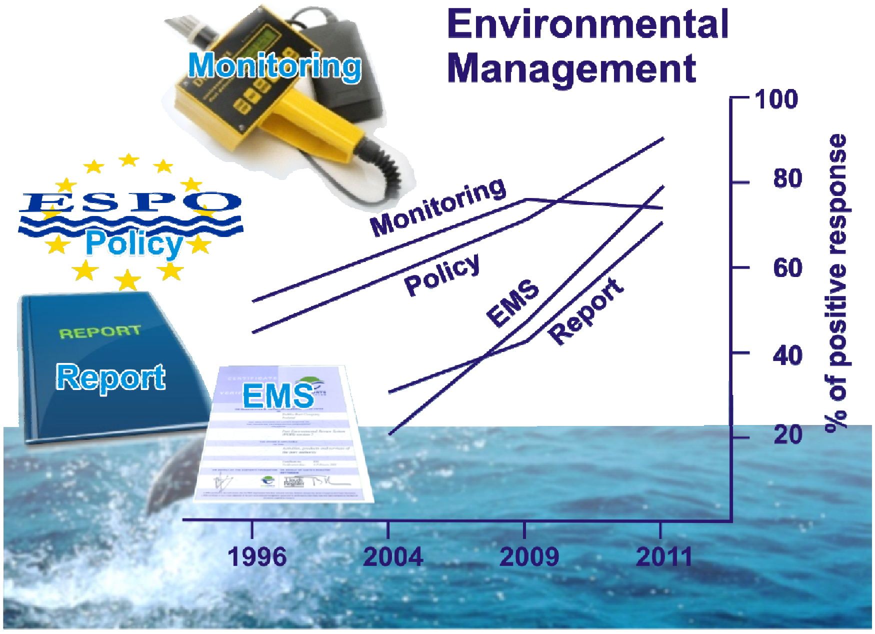
Table 5.3: Performance of environmental management of international ports

		Oceania		Asia		Africa		North America		Latin America		ESPO		UK	
	QUESTIONS	**% Y**	% N	**% Y**	% N	**% Y**	% N	**% Y**	% N	**% Y**	% N	**% Y**	% N	**%Y**	**%N**
1	Does the port have a separate environmental section in the website?	**56**	44	**4**	96	**20**	80	**16**	84	**20**	80	**69**	31	**86**	14
2	Does the port have any EMS?	**60**	40	**20**	80	**32**	68	**28**	72	**20**	80	**48**	52	**68**	32
3	Does the port have any Environmental Policy?	**72**	28	**28**	72	**36**	64	**44**	56	**28**	72	**72**	28	**89**	11
4	Is the Environmental Policy made available to the public?	**36**	64	**8**	92	**12**	88	**24**	76	**16**	84	**62**	38	**89**	11
5	Does the port publish an Environmental Report / Review?	**56**	44	**20**	80	**20**	80	**36**	64	**16**	84	**43**	57	**54**	46
6	Is environmental monitoring carried out in your port?	**72**	28	**32**	68	**40**	60	**56**	44	**24**	76	**77**	23	**71**	29
7	Has the port identified environmental indicators to monitor trends in environmental performance?	**44**	56	**16**	84	**24**	76	**44**	56	**8**	92	**60**	40	**68**	32
8	Does the port publish factual data by which the public can assess the trend of its environmental performance?	**4**	96	**0**	100	**8**	92	**20**	80	**0**	100	**36**	64	**43**	57
Average		**50**	**50**	**16**	**84**	**24**	**76**	**34**	**66.5**	**16.5**	**83.5**	**58**	**41.6**	**71**	**29**

Overall, the European port authorities tend to have a higher percentage in the existence of environmental management components, followed by the ports from Oceania. The results illustrate that in some continents, especially Asia and Latin America, further progress could be made. The components that have a better acceptance and implementation are the existence of an environmental policy, an EMS and a monitoring programme. In fact, these three components were shown to be the ones with highest scores in both, internal and external stakeholders' assessments.

The proposal for the European Port Observatory in environmental management components is presented in the following figure, which demonstrates progress through time.

Figure 5.2: Changes over time in components of environmental management



The responses from 1996, 2004 and 2009 were compiled from ESPO Environmental Reviews and the ones from 2011 from the EPI Tool. The sample did not include the same ports year-on-year and the size of sample was also different each year. Nevertheless, it can be stated that trends of progress are reasonably representative.

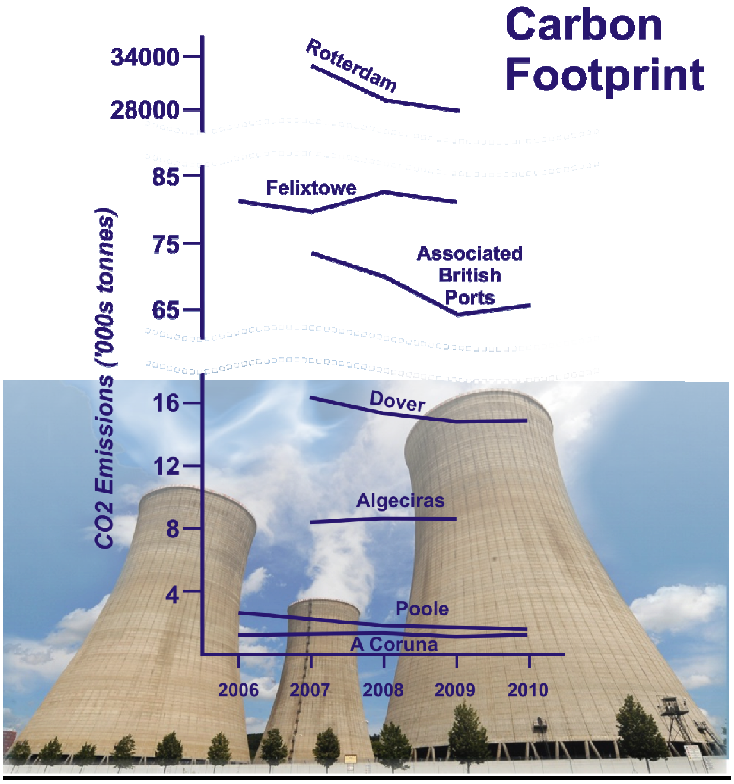
Operational Performance Indicators

Concerning the operational indicators, research about best practices in monitoring and reporting Carbon Footprint, waste management and water consumption in ports was made. The data were collected mainly from publicly available environmental reports or reviews uploaded in port authorities' websites or papers given in International Conferences. This information demonstrated that the selected indicators are currently measured within the sector, and there are a wide range of methodologies used in reporting results.

Increasingly, ports are committed to calculating and reporting their Carbon Footprint. This is demonstrated in Figure 5.3 which shows trends in CO_2 emissions at selected ports.

The graphic include examples of different size categories of ports. This image was submitted to ESPO as potential format for the EU Observatory of performance indicators.

Figure 5.3: Trends in Carbon Footprint emissions at selected ports



Amongst the main conclusions it is interesting to note that most of the researched ports have been calculating their Carbon Footprint since, at least, 2007. In addition, the majority of ports have experienced a reduction in their total emissions, the most significant being the port of Rotterdam, which has decreased its emissions by 15.5% between 2007 and 2009. Nevertheless, comparisons between these results must be treated with caution because they have not followed the same calculation methodology (they are usually either the Greenhouse Gas (GHG) Protocol or the methodology developed by the Climeport Project- see Section 2.4) and even more so because the results are not standardised to a common ground (tonnes of cargo, TEU's, or number of passengers).

As has been mentioned before, port Waste Management is a potentially complex issue in terms of the range of material and substances that may be defined as waste within any port area. In order to know what is generally being recycled by port authorities, a research was conducted investigating the current best practices, shown in Table 5.4 by seven

European ports. It is worth pointing out that this indicator only takes into account the port waste, not the ships waste because it is already regulated by the MARPOL Convention.

Table 5.4: Examples of waste management in European ports

Source	A Coruna	Algeciras	Cartagena	Castellon	Catalan Ports	Bilbao	Santander
Solid Waste							
Organic	1100 t		196.64 t	1152 t	4120 kg	410 t	
Paper	344 t	Total solid waste 1.3tonnes	8.82 t	1.4 t	861 kg	13.88 t	5540 kg
Plastics	57 t		3.9 t	10.1 t	0.095 m3		140 kg
Glass					10 kg		
Non-hazardous industrial waste							
Scrap metal				154 t	4873 kg	44.94 t	
Wood	3321 m^3			165 t	1 m3	1052 t	
Electronic waste			460 kg	0.19 t	54 u		
Polystyrene	4615 m^3						
Remains of nets	41 t						
Loading waste, sweepings and bulks	1257 t						
Aerosols		0.019 t					
Oil filters		0.14 t			4 u		
Floating debris				11.1 t			
Hazardous waste							
Ink cartridges	152 u		167 u		117 u		
Used Oil	2400 l	1 t		10 kg	3 l	3.383 t	1.5 t
Fluorescents	1201 l		160 kg	24 kg	209 u	228 kg	80 kg
Batteries		0.313 t	400 kg	499 kg	31.7 kg	823 kg	43 u

Port waste may be classified as i) solid waste, which includes organic waste, paper and cardboard, plastic and glass; ii) non-hazardous industrial waste, such as scrap metal, wood or electronic waste; and iii) hazardous waste, which includes ink cartridges, used oil, fluorescents and batteries. Reporting port waste itself is another complex issue due to the range of options by which it may be expressed. Some components may be reported in units, volume (litres or cubic meters) or weight (kilograms or tonnes).

Table 5.5 lists the top recycled wastes from the ports analysed and the number of times each topic was reported. This list provides an insight into the priority components that are considered feasible and relevant to recycle. The top position is for solid waste (paper, plastic and organic) followed by hazardous waste (fluorescents, used oil and batteries).

Table 5.5: Top recycled wastes from the ports analysed

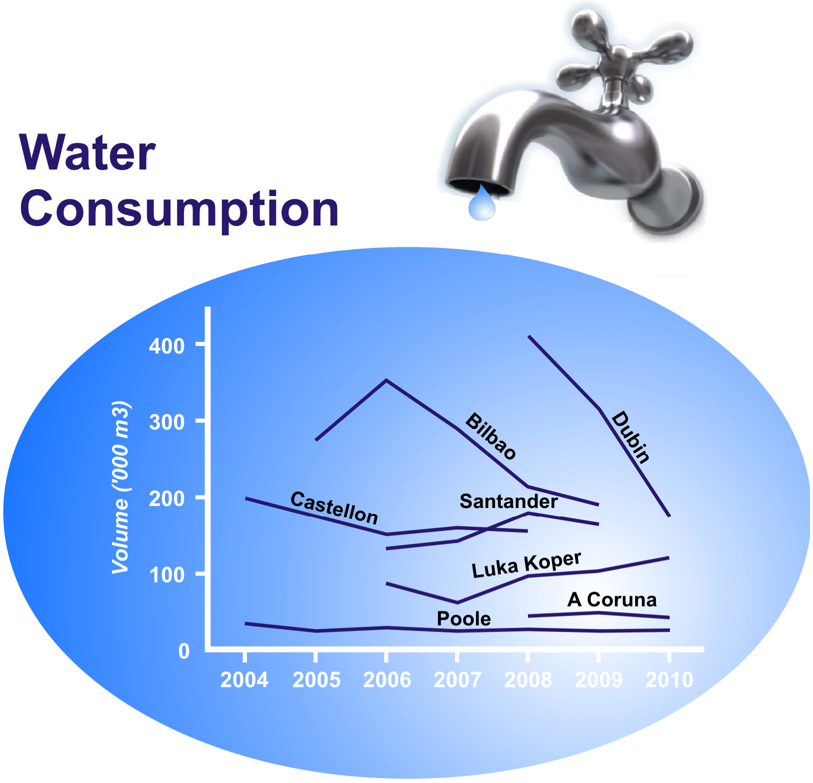
Top recycled wastes	Number of times reported
Paper	7
Plastic	6
Organic	6
Fluorescents	6
Used oil	6
Batteries	6
Wood	4
Electronic waste	3
Scrap metal	3
Ink cartridges	3
Oil filters	2

A proposal for the dashboard in terms of waste management is presented in Figure 5.4:

Figure 5.4: Trends in waste management at selected ports

Following the analysis of Carbon Footprint and Waste Management, a research on water consumption in port authorities was carried out. The results are presented in Figure 5.5:

Figure 5.5: Trends in water consumption at selected ports



The analysis demonstrates that, in general, the researched ports tend to decrease the total water consumption over the years, exemplified particularly in Dublin and Bilbao ports, which have had a reduction of 57.7% and 46.2% respectively. However, the evolution of the port commercial activities should be taken into account to draw confident conclusions.

While some ports have reported the water consumption only from the Port Authority usage, other ports having included the whole port area water consumption. Knowing the major water sources contributes to have a better water management and may lead to cost savings.

These examples of best practices have demonstrated that a culture of EPI monitoring is established within the sector, confirmed that some port authorities are willing to make information available, proved the feasibility of calculating and displaying trends, and provided detail of yearly changes and reduced environmental impacts.

6 Conclusions

This study has investigated the identification and selection of Environmental Performance Indicators (EPIs) for sustainable port management and the capacity for Port Authorities to adopt and implement them. Many findings have emerged as this research has progressed, which are identified and discussed in this chapter together with the implication they may have on future investigations. The research pathway has validated the research hypotheses and has fulfilled the research objectives established at the beginning of the research.

Initially, this thesis has confirmed, by providing facts and figures in Section 2.2, that the port sector and the shipping industry are vital for maintaining the global economy and the welfare of the current society. Modern ports are real economic generators, being able to handle any type of goods and being a major provider of direct and indirect jobs. In addition, it has been demonstrated that, compared with other transportation methods such as highway, railway and air transportation, shipping consumes less energy, produces fewer exhaust emissions and it has a smaller frequency of accidents per tonne of cargo moved.

Nevertheless, port authorities, although diverse in size, geographical surroundings, activity profile and administration, share a common factor: they all have to satisfy economic demands and industrial activity with sustainable development, compliance with legislation and cost and risk reduction. Any kind of economic and industrial activity has a certain impact on the environment and ports are no exception. Therefore, port environmental managers need to apply performance indicators in order to demonstrate status and progress, and the overall trends of these issues.

The thesis considers in Section 3.1 that the adoption and use of Environmental Performance Indicators may bring benefits and added-value to port authorities because indicators monitor the progress made, provide a picture of trends and changes over time, measure the extent to which environmental goals are being achieved, are helpful in building future objectives and targets and have a key role in providing early-warning information. In addition, legislative and regulatory pressures and local stakeholder expectations have increased the need for the sector to demonstrate its environmental credentials, to report initiatives, and to produce tangible evidence of progress. These reasons confirms the hypothesis i) which states that sustainable development of port area operations requires the use of appropriate EPIs.

In Section 3.4, the research has identified more than 300 indicators already in use or with potential for use, which demonstrate the variety of monitoring and environmental actions that are currently undertaken by some ports and prove the hypothesis ii) that there are a range of potential EPIs that may be applied to deliver effective environmental management. These indicators are classified into 25 sub-categories demonstrating the wide range of activities, tasks and responsibilities with which the port environmental management is involved. This confirms that port areas represent some of the most intensive and complex interactions at the point of contact between land and sea.

This comprehensive list of indicators may be seen as a helpful inventory for port managers to have a broader understanding of the indicators that may be applied for monitoring in ports. This list was also used as a baseline for the selection of the final set of indicators for the proposed Observatory of Port Performance (ESPO).

The related project (PPRISM) evolved with the analysis and examination of each indicator against specific criteria, reducing them to 37 indicators categorised as potential indicators for use. After discussions with port and marine professionals, and both quantitative and qualitative assessments from a wide range of port stakeholders, a final set of twelve indicators was proposed: a checklist of nine Environmental Management indicators and three operational indicators, namely Carbon Footprint, waste management and water consumption. These indicators are presented and described in chapter 4.

This research led to the recommendation of the three operational indicators that were accepted by ESPO for use in the proposed Observatory. The research confirms that the three operational indicators are appropriate for implementation within European ports because they are related to high priority issues identified by port professionals in successive ESPO Environmental reviews. The nine environmental management indicators are also recommended for adoption because they are measures of the port authority's and sector's competence and capability to manage. As seen in Table 2.2, environmental priority issues change with time and, therefore, relevant EPIs may also have to change with time and circumstances. However, if effective management indicators are in place, the port would have the ability to manage a wide range of environmental issues and to deliver environmental protection and sustainability as such changes occur. All the proposed components are related to terminology of recognised environmental management standards.

In order to assist port authorities in calculating and reporting the proposed indicators, a user-friendly methodology was developed as part of this research pathway, called the EPI Tool and introduced in chapter 5. This tool was sent to all ESPO members encouraging them to calculate and report the proposed indicators and to adopt these indicators within their environmental programme. For the ports that had not calculated these indicators before, the tool provided an opportunity to initiate and implement an appropriate programme because it gave them service support in carrying out the calculations. Ports that had previous experience of those calculations were asked to provide the port sector with environmental performance data (with the promise that this would be treated in confidence and reported anonymously). The tool includes guidelines for use, the calculation method itself, and a reporting approach that produces graphics readily adapted to be included in an Environmental Report. The development of the EPI Tool has the potential to make a significant contribution to the sector's proposed Observatory because ports that have adopted the tool can build on their performance on a yearly basis with a consistent methodology.

The overall replies and contributions from ports are in line with the previous feedback responses from stakeholders. This confirms the general feasibility and acceptability of the proposed indicators. The answers from port authorities proved that a culture of EPI monitoring is already established within the sector and some port authorities are willing to make information available. Both quantitative and qualitative data and information is available that could readily be incorporated into a meaningful 'dashboard' (see Figure 5.1) of European, port sector, environmental performance. The hypothesis iii) that port professionals are actively and currently using EPIs has been validated with many examples of existing good practice having been reported for several years.

The total number of respondents may reasonably be claimed as a representative coverage of the sector in terms of the size of ports as it includes results from each of the four size categories as recognised by ESPO. Similarly, it may be suggested that participating or contributing ports were representative in terms of the geographical locations with results from 23 different European maritime states being included. The feedback obtained from port authorities contributed to the amendment of the tool.

Once the proposed indicators were proved to be satisfactory, the research continued to demonstrate that what is representative to profile the sector's performance is to display trends of performance rather than absolute values. Examples of best practices in monitoring and reporting indicators over time among European ports were researched, proving in Section 5.3 that the selected indicators are currently measured within the sector. The research shows that although the challenge of the harmonisation of tools, methodologies and techniques remain, trends of progress are reasonably representative.

The research has revealed the port sector's progress to date. However, there is scope for further adoption and implementation of EPI use within port Environmental Management Programmes. Firstly, the use of environmental indicators should be further promoted and encouraged throughout European port authorities via Port Associations, Training Programmes, and international conferences. This requires an integrated communication exercise and ESPO and national port associations are well-placed to achieve this end. Secondly, the developed Tool could be presented to port authorities as a science-based and user-friendly methodology to assist the calculation and reporting of the indicators. There are more than 1200 ports in Europe and the challenge is to involve as many of them as possible.

The implementation of Environmental Performance Indicators and the adoption of the Tool are of mutual benefit to several interested parties. Individual port authorities can use the indicators to provide summarized data on their environmental performance, and the tool facilitates their calculation and reporting. National port organisations may apply the indicators in order to provide evidence of pro-active monitoring and reporting. The port sector in general may demonstrate its overall performance using the indicators to show at-a-glance trends. Finally, the European Commission can see the extent to which European Directives are being put into practice.

The study aimed at selecting indicators appropriate and relevant for the European port sector as a whole. As a consequence, the proposed indicators considered environmental issues which tend to be shared by all European ports. Nevertheless, there are 'site specific' indicators according to the characteristics of each port that also should be taken into account. It is recommended that ports also adopt the most appropriate indicators relevant to their Significant Environmental Aspects, especially in the case of environmental condition indicators.

Overall, the three research objectives specified at the beginning of the research have been achieved:

i) A set of key Environmental Performance Indicators for sustainable port management in European Ports have been identified, analysed, assessed and accepted by the port community.

ii) A science-based tool has been delivered for the effective application of these selected indicators.

iii) A proposal for a future European Port Observatory has been provided based on examples of current best practices in European port authorities.

Future research

Based on the experience of this research pathway, it may reasonably be suggested that future research into this subject area could usefully focus on:

- The development of EPI-specific tools for application where ports require local action responses.
- The development of an EPI protocol specifically designed for the special cases of small ports.
- Integrated management of port and shipping interests through agreed programmes and the calculation of appropriate indices.
- Further research into the application of EPIs to Environmental Management of the Logistic Chain.

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Glossary of terms

Environmental aspect: Element of the Port Authority's activities, products or services which can interact with the environment.

Environmental audit: A systematic evaluation to determine whether or not the environmental management system and environmental performance comply with planned arrangements, and whether or not the system is implemented effectively, and is suitable to fulfil the Port Authority's environmental policy.

Environmental impact: Any change to the environment, whether adverse or beneficial, wholly or partially resulting from the Port Authority's activities, products or services.

Environmental issue: A generic term for all natural and commercial resources, environmental impact or effects and user /operator conflicts relevant to management.

Environmental management: Management that enables the Port Authority to establish an environmental policy and objectives comply with them and demonstrate them to the outside world. The policy must be relevant to the Port Authority's activities, products, services and their environmental effects. It should also be understood, implemented and maintained at all staff levels.

Environmental management program: A description of the company's specific objectives and activities to ensure protection of the environment at a given site, including a description of the measures taken or envisaged to achieve such objectives and where appropriate the deadlines set for implementation of such measures.

Environmental Management System: The part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy.

Environmental objective: Overall environmental goal, arising from the environmental policy, that an organisation sets itself to achieve, and which is quantifiable where practicable.

Environmental performance: Measurable outputs of the environmental management system, relating to the Port Authority's control of the impacts of its activities, products or services on the environment, based on its environmental policy, objectives and targets.

Environmental Performance Indicator (EPI): A specific expression providing information about an organisation's environmental performance.

Environmental policy: Statement by the Port Authority of its intentions and principles in relation to its overall environmental performance which provides a framework for action and for the setting of its environmental objectives and targets.

Environmental review: an initial comprehensive analysis of the environmental issues, impact and performance related to activities in the port area.

Environmental target: detailed performance requirement, quantified where practicable that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives.

Monitoring: Activity involving repeated observation, according to a pre-determined schedule, of one or more elements of the environment to detect their characteristics (status and trends).

Significant Environmental Aspect: An aspect with a significant impact on the environment. Screening for significance: can be based on legal requirements, policy statements and risk analysis of the impact of the aspect. If an impact is regarded as significant (e.g. opinion of stakeholders), the aspect has to be regarded as significant.

Appendices

Appendix I: ESPO Environmental Review 2009: participating ports

Appendix II: Environmental legislation affecting ports

Appendix III: Port associations

Appendix IV: Research projects

Appendix V: Selection of indicators

Appendix VI: ESPO SD Committee Assessment form

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Appendix IX: On-line survey

Appendix X: EPI Tool

Appendix XI: Step-by-step guide to EPI Tool

Appendix XII: EPI Tool results

Appendix XIII: List and results of international research

Appendix I: ESPO Environmental Review 2009: participating ports

Table App.1: ESPO Environmental Review 2009: list of participating ports

Number	Name	Country	Website
1	Hamburg	Germany	www.hpa-hamburg.de
2	Dublin	Ireland	www.dublinport.ie
3	Koper	Slovenia	http://www.luka-kp.si/eng/
4	Thessaloniki	Greece	www.thpa.gr
5	Calais	France	http://www.calais-port.com
6	Galway	Ireland	www.galwayharbour.com
7	Le Havre	France	http://www.havre-port.fr
8	Lerwick	UK	www.lerwick-harbour.co.uk
9	Aberdeen	UK	http://www.aberdeen-harbour.co.uk
10	Constantza	Romania	www.constantza-port.com
11	Portland	UK	www.portland-port.co.uk
12	Port	Finland	www.portofturku.fi
13	Kotka	Finland	http://www.portofkotka.fi
14	Genoa	Italy	www.porto.genova.it/
15	Aviles	Spain	www.puertoaviles.com
16	Huelva	Spain	http://www.puertohuelva.com
17	Le Légué	France	http://cci-cotesdarmor-prod.audaxis.com/
18	Vigo	Spain	www.apvigo.es
19	Skagen	Denmark	www.skagen-havn.dk
20	Ghent	Belgium	www.skagen-havn.dk
21	Rønne	Denmark	www.roennehavn.dk
22	Copenhagen	Sweden	www.cmport.com
23	Harwich	UK	www.harwich.co.uk
24	London Thamesport	UK	www.londonthamesport.co.uk
25	Fowey	UK	www.foweyharbour.co.uk
26	Dover	UK	www.doverport.co.uk
27	Felixstowe	UK	www.portoffelixstowe.co.uk
28	Tor Bay	UK	www.tor-bay-harbour.co.uk
29	kolding	Denmark	www.koldingport.dk
30	Milford Haven	UK	www.mhpa.co.uk
31	Thyboron	Denmark	www.thyboronport.dk
32	Stockholm	Sweden	www.stoports.com
33	Landskrona Hamn AB	Sweden	www.landskrona-hamn.se
34	Helsingborg	Sweden	www.port.helsingborg.se
35	Larne	UK	www.portoflarne.co.uk
36	Nordfjord	Norway	www.nordfjordhavn.no
37	Bremen	Germany	www.wirtschaft.bremen.de
38	Ostfriesische Insel- und Küstenhäfen	Germany	N/A
39	Gävle	Sweden	www.wirtschaft.bremen.de

Number	Name	Country	Website
40	Karlshamn	Sweden	www.wirtschaft.bremen.de
41	Emden	Germany	www.emden-port.de
42	Peterhead	UK	www.peterheadport.co.uk
43	Brunsbüttel	Germany	www.schrammgroup.de
44	Cardiff, Barry, Port Talbot & Swansea	UK	www.severnvts.co.uk
45	Lübecker Hafen Gesellschaft	Germany	www.lhg-online.de
46	Hvide Sande	Denmark	www.hvidesandehavn.dk
47	Brake	Germany	www.nports.de
48	Sassnitz	Germany	www.faehrhafen-sassnitz.de
49	Southampton	UK	www.southamptonvts.co.uk
50	Amsterdam	Netherlands	www.portofamsterdam.nl
51	Rostock	Germany	www.rostock-port.de
52	Falmouth Docks	UK	www.ap-group.co.uk
53	Göteborg	Sweden	www.portgot.se
54	Bilbao	Spain	www.bilbaoport.es
55	Piraeus	Greece	www.olp.gr
56	Dubrovnik	Croatia	www.portdubrovnik.hr
57	Rijeka	Croatia	www.portauthority.hr/rijeka
58	Grimsby & Immingham	UK	www.abports.co.uk
59	Plymouth	UK	www.abports.co.uk
60	Falmouth	UK	www.falmouthport.co.uk
61	Teignmouth	UK	www.abports.co.uk
62	Waterford	Ireland	www.abports.co.uk
63	Cork	Ireland	www.portofcork.ie
64	Lowestoft	UK	www.abports.co.uk
65	Ayr & Troon	UK	www.abports.co.uk
66	Ploce	Croatia	www.port-authority-ploce.hr
67	Tyne	UK	www.portoftyne.co.uk
68	Tallinn	Estonia	www.portoftallinn.com
69	Nakskov	Denmark	N/A
70	València	Spain	www.valenciaport.com/
71	A Coruña	Spain	www.puertocoruna.com
72	Odense	Denmark	www.odensehavn.dk
73	Korsoer	Denmark	www.odensehavn.dk
74	Marseille	France	www.marseille-port.fr
75	Puerto de Marin	Spain	www.apmarin.com
76	Santander	Spain	www.puertosantander.es
77	Gijón	Spain	www.puertosantander.es
78	Paris	France	www.paris-ports.fr
79	Aalborg	Denmark	www.aalborghavn.dk
80	Castelló	Spain	www.portcastello.com
81	Oslo	Norway	http://www.oslohavn.no/english/
82	Alicante	Spain	www.puertoalicante.com

Number	Name	Country	Website
83	Aarhus	Denmark	www.aarhushavn.dk
84	Belfast	UK	www.belfast-harbour.co.uk
85	Antwerp	Belgium	www.portofantwerp.com
86	Grenaa	Denmark	www.port-of-grenaa.com
87	Koege	Denmark	www.koegehavn.dk
88	Pietarsaari	Finland	www.portofpietarsaari.fi
89	Teignmouth	UK	www.teignmouthharbour.com
90	Ramsgate	UK	portoframsgate.co.uk
91	Cannes	France	www.riviera-ports.com
92	Brest	France	http://www.brest.port.fr/
93	Bristol	UK	http://www.bristolport.co.uk/
94	la Rochelle	France	www.larochelle.port.fr
95	Randers Havn	Denmark	www.randershavn.dk
96	Varna	Bulgaria	http://www.bgports.bg/
97	la Nouvelle	France	http://www.port-la-nouvelle.com/
98	Rotterdam	Netherlands	www.portofrotterdam.com
99	Sundsvall oljehamn AB	Sweden	http://www.sundsvallshamn.se/
100	Norrköpings Hamn och Stuveri AB	Sweden	http://www.norrkoping-port.se/
101	Hargshamn	Sweden	www.hargshamn.se
102	Halmstad	Sweden	http://www.halmstadharbour.se/
103	Neath	UK	No website
104	Rouen	France	www.rouen.port.fr
105	Trelleborg	Finland	www. trelleborgshamn.se
106	Oulu	Finland	www.ouluport.com
107	Zeeland	Netherlands	www.zeeland-seaports.com
108	Harlingen	Netherlands	www.harlingen.nl
109	Riga	Latvia	http://www.freeportofriga.lv/
110	Dunkerque	France	www.portofdunkerque.com
111	Associated Danish Ports	Denmark	www.adp-as.com
112	Hirtshals	Denmark	portofhirtshals.com
113	Trelleborg	Sweden	http://www.trelleborgshamn.se/en
114	Visby	Sweden	www.visbyport.com
115	Shannon Foynes	Ireland	www.sfpc.ie
116	Zeebrugge	Belgium	www.portofzeebrugge.be
117	Helsinki	Finland	www.portofhelsinki.fi
118	Algeciras	Spain	www.apba.es
119	Poole	UK	www.phc.co.uk
120	Limassol	Cyprus	www.cpa.gov.cy
121	Galati	Romania	www.romanian-ports.ro
122	Barcelona	Spain	www.apb.es

Appendix II: Environmental legislation affecting ports

International conventions

Table App.2: Environmental international conventions affecting ports

Name, acronym and year	Description
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION), 1969	The INTERVENTION Convention affirms the right of a coastal state to take such measures on the high seas as may be necessary to prevent, mitigate or eliminate danger to its coastline or related interests from pollution by oil. In view of the increasing quantity of other substances, mainly chemicals, carried by ships, the Convention was extended with the International Convention Relating to Intervention on the High Seas in Cases of Marine Pollution by Substances other than Oil (1973).
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention)	The London Convention has a global character, and contributes to the international control and prevention of marine pollution. It prohibits the dumping (deliberate disposal at sea) of certain hazardous materials, requires a special permit for the dumping of a number of other identified materials and a general permit for other wastes.
International Convention for the Safety of Life at Sea (SOLAS), 1974	The SOLAS Convention is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The main objective of the SOLAS Convention is to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements.
International Convention for the Prevention of Pollution from Ships (MARPOL) 1973/1978.	The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships. Its regulations aim at preventing and minimizing pollution from ships and it contains six technical Annexes including Regulations for the Prevention of Pollution by Oil, Noxious Liquid Substances in Bulk, Harmful Substances Carried by Sea in Packaged Form, Sewage from Ships, Garbage from Ships and Air Pollution from Ships.
International Convention on Standards of Training, Certification and Watchkeeping (STCW), 1978.	The STCW Convention was the first to establish basic requirements on training, certification and watchkeeping for seafarers on an international level. Previously, the standards of training, certification and watchkeeping were established by individual governments, usually without reference to practices in other countries. As a result, standards and procedures varied widely.

Name, acronym and year	**Description**
International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), 1990	Ships are required to carry an oil pollution emergency plan and to report incidents of pollution to coastal authorities. The convention details the actions that are to be taken in case of accident. A Protocol to the OPRC relating to hazardous and noxious substances (OPRC-HNS Protocol) was adopted in March 2000 and entered into force in June 2007.
International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS), 2001	The Convention prohibits the use of harmful organotins in anti-fouling paints used on ships and establishes a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.
International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM), 2004	The Convention aims to prevent the potentially devastating effects of the spread of harmful aquatic organisms carried by ships' ballast water from one region to another. The Convention will require all ships to implement a Ballast Water and Sediments Management Plan. Although it was adopted in February 2004, it is not yet in force because it has not been ratified by, at least, 30 States, which represents the 35 per cent of world merchant shipping tonnage.
The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009	The Convention is aimed at ensuring that ships, when being recycled after reaching the end of their operational lives; do not pose any unnecessary risk to human health and safety or to the environment.

Source: Adapted from International Marine Organisation, 2011

European Directives

Table App.3: Environmental European directives affecting ports

Name, acronym and year	Description
Conservation of Wild Birds Directive 1979/409/EEC	This Directive provides a comprehensive scheme of protection for all wild bird species naturally occurring in the EU. It was adopted as a response to increasing concern about the declines in Europe's wild bird populations resulting from pollution, loss of habitats as well as unsustainable use.
Environmental Impact Assessment (EIA) Directive 1985/337/EEC (Amended by 2009/31/EC)	EIA Directive aims to provide a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation of individual projects with a view to reduce their environmental impact.
Conservation of Natural Habitats and of Wild Flora and Fauna Directive 1992/43/EEC	Habitats Directive aims to protect over 1.000 animals and plant species and over 200 so called ‘habitat types’ (e.g. special types of forests, meadows, wetlands), which are of European importance.
VOC Emissions Directive 1994/63/EC	VOC controls the Volatile Organic Compound emissions resulting from the storage of petrol in terminals and its distribution from terminals to service stations.
Ambient Air Quality Assessment and Management Directive 1996/62/EC	This Directive lays down the basic principles of a strategy for establishing quality objectives for ambient air, drawing up common methods and criteria for assessing air quality and obtaining and disseminates information on air quality.
IPPC Directive 1996/61/EC	Integrated Pollution Prevention and Control (IPPC) Directive controls the emissions from a wide range of industrial installations.
WIPD Directive 2000/76/EC	Waste Incineration Plants Directive sets operational conditions and technical requirements for Waste Incineration Plants**.**
Water Framework Directive 2000/60/EC	The Directive commits EU Member States to achieve good qualitative and quantitative status of all water bodies by 2015. It is a framework in the sense that it prescribes steps to reach the common goal rather than adopting the more traditional limit value approach.
Port reception facilities for ship-generated waste and cargo residues Directive 2000/59/EC	The Directive goes one step further than the MARPOL Convention by addressing in detail the legal, financial and practical responsibilities of the different operators involved in the delivery of ship generated waste and cargo residues in European ports.

Name, acronym and year	Description
LCP Directive 2001/80/EC	Large Combustion Plants Directive controls the air emissions of certain pollutants from Large Combustion Plants.
Strategic Environmental Assessment (SEA) Directive 2001/42/EC	SEA Directive aims to provide a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation of public plans or programmes with a view to reduce their environmental impact.
Assessment and Management of environmental Noise Directive 2002/49/EC	Noise Directive is aimed at controlling noise perceived by people in built-up areas, in public parks or other quiet areas in an agglomeration, in quiet areas in open country, near schools, hospitals and other noise-sensitive buildings and areas.
Community vessel traffic monitoring and information system and repealing Directive 2002/59/EC	This directive aims to establish a European Union (EU) vessel traffic monitoring and information system with a view to enhancing safety and minimising the environmental impact of shipping accidents. It sets the requirements for the notification of dangerous and polluting goods carried on board ships.
Public Access Environmental Information Directive 2003/04 EC	The Directive obliges port administrations to possess and update environmental information relevant to their activities and make, on their own initiative, this information available on electronic databases that are publicly and easily accessible.
Environmental Liability Directive 2004/35/EC	The Directive establishes a framework for environmental liability based on the “polluter pays” principle, with a view to preventing and remedying environmental damage.

Source: Adapted from EUR-Lex Access to European Union Law, 2011

Appendix III: Port associations

National level

Table App.4: Examples of port associations at a national level

Name	Description
Ports Australia	Ports Australia represents the marine and port authorities in Australia and aims to promote public awareness, understanding and support for ports' contribution to national and regional development and their key role in transport supply chains. Ports Australia has contributed to the development of policies, strategies and guiding principles for port sustainable activities.
British Ports Association (BPA)	BPA was created in 1992 and represents the interests of its 85 full members and numerous associate members. The response of the British ports' sector to environmental responsibilities has been progressively more supportive and proactive in terms of initiatives, projects and programmes involving management schemes, training, monitoring, research and collaborative involvement in coastal zone management and conservation issues.
Associated British Ports (ABP)	ABP owns and operates 21 ports all around the UK and handles approximately a quarter of the country's seaborne trade. ABP has implemented an Environmental Policy which seeks to establish a balance between the need to act commercially and their commitment to the environment.

Source: Port associations' websites, 2011

Regional level

Table App.5: Examples of port associations at a regional level

Name	Description
European Sea Ports Organisation (ESPO)	ESPO was founded in 1993 and represents the European ports, focussing on the development of a common European port policy, in which ESPO gives priority to the environment. One of the first ESPO tasks was the publication of the Environmental Code of Practice in 1994, which was the first European code for ports, setting out the basic principles of environmental management applicable to all types of ports. A reviewed Environmental Code of Practice was published in 2003, taking into consideration the policy and practice evolutions since 1994. Two codes more have been published, the ESPO Code of practice on the Birds and Habitats Directives in 2006 which set out recommendations to port managers working with the Birds and Habitats Directives and the ESPO Code of Practice on

	Societal Integration of Ports in 2010, which encouraged members to be pro-active the field of societal function of ports. Apart from the Codes of practice, ESPO has conducted environmental surveys on a regular basis in order to identify the issues that are at stake for EU ports in the field of environment and to establish a port sector's European benchmark of environmental performance. The first survey was conducted in February 1996 and 281 ports from 15 different European countries took part in this questionnaire. In 2004, a second study was undertaken, receiving answers from 129 ports. Finally, in 2009 a third major environmental survey was carried out, updating the results of previous similar exercises and assessing the progress that has been achieved over the past 14 years. The innovation was the development of a web based tool, which made easier the completion of the review online and facilitated the analysis of the results. Furthermore, every year since 2001, ESPO has published an Annual Report. These reports describe improvements in environmental aspects, activities carried out by ESPO during the year, ESPO members and structure, European port statistics, among others.
EcoPorts Foundation (EPF)	The EcoPorts Foundation (EPF) is a non-profit organisation established in 1999 as a formal structure for the exchange of experience in areas of port environment and sustainability. EcoPorts Foundation developed voluntary projects such as the ECOPORTS Project (1997-1999) and promoted best environmental practice. This research project led to the development and implementation of environmental management tools such as the Self Diagnosis Method (SDM), the Port Environmental Review System (PERS) certification or a Noise management system. Other activities carried out by the Foundation were environmental training of port managers, creation of a solutions' database (exchange of experiences and best practices) and the organisation of workshops and international conferences. Since February 2011, EcoPorts is integrated within the structure of ESPO and the EcoPorts tools SDM and PERS are available to the broad ESPO membership.
American Association of Port Authorities (AAPA)	AAPA was founded in 1912 and is a trade association which represents more than 160 public port authorities in the United States, Canada, the Caribbean and Latin America. AAPA promotes the common interests of the port community, and provides leadership on trade, transportation, environmental and other issues related to port development and operations. Since 1973, AAPA has recognized best environmental practices in the port industry celebrating the Environmental Improvement Awards.

Name	Description
California Association of Port Authorities (CAPA)	CAPA has been in existence since 1940 and is committed to promoting the interests of California's ports, maintaining the state's leading role in the maritime industry, and leading the way in innovative and cutting edge environmentally-friendly port operations. The ports employ environmental planning departments to ensure compliance with state, regional, and local regulations. CAPA works regularly with local jurisdictions, local communities and other interests to pursue long-term solutions to goods movement challenges, including the protection of the environment.
Baltic Ports Organisation (BPO)	BPO represents forty ports in nine countries on all sides of the Baltic Sea. The main objective of the organisation is to improve the competitiveness of maritime transport in the Baltic region by increasing the efficiency of ports. It also aims to improve co-operation with port users and operators, authorities and interest groups; apply new technology in the port sector, and promote good environmental behaviour.
Port Management Association of Eastern and Southern Africa (PMAESA)	PMAESA is a regional organisation for the ports and maritime sector in Eastern and Southern Africa. It seeks to promote best practices among member ports by creating an enabling environment for exchange of information and capacity building to contribute to the economic development of the region.
European Federation of Inland Ports (EFIP)	EFIP is acting as the unique voice of nearly 200 inland ports in 19 countries in Europe since 1994. EFIP highlights and promotes the role of inland ports as nodal points for intermodal transport, combining road, rail, maritime and inland waterway transport. EFIP actively follows all developments in the field of EU transport and environmental representing the inland ports to the European institutions.
North Adriatic Ports Association (NAPA)	NAPA is composed by five port authorities: port of Ravenna, Venice, Trieste, Koper and Rijeka. The association anticipates cooperation in the development of maritime and hinterland connections, visits from cruise lines, environmental protection, safety and information technology.

Source: Port associations' websites, 2011

International level

Table App.6: Examples of port associations at an international level

Name	Description
International Maritime Organisation (IMO)	IMO is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. It has promoted the adoption of around 50 conventions and protocols and adopted more than 1.000 codes and recommendations concerning maritime law such as safety issues, rescue, lifesaving appliances, fishing ships' safety, load lines, flag state implementation, and oil pollution. Examples of environmental significant conventions adopted by IMO are mentioned in Table 2.3.
International Association of Cities and Ports (IACP)	IACP is an international network of public and private stakeholders implicated in the sustainable development of the port city. IACP brings together elected representatives of cities and other local government, maritime, and waterway bodies; port administrations and their national tutelary authorities, urban and port operators; enterprises installed in port cities; service providers for city – port projects, architects, landscape architects, and urban planners and universities and research institutes. It aims to build contacts between the cities and their ports, creating an international exchange of knowledge and experience as well as showing the projects and achievements that port and cities have accomplished.
GreenPort Journal	GreenPort is a quarterly magazine which provides business information on environmental best practice and corporate responsibility centred on marine ports and terminals, including shipping, transport and logistics. It provides analysis of the latest trends and opinions, offering case studies, interviews and project based features. GreenPort also produces the highly respected series of annual GreenPort conferences and events, such as the GreenPort Conference or the GreenPort Congress. The emphasis of these events is to examine practical, economically viable solutions as well as applications and case studies.
International Association of Ports and Harbours (IAPH)	IAPH represents today 230 ports in about 90 countries. Its principal objective is to develop and foster good relations and cooperation among all ports and harbours in the world by proving a forum to exchange opinions and share experiences on the latest trends of port management and operations. IAPH strives to emphasize and promote the fact that ports form a vital link in the waterborne transportation and play such a vital role in today's global economy. On April 2008, the International Association of Ports and Harbours requested its Port Environment Committee to provide a mechanism for assisting the ports to combat climate change. In July 2008, the C40 World Ports Climate Declaration

	was adopted when 55 ports from all over the world came together at the C40 World Ports Climate Conference in Rotterdam to commit to jointly reduce the threat of global climate change. Following-up the conference appeared the World Port Climate Initiative. Although it is related to the IAPH, it has been treated as a separate organisation in this report.
World Port Climate Initiative (WPCI)	Its missions are to raise awareness in the port and maritime community of need for action; initiate studies, strategies and actions to reduce port emissions and improve air quality; provide a platform for the maritime port sector for the exchange of information; make available information on the effects of climate change on the maritime port environment and measures for its mitigation. Past and current projects include: Low Emission Yard Equipment, On-shore Power Supply, Carbon Footprint, Environmental Ship Index and Efficient Lighting, Intermodal Transport and sustainability in Lease Agreements.

Source: Port associations' websites, 2011

Appendix IV: Research projects

Table App.7: Description of selected research projects

Project name, acronym and years	Description
Environmental Challenges for European Port Authorities (ECEPA) 1995 - 1996	ECEPA Project demonstrated new technologies for cleaner environment. A guideline titled "Soil Recycling in European Ports" was developed and the practical benefits of sharing knowledge on technological and procedural solutions for re-use of contaminated port sites were demonstrated.
Methodologies for estimating air pollutant emissions from transport (MEET) 1996 – 1997	The overall objective of the project was to develop and provide models to estimate and evaluate the impact of transport on air pollutant emissions and energy consumption.
MARPOL rules and ship generated waste (EMARC) 1996 – 1997	The project assessed the effects of MARPOL Regulations on the port environment throughout Europe and investigated systems for the management of ships' waste.
ECO-Information in European ports (ECO-Information) 1997-1999	The project aimed to improve environmental conditions in port areas by developing an extended network of port authorities, acting as a catalyst for action amongst many European port authorities and stimulating considerable progress in port environmental management. The project developed an environmental information-system which was mainly based on i) a diagnosis tool, ii) an information engine, and iii) a communication platform. The Self Diagnosis Method 98 was a diagnosis tool that allowed ports to assess their environmental situation and performance by supporting environmental port managers to periodically review their port's environmental performance and the progress achieved through time. The information engine was an on-line database containing practical experiences from projects of ports, concerning the development and implementation of environmental solutions. A communication platform was the ECO-website (www.ecoports.com) offering the opportunity for the ports to find and exchange information and to get in touch with specialists in each port.

Project name, acronym and years	Description
Harbours - Silting and Environmental Sedimentology (H-SENSE) 1998 – 2001	H-SENSE project aimed at developing a predictive sedimentological model for the management of harbour activities with regard to silting and the evaluation of environmental pollution.
Towards an Environmentally Friendly Port Community (ECOPORT) 1998 – 2000	The aim of the project was to develop a methodology that would enable port areas to adopt Environmental Management Systems and meet the EU requirements for a sustainable and environmentally-friendly European Transport Policy. It was undertaken by the Valencia Port Authority and co-funded by the European Union.
Automatic Tool for Environmental Diagnosis (HADA) 2002 – 2005	The main objectives of the project were to design a system for air quality control in port areas, to create a system for monitoring and reducing noise levels, to develop a particle emission model and to create a real-time decision-making and response system for taking action in the event of irregular situations.
Port Environmental Indicator System (INDAPORT) 2002 – 2003	INDAPORT Project aimed at obtaining an Environmental Indicator System that provides the most precise information possible on the state and the evolution of the environment within the port boundary.
Information exchange and impact assessment for enhanced environmental conscious operations in European ports and terminals (ECOPORTS) 2002 – 2005	The main goals of ECOPORTS Project were to harmonise the environmental management approach of port authorities in Europe, to exchange experiences in order to avoid double work and to implement best practices in respect of port-related environmental issues. The products of the project were an Environmental Management and Information System (EMIS) which included a training system, a Decision-Support System (DSS), a Strategic Overview of Significant Environmental Aspects (SOSEA), a Self Diagnosis Method (SDM), and a Port Environmental Review System (PERS). These tools and methodologies continued available for port authorities after the end of the project.
Environmental Integration for Ports and Cities (SIMPYC) 2004 – 2008	SIMPYC Project aimed at finding solutions to some of the problems arising from port-city relations by co-ordinating the actions between ports and city councils. It also aimed at providing solutions to the environmental management of fishing and leisure ports located in small municipalities.

Project name, acronym and years	Description
Noise Management in European Ports (NoMEPorts) 2005-2008	The project’s objective was the reduction of noise, noise related annoyance and health problems of people living around port industrial areas through demonstration of a noise mapping and management system and through the development of a Good Practice Guide.
Port Environmental Information Collector (PEARL) 2005-2008	PEAR Project focused on the development of a Port Environmental Management System Platform capable of optimal exploitation of space and in situ data products and models.
Regeneration of Port-Cities: Elefsina Bay 2020 (ELEFSINA) 2005 – 2009	The project established a collaborative approach to the integrated socio-environmental regeneration of the urban agglomeration of the Bay of Elefsina.
Risk Management Systems for Dangerous Goods Transport in Mediterranean Area (MADAMA) 2006 – 2008	Its main objective was to understand, define and harmonise actions in relation to the control and protection of dangerous goods in the transport chain and improve the security and risk control and management by the use of ICT tools in order to obtain a sustainable mobility and better environment in the Mediterranean area.
Energy Efficiency in Container Port Terminals (EFICONT)	The project consisted in integrating a set of significant improvement measures in terms of energy efficiency in ports, especially in container port terminals (CPTs) by improving the port productivity and by reducing the operational cost and increasing the competitiveness of the companies.
Effective Operation in Ports (EFFORTS) 2006 – 2009	EFFORTS was a project focussed on improving EU port operations competitiveness and sustainability, enhancing the communication among the port communities and enhancing the use of innovative sustainable solutions in EU ports.
CLEAN SHIPPING Project (2007 – 2012)	The project started in order to increase focus on the environmental issues of shipping. One of the results of the project is the Clean Shipping Index, an index taking a holistic perspective on the environmental issues of shipping.
Mediterranean Ports’ Contribution to Climate Change Mitigation (CLIMEPORT) 2009 – 2012	CLIMEPORT aims at evaluating the contribution of the Mediterranean ports to the different environmental aspects which are involved in climate change and develop tools and best practices that can be widely used to mitigate the contribution of Mediterranean ports to climate change.

Project name, acronym and years	Description
Sustainable management for European local Ports (SuPorts) 2010 - 2012	It is a three year project involving ten partners in seven European countries. The project aims to develop a better understanding of the impact of ports on the immediate marine and coastal environment and to help small ports to be environmentally friendly.
Shared strategies and actions for strengthening at maritime and logistics sectors in the Mediterranean (SECURMET) 2009 – 2012	It is a project focused on maritime safety and environmental protection that the Liguria Region launched in the new European programme MED. The project promotes common strategic actions aimed at strengthening safety of the maritime cluster in the Mediterranean and has the ambitious goal of strengthening the alliance between Regional Governments, Ministries, Port Authorities and Research Centres (ReCRIS) initiated during previous projects in order to capitalize already obtained results.
Port Performance Indicators: Selection and Measurement (PPRISM) 2010-2011	The project is aimed to identify a set of sustainable, relevant and feasible port performance indicators to be implemented at EU level in order to measure and assess the impact of the European Port System on society, environment and economy. To this end, a typology of port performance indicators will be created, validity and data availability will be assessed, and the indicators will be proposed to key stakeholders for assessment in terms of their suitability to be implemented at EU level.

Source: Research projects' websites, 2011

Appendix V: Selection of indicators

The criteria and their characteristics used for the selection of the indicators were presented in Table 4.1 (page 107). In order to find out the most significant indicators, each indicator was assessed in terms of the following five criteria:

1. Policy relevant: Does the indicator reflect the aims of the environmental policy, objectives and targets and the environmental legislation?

2. Informative: Does the indicator provide information about the status and trends of the port environmental performance over time?

3. Measurable: Does the indicator use measurable and/or readily available data?

4. Representative: Does the indicator provide a clear picture of environmental conditions and pressures on the environment?

5. Practical: Is the indicator straightforward to monitor?

When an indicator had an affirmative response to the specific criteria, it was indicated with a tick (√). The methodology followed is that an indicator has been considered as LOW significant if it has any, one, two or three ticks (√); 4 ticks meant that it was a MEDIUM significant indicator and, finally, an indicator with 5 ticks was regarded as HIGH significant. The major limitation of this assessment process is that this is a subjective methodology based on the candidate's own research and opinion about each indicator.

The indicators are grouped into the three categories of Environmental Performance Indicators explained before in this thesis. Although some indicators belonging to the same subcategory (e.g. Carbon Footprint or waste management) had several indicators assessed as medium or high significant, it was attempted to select only one indicator per subcategory, the one that appeared to provide more information.

If appropriate, comments are provided in brackets next to each indicator, explaining any anomaly or matter of discussion. At the end of the assessments (page 199), it is discussed that although some Environmental Condition Indicators matched affirmatively only to three criteria, they were assessed as Medium significant indicators because these indicators are relevant and significant in the monitoring of key elements of the ecosystems and habitats of the port area.

Environmental Management Indicators

Table App.8: Methodology to select Environmental Management Indicators

Indicator	1	2	3	4	5	Significance (and comments)
Does the Port Authority have an Environmental Management System (EMS)?	√		√		√	LOW (included in indicator below)
Number and type of EMS certifications	√	√	√	√	√	HIGH
Year(s) of certification	√	√	√		√	LOW (EMS included above)
Has the port completed the Self Diagnosis Method?			√		√	LOW
Have any customers requested that the port (or terminal) to be EMS certified?			√			LOW
Does the port have an Environmental Policy?	√		√	√	√	MEDIUM
Is the policy signed by Chief Executive / Senior Management?			√		√	LOW (Environmental Policy is already taken into account in the above indicator. These indicators are too specific).
Is the policy communicated to all relevant stakeholders?			√		√	
Is the policy communicated to all employees?			√		√	
Is the policy publicly available on the port's website?			√		√	
Does the policy aim to improve environmental standards beyond those required by legislation?	√			√		
Does the policy include reference to ESPO Code of Practice (2003)?	√		√		√	
Does the policy include reference to major objectives?	√	√		√		
Does the policy include reference to publication of an Environmental Report?	√		√		√	
Does the policy include reference to the identification and control of the port's Significant Environmental Aspects?	√		√		√	
Does the policy include reference to introduction / maintenance of an Environmental Management System?	√		√		√	
Has the port defined objectives for environmental improvement?	√		√		√	LOW
Has the port defined targets for its objectives?	√		√		√	LOW
Have the objectives and targets been communicated?	√		√			LOW
Does the port have quantitative objectives?	√		√		√	LOW
Number of environmental objectives and targets defined	√		√		√	LOW
Number of environmental objectives and targets achieved	√		√		√	LOW
Percentage of environmental targets achieved	√	√	√		√	MEDIUM (the % of targets achieved is more informative

						than the above EPI)
Indicator	**1**	**2**	**3**	**4**	**5**	**Significance (and comments)**
Have management programmes and action plans been prepared to achieve each objective?	√					LOW
Does the port have an Environmental Monitoring Programme?	√	√	√	√	√	HIGH
Has the port identified environmental indicators to monitor trends in environmental performance?	√		√			LOW
Number of environmental parameters monitored	√	√	√	√	√	HIGH (additional indicators related to monitoring)
Frequency of monitoring each parameter						
Number of monitoring locations for each parameter						
Number of days in a year that the limit value has been exceeded for each parameter						
Does the inventory consider aspects from the activities of tenants and operators?				√		LOW
Does the port have an inventory of Significant Environmental Aspects?	√		√	√	√	HIGH (included in indicator below)
Number of Significant Environmental Aspects identified	√	√	√	√	√	HIGH
Does the port have a representative responsible for managing environmental issues?			√		√	LOW
Are the environmental responsibilities of this representative documented?			√		√	LOW
Are all personnel aware of the responsibilities and authority of this representative?						LOW
Are the environmental responsibilities of other key personnel documented?			√		√	LOW
Number of levels of management with specific environmental responsibilities			√			LOW
Number of employees who have requirements of professional competence on environmental matters in their jobs	√					LOW
Does the Port Authority have an environmental training programme for its employees?	√		√		√	LOW
Is the environmental training fitted to employees' activities and responsibilities?	√		√			LOW
Have all the personnel whose work may create an impact on the environment received appropriate training?	√				√	LOW
Are environmental issues included in induction programmes for new employees?	√		√		√	LOW
Has the Port Authority established procedures for identifying training needs?			√			LOW
Annual number of environmental training courses for port			√		√	LOW

employees						
Indicator	**1**	**2**	**3**	**4**	**5**	**Significance (and comments)**
Number of port employees trained in environmental issues		√	√		√	LOW
Annual number of hours invested on environmental training for port employees			√		√	LOW
Frequency of environmental training sessions for port employees	√		√			LOW
Percentage of port employees that have received environmental training	√	√	√		√	MEDIUM (the % is more informative than the above training EPIs)
Number of trained people working with hazardous cargo			√			LOW
Are all employees aware of the importance of compliance with environmental policy?	√					LOW (It is hard to identify to what extent the employees are aware of environmental matters)
Are all employees aware of the potential environmental impacts of their work activities?						
Are all employees aware of their responsibility to conform to the environmental policy and management objectives?						
Are all employees aware of the objectives, actions and programmes carried out by the port in order to improve its environmental performance?						
Does the port publish a publicly available Environmental Report?			√		√	LOW
Does the port publish factual data by which the public can assess the trend of its environmental performance?		√	√		√	LOW
Are there procedures to communicate environmental information internally between the key environmental personnel?			√			LOW
Are there procedures to exchange port environmental information with stakeholders including external parties?			√			LOW
Are there procedures to consult with the Local Community on the port's environmental programme?			√			LOW
Frequency of meetings and consultations with external stakeholders	√		√		√	LOW
Frequency of internal meetings with key environmental personnel	√		√		√	LOW
Annual number of environmental publications published			√		√	LOW
Annual number of press articles published concerning environment			√		√	LOW
Does the port website show environmental information?	√		√		√	LOW
Number of hours invested on environmental presentations given to stakeholders or interest groups			√			LOW
Annual number of national and international conferences			√			LOW

organized by the Port Authority						
Indicator	**1**	**2**	**3**	**4**	**5**	**Significance (and comments)**
Annual number of congresses and conferences attended by port employees concerning environment			√		√	LOW
Number of universities and research institutes co-operating with the port in the field of environment	√		√			LOW
Annual number of groups and students visiting the port for environmental education purposes						LOW
Does the port have an Emergency Response Plan?	√		√		√	LOW
Does the Emergency Response Plan include the potential environmental consequences and actions to be taken in the event of explosion, fire, floods, oil/chemical spill, and shipping accident?	√		√			LOW
Does the Emergency Response Plan specify the responsibility and role of each body: Port Authority, tenants and operators, ship agents, and external agencies?	√		√			LOW
Does the port have an Emergency Response Plan specially designed for handling hazardous cargo?	√		√		√	LOW
Does the port have a Cargo Handling Plan?			√		√	LOW
Does the port have an Oil Spill Response Plan?			√		√	LOW
Annual number of environmental accidents reported	√	√	√		√	MEDIUM
Average response time in case of environmental accidents						LOW
Average response and correction time in case of environmental accidents						LOW
Maximum response time in case of environmental accidents						LOW
Number of bunkering related pollution accidents			√			LOW
Number of vessel related pollution accidents			√			LOW
Number of cargo related pollution accidents			√			LOW
Total number and volume of oil and chemical spills	√	√	√		√	MEDIUM
Annual number of emergency drills			√		√	LOW
Frequency of safety equipment revisions			√		√	LOW
Number of environmental inspections			√		√	LOW
Does the port have a representative responsible for managing safety issues?	√		√		√	LOW
Are the responsibilities of this representative documented?			√			LOW
Are all personnel familiarised with safety regulations?						LOW
Has the Port Authority carried out an Environmental Risk Assessment during the last 5 years?	√					LOW
Amount of annual hazardous cargo handled		√	√			LOW
Number of Seveso II sites (sites containing large quantities of	√		√			LOW

dangerous substances defined by the Directive 2003/105/EC)						
Indicator	**1**	**2**	**3**	**4**	**5**	**Significance (and comments)**
Has an environmental audit been conducted?			√		√	LOW
Number of environmental audits conducted		√	√	√	√	MEDIUM
Number of nonconformities found in environmental audits		√	√		√	LOW
Number of nonconformities addressed		√	√			LOW
Time spent on addressing nonconformities						LOW
Does the port have an inventory of relevant environmental legislation and regulations related to its liabilities and responsibilities?	√		√		√	LOW
Are there procedures to maintain and update the inventory?			√			LOW
Are there methods to deal with non-compliance with internal and external standards?			√			LOW
Number of prosecutions received for non-compliance with environmental legislation	√	√	√	√	√	HIGH
Number of fines received for non-compliance with environmental legislation	√	√	√	√	√	HIGH (included in above)
Percentage of compliance with environmental legal requirements	√	√				LOW
Total number of environmental licenses obtained			√		√	LOW
Total number of environmental licenses withdrawn or refused			√		√	LOW
Total annual number of environmental complaints received	√	√	√		√	MEDIUM
Annual number of environmental complaints received from NGOs	√	√	√		√	MEDIUM (included in the indicator above)
Annual number of environmental complaints received from people working in port area						
Annual number of environmental complaints received from the Local Community						
Annual number of environmental complaints received from Port Authority' employees						
Total annual number of environmental complaints investigated	√		√			LOW
Total annual number of environmental complaints resolved where no further action was necessary	√		√			LOW
Total annual number of environmental complaints resolved where further action was necessary	√		√			LOW
Does the port have a budget specifically for environmental protection?	√		√		√	LOW
Amount of funding allocated to environmental training of employees	√		√			LOW
Amount of funding allocated to control environmental impacts						
Amount of funding allocated to emergency response and prevention						

Amount of funding allocated to environmental monitoring						
Amount of funding allocated to stakeholder engagement and outreach activities						
Amount of funding allocated to environmental reporting						
Amount of funding allocated to biodiversity protection						
Indicator	**1**	**2**	**3**	**4**	**5**	**Significance (and comments)**
Total annual budget allocated to environmental protection	√		√			LOW
Percentage of total budget allocated to environmental protection	√		√		√	LOW
Percentage change of environmental budget compared to the previous year	√		√		√	LOW
Are copies of ESPO Environmental Review (2001) available in the port?			√			LOW
Are there procedures to involve all port users in the development of the environmental programme?						LOW
Number of pollution prevention initiatives implemented	√		√		√	LOW
Number of pollution reduction solutions implemented	√		√		√	LOW

Operational Performance Indicators

Table App.9: Methodology to select Operational Performance Indicators

Indicator	1	2	3	4	5	Significance (and comments)
Total annual energy consumption by energy source	√	√	√	√	√	HIGH
Percentage of energy sources of the total energy consumption	√	√	√	√	√	HIGH (included in above)
Does the port have a programme to increase energy efficiency?	√		√			LOW
Number of energy-efficiency initiatives implemented	√		√		√	LOW
Amount of energy saved due to energy-efficiency improvements	√	√	√	√		MEDIUM
Does the port produce any form of renewable energy?			√		√	LOW
Does the port provide shore-side electricity at any of its berths?			√		√	LOW
Number of vessels using shore-side electricity		√	√			LOW
Percentage of low consumption lights compared to total number of lights			√	√		LOW
Total annual renewable energy consumption	√		√		√	LOW
Percentage of renewable energy per total energy consumed	√	√	√	√	√	HIGH (the % is more informative than above EPI)
Total annual water consumption	√		√	√	√	MEDIUM
Total annual water recycled and reused			√	√		LOW
Percentage of water recycled per total water consumption	√	√	√	√		MEDIUM

Indicator	1	2	3	4	5	Significance (and comments)
Does the port measure or estimate its Carbon Footprint?	√		√			LOW
Does the port take measures to reduce its Carbon Footprint?	√		√			LOW
Total annual greenhouse gas (GHG) emissions (Carbon Footprint)	√	√	√	√	√	HIGH
Annual greenhouse gas (GHG) emissions from direct emissions (scope 1)	√	√	√	√	√	HIGH (included in the indicator above)
Annual greenhouse gas emissions (GHG) from energy indirect emissions (scope 2)						
Annual GHG emissions from other indirect emissions (scope 3)						
Percentage of each scope contributing to the total emissions		√	√	√	√	
Percentage of annual changes in greenhouse gas (GHG) emissions	√	√	√		√	MEDIUM
Kilometres driven by port vehicles			√			LOW
Number of initiatives implemented to reduce greenhouse gas emissions	√		√			LOW
Level of noise in terminals and industrial areas Lden (overall day-evening-night)	√	√	√	√	√	HIGH
Level of noise in terminals and industrial areas Lday (7:00 – 19:00 hrs)	√	√	√	√	√	HIGH (included in the indicator above)
Level of noise in terminals and industrial areas Levening (19:00-23:00 hrs)						
Level of noise in terminals and industrial areas Lnight (23:00 – 7:00 hrs)						
Average noise exposure during an 8-hour working day						
Maximum level of noise in terminals and industrial areas L_{MAX}			√			LOW
Frequency of noise measurements	√	√				LOW
Existence of a noise-zoning map	√		√		√	LOW
Frequency of verification of the noise-zoning map						LOW
Compliance with limits at day, evening, and night time for noise level	√	√	√	√	√	HIGH
Number of measures implemented to reduce noise levels	√		√			LOW
Annual number of noise complaints			√		√	LOW
Number of local residents affected by noise from port area operations						LOW
Total annual port waste collected by type	√	√	√	√		MEDIUM
Annual amount of port solid waste recycled	√	√	√	√		MEDIUM (included in the indicator above)
Annual amount of port liquid waste recycled						
Annual amount of port non-hazardous industrial waste recycled						
Annual amount of port hazardous waste recycled						
Percentage of each above-mentioned waste type						
Existence of separate containers for the collection of port waste			√		√	Included in above

Indicator	1	2	3	4	5	Significance
Percentage of disposal methods of port waste: landfill, incineration, recycling, and compost	√	√	√	√		MEDIUM
Hazardous waste eliminated by pollution prevention		√				LOW
Annual amount of oil collected and recycled		√		√		LOW
Percentage of waste handled per total cargo handled						LOW
Number of operations with high levels of waste						LOW
Number of port stakeholders with a Waste Management Plan	√					LOW
Frequency of cleaning the port area						LOW
Time spent on litter collection						LOW
Annual amount of ship waste MARPOL Annex I (oil) collected	√	√	√			Already requested by MARPOL legislation
Annual amount of ship waste MARPOL Annex II (noxious liquid substances carried in bulk) collected						
Annual amount of ship waste MARPOL Annex III (harmful substances) collected						
Annual amount of ship waste MARPOL Annex IV (sewage) collected						
Annual amount of ship waste MARPOL Annex V (garbage) collected						
Annual total amount of ship waste collected in ship waste reception facilities (Annexes of Marpol convention)	√	√	√			LOW (included in above)
Existence of ship waste reception facilities			√		√	LOW
Total annual amount of ship waste collected	√	√	√			LOW
Number of initiatives implemented to reduce, recycle or reuse waste	√		√			LOW
Existence of a system to jointly collect and manage the waste from ships and port area	√		√		√	LOW
Existence of a waste water treatment plant	√		√		√	LOW
Existence of an oil spillage treatment plant	√		√		√	LOW
Annual cost of waste treatment						LOW
Has the Port Authority carried out an Environmental Impact Assessment (EIA) during the last 5 years?	√		√		√	LOW
Is the port involved with other organisations in the development of coastal or estuary management plans?						LOW
Has the Port Authority experienced, or does it anticipate any restrictions on development / expansion due to environmental planning controls?			√			LOW
Annual quantity or volume of dredged sediment	√	√	√			LOW
Annual amount of time and money spent on dredging activities	√					LOW
Frequency of dredging	√		√			LOW
Dredging efficiency: quantity of dredged sediment divided by fuel		√				LOW

Indicator	1	2	3	4	5	Significance (and comments)
consumption						
Indicator	**1**	**2**	**3**	**4**	**5**	**Significance (and comments)**
Number of research projects undertaken to evaluate both the short and the long term effects of dredging	√		√			LOW
Number of measures implemented to reduce negative ecological effects of dredging	√		√			LOW
Number of turtles harmed by dredging						LOW
Beneficial use of dredged material (definition and description of practices)		√				LOW
Percentage of dredged sediment going to beneficial use	√	√	√		√	MEDIUM
Existence of facilities for the treatment and cleaning of the dredged sediments	√		√		√	LOW
Number of researchers and projects carried out concerning dredging disposal			√			LOW
Number of environmental licenses withdrawn or refused for dredging disposal	√		√		√	LOW

Environmental Condition Indicators

Table App.10: Methodology to select Environmental Condition Indicators

Indicator	1	2	3	4	5	Significance (and comments)
Concentration of selected air pollutants: NOx, SOx, PM10, VOCs, CO, O	√	√	√	√	√	HIGH
Dust	√	√	√	√	√	PM10 is included above
Other harmful air pollutants		√				LOW
Algal Growth Potential (AGP)		√		√		LOW
Quantity of anthropogenic debris collected		√	√	√	√	MEDIUM
Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)	√	√	√	√	√	HIGH
Dissolved Oxygen (DO)		√	√	√	√	Included in above
Concentration of inorganic ions (nutrients)		√	√	√		Site-specific indicator
Microbiology (Coliform Bacteria)	√	√	√	√	√	HIGH
Oil content (Hydrocarbons)		√	√	√	√	Site-specific indicator
pH						
Water salinity	√	√	√	√	√	HIGH
TOC, TOD, TDS, and TSS		√	√			LOW

Indicator	1	2	3	4	5	Significance (and comments)
Water transparency / Turbidity	√	√	√	√	√	HIGH
Water Colour		√			√	LOW
Water Temperature	√	√	√	√	√	HIGH
Other harmful water pollutants		√				LOW
Soil quality indicators		√				LOW
Sediment quality: concentration of nutrients		√	√	√	√	MEDIUM
Sediment quality: Polycyclic Aromatic Hydrocarbons (PAHs)		√	√	√		LOW
Particle size		√		√		LOW
Other harmful sediment pollutants		√				LOW
Heavy metals		√	√	√		Site-specific indicator
Is the port located in or it contains a designated protected area?	√		√			LOW
Area of land and water owned, leased, or managed within designated protected areas	√		√			LOW
Number of habitats protected or restored	√		√			LOW
Percentage of algae coverage at particular sites		√	√	√	√	MEDIUM
Percentage of change in the size of algae blooms at particular sites		√				LOW
Other aquatic flora monitoring: quantity and variety of aquatic flora species		√	√	√		MEDIUM*
Plant diversity: number of plant species per survey plot in arable land, woodland and grassland, and boundary habitats		√		√		LOW
Area of mangroves (various kinds of trees that grow in saline coastal sediment habitats)		√				LOW
Benthic fauna monitoring: quantity and variety of benthic fauna found in sediments samples within the seabed		√	√	√		MEDIUM*
Trawling monitoring: quantity and variety of fish, crustaceans and other species which live on the seabed and within the water column		√	√	√		MEDIUM*
Marine ecosystem integrity: percentage of large fish (equal to or larger than 40 cm)						LOW
Annual number of fish deaths in a specific watercourse						LOW
Birds monitoring: quantity and variety of farmland birds, woodland birds, water and wetland birds, and seabirds		√	√	√		MEDIUM*
Butterflies monitoring: quantity and variety of generalists (wider countryside) and specialists species of butterflies		√				LOW
Population of a specific animal species within a defined area		√				LOW
Number of International Union for the Conservation of Nature and Natural Resources (IUCN) Red List species and national conservation list species with habitats in port areas	√	√				LOW

Indicator	1	2	3	4	5	Significance (and comments)
Change of species diversity at particular sites		√	√	√		MEDIUM*
Area of sensitive habitats exceeding critical loads for acidification and eutrophication						LOW
Number of widely established (more than 50 per cent) invasive species in freshwater, marine and terrestrial environments		√				LOW
Amount of time that people spend volunteering in biodiversity conservation						LOW
Odour indicators		√				LOW

* The indicators ‘flora monitoring’, ‘fauna monitoring’, ‘trawling monitoring’ and ‘birds monitoring’ may not be regulated by legislation (therefore they do not comply with question 1 - Policy Relevant) and they may not be simple to calculate (therefore they do not comply with question 5 -Practical). However, they have been assessed as Medium significance and recommended for potential application because these indicators are relevant and significant in the monitoring of key elements of the ecosystems and habitats of the port area. Most of the researched ports already have some of these indicators implemented, calculated and reported.

Appendix VI: ESPO SD Committee Assessment Form

NAME OF PORT……………………………………………………(*CONFIDENTIAL*[1]*)*
INDICATOR……………………………………………………….DEFINITION………………………………………………………………………………………

1. Stakeholder acceptance (rate on a 1-5 scale where 1=least likely and 5=most likely, N/O = No Opinion and N/A = Not Applicable)

Do you think that the indicator:	**1**	**2**	**3**	**4**	**5**	**N/O**	**N/A**
1)… is generally acceptable as an indicator of port (sector) performance?							
2)… is relevant for policy makers at an EU level?							
3)… is relevant for policy makers on a local/regional level?							
4)… serves the objective of continuous improvement of environmental quality?							
5) …is useful for ports and their users for competitive purposes?							
6) …is useful in increasing public and social awareness of port activities?							
7) …is useful to anticipate trends and other cycles?							
8) …assists the port with compliance, and cost and risk reduction?							
9) …is useful to benchmark the European system in a global context? (Recommend delete)							

2. Implementation feasibility (rate on a 1-5 scale where 1=least likely and 5=most likely, N/O = No Opinion and N/A = Not Applicable)

Do you think that the implementation of the indicator…	**1**	**2**	**3**	**4**	**5**	**N/O**	**N/A**
10)… is generally feasible?							
11)… is feasible from the point of view of data availability?							
12)… is feasible from the point of view of data reliability?							
13)… is feasible from the point of view of calculation methodology?							
14)… is feasible from the point of view of cost (e.g. cost of data collection, calculation complexity)?							
15)…could be calculated for the port AREA?							
16)…could be compiled by the Port Authority?							

3. Additional comments and remarks (when scores of 1 or 2 are given, please explain your response)

Appendix VII: Clean shipping Project Assessment Form

ANONYMOUS

CLEANSHIP PROJECT

Professional assessment

ENVIRONMENTAL PERFORMANCE INDICATORS

JOB DESCRIPTION: ………………………………………………………………

To what extent, on a scale 1 – 5 (where 1 = least and 5 = most), do you consider that the following factors are *acceptable* and *feasible* as Environmental Performance Indicators?

	INDICATOR (Condition)	1	2	3	4	5
1	Carbon dioxide emissions – port area					
2	Total amount of waste port area (excl. ships)					
3	Water consumption – port authority					
4	Air quality					
5	Water quality					
6	Sediment quality					
7	Shore-based supply					
8	Port: Shipping collaboration					
9	*Other*					
10	*Other*					

	INDICATOR (Management)	1	2	3	4	5
11	Environmental Management Programme					
12	Environmental Policy					
13	ESPO Code of Practice					
14	Inventory of Legislation					
15	Inventory of Aspects					
16	Objectives and Targets					
17	Environmental Training					
18	Monitoring programme					
19	Review Process					
20	Environmental Report					

Factors 1-10 inclusive represent EPIs of Environmental Condition. Factors 11-20 inclusive represent performance indicators of Environmental Management

Comments:

Appendix VIII: BPA Conference 2010 Assessment Form

British Ports Association "Speaking for UK ports"

ANONYMOUS

BRITISH PORTS ASSOCIATION CONFERENCE

Torquay, October 2010

ENVIRONMENTAL PERFORMANCE INDICATORS

Port professional assessment

To what extent, on a scale 1 – 5 (where 1 = least and 5 = most), do you consider that the following factors are *acceptable* and *feasible* as Environmental Performance Indicators:

	FACTOR	1	2	3	4	5
1	Carbon dioxide emissions					
2	Total amount of waste					
3	Water consumption					
4	Noise					
5	Air quality					
6	Energy consumption					
7	Existence of Environmental Management System					
8	Active programme of monitoring					
9	Evidence of environmental reporting					
10	Stakeholder involvement programme					
11	*(Other…)*					
12	*(Other…)*					

- **Factors 1-6 inclusive represent EPIs of Environmental Condition.**
- **Factors 7-10 inclusive represent performance indicators of environmental management**

Results of this assessment exercise will be used to guide development of the proposed ESPO 'Dashboard' of Port Performance Indicators.

Thank you for your cooperation,

Dr Chris Wooldridge & Marti Puig Duran
Cardiff University

On behalf of PPRISM research partner

PPRISM ESPO CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

Appendix IX: On-line survey

PPRISM External Stakeholder Assessment SurveyMonkey

In what field of expertise are you working?

Port authority ○	○ Barge transport
Terminal operator ○	○ Government
Technical-nautical services ○	○ Academics and/or consultants
Shipowner ○	○ Trade union
Shipper ○	○ NGO
Road transport ○	○ Member of a local community adjacent to a port
Rail transport ○	○ Other (please specify)

Are you working and/or residing in one of the European Union Member States?

Yes ○	No ○

Do you think the indicator Carbon Footprint is acceptable and feasible?

Strongly Agree ○	Agree ○	Neutral ○	Disagree ○	Strongly Disagree ○	No Opinion ○

Do you think the indicator Amounts of Waste Produced is acceptable and feasible?

Strongly Agree ○	Agree ○	Neutral ○	Disagree ○	Strongly Disagree ○	No Opinion ○

Do you think the indicator Total Water Consumption is acceptable and feasible?

Strongly Agree ○	Agree ○	Neutral ○	Disagree ○	Strongly Disagree ○	No Opinion ○

Do you think the indicator Existence of an Environmental Management Programme is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

Do you think the indicator Existence of an Environmental Policy is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

Do you think the indicator Reference to ESPO Code of Practice in Port Policy is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

Do you think the indicator Existence of an Inventory of Legislation is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

Do you think the indicator Existence of an Inventory of Significant Environmental Aspects is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

Do you think the indicator Existence of Objectives and Targets is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

Do you think the indicator Existence of Environmental Training is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

Do you think the indicator Existence of an Environmental Monitoring Programme is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

Do you think the indicator Existence of an Environmental Report is acceptable and feasible?

Strongly Agree	○	Agree	○	Neutral	○	Disagree	○	Strongly Disagree	○	No Opinion	○

ENVIRONMENTAL PERFORMANCE INDICATORS TOOL FOR PORT AUTHORITIES

CONFIDENTIAL

1) PORT PROFILE

Name of Port: ☐

Contact Name: ☐

Contact e-mail address: ☐

Please indicate size of Port:
(complete at least one option)

☐ annual tonnes cargo handled
☐ annual million passengers
☐ annual TEUs
☐ square meters (port area)

Year in which the data refers to: ☐

Country: ☐

Job Position: ☐

2) CONSOLIDATED ENVIRONMENTAL MANAGEMENT INDICATORS

Does Port's Authorities Management Programme include or make reference to:

No.	ENVIRONMENTAL MANAGEMENT INDICATOR	WEIGHTING	RESPONSE (YES/NO)	RESULT
1	Environmental Management Programme	1	☐	
2	Environmental Policy	1.5	☐	
3	ESPO Code of Practice	0.5	☐	
4	Inventory of Legislation	1.5	☐	
5	Inventory of Significant Environmental Aspects	1.5	☐	
6	Objectives and Targets	1	☐	
7	Environmental Training	0.75	☐	
8	Environmental Monitoring Programme	1.25	☐	
9	Environmental Report		☐	

FINAL INDEX ☐

3) CARBON FOOTPRINT

Please select the period for which you are calculating your Carbon Footprint: [ ] **months**

Does the data concerning the greenhouse gas emissions of installations and activities apply to:

i) Facilities exclusively under the operational control of Port Authority?

ii) Areas and facilities managed by major operators and tenants? (Includes data for i) above)

iii) The whole port area?

Source description	Unit	Input Data	Kg CO_2e per unit	Total kg CO_2e	Total tCO_2e
SCOPE 1: DIRECT EMISSIONS					
STATIONARY SOURCES					
Natural Gas	kWh		0.184		
	therms		5.391		
LPG	kWh		0.214		
	therms		6.285		
	litres		1.497		
Gas oil	tonnes		3498		
	kWh		0.277		
	litres		3.029		
Fuel Oil	tonnes		3229		
	kWh		0.266		
Burning oil	tonnes		3165		
	kWh		0.247		
Diesel	tonnes		3201		
	kWh		0.253		
	litres		2.669		
Petrol	tonnes		3172		
	kWh		0.243		
	litres		2.331		
Industrial Coal	tonnes		2338		
	kWh		0.313		
Woods pellets	tonnes		121.5		
	kWh		0.026		
COMPANY OWNED VEHICLES					
Diesel	litres		2.669		
	km		0.1983		

Petrol	litres		2.331		
	km		0.2078		
				TOTAL SCOPE 1	

Source description	Unit	Input Data	Kg CO2e per unit	Total kg CO2e	Total tCO2e
SCOPE 2: ENERGY INDIRECT EMISSIONS					
Electricity	Kwh		0.54522		
				TOTAL SCOPE 2	

Source description	Unit	Input Data	Kg CO2e per unit	Total kg CO2e	Total tCO2e
SCOPE 3: OTHER INDIRECT EMISSIONS					
BUSINESS TRAVEL					
Diesel car	km		0.1983		
Petrol car	km		0.2078		
Taxi	km		0.224		
International train	km/passenger		0.018		
National train	passenger km		0.0611		
Light rail and tram	passenger km		0.084		
Underground	passenger km		0.0786		
Long haul flight	passenger km		0.1235		
Short haul flight	passenger km		0.1081		
EMPLOYEES COMMUTING					
Diesel car	km		0.1983		
Petrol car	km		0.2078		
Bus	passenger km		0.069		
National train	passenger km		0.0611		
Light rail and tram	passenger km		0.084		
Underground	passenger km		0.0786		
Water consumption	m3		0.4		
				TOTAL SCOPE 3	

TOTAL CARBON FOOTPRINT

4) PORT WASTE MANAGEMENT

Does your port recycle port waste (Y/N)? ☐

If yes, could you identify what is being recycled in your port by ticking (√) the appropriate boxes and specify the quantity, if known?
(Results may be entered either in kg, tonnes, litres or units per annum, depending on your accounting method)

Source description	Recycled?	kg/year	tonnes/year	litres/year	units/year	TONNES/YEAR
SOLID WASTE						
Organic Waste	☐					
Cardboard and paper	☐					
Plastics	☐					
Glass	☐					
Other (please, specify):						
-	☐ ☐					
					TOTAL SOLID WASTE	
LIQUID WASTE						
Grey water	☐					
black water	☐					
Ballast water reception	☐					
Other (please, specify):						
-	☐ ☐					
					TOTAL LIQUID WASTE	

Source description	Recycled?	kg/year	tonnes/year	litres/year	units/year	TONNES/YEAR
NON-HAZARDOUS INDUSTRIAL WASTE						
Scrap metal	☐					
Loading waste, sweepings and bulks	☐					
Wood	☐					
Remains of nets	☐					
Electronic waste	☐					
Aerosols	☐					
Oil filters	☐					
Floating debris	☐					
Contaminated rags	☐					
Contaminated drums	☐					
Tires	☐					
Polystyrene	☐					
Other (please, specify):						
-	☐					
-	☐					
-	☐					
					TOTAL NON-HAZARDOUS INDUSTRIAL WASTE	

Source description	Recycled?	kg/year	tonnes/year	litres/year	units/year	TONNES/YEAR
HAZARDOUS WASTE						
Ink cartridges	☐					
Used oil	☐					
Fluorescents	☐					
Alkaline Batteries	☐					
Button Batteries	☐					
Other Batteries (kg)	☐					
Other (please, specify):						
-	☐					
-	☐					
-	☐					
-	☐					
					TOTAL HAZARDOUS WASTE	
NON-RECYCLED WASTE (direct to landfill)						

TOTAL AMOUNT OF GENERATED WASTE	
TOTAL AMOUNT OF RECYCLED WASTE	
PERCENTAGE OF RECYCLED WASTE	

5) WATER CONSUMPTION

Does your port monitor the water consumption? (YES/NO) [ ]

If yes, could you identify the different water usages by ticking (√) whether is drinking water or ground water and specify the quantity, if known, please?
(You can enter the results either in litres or cubic meters, depending on your accounting method)

Please enter the period for which you are calculating your water consumption: [ ] **months**

Source description	Drinking water?	Non-drinking water?	litres	cubic metres	CUBIC METRES
PORT AUTHORITY CONSUMPTION					
Port Authority buildings	☐	☐			
Irrigation	☐	☐			
Other (please, specify):					
-	☐	☐			
-	☐	☐			
-	☐	☐			

TOTAL DRINKING WATER PORT AUTHORITY CONSUMPTION [ ]

TOTAL GROUND WATER PORT AUTHORITY CONSUMPTION [ ]

TOTAL PORT AUTHORITY CONSUMPTION [ ]

Source description	Drinking water?	Non-drinking water?	litres	cubic metres	CUBIC METRES
PORT AREA CONSUMPTION					
Cleaning of common areas	☐	☐			
Water supplied to vessels	☐	☐			
Third Parties consumption	☐	☐			
Other (please, specify):					
-	☐	☐			
-	☐	☐			
-	☐	☐			

TOTAL DRINKING WATER PORT AREA CONSUMPTION [ ]

TOTAL GROUND WATER PORT AREA CONSUMPTION [ ]

TOTAL PORT AREA CONSUMPTION [ ]

TOTAL WATER CONSUMPTION [ ]

6) OVERALL RESULTS

Port of ______

Year ______

Carbon Footprint

The input data refer to: ______

	Tonnes of CO2	Percentage
Scope 1: direct emissions		
Scope 2: energy indirect emissions		
Scope 3: other indirect emissions		
Total emissions		

Standardised results:

	tonnes CO_2/annual handled tonnes year
	tonnes CO_2/annual millions passengers year
	tonnes CO_2/ annual TEUs year
	tonnes CO_2/ m^2 year

Port waste

	Tonnes/year	Percentage
Urban solid waste		
Non-hazardous industrial waste		
Hazardous waste		
Non- recycled waste		

Total amount of generated waste		tonnes/year
Total amount of recycled waste		tonnes/year
Percentage of recycled waste		%

Water consumption

Port Authority water consumption		m^3/ year
Port Area water consumption		m^3/ year
Total water consumption		m^3/ year

Environmental management

FINAL INDEX ______

7) FEEDBACK ASSESSMENT (OPTIONAL)

Has the Authority ever calculated its Carbon Footprint before? (Y/N) ☐

Has the Authority ever calculated its waste management before? (Y/N) ☐

Has the Authority ever calculated its water consumption before? (Y/N) ☐

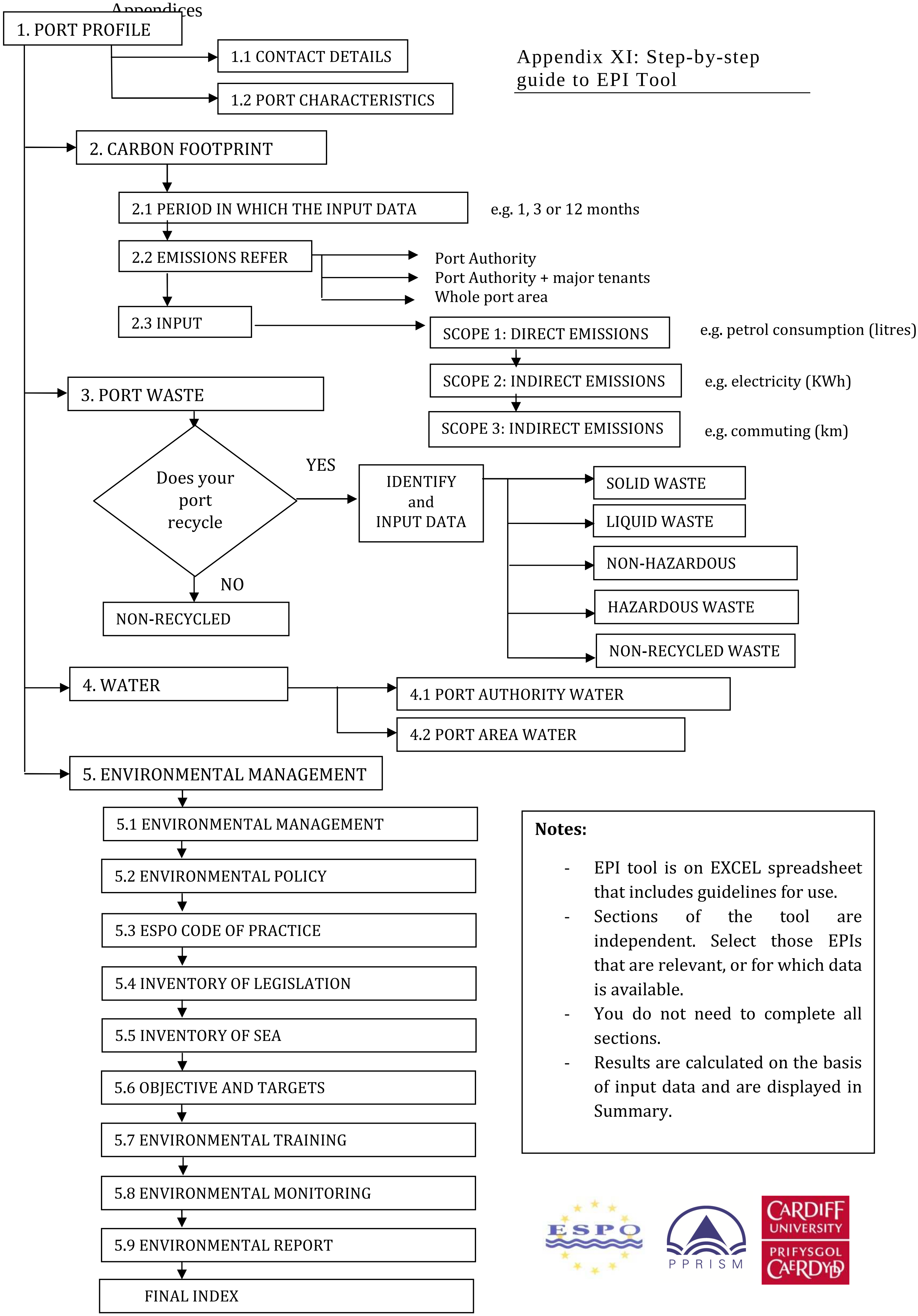
To what extent, on a scale 1 - 5 (where 1=least and 5=most), do you consider that this tool is practical in terms of:

Least…………..….Most

	1	2	3	4	5
1- Time invested					
2- Effort invested					
3- Easy to understand					
4- User-friendly					

Please, add further comments you would like to point out or aspects that could be improved about this EPI calculator tool:

Appendix XI: Step-by-step guide to EPI Tool



Notes:

- EPI tool is on EXCEL spreadsheet that includes guidelines for use.
- Sections of the tool are independent. Select those EPIs that are relevant, or for which data is available.
- You do not need to complete all sections.
- Results are calculated on the basis of input data and are displayed in Summary.

Appendix XII: EPI Tool results

Quantitative results

Carbon Footprint:

Table App.11: EPI Tool Carbon Footprint results

	Carbon Footprint (tonnes CO2/year)				Normalised results			
Code	**Scope 1**	**Scope 2**	**Scope 3**	**Total emissions**	**tonnes CO2 / million tonnes cargo**	**tonnes CO2 / thousand passengers**	**tonnes CO2 / thousand TEU**	**tonnes CO2 / ha**
P1	2148	11791	152	14090	917	378	29.6	40.3
P2	142	5652	236	6029	85	1.27	2.14	12.9
P3	44	860	179	1083	33	N/A	4.83	0.241
P4	2026	37985	0	40012	1238	1917	71.9	N/A
P5	6777157	702075	2370724	9849956	22912	N/A	884	N/A
P6	702	2442	4	3148	103	4.12	12.4	1.60
P7	203	2394	72	2670	691	N/A	N/A	1.57
P8								
P9								
P10	2000	2835	47	4882	174	2.77	8.81	18.2
P11	0	2707	0	2707	39	47.2	0.555	0.563
P12	102	1443	35	1580	67	0.768	N/A	2.11
P13	1019	9705	0	10724	345	N/A	64.5	N/A
P14	75	26	8	110	172	0.358	N/A	5.20
P15	28183	13789	2581	44553	250	N/A	5.26	3.41
P16	1266	2531	0	3797	1115	4.29	53.0	47.5
P17	208	6593	92	6893	677	35.6	50.3	46.0
P18	289	4032	9	4330	1349	1.21	314	19.2
P19	1879	4957	0	6836	79	3.31	7.17	N/A
P20	1441	7585	13	9038	239	0.88	N/A	17.4
P21	9507	16079	74	25660	212	99.7	3.25	N/A
P22								

Code	Scope 1	Scope 2	Scope 3	Total emissions	tonnes CO2 / million tonnes cargo	tonnes CO2 / thousand passengers	tonnes CO2 / thousand TEU	tonnes CO2 / ha
P23								
P24								
P25	17884	757856	74	775814	76684	1490	310325	10344
P26								
P27								
P28	112	0	27	139	20	0.109	2.75	N/A
P29	651	4501	1296	6448	150	1.86	3.31	7.78
P30	222	3002	27	3251	51	6.44	0.773	6.38
P31	17	2903	0	2920	345	0.240	110	N/A
P32	31	0	0	31	10	0.007	5.14	455000
P33	1754	42473	115	44342	1210	5.60	292	62.6
P34	0	10490033	0	10490033	960098	1039	26760	N/A
P35	839	1542	1	2382	427	N/A	14.4	19.8
P36								
P37								
P38								
P39	352	31	209	592	244	2.33	N/A	10.5
P40	549	3385	69	4003	91	2.37	4.55	11.1
P41								
P42	177	2206	36	2419	447	0.949	12.0	N/A
P43	662	11241	525	12427	175	23.6	5.27	N/A
P44	500	1129	0	1629	119	N/A	28.9	19.7
P45								
P46	151	875	0	1025	33	3.19	3.47	N/A
P47	3188	11141	33	14363	596	1.07	N/A	N/A

Waste management

Table App.12: EPI Tool Waste Management results (tonnes/year)

Code	Solid	Liquid	Non-hazardous	Hazardous	Non-recycled	% Recycled waste
P1	590	0	1933	280	464	85.8
P2	5865	0	71.4	3.82	0.00	100
P3	12706	1145	22.9	0.00	0.00	100
P4	3.26	548000	35.1	1.88	6.81	100
P5						
P6	1.31	994	139	2.93	197	85.3
P7	1.70	0.57	65.2	1.36	948	6.76
P8						
P9						
P10	451	40.0	315	21.5	0	100
P11						
P12	612	1178	51.6	10.5	0	100
P13	28.5	0	1017	6.50	370	74.0
P14						
P15						
P16	0	0	148	430	2650	17,9
P17						
P18	798	54.0	567	540	220	89.9
P19	365	58083	131	1344		100
P20	4036	89769	14.8	0	500	99.5
P21	26.8	0	58.4	8.46	263	26.2
P22						
P23	13.0	0	335	7.30	0	100
P24	0	4909	0	0	0	100
P25						
P26	1225	165	1.60	0	3635	27.7
P27						
P28						
P29	1.30	0	367	13.3	77.0	83.2
P30	75.9	0	193	7.00	227	54.9
P31	5.72	0	6.43	3.47	5.34	74.5
P32	18.5	610324	209	13.0	0	100
P33						
P34	3396	29869	139	122	760	97.8
P35	59.5	328090	0	0	0	100
P36	162	2629	85.0	3.00	242	92.2
P37	429	0	0	3.15	0	100
P38						
P39	381	8.00	48.8	18000	0	100
P40						
P41	645	18458	77.3	45.4	0	100

Code	Solid	Liquid	Non-hazardous	Hazardous	Non-recycled	% Recycled waste
P42						
P43	510	0	0	0	0	100
P44	30.0	82.0	1009	7.43	0	100
P45	112	864	226	0	0	100
P46						
P47	81.8	0	65.7	59.1	814	20.3

Water consumption:

Table App.13: EPI Tool Water Consumption results (m3/year)

Code	Port authority	Port area	TOTAL
P1	1880	7690	9570
P2	50488	403790	454278
P3			
P4	187587	615536	803123
P5			
P6	8745	1744	10489
P7	-	360000	360000
P8	-	132000	132000
P9	9750	31300	41050
P10	78600	178908	257508
P11	785,55	-	785,55
P12	9051	149469	158520
P13	115000	N/A	115000
P14	120	2404	2524
P15	897	-	897
P16			
P17			
P18	5600	32000	37600
P19	3979	18497	22476
P20	105399	380448	485847
P21			
P22	20694	-	20694
P23			
P24	232	-	232
P25			
P26	31000	76830	107830
P27			
P28			
P29	28292	19833	48125
P30	5359	341492	346851
P31	26688	40000	66688
P32	-	922715	922715
P33	7000	-	7000
P34	118874.7	167978.9	286853.6
P35	20975	-	20975

Code	Port authority	Port area	TOTAL
P36	1750	16800	18550
P37	58285	-	58285
P38	25	2750	2775
P39			
P40			
P41			
P42			
P43			
P44	76703	-	76703
P45	3600	35083	38683
P46			
P47	6544	-	6544

Environmental management

Note: The symbol '√' indicates presence of each environmental management component in the port management programme.

Table App.14: EPI Tool Environmental Management results

Code	EMS	Policy	ESPO Code	Legislation	SEA	Objectives	Training	Monitoring	Report	Score
P1	√	√		√		√	√	√	√	8
P2	√	√	√	√		√	√		√	7.25
P3	√	√				√		√	√	5.75
P4	√	√		√	√	√		√	√	8.75
P5	√	√	√	√	√	√	√	√	√	10
P6		√	√	√		√		√	√	6.75
P7		√	√	√	√		√	√	√	8
P8										
P9	√	√		√		√	√	√	√	8
P10	√	√	√	√		√	√	√	√	8.5
P11	√	√	√	√		√	√	√	√	8.5
P12				√		√	√	√		4.5
P13	√	√	√	√		√	√	√		7.5
P14	√	√		√		√	√	√	√	8
P15	√	√		√	√	√	√		√	8.25
P16	√	√	√	√	√	√	√	√	√	10
P17	√	√	√	√	√	√	√	√	√	10
P18	√	√		√	√	√	√		√	9.5
P19	√	√	√	√	√	√				7
P20	√	√	√	√		√	√	√	√	8.5
P21	√	√		√			√			4.75
P22		√	√				√			2.75
P23	√	√				√		√		4.75

Code	EMS	Policy	ESPO Code	Legislation	SEA	Objectives	Training	Monitoring	Report	Score
P24	√	√		√		√		√		6.25
P25		√		√	√	√		√	√	7.75
P26	√	√	√	√	√	√	√	√	√	10
P27	√	√	√					√		4.25
P28		√		√		√		√	√	6.25
P29	√	√	√	√	√	√	√	√	√	10
P30	√	√	√	√		√	√	√	√	8.5
P31	√	√	√	√	√	√	√	√	√	10
P32		√		√	√	√	√			6.25
P33	√	√	√	√	√	√	√	√	√	10
P34	√	√		√	√	√		√		7.75
P35	√	√		√		√	√	√	√	8
P36										
P37				√		√				2.5
P38	√						√			1.75
P39	√	√					√			3.25
P40	√	√		√	√	√		√	√	8.75
P41	√	√	√	√	√	√	√	√	√	10
P42	√	√		√		√	√	√	√	8
P43			√	√		√	√	√	√	6
P44										
P45	√	√	√	√		√			√	6.5
P46	√	√	√	√	√	√	√		√	9.25
P47	√	√	√	√		√	√	√	√	8.5
Number of times	35	40	23	38	18	38	31	33	31	Average 7.4
Percentage	74.5	85.1	49	80.8	38.9	80.8	66	70.2	66	

Qualitative results

All the comments provided by the respondent ports have been analysed and classified into three categories of response:

A) For information / No action

B) Follow-up direct with port / feedback to port

C) Accept and incorporate into recommendations

Carbon Footprint

Table App.15: Stakeholders' comments on Carbon Footprint

Code	Comment	Decision
P3	Natural Gas and Electricity derive from green sources, so their actual CO_2 emission is zero.	A
P8	Port Authority furnish electric energy to all port area and respective activities and clients	A
P11	Port area is 645 acres or 260.84 hectares. The gas oil consumption relates to marine gas oil for water craft. There are no figures available for scope 3 employee commuting**.**	A
P12	Even without organizational units of SWAH & HBH are missing: fuel volumes for heating, fuel consumption of ships, mission kilometres (explaining the mode of transport), KG-trips just for the distance (disadvantage: environmentally friendly vehicles will be displayed too badly), water consumption in the SV port?	B
P13	Heat demand is covered by distributed heating system of the municipality. The respective power plant is gas fired. Peak loads are covered from a coal fired power plant. | Additional travel emissions are caused by ferry usage [6.000km in 2011 expected] as well as public transport at the destinations. All figures for business travel are estimates calculated from 2011 data up to September. No figures can be given for commuting but public transport has a minor share. Most employees live within a 20km range from the port and use their private cars.	A
P14	- Energy consumption: data is extracted from invoices - No breakdown of consumption by category: cranes, etc. - Diesel used by PA cars in port areas - Data for business travel difficult to collect - The number of cars should be added in the questionnaire	A C

Code	Comment	Decision
P18	- Natural gas: 9.127 kWh/m³; gas oil includes towing, dredging, floating cranes, quay cranes and souding vessels; burning oil: 36.292 MJ/l and 1 MJ = 0.277 kWh; electricity includes buildings, net losses, public lighting, electric cranes, bridges and locks. Fuel use by company owned vehicles is included in scope 3 "Business travel". No distinction available between "long" and "short" haul flight: worst case chosen for all km (= long haul). No distinction available between diesel and petrol for employees commuting: worst case chosen (all petrol). "Bus" under "employees commuting" covers common transport for employees and not "public transport". Bus public transport is included in "light rail and tram" under "employees commuting". - Water consumption was not filled out since it is not clear what this covers	A B
P21	Other Stationary Sources - Vessels on berth - 65 kton CO2 /Y + Cargo Handling Equipment - 4 kton CO2	A
P22	- You are missing one important factor in Scope 2: District heating (used widely in Finland). - Electricity: should the amount used include only use of port authority or also buildings owned by the port and rented to operators? Water consumption: like the electricity. - Electricity and water consumptions are quite difficult to divide.	C B A
P23	The terminals are excluded of the calculation of CO_2. What are the Emission Factors taken into account because these above are different from French factors, different from European factors and WPCI Factors	B
P24	Carbon Footprint will be calculated in 2012. For this reason, we still do not have all the data.	A
P25	Electricity incl. District Heating Part of electricity is renewable Lower differentiation within business travel than asked Business Travel Flights incl. Compensation; Port-owned ships incl. in vehicles (because they are not stationary)	A
P26	The Port Authority is in the process of developing a holistic framework for calculating the Carbon Footprint of PA.	A
P27	At the moment the port authority does not use these environmental indicators. In the mean time LSPA periodically proceeds to monitor in the port areas the quality of air and sea waters.	A
P35	- Data referring to cargo and passengers throughput already added at market trends indicators.	C

	Scope 1: notice blanquets are sources not used (is not referring "NA" data). Scope 3. Business travel. Only available total CO2 emissions. D data dissemination is not yet available, it will from 2011. Scope 3: employees commuting. It has to be added "motorbike" : 351.828 Km	A C
P41	1.1 Natural gas generated heat - also sold to operators in the port territory. Fuel oil, diesel and petrol only PA consumption. 6.1.2 Electricity consumption includes all the port territory, operators, agents, offices etc, except only few operators. 6.1.3 Water consumption includes all the port territory, operators, agents, offices etc, except only few operators	A
P43	We have to report (according to our environmental permit) annually emissions from berthed vessels. There was no required data concerning these matters	C
P46	The Port Authority does not calculate the Carbon Footprint	A
P49	**Scope 1:** Where do you put diesel used for operational vessels? -Company cars - no possibility to leave data regarding CNG, ethanol **Scope 2:** No possibility to leave data regarding district heating - no possibility to choose a lower emission factor when using environmentally labelled energy Business travel, diesel car, the result is not showing in tonnes, but in kg - business travel plane, in our port we get the estimated tonnes from our travel agent, we don´t have data in km Scope 3: within our scope 3 we include the scope 1 & 2 emissions from three of our terminals, there are no possibility to add this information. Would be good with a question asking if your port has calculated a Carbon Footprint. If yes, also make it available.	B C C C B B
P52	It appears a difference regarding the coefficients used for the different calculations with the French method requested by the law	B
P53	We only have the figures from Fredericia Havn A/S. Our building are using de-central heating, but we do not have the exact figures. Any other figures are N/A.	A
P56	6.1.2 Electricity - number shows total consumption of electricity for PA buildings and for owned ships supply.	A

Waste Management

Table App.16: Stakeholders' comments on Waste Management

Code	Comment	Decision
P3	Solid waste and sludge/bilge are measured in m^3. Fishing for litter is a project for collecting waste out of fisher nets.	A
P4	Solid waste refers only to the quantities generated by Port Authority activities. Port operators report their own generated wastes only to Environmental Protection Agency, according to national laws.	A
P5	Please find the attached excel file in which you can find the figures of 2000 up to 2010 for ship- and cargo generated waste. Regarding waste figures of the Port Authority and waste figures in the Port Area itself are both not traceable. For the Port Authority these are fixed contracts based on a maximum capacity of the containers, and not on actual waste figures. The Port Authority is recycling its waste as much as possible, but also in this case numbers are not known. Waste production figures in the port area are also unknown.	A
P8	Separated containers for paper and card, glass and plastics are provided by the Port Authority but the Municipality is responsible for the waste collection. So, the results are not included in this report but represent 170-300 cubic meters of paper and card more the same volume of glass and of plastics. Some wastes are usually collected and PA has appropriate containers or storage areas. If there isn't production in 2010 the field is with 0.	A
P11	Information applies generally to Port Authority waste including state management but excluding specific tenant generated waste streams. Plastics are included under dry recyclables. Floating debris segregated into specific waste streams. Non-recycled waste either to landfill or incineration, totals 164.6 tonnes of the total 827.17 tonnes (19.9%). Note recycled box ticked correctly but spread sheet not calculating. These figures exclude construction and demolition arisings from port related project or maintenance works.	A
P12	What is "Port Waste"? "Domestic wastes" are quantitatively not recorded but orderly disposal (incinerator or recycling of paper and recyclable materials (dual system), disposal of hazardous materials is via an electronic waste verification procedures.	B
P13	Disposal of gray water (passenger ships) from 2012. Since 2011 elevated disposal needs of passenger ships of chemicals (for example "Peroxide" , X-ray solutions" , "Photo developer solutions")	A
P14	Breakdown of waste category quite difficult to do	B

Code	Comment	Decision
P18	Completing the indicator on waste is according the PA not feasible.	A
P22	The picture above is not counting all fractions (see liquid waste)	C
P25	port waste lie in ministerial responsibility, PA-owned waste will be partly recycled (paper), started with waste management this year	A
P34	There is some kind of waste whose figures aren't known as they are under responsibility of the municipality.	A
P35	PA outsources the Marpol management (ship waste). Available data not included in the box above is as follows (recycled and non recycled): Marpol I: 49.993m^3; Marpol II: 497 m^3; Marpol IV: 4.473 m^3; Marpol V: 50.319 m^3	A
P42	We don't separate grey and black water	A
P46	The Port Authority has contracts with two companies for the disposal and recycling of wastes, so there is no actual image of the above.	A
P49	The waste from some of our terminals is not included in this statistics. The above mentioned statistics have been sent to the Swedish Maritime Administration. Unsure if most of the statistics under solid waste should have been placed under non recycled waste. Should mixed waste, non combustible waste and combustible waste be included under the section non-recycled waste or not?	A B
P50	The Port has a policy of recycling; however, 2011 is the first year that we will be producing any statistics.	A
P56	According to present national legislation, the Port Authority is responsible for management of ship-generated waste (which is delivered by ships visiting the Seaport). In the attached file you will find some information about waste management.	A

Water Consumption

Table App.17: Stakeholders' comments on Water Consumption

Code	Comment	Decision
P5	The Port Authority does not have this data available. This counts for the Port Authority buildings and vessels, but also for the Port Area.	A
P8	We don't have now the water consumption discriminated by the items above, but the third parties consumption is almost 50% of the total volume of water distributed.	A
P12	Consumption of port users are not included and are not covered.	B
P13	The port authority produces its own drinking water [85.558 m^3 in 2010]; additional water is provided from the public water works. Waste water amounts to 108.576m^3 in 2010 and is measured with 163.000m^3 at the connection point to the public sewers. The additional waste water originates from rain and ground water flowing into the sewer system.	A
P14	No data collected for companies set up in port areas	A
P23	Information is only available for the eastern harbour	A
P25	no date about irrigation (ground Water usage) and port consumption	A
P27	The Port Authority does not monitor the consumption of water in the entire port areas. The water supply to vessel is a private service gave in concession by the port authority to a private company. Port operators and terminals are responsible for water consumption and pay directly this service.	A
P30	Port Authority consumption includes passengers' consumption	A
P40	Input data for Port Authority water consumption is based on specification of invoices for water consumption for Split Port Authority.	A
P41	6.3.1 includes water leakage, cleaning and fire rescue system testing consumption	A
P51	No measuring of water consumption	A

Environmental Management

Table App.18: Stakeholders' comments on Environmental Management

Code	Comment	Decision
P4	This Management Programmes refers only the activities of Port Authorities.	A
P5	Our Corporate Social Responsibility policy and the (strategic) policy making and operations in general include all the environmental aspects as mentioned above. The Port Authority is in cooperation with other relevant authorities in the region working on its environmental and sustainable development and performance. For example, next to SEA, we also execute an environmental impact assessment. So, all the above mentioned environmental management tools are present within the port, but not in separate documents, but integrated in our (strategic) policy making and operations.	A
P9	information not available	B
P11	PERS and ISO 14001 compliant	A
P12	What is meant by "Inventory of SEA"?	B
P13	Environmental Monitoring is done by the municipality, results are discussed with PA. PA elaborates selective studies on noise and air emissions	A
P22	Environmental management program is made according to ISO 14011: there is no reference to ESPO Code of practise. SEA = assessment of environmental impacts; needs explanation!	A C
P25	Started with monitoring, targets e.g., but only first steps. What does SEA means?	B
P28	Next year the Port Authority will approve the new green port programme. The plan provides a new strategy to reduce air pollution generated from ships, decreases power consumption, and promotes a sustainable economic activity. Now we are monitoring, with a mobile lab, the air pollution in the areas of our three ports (Olbia, Golfo Aranci, Porto Torres)	A
P36	We don't know what SEA means, so we cannot reply to that point.	B
P49	Not clear what SEA stands for	B
P53	A/S does not have a specific Port Management Programme.	B

Appendix XIII: List and results of international research

The questions researched have been the following:

1: Does the port have a separate environmental section in their website?

2: Does the port have an Environment Management System?

3: Does the port have an Environmental Policy?

4: Is the Environmental Policy made available to the public?

5: Does the port publish an Environmental Report / Review?

6: Is environmental monitoring carried out in the port?

7: Has the port identified environmental indicators to monitor trends in environmental performance?

8: Does the port publish factual data by which the public can assess the trend of its environmental performance?

Note: The symbol '√' indicates an affirmative response to each specific question.

Ports of Oceania

Table App.19: List and results of ports of Oceania

No	Name	Country	Tonnage	1	2	3	4	5	6	7	8
1	Hedland	Australia	>25 millions	√	√	√		√	√		
2	Darwin	Australia	1 - 10 million		√	√	√		√	√	
3	Melbourne	Australia	>25 millions	√	√	√	√	√	√	√	
4	Broome	Australia	<1 million		√	√			√		
5	Brisbane	Australia	>25 millions	√	√	√	√	√	√	√	
6	Abbot point	Australia	10 - 2 million	√	√	√	√	√	√	√	
7	Geelong	Australia	-		√	√		√	√		
8	Burnie	Australia	1 - 10 million			√		√	√	√	
9	Esperance	Australia	10 - 25 million	√	√	√	√	√	√	√	√
10	Geraldton	Australia	1 - 10 million	√	√	√	√	√	√	√	
11	Kembla	Australia	>25 millions	√	√	√		√	√	√	
12	Albani	Australia	1 - 10 million			√	√	√	√	√	
13	Wallaroo	Australia	<1 million	√	√	√			√		
14	Tevenard	Australia	1 - 10 million	√	√	√			√		
15	Lincoln	Australia	1 - 10 million	√	√	√			√		
16	Dampier	Australia	>25 millions	√	√	√	√	√	√	√	
17	Apia	Samoa	-								

No	Name	Country	Tonnage	1	2	3	4	5	6	7	8
18	Nelson	New Zeeland	1 - 10 million	√	√	√	√	√	√	√	
19	Marlborough	New Zealand	<1 million			√		√			
20	Timaru	New Zeeland	1 - 10 million								
21	Bluff	New Zealand	1 - 10 million					√			
22	Otago	New Zealand	-	√					√		
23	Pappete	French Polynesia	<1 million								
24	Kimbe	Papua New Guinea	-								
25	Malau	Fiji	-	√							

Ports of Asia

Table App.20: List and results of ports of Asia

No	Name	Country	Tonnage	1	2	3	4	5	6	7	8
26	Ennore	India	10 - 25 million						√	√	
27	Paradip	India	>25 millions					√			
28	Chennai	India	<1 million		√	√			√		
29	Kuantan	Malaysia	1 - 10 million		√	√			√		
30	Chittagong	Bangladesh	>25 millions						√	√	
31	Karachi	Pakistan	<1 million								
32	Qasim	Pakistan	1 - 10 million								
33	Qingdao	China	>25 millions		√	√			√		
34	Shangai	China	>25 millions								
35	Ningbo	China	>25 millions								
36	Yangzhou	China	-								
37	Wenzhou	China	>25 millions								
38	Keelung	Taiwan	>25 millions								
39	Huliaren	Taiwan	10 - 25 million					√			
40	Taipei	Taiwan	-								
41	Busan	South Korea	10 - 25 million								
42	Ulsan	South Korea	-	√		√	√		√	√	
43	Bangkok	Thailand	-								
44	Prachuap	Thailand	-								
45	Da Nang	Vietnam	1 - 10 million		√	√			√		
46	Galle	Sri Lanka	-								
47	Macao	Macau	-								
48	Yokohama	Japan	>25 millions			√	√	√			
49	Tokyo	Japan	>25 millions					√			
50	Singapore	Singapore	>25 millions		√	√		√	√	√	

Ports of Africa

Table App.21: List and results of ports of Africa

No	Name	Country	Tonnage	1	2	3	4	5	6	7	8
51	Tanger	Morroco	1-10 millions								
52	Casablanca	Morroco	10 - 25 million								
53	Massawa	Eritrea	<1 million								
54	Abidjan	Costa Ivori	10 - 25 million		√	√			√		
55	Dakar	Senegal	1-10 millions		√	√			√		
56	Durban	South Africa	>25 millions		√	√	√	√	√	√	
57	Cape Town	South Africa	1-10 millions		√	√	√	√	√	√	
58	Digna	Sudan	<1 million								
59	Mombasa	Kenya	10 - 25 million	√	√	√			√		
60	Pemba	Mozambique	<1 million								
61	Maputo	Mozambique	1-10 millions	√		√	√				
62	Luderitz	Namibia	<1 million		√	√	√	√	√	√	√
63	Walvis	Namibia	1-10 millions		√	√	√	√	√	√	√
64	Pennington	Nigeria	-								
65	Algiers	Algeria	<1 million								
66	Bejaia	Algeria	10 - 25 million		√	√			√		
67	Alexandria	Egypt	<1 million								
68	El Arish	Egypt	-	√				√			
69	Djibouti	Djibouti	1-10 millions								
70	Namibe	Angola	-								
71	Gabes	Tunisia	1-10 millions	√					√	√	
72	Zarzis	Tunisia	<1 million	√					√	√	
73	Misurata	Liban	-								
74	Grande	Cape Verde	<1 million								
75	Tanga	Tanzania	<1 million								

Ports of North America

Table App.22: List and results of ports of North America

No	Name	Country	Tonnage	1	2	3	4	5	6	7	8
76	Freeport	USA	<1 million		√	√		√	√		
77	Boston	USA	10 - 25 million		√	√	√	√	√	√	√
78	Los Angeles	USA	>25 millions	√	√	√	√	√	√	√	√
79	Jacksonville	USA	1-10 millions								
80	San Diego	USA	1-10 millions	√	√	√	√	√	√	√	√
81	Hueneme	USA	-			√	√		√	√	
82	Savannah	USA	10 - 25 million		√	√	√	√	√		
83	Hilo	USA	<1 million								
84	San Luis	USA	-								
85	Brownsville	USA	1-10 millions								
86	Morro	USA	-						√	√	√
87	Manantee	USA	1-10 millions	√					√	√	√
88	Delaware	USA	10 - 25 million								
89	Morehead	USA	1-10 millions			√			√	√	
90	Wilmington	USA	1-10 millions			√			√	√	
91	Monterey	USA	-								
92	Coos Bay	USA	1-10 millions								
93	Alberni	Canada	-								
94	Quebec	Canada	>25 millions								
95	Montreal	Canada	>25 millions			√	√	√	√	√	
96	Victoria	Canada	-					√	√	√	
97	Colborne	Canada	>25 millions	√	√	√		√	√	√	
98	Trois-Rivieres	Canada	1-10 millions								
99	Thunder Bay	Canada	1-10 millions								
100	Tasiilaq	Greenland	-		√	√		√	√		

Ports of Latin America

Table App.23: List and results of ports of Latin America

No	Name	Country	Tonnage	1	2	3	4	5	6	7	8
101	Cozumel	Mexico	<1 million								
102	Ensenada	Mexico	1-10 millions	√	√	√		√	√	√	
103	Acajutla	El Salvador	1-10 millions								
104	Kingsdom	Jamaica	1-10 millions								
105	San Juan	Puerto Rico	1-10 millions								
106	Caldera	Costa Rica	1-10 millions								
107	Cabezas	Nicaragua	<1 million								
108	Guanta	Venezuela	<1 million								
109	La Guaira	Venezuela	<1 million								
110	Rio Janeiro	Brasil	1-10 millions	√		√	√	√	√	√	
111	Navegantes	Brasil	-		√	√		√	√		
112	Valparaiso	Chile	-		√	√			√		
113	Punt Arenas	Chile	<1 million								
114	Buenos Aires	Argentina	10 - 25 million								
115	Ushuaia	Argentina	-								
116	Ilo	Peru	<1 million			√	√				
117	Manta	Ecuador	<1 million								
118	Bolivar	Ecuador	1-10 millions								
119	Barranquilla	Colombia	1-10 millions								
120	Montevideo	Uruguay	1-10 millions	√	√	√	√		√		
121	Colonia	Uruguay	<1 million	√	√	√	√		√		
122	Aguirre	Bolivia	<1 million								
123	Balboa	Panama	>25 millions	√				√			
124	Plata	Dominic rep.	1-10 millions								
125	Barrios	Guatemala	-								