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Methodology for the selection and implementation of environmental aspects and performance indicators in ports

by

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A Doctoral Thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Chemical Engineering

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Abstract

It is broadly known that efficient ports are crucial for the economic development of their surrounding area. However, the loading and unloading of goods in the ports, the related ship traffic, and the hinterland distribution can cause a number of negative environmental impacts.

In this thesis, the concepts of environmental aspects and indicators are reviewed, as two relevant elements used in the environmental management. The importance of both elements within an Environmental Management System (EMS) is also justified. Although EMS standards recognise that the identification of environmental aspects and the use of indicators are essential processes, they do not specify any methodology to undertake these tasks. In addition, the present research demonstrates that although there is a high percentage of European ports that have already identified their significant aspects and performance indicators, most of these ports do not use any standardized method. This suggests that some of the procedures used by ports may not necessarily be science-based, systematic in approach or appropriate for implementing effective environmental management.

For these reasons, it was detected that a new methodology able to identify ports' aspects and their most adequate indicators was needed. The developed methodology is called EPORTS.CAT and it comprises two main tools: a Tool for the identification and assessment of Environmental Aspects in Ports (TEAP) and a Tool for the identification and implementation of Environmental Indicators in Ports (TEIP). The first aims at the identification of the major environmental aspects that may be generated in a port and the assessment of their significance (TEAP); and the second at the identification of performance indicators that are related with the aspects and the provision of guidelines for their implementation (TEIP).

This method has been developed after analysing the strengths, weaknesses and challenges of the existing techniques, the recommendations from the Environmental Management System (EMS) standards and the advice of specialists. This is a computer and science-based tool (www.eports.cat) that provides a quick calculation and outputs, and it is designed to be as user-friendly as possible in order to facilitate its completion by the user (e.g. port environmental manager). This new methodology is applicable to all types of ports no matter the size, geographical location or its commercial profile; it provides targeted and specific results for each one. EPORTS.CAT is a practical and time-saving tool for port managers to easily determine significant aspects and indicators in their port areas.

Resum

És àmpliament reconegut que els ports són crucials per al desenvolupament econòmic de les àrees del seu entorn. No obstant, la càrrega i descàrrega de mercaderies en els ports, el tràfic de vaixells, així com la distribució de mercaderies cap a l'interior poden causar una sèrie d'impactes ambientals negatius.

En aquesta tesi s'analitzen els conceptes d'aspecte i indicador ambientals, que són dos elements rellevants utilitzats en la gestió ambiental. També es justifica la importància que tenen tots dos elements dins d'un Sistema de Gestió Ambiental (SGA). Encara que les normes dels SGA reconeixen que la identificació dels aspectes ambientals i l'ús dels indicadors són processos essencials, no especifiquen cap metodologia per a realitzar aquestes tasques. A més, la recerca duta a terme en aquesta tesi demostra que, si bé hi ha un alt percentatge de ports europeus que ja ha identificat els seus aspectes més significatius i els indicadors més convenients, la majoria d'aquests ports no utilitza cap mètode estandarditzat. Això suggereix que alguns dels procediments utilitzats pels ports poden no tenir necessàriament una base científica, o bé, no ser sistemàtics o apropiats per al propòsit d'implementar una correcta gestió ambiental.

Per aquestes raons, es va detectar que era necessària una nova metodologia capaç d'identificar aspectes ambientals en ports i els seus indicadors més adequats. La metodologia desenvolupada es diu EPORTS.CAT i consta de dues eines principals: la *Tool for the identification and assessment of Environmental Aspects in Ports (TEAP)* i la *Tool for the identification and implementation of Environmental Indicators in Ports (TEIP)*. La primera té per objectiu identificar els principals aspectes ambientals que poden generar-se en un port i avaluar-ne la seva significança (TEAP); i la segona identificar els indicadors que estan relacionats amb els aspectes i proveir de directrius per a la seva correcta aplicació (TEIP).

Aquest mètode ha estat desenvolupat després d'analitzar els punts forts i febles de les tècniques existents, estudiar les recomanacions de les normes dels Sistemes de Gestió Ambiental (SGA) i obtenir l'assessorament d'especialistes. Es tracta d'una eina amb una base científica i informàtica (www.eports.cat) que proporciona un càlcul ràpid, i està dissenyada per a ser el més fàcil usar possible. Aquesta nova metodologia és aplicable a tot tipus de ports sense importar la seva mida, ubicació geogràfica o perfil comercial; proporciona resultats específics per a cada un. EPORTS.CAT és una eina pràctica i que permet estalviar temps als responsables portuaris per tal de determinar fàcilment els aspectes i indicadors significatius en les seves zones portuàries.

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Acronyms

Acronym	Meaning
AAPA	American Association of Port Authorities
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
ECI	Environmental Condition Indicators
ECOPORTS	Information exchange and impact assessment for enhanced environmental conscious operations in European ports and terminals
EPI	Environmental Performance Indicator
ESPO	European Sea Ports Organisation
EU	European Union
GHG	Greenhouse gas
GRI	Global Reporting Initiative
IAPH	International Association of Ports and Harbours
INDAPORT	Port Environmental Indicator System
ISO	International Organisation for Standardisation
IMO	International Maritime Organisation
LCA	Life Cycle Assessment
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MPI	Management Performance Indicators
NGOs	Non-governmental organisations

Acronym	Meaning
OECD	Organisation for Economic Co-operation and Development
OPI	Operational Performance Indicators
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated biphenyl
PEARL	Port Environmental Information Collector
PERS	Port Environmental Review System
PERSEUS	Policy-oriented marine Environmental Research in the Southern EUropean Seas
PIANC	World Association for Waterborne Transport Infrastructure
PM	Particulate Matter
POPs	Persistent organic pollutants
PORTOPIA	Port Observatory for Performance Indicator Analysis
PPRISM	Port Performance Indicators: Selection and Measurement
SEA	Significant Environmental Aspect
SDM	Self-Diagnosis Method
SOSEA	Strategic Overview of Significant Environmental Aspects
TBT	Tributyltin
TEAP	Tool for the identification and assessment of Environmental Aspects in Ports
TEIP	Tool for the identification and implementation of Environmental Indicators in Ports
TEUs	Twenty-foot Equivalent Units
VOCs	Volatile Organic Compounds
WPCI	World Port Climate Initiative

Chapter 1. INTRODUCTION

The first chapter of this thesis is divided in five sections: the first one introduces the importance of the shipping industry, mentioning its evolution over the recent decades and its benefits compared to the other modes of transport. The second section presents the characteristics of the port sector, emphasising the organisation of a port and some facts on their performance. The third section explains the motivations and the need to carry out this thesis, the fourth one presents its general scope and objectives, and finally the fifth section defines the structure of the thesis, by explaining to the reader the topics and issues that are discussed in each chapter.

1.1 The shipping industry

Maritime transport is the transport of both people (passengers) and goods (cargo) by sea-going vessels (Arora, 2012). The international trade and the exchange of goods and commodities are essential to improve the quality of the life of human beings all over the world. Without shipping, the import and export of goods on the necessary scale for the modern world would not be possible. Shipping is the main mean of transport for international trade and it is estimated that 90% of world trade is transported by the shipping industry (ICS, 2015). 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. The world fleet is registered in over 150 nations, and manned by over a million seafarers (ICS, 2015).

International waterborne trade contributes to the functioning of the global economy and represents a significant share of gross domestic product for many countries. The major commodities transported by the maritime transport are classified into the following categories:

- **General cargo:** it includes a mix of cargoes and packaged items, such as forest products, heavy equipment, manufactured goods, machinery, furniture, steel, and food products, among others, that are handled in any other method different than containers, such as boxes, barrels, packages, and pallets.

- **Freight containers:** they are a reusable transport and storage unit for moving products and raw materials between locations or countries. There are approximately 17 million intermodal containers in the world (Allport cargo services, 2016). A large proportion of the world's long-distance freight is transported in shipping containers. Its capacity is measured in Twenty-foot Equivalent Units (TEUs), and it can be easily transferred between different modes of transportation, such as ships, trains and trucks.

- **Liquid bulk cargo:** it is liquid cargo transported in bulk by tankers. Liquids may be categorised as non-edible and dangerous such as chemicals, crude oil and petroleum products; and edibles and non-dangerous liquids such as cooking oil, fruit juices, milk, and wine.

- **Dry bulk cargo:** it is cargo transported unpacked in large quantities, including raw materials and manufactured products. The United Nations Conference on Trade and Development (UNCTAD, 2015) considers that the major dry bulk substances are iron ore, grain, coal, phosphates, and bauxite/alumina. However, this category also covers many other commodities, namely bulk minerals (e.g. sand and gravel), chemicals (e.g. fertilizer), dry edibles (e.g. flour or sugar), cement, gypsum, and wood chips.

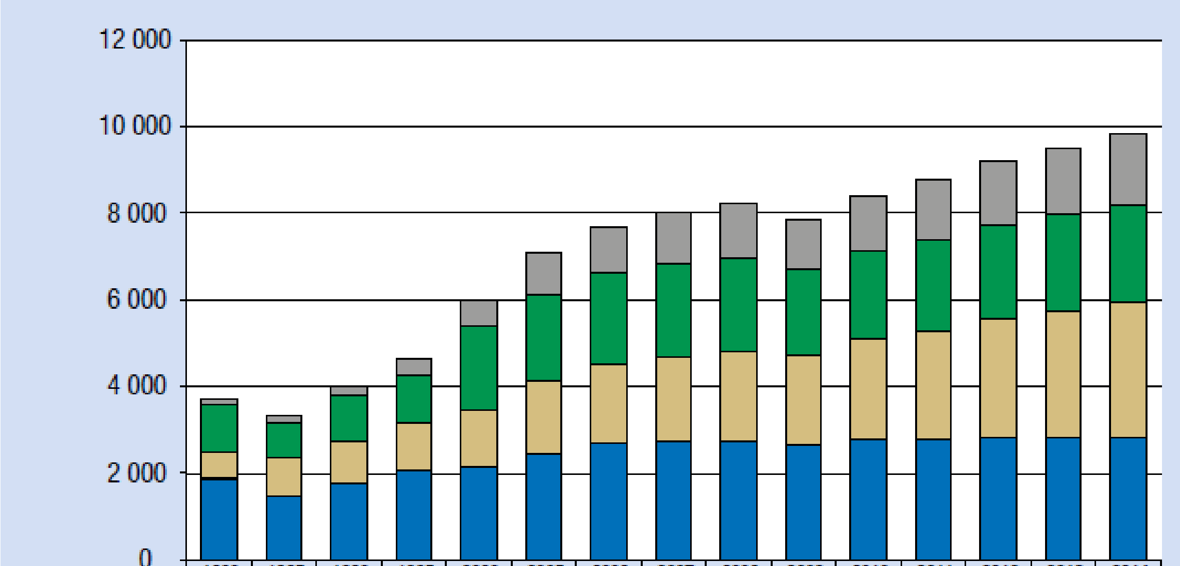
- **Ro-ro:** it stands for 'Roll-on/Roll-off' and it focuses on the transport of wheeled equipment for carrying cargo, such as automobiles, trucks, trailers or semi-trailers. Vehicles are driven on and off the ship on their own wheels, which allow the cargo to be efficiently 'rolled on' and 'rolled off'. Although ferries usually perform short journeys for a mix of passengers, cars and commercial vehicles, the term ro-ro is generally reserved for larger ocean-going vessels.

- **Passengers:** they make sea journeys on cruise ships or ferries. A cruise ship is intended to provide passengers with a full tourist experience, calling at ports of cities with tourist attractions. Modern cruise ships are fully equipped with facilities for entertainment aboard such as theatres, cinemas, luxury dining halls, shopping malls and leisure facilities including swimming pools, gyms and even climbing walls. Ferries also carry passengers, cargo and vehicles, operating usually on a regular return service.

1.1.1 Evolution of the shipping industry

It is broadly acknowledged that over the last decades the international seaborne trade among European Union (EU) member states and non-EU countries has increased massively, converting ports and harbours into important industrial centres. This section shows the evolution of the shipping industry over the recent years, initially from a global perspective and, secondly, from a European point of view. The information is mainly obtained from the United Nations Conference on Trade and Development (UNCTAD, 2015) in the case of the global perspective, and from the Eurostat Statistics of the European Commission (EC, 2016) in the European perspective.

Figure 1.1 below demonstrates that the world seaborne trade reached the total number of 9.84 billion tonnes in 2014, which is an increase of 3.4% compared to 2013 (UNCTAD, 2015). Globalisation and the rapid economic development in several parts of the world, such as China and India, are the major drivers of this shipping growth. Furthermore, the previsions indicate that this amount may double within the next 25 years (OECD, 2011) and may triple by 2060 (UNCTAD, 2011).



	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Container	102	152	234	371	598	969	1 076	1 193	1 249	1 127	1 280	1 393	1 464	1 544	1631
Other dry cargo	1 123	819	1 031	1 125	1 928	2 009	2 112	2 141	2 173	2 004	2 022	2 112	2 150	2 218	2272
Five major bulks	608	900	988	1 105	1 295	1 709	1 814	1 953	2 065	2 085	2 335	2 486	2 742	2 923	3112
Oil and gas	1 871	1 459	1 755	2 050	2 163	2 422	2 698	2 747	2 742	2 642	2 772	2 794	2 841	2 829	2 826

Figure 1.1: International seaborne trade over years (millions of tonnes) (UNCTAD, 2015).

The figure demonstrates that the international seaborne trade has continued to raise in the recent years, although the existing global economic recession. The only year that it decreased during the last decade was in 2009, corresponding to the beginning of the economic downturn.

The figure also shows that the five major bulk commodities (namely iron ore, coal, grain, phosphate rock and bauxite/alumina) are the goods that are more shipped, accounting for almost 32% of the total seaborne trade. This category increased by 6.5% in 2014 compared to the amount of goods shipped during the previous year. This growth was supported by the strong expansion in iron ore trade (+12.4%) which accounted for about

43% of the five major bulk cargo and reached 1.34 billion tons (Clarksons Research, 2015). In contrast, coal trade shipments increased by a modest 2.8%, a much slower rate than the double-digit growth recorded in 2012 (+12.3%), with total volumes at 1.2 billion tons. Grain shipments (including wheat, coarse grain and soybean) have increased by 11.1% in 2014 and totalled 430 million tons. Shipments of phosphate rock increased by 7.2%, taking the total volume to 30 million tons. The only bulks that have not increased are bauxite and alumina trade, which have diminished by 24.5% in 2014, reaching 105 million tons (Clarksons Research, 2015).

The second group of most handled commodities is the tankers' trade, which includes crude oil, petroleum products and gas. These commodities slightly declined from a share of nearly 30% of the total seaborne trade in 2013 to 28.7% in 2014. Crude oil shipments reached 1.7 billion tons in 2014, a drop of 1.7% over the previous year. On the contrary, refined petroleum products have increased by 1.7% in 2014 and reached 977 million tons. The increasing exports from Western Asia (+6.3%) and the United States (+4%) and imports to Latin America (+11.8%) and developing Asia (other than China) (+6.3%) helped to support this growth (Clarksons Research, 2015). Liquefied Natural Gas (LNG) also increased its share in 2014, having a higher demand in China, India, the United Kingdom, Brazil, Mexico and Japan (British Petroleum, 2015). Some observers predict that LNG volumes will double by 2020 (UNCTAD, 2015), since environmental regulations and air emission controls may lead to a growing role for gas. Australia emerges as the world-leading exporter, together with other producers such as the Russian Federation, the United States, Canada and East Africa (Lloyd's List, 2015).

The category 'Other dry cargo' includes the rest of the other bulk commodities not mentioned previously and general cargo, and it also increased 2.4% in the last year. The volumes of the global shipments of minor bulk commodities reached 1.43 billion tons. Finally, the last commodity is containerised cargo, which represents around 15% of the total trade in 2014. Container cargo increased by 5.6% from 2013 to 2014 and reached 171 million TEUs (UNCTAD, 2015).

In EU ports, the total gross weight of goods handled was estimated at close to 3.8 billion tonnes in 2014 (EC, 2016), as demonstrated in figure 1.2. In this case, the graph also shows a lightly increase (+2%) compared to 2013; however, the gross weight of goods handled in 2014 was still lower than the annual volumes handled before the economic downturn in Europe in 2009. The EU seaborne trade accounts for 38.6% of the total world seaborne trade.

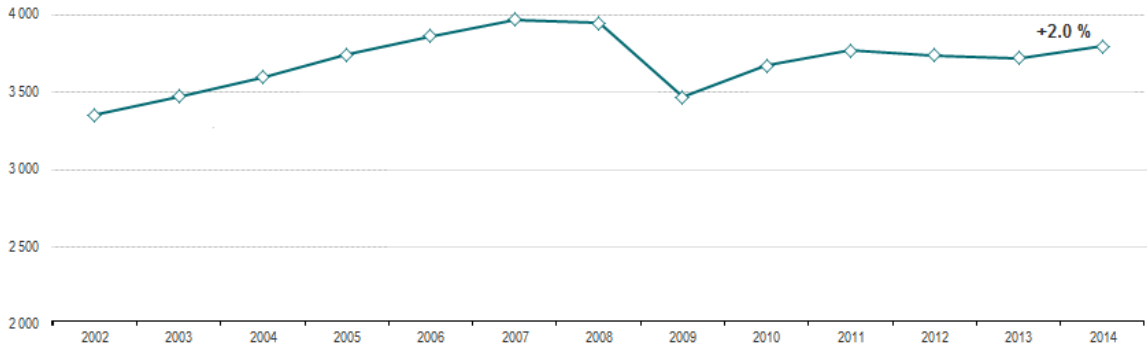


Figure 1.2: EU seaborne trade over years (millions of tonnes) (EC, 2016).

By type of goods, liquid bulk goods accounted for 37% of the total tonnage of cargo handled in the main EU ports in 2014, followed by dry bulk goods (23%), containerised goods (21%) and Ro-Ro mobile units (12%) and other cargo (7%) (EC, 2016). The number of passengers passing through EU ports increased 0.6% between 2013 and 2014, reaching 402 million passengers. Greece (18.76%), Italy (17.96%), and Denmark (10.29%) are the three leading sea passenger transport countries in 2014.

The Netherlands remained as the largest maritime freight transport country in Europe in 2014, representing 15% of the total EU share. It was followed by the United Kingdom (UK) and Italy, with shares of 13.3% and 11.7%, respectively. Compared with 2013, the biggest relative increases in port activity were recorded by Malta (+11.6%), Spain (+7.6%), Latvia (+7%) and Poland (+6.9%). The largest relative decreases were recorded in Bulgaria (-5.6%), Croatia (-3.9%) and Italy (-3%).

1.1.2 Benefits of the shipping industry

Water transportation presents more advantages in transporting goods compared to road, rail and air transportation. The main strengths of maritime transport are: i) it is a more economic mode of transportation, consuming less energy per cargo moved, and therefore it is a more energy efficient transport, producing fewer exhaust emissions per tonne of cargo transported; and ii) it is a safer transportation method, having a lower frequency of accidents. Below, these two advantages are explained in more detail.

In terms of energy efficiency, shipping is the clear leader compared to other transport modes. Since the costs of fuel currently account for up to 50% of operating costs (ICS, 2015), ship owners have a strong incentive to reduce their fuel consumption. The shipping industry has 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 (Puig, 2012). Figure 1.3 draws a comparison on the fuel efficiency by different transport modes. The graph shows that, by ship, one tonne of cargo travels 312 kilometres with one litre of fuel, being this one the most favourable option.

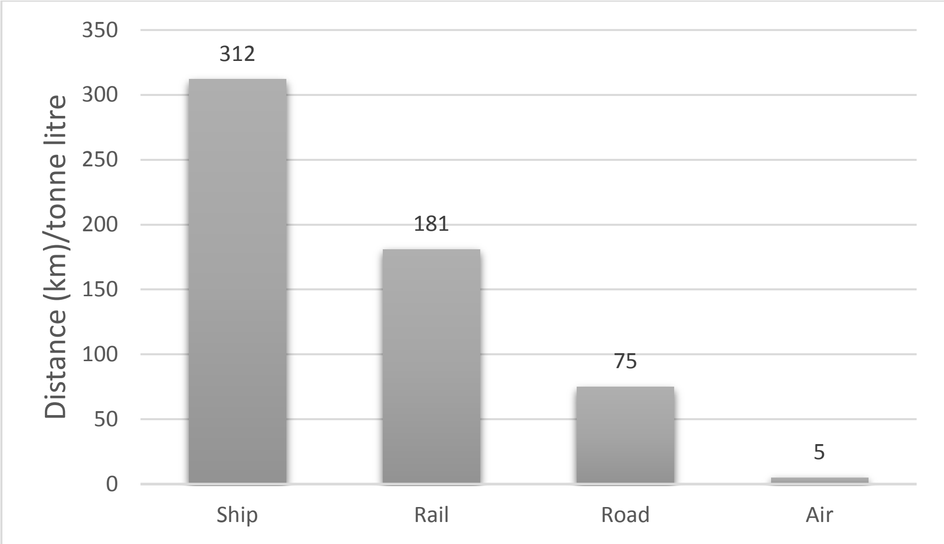


Figure 1.3: Comparison on the distances that one tonne travels with one litre of fuel (adapted from St. Lawrence Seaway, 2016).

In relation to this, shipping is recognised as the most efficient form of commercial transport in terms of CO_2 emissions, compared to road vehicles and air transportation. As shown in figure 1.4, shipping emits 10 grams of CO_2 per tonne of cargo transported for each kilometre. Nevertheless, it should be pointed out that the large scale of the shipping industry means that it is a significant contributor to the world's total greenhouse gas emissions, around 3% of total global CO_2 emissions (ICS, 2015).

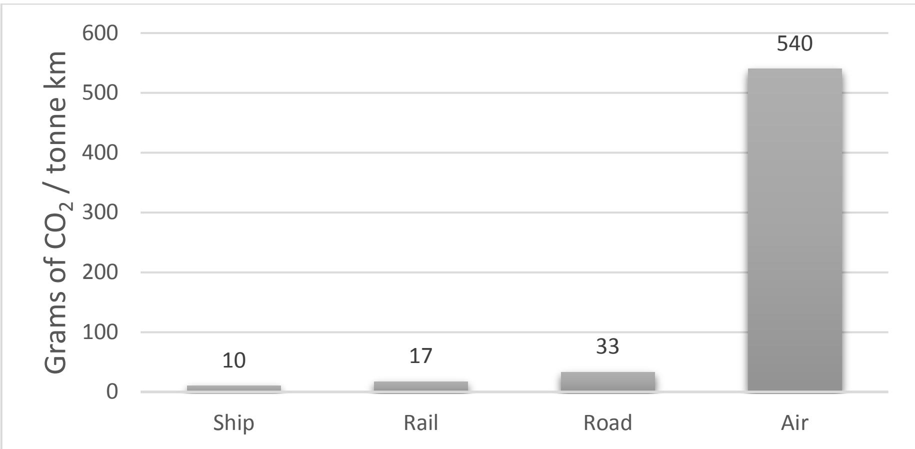


Figure 1.4: Comparison on the CO_2 emissions per tonne transported one kilometre (adapted from ICS, 2015 and St. Lawrence Seaway, 2016).

The maritime mode of transportation also compares very favourably when it comes to safety. As it is shown in figure 1.5, ships have an average number of five accidents per billion tonne of cargo transported one kilometre, a number much lower compared to road transportation.

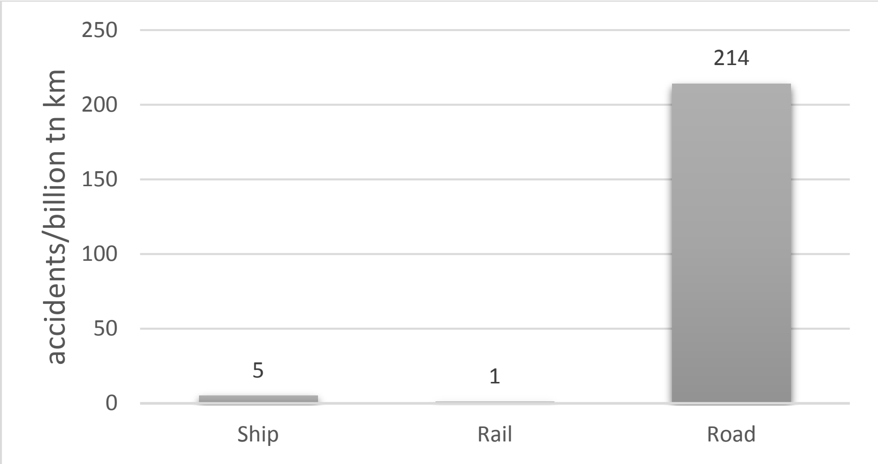


Figure 1.5: Comparison on the number of accidents per billion tonnes transported one kilometre (adapted from Lawson, 2007).

The maritime transport, and more concretely ships, also pose other advantages compared to other means of transport. On one hand, there exist capacious vessels that can transport large amount of oil, containers or bulk cargo. This results on a higher efficiency in terms of human, economic and sustainable resources. On the other hand, there are ships suitable for all kind of cargo, such as LNG tankers, refrigerated cargo, bulk carriers, ro-ro, among others. This means that they are already prepared to carry any sort of commodity.

It is interesting to point out that shipping also contributes to reduce the road traffic congestion, since one marine ship is capable of carrying an average of 25,000 tons of cargo, equivalent to the capacity of 225 rail cars and 870 trucks (St Lawrence Seaway, 2016). This demonstrates that the use of water transportation is efficient to reduce the traffic congestion. This issue should be taken into account because it is strictly related to delays in transportation, increase of greenhouse gas emissions, and higher air contamination and noise.

Goods are transported from the producer to the consumer through various modes of transport using various nodal points. Maritime ports play a crucial role in the logistic chain because they are the point of contact between sea and land, and they constitute one of these nodal points. The following section introduces the concept of port, its organisation, the services that it provides and the facilities that it may have.

1.2 The port sector

The traditional definition of a port is a shelter that allows the reception of ships. However, the concept of port has evolved rapidly in the recent decades. The European Sea Ports Organisation (ESPO), which represents port authorities, port associations and port administrations, proposed a detailed definition: “a port may be understood to be an area of land and water made up of such construction 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 to the hinterland, and can also include the activities of business linked to sea transport” (Mokkhavas, 2002).

The ESPO definition is more comprehensive because it stresses that a port is not merely an organisation that provides a single service, but instead many different activities are performed simultaneously within the ‘port area’. This port area is comprised of water and land. On the one hand, water areas include safe access routes for ships to enter and leave the port, and places for ships to be safely anchored and berthed. On the other hand, land areas include facilities and equipment for the loading, unloading, transportation and storage of goods, and for the embarking and disembarking of passengers. In addition, ports should have proper facilities in order to dispose of the ship waste.

As a result, ports are complex organisations from all points of view: economically, socially, culturally, and administratively, because of the range of interests and responsibilities of the parties involved. Ports may differ very much in their size and the type of traffic. Some are highly specialised, serving only a specific industrial site, such as a refinery or a mine. However, most of them are open to calls by any kind of ships, regardless their ownership or origin (OECD, 2011). These factors, in conjunction with the local geography and hydrography, imply that each port is unique (Bichou and Gray, 2005).

1.2.1 Port organisation

There are several types of management or decision levels inside the port area, having each one different responsibilities. The highest hierarchy of management is the port authority, which is the governing body for all the activities carried out inside the port. A second level is occupied by the licensed companies, which are private sector organisations that exert their activity under a temporary concession. These companies provide services, such as loading and unloading the cargo, supplying fuel to ships or developing maintenance operations (Peris-Mora et al., 2005). There is a third level of management, which includes the companies that provide services to licensed companies.

Port authorities may be public or private. The authority is responsible not only for having their own liabilities and responsibilities with regard to compliance with environmental legislation and for establishing the regulations that the ships and other companies using the port have to follow, but also for enforcing the public law inside the harbour. Governments transmits responsibilities to port authorities in order to ensure that the licensed companies, ships and other suppliers and clients comply with the law (Peris-Mora et al., 2005). It may be considered that in a court of law, the authority may be deemed to be in a position to influence the performance of their tenants and operators.

It is also responsibility of the port authority to collect the fees and charges from those who use the port, to ensure the proper use of common facilities, to provide port services and to guarantee safe maritime access for ships. The authority controls the movement of ships in and out of the port and makes sure that they remain safe. The authority has to make sure that all the issues that involve the protection of the environment are being considered (AUSMEPA, 2009).

1.2.2 Port sector performance

There are more than 2,900 commercially active ports worldwide (Lloyd's Marine Intelligence Unit, 2007), being the United States the country with the largest number of ports (551) (World Port Source, 2015). According to the World Port Ranking 2014 (AAPA, 2014), the top three world's busiest ports in terms of total cargo throughput are the Port of Shanghai (China), the Port of Singapore (Singapore) and the port of Guangzhou (China). As it can be seen in figure 1.6, which provides a top-20 ranking of the world's largest ports in terms of the total tonnage of their throughput, the first European port that appears on the ranking is the port of Rotterdam (The Netherlands) and it is located on the seventh position. The next EU port on the ranking is the port of Antwerp (Belgium), being located in the 17th position.

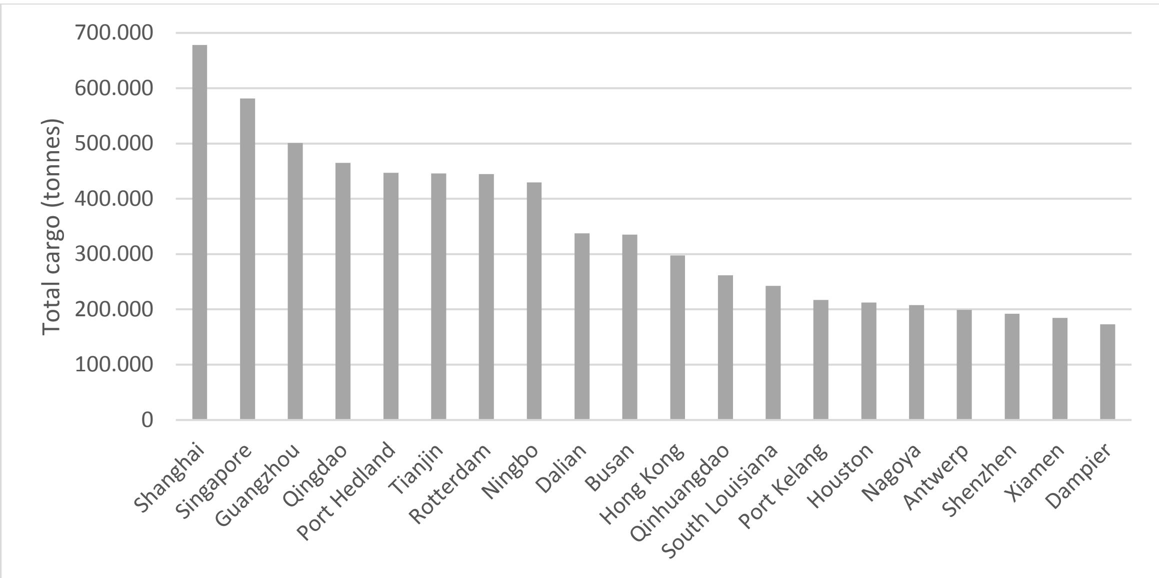


Figure 1.6: World's largest ports in 2014 (AAPA, 2014).

In Europe, there are more than 1,200 ports along the 100,000 kilometres of coastline, providing 1.5 million direct jobs, with the same amount employed indirectly (EC, 2015). Direct port employment is created through cargo handling services, ship operations and nautical services. Typical direct jobs include dock workers, ship agents, pilots, tug boat operators, freight forwarders, port authority employees, ship chandlers, warehouse operators, terminal operators and stevedores. Indirect jobs of ports' activities are, for example, jobs in local office supply firms, equipment suppliers, maintenance and repair, insurance companies, consulting and other business services.

The Eurostat Statistics (EC, 2016) specifies that the ports of Rotterdam, Antwerp and Hamburg (all located on the North Sea coast) maintained their positions as the top three ports in 2014, in terms of both the gross weight of goods and the volume of containers handled. Rotterdam on its own accounted for close to 10% of the total tonnage of goods handled, Antwerp for more than the 4%, and Hamburg for almost the 3% (EC, 2016). With regards to containers, Rotterdam handled 11.6 million Twenty-foot Equivalent Units (TEUs) in 2014, which equals to 11.5% of the total EU containers handled. It was followed by Hamburg with 9.8 million TEUs (9.6%) and Antwerp with 8.8 million TEUs (8.7%) (EC, 2016).

All these top three cargo ports recorded increases in the tonnages handled in 2014 with respect the previous years. Whereas Rotterdam saw an increase of 1.6% in total tonnage from 2013, both Antwerp and Hamburg recorded a growth of between 4% and 5% (EC, 2016). Most of the top 20 EU container ports reported an increase in the number of TEUs handled in 2014. The largest increases were recorded by the ports of Sines in Portugal (+31.9%), Genova in Italy (+30.3%) and Southampton in the United Kingdom (+27.2%). Only two of the top 20 ports reported handling a lower volume of TEUs in 2014 than in the previous year: Bremerhaven in Germany (-1.6%) and Marseille in France (-0.5%).

1.3 Research motivations

As demonstrated in the previous figures 1.1 and 1.2, the fluctuations of the recent years in the economic growth do not hide the overall expansion of the international and European maritime trade. For instance, the global seaborne trade increased by +64% in the last 15 years, and by +146% in the last 25 years. As it has also been explained previously, shipping is vital to the worldwide economy, with around 90% of world trade being carried by the international shipping industry (ICS, 2015). It is widely known that the port sector plays a crucial role in the logistic chain (Puig et al., 2014), since it joins the sea and land transportation.

Since worldwide maritime cargo has increased in most of the ports, port facilities have necessarily been expanded and developed with new quays, deeper channels and modern cargo handling facilities (Alderton, 2005). The intensive levels of routine port activities and the operations associated to the development of port facilities contribute significantly to the provision of both direct and indirect employment, and to the economic development not only of their surrounding coastal area but also of the hinterland regions to which they are connected (Paipai, 1999).

However, the magnitude of these activities, with large ports and large vessels, make port activities subject to special precautions in order to ensure that they are consistent with sustainable development. Many authors have stated that daily port operations and activities may have adverse consequences on the environment (e.g. Gupta et al., 2005; Dinwoodie et al., 2012), impacting on air (e.g. Bailey and Solomon, 2004; Cooper, 2003), water (e.g. Grifoll et al., 2011; Kröger et al., 2006), and soil and sediments (e.g. Edoho, 2008; Ray, 2008), affecting both the terrestrial and marine environments.

As seen in the previous section 1.1.2, maritime transport has the lowest fuel consumption compared to aviation or land-based modes. However, a large part of the global fleet of commercial vessels is not as energy efficient as it would be desirable (OECD, 2011) since shipping uses the residual fuel that can no longer be used on land due to environmental restrictions. Since ports constitute an important part of the global shipping infrastructure, it is considered that part of the environmental impacts of shipping occur in or in the immediate vicinity of ports.

Main environmental concerns generated in ports due to the shipping activities are the emissions of particles (PM10 and PM2.5), CO_2, NO_x, SO_2 and noise from the ship's main and auxiliary engines. Other major environmental impacts caused by shipping are oil or chemicals spills, either accidental or deliberate, and the spreading of invasive species through exchange of ballast water between continents and climatic zones.

The use of machinery for the loading and unloading of substances also may generate noise and emissions of greenhouse gases. Dust may be emitted from the handling of substances such as grain, sand and coal. Incoming or outgoing goods are distributed along the hinterland by truck, train or inland waterways. This road and rail traffic from/to the port area may also cause additional environmental problems. In many instances, the construction of new or extended port facilities cause conflicts over land use, for instance with wildlife refuges and bird habitats, but in some cases also with local house planning (OECD, 2011).

The previous examples demonstrate that ports are complex areas, where there exist not only the interactions between sea and land, but also the connexions port - city, and port - logistic chain. In order to deliver compliance with legislation, environmental protection and sustainable development, an effective port environmental management is needed within the port area. This management needs to take into account the potential impacts on the environment, mitigating options, methods of prediction, information on legislation and regulations and data on environmental indicators (PPRISM, 2012). In addition, as environmental awareness is increasing throughout society, effective environmental management is also essential if stakeholders are to continue their support for port operations and development. Therefore, the thesis motivation is to assist ports in those issues identified as critical during the implementation of the environmental management systems. For this reason, a method to improve the environmental management in ports will be developed.

1.4 Aim and objectives

The general aim of this research is to develop a method that assists port authorities to improve and carry out their environmental management in a more effective way (EPORTS.CAT). This method is composed of two main parts: the first one includes a tool for the identification and assessment of environmental aspects in ports (TEAP), and the second one that provides a set of environmental indicators for monitoring in the port area (TEIP).

Although, by definition, each port is unique in terms of its characteristics, ports face common challenges, such as complying with legislation (either local, national or international), minimising the environmental impact and following environmental standards. For this reason, the tool developed in this thesis is generic, applicable to all of them and with a common methodology. It is expected that this method will be user-friendly, reliable, scientific accurate, and freely available online to all ports willing to use it.

Generally, the thesis is focused on the EU level and therefore it has a European perspective to evolution of sector-response options, legislation and management response initiatives and options. However, this fact does not ignore or detract the international examples and perspectives that are already included in the thesis.

In order to accomplish this general aim of this study, the following specific research objectives were established:

- Review the literature written on the initiatives, research projects, environmental legislation, and actions implemented within the port sector in terms of the environmental management.
- Research on the main issues that concern an Environmental Management System (EMS), such as the concept, existing standards, key elements, and advantages of its implementation. Special attention will be given on the requirements that the main EMS standards present in relation to environmental aspects and indicators.
- Review the existing methodologies developed for the identification and assessment of environmental aspects and indicators in ports.
- Identify the existing environmental aspects in ports, as well as their related impacts and indicators, based on very broad sources of information.

- Develop the tools that will be used for the identification and assessment of aspects and for the identification and implementation of indicators in ports.
- Test the tools through specific port stakeholders and experts. This test will be very useful in order to obtain feedback and proposals for improvement.
- Implement the proposed amendments in order to create an improved and final version of the methodology.
- Disseminate the final methodology among the port sector. Dissemination actions will include articles in port magazines, participation and presentations in port conferences or distribution via port sector organisations.

1.5 Structure of the thesis

The research that has been developed and presented in this thesis is structured in seven chapters. The contents of each chapter are presented below:

Chapter One introduces some facts and figures on the shipping industry and the port sector, their economic and social importance. This chapter also presents the research motivations, the aim and objectives of this study, and the organisational structure of this thesis.

Chapter two provides a deep review on the environmental management in ports. This review initially provides an evolution of port environmental management, based on the several initiatives developed by ESPO, the research projects that have been carried out, and other initiatives from other port organisations. Secondly, a review on the environmental legislation affecting ports is presented, at international and European Union level. Thirdly, the concept, main elements and advantages of implementing an Environmental Management System are explained. The last section of this chapter provides facts and figures on the environmental management performance of the EU ports, based on the results of the *European Port Industry Sustainability Report 2016*.

Chapter three focusses on environmental aspects and indicators. For each of these two components, the concept, types and importance are presented. A review of the relevance that the aspects and indicators have within the existing EMS standards is given. Thirdly, a state of the art is presented on the existing methods used to identify and assess environmental aspects and in implementing environmental indicators. Based on this research, the need for a methodology is presented.

Chapter four presents the development of the tool for the identification and assessment of environmental aspects (TEAP). The actions that have been carried out in order to develop this tool are described, which includes a research on the existing environmental aspects, and a description of the environmental aspects and their associated impacts. An application of the tool, showing screenshots of the different steps, is also provided.

Chapter five focusses on the development of the tool for the identification and implementation of environmental indicators in ports (TEIP). Following the same structure as the previous chapter, this one presents the actions that have been followed to develop this tool. It includes a research on the existing port environmental indicators, a classification of the researched indicators, the selection of criteria for the assessment of indicators and their filtering through these criteria. The structure of the indicators' and recommendations' guidelines is presented, and several screenshots of the tool are displayed in the TEIP application section.

Chapter six is based on the validation process of both tools. It provides the feedback obtained from the different stakeholders and the proposals of improvement that were obtained throw this engagement process. As a result, an updated and improved version of each tool was obtained, and explained in this chapter.

Chapter seven draws the conclusions obtained after carrying out the research.

Chapter 2. ENVIRONMENTAL MANAGEMENT IN PORTS

This chapter aims at providing the reader with the main basis and progress in relation to the environmental management of the port sector. It is divided in four main sections. Initially, the evolution of the port environmental management in the last 20 years is presented. Secondly, the main pieces of international and European legislation affecting ports and the environment are listed. In the third section, an introduction to the concept of an Environmental Management System (EMS) is provided. It includes an explanation of the key elements that compose an EMS, the benefits that their existence may bring to the port authorities and a description of the three main EMS standards for ports. The last section of this chapter provides figures obtained from several research questionnaires that allow to evaluate the environmental management performance at EU ports.

2.1 Evolution of port environmental management

Several port associations around the world introduced codes of practice, policies and strategies in order to promote the environmental awareness among ports and to provide adequate measures to diminish the adverse environmental impacts of port activities (see section 4.2 for more detail). Below, these initiatives are presented, as well as the research projects that have been realised in the recent years in relation to these issues.

2.1.1 ESPO initiatives

In Europe, with the need to take the environmental concerns into consideration, the European Sea Ports Organisation (ESPO) published in 1994 the first *ESPO Environmental Code of Practice* (ESPO, 1994). It was the first European code for ports, representing the sector's strategic view on environmental liabilities and responsibilities, and providing guidelines on best practice. This code was updated in 2003 (ESPO, 2003) bearing in mind the policy and practice evolutions. The Code was replaced in 2012 by the *ESPO Green Guide* which introduced a common framework for action under 'Five Es': Exemplify, Enable, Encourage, Engage and Enforce. These are applied to five selected environmental issues: air quality, energy conservation and climate change, noise management, waste management and water management (ESPO, 2012). The guide was accompanied by two online annexes: one consisted of good practices being in place in European ports and the other summarised the most significant pieces of EU legislation that influence the environmental management in port areas. In addition, two more specialized codes were published, the *ESPO Code of practice on the Birds and Habitats Directives* (ESPO, 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* (ESPO, 2010a), which encouraged members to be pro-active in the field of societal function of ports.

Apart from the codes of practice, ESPO has conducted regularly environmental surveys in order to study and analyse the environmental benchmark performance of ports, their main environmental concerns, and the trends of the sector. In February 1996, the first environmental survey was conducted in order to assess the response to the recommendations of the first ESPO code of practice. The first *Environmental ESPO Questionnaire* was useful to obtain an overview of the most important environmental problems in ports. 281 ports from 15 different European countries responded to the questionnaire.

In April 2005 the results of a second study, the *ESPO Environmental Survey 2004*, were published (ESPO, 2005). In that case, 129 ports participated in the survey. The survey identified the issues which were at stake for EU ports in the field of environment and also established a port sector's European benchmark of environmental performance. It allowed a comparison of the results of both studies and also an investigation of emerging trends. In these initial surveys ports responded in hard-copy via postal systems.

In 2009, a third major environmental survey was carried out, the *ESPO/Ecoports Port Environmental Review 2009* (ESPO, 2010b), updating the results of previous similar exercises and assessing the progress that had been achieved over the past 14 years. This questionnaire was more comprehensive than those previously undertaken since it also covered issues related to performance indicators, local community engagement, energy efficiency and port planning and development. For the first time, data collection benefited from the development of a web based tool that facilitated online submission by interested ports and improved analysis and interpretation of results. In this survey, 122 ports from 20 European Maritime States participated.

In line with the commitment to increase transparency in the port sector, in spring 2013 a comprehensive port performance data collection exercise was carried out (ESPO, 2013). The environmental outcomes of this exercise updated the review. In this case, 79 ports of 21 European Maritime States provided environmental data (Puig et al., 2015a).

In March 2016, the first *European Port Industry Sustainability Report 2016* (ESPO, 2016) was published, in the framework of PORTOPIA project. This report compiled data on 6 dimensions, in line with the principles of integrated reporting: i) market trends and structure, ii) socio-economic, iii) environment and Occupational Health, Safety and Security (OHSS), iv) logistic chain and operational performance, v) governance and vi) user perceptions on port quality. The environmental data was obtained from the responses of 91 EU ports to the EcoPorts Self-Diagnosis Method (SDM).

2.1.2 Research projects

Further to the commitment at the policy level through the several ESPO Codes of Practice, the EU port sector has undertaken numerous 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 related to port and environment are presented, together with their acronyms and the dates of the projects being undertaken. They are listed in chronological order.

Table 2.1: Examples of research projects (Puig, 2012).

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
Work organisation in ports	WORKPORT	1998 - 1999
Harbours - Silting and Environmental Sedimentology	H-SENSE	1998 – 2001
Towards an Environmentally Friendly Port Community	ECOPORT	1998 – 2000
Port Environmental Indicator System	INDAPORT	2002 – 2004
Automatic Tool for Environmental Diagnosis	HADA	2002 – 2005
Information exchange and impact assessment for enhanced environmental conscious operations in European ports and terminals	ECOPORTS	2002 – 2005
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
Clean Baltic Sea Shipping	CLEANSHIP	2010-2013
Policy-oriented marine Environmental Research in the Southern EUropean Seas	PERSEUS	2012-2015
Port Observatory for Performance Indicator Analysis	PORTOPIA	2013-2017

Table 2.1 demonstrates that a wide range of research and development projects concerning ports and the environment have been undertaken in the last 20 years, as a mutual collaboration between port authorities, research institutes, universities, and environmental experts.

Some examples of the most relevant projects are ECOPORTS (2002-2005), PEARL (2005-2008), PPRISM (2010 - 2011) and PORTOPIA (2013-2017). The first project promoted the share of knowledge and experience between European ports in the field of the environmental management. The main goals of ECOPORTS 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 (EC, 2011a). PEARL aimed at researching and improving the understanding of the environmental monitoring needs of European ports (Darbra et al., 2009). A ranking of the port's environmental monitoring needs was developed, providing also an idea of the most required environmental indicators. PPRISM project had the goal of identifying a final set of indicators, both relevant and accepted by port stakeholders, which contribute to provide insight into the overall performance of the European port system. In addition, this project was very useful to establish the culture of performance measurement in European ports (Puig et al., 2014). PORTOPIA is a project under development and it may be seen as a continuation of the PPRISM project. It aims at developing a Service Cloud where European ports can administer their performance based on selected performance indicators (PORTOPIA, 2014). The author of this thesis has contributed as research assistant on the above-mentioned research projects PPRISM and PORTOPIA.

As mentioned, as a result of these projects, useful methodologies to assist ports in their environmental management emerged. For instance, several tools were developed as a consequence of the ECOPORTS project, namely a methodology for identifying environmental risk and establishing priorities for action, entitled Self-Diagnosis Method (SDM) (Darbra et al., 2004); a methodology to identify environmental aspects in ports, called Strategic Overview of Significant Environmental Aspects (SOSEA) (Darbra et al., 2005); and a standard to achieve an Environmental Management System, named Port Environmental Review System (PERS) (ESPO, 2011). These tools continued to be available for use by port authorities after the end of the project.

Another example is the NoMEPorts research project (2005-2008) which 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).

It has been demonstrated that the above-mentioned initiatives carried out by the ESPO and the development of research projects are driving forces for the improvement of the environmental performance and to increase the awareness on these matters within the port sector. However, it is not the only agent of change. There have been other major environmentally-friendly initiatives developed within the port sector in the recent years by other organisations, which are presented in the following section.

2.1.3 Other initiatives

Within the other initiatives' section, seven examples of port organisations are provided. It is interesting to mention that the International Association of Ports and Harbours (IAPH), an organisation representing about 180 ports in 90 countries around the world, promoted the creation of the World Port Climate Initiative (WPCI) through the IAPH Port Environmental Committee. WPCI was created in 2008 with the aim of assisting ports to combat climate change by promoting best practices that reduce greenhouse gas (GHG) emissions and improve air quality. Examples of these best practices are: i) the release of the Carbon Footprinting Guidance Document (WPCI, 2010) that serves as a reference for ports looking to develop or improve their GHG emissions inventories; ii) the promotion of the use of Onshore Power Supply (replacing on board-generated power from diesel auxiliary engines to electricity generated onshore) (WPCI, 2013); or iii) the development of an Environmental Ship Index (ESI), which identifies seagoing vessels that perform better in reducing the amount of nitrogen oxide (NO_x) and sulphur oxide (SO_x) (WPCI, 2015a). Another WPCI working group developed guidelines on safe procedures for Liquefied Natural Gas (LNG) bunkering operations, providing ports around the world with implementation guidelines to pursue this technology (WPCI, 2015b).

The World Association for Waterborne Transport Infrastructure (PIANC) is a forum where professionals around the world join forces to provide expert advice on cost-effective, reliable and sustainable infrastructures to facilitate the growth of waterborne transport (PIANC, 2015). The Environmental Committee of PIANC has several active working groups covering issues of carbon management, climate change, environmental risk management, sea turtles and mammals, dredging and port and waterway construction, among others. In 2014, PIANC and IAPH agreed to set up a joint working group on ‘Sustainability reporting for ports’ which aims at providing guidance to ports on how to measure and report their economic, environmental and social performance in a common approach.

The American Association of Port Authorities (AAPA) published an Environmental Management Handbook designed to assist ports in effectively managing their environmental issues (AAPA, 1998). In addition, AAPA has the Environment Committee, which aims at monitoring, collecting and disseminating information related to all aspects of the environmental impact of ports, including air quality, water quality, storm water, contaminated sediment, sustainability and environmental management systems. This committee recognizes port achievement in environmental performance and facilitates the sharing of best management practices related to enhancing the coastal environment, managing environmental impact and engaging stakeholders and communities (AAPA, 2015).

The Baltic Ports Organisation (BPO) has an environmental group that consists of nine environmental managers from Baltic ports. This working group organises environmental seminars and training sessions, follows the regulatory developments that affect environmental issues (e.g. SO_x and NO_x emissions or port reception facilities for sewage from passenger ships), and shares examples of good environmental management and practices, among others (BPO, 2013).

The British Ports Association (BPA) also has an environmental policy group, which focusses on the management of Marine Conservation Zones (MCZs) and Marine Protected Areas (MPAs), and the implementation of the Marine Strategy Framework Directive (BPA, 2015).

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, 2015). It also produces the annual GreenPort Congress. This event aims at examining practical and economically viable solutions as well as applications and case studies.

Another environmental initiative developed within the port sector is the Green Award certification. It certifies ships that are further clean and safe. The certification procedure consists of an office audit and an audit of each individual ship applying for certification. This scheme is open to oil tankers, chemical tankers and dry bulk carriers from 20.000 deadweight tonnage (DWT) and upwards, Liquefied Natural Gas (LNG) and container carriers and inland navigation vessels. Amongst many others, the assessment focuses on crew, operational, environmental and managerial elements. Ships with a Green Award certificate receive a considerable reduction on port dues at ports in Belgium, Canada, Latvia, Lithuania, the Netherlands, Oman, New Zealand, Portugal and South Africa (Green Award, 2009).

The pressures caused by environmental legislation, at all levels, also have contributed to the improvement of the environmental performance. In the following paragraphs, examples of international and EU legislation are provided.

2.2 Environmental legislation affecting ports

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. 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 related to environmental protection and sustainable development.

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 related 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. Several organisations, associations, and port agencies around the world have introduced 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. Examples of these pieces of legislation are provided below, classified into international level and EU level.

2.2.1 International level

The international legislation is regulated by the International Maritime Organisation (IMO). 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 2.2 presents the name, the acronym and the year of the nine IMO conventions that have been selected as the most important ones related to the environment.

Table 2.2: International environmental conventions affecting ports (Adapted from IMO, 2011).

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 Management of Ships' Ballast Water and Sediments	BWM	2004
International Convention for the Safe and Environmentally Sound Recycling of Ships	Hong Kong Convention	2009

Out of all the examples of international conventions provided in the previous table, there is one regulation that is especially relevant for the port sector. It is the International Convention for the Prevention of Pollution from Ships, commonly known as MARPOL Protocol 73/78, which aims at preventing and minimising the pollution from ships and to successfully control their discharges. Although the Convention was approved on November 1973, an updated Protocol was adopted in 1978 as a result of a large number of tanker accidents occurred on the years 1976 and 1977. The instrument entered into force on October 1983. In 1997, a new piece of legislation on NO_x and SO_x was added, which entered into force on May 2005 (IMO, 2014a).

This convention currently includes six technical annexes that provide guidance on the products that are requested to be collected in the port and not dumped at sea. Ports are requested to supply sufficient reception facilities to receive residues and oily mixtures generated from ship operations. Annex I of the convention covers the prevention of oil pollution from operational measures as well as from accidental discharges. The second annex (Annex II) details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk. Annex III contains general requirements for the prevention of pollution by harmful substances (those identified as marine pollutants in the International Maritime Dangerous Goods Code). Annex IV contains requirements to control pollution of the sea by sewage. Annex V deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of. Annex VI sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts as well as particulate matter and prohibits deliberate emissions of ozone depleting substances (IMO, 2014a).

2.2.2 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.

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 2.3:

Table 2.3: European environmental directives affecting ports (adapted from EUR-Lex, 2016).

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

The above-mentioned directives demonstrate that there is a wide range of environmental issues affected by legislative and regulatory pressures. For example, the requirements of several directives may affect port development, such as the Environmental Impact Assessment, the Strategic Environmental Assessment, or the Birds directives. The designation of protected areas under the Habitats Directive poses limitations on both dredging and disposal of dredged material. The Noise Directive may require carrying out port noise maps, action plans for its management and noise reductions, if necessary. The Water Framework Directive and the Air Quality 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 affect European ports bordering the marine area with which the conventions are concerned. These include:

- **Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)** combines and up-dates the 1972 Oslo Convention on dumping waste at sea and the 1974 Paris Convention on land-based sources of marine pollution. It was open for signature in 1992 and entered into force in 1998. It regulates the international cooperation on environmental protection in the North-East Atlantic.

- **Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention)** was signed in Bucharest in 1992 and entered into force in 1994. It regulates the control of land-based sources of pollution; the dumping of waste; and joint action in the case of accidents (such as oil spills).

- **Convention on the protection of the marine environment of the Baltic Sea area (Helsinki Convention, HELCOM)** was signed in 1992 and entered into force in 2000. It regulates the land-based pollution of the whole of the Baltic Sea area.

- **Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention, UNEPMAP)** was adopted in 1976 and it is composed of seven Protocols addressing specific aspects of Mediterranean environmental conservation, including the dumping protocol (from ships), the prevention and emergency protocol (pollution from ships and emergency situation) or the land-based sources and activities protocol.

Apart from the international, European and other regional regulatory proposals that have already been mentioned, each country has its own national legal statements. In order to assist organisations in complying with their applicable legislation and in ensuring the continual improvement of their environmental performance, the achievement of an Environmental Management System (EMS) certification is highly recommended. The particularities of EMS standards are explained in the following section.

2.3 Environmental Management System

This section introduces the concept of EMS, defines the key elements that are needed for their establishment, lists the benefits and advantages that implementing an EMS may bring to the companies, and presents the three EMS standards that exist within the port sector.

2.3.1 Concept

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 (see figure 2.1) for continual improvement of the environmental performance (EPA, 2016) (also known as Deming or Shewhart cycle). These steps are repeated over and over again so that the last step, conducting a management review, leads to new ideas, targets and recommendations that then become the starting point for the renewed management commitment.

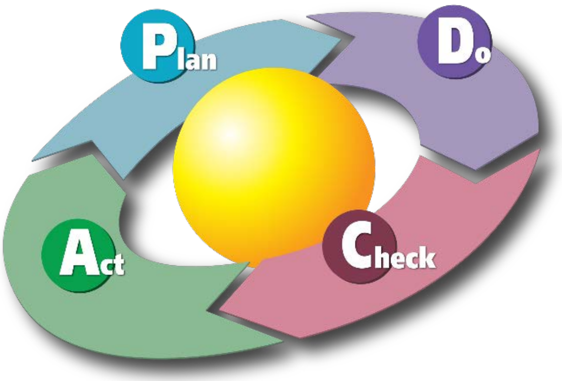


Figure 2.1: Plan-Do-Check-Act management cycle (IACBE, 2015)

Within the *Plan* step, the objectives and targets (or goals) are established. In the *Do* step, the plan is implemented. In *Check*, the actual results are studied and compared against the expected results (targets or goals defined in the *Plan*) to ascertain any differences. If the results show that there is an improvement to the prior baseline, then that becomes the new baseline in *Act*, ensuring in this way the continual improvement. If the *Check* shows that there is not an improvement, then the existing baseline remains in place (IACBE, 2015).

As reported by *European Port Industry Sustainability Report 2016* (ESPO, 2016), 70% of the respondent ports have a form of Environmental Management System in place. Progress achieved can be easily demonstrated when compared with the same exercise in 2013 (54%), 2009 (48%) or in 2004 where only 21% of the respondent ports had an EMS (Puig et al., 2015a). 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.

2.3.2 Key elements of an EMS

This section describes the key and common elements that compose an EMS. These elements are presented in the picture below, following the *Plan-Do-Check-Act* cycle as mentioned previously.

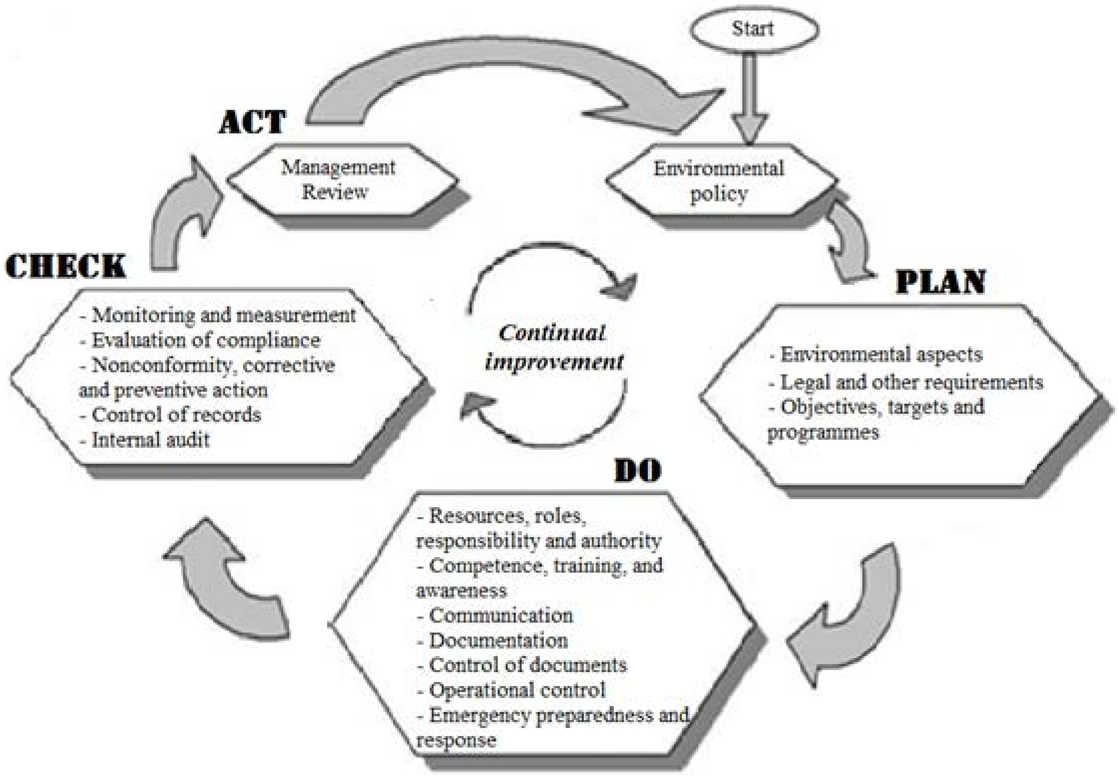


Figure 2.2: Key elements of an EMS (Adapted from EPA, 2003)

The first action in order to establish an EMS is to define the environmental policy of the organisation. It is described below:

- **Environmental policy:** it 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 and it should contain specific commitments to compliance, continual improvement and prevention of pollution (ISO, 2004). The environmental policy represents a tangible demonstration of commitment, and it should be accepted and signed by the highest level of management. The policy must be documented and regularly reviewed and rewritten, as necessary, to reflect changes in activities or services. It should be concise, avoiding generic language, actively distributed to all employees and available to the general public.

The next step is the *Plan* section, which includes the environmental aspects; legal and other requirements; and objectives, targets and programmes.

- **Environmental aspects:** an environmental aspect is an element of the activities, products and services of the port that can interact with the environment, such as waste generation or noise emissions. The port should establish a procedure to identify its aspects and to determine those that can have a significant impact on the environment (ISO, 2004).

- **Legal and other requirements:** the port authority should identify and ensure compliment to relevant laws and regulations, including local, state, national and international legal requirements, as well as other requirements to which the port subscribes. It includes agreements with public authorities and customers, voluntary principles or codes of practice (ISO, 2004).

- **Objectives, targets and programmes:** the port authority should establish environmental goals, in line with the policy, environmental aspects, and views of interested parties, among others. 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, 2004). For example, an objective could be 'better management for water runoff', and a target 'to reduce the amount of water used by 20% by 2016'.

The *Do* step implies the implementation and operation and it is composed of the following elements:

- **Resources, roles, responsibility and authority:** environmental roles, responsibilities and authorities should be defined, documented and communicated, since it is very important to know who is responsible for what. The commitment of all employees is required in order to guarantee effective environmental management. Resources include human resources and specialized skills, organisational infrastructure, technology and financial resources.

- **Competence, training and awareness:** the authority should ensure that port employees are trained and capable of carrying out their environmental responsibilities. Implementing a training programme and awareness-raising activities aims at delivering 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 (2004) states that the port authority should identify training needs and take action to meet them.

- **Communication:** a set of procedures should be established to ensure that internal and external communication is carried out properly. Internal communication contributes to keep employees updated with the progress being made towards the environment, and external communication to ensure that stakeholders are kept informed of the port's environmental progress. Methods of internal communication include regular work group meetings, newsletters, bulletin boards and intranet sites; and for external communication annual reports, newsletters, websites and community meetings.

- **Documentation:** it specifies the documentation that the Environmental Management System should include.

- **Control of documents:** it aims at ensuring that ports control and maintain documents in a proper manner to implement the EMS.

- **Operational control:** the port should evaluate its activities that are associated with its identified environmental aspects and ensure that they are conducted in a way that the adverse impacts on the environment are controlled or reduced.

- **Emergency preparedness 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, 2016). 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 (ISO, 2004). 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 third step is *Check*, which comprises five elements (see figure 2.2):

- **Monitoring and measurement:** 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, 2004). 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). Environmental Performance Indicators (EPIs) are specific elements used to express the results of the monitoring, for example the amount of ship waste generated or the level of noise in terminals.

- **Evaluation of compliance:** the port authority should be able to demonstrate that it has evaluated its compliance with the legal requirements and other identified requirements (ISO, 2004).

- **Nonconformity, corrective action and preventive action:** the port should establish and maintain a procedure to deal with non-conformities (non-fulfilment of a requirement), and for taking corrective and preventive actions.

- **Control of records:** the port authority should establish, implement and maintain a procedure for the identification, storage, protection retrieval, retention and disposal of records (ISO, 2004).

- **Internal audit:** the port authority should ensure that internal audits are conducted at planned intervals (usually annually). They evaluate how well the EMS is performing in terms of meeting its regulatory requirements and its EMS goals.

Finally, the fourth and last step is the *Act*, which is composed of the management review:

- **Management review:** top management should review the port EMS, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness. Reviews should include assessing opportunities for improvement and the need for changes to the EMS, including objectives and targets (ISO, 2004).

2.3.3 Advantages of an EMS

The advantages of setting up and using an Environmental Management System have been widely reported (e.g. NetRegs, 2015; Chircop and Linden, 2006; ESPO, 2011), basically based on evidences of organisations that have adopted an EMS standard for their operations in the previous years. These benefits do not cover only an improvement on the environmental performance, but also on several other issues. Below, a compilation list of the main benefits is presented.

- **Continual improvement of the environmental quality:** it is the main objective of establishing an EMS. Environmental impacts may be reduced through a proper identification of the environmental aspects, a better management of the environmental issues and a raise of staff awareness.

- **Better regulatory compliance:** EMS provides a structured framework for identifying and meeting legal requirements and for an easier day-to-day management. This may reduce possible fines and other regulatory complications over time.

- **Reduction of future liabilities and constraints:** EMS provides a consistent way to avoid limitations imposed by future regulations, material shortages, community complaints, among others..

- **Better management of the resources:** EMS ensures that policies and procedures are in place aiming at ensuring a more effective use of natural resources.

- **Reduction of risk:** the existence of an EMS implies the identification of environmental risks, a better management of them, and therefore it may lead to their reduction.

- **Reduction of operating costs:** EMS contributes to achieve real cost savings through reductions in insurance costs (insurance companies tend to recognize the risk reduction that accompanies a formal EMS) and in the reduction of waste generation and energy and water consumption, among other savings.

- **Increase confidence of banks:** it may appear easier to raise investment from banks and other financial institutions, which are increasingly keen to see that organisations control better their environmental impact through an EMS.

- **Lighter regulation:** even if an EMS is not a regulatory requirement, by showing the commitment to environmental management, it may benefit through less frequent site visits or reduced fees from environmental regulators.

- **Promotion of the monitoring:** the establishment of an EMS encourages the application of performance indicators in order to assess the state of the environment and to track the efficiency of the management system.

- **Improvement in communication:** it is also demonstrated that implementing an EMS may improve relationships and influence with regulators, staff of the organisation, customers, stakeholders and local community.

- **Demonstration of commitment and leadership:** a registered EMS may demonstrate commitment, leadership and responsibility to managers, local governments and also the public in general, especially to the businesses in the area.

- **Marketing advantage:** applying for a certification of the port EMS has become a differential factor that can lead to a competitive advantage since the organisation has made a public commitment to continual environmental improvement. The main standards to obtain a certified EMS are presented in the following section.

2.3.4 Existing EMS standards

There are three main standards within the European port sector to put in place an EMS: the International Organisation for Standardisation (ISO) 14001 (ISO, 2015), the Eco-Management and Audit Scheme (EMAS) Regulation (EC, 2009a) and the Port Environmental Review System (PERS) (ESPO, 2011). All three are widely recognised and implemented among the sector.

Firstly, ISO 14001 defines the requirements with guidance for use to implement an EMS. It belongs to a set of ISO 14000 norms on environmental management that were developed in September 1996, after the success of the ISO 9000 standards on quality management system and the increase of environmental awareness due to the Rio Conference (1992). Other standards of the family focus on specific approaches, such as audits (ISO 14011), communications (ISO 14063), labelling (ISO 14020), life cycle analysis (ISO 14044), environmental performance evaluation (ISO 14031) and climate change (ISO 14064). The second version of this standard was published in 2004, and the third (and most updated) version was released on September 2015 (ISO, 2015).

Secondly, the EU Eco-Management and Audit Scheme (EMAS) is a voluntary environmental management instrument, which was developed in 1993 by the European Commission. In order to register with EMAS, organisations must meet the requirements of the EU EMAS Regulation (EC 1221/2009), available for participation by companies since 1995. Although it was originally restricted to companies in industrial sectors, since 2001, EMAS is open to all economic sectors, including public and private services. The latest revision (EMAS III) came into effect on January 2010 (EC, 2009a).

Finally, the Port Environmental Review System (PERS) 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 (ESPO, 2011). As mentioned, PERS was developed as a result of the ECOPORTS project and it is currently awarded by ESPO and independently audited and certified by Lloyd's Register.

Table 2.4 presents the structure of ISO 14001, EMAS and PERS following their original format and nomenclature, so that their requirements may be compared. The structure of the ISO standard presented in this table is from the version of 2004, in order to compare with the EMAS structure, which has not been updated yet. These requirements are also categorised into the *Plan-Do-Check-Act* model mentioned before in section 2.3.1.

Table 2.4: Comparison of the ISO 14001, EMAS and PERS structure

	ISO 14001 Clause	EMAS Steps	PERS requirement
	N/A[1]	N/A	1.0 Port Profile
	4.1 General requirements	A.1 General requirements	N/A
	4.2 Environmental policy	A.2 Environmental policy	1.1 Policy statement
PLAN	4.3.1 Environmental aspects	A.3.1 Environmental aspects	1.2 Environmental aspects and legal requirements
	N/A	B.1 Environmental review	
	4.3.2 Legal and other requirements	A.3.2 Legal and other requirements	
		B.2 Legal compliance	
	4.3.3 Objectives, targets and programmes	A.3.3 Objectives, targets and programmes	1.1 Policy statement
	N/A	B.3 Environmental performance	N/A
DO	4.4.1 Resources, roles, responsibility and authority	A.4.1 Resources, roles, responsibility and authority	1.3 Responsibilities and resources
	4.4.2 Competence, training, and awareness	B.4 Employee involvement	N/A
	4.4.3 Communication	B.5 Communication	1.5 Environmental Report
	4.4.4 Documentation	A.4.4 Documentation	N/A
	4.4.5 Control of documents	A.4.5 Control of documents	N/A
	4.4.6 Operational control	A.4.6 Operational control	N/A
	4.4.7 Emergency preparedness and response	A.4.7 Emergency preparedness and response	1.2 Environmental aspects and legal requirement
CHECK	4.5.1 Monitoring and measurement	A.5.1 Monitoring and measurement	
	4.5.2 Evaluation of compliance	A.5.2 Evaluation of compliance	1.4 Conformity review
	4.5.3 Nonconformity, corrective and preventive action	A.5.3 Nonconformity, corrective and preventive action	1.4 Conformity review
	4.5.4 Control of records	A.5.4 Control of records	N/A
	4.5.5 Internal audit	A.5.5 Internal audit	1.1 Policy statement
ACT	4.6 Management Review	A.6 Management review	1.4 Conformity review
	N/A	N/A	1.6 Best practices

[1] N/A stands for Not Applicable

As it is shown in table 2.4, although ISO 14001 and EMAS have a similar structure, the second one is more demanding in some issues. For example, EMAS requires an initial environmental review (step B.1) whereas in ISO 14001 it is just recommended. This review is an initial analysis of the environmental aspects, impacts and performance related to activities, products and services of the port (EC, 2009a). EMAS also requires the production of an annual environmental statement (within the *check* section), which is written by the organisation when the EMS has been implemented. It describes not only the activities but also the targets for future improvement and the environmental performance of the organisation. In order to achieve an EMAS certificate, once the environmental review, the environmental statement and the full EMS are completed, they must be submitted to be verified by a third party (accredited environmental verifier) to ensure that it accurately reflects the information portrayed. When all these documents have been verified, the organisation can be registered at EMAS. In the case of ISO 14001, there is a certification process by an external auditor, but there is not any need for registration. The validation of the EMS certification in both ISO 14001 and EMAS is three years. However, as mentioned, the environmental statement of EMAS needs to be published annually. With regards to PERS, it 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 next section presents the results of a couple of investigations that were carried out in order to study the current environmental performance in European ports. It shows the current performance of the sector, as well as some trends on specific issues of the environmental management, such as the top priorities of the sector.

2.4 Environmental management performance at EU ports

This section aims at providing facts and figures on the environmental management performance of the European port sector. Initially, some of the latest results of the *European Port Industry Sustainability Report 2016* (ESPO, 2016) are presented. This initiative has already been described in the previous section 2.1.1, within the ESPO initiatives. Secondly, a description of four case studies of EU ports is presented, based on two ports from the Mediterranean and two from the Black Sea.

2.4.1 European Port Industry Sustainability Report 2016

One of the main outcomes of this report is the update of the top environmental concerns of the port sector. Ports were requested to rank, among the issues presented in table 2.5, the top-10 priorities of the port (where 1 is the most important).

Table 2.5: List of potential environmental concerns

Air quality	Antifouling paints	Bunkering
Cargo Spillage (handling)	Climate change	Conservation areas
Contaminated land	Dredging: operations	Dredging: disposal
Dust	Environmental risk assessment	Energy consumption
Garbage/ port waste	Habitat / ecosystem loss (water)	Habitat/ecosystem loss (land)
Hazardous cargo (handling/storage)	Industrial effluent to water	Industrial emissions to air
Light pollution	Noise	Odours
Pollution from rivers	Port expansion (land related)	Port expansion (water related)
Sediment contamination (marine)	Ship discharge (ballast)	Ship discharge (bilge)
Ship discharge (sewage)	Ship exhaust emissions	Ship waste
Soil contamination (land)	Rain water treatment	Relationship with local community
Vehicle exhaust emissions (including cargo handling)	Water quality	Others

Based on the results of this exercise, the table below presents the 2016 environmental priority issues together with the ones from the similar exercises that took place in 1996, 2004, 2009 and 2013, so that the variations over time are demonstrated. Although some priority issues change their ranking with time, certain components retain their significance for the sector. Environmental issues that consistently appear over time are mapped with the same colour in order to facilitate their identification by the reader.

Table 2.6: Top-10 environmental priorities of the European port sector over time (ESPO, 2016).

	1996	**2004**	**2009**	**2013**	**2016**
1	Port Development (water)	Garbage / Port waste	Noise	Air quality	Air quality
2	Water quality	Dredging: operations	Air quality	Garbage/ Port waste	Energy Consumption

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

The changes in the priority ranking may be indicative of the fluctuating aspects that continuously challenge ports in terms of environmental protection and sustainable development. Curiously, all the priorities of the 2013 top-10 remained in 2016. On one hand, energy consumption, noise, the relationship with the local community, port development and water quality gained importance. On the other hand, the handling of port and ship waste, dust and dredging moved down in the top-10 scale (ESPO, 2016).

Air quality has been identified as the current top environmental priority by the European port sector as a whole, as in 2013. This reflected the significance of this aspect due to its direct relation with the health of people working or living around ports. It is in line with the several ongoing initiatives that aim to control the exhaust emissions of air pollutants by vessels, such as the On-shore Power Supply (shore side electricity) or the differentiated port dues for ships with low sulphur content emissions or with a voluntary vessel speed limit. There has been an increasing awareness of the impacts generated by burned gases (e.g. carbon dioxide, nitrogen and sulphur oxides) among society. Examples of these impacts are the acid rain, global warming or the depletion of non-renewable resources.

The second position is for energy consumption, which is directly associated with the costs of electricity and fossil fuels. It entered in the ranking in 2009, coinciding with the beginning of the global recession and it gained more importance in 2013, when the recession was still present in most of the European countries, occupying the 3rd position in the ranking. Improved energy efficiency also may contribute to the reduction of costs and air emissions.

Noise management is maintained as a high priority issue. Main operations that can generate unwanted noise in a port area are the engines of ships and port machinery. Noise may cause nuisances to wildlife and to the people working or living around ports. The European Noise Directive (EC, 2002) is considered to be one of the main triggering factors for the high priority on noise within the ports environmental agenda. The existence of European projects to evaluate the noise impact in the port area, such as NoMePorts (NoMEPorts, 2008), is a proof of the importance of this issue within the port sector and the European Commission (EC).

Relationship with the local community, which was a new entry in 2009, occupies the fourth position. Port authorities are increasingly becoming aware of the importance of developing cooperative synergies with cities, improving the accessibility of port areas to citizens and promoting a positive image of the port to the general public (ESPO, 2010a).

The management of garbage and port waste has remained as a high profile issue within the environmental priorities of the sector. Moreover, ship waste entered into the Top-10 priorities for the first time in 2013, probably as a result of the whole debate over the adequacy of port reception facilities to accommodate new types of ship waste and increased volumes. It has been regulated through the port reception facilities Directive (EC, 2000a) and the International Convention for the Prevention of Pollution from Ships (MARPOL Protocol) (IMO, 2014a).

Another interesting fact is that there are three issues that have appeared consistently in the priority list of the port sector over the last 20 years, although they are not in the top positions of the table. These issues are port development (land), dredging operations, and dust.

Apart from the top priorities, other interesting outcomes of the report are the trends of selected components of environmental management. The major objective of environmental management is to control the impact of the port activities, products and services on air, water, soil and sediment (Gupta el al., 2005). The European port sector has monitored these indicators since the first ESPO environmental report, back in 1996, as illustrated in the table below. The monitoring of trends over time highlights tendencies and assists both the sector and policy makers.

Table 2.7: Trends over time of selected components of environmental management (Percentage of positive responses) (ESPO, 2016).

Indicator	**1996 %**	**2004 %**	**2009 %**	**2013 %**	**2016 %**	**change 04-16***
Does the port have an Environmental Policy?	45	58	72	90	92	+34
Does the port publish an annual Environmental Report?	-	31	43	62	66	+35
Does the port have designated environmental personnel?	55	67	69	94	94	+27
Does the port have an Environmental Management System?	-	21	48	54	70	+49

Is environmental monitoring carried out in the port?	53	65	77	79	82	+17
Has the port identified Environmental Performance Indicators?	-	48	60	64	66	+18
Existence of an inventory of Significant Environmental Aspects (SEA)	-	-	-	84	89	+5

*Percentage of change has been calculated between 2004 and 2016 since data from 1996 is not available for all the indicators.

Within the constraints and cautions associated with variations in sample size and composition, the results clearly demonstrate evidence of the progress achieved by the port sector during these 20 years. Those trends confirm the positive enhancement of considerations related to awareness of significant aspects, implementation of monitoring programmes, deliver compliance with environmental legislation or the publication of annual environmental reports.

According to the results, the issue with a higher rate of positive responses is the designation of environmental personnel, with a remarkable percentage of 94%. It is followed by the publication of an Environmental Policy (92%). The issues that have increased the most between 2004 and 2016 are, in this order, the existence of an Environmental Management System (+49%), the publication of an Environmental Report (+35%) and the implementation of an Environmental Policy (+34%).

A total number of 64 ports out of the 91 are EMS certified, being 46 of them under ISO 14001, 5 under EMAS, and 26 ports have achieved the PERS certificate. The total amount adds up to more than 64 since some ports are certified under more than one system, as represented in figure 2.3:

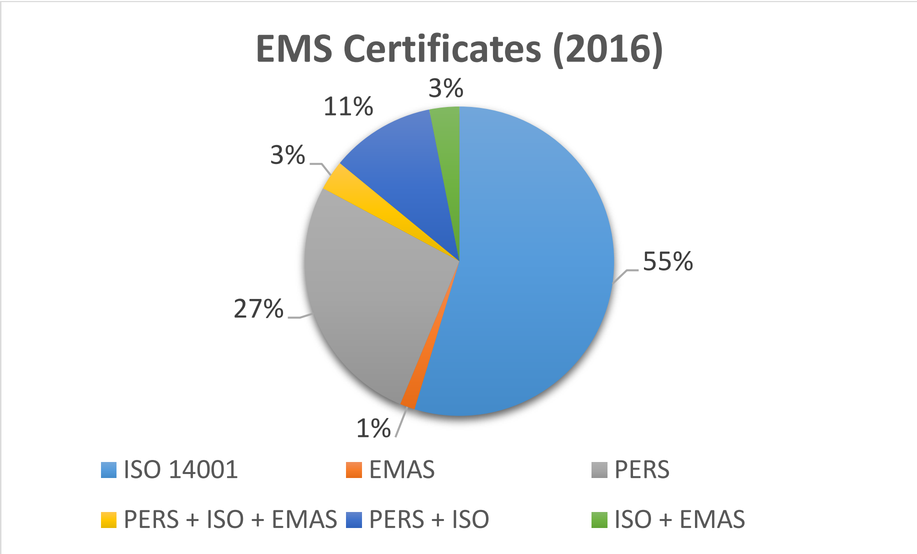


Figure 2.3: Distribution of EMS certificates in 2016 (ESPO, 2016)

The same report also published the percentage of ports that have an updated inventory of Significant Environmental Aspects, which resulted in 89% (ESPO, 2016). It is also interesting to highlight that 66% of the ports have identified Environmental Performance Indicators for use, having this percentage increased +18% since 2004.

Within the environmental management, monitoring is an essential element since it is crucial for a port to evaluate the state of the environment (Wooldridge et al., 1999). According to the results presented in the table above, 82% of respondent ports have implemented an environmental monitoring program in order to monitor trends in their environmental performance. It demonstrates that environmental monitoring is becoming well established within the sector. Table 2.8 presents the percentage of ports that are currently monitoring selected environmental issues.

Table 2.8: Percentage of ports that monitor environmental issues in 2016 (ESPO, 2016).

Indicators	2013 (%)	2016 (%)	% change 2013-2016
Waste	67	79	+12
Energy consumption	65	73	+8
Water quality	56	70	+14
Air quality	52	65	+13
Sediment quality	56	63	+7
Water consumption	58	62	+4
Noise	52	57	+5
Carbon Footprint	48	47	-1
Soil quality	42	44	+2
Marine ecosystems	35	36	+1
Terrestrial habitats	38	30	-8

The previous results demonstrate the wide variability of issues that are currently monitored within the port sector. It is interesting to note the high focus attached to waste and energy consumption issues. Monitoring marine ecosystems and terrestrial habitats are the ones less implemented among the sector.

2.4.2 PERSEUS Questionnaire

An environmental questionnaire was developed within the framework of the PERSEUS project (Policy-oriented marine Environmental Research in the Southern EUropean Seas, 2012-2015, see section 2.1.2) in order to gain an insight on the environmental management of four selected ports. The overall scientific objectives of PERSEUS were to evaluate the dual impact of human activity and natural pressures on the Mediterranean and Black Seas (PERSEUS, 2012). This questionnaire was developed by the Polytechnic University of Catalonia (UPC), being the author of this thesis one of its contributors.

The ports that were selected to conduct this research were the ports of Barcelona and Thessaloniki (Greece) from the Mediterranean Sea, and the ports of Constanta (Romania) and Varna (Bulgaria) from the Black Sea. In order to study the environmental management of these selected ports, a one-hour electronic questionnaire was sent to the corresponding port environmental officer. This questionnaire, which was intended to be as user-friendly as possible, aimed at assessing the environmental performance of the ports. It covered a broad range of components of environmental management, structured in the five sections described below. The full questionnaire is provided in the Annex I of this thesis.

- **Port profile:** this section requested information about the size of the port in terms of cargo handled, passengers, TEU's, and number of vessels. This information was inquired in order to further assist in the interpretation of the results. A screenshot of this section is showed in figure 2.4:

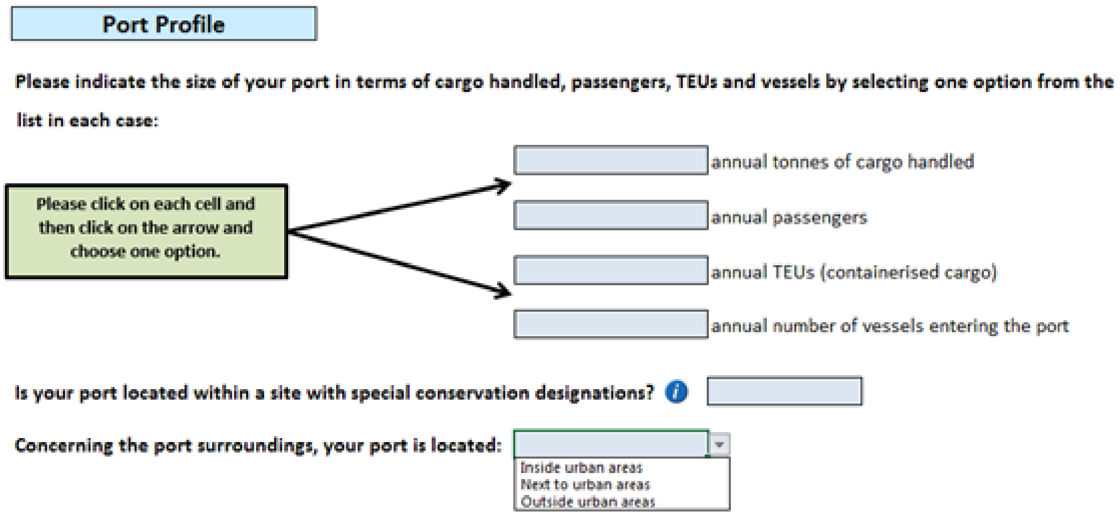
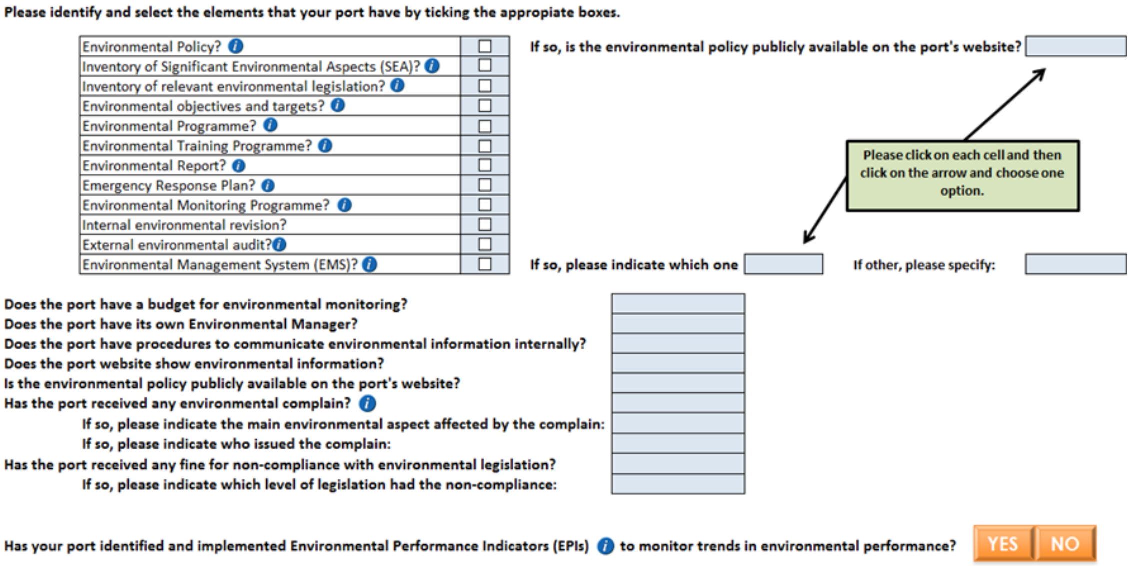


Figure 2.4: Screenshot of the PERSEUS Questionnaire port profile section

- **Port activities:** this section aimed at identifying the activities carried out in the port. A research on port activities was conducted and a large checklist was provided to the respondents, who had to select the ones that are applied to their port. Depending on the activities that are performed, the port is more likely to create impacts on different environmental compartments. A total number of 34 port activities were identified as potential activities to be carried out in a port (see Annex I). Although most of the activities were obtained from the Self-Diagnosis Method (SDM) (EcoPorts Foundation, 2004) and the INDAPORT project (Peris-Mora et al., 2005), other sources such as port web-sites were also considered in order to compile a comprehensive list.

- **Port environmental aspects:** a list of the main categories of aspects was provided in the questionnaire and the respondent had to rank them according to their relative importance. It consisted of ten aspects: emissions to air, water, soil, and sediments, noise, waste, changes in terrestrial habitats and marine ecosystems, odour and resource consumption. In addition, the options of black spaces were also provided just in case the respondent wanted to add any other aspect that was not mentioned. These ten aspects were obtained from the SOSEA tool (Darbra et al., 2005, see section 3.3.1).

- **Port environmental management:** this section was associated to the efforts made by the port authority towards the implementation of an effective environmental management within the organisation. A checklist of eighteen environmental management components was included in the questionnaire. They were presented in a Yes / No response format and were related to terminology recognised in international environmental standards (such as ISO 14001). An example is provided in figure 2.5:



Please identify and select the elements that your port have by ticking the appropiate boxes.

Environmental Policy? ☐
Inventory of Significant Environmental Aspects (SEA)? ☐
Inventory of relevant environmental legislation? ☐
Environmental objectives and targets? ☐
Environmental Programme? ☐
Environmental Training Programme? ☐
Environmental Report? ☐
Emergency Response Plan? ☐
Environmental Monitoring Programme? ☐
Internal environmental revision? ☐
External environmental audit? ☐
Environmental Management System (EMS)? ☐

If so, is the environmental policy publicly available on the port's website?

Please click on each cell and then click on the arrow and choose one option.

If so, please indicate which one

If other, please specify:

Does the port have a budget for environmental monitoring?
Does the port have its own Environmental Manager?
Does the port have procedures to communicate environmental information internally?
Does the port website show environmental information?
Is the environmental policy publicly available on the port's website?
Has the port received any environmental complain?
If so, please indicate the main environmental aspect affected by the complain:
If so, please indicate who issued the complain:
Has the port received any fine for non-compliance with environmental legislation?
If so, please indicate which level of legislation had the non-compliance:

Has your port identified and implemented Environmental Performance Indicators (EPIs) to monitor trends in environmental performance? YES NO

Figure 2.5: Screenshot of the PERSEUS Questionnaire port environmental management section

- **Port environmental performance indicators:** the questionnaire presented more than 75 indicators, being classified as operational and condition indicators. The respondent was asked to select the ones that are implemented within the port. This list of indicators was obtained from the research carried out within the PPRISM project (see section 2.1.2). In case that the respondent had not implemented indicators, the questionnaire asked for the reasons for not implementing EPIs, such as luck of budged or lack of trained personnel.

After the completion of this questionnaire, the research team visited the selected ports and had interviews and discussions with the environmental managers. The interviews were useful to further discuss issues that were not clear enough from the questionnaire and to raise new issues of discussion. From the information gathered in the questionnaire plus the information obtained in the port visit, an individual report was prepared for each port. The resulting reports were sent confidentially to the respective port environmental manager for their approval.

The study demonstrated that the selected ports are committed to deliver continuous improvement of environmental quality and sustainable development and that they have incorporated environmental practices within their daily management. The reports presented the main issues that were at stake for these ports and their actions to prevent and mitigate their related environmental impacts. The main priorities of these ports resulted to be waste management, followed by water discharges and air emissions. In addition, 75% of the studied ports have implemented an environmental policy and publish an annual environmental report.

On the contrary, only half of the pilot ports have implemented a full Environmental Management System (EMS) and the same percentage provide environmental training to the port employees. In addition, two port authorities have received complaints on air emissions and dust. Based on the results obtained in this questionnaire, it can be seen that port environmental managers are not always aware of the significant aspects that are affected in their port and most of them do not use a procedure of this identification. Actually, just one of the pilot ports had already a method for this identification. The lack of well-established methodologies for identifying environmental aspects was considered as one of the weakest points identified in this research concerning the environmental management.

Regarding the indicators, all pilot ports recognised that they are using environmental indicators to measure their performance. One port mentioned the Global Reporting Initiative as a methodology to select indicators, and another authority stated that indicators were selected according to the significant aspects and legal requirements that are applicable to the port. However, the other two ports admitted that they did not followed any method or standard in the moment of deciding which indicators to use.

The lack of a well-established methodology for identifying environmental aspects plus the fact that indicators are sometimes selected without a scientific criterion behind them demonstrated that further research on the application of port environmental aspects and indicators is needed. In the next chapter, these two elements are studied in detail.

Chapter 3. ENVIRONMENTAL ASPECTS AND INDICATORS RESEARCH

This chapter presents some of the factors that demonstrate that a research on the identification and assessment of environmental aspects and indicators in port areas is required. Firstly, the concepts of environmental aspects and indicators are introduced. This includes their classification and importance. Secondly, the requirements in terms of aspects and indicators from the existing standards to achieve an Environmental Management System (EMS) are highlighted. The third section reviews the existing methods for the identification and assessment of environmental aspects and indicators. The last section compiles the several reasons that have emerged in this chapter that demonstrate the need for the development of a tool aiming at identifying Significant Environmental Aspects (SEAs) and their most suitable Environmental Performance Indicators (EPIs).

3.1 Concept

As mentioned previously, this section introduces the concept, classification, and importance of aspects, firstly; and indicators, secondly.

3.1.1 Environmental aspects

An effective port environmental management requires awareness and knowledge of its environmental aspects in order to know what is required to be properly managed from the environmental point of view (ESPO, 2011). According to ISO 14001 (2004), an environmental aspect is an element of an organisation’s activities, products and services that can interact with the environment. Examples of them are water discharges, emissions to air, waste generation or noise emissions.

Each port has different environmental aspects depending on activities that are carried out within the port area. Port environmental managers should identify and evaluate all the aspects associated with the port's activities, products or services that can interact with the environment. These may be associated not only with the productive process and auxiliary operations, but also with the products and services realised by the company's own employees or contractors (Valenciaport et al., 2003).

In the process of identifying and evaluating environmental aspects, there are two steps that have to be properly defined. The first one is the 'identification of environmental aspects', which is the process of detecting and recording all the aspects of an organisation that interact with the environment. The second step is the 'assessment of the significance', which is the application of specific criteria to determine the significance of the previously identified environmental aspects through qualitative or quantitative systems.

It is highly recommended that port authorities select the most significant aspects, called the Significant Environmental Aspects (SEAs), in order to focus their time, efforts and resources on those issues with major potential for environmental impact, providing the greatest assurance that the environment will be protected (Puig, 2012). A SEA, as defined by the ISO 14001 (2004), is an environmental aspect that has or can have a significant impact on the environment. According to the *ESPO Port Performance Dashboard 2013* (ESPO, 2013), 84% of European ports have already identified SEAs. This is a reasonable high percentage of ports, which demonstrates that the sector is committed to the environmental protection and to the continual improvement of the quality of the environment.

It is important to differentiate an environmental impact from an environmental aspect. An environmental impact is any change to the environment, either adverse or beneficial, that result wholly or partially from the environmental aspects. The relationship between environmental aspects and impacts is one of cause and effect (ISO, 2004). For example, the combustion of fuel for the use of the port machinery is a port activity that generates air emissions, which is an environmental aspect. An effect of this aspect is the global warming, which involves a change to the environment and, therefore, it is an impact.

Classification

Environmental aspects may be classified as direct and indirect. Direct aspects are associated with activities, products and services of the organisation itself over which it has direct management control. All organisations have to consider the direct aspects of their operations. Indirect environmental aspects can result from the interaction of an organisation with third parties. Direct environmental aspects can be controlled by internal management decisions, whereas indirect environmental aspects require an organisation to use its influence on subcontractors, suppliers, customers and users of their products and services to gain environmental benefits (EC, 2009b).

In addition, environmental aspects may be generated in normal and abnormal conditions, as well as in emergency situations. Normal conditions refer to routine working conditions (e.g. provision of services or production), whereas abnormal conditions are related to conditions which can be controlled but are considered 'special' (e.g. maintenance or cleaning). Finally, emergency situations concern uncontrolled situations such as incidents and accidents (Valenciaport et al., 2003). Incidents are not planned situations in which a risk to the environment is originated, although the consequences are of minor importance, such as small leaks, spills, or stains on the ground, and accidents are not planned situations that may pose a major risk on the environment.

Scope

Since all the activities may generate impacts on the environment, sometimes it may be difficult to know the scope in the identification of aspects. In other words, it may be difficult to know until which extent this identification process should be detailed. The process of identifying aspects has to be carried out in a rigorous way in order to be credible, meet the demands of different interested parties and execute effective internal work procedures (Zobel et al., 2002). A generic identification of aspects may not provide significant information and a deep exhaustiveness may cause that the subsequent exercise of significance assessment becomes a laborious task. This degree of exhaustiveness should be realistic and adequate to the typology and complexity of the organisation.

A balance has to be found in order to obtain, gradually, the continual environmental improvement in which any organisation willing to achieve an EMS is committed. For instance, in the case of a complex company with a huge amount of activities, products and services, the environmental aspects derived from the administrative department of the company may be neglected because this is not its core business. However, this omission does not imply that there is a mismanagement in the identification. Most likely, these aspects will be considered in the future, when the company has already achieved an optimum level of management in other areas. On the contrary, if the objective is to implement an EMS in an office building, the identification of aspects will, most probable, be related to the proper management of the natural resources and of the waste generated.

The process of identification and assessment of aspects is an on-going review process. This means that although at a certain point some aspects may be considered as not significant in an organisation, they have to be continually re-assessed since the current circumstances of the organisation may vary and, therefore, the significance too. Many authors and reports agree that the revision of the significance should be carried out, at least, once a year. In addition, this revision should be also performed if there are changes in the activities, processes and machinery, introduction or changes to the legal requirements, or detection of situations that were not contemplated initially (Fundació MAP, 2006).

Importance of environmental aspects

The establishment of a procedure for the identification and assessment of environmental aspects is one of the requirements and essential tasks for the development and implementation of an Environmental Management System (EMS). An adequate identification and compilation of aspects is crucial since the decisions taken at this stage may not only affect many other components of the system (Zobel et al., 2002) but it also may determine the focus and scope of the whole EMS (Zobel and Burman, 2004). Aspects are decisive for the implementation of objectives and targets and for defining the environmental policy of the port.

The identification of SEAs commits ports to continuous environmental improvement since they have to be constantly aware of the impacts that may be generated. In addition, determining the SEAs allows a port to know which are the main stakeholders' concerns and the issues that should be reported to them. Actually, reporting to interested parties is necessary for achieving credibility, without which stakeholders may question the results.

3.1.2 Environmental indicators

One of the first definitions of environmental indicators was provided by the OECD (1993): "environmental indicators are instruments which evaluate the positive or negative state of the environment and the consequences of applied measures". An updated definition was provided by the United Nations (1997) as "an information tool that summarises data on complex environmental issues to show overall status and trends of those issues".

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, Environmental Performance Indicators (EPIs) concern an organisation's impacts on living and non-living natural systems, including ecosystems, air, water, soil and sediment (Dantes, 2003).

The purpose of the indicators is to assist in the understanding of the environmental impacts of the port, to know if the operational control of the environmental aspects is effective and if the applied environmental management achieves a good environmental performance. To sum up, an EPI is a parameter that provides information and describes the state of the environment.

In order to evaluate environmental performance of port authorities and to track progress towards continuous improvement, relevant EPIs may be utilised (Donnelly et al., 2007). In this way, port authorities can demonstrate compliance and continuous improvement through scientific evidence and quantifiable measures.

Classification

Since the information provided by the indicators is broad and diverse, it is required to classify them into different categories. There exist several models for organizing the indicators, which are detailed below.

In general terms, indicators may be classified between qualitative and quantitative. The indicators of the first category express presence or absence (Yes/No) of something, whereas the ones of the second category express a value, such as distance, weight, or amount.

At the same time, the standard ISO 14031 Environmental Performance Evaluation (ISO, 1999) identifies five types of quantitative indicators, defined in terms of the basis of their calculation, namely i) direct, ii) relative, iii) indexed, iv) aggregated and v) weighted. According to ISO 14031 (1999), direct (absolute) indicators provide 'basic data or information', such as the emissions of a contaminant. This is the primary form of data for all the indicators and the one in which most of them are expressed. Relative (normalised) indicators provide 'data or information compared to or in relation to another parameter', such as the emissions of a contaminant per tonnes of cargo handled in the port. Indexed indicators describe 'data or information converted to units or to a form which relates the information to a chosen standard or baseline', such as the emissions of a contaminant in the current year expressed as percentage of those emissions in a baseline year. Aggregated indicators provide 'data or information of the same type, but from different sources collected and expressed as a combined value', such as the emissions of a contaminant from all facilities in a given year. Weighted indicators provide 'data or information modified by applying a factor related to its significance'. An example could be an environmental management index of key EMS components, obtained from the weighting attached to each one.

ISO 14031 (ISO, 1999) states that the use of relative, indexed, aggregated and weighted indicators instead of the direct ones can show a deeper insight by certified companies for the evaluation and monitoring of their environmental performance (ISO, 1999).

Looking more specifically into EPIs, the same standard (ISO 14031) defines three categories of indicators that can be used to support environmental management: i) Management Performance Indicators (MPI); ii) Operational Performance Indicators (OPI); and iii) Environmental Condition Indicators (ECI).

Management Performance Indicators provide "information about the management efforts that influence the environmental performance of the port" (ISO, 1999). They may be 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. ISO 14031 (1999) distinguishes four main sub-categories of MPI: implementation of policies and programmes, conformance, financial performance, and community relations.

Operational Performance Indicators provide "information about the environmental performance of the port's operations" (ISO, 1999). They take into account issues related to an organisation's operations, including activities, products or services. For instance, OPI include input indicators such as raw materials, energy and water consumption, and output indicators such as Carbon Footprint, noise, or waste management. Port development operations are also included in this category.

Environmental Condition Indicators provide "information about the local, regional, national or global condition of the environment" (ISO, 1999). This information may help port environmental managers to better recognise the potential impacts that may interact with the environment, and consequently, assist in the planning and implementation of environmental performance evaluation. 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.

In general, management indicators tend to be qualitative (expressing presence or absence of a range of environmental management elements); and operational and condition indicators are likely to be quantitative (expressing data on the performance and condition of the environment).

Environmental indicators also can be classified as lagging and leading indicators (GEMI, 1998). On one hand, lagging indicators are considered as 'end-of-process' because they are mainly used to report processes' outputs. Although they tend to be quantitative and easy to measure and understand, they are hard to change, basically because they provide data from past events. Lagging indicators are generally preferred by the public and regulators. Examples of lagging indicators are the number of fines or complaints obtained or the amount of toxic contaminants released to air, water or soil. On the other hand, leading indicators are considered as 'in-process' because they try to predict future events or tend to change ahead that event. They usually are qualitative indicators and can be difficult to quantify and evaluate. Examples of leading indicators are the number of environmental compliance audits conducted during a year or the existence of an environmental policy. A balanced and realistic combination of both, lagging and leading indicators, are essential towards a more effective measurement of the performance. Therefore, both types of indicators are highly recommended to be used in ports.

Another classification of indicators was proposed by the Organisation for Economic Co-operation and Development (OECD), classifying them as pressure, state and response indicators (OECD, 1993). Pressure indicators describe impacts from human activities exerted on the environment. Examples of indicators are noise emissions and consumption of natural resources. These impacts may affect the state of the environment. State indicators are designed to give an overview of the situation concerning the environment and its development over time. Examples include air and water quality indicators.

Response indicators are the ones that provide a response to these changes and concerns through environmental, economic and sectoral policies and through changes in awareness and behaviour. Examples of indicators include the categories of environmental complaints and environmental legislation.

Potential users of EPIs

Nowadays, indicators are widely used worldwide in many sectors by a wide range of actors, such as scientists, governments, private-sector companies, public entities or 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 indicators, firstly in the field of economics and right after in the field of environment. Examples of the initial environmental 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 been published.

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

Within 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 organisation, 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, industrial or shipping repair companies; iii) 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 organisations such as non-governmental organisations (NGOs), local inhabitants, the press, environmentalist groups, and other non-market players. Apart from these mentioned stakeholders, other users of indicators include auditors, banks, insurance companies, sector organisations, and other port national or regional associations.

Importance of environmental indicators

Indicators are increasingly being developed and used as management tools to address environmental issues (e.g. Belfiore, 2003). The use of indicators is strongly recommended due to several reasons. Firstly, indicators monitor progress and provide a picture of trends and changes over time (e.g. Lehane et al., 2002). The second reason is that indicators provide simplified data that not only show clearly how an individual authority is performing, but also assess the national and regional benchmark performance of the sector (De Leffe et al., 2003). Thirdly, indicators may be used to evaluate the effectiveness of policies implemented, by measuring the progress towards environmental targets (e.g. DEFRA, 2003) and to provide a firm basis for future objectives (Dantes, 2003). In addition, 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 (De Leffe et al., 2003). Finally, environmental indicators may be used as a powerful tool to raise public awareness on environmental issues (Gautam and Singh, 2010).

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. 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 a port authority and the weaknesses that indicators have.

Table 3.1: Strengths and challenges of EPIs (De Leffe et al., 2003).

STRENGTHS	CHALLENGES
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 most suitable 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.

One of the major advantages of using indicators, as mentioned in the previous table, is that they provide enough information that allows the users to know whether the organisation is in compliance with the allowed legal parameters. EPIs are also helpful for the identification of environmental risks and assist in the reduction of costs. On the contrary, there are still some challenges faced in the implementation of EPIs, mainly related to the simplicity of the indicators (and the difficulty of describing the environment in just some parameters), the limited data availability that may exist or the sensitivity that some indicators can demonstrate at short-term environmental changes.

The use of Environmental Performance Indicators has been continuously encouraged by ESPO among its members. It was initially suggested in the *ESPO Code of Practice 1994* (ESPO, 1994), as presented in section 2.1.1 of this thesis, the first European ports' code of practice of its kind. Later on, the updated *Environmental Code of Practice 2003* (ESPO, 2003) reiterated the importance of identifying EPIs and carrying out environmental monitoring. This Code set out 10 recommendations which the EU port sector was encouraged to follow, being one of them "to promote monitoring, based on environmental performance indicators, in order to measure objectively identifiable progress in environmental port practices" (ESPO, 2003). The use of indicators has also been reaffirmed in the ESPO Green Guide (ESPO, 2012).

After the presentation of these two crucial elements of an EMS (aspects and indicators) and having demonstrated that both are two essential elements to be considered in a proper environmental management of any port, next section researches actually the importance and requirements that the three EMS standards (presented in section 2.3) request with regards to these two specific elements.

3.2 Importance of aspects and indicators within the EMS

In this section, the requirements that the main EMS standards demand in relation with the environmental aspects (firstly) and with the environmental indicators (secondly) are presented.

The establishment of a procedure for the identification and assessment of environmental aspects is one of the requirements and key tasks for the development and implementation of an Environmental Management System. It is important to note that standards do not require just a list of environmental aspects, but also a procedure to ensure that all the

Significant Environmental Aspects are identified, and that all the legal requirements applicable to them are known.

Adequate identification and compilation of aspects is recognized as one of the most complicated parts in establishing an EMS (Lundberg et al., 2007). As mentioned before, it is a crucial step since the decisions taken in this stage may not only affect many other components of the system (Zobel et al., 2002), such as setting objectives and targets or defining monitoring needs, but it also may determine the focus and scope of the whole EMS (Zobel and Burman, 2004).

Concerning indicators, they are used within management systems to measure and report the environmental performance of an organisation, since they contribute to the compulsory evaluation of the environmental aspects and they supply quantitative information on the performance of the organisation (Perotto et al., 2008). For this reason, indicators are key elements that are able to verify whether the objective of continual improvement is carried out or not in an organisation.

Figure 3.1 demonstrates that the identification and assessment of aspects and the establishment of EPIs (highlighted in red) are key steps in the process of developing an environmental performance evaluation. As it can be seen, they interact directly with several elements of an EMS.

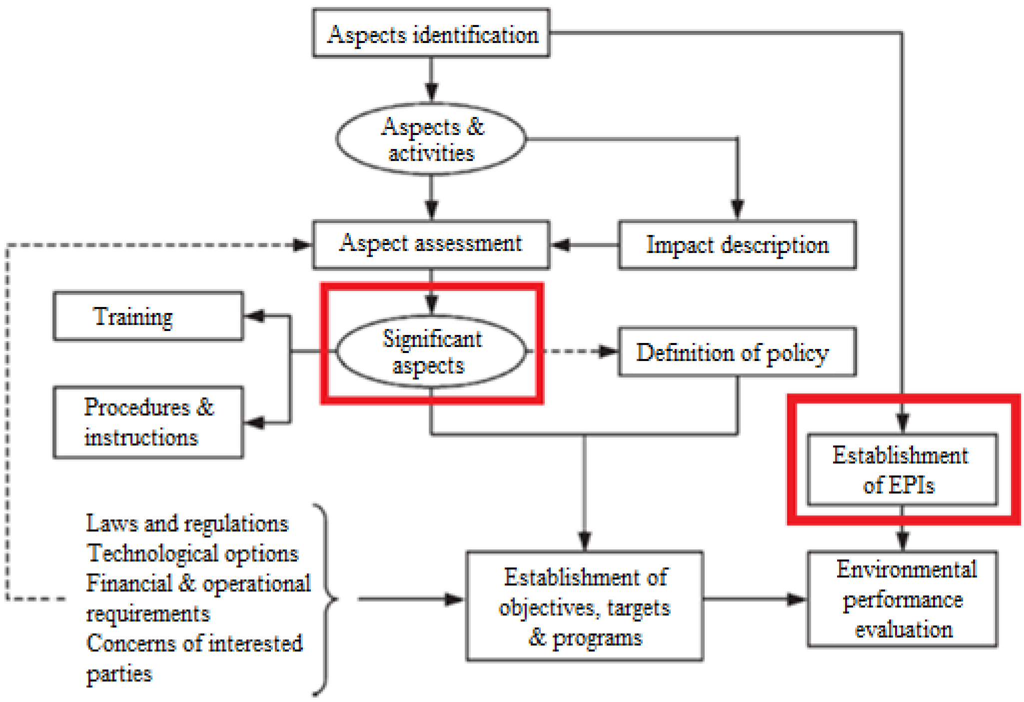


Figure 3.1: Relations between aspects, indicators and other EMS components (Zobel and Burman, 2004).

The previous figure shows that the analysis of the activities and their associated aspects of any organisation may conduct to the identification and description of the environmental impacts that are generated. The study of these impacts contribute to the assessment of these aspects and to obtain the list of SEAs of the organisation. As a result, the environmental policy of the organisation should be defined taking into account the significant aspects. These aspects together with the mentioned policy form the basis for establishing the set of environmental objectives and targets of the organisation. The Environmental Performance Indicators (EPIs) that are established should be derived from the identified aspects. These indicators, together with the objectives and targets, allows an organisation to develop an evaluation of the environmental performance.

Although the key elements of any EMS have already been described in the previous section 2.3.2, the table 3.2 below presents the interactions between environmental aspects, indicators and the rest of elements of an EMS, demonstrating that there is a high influence among them.

Table 3.2: Sections of an EMS related with environmental aspects and indicators (ISO, 2004).

Section	Description
Environmental policy	It should include a commitment to comply with legal requirements which relate to the environmental aspects. 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.
Legal and other requirements	The port should establish, implement and maintain a procedure to have access to the applicable legal requirements related to its environmental aspects.
Objectives, targets & programmes	When establishing and reviewing its objectives and targets, the port should take into account its Significant Environmental Aspects.
Competence, training and awareness	The port should identify training needs associated with its environmental aspects.
Communication	With regards to its environmental aspects, the port should establish, implement and maintain a procedure for internal communication. The port should decide whether to communicate externally about its SEAs.
Documentation	The EMS documentation should include documents to ensure the effective planning, operation and control of processes that relate to its significant aspects.
Operational control	The port should identify and plan those operations that are associated with the identified SEAs consistent with the policy, objectives and targets, in order to ensure that they are carried out under specified conditions.
Monitoring and measurement	The port should establish and maintain a procedure to monitor and measure, on a regular basis, the key characteristics of its operations that can have a significant environmental impact. Indicators are the appropriate elements to carry out the monitoring.
Evaluation of compliance	The port should establish, implement, and maintain a procedure for periodically evaluating compliance with applicable legal requirements. This step is also supported with indicators.

Management review	Input to management review should include changing circumstances, including developments in legal and other requirements related to its environmental aspects.

As mentioned, the EMS in the port sector are mainly implemented following the specifications proposed by the standards of ISO 14001, EMAS or PERS. This section reveals the specific information and requirements regarding environmental aspects and indicators that are provided on these three main standards.

3.2.1 ISO 14001 (2004)

ISO 14001 standard states that the organisation should establish, implement and maintain a procedure to identify the environmental aspects of its activities, products and services. This process should consider both normal and abnormal operating conditions, as well as reasonable foreseeable emergency situations (ISO, 2004). In addition, it is also stated that the organisation should determine those aspects that have or can have significant impacts on the environment, in other words, the Significant Environmental Aspects of the port. The standard remarks that the document of aspects has to be registered and kept up to date.

ISO 14001 (2004) recognises that it does not exist a single procedure for identifying environmental aspects, and it gives some examples of aspects that may be considered, such as emissions to air, releases to water, releases to land, use of raw materials and natural resources, use of energy, and waste products. In addition to those environmental aspects that the port authority can control directly, the authority should also consider the aspects that it can influence, such as those related to the provision of services. In all circumstances, it is the authority that determines the degree of control and also the aspects it can influence (ISO, 2004).

ISO 14001 (2004) states that the method to identify aspects should provide consistent results and include the establishment and application of evaluation criteria, such as those related to environmental matters, legal issues and the concerns of internal and external interested parties. The process of identification and evaluation of environmental aspects should take into account the location of activities, cost and time to undertake the analysis, and the availability of reliable data (ISO, 2004).

Concerning indicators, there are two main sections in the ISO 14001 that imply their use: ‘monitoring and measurement’ and ‘evaluation of compliance’. According to the standard, the organisation should establish and maintain a procedure to monitor and measure the key characteristics of its operations that can have a significant environmental impact and a procedure for periodically evaluate compliance with legal requirements (ISO, 2004). The way to do so is through indicators.

ISO 14001 does not provide any specification in terms of examples of indicators or methodologies for their implementation. However, there is one concrete standard, ISO 14031 (ISO, 1999) on environmental performance evaluation and belonging to the ISO 14000 family, which provides examples of indicators to be implemented. As mentioned in section 3.1.2, this standard categorizes the indicators in three groups: management, operational and environmental condition. More information on the indicators provided in this standard is given in section 5.1 of this thesis.

As a conclusion, it has been demonstrated that the standard ISO 14001 details the importance for a port to identify environmental aspects and indicators. Although the standard also provides some advices and criteria to follow in their selection, it does not establish a specific methodology to determine the significance of the aspects or the selection of indicators.

3.2.2 EMAS (2009)

This standard defines four steps in order to proceed to the identification and evaluation of aspects (EC, 2004a):

<u>1) Selection of an activity, product or service large enough for meaningful examination and small enough to be sufficiently understood:</u>

The port should consider the activities not only in normal operating conditions but also in start-up and shutdown conditions and in reasonably foreseeable emergency conditions. In addition, past, present and planned activities of the port should be considered.

<u>2) Identification of direct and indirect environmental aspects of the activities, products and services:</u>

All the organisations have to consider both direct and indirect aspects of their activities, products and services in order to understand how they interact with the environment. In this process, it is essential to look in an open-minded, unbiased and comprehensive way at the specific environmental aspects generated (EC, 2009b). The EMAS standard (EC, 2009a) provides ways to identify all the direct environmental aspects, such as talking to employees and stakeholders, examining the legislation (e.g. substantive law or technical requirements), reviewing documents (e.g. safety data sheets, licences), or evaluating existing performance indicators.

Annex I of the standard (EC, 2009a) provides a list of direct environmental aspects that cover the activities over which the port authority has management control. The list is not limited and include, among others, emissions to air, releases to water, recycling, reuse and disposal of solid and other wastes, use and contamination of land, and use of natural resources and raw materials.

According to EMAS, the port authority should identify indirect aspects although they result from the activities of third parties. As mentioned previously, direct environmental aspects can be controlled by internal management decisions, whereas indirect environmental aspects require an authority to use its influence on subcontractors, suppliers, customers and users of their products and services to gain environmental benefits. Annex I of the EMAS regulation (EC, 2009a) also provides some examples of indirect aspects, such as the environmental performance and practices of contractors, subcontractors and suppliers or the administrative and planning decisions.

The EMAS Guidance document (EC, 2009b) mentions that talking to customers, subcontractors and suppliers, NGOs and other stakeholders is also a good procedure to identify indirect aspects. In addition, inquiring subcontractors and suppliers about the environmental performance of their activities and products, incorporating ‘green clauses’ into their contracts, or training subcontractors and suppliers (e.g. provide advice to decrease environmental hazards) are mechanisms to influence third parties.

There may be cases where it may be difficult to classify an aspect as ‘direct’ or ‘indirect’. In this case, it should be kept in mind that the main objective is to get a complete overview on the environmental relevance of the port’s activities, products and services and to address all existing environmental aspects. The important issue is to make sure that all aspects are identified so that they can be managed, not to categorise an issue as direct or indirect (EC, 2009b).

<u>3) Identification of environmental impacts, considering actual and potential, positive and negative impacts associated with each aspect:</u>

For each identified environmental aspect, either direct or indirect, the potential impacts on the environment have to be defined. This will be much helpful in order to proceed to the identification of the significant aspects, based on the impacts that they generate.

Organisations must be able to demonstrate that the SEAs associated with their activities have been identified and that significant impacts associated with these aspects are addressed within the management system.

<u>4) Evaluation the significance of aspects:</u>

As mentioned before, an aspect is significant when the impacts that it generates on the environment are also significant. All the identified environmental aspects have to be examined and evaluated in order to decide whether they are significant or not. To assess the significance of the environmental aspects, a set of criteria should be defined.

According to EMAS (EC, 2009a), the criteria ‘should be comprehensive, reproducible and capable of independent checking’ and should take into account the legislation. These criteria may include issues such as data about material and energy flows, views of interested parties or information about the condition of the environment.

All these steps demonstrate that the EMAS regulation provides a more comprehensive guide on the identification and assessment of aspects than ISO 14001. Apart from the regulation itself, several guidance documents have been also released in order to assist in the understanding and implementation of the regulation. EMAS provides examples of direct and indirect aspects, a list of criteria to assess aspects, and the four aforementioned steps. However, the regulation does not establish any specific procedure.

Concerning environmental indicators, EMAS standard recognises that the reporting of the environmental performance should be on the basis of generic and sector-specific performance indicators. This would assist organisations in comparing their environmental performance both over different reporting periods and with the environmental performance of other organisations (EC, 2009a). The standard remarks that EPIs should be developed through information exchange and collaboration between Member States.

Annex IV of the standard provides the specifications for the environmental reporting. Since reporting should provide data on actual impact, it should be based on relevant existing EPIs, which are, at the same time, associated with the environmental aspects of the port.

The standard also mentions some characteristics that the indicators should comply. Among others, the standard specify that indicators should give an accurate evaluation of the port's environmental performance, be understandable and unambiguous, or allow for comparison with sector, national or regional benchmarks (EC, 2009a).

EMAS protocol gives a list of nine core indicators distributed on six key environmental areas, namely material and energy efficiency, water, waste, biodiversity and emissions. Although these core indicators are highly recommended for use and report, the standard is flexible and states that 'where an organisation concludes that one or more core indicators are not relevant to its significant direct environmental aspects, that organisation may not report on those core indicators, but it shall provide justifications to that effect with reference to its environmental review' (EC, 2009a).

3.2.3 PERS (2011)

The Port Environmental Review System (PERS) standard states that the port authority should identify the Significant Environmental Aspects of the activities, products and services of both, the ones that can be controlled by the authority and the ones over which it can have an influence, such as tenants, agencies, sub-contractors, and port users (ESPO, 2011).

PERS also mentions some criteria that have to be considered in assessing the significance of the aspects. These criteria are legal requirements, policy statements, concern of stakeholders and the risk analysis of the impact. Legal requirements are considered to be one of the main drivers in considering the significance.

This standard establishes that the identification of significant aspects should be carried out by a designated environmental co-ordinator working with personnel responsible for the relevant activities and operations (ESPO, 2011). Significant aspects should be identified and recorded in the format of the Environmental Aspect Register. In line with the ISO standard, PERS protocol also states that this information should be kept up to date.

The protocol also gives importance to the identification of performance indicators, existing one specific clause on this issue. According to PERS (ESPO, 2011), the port should identify from five to ten EPIs relevant to the major environmental aspects and to the policy of the port in order to facilitate monitoring of the environmental performance. The standard provides around 20 examples of environmental indicators likely to be monitored in port areas.

In addition, the 'environmental report' section of the protocol states that one of information requirements of the report is providing an overview of the major environmental aspects, impacts, and port's performance on these issues. Ports that apply PERS certification for the first time may choose to give a qualitative summary on the actual performance. However, ports that apply for re-certification of PERS are obliged to give more detailed information on their environmental performance, based on the results of their monitoring of Environmental Performance Indicators (ESPO, 2011).

3.2.4 Summary

To conclude, in terms of environmental aspects, PERS and ISO have relatively similar requirements: the need for the identification of significant aspects is demonstrated and some criteria are given; however, no specific methodology is provided and it is the decision of the port to define this procedure. In contrast, EMAS standard provides more detailed information on the assessment of environmental aspects.

In terms of indicators, PERS protocol encourages more than ISO the use of EPIs, since PERS standard contains one specific requirement concerning indicators and a large number of examples of EPIs are provided. EMAS suggests nine indicators although it is flexible. All three standards do not mention how each port should select its indicators.

As it has been observed, all the EMS standards require a method for identifying environmental aspects and assessing indicators. For this reason, in the next section the results of a research conducted on the existing methods within the EU port sector is presented.

3.3 State of the art on aspects and indicators' methodologies

Although a procedure for the identification and assessment of environmental aspects is required by any EMS standard, there are few recognized methods or guiding principles in the literature on how and how often this identification should be performed. A similar case occurs with the indicators: standards require that a set of indicators should be selected in order to monitor their environmental performance, however they do not provide any specific guidance to which indicators use. This section firstly researches on the already existing methods used for the identification and assessment of aspects, and secondly on the methods for indicators.

3.3.1 Environmental aspects

The research on the methods for environmental aspects is divided into two parts. The first one presents the methods that have been developed exclusively within the port sector and the second one presents methods that are used by other sectors or organisations. The majority of published studies about the procedures for identifying environmental aspects focus on organisations of the industrial sector (Zobel et al., 2002).

Methods from the port sector

This section presents the methods for the identification and assessment of aspects that have been developed particularly for the port sector. Initially, two main procedures that were created as a result of two major research projects are explained. Later, other methodologies that are being used by individual ports are also presented.

These two important methods for the identification of aspects were developed both as a result of two major EU research projects (already mentioned in table 2.1): *ECOPORT: Towards an Environmentally Friendly Port Community* (1998 – 2000) and *ECOPORTS: Information exchange and impact assessment for enhanced environmental conscious operations in European ports and terminals* (2002 – 2005).

a) ECOPORT method

Within the framework of the research project ECOPORT, leaded by the Port Authority of Valencia, the first method was developed. Firstly, the aspects are identified following a template, based on the type of aspects involved and the working conditions in which they may occur, such as normal conditions, cleaning, maintenance, incidents or emergencies (See figure 3.2).

Activity, Product o Service:					
Environmental aspects	*Operating Conditions*				
	Normal	Cleaning	Maintenance	Incidents	Emergencies
Air emissions					
• Combustion gases					
• Volatile products					
• Refrigerating gases					
• Welding gases					
Deposits to water					
Waste generation					
• Hazardous					
• Inert					
• Urban					
Spills and escapes					
• Escapes from underground deposits					
• Spills and escapes from piping and superficial deposits					
Use of resources					
• Water					
• Electric energy					
• Fuel					
• Paper/ Cardboard					
• Plastics					
• Hazardous products					
Noise					

Figure 3.2: Template for the identification of aspects in the ECOPORT project (Valenciaport et al., 2003).

Once the template has been filled in, the aspects associated with the port's activities, products and services are identified. Next step is to assess them in order to determine whether the environmental impacts are significant or not. The environment manager should assess the significance of aspects by following these three criteria: i) frequency or probability, ii) control of the impact, and iii) severity (risk and/or quantity). For each of these three criteria, weightings are applied, which are specified in Annex II of this thesis. The significance of the aspect is calculated by multiplying the values of these three factors. The procedure contemplates that the significant aspects are the ones that have obtained a score of within 20% of the highest values (Valenciaport et al., 2003).

The Significant Environmental Aspects obtained previously are listed in an inventory, in accordance with the model of the table 3.3. This inventory records the significant aspects that have been obtained through this method. In order to take these aspects into consideration, they will have to be contemplated within the environmental objectives of the port.

Table 3.3: Inventory of Significant Environmental Aspects

Significant Environmental Aspect		**Generation sites**	**Significance**	**Indicator**
Code	**Description**			

The method proposes that the inventory of aspects should be updated and re-assessed on an annual basis, since there are some factors that may vary, such as the achievement of objectives, introduction of new legislation, development of new facilities, or modifications and changes in processes (Valenciaport et al., 2003).

b) ECOPORTS method

Another procedure for identifying Significant Environmental Aspects in ports was developed in the framework of the ECOPORTS project (2002-2005). This methodology, called Strategic Overview of Significant Environmental Aspects (SOSEA), aimed at helping port managers to identify and rank the SEAs (Darbra et al., 2005).

This tool was developed within the aforementioned project and in close collaboration with port environmental managers. In fact, during its elaboration the method was tested in a set of ports in order to prove its adequacy. This methodology is based on the ISO 14001 vocabulary and requirements and it can be applied in approximately half a working day. The SOSEA method consists of three parts, each one with a specific objective.

The first one is a matrix of environmental activities and aspects, modified from the Leopold matrix (Leopold et al., 1971). The rows of the matrix contain the environmental aspects whereas the columns contain the activities liable to cause an environmental impact (See figure 3.3). When an activity generates an aspect, a tick has to be placed in the corresponding box. The number of ticks of each row must be counted and written at its end. The aspect with the highest number of ticks is taken as a reference and a relative value is established above which an aspect is considered significant: all the aspects having at least 50% of the reference score are regarded as significant. In the case of the example of the figure 3.3, if discharges to water has ten ticks, all those having five or more are considered significant (Darbra et al., 2005). Once the checklist is completed, the port has a complete view of all activities and their related environmental aspects. The Leopold matrix was considered as a very useful method for the Environmental Impact Assessment of civil engineering works, such as roads, airports, and railways. The SOSEA methodology adapted it to the case of ports.

		ACTIVITIES																			RESULTS
		Port Authority							Port Area												
									Tenants							Other Agencies					
		Port Engineering	Dredging	Marine engineering	Administrative and Planning Activities	Shipping and Navigation	Emergency Plans	....	Cargo handling operations	Cargo storage	Port based industry	Fisheries & Aquaculture	Ship building and repair	Stakeholders activities	....	Waste Management	Port installations maintenance	Land traffic	Recreation and tourism	Bunkering	
ASPECTS	Emissions to air					×	×											×			3
	Discharges to water	×	×	×		×	×		×			×		×					×	×	10
	Emissions to soil								×	×				×							3
	Emissions to sediments		×								×									×	3
	Noise													×				×			2
	Waste production				×				×		×	×	×				×		×	×	8
	Changes in terrestrial habitats	×		×																	2
	Changes in marine ecosystems	×	×	×		×						×	×							×	7
	Odour																				0
	Resource consumption					×				×	×		×			×		×		×	7
	Port development (land)	×		×							×							×			4
	Port development (sea)	×																	×		2
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Figure 3.3: Matrix of activities and aspects from the ECOPORTS project (Darbra et al., 2005).

The second section comprises questions on the current management of the Significant Environmental Aspects identified previously. These questions concern the existence of relevant regulations, the body responsible for their fulfilment, the opinion of port stakeholders and their possible complaints, and the environmental monitoring actions carried out by the port. With all this information, the environmental manager would get a clear view of where efforts should be focused and resources allocated (Darbra et al., 2005). These questions are included in the Annex III of this thesis.

The information gathered before is summarized on the table ‘Strategic Aspects Overview’. In this table, the previously selected SEAs are located in the columns and the reasons why they are of interest for the port are located in the rows. These reasons include, among others, legislation, port policy, port employee health, complains, port image, and port development. Again, a tick is written when a reason applies to the aspect, so that the table filled-in indicates the main reasons for the selection of aspects.

c) Individual ports’ methods

A research was carried out in order to study whether ports are using a method to select aspects or not. The research integrated all the 40 European port authorities that are present in the ESPO Sustainable Development Committee plus 11 EU ports that are examples of best practices. Apart from these 51 EU port authorities, a total number of 17 marinas and 13 port operators were also included in the research, in order to have a complete vision of the port sector and the related environmental aspects. In addition, it was considered interesting to include in this research ports from outside Europe, in order to find out to which extend non-EU ports are familiarised with the reporting of environmental aspects. This worldwide study was composed of 39 port authorities from America, Oceania, Africa and Asia, and from different sizes (small, medium and large ports) according to their total tonnage handled. All these results are provided in Annex IV of this thesis.

When analysing a port, three possible response options were identified concerning the provision of environmental aspects and methodologies, each one associated to a colour. The best response (coloured in green) was the one in which the organisation (e.g. port authority or port operator) provided the list of its significant aspects as well as the methodology used. An acceptable option was when the organisation published the names of the aspects without the methodology (yellow option). Finally, the not reported option (coloured in red) was when the environmental aspects were not mentioned at all.

From the EU ports, there were seven ports that had already adopted their own procedures to identify and rank environmental aspects and make it publicly available on their report. The ports that report the methodology are the Italian port of Livorno and the Spanish ports of A Corunna, Vigo, Cartagena, Algeciras, Valencia, and Roses. Although all the procedures vary between them and no one is the same, they share the fact that a set of criteria is used for the assessment of the significance. Next paragraphs specify the technique used by each one.

The port of Livorno has a methodology to identify aspects and a methodology to evaluate their significance. In order to identify aspects, the environmental manager has to complete a table about the interactions between activities and aspects. To evaluate the aspects, the port considers seven criteria. These criteria are i) compliance with legislation, ii) hazardousness of the impacts, iii) location, iv) stakeholders concerns, v) probability of occurrence, vi) lack of data, and vii) possibility to improve (Port of Livorno, 2012). Each criterion is analysed and a score is given between 1 and 4 (where 1 is negligible and 4 highly significant). The values obtained in each criterion are summed up (the maximum value is 28 and the minimum is 7). If this value is equal or higher to 15 the aspect is significant, if the value is lower the aspect is not significant.

The port of A Corunna does not specify the procedure to identify aspects but it does explain the method to evaluate the environmental aspects. Three criteria are defined: i) magnitude, ii) nature of the aspect, and iii) influence to the receiving environment. A value between 1 (less significant) and 10 (higher significance) is given to each criterion for each aspect. The three values are summed up, so that a final value between 3 and 30 is obtained for each aspect. The aspects are ordered from higher to lower score and the 20% of the aspects with higher score are regarded as significant (Puerto de A Coruña, 2013).

The Port of Vigo has defined three criteria in order to rank the significance of the aspects. These criteria are i) the frequency of the aspect generation, ii) the hazardousness of the aspect, and iii) the area of influence of the aspect. The values obtained in each criterion are summed up, so that each aspect will have a final score. The method defines that the aspects that have a score higher of eight points are considered significant (Puerto de Vigo, 2010). The report does not specify the range of values provided by each criterion.

Another port that identifies Significant Environmental Aspects is the Port of Cartagena. In the EMAS Environmental Declaration 2011 of the port, it is stated that the port carried out an inventory of environmental aspects. The document also reports the procedure that the port used to define whether these aspects were significant or not (Puerto de Cartagena, 2011). The main criteria used for the assessment were the frequency of occurrence (low, medium or high) and the consequences (mild, medium or serious). Depending on the results of the frequency and consequences combination, the significance is obtained, following the relations showed in table 3.4, where 'Yes' means that the aspect is significant:

Table 3.4: Table of Frequency/Consequences in the Port of Cartagena (Puerto de Cartagena, 2011).

	Consequences		
Frequency	Mild	Medium	Serious
Low	NO	NO	YES
Medium	NO	YES	YES
High	NO	YES	YES

The Port Authority of Algeciras also has a procedure to assess the significance, not for identifying aspects. In order to classify the aspects as significant or not, the port authority obtains a final score for each aspect, by applying a set of assessment criteria. These criteria are the magnitude, seriousness, spread, reversibility of the impact, and the probability of occurrence (Puerto Bahía de Algeciras, 2014).

In the port of Valencia, the environmental manager identifies the direct and indirect environmental aspects in both normal and abnormal situations. Potential environmental issues are assessed by analysing accidents and emergency situations that have occurred in the past as well as analysing the facilities and the operations carried out. The significance of the aspects is determined through the analysis of two factors: the frequency and the severity. Although both factors are studied for each aspect, according to this method, only the severity is relevant to determine the significance. It is considered that an aspect is significant when the severity is categorized as high (Valenciaport, 2013).

Finally, the last example is from the Port of Roses. To evaluate the significance, three criteria are considered: i) probability of occurrence, ii) the consequences and iii) corrective and preventive measures applied to the assessed aspect during the current year. Each criterion has a value between 1 and 3. The two first criteria are multiplied between them, whereas the third one is multiplied by a correction factor and the value obtained is subtracted from the product of the first two. The final value obtained for each aspect will give its significance (Port de Roses, 2012), according to the table 3.5. The port establishes that the aspects with a High level of significance are the Significant Environmental Aspects of the port (Port de Roses, 2012).

Table 3.5: Assessment of the significance in the Port of Roses (Port de Roses, 2012).

Significance	**Level**
Significance ≤ 1	Low
1 < Significance ≤ 2	Medium
Significance ≥ 2	High

As mentioned, apart from the 51 EU ports, the research also included the environmental reports and reviews of 39 non-European port authorities, 13 port operators and 17 marinas. Concerning non-EU ports, the research demonstrated that only two ports, from the researched ones, provide the list of aspects and any of them provide the method used. It is a not expected result which shows that the researched international ports do not have the use of aspects as a regular step in the environmental management. In port operators and marinas, the situation is much better. Out of the 13 port operators, five of them provide both the method and the list, whereas only one operator provides the indicators. With regards to the marinas, eight of them provide the list of aspects and the methodology used to assess their significance. These methods are based on a set of criteria in which the aspects are evaluated. The most common criteria that appear in these examples are the frequency, the danger, duration and the quantity of the aspects.

In addition to this, it was considered interesting to research other industrial areas outside the port sector where there may be other techniques to identify and assess aspects. The results are presented in the next section.

Other sectors

It was found that in other sectors there are several procedures that may be put in place in order to assess and evaluate possible environmental impacts or risks, to identify environmental compliance, or to reduce pollution. Table 3.6 indicates some of these methods and their characteristics. The methods may be selected depending on the sector, the data sources, or the objectives of the assessment.

Table 3.6: Techniques used to carry out environmental assessments (Adapted from EPA et al., 2003).

Methods	Characteristics
Emission Inventories	Used to quantify emissions of pollutants to the air.
Environmental Compliance Audits	Used to assess compliance with environmental regulations. Their scope and level of detail vary. These are not typically directed at examining environmental impacts (particularly for products).
Environmental Cost Accounting	Used to assess the full environmental costs associated with activities, products, or services.
Environmental Impact Assessments	Used to satisfy requirements regarding the evaluation of environmental impacts associated with proposed projects. Methodology not typically used to assess environmental impacts associated with existing operations.

Environmental Property Assessments	Used to assess potential environmental liabilities associated with facility or business acquisitions or divestitures. These assessments typically do not assess impacts associated with products or services.
Failure Mode and Effects Analyses	Commonly used in the quality field to identify and prioritize potential equipment and process failures as well as to identify potential corrective actions.
Life Cycle Assessments	Used to assess the impacts of products or processes, from raw material procurement through disposal. These methodologies are described in ISO 14040-14048.
Pollution Prevention or Waste Minimization Audits	Used to identify opportunities to reduce or eliminate pollution at the source and to identify recycling options. Requires a fairly rigorous assessment of facility operations.
Process Flow Diagrams	Used to allow an organisation to visualize and understand how work gets accomplished and how its work processes can be improved.
Process Hazard Analyses	Used to identify and assess potential impacts associated with unplanned releases of hazardous materials.
Project Hazard Reviews	Used to assess and mitigate potential safety hazards associated with new or modified projects. Typically do not focus on environmental issues.
Activity-based assessment	It consists of dividing the organisation in areas, processes or activities and then identifying the associated aspects and impacts.
Risk Analysis and Assessment	Used to assess potential health and/or environment risks typically associated with chemical exposure.
Traffic Light scheme	It is based on the different levels of threats that may be generated on the environment.
Criteria-based method	In this technique, aspects are assessed following a set of questions or criteria. There is not any established set of criteria, it may vary depending on the characteristics of the organisation.

From this extensive list, there are some techniques that are useful only for the identification of aspects and other that aim at assessing the significance. Some of the most commonly used techniques to identify aspects, especially in the industrial sector, are the Process Flow Diagram, the Life Cycle Assessment (LCA) and the activity-based assessment. Examples of methods used to assess the significance are, for instance, the Risk Analysis and Assessment method, the Traffic Light scheme, or the criteria-based method. All these methods are explained below in two differentiated sections:

a) Methods for the identification of aspects

The Process Flow Diagram gives a thorough visualisation and understanding of all the organisation facility's processes and how they might be improved. A Process Flow Diagram consists of three main phases: i) the inputs of the process or activity (which include the consumption of energy, raw materials, chemicals and other resources), ii) step-by-step process flows, and iii) process outputs (which include products, air emissions, noise, odour, radiation, wastewater discharges, and solid and hazardous waste). In order to carry out this assessment, several tasks have to be put into practice (EPA et al., 2003):

1. Subdividing the facility into appropriate units. In other words, the first task is to identify the activities and processes that are carried out within the facility.
2. Developing the process flow diagrams. Based on the activities and processes identified previously, material balance sheets (a diagram of their inputs and outputs) should be created.
3. Identifying environmental aspects and determining the SEAs. The information from each flow diagram should be transferred onto a separate environmental aspect identification form, for each process or activity. In order to obtain the final list of SEAs, the environmental aspects have to be evaluated against criteria.
4. Documenting the approach. The approach followed in the identification of aspects and in the determination of their significance has to be described in a written procedure.
5. Reviewing and revising the environmental aspects over time. A regular revision of the environmental aspects and objectives of a company is an essential step in developing an EMS, aiming at ensuring continuous improvement.

As seen before, step 3 is useful for the identification of aspects. Figure 3.4 provides an example of a Process Flow Diagram. The diagram represents a dyeing process of a textile-finishing company and it shows the inputs and outputs of the process. In this example, the resulting environmental aspects are air emissions, waste generation and consumption of raw materials.

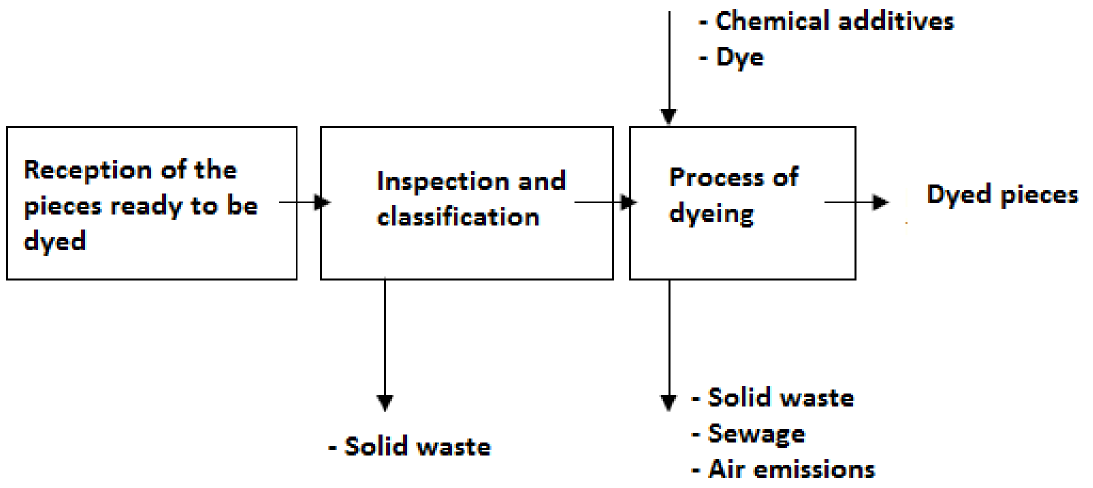


Figure 3.4: Example of a Process Flow Diagram in a dyeing process (Generalitat de Catalunya, 2016).

The second method presented is the Life Cycle Assessment (LCA). This is a technique used to assess environmental impacts associated with all the stages of a product's life, from the raw material extraction to materials processing, manufacture, distribution, use, storage, and disposal or recycling. Table 3.7 shows a template for a Life Cycle Assessment, where in each stage, the environmental impacts on air, water, soil and natural resources have to be assessed. By filling this template, the respondent may identify the areas where the major impacts are produced, and therefore associate these impacts with the aspects. In the same case as the example above, this method is only useful for the identification of aspects, not for their assessment.

Table 3.7: Template for Life Cycle Assessment (Generalitat de Catalunya, 2016)

Life Cycle Assessment						
Impacts	**Raw materials**	**Manufacture**	**Distribution**	**Use**	**Storage**	**Final disposition**
On Air						
On water						
On soil						
Natural resources						
Other						

An application of this method to a professional company is detailed by Gernuks et al. (2007), where the LCA was used for the cars' company Volkswagen. Since it is a product-related business (cars and components), LCA is an accepted and appropriate tool to assess product-related environmental impacts.

Finally, the third example of this set of techniques is the activity-based assessment. This methodology divides the organisation in areas, processes or activities and then the associated aspects and impacts are identified. Table 3.8 shows an example of this method where, for each activity, the associated aspects and impacts are described.

Table 3.8: Example of the activity-based assessment method (Generalitat de Catalunya, 2016).

Activity	**Aspect**	**Environmental impact**
Administrative tasks	Waste generation: office waste (paper, cardboard, plastics, ink or toner cartridge), empty packaging, batteries.	Air, water and soil contamination Waste management
Energy supply to PCs	Natural resources consumption: electricity	Pollution of the environment caused by indirect activities
Consumption of office equipment	Indirect aspects associated with the consumption of materials	Pollution of the environment caused by indirect activities

It also may be interesting, in the process of identification of aspects, to consider the views of the interested parties, such as neighbours, regulators, or NGOs. Actually, this method is already mentioned on the EMAS standard. The environmental manager of the port can obtain information on the main environmental concerns of the local community through the stakeholders' opinion. For instance, this technique was used by the Swedish National Rail Administration, an example of a large public organisation. A questionnaire survey, interviews and participating observations were used to find out the main problems encountered in the identification of environmental aspects (Lundberg et al., 2007).

b) Methods for the assessment of the significance

The three examples of methods that are useful for the assessment of aspects (Risk Analysis and Assessment, Traffic Light scheme, and criteria-based method) are explained below. The first example is the Risk Analysis and Assessment, based on the Spanish standard UNE 150008:2008 (AENOR, 2008), and called 'Environmental risk analysis and assessment'. It provides a methodology for the analysis and assessment of environmental risk. This method is based on the definition of risk that is considered as 'the combination of the probability or the frequency of occurrence of a specific risk with the magnitude of the consequences of this occurrence' (Royal Society, 1992). In other words, risk is calculated from the product of the probability and the consequences. By using this method, the risk associated to each environmental aspect can be calculated.

On one hand, according to the standard, the probability is classified depending on the frequency that this risk has to occur. There are five options: i) improbable, ii) possible, iii) probable, iv) highly probable, and v) most probable. Each option has a value, ranging from 1 to 5, respectively.

On the other hand, to assess the magnitude of the consequences, this standard considers four factors. These are: i) the sources of risk, which includes the hazardous profile of the substance (not dangerous, slightly dangerous, dangerous and very dangerous), the factors that determine the environmental performance (volatile, persistent, and bio-accumulative), and the quantity of the substance; ii) the primary control systems (not efficient, little efficient, efficient, and very efficient); iii) the transport systems (through air, water, or soil), and iv) the vulnerability of the surroundings (natural environment, human environment, and socio-economic environment). A punctuation is given to each factor, so that the final value of the consequences is obtained from the sum of all them. The minimum value is 10 and the maximum value 40. Depending on this value, the consequences would be classified as not relevant (1), mild (2), moderate (3), severe (4), and critical (5).

The final score of the risk is obtained from the product of the values obtained in the probability (1-5) and the consequences (1-5), resulting a final value between 1 and 25. According to this final score, the risk associated with an aspect may be Low Risk (1-2), Tolerable Risk (3-7), Medium Risk (8-13), High Risk (14-20) or Very High Risk (21-25), as shown in table 3.9. Aspects ranked as High or Very High Risk may be considered as Significant Environmental Aspects.

Table 3.9: Matrix of the Risk Analysis and Assessment method (AENOR, 2008).

Consequences/ Probability	**Most probable (5)**	**Highly probable (4)**	**Probable (3)**	**Possible (2)**	**Improbable (1)**
Critical (5)	Very High Risk (25)	High Risk (20)	High Risk (15)	Medium Risk (10)	Tolerable Risk (5)
Severe (4)	High Risk (20)	High Risk (16)	Medium Risk (12)	Medium Risk (8)	Tolerable Risk (4)
Moderate (3)	High Risk (15)	Medium Risk (12)	Medium Risk (9)	Tolerable Risk (6)	Tolerable Risk (3)
Mild (2)	Medium Risk (10)	Medium Risk (8)	Tolerable Risk (6)	Tolerable Risk (4)	Low risk (2)
Not relevant (1)	Tolerable Risk (5)	Tolerable Risk (4)	Tolerable Risk (3)	Low risk (2)	Low risk (1)

The second method is called 'Traffic Light scheme' and it is based on a qualitative ranking of the aspects (White Young Green, 2014). There is a ranking of five categories, representing the different levels of threats that may be generated on the environment (See table 3.10).

Table 3.10: Legend of the 'Traffic Light' scheme (White Young Green, 2014).

R	**Red:** the aspect is controlled weakly and poses great threat to the environment and/or the organisation
A	**Amber:** the aspect is controlled but poses great threat to the environment and/or the organisation
G	**Green:** the aspect is controlled and poses only a moderate threat to the environment and/or the organisation
B	**Blue:** the aspect requires further research to establish the true extent of any threat or opportunity
Blank	**Blank:** the aspect poses little or no threat to the environment and/or the organisation

As shown in the example of table 3.11, several elements of each environmental aspect are analysed. The significance of each aspect is assessed depending on the colours that are obtained. If 'red' or 'amber' is obtained, the aspect will be considered significant.

Table 3.11: Example of the 'Traffic Light' scheme (White Young Green, 2014).

Aspect	**Environment**	**Legal requirements**	**Taxes & legal costs**	**Cost saving**	**Notes**

Electricity	A		G	R	No control over electricity use and costs
Gas	A		G	R	No control over gas use and costs
Water	G	A		G	Requirement to monitor water treatment plant

Finally, the third technique is a criteria-based method. This is a very common and used methodology, where aspects are assessed following a set of questions or criteria. There is not a common set of criteria, they may depend on the type of organisation and the nature of the aspects. Weightings may be applied in order to give different levels of importance to the criteria. Table 3.12 provides examples of criteria that may be suggested for the assessment of environmental aspects. Based on the response to these criteria, the aspects will be considered, or not, significant (Palantzas, 2012).

Table 3.12: Examples of criteria for the assessment of aspects (e.g. Palantzas, 2012; EPA et al., 2003)

Criteria
Toxicity of waste generated
Quantity of waste generated
Physical surroundings
Dangerousness
Current legislation
Future legislation
Concerns from stakeholders
Frequency
Severity of the impact
Probability of occurrence
Possibility to minimise
Effects over third parties
Effects over the environment
Reversibility of the impact

It is interesting to point out that the number of criteria that the organisation uses is not proportional to the quality of the assessment. In other words, not for having a large list of criteria the assessment will be considered better. On the contrary, a demanding list of criteria may lead to such a laborious task that makes the assessment unfeasible to be carried out. The important issue is to identify and use the criteria that make sense with the organisation. For instance, there is no point in including the criterion of toxicity if the company does not generate any hazardous waste, but generates, on the contrary, large quantities of solid urban waste. In this case, the adequate criterion that should be selected is the ‘quantity of waste generated’. Another meaningless example is the consideration of the ‘physical surroundings’ criterion a in an industry that is located within an industrial park. This criterion would be more meaningful if it were located in an area of special natural interest. One of the most important criterion that should be contemplated by any organisation is to consider significant the aspects that are affected by the environmental legislation and the ones that are stated in the environmental policy of the organisation.

3.3.2 Environmental indicators

A research has been conducted on the existing methods for the identification and assessment of indicators. In contrast with environmental aspects, not many standardised methods were found for the indicators. It can be stated that such a response may be deemed inadequate or restricted given the significance of the role of indicators. According to Niemeijer and de Groot (2008), although the use of indicators and their reporting is undeniably useful, there is still considerable opportunities for improvement in the indicator selection process. The lack of robust procedures for selecting indicators makes the validation of the information provided by those indicators even more difficult (Dale and Beyeler, 2001). In addition, a more rigorous and transparent method for the identification and assessment of indicators would increase the scientific credibility of the environmental assessment reports (Belnap, 1998; Slocombe, 1998; Dale and Beyeler, 2001). The methods that have been found are presented below classified in two groups: the methods that have been developed focussed on the whole port sector; and the methods that are used in individual ports.

a) Port sector’s methods

An example of a procedure was found in the port sector that explains a methodology proposed to obtain a system of indicators. It is a method that was developed as a result of the research project INDAPORT (2002–2004). This project aimed at establishing systems of indicators in order to implement a sustainable environmental port management (Peris-Mora et al., 2005). The research pathway included the identification of 21 port activities that were applicable to the case study of the Port of Valencia, which were submitted to environmental analysis. Each activity was described through a steps-diagram process, which allowed the identification of inputs and outputs environmental aspects affected by these activities – processes. A cross matrix of aspects and activities, where the activities were shown in the columns and the aspects in the rows, permitted the identification of the most relevant impacts from activities. Experts’ panel was used in order to find out which were the most significant impacts. Finally, as a result of the described methodology, 17 selected port system indicators were provided.

b) Individual ports' methods

A research on the current methodologies used in ports to identify indicators was also carried out. In this case, the same sample as the one applied in the aspects' research was taken into account (see section 3.3.1), considering 51 EU ports, 39 non-European ports, 13 port operators and 17 marinas. In addition, 25 worldwide organisations were also studied. The results of this indicator's research are presented in Annex IV, together with the aspects' evaluation research. The research also considered three possible responses, each one associated to a colour. The results coloured in green mean that the list of indicators and the methodology are provided; in yellow only the indicators are provided and in red neither the list of indicators nor the methodology.

Within the sample of the EU port authorities, the research demonstrated that a large number of ports publish the list of indicators that they use (37 out of 51); however, just a few explain the origin of these indicators (10 out of 51). In all these 10 cases, the sources of the indicators were standardised lists of indicators, such as the ones provided by the Global Reporting Initiative (GRI, 2013) or by the EMAS standard (EC, 2009a). Particularly, the port authorities of A Coruña, Antwerp, Ceuta, Bremen, Hamburg, Stockholm and Rotterdam use the GRI proposal; the Port Authority of Livorno use EMAS standard guidelines; the Port Authority of Valencia use EMAS and GRI, and finally the Port Authority of Cartagena use EMAS and particular legislation.

In the non-EU port authorities, the results are less encouraging. Although there are 26 ports that mention and publish the list of indicators, only one port provide the method and the resulting indicators. This is the case of the port of Singapore, which uses the GRI guidelines.

With regards to port operators, 38.5% of them provide the list of indicators and 30.8% the methodology. In particular, Cosco Group and Maersk Group are using the GRI and the Terminal de Contenidors de Barcelona (TCB) and the Terminal de Contenedores de Gijón (TCG) are using EMAS as a method to obtain a set of indicators to monitor their performance.

In terms of marinas, there is a higher percentage (47%) of ports that publish both the indicators and the methodology. In this case, all the marinas follow the methodology suggested by the EMAS standard (EC, 2009a), as sources of indicators.

The sample of the 25 international port organisations included a worldwide organisation (International Association of Ports and Harbours) and then two organisations from Oceania, nine from Europe, eight American organisations, three from Asia and two from Africa (see table 5.5). Unfortunately, any of the organisations provided its methodology for the identification of indicators.

3.4 The need for a methodology

In the first section of this chapter, the benefits and importance for identifying environmental aspects and indicators have been detailed. Several reasons have been provided which demonstrate that they are key elements of the whole environmental management of a port.

As mentioned before, ISO 14001, EMAS and PERS specifications determine that procedures have to be established in order to ensure that all the Significant Environmental Aspects are identified. However, since each organisation has its own characteristics and distinctive features, the standards do not establish a common methodology for the identification and assessment of the environmental aspects. In other words, even though the requisites are defined, the means for achieving them are not. The same happens with the Environmental Performance Indicators: their use is requested in all the three standards although they do not specify which particular indicators use. Some examples of EPIs are provided by the standards, although the final decision relies on each individual port, in accordance with their significant aspects. The same happens with the standard ISO 14031 (ISO, 1999), which provides examples of different indicators from which each company can make its own selection. This standard recognises that it is not possible to provide a single set of universally relevant indicators because of the diversity of organisations and their policies, objectives and structures. Although it states that the organisation should select indicators for environmental performance evaluation that are recognised as important, it does not provide any clear guidance or criteria by which each organisation could make its own selection.

In order to understand better the methodologies available for the identification of aspects, a research was carried out on the existing methods for their selection. It demonstrated that two major procedures have been developed apart from the existing methodologies used in each individual port. It is acknowledged that the development of these two methods (SOSEA and ECOPORT) was positive for the sector for several reasons. For instance, it contributed to familiarize port managers with the concept of environmental aspect, to enhance the environmental awareness among European ports, to review and collect relevant regulations affecting aspects, to identify the reasons why a given aspect is important for a port, or to encourage port managers to achieve a complete Environmental Management System (EMS).

Although it is recognised that the SOSEA and the ECOPORT methodologies were positive to initiate the pathway to achieve a sustainable environmental management of ports, there are some reasons that indicate that currently they should be improved and updated to the new ports requirements. Firstly, these tools considered the port environmental aspects as broad categories, such as emissions to air, water, soil and sediments, waste production, or resource consumption, and they did not enter into a very deep detail of the aspects. Secondly, these tools selected the significant aspects based on the subjective opinion of the port environmental manager (or the respondent), not from a methodically-sound way. In addition, there was no evidence of their current use among the researched ports. Moreover, these methods were paper-based and, nowadays, an 'on-line' method would be desirable. After reviewing the literature carefully, it can be stated that no updated methodology has been developed as a generic tool for the aspects identification in the port sector after the two described methods.

Concerning the individual port methodologies, it was found that the methods for the identification and assessment of environmental aspects can differ considerably between port authorities. Since there is not any specific guidelines on how to satisfy these requirements, it may be difficult for some ports to identify and select Significant Environmental Aspects in a credible and scientific way. Each port authority should identify its Significant Environmental Aspects according to the types of its activities, products and services that better fit to the reality, characteristics and circumstances.

As mentioned in section 3.1.1 of this thesis, 84% of European ports have already identified Significant Environmental Aspects (ESPO, 2013), being it a remarkable percentage compared with the resulted obtained in the research of the individual ports' in section 3.3.1. However, it does not mean that these ports have developed a consistent methodology for this identification. It was confirmed in conducting the research of this thesis, when it was noticed that ports do not detail the methodology used to find out the significance of the aspects. This fact demonstrates that most of the ports do not have a methodology to calculate the significance, and the ones that use a methodology do not make it public.

In relation to the indicators, the same survey revealed that 64% of the respondent ports have identified environmental indicators to monitor trends in environmental performance (ESPO, 2013). Nevertheless, when ports were asked to name the environmental indicators used, the responses provided almost 100 different indicators. It confirms the statement provided at the beginning of this thesis that ports are different in their nature. This wide range of indicators 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 adopt, due to the variety in the selected indicators. This was also confirmed in the research of the sector, where only one procedure was found explaining how to create a system of indicators.

These reasons plus the fact that ports have difficulties in the identification and selection of significant aspects in a credible and scientific way have contributed to identify the need for the creation of a common method (EPORTS.CAT) that would assist ports to perform this task in a more reliable manner. As mentioned before, even if each port is different, having a standard methodology that can provide specific results for each port is desirable to mutual advantage of sector and individual ports. This method, which is publicly available to all ports, should be based on an interactive tool that selects appropriate aspects and indicators for each organisation based on each particular features.

As a consequence, as a main objective of this thesis, a methodology will be created, composed of two major and differentiated tools. The first tool will aim at identifying and assessing port environmental aspects in an easy-to-use and scientifically-sound way (TEAP). The second tool will aim at proving a set of performance indicators especially selected for the port user and which is based on the previously identified environmental aspects of the port as well as other port characteristics (TEIP). EPORTS.CAT will be developed specifically for the port sector and it will be valid for any port authority, including sea ports and inland ports. Disseminating this tool among port stakeholders will be helpful to build trust and to prove that the port uses a valid and credible method.

Chapter 4. TOOL FOR THE IDENTIFICATION AND ASSESSMENT OF ENVIRONMENTAL ASPECTS IN PORTS (TEAP)

As mentioned in the previous chapter, there is a need for the development of a method to identify environmental aspects and indicators in ports, EPORTS.CAT, which consists of two tools. This chapter presents the steps that have been done for the development of the first tool. The resulting tool has been named *Tool for the identification and assessment of Environmental Aspects in Ports (TEAP).*

This chapter is divided into four sections: firstly, the identification of port environmental aspects, then their description, third the development of the tool and finally its application.

4.1 Research and selection of port environmental aspects

Before developing TEAP, it was necessary to conduct a deep research on environmental aspects in ports. A research was carried out in order to identify the existing environmental aspects, based on a very broad sources of information. These sources may be divided in two main categories, a literature review and a ports' research. Both are explained below.

The literature review included scientific papers (e.g. Zobel and Burman, 2004; Zobel et al., 2002; Lundberg et al., 2007), the results of previous research projects, such as ECOPORTS (EcoPorts Foundation, 2004) and PPRISM (PPRISM, 2012), environmental aspects proposed from public or private research institutions (e.g. GRI, 2011; Transport Research Knowledge Centre, 2010) and the aspects already mentioned in the questionnaire that was developed within the PERSEUS project (see section 2.4.2 of this thesis).

The ports' research was based on the aspects that are identified and reported by ports. The research was focussed on the same sample of ports as the research conducted in section 3.3.1 about methodologies to identify and assess aspects. That sample was composed of 51 European port authorities, 39 non-EU ports, 17 marinas, and 13 port operators.

Although the main source of information for this research was annual environmental reports and reviews (e.g. Valenciaport, 2011; Bremen Ports, 2011), other sources were also considered, such as port web-sites (e.g. Port of Tallinn, 2015; Freeport of Riga Authority, 2015; Port of Helsinki, 2015), or the EMS Declarations of the port authorities (e.g. Puerto de A Coruña, 2013; Port of Livorno, 2012; Puerto de Vigo, 2010), marinas (e.g. Club de Mar, 2012; Club Nautico Portosín, 2012; Marina Port Vell, 2013) and terminal operators (e.g. Decal, 2012; TCB, 2012; TEPSA, 2011).

As mentioned in section 3.3.1, the research classified ports into three categories, whether they provide their method and aspects, only the resulting aspects or any reference to them at all. Annex IV lists the names of the organisations that have been researched, the country where they are located, the size of the port, the number of aspects that are provided and in which of the three above-mentioned categories they have been classified. The document or report from where the information was obtained is also mentioned.

As a result, it was found that 21 EU ports, two non-EU ports, six operators and eight marinas provide their list of SEAs. On average, each organisation provides 15 aspects in normal and abnormal conditions.

An interesting observed fact is that a considerable number of ports that do not report on their SEAs have already achieved an ISO or another EMS certificate. Since in order to obtain these certificates it is necessary to identify environmental aspects, it demonstrates that there are several ports that although they have carried out this identification, not all they make public the list or the method used.

Based on both sources, the literature review and the ports' research, a compilation of port environmental aspects was generated. An initial list of 55 different port environmental aspects, classified on nine categories, was created. This list of aspects is provided on the Annex V of this thesis. Since this number of aspects was perceived as being over-complex in terms of developing a user-friendly, practicable and pragmatic tool, these different aspects were studied and reduced to a final list of 17 aspects classified in seven categories (see table 4.1 below). This reduction was done on the basis of evaluation and feedback received from port environmental specialists from the sector and academia. The definition of the short list of aspects (17) is also provided on the Annex V.

Table 4.1: Final list of port environmental aspects

Emissions to air	**Resource consumption**
Emissions of combustion gases	Water consumption
Emissions of other gases	Electricity consumption
Emissions of particulate matter	Fuel consumption
Odour emissions	**Waste production**
Discharges to water/sediments	Generation of solid urban waste
Discharges of wastewaters	Generation of hazardous waste

Discharges of hydrocarbons	Generation of other waste
Discharges of other chemicals	**Noise**
Discharges of particulate matter	Noise emissions
Emissions to soil	**Effects on biodiversity**
Emissions to soil and groundwater	Ecosystems and habitats

These are the potential aspects that might be generated as a result of the activities, products or services of the port in normal and abnormal conditions. However, it should be mentioned that in emergency conditions other environmental aspects might be generated (they are listed in Annex V), although they are not considered in the matter of this thesis.

The seven categories of aspects are presented in more detail in the next section, explaining their definition and sources, the related impacts, relevant international legislation, and measures to mitigate the impacts.

4.2 Description of aspects and their associated impacts

It has been largely reported that although ports around the world are major centres for the economic development of the areas where they are located, port and shipping activities also pose negative externalities to their surrounding natural habitats. It is, therefore, extremely necessary to be aware of the issues that are at stake from the environmental point of view in European ports and impacts that may be generated.

Several exhaustive studies have been carried out in the recent years in order to research on the environmental impacts generated by port activities. For instance, the report *Assessment of the Environmental Impact of Port Development* (UN, 1992) studies and categorises the port impacts into three levels: location, construction and operation of the port. Trozzi and Vaccaro (2000) explain and differentiate the impacts produced by ships calling at ports and the ones generated on-land. Another study carried out by the National Institute of Ocean Technology developed the *Environmental impact assessment guidelines for ports and harbours* (NIOT, 2003). Puertos del Estado, the Spanish national ports' organisation, published a report on the port activities susceptible to cause air emissions and possible mitigation actions (Puertos del Estado, 2005). The report *Environmental impacts of international shipping* (OECD, 2011) focuses on the main environmental concerns produced by shipping activities, such as exhaust emissions and energy use.

In addition, a large number of scientific articles have also been published in the recent years, being most of them focused on actual case studies on particular environmental impacts of a port (Casado-Martinez et al., 2009; Corbett and Fischbeck, 1997; Drake et al., 2007; Esslemont et al., 2004; Fleming et al., 2006; Isakson et al., 2001; Lena et al., 2002; Lewis et al., 2001; Lin and Lin, 2006; Mestres et al., 2010; Ng and Song, 2010; Saxe and Larsen, 2004; Thomas et al., 2003). Many papers also have researched on policy solutions to effectively regulate the impacts generated by the port sector (Brennan, 2006; Darbra et al., 2009; Giuliano, 2007; Grech et al., 2013; Lin and Lin, 2006; Feiock and Stream, 2001).

Based on an extensive literature review, the seven categories of environmental aspects mentioned in the previous section have been studied. For each aspect, its definition, emission sources, its related environmental impacts, the most relevant international legislation affecting it and some possible measures used to mitigate these negative impacts are presented. It includes both, the impacts caused on land by the port activities themselves (such as the handling of goods) and the problems caused at sea by ships calling at ports (shipping traffic near the port).

4.2.1 Emissions to air

Definition

Air emissions include substances, material and energy escaping to the atmosphere. The main pollutants originated in port areas are dust, carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM), hydrocarbons (HC), Volatile Organic Compounds (VOCs) and chemical vapours. Odour is also included in this section since it is defined as any kind of release to the air that produce unpleasant smell.

Sources

These pollutants in ports may originate from different sources located either at sea or on land. Ships are the main source of air emissions at sea, producing gases, smoke, soot and fumes. Typical pollutants generated by ships in manoeuvring and berthing are NO_x, SO_x and PM. On land, major pollutants generated are dust, combustion gases (CO_2, CO, HC, and NO_x), VOCs and chemical vapours. Carbon monoxide (CO) is a product of incomplete combustion of organic matter due to insufficient oxygen supply to enable complete oxidation to carbon dioxide (CO_2).

Dust may be released from four main sources: i) transport, handling and storage in piles at the open air of dry bulk materials; ii) construction activities; iii) vehicle traffic that rise the dust accumulated in dirty roads; and iv) ship maintenance activities. Combustion gases are produced from the burning of fossil fuels, basically from four main activities: i) port and passenger car traffic; ii) heavy vehicle traffic; iii) cargo handling equipment; and iv) construction equipment (Puig, 2012).

VOCs emissions may be released during the loading and unloading of petroleum products (Trozzi and Vaccaro, 2000). Vapours of chemical products may be released into the atmosphere essentially in the handling of non-oil liquid bulk and in the subsequent cleaning of storage tanks. In addition, 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.

Impacts

The main impact of the presence of these pollutants in the atmosphere and their interaction is the creation of air pollution. Nitrogen oxides (NO and NO_2) react with ammonia, moisture, and other compounds to form nitric acid vapor and related particles. Small particles can penetrate deeply into sensitive lung tissue and damage it, causing premature death in extreme cases. Inhalation of such particles may cause or worsen respiratory diseases such as emphysema and bronchitis. It may also aggravate existing heart diseases (EPA, 2014a).

VOCs emissions are both unpleasant and hazardous to health. Accidental leaks of chemical products may cause problems such as toxic material emission, explosions, fumes, odours and hazardous airborne emissions.

When oxides of nitrogen (NO_x) and Volatile Organic Compounds (VOCs) react in the presence of sunlight, ground level (tropospheric) ozone (O_3) is formed. Although ozone is beneficial in the upper atmosphere (EPA, 2014b) to protect from the sun's harmful rays, at a ground level it may irritate the respiratory system, causing coughing, choking, and reduced lung capacity (EPA, 2012). This ozone is a major health hazard in many regions of the world and a cause of vegetation damage and reduced crop yields. It is the main component of smog. People with lung disease, children, older adults, and people who are active outdoors may be particularly sensitive to ozone.

Sulphur emissions (SO_x) are a major cause of acid rain and the acidification of soil, groundwater and lakes (EPA, 2012). Current scientific evidence links short-term exposures to SO_2 (ranging from 5 minutes to 24 hours) with an array of adverse respiratory effects, including bronchoconstriction and increased asthma symptoms (EPA, 2014e).

Carbon dioxide (CO_2) 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. Carbon monoxide (CO) is a colorless, odorless gas emitted from combustion processes. CO can cause harmful health effects by reducing oxygen delivery to the body's organs, such as heart and brain, and tissues. At extremely high levels, CO can cause death (EPA, 2014c).

With reference to Particulate Matter (PM), the size of particles is directly linked to their potential for causing health problems. Small particles (less than 10 micrometers in diameter) pose the greatest problems, because they can get deep into the lungs, and some may even get into the bloodstream (EPA, 2014d).

Dust can constitute visual, physical, chemical, or health hazards for employees or the public (EcoPorts Foundation, 2004). There are some factors that influence on the intensity and effects of the emissions, such as the chemical characteristics of the dust, location of the release, prevailing wind direction and speed, size and weight of the particles, and proximity of local residents or sensitive areas (Puertos del Estado, 2005). Apart from these consequences, air pollution also may affect the local climate, building structures, the weather, or create a visibility problem (Ecoports Foundation, 2004).

Relevant international legislation

As mentioned in section 2.2.1, in order to prevent air pollution from ships, the International Maritime Organisation (IMO) developed the Annex VI of the MARPOL Protocol, which entered into force on 19 May 2005. This is the main international regulation that sets limits on the emissions of SO_2, NO_x, prohibits deliberate emissions of ozone depleting substances, and regulates shipboard incineration and the emissions of Volatile Organic Compounds from tankers (IMO, 2014c).

The protocol limits the sulphur content in marine fuels to 3.5%, being expected to progressively reduce it up to 0.5% in 2020 (IMO, 2014a). There are areas that are provided with a higher level of protection than other areas due to reasons related to their oceanographic and ecological conditions and sea traffic (IMO, 2014b), called Emission Control Areas (ECAs). In these areas, the regulation is currently limited to 0.10% from January 2015 (IMO, 2014a).

Concerning the emissions of particulate matter, MARPOL Annex VI currently provides no limits for emissions of PM, however, it is acknowledged by many authors that low-sulphur fuels produce much less PM than heavy fuel oil. By using 0.1% sulphur marine gas oil, PM emissions can be cut by as much as 80% (ICCT, 2007).

The emissions generated on land are regulated in Europe by the Directive 1999/30/CE (EC, 1999) that establishes limit values for sulphur dioxide, nitrogen oxides, particulate matter and lead in ambient air.

Measures

Emissions emitted in port areas may contribute to exceed relevant air quality standards. Many port cities have ambient concentrations of NO_2 and PM10 (or PM2.5) that exceed national or regional standards or the recommendations of the World Health Organisation (WHO) (OECD, 2011). Monitoring air quality is a highly recommended measure to ensure that air quality does not pose a health risk for humans. Port authorities may find themselves under pressure to reduce the emissions generated within their port area and have, therefore, to implement measures to prevent and minimise them. Since each port is unique in terms of pollution levels, emission sources, geographical and meteorological conditions every port should find the most adequate way to reduce its emissions.

Port organisations have continuously promoted the adoption of measures to reduce the air emissions in ports. For instance, the International Association of Ports and Harbours (IAPH) adopted a Clean Air Program and developed a tool box aimed at tackling air quality problems in port areas (IAPH, 2014). This tool box provides ports quick access to information, options and tools that may be used to start the planning process to address port-related air quality issues.

In order to reduce the risk of spreading hazardous dust when it is stored, the use of covers, screens, and guards might be very useful (UN, 1992). Other solutions are reducing the stockpile heights to lessen the potential for wind impact, or watering bulk stockpiles by automatic sprinklers (Comtois and Slack, 2007). Tarpaulin sheets could be used to cover trucks to prevent dust emissions (NIOT, 2003). As seen above, construction activities may generate dust emissions. Some measures to control dust emissions from port development activities are water scattering the construction site, the use of proper transport methods, such as a conveyor belt for excavated material or screens around the construction site. A green belt zone or open space between the construction site and the local community could be an effective buffer. Temporary pavement of roads in a construction site could considerably reduce dust emission.

Below, three specific examples of effective measures that are currently used by ports to lessen air emissions are presented, which are improving fuel quality, using new technologies and implementing shore-side electricity. The first example is to improve the quality of the fuel used for shipping. This can be achieved through the adoption of the MARPOL Convention (IMO, 2014a). As an incentive, some ports offer reduced fees to ship-owners who verify their continuous operation of ships with low sulphur content, which is called Differentiated Port Dues. The exact discount depends on the extent to which the sulphur content falls below these limits. For example, almost 30 ports from Sweden differentiate their dues for the sulphur content of the fuel used by ships (Swedish Marine Administration, 2013).

The second example is the use of technologies for the reduction of emissions. There are several technical developments that may be applied to the port machinery in order to lower the air emissions, being either owned by the port itself or by firms operating in the port area. For instance, particle filters may be applied to diesel trucks and tractors, diesel-powered cranes may be replaced with electric cranes, or hybrid systems (diesel/battery power) may be used to reduce emissions.

The third example is on the use of shore-side electricity. Ships often use their auxiliary engines while they are in a port for heating, lighting, connecting appliances, among other, especially in passenger ferries and cruise ships. The use of these auxiliary engines create emissions to the atmosphere. The shore-side electricity (also known as On-shore Power Supply) allows vessels to plug to the electricity grid of the port, reducing not only NO_x,

SO_2 and particle emissions, but also the level of noise produced by the vessels' engines. Two decisive factors have to be considered in determining the suitability of On-shore Power Supply in a port: the time spent at berth and the amount of power that they need. The main concern related to the use of this technology is lack of an international standard for the plug-in systems, since the electricity system varies between countries in terms of voltage and frequency.

4.2.2 Discharges to water/sediments

Definition

Water discharges refer to any kind of release to the port waters. In port areas, the main releases to water have different nature:

- **Bilge water:** it is the water collected in the lowest compartment of a ship or boat (called bilge), where the two sides of the ship converge. In the bilge, there are the bilge wells that collect the residual waters from the entire engine room. Bilge water is a mixture of a variety of substances, including fresh water, sea water, oil, sludge, chemicals and various other fluids.

- **Ballast water:** it is used to provide stability and manoeuvrability to a ship. The common definition of ballast water is 'fresh or salt water, sometimes containing sediments, held in tanks and cargo holds of ships to increase stability and manoeuvrability during transit' (bhpbilliton, 2011).

- **Sewage:** it is waste matter from domestic or industrial establishments that is carried away in sewers or drains for dumping or conversion into a form that is not toxic (Minnesota Administrative Rules, 2013).

Sediments are fragmented materials that originate from erosion of rocks and are transported by, suspended in, or deposited by water (EPA, 2011). Sediment pollution has been included within the category of emissions to water, since it occurs when any liquid discharge, such as fuel, or solid product, such as waste, reaches the bottom of the sea (EcoPorts Foundation, 2004).

Sources

As in the case of air emissions, the sources of water discharges may be located either at sea or on land. The major possible sources of water pollution from ships are accidental spills or deliberate discharges of bilge water, ballast water, sewage, antifouling paints, chemical substances, lubricants, fuels, oily wastes and garbage (Trozzi and Vaccaro, 2000). Antifouling paints are specialized coatings applied to ships and boats to prevent or slow the growth of parasites attached to the hull under water. In addition, these coatings also may act as a barrier against corrosion on metal hulls, preventing invasive aquatic species from being transported from one part of the world to another or reducing the friction between ship hulls and the surrounding water.

On land, runoff from raw material storage, spills in the handling of liquid bulk and wind-blown dust are the main sources of port water contamination. If the bulk storage areas are not protected from rainwater, runoff waters produced by the rain may drag dry bulk particles to the dock. Other activities that may cause oil spills, garbage discharges, and leaks of other substances into water are the port construction works and vessels' construction. Sewage and wastewater may be emitted not only from bathrooms and galleys on-board all ships, but also from industrial and municipal sewers in ports.

Oil spills in ports may result from the activities of bunkering and loading and unloading the vessels to the storage tanks through a pipe system. Large accidental oil and chemical spills may occur as a result of collisions involving tankers, the largest of which can carry several hundred tonnes of crude oil (OECD, 2011). Sediment pollution may result from liquid runoff from quay and storage area, spills from bulk cargo operations, or from wind-blown dust. Spillages can introduce heavy metals and other pollutants into the water and consequently to the sediments. Moreover, activities such as dredging, bunkering and shipping also can produce emissions to the bottom of the sea.

Impacts

The introduction of organic matter into the environment, such as coal, metal ores, sewage, fertilisers and other nitrogen and phosphorus-rich substances, can lead to potential harmful effects on human and wildlife health, the environment, fisheries and recreational pursuits (EcoPorts Foundation, 2004). These organic materials in runoff are decomposed to the inorganic form, spending dissolved oxygen and increasing the nutrient level in water. This process, known as eutrophication, leads to an increase of phytoplankton and a depletion of oxygen in the water, which induces to reductions in specific fish and other animal populations.

Accidental spills of oils, lubricants, fuels and other oily liquids may be sources of water pollution. Once an oil or oily compound is discharged into water, it is spread on the surface by winds and currents, forming a thin layer. On the surface of seas in tropical or temperate zones, oils can be polymerized gradually by biodegradation and eventually form dense particles which sink. Oil and oily wastes discharged from ships may affect seriously the flora and fauna of the coastal habitats, since the Polycyclic Aromatic Hydrocarbons (PAHs) that are present in crude oil are toxic to marine life. In addition, these wastes may reach nearby beaches and spoil recreational activities, which cause serious damage to tourism.

Ballast water acquired in one region may contain invasive aquatic species which, when discharged in another part of the world, would displace native species and disrupt the balance of the marine ecosystem (OECD, 2011). Antifouling substances may leach into water and therefore present danger since some of these compounds are found to be highly toxic, such as the tributyltin (TBT). Historically, antifouling products contained heavy metals, such as copper and tin. These products present a real environmental risk, with possibly severe adverse effects on shell-fishes, sea mammals and fish. Ship maintenance activities may also release antifouling compounds into the environment. Finally, the discharges of wastes into port waters may be harmful to the ecosystem since they include organic, biological, chemical and toxic pollutants (OECD, 2011). Wastes and sewage may bring bacteria and viruses, which pose a risk to swimmers and may infect fishes.

Construction works, such as dredging, sand compaction, pile driving and deposition of rubble may cause a re-suspension of sediments and turbid water (UN, 1992). These may lead to an increased level of suspended solids and a reduction of the sunlight penetration, affecting therefore the existing ecosystems. If dredged material is contaminated by heavy metals or other pollutants remaining from past industrial activities, the impacts are even more significant.

Sediment pollution poses serious threats to the benthic environment, including worms, crustaceans, and insect larvae that inhabit the bottom of a water body. Pollution can lead to their death, 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 (UN, 1992). 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 (EPA, 2011).

Relevant international legislation

The International Maritime Organisation (IMO) has promoted several conventions in order to regulate pollution from ships at sea. In 2004, the IMO adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (IMO, 2014e), in order to prevent, reduce and eliminate the transfer of harmful aquatic organisms and pathogens from ships' ballast water and sediments. The convention describes where, when and how ballast water discharges are allowed to take place. Although the convention was adopted in 2004, it is not yet in force, since not enough countries have ratified it (IMO, 2014e). It should be ratified by at least 30 States, which represent 35% of world merchant shipping tonnage.

Annex IV of the MARPOL Convention contains a set of regulations regarding the discharge of sewage into the sea from ships and the provision of facilities at ports and terminals for their reception (IMO, 2014d). Other conventions from IMO that concern issues of water pollution are the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention, 1972) (IMO, 2014f), the International Convention on Oil Pollution Preparedness, Response and Co-operation

(OPRC, 1990) (IMO, 2014g), and the International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS, 2001) (IMO, 2014h).

The European Commission established in 2000 a framework directive for the protection and management of inland surface waters (rivers and lakes), groundwater, transitional waters, and coastal waters. Coastal waters include marine waters up to one nautical mile from shore. This Directive, entitled Framework for Community action in the field of water policy (Water Framework Directive) (EC, 2000b), aims at achieving good qualitative and quantitative status of all water bodies by 2015.

Measures

Monitoring water quality in port areas is an essential measure to ensure that the water quality neither pose a health risk for humans and nor 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 it has a good physical and chemical balance to sustain a healthy ecosystem. Although accidental spills and discharges are unavoidable, some actions could be prepared in view to minimise the dispersals. For instance, in case of an oil spill, it is highly recommended to own recovery vessels, have oil fences, and use treatment chemicals (OECD, 2011). Proper contingency plans and a prompt reporting system are other keys to prevent an oil dispersal. New tankers are required to have double hulls or alternative designs with similar properties in order to attenuate the oil spills. Ports in different parts of the world have differentiated port fees to stimulate early introduction of double hulls. Appropriate regulations on ship discharges and provision of reception facilities are indispensable for a proper control of the water emissions from ships.

In order to properly manage the ballast water, new technologies are being developed, aiming at destroying any living organisms contained in the 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" (Trozzi and Vaccaro, 2000). Some actions have been taken in the last years to reduce negative impacts of antifouling products on the environment. As the toxicity of the various substances became apparent, such as TBT (tributyltin - widely used by the shipping industry as an antifouling product), the use of antifouling containing biocides was banned in 2003. These antifouling products that in 2008 still were present in ships were to be removed or alternatively be encapsulated with other coats of paint to prevent the substances leaching on the water.

Measures against runoff of dust in the port waters 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, or providing special equipment for cargo handling and transport. 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. A proper disposal of dredged material is critical in preserving the environment, and therefore, monitoring surveys should be carried out in dredged sediments in order to guarantee that they do not pose any risk to the environment.

4.2.3 Emissions to soil

Definition

This aspect considers the emissions to soil, ground or land that are released by current or past port activities. From an environmental point of view, soil is the top layer of the earth's surface, which is composed of mineral particles mixed with organic matter (Kiely, 1997). Soil is a component of the natural environment, essential for the life of plants, animals and humans. As a consequence, soil degradation reduces quantitatively and qualitatively the current capacity to produce goods and services, such as agriculture, industry, housing, and leisure. Therefore, the soil protection and the implantation of good practices is vital in all the sectors that could affect its quality (Port de Barcelona and ARC, 2008).

Sources

There are five main sources of soil pollution in port areas (Paipai, 1999; Port de Barcelona and ARC, 2008): i) accidental discharges of oil or chemical products either in the handling or in the storage of these products, ii) spills of dust spread during the transportation or in the storage, iii) leaks of fuel from on-land vehicle and equipment, iv) disposal of dredged material on land that may cause leaks of harmful substances into soil and groundwater, and finally v) mismanagement of waste, including uncontrolled dumping of residues or their inadequate storage.

Impacts

The main consequence of emissions to the soil is the contamination of the surrounding land, groundwater or water courses due to leaching. Land contamination may reduce land value, prevent future development and be a hazard for the environment and for the human health (EcoPorts Foundation, 2004). Soil pollution may pose toxicological hazards for human health by inhalation of toxic vapours, ingestion (directly through hands contact or indirectly through food or water pollution) or skin absorption (Port de Barcelona and ARC, 2008). Soil and groundwater contamination may affect plants and organisms living there and usually it not only affects individual species, but also the natural biological communities. Another physical hazard that it may produce is the corrosion of underground metal structures and pipes.

It is important to take into account that the most serious impacts generated by a polluted soil may remain in the ground for a long-term. The consequences of soil pollution are not identified immediately and the potential hazards may take years to be manifested.

Relevant international legislation

With regards to legislation, there is not any regulation from the International Maritime Organisation (IMO) that directly legislates soil pollution. In the European Union level, there is not any specific European Directive dealing with soil pollution, although there are several directives that make reference to this issue. For instance, the EU Directive on Environmental liability with regard to the prevention and remedying of environmental damage (EC, 2004b) applies a 'polluter pays' principle, according to which the polluter is responsible when environmental damage occurs. In addition, other EU directives that support the prevention and clean-up of soil contamination are the EU Waste Framework Directive (EC, 2008a) that addresses the prevention of pollution from waste; the EU Water Framework Directive (EC, 2000b) that requires a program of measures to address land contamination that causes water pollution; the EU Groundwater Directive (EC, 2006) that aims at preventing or limiting pollutants into groundwater, and the EU Directive on Nitrates from Agricultural Sources (EC, 1991) that addresses the environmental impacts of excess nitrogen.

Apart from the European Directives, each country also has national regulations on soil pollution. In the particular case study of the Spanish legislation, the Law 10/1998 on Waste defines the concept of polluted soil (Gobierno de España, 1998). The Royal Decree 9/2005 establishes the potentially soil polluting activities and the criteria and standards implemented to declare these soils as polluted (Gobierno de España, 2005). The Law 26/2007 on environmental responsibility aims at promoting the preventive mechanisms to avoid damages on the environment (soil included) (Gobierno de España, 2007).

Measures

It is extremely necessary for ports that handle and storage chemicals liable to pollute the soil to take some preventive actions in order to avoid soil pollution. These actions include the confinement of tanks, pipes, or drums that are storing or transporting chemicals or the adoption of a prevention plan, especially when the activity that is carried out involves a risk of soil contamination (Port de Barcelona and ARC, 2008). This plan should be aimed at preventing the spills, detecting them as soon as possible, and acting against their effects.

Since the port activities that pose risks to soil pollution are diverse, there are some techniques that may be helpful in the preparation of a specific plan. Some of these measures are proposed in a report conducted by the Port of Barcelona and ARC (2008). The first issue that has to be taken into account is to use materials compatible with the substances and the conditions of the activity; for instance, special alloys for some acids, incompatibilities between certain plastics and solvents, among others. The possibility of corrosion has to be studied carefully, which can be minimised by using corrosion resistant coatings or removing water and humidity. Port workers should have training on malpractices and mistakes that should be avoided to prevent discharges to soil. In the areas with a high risk of spillages, absorbent materials should be distributed, such as barriers, or filters for sewers. In addition, it is highly recommended to make a corrective and preventive inspection of different elements, such as looking for cracks in the pavement, verifying periodically the operation of detectors, checking the distribution and accessibility of absorbents, or calibrating correctly the measurement equipment. Finally, another preventive technique is to install devices close to points that have a higher probability of spillages in order to detect leaks.

In case that a port has soil pollution, the port authority should put in place corrective measures to amend the situation as soon as possible. There is a wide range of soil remediation measures used to eliminate the pollution and, depending on the type of soil, the location of the spillage, or the technologies available, the treatment would vary. Examples of treatments are the thermal treatment, phytoremediation, soil vapour extraction, biosparging, electric resistance heating, or land farming (Miller, 2014).

4.2.4 Waste production

Definition

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. In accordance with MARPOL 73/78 (IMO, 2014a) and EU Directive 2000/59/EC (EC, 2000a), ports are obliged to ensure adequate port facilities for the reception of ship wastes of oil, noxious liquid substances, sewage and garbage, without causing undue delay to ships. These regulations also request ports to prepare and implement port waste management plans. The main aim of the existence of these management plans and reception facilities is to eliminate the dumping of wastes illegally to the sea environment (Palabıyık, 2003). According to European directive on Port Reception Facilities (EC, 2000a), a port reception facility is defined as “any facility, which is fixed, floating or mobile and capable of receiving ship-generated waste or cargo residues”. Fixed facilities include tanks, platforms and depositories; and floating facilities refer to collection vessels and mobile facilities to collection vehicles.

Sources

Waste in ports may originate from ships, port industries, port authority or construction works. Residues from ships are classified in several categories, following the instructions of the MARPOL protocol (IMO, 2014a):

- Oily residues cover fuel residues, used engine oil, bilge water and oily tank washings.
- Noxious liquid substances in bulk comprise chemical wastes derived from bulk chemical transportation, including residues and mixtures containing noxious substances.

- Garbage from ships include domestic wastes, such as food and packaging, or small dangerous waste.

Other wastes that may be originated in a port from industries or a port authority are solid waste (e.g. organic, cardboard and paper, plastics or glass), non-hazardous industrial waste (e.g. scrap metal, wood, electronic waste, oil filters, tires), and hazardous waste (ink cartridges, used oil, fluorescents, batteries).

Impacts

Floating garbage, produced mainly from shipping activities, generates water pollution, opacity and loss of light for the photosynthesis. Waterfront industries generate various kinds of wastes and some of them may be disposed of in the port area or at sea. Disposal of these wastes into port waters may introduce organic, biological, chemical and toxic pollutants on the environment. These pollutants may degrade water quality causing problems such as oil pollution, odour or unsanitary conditions. This pollution can pose risks to both, the marine environment and the human health. In particular, micro plastics are emerging as a major environmental and health issue, since these fragments, which contain Persistent Organic Pollutants (POPs), can be ingested by species and make their way up the food chain to humans (GESAMP, 2010).

Relevant international legislation

The major regulative requirement from the International Maritime Organisation concerning waste from ships is the widely known MARPOL Convention (IMO, 2014a). As discussed above, the Convention includes six technical annexes that provide guidance on the products that are requested to be collected in the port and not dumped at sea. Out of these six annexes, Annex V deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of.

Apart from MARPOL, there is also another international convention that relates to the management of waste in the shipping sector. This is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (IMO, 2014f), generally known as London Convention. This was one of the first international conventions for the protection of the marine environment from human activities, which came into force on 30 August 1975. It contributes to the international control and prevention of marine pollution by prohibiting the dumping of certain hazardous materials. Dumping is defined as the deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures, as well as the deliberate disposal of these vessels or platforms themselves.

In the European level, there is one directive also regulating the management of ship-generated waste. This is the Directive 2000/59/EC called Port reception facilities for ship-generated waste and cargo residues (EC, 2000a). This Directive and the MARPOL Convention both aim at preventing the pollution from ships; however, the Directive focuses on ship operations in European Union ports and the Convention regulates discharges by ships at sea. The Directive addresses in detail the legal, financial and practical responsibilities of the different operators involved in delivery of ship-generated waste and cargo residues.

Measures

In order to preserve the port water quality, periodical clean-up of floating wastes is necessary. Ships can limit garbage problems by using recyclable materials and by collecting and sorting waste on-board. According to provisions of the MARPOL Convention, ships are required to dump their residues and oily mixtures on-shore on the reception systems, and, at the same time, ports are requested to provide sufficient reception facilities to receive these wastes. Port authorities and the industries located in port areas also can separate their waste according to what is being recycled. Sewage and garbage generated by port activities can be handled by a municipal treatment system or by the port's own treatment facilities.

MARPOL's Annex V provides rules for the prevention of pollution by garbage. It bans any disposal of plastics into the sea and restricts the discharge of other garbage from ships into coastal waters. The Annex also states that the provision of port reception facilities for the different types of waste at ports and terminals must be ensured (IMO, 2014a). The EU Directive 2000/59/EC, titled Port reception facilities for ship-generated waste and cargo residues Directive (EC, 2000a), goes one step further 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. Sewage or garbage from port activities can be handled by a municipal treatment system or by the port's own treatment facilities.

4.2.5 Resource consumption

Definition

This aspect considers the consumption of natural resources, including non-renewable resources such as fossil fuels (coal, petroleum and natural gas), and raw materials (EcoPorts Foundation, 2004). The consumption of water and electricity are also included in this category.

Sources

The combustion of fossil fuels on site includes two types of sources: i) stationary sources such as operational machines, cranes, heating or cooling; and ii) 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.

Shipping is another major source of energy consumption, not only to provide the vessels' propulsion but also to guarantee the on-board living conditions.

Impacts

As it has been mentioned in air emissions, 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). 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). Finally, the consumption of fossil fuels also contributes to the exhaustion of non-renewable resources.

Relevant international legislation

With reference to legislation, the issues of resource consumption are not contemplated in any convention of the IMO. On contrast, in the European level, there is certainly a directive that concern these issues: the Directive 2012/27/EU on Energy Efficiency (EC, 2012). This Directive was adopted on October 2012 and establishes a common framework of measures for the promotion of energy efficiency within the EU in order to ensure the achievements of the goals by 2020. These targets are to reduce the greenhouse gas levels by 20%, to increase the share of renewables to 20%, and to reduce the energy consumption by 20% (Lowe, 2011). The Directive lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy.

Measures

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). Calculating the Carbon Footprint can contribute to identify the main sources of energy consumption of the port authority and therefore to discover the opportunities to reduce the emissions. Another way to decrease the consumption from ships is reducing the speed of the vessels.

4.2.6 Noise

Definition

According to the Self-Diagnosis Method (EcoPorts Foundation, 2004), noise is defined as unwanted sound. Noise pollution has become an increasingly significant environmental issue for many port authorities, as it has been seen in section 2.4. In the *European Port Industry Sustainability Report 2016* (ESPO, 2016), port managers identified noise as the third environmental priority of the sector. In the same exercise from 2013, noise was ranked in the fourth position (ESPO, 2013). One of the reasons that contribute to this significance is the fact that a major port works 24 hours per day, 365 days per year and it may generate nuisances and complaints from the local stakeholders and disturb adjacent neighbours.

Sources

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, the heating, and the air condition systems (Trozzi and Vaccaro, 2000). Road traffic includes passenger cars, trucks and tractors. Cargo operations refer to noise from machinery such as quay-crane, pumps, among others (Trozzi and Vaccaro, 2000). Underwater noise may be generated by equipment during dredging operations (Grech et al., 2013). Construction activities may contribute to create noise and vibrations, mainly generated by construction equipment, truck traffic, work vessels and other similar sources.

Impacts

Noise may cause nuisances among employees and local people, interfering with their sleep, communication and privacy. It may aggravate stress, reduce working efficiency and, on top of that, high levels of noise may lead to hearing loss (NIOT, 2003). Therefore, noise may constitute an occupational hazard, result in complaints, and be considered a public offence under the law (EcoPorts Foundation, 2004). Noise from ships can impact to the fish and sea mammal behaviour, making them more susceptible to predators and other threats (University of Bristol, 2010). The extent to which noise from harbour activities is perceived as a nuisance depends on the sound pressure, the frequency, wind direction and the distance to local communities (OECD, 2011). It is estimated that in some areas, background marine noise has doubled each decade since the 1950s, due to the development of faster and larger ships as well an increase in traffic of vessels (OSPAR, 2010).

Legislation

In order to legislate noise concerns, there are some specifications adopted from the IMO on noise generated by ships, and from a European Directive on noise generated on-land. The Code from the IMO is entitled *Code on noise levels on board ships* and it has been developed to provide international standards for protection against noise. Although this Code entered into force on 1 July 2014, it is included under the provisions of regulation of the SOLAS Convention (International Convention for the Safety of Life at Sea, 1974) (IMO, 2014i), as an amendment to this Convention. The Code recognizes the need to establish mandatory noise level limits for machinery spaces, control rooms, workshops, accommodation and other spaces on board ships (MSC, 2012).

The EU provision refers to the Assessment and Management of environmental Noise Directive (2002/49/EC) which aims to "define a common approach intended to avoid, prevent or reduce the harmful effects, including annoyance, due to the exposure to environmental noise" (EC, 2002). In addition, this provision also aims at providing a basis for developing measures to reduce noise emitted by major sources, in particular road and rail vehicles and infrastructure, industrial equipment and mobile machinery. To achieve these aims, several actions have to be progressively implemented in European ports.

Measures

Measures to address noise pollution should be taken by port authorities. Adopting low noise equipment, installing sound insulation fences, switching to electric port vehicles and machinery, or limiting working hours may contribute to reduce considerably the noise produced. Lowering speed limits for vessels or allowing shore-side electricity to replace power produced on-board may also contribute to cut noise levels in the port area. As mentioned in section 2.1, the Noise Management in European Ports (NoMEPorts) research project 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). In addition, workers should be provided with protective equipment, such as ear plugs.

4.2.7 Effects on biodiversity

Definition

The coastal and marine ecosystems provide an extraordinary biodiversity of plants and animals. For this reason, the surrounding terrestrial and marine 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). 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 (UN, 1992).

Sources

It is broadly acknowledged that port activities may impact on the existing biodiversity, in both terrestrial and marine environments. The main on-land port activity that is more likely to disturb the habitat of the species and their natural behaviour is the handling and storage of cargo. It may cause spills or leaks of products, including toxic or harmful materials, organic matter, or oily compounds, and therefore aggravates the deterioration of aquatic biota and fishery resources. In addition, dust dispersion on-land may cover and affect plants, and the dumping of litter may be hazardous to wildlife (UN, 1992).

Shipping and bunkering have a potential influence on marine ecosystems, since leaks of oils and oily wastes produced in these activities may directly cause damage to fishery resources, aquatic biota and coastal habitat. Discharges of petrochemical products can coat aquatic life and contaminate fish and shellfish, with implications for commercial resources. They are known to be carcinogenic and alter the anatomy and functions of organisms. Biodegradation of oil generates polymerized oil particles and toxic aromatic fractions, which indirectly cause damage to bottom biota and habitats (UN, 1992). As a result of these impacts, marine ecosystems may be affected, ranging from disturbances to organisms living there to their death. Port development activities, especially dredging activities and building new infrastructures (terminals, rails, pipeline, roads), also have serious implications to the marine ecosystems and habitats.

Impact

Port activities may pose serious threats to the ecosystems and habitats, such as changes in the vegetation cover, changes to benthos, changes in marine and coastal ecosystems, or changes in migratory routes. Deterioration of water quality usually gives rise to changes in aquatic biota; such as a decrease in the variety of different species. Further deterioration may lead to the destruction of all kinds of aquatic biota (UN, 1992). Wastes may cause that terrestrial and marine habitats become entangled in plastics, nets and packing material. Furthermore, certain marine species may mistake plastic bags for food and ingest them (Paipai, 1999), which can affect these species severely. Spillages of organic cargo also have to be taken into account since they can deplete oxygen from the water and affect aquatic life. As mentioned before, the introduction of new species from ballast water may alter the natural ecosystem.

Dredging activities, sometimes carried out to increase the port capacity to handle ships, also may affect the physical environment. On one hand, dredging removes the sediments and therefore it may affect the associated benthic organisms, such as sponge, coral reefs and sea grass habitats (Grech et al., 2013). On the other hand, dredging may lead to a loss of fishery resources since it involves changes in bathymetry (underwater depth), hydrography (tidal flow, currents, velocity, and waves), re-suspension of contaminants, and an increase in turbidity and a decrease of light (Paipai, 2009). Disposal of dredged material may be done either on land or at sea. On land, it may cause destruction of plants, loss of vegetation, odour, unsightly view and other nuisances to the local community (EcoPorts Foundation, 2004). Dumping of dredged material at sea may increase the total suspended solids and the turbidity level. This increase may pose risks to the surrounding natural ecosystems.

Finally, port expansion can generate some impacts in the marine ecosystems, similar to the ones generated by dredging: disturbances to the benthic habitat, increase of turbidity over a wide area, re-suspension of contaminants, and an alteration of the coastal hydrography causing changes in currents (Ecoports Foundation, 2004). The occupation of physical space to acquire land for port development also may generate several consequences on the terrestrial biodiversity of any port, for instance, the destruction of natural areas close to the port (such as wetlands or dune systems) or disturbances to the flora and fauna (Ecoports Foundation, 2004).

Relevant international legislation

Although there is not any convention dealing exclusively with the protection of the biodiversity at sea, several of the conventions that have already been explained before are strongly related to the preservation of the ecosystems and habitats. Examples of provisions that deal with the conservation of the marine environment from pollution are the International Convention for the Safety of Life at Sea (SOLAS, that has a chapter that deals with the carriage of dangerous goods) (IMO, 2014i), the International Convention for the Prevention of Pollution from Ships (MARPOL Protocol) (IMO, 2014a), the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) (IMO, 2014g), the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (IMO, 2014f), the International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS) (IMO, 2014h), and the International Convention for the Control and Management of Ships' Ballast Water and Sediments (IMO, 2014e).

The governments of the EU adopted the Habitats Directive in 1992 (EC, 1992), which complemented the Birds Directive adopted in 1979 (EC, 1979), aiming to protect the most seriously threatened habitats and species across Europe. Both Directives have been substantially amended several times and they are the basis of the Natura 2000 network of protected areas. The Birds Directive requires the establishment of Special Protection Areas (SPAs) for birds and the Habitats Directive similarly requires Special Areas of Conservation (SACs) to be designated for species other than birds, and for habitats. Together, SPAs and SACs make up the Natura 2000 network of protected areas. According to the *ESPO / Ecoports Port Environmental Review 2009* (ESPO, 2010b), 52% of EU ports are located within or contain a Natura 2000 site. In addition, there is also the EU Marine Strategy Framework Directive (EC, 2008b) aiming at promoting sustainable use of the seas and conserve marine ecosystems.

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 (ESPO, 2006). In addition, the European Commission published in 2011 the report ‘EC Guidelines on the implementation of the Birds and Habitat Directives in estuaries and coastal zones with particular attention to port development and dredging’ (EC, 2011a) and the EC Working Document ‘Integrating biodiversity and nature protection into port development’ (EC, 2011b).

Measures

In order to prevent these impacts on the environment, 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 (UN, 1992). For instance, a survey on the contamination of bottom sediments should be undertaken before dredging. In case that substances or materials listed in the annexes of the London Dumping Convention are found during the survey, the dredged material should be treated in accordance with the respective provisions of the convention.

One of the key impediments for the conservation of biodiversity in coastal areas is the lack of scientific and statistical information on both, the current state of biodiversity and on the risks posed by maritime traffic. As a result, mapping the biodiversity hotspots may be considered a priority task for researchers (IUCN, 2009).

4.3 Development of the TEAP tool

As it has been demonstrated in the previous chapters, the identification of environmental aspects is a basic element of any system aiming at guaranteeing an effective environmental management in ports.

This section presents and describes the part of the tool (TEAP) that has been developed in order to assist port authorities in identifying and assessing the significance of environmental aspects. The tasks and developments carried out in this section have been validated in chapter 6 by a set of port managers, experts and stakeholders. Therefore, the outputs presented below may be slightly amended, since the final version is the one displayed in chapter 6.

TEAP method has been elaborated after analysing the weaknesses and strengths of the existing methodologies for the identification of aspects, the recommendations from the EMS standards previously researched, the output of the research carried out under PERSEUS, and from the advice of the port members and experts. This is a computer-based tool, which provides two main advantages: i) it facilitates its completion by the user and ii) it provides a quick response and calculation.

As mentioned in section 3.3.1, the process of identifying and evaluating environmental aspects is composed of two major steps; firstly, the identification of aspects of the organisation that interact with the environment, and secondly the assessment of their significance in order to obtain the final list of SEAs. The methodology that has been developed within this thesis comprises these two different steps, involving three tasks for the identification of aspects and four more tasks for the assessment of the significance. All the tasks carried out are explained below.

4.3.1 Identification of the aspects

In order to develop this part of the tool, three main tasks were needed to be carried out. These are the identification of port activities, the identification of the port environmental aspects, and the creation of the relationships between activities and aspects. These three tasks are explained below one by one:

Task 1: Identification of port activities

All the activities carried out in a port may generate impacts on the environment, either direct or indirect, beneficial or harmful. Since port activities are strongly related to environmental aspects, they have to be considered and taken into account in this research. Related to that, it was found that most of the existing methods for the identification of aspects use the activities performed by an organisation as a way to obtain the corresponding aspects. For this reason, the first step was to identify the range of possible activities that are likely to be developed in ports. This list of port activities is showed in table 4.2 below.

Table 4.2: List of port activities identified in the research (adapted from EcoPorts Foundation, 2004).

Administrative services	**Cargo handling and/or storage of:**
Bunkering	Containers
Marine-based cargo transport (Shipping)	Dry bulk
Land-based cargo transport (e.g. train, truck)	Oil, gas and petroleum products
Passengers transportation (ferry & cruise ships)	Hazardous cargo (non-oil)
Dredging	Liquid bulk (non-oil)
Disposal of dredged material	Perishable goods
Fishing & Aquaculture activities	Vehicles / Trade cars
Maintenance of port installations and infrastructure	Ro-Ro
Maintenance of port vehicle and equipment	**Port based industry:**
Ship building, repair and maintenance	Aggregate industry
Port development	Chemical & pharmaceutical plants
Pilotage	Fish market and processing
Towing	Agro food Industries
Mooring	Metal ore processing and refining
Marinas and yacht clubs	Oil refineries
Water sports	Power stations
Port Waste Management	Steel works
Ship Waste Management	

This table was based on the list of activities already identified within the questionnaire of the PERSEUS project (see section 2.4.2 of this thesis). Only two more activities were added: the *disposal of dredged material* and the *maintenance of port vehicle and equipment*. *Dredging* and the *disposal of dredged material* are considered as two different activities, with distinct impacts on the environment, because the first one aims at gathering up bottom sediments and the second one at putting them in place. The *maintenance of port vehicle and equipment* is also considered as another activity not included within *maintenance of port installations and infrastructure*, and for this reason it was added to the compilation.

In contrast, the activities *port expansion (land)* and *port expansion (sea)* were grouped in this updated table as *port development* activities. In this way, the resulting activities were 35, each one described in Annex VI of this thesis. Some of these activities are clearly developed by the port authority, such as the administrative services or maintenance of port installations; other activities may be carried out by either the authority or a specialised company, such as dredging or mooring; and finally other activities are usually carried out by terminal operators, such as the loading and unloading of products.

Task 2: Identification of port environmental aspects

The second task was to identify the environmental aspects that are likely to be generated within the port sector. As already mentioned in section 4.1, the research contributed to gather a representative set of port environmental aspects. A total amount of 55 aspects, classified under nine categories, was initially compiled. This number of aspects was reduced to a final list of 17 aspects, divided in seven categories (see table 4.3 below):

Table 4.3: Final list of port environmental aspects

Emissions to air	**Resource consumption**
Emissions of combustion gases	Water consumption
Emissions of other gases	Electricity consumption
Emissions of particulate matter	Fuel consumption
Odour emissions	**Waste production**
Discharges to water/sediments	Generation of solid urban waste
Discharges of wastewaters	Generation of hazardous waste
Discharges of hydrocarbons	Generation of other waste
Discharges of other chemicals	**Noise**
Discharges of particulate matter	Noise emissions
Emissions to soil	**Effects on biodiversity**
Emissions to soil and groundwater	Ecosystems and habitats

Task 3: Creation of the relationships between activities and aspects

The third step was the definition of the interactions between the port activities identified in task 1 and the port environmental aspects determined in task 2. For each activity, all the aspects that interact with it were determined. Table 4.4 shows the examples of these interactions for the particular activities of bunkering and dredging. In addition, a weighting was allocated to each aspect (5, 3 or 1 points) according to its relevance for the particular activity. The aspects that were considered more specific and relevant for that activity received 5 points, whereas the aspects that were considered more generic received 1 point. In the moment of establishing the weightings, the aspects that were more characteristic of each activity were highlighted.

For example, in the activity of bunkering, the discharges of hydrocarbons is a relevant aspect since it is highly likely to occur and, for this reason, it has 5 points. On the contrary, although noise can be generated in this activity, it is not one of the main environmental aspects related to it. The complete list of interactions between activities and aspects, as well as the associated weights, is provided in Annex VII of this thesis.

Table 4.4: Examples of interactions between activities and aspects

Activity	Aspects	Weighting
Bunkering	Discharges of hydrocarbons	5
	Emissions of other gases	3
	Emissions of combustion gases	1
	Fuel consumption	1
	Noise emissions	1
Dredging	Effects on biodiversity	5
	Discharges of particulate matter	3
	Noise emissions	3
	Discharges of other chemicals	1
	Generation of other waste	1
	Fuel consumption	1
	Emissions of combustion gases	1

4.3.2 Assessment of the significance

In order to proceed to the step of assessment of the significance, four more tasks were developed. These tasks are the definition of the criteria to assess the aspects, the establishment of the weighting of the criteria' responses, the creation of the connections between aspects and criteria and, finally, the assessment of the significance. Each task is explained in the following paragraphs:

Task 4: Definition of the criteria

A list of possible criteria likely to be used for the assessment of the significance of the aspects was compiled, obtaining a total number of 23 criteria. This list is provided in Annex VIII of this thesis. The set of criteria was obtained from an extensive literature review (e.g. Block, 1999; EPA, 1999, Easibind, 2012), including best examples of ports that provide their criteria (e.g. Marina Port Vell, 2013; Puero de A Coruña, 2013; Port of Livorno, 2012), the EMS standards' recommendations (EC, 2009a; ISO 2004), among others.

It was agreed that a too extensive number of criteria would be over demanding and it would not simplify the process of assessing the significance. In addition, some of those criteria were redundant and some others were not adequate to assess the significance of port environmental aspects. After analysing these criteria carefully, it was reduced to a more pragmatic list of 8 criteria. These criteria are provided in tableTable 4.5, along with their definition.

Table 4.5: Set of criteria to assess aspects with definition

Criteria	Definition
Frequency	The number of times that the port activities can generate this aspect.
Aspect duration	The length of time that the aspect lasts.
Extent of the impact	The area of influence of the impact in relation with the port surroundings.
Stakeholders' complaints	It considers the port stakeholders and local community complaints on each environmental aspect.
Legal compliance	It considers if this aspect is affected by legal requirements, if permissible levels are exceeded and if fines have been released in relation to this aspect.
Severity of the impact	It considers the degree of impact that this aspect generates.
Quantity of waste	This criterion measures the quantity or the volume of waste that has been generated.
Consumption of resources	It is determined by comparing the consumption of the current year with the consumption of the previous years.

It is generally accepted by the broad scientific and legislative community that legal compliance is an important criterion that should be clearly taken into account. Therefore, when permissible levels are exceeded for a particular aspect, this will be automatically significant.

Another relevant criterion is to consider the views of interested parties, represented by the criterion stakeholders' complaints. The complaints released by the community have to be seriously taken into account since they represent the issues that the local community considers important. Examples of these aspects are the emissions of dust, noise emissions, odour emissions, or light pollution.

The frequency and the duration of the activities, in other words, how often and how long the activities performed in the port take, are two more criteria considered relevant. The extent of the impact considers the physical surroundings of the port and the area of influence of the impact, for instance, if the port is located next to a sensitive place (e.g. city, protected area) or not, if the effects are located exactly in one point or they are spread only within the port boundaries, among others.

Finally, other criteria that have been included in the final set are the severity of the impact, the quantity of waste and the consumption of resources.

Task 5: Establishment of the weighting for the criteria' responses

For each of the above-presented criterion, several possible option responses were established. In addition, a weighting between 0 and 5 was assigned to each response, based on the significance of the impact generated on the environment. If the impact has a higher significance, a higher weight is assigned. Annex VIII provides the list of criteria, with the possible responses for each one and the related weighting. Table 4.6 shows the examples of the possible responses and weighting for the criteria 'frequency' and 'stakeholders' complaints'.

Table 4.6: Examples of criteria and their possible responses and weight

Criteria	Possible responses	Weighting
Frequency	The aspect is generated continuously	5
	The aspect is generated at least once a day	4
	The aspect is generated at least once a week	3
	The aspect is generated less than once a week	1
Stakeholders' complaints	Five or more complaints have been received	5
	Between two and four complaints have been received	3
	One complaint has been received	1
	No complaints have been received	0

Task 6: Creation of the connections between aspects and criteria

Since not all the criteria are applicable to all the aspects, an assessment was carried out on which criterion has influence on each aspect. Depending on the nature of the aspect, the applicability of the criteria varies. As it is shown in figure 4.1, the boxes that are coloured in yellow mean that there is an interaction between them.

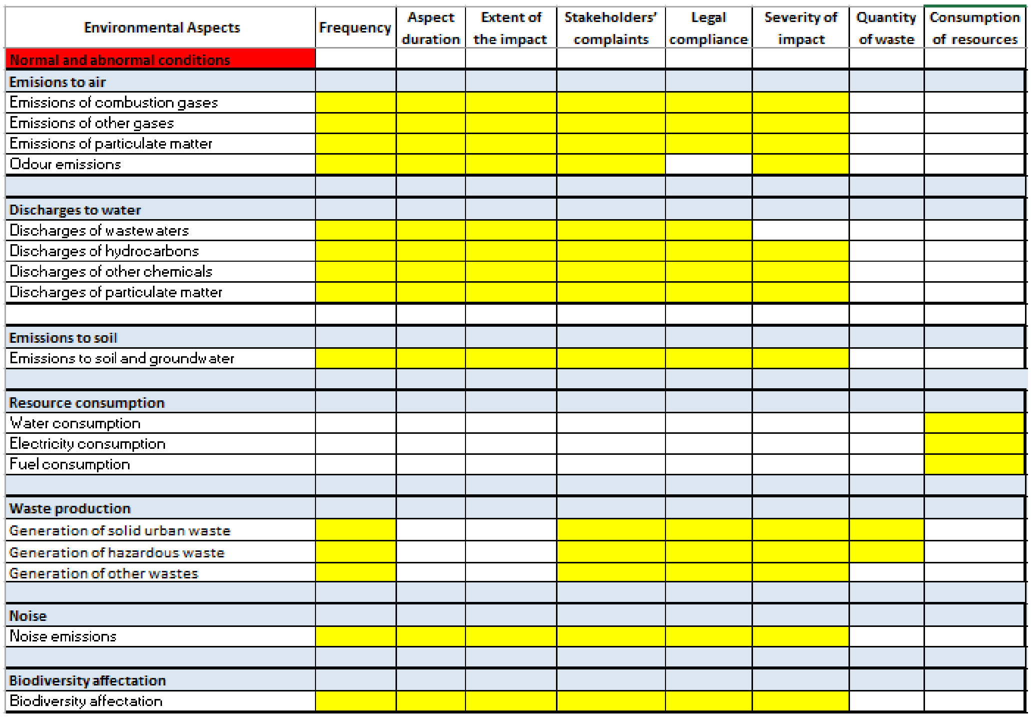


Figure 4.1: Connections between aspects and criteria

As presented in figure 4.1Figure 4., each aspect is assessed through the set of criteria that apply to it. For instance, the aspect 'emissions of combustion gases' has six criteria that assess its significance. On the contrary, the three aspects of the category resource consumption (namely water, electricity and fuel consumption) only have one criterion (consumption of resources) that applies to them. Each response of the criteria has a punctuation, as presented in table 4.6.

Task 7: Assessment of the significance

An average value for each aspect (between 0 and 5) is achieved, by summing the scores obtained in each criterion and dividing it by the total number of criteria that have been applied to this aspect. This average value is calculated according to the following formula:

$$Average\ value\ of\ each\ aspect = \frac{\sum punctuation\ of\ each\ criterion}{number\ of\ criteria\ applied} \quad \text{(Eq. 1)}$$

The final average values obtained, used to assess the significance of the aspects, are ranked in descending order, and therefore the aspects located in the top positions are the ones with a higher significance. It is considered that the aspects with a punctuation of 2.5 (which is half of the total score) or more are the Significant Environmental Aspects.

The list of environmental aspects is reduced to the final list of SEAs through the use of criteria.

4.4 TEAP application

Whereas the previous section explained the tasks that have been carried out internally to develop this tool, this section shows how it is applied from the point of view of the user. The respondent has to access the TEAP through the website www.eports.cat/teap. There are five main steps and the user has to contribute in three of them, namely Step 1, Step 2 and Step 4. Step 3 and 5 provide outputs to the user. The five steps are presented below:

- Step 1: Port contact details
- Step 2: Port activities
- Step 3: Environmental aspects
- Step 4: Application of criteria
- Step 5: Significant Environmental Aspects

The first step requires some basic contact details of the respondent. The second and the third step aim at identifying the environmental aspects of the port, based on the port activities that are carried out. The fourth and the fifth steps aim at selecting the ones that are significant for the port, based on a set of criteria.

Each one of these steps is presented below, with a screenshot of the interface of the tool in each one. It is important to point out that these screenshots do not belong to the final version of the tool, since it has been amended and improved to an updated version as a result of the validation process. Chapter 6 presents the feedback obtained in the validation process and the screenshots of the final version.

4.4.1 Step 1: Port contact details

Initially, the respondent has to enter the name and country of the port and their own contact details. All this information is confidential and only the respondent of the tool and the research team will have access to the results. In figure 4.2, a screenshot of the front page of the tool is showed:

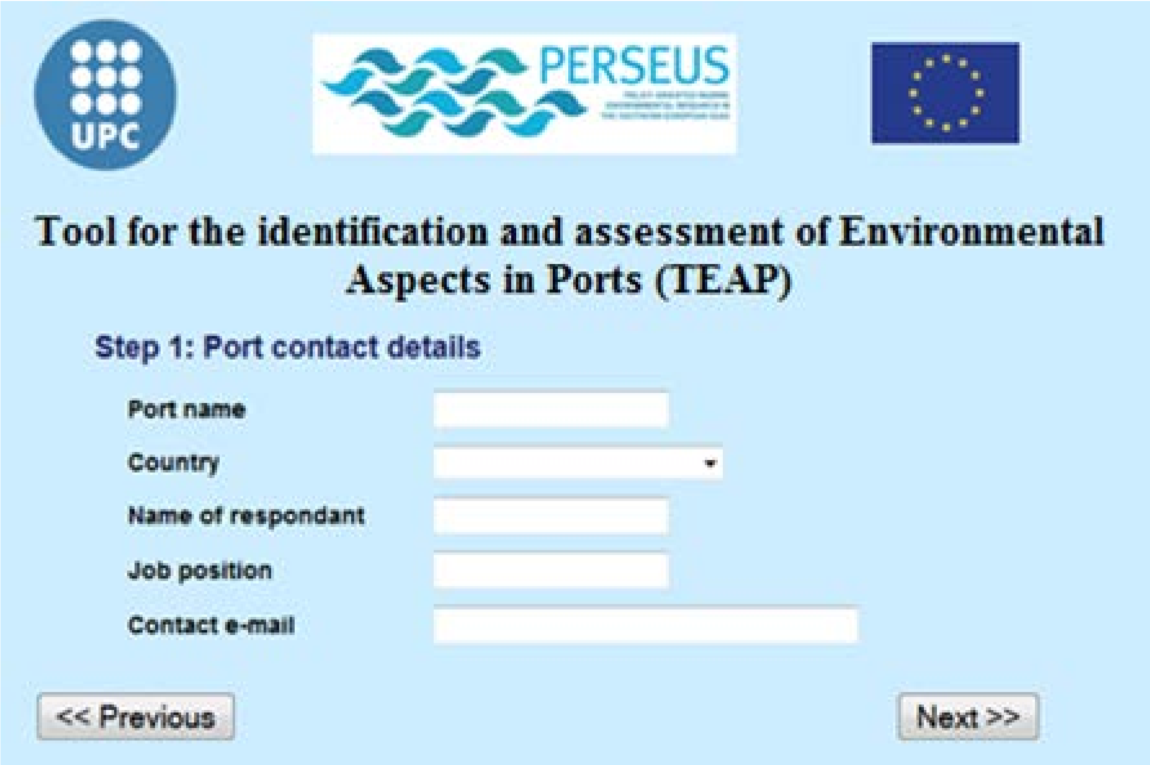


Figure 4.2: Screenshot of TEAP Step1: Port contact details

4.4.2 Step 2: Port activities

Once the contact details have been introduced, the respondent has, initially, to select the activities that are carried out in the port out of the possible 35 activities, as showed in figure 4.3 below.

A definition of each activity is provided by selecting the information button (*i*). As mentioned before, each activity is associated with several environmental aspects, and therefore, when an activity is selected, the related environmental aspects are activated. The complete list of interactions between activities and aspects, as well as the associated weights, are provided in Annex VII of this thesis.

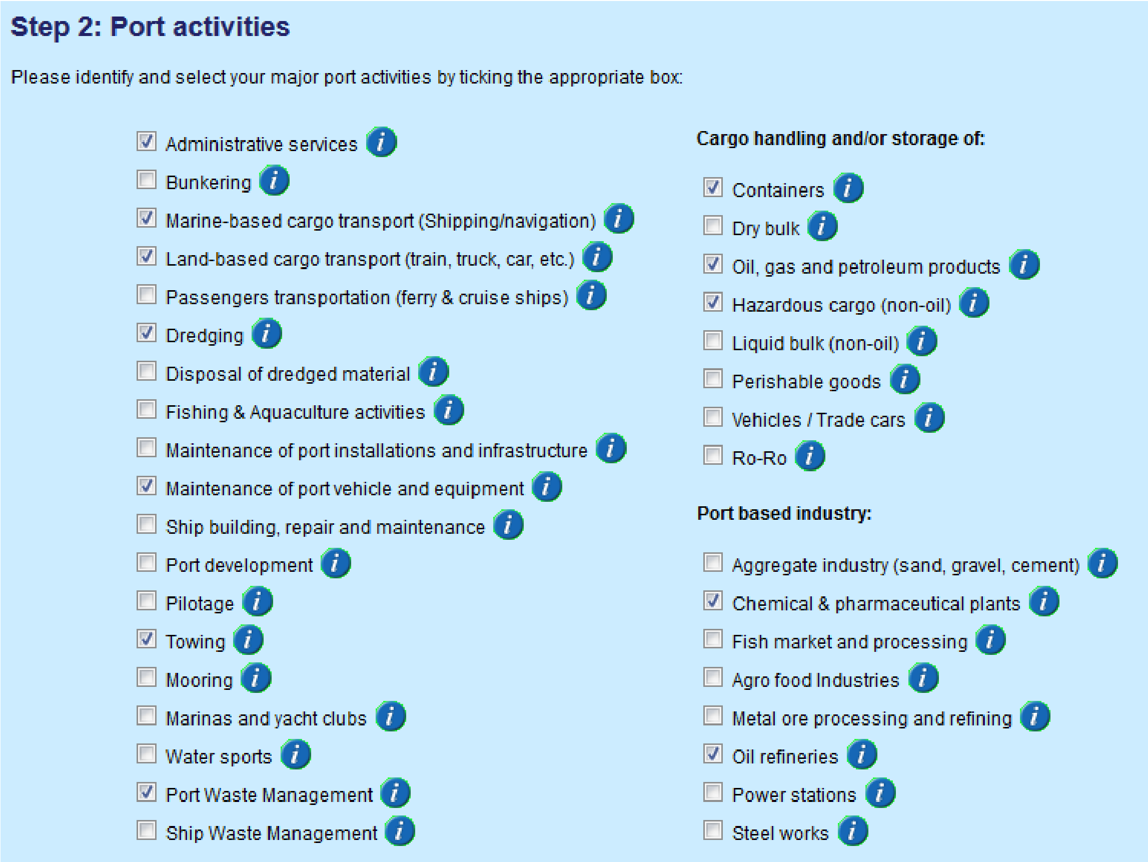


Figure 4.3: Screenshot of TEAP Step 2: Port activities.

4.4.3 Step 3: Environmental Aspects

The tool sums the total number of points obtained by each aspect, derived from the activities that have been selected, and ranks them accordingly in descending order (see figure 4.4). As a result, an extensive list of the port's aspects is generated. In order to find out the list of the main environmental aspects, a threshold value has been established within this methodology: the aspects with a score equal or higher than the 50% of the maximum score are selected to be further evaluated in the next step (coloured in red figure 4.4). This percentage is based on experts' opinions and on other methodologies identified in the literature review (e.g. Valenciaport, 2013; Marina Port Vell, 2013).

Figure 4.4: Screenshot of TEAP Step 3: Environmental aspects

4.4.4 Step 4: Application of criteria

The top half environmental aspects selected in the previous step (coloured in red) are reviewed and assessed against the criteria already presented in section 4.3.2. As showed in figure 4.1, each aspect is assessed only with the criteria that apply to it, based on the nature of the aspect.

For instance, the first aspect that appeared in the resulting list of the example provided in figure 4.4 was *Discharges of hydrocarbons*. Then, it is the first aspect that is assessed following the application of criteria. According to the previous figure 4.1, *Discharges of hydrocarbons* is assessed by six criteria. Figure 4.5 shows the first four criteria and the possible responses to each one, to be answered by the respondent. The screenshot of figure 4.5 is just an example of possible responses to the application of criteria step.

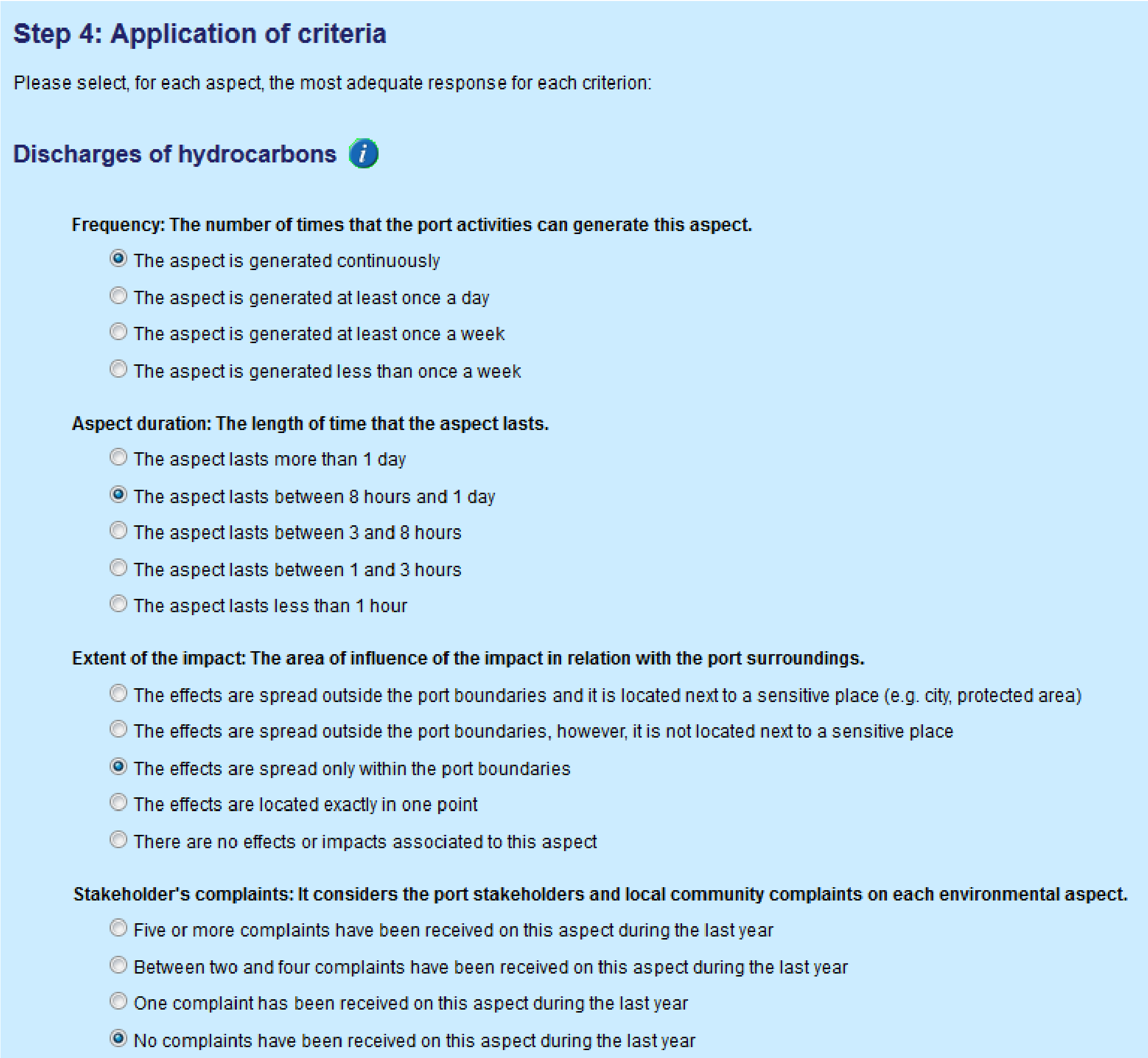


Figure 4.5: Screenshot of TEAP Step 4: Application of criteria

4.4.5 Step 5: Significant Environmental Aspects

From the punctuation obtained in each criteria, an average value for each aspect is obtained. This value is comprised between 0 and 5 because these are the intervals of the criteria, in other words, the minimum possible value is 0 and the maximum is 5. This final value is used to assess the significance of the aspect, since they are ranked in descending order, so that the aspects located in the top positions are the ones with a higher significance.

It is considered that the aspects with a punctuation of 2.5 or higher are significant aspects. Figure 4.6 shows an example of a screenshot of the final list of Significant Environmental Aspects of the port.

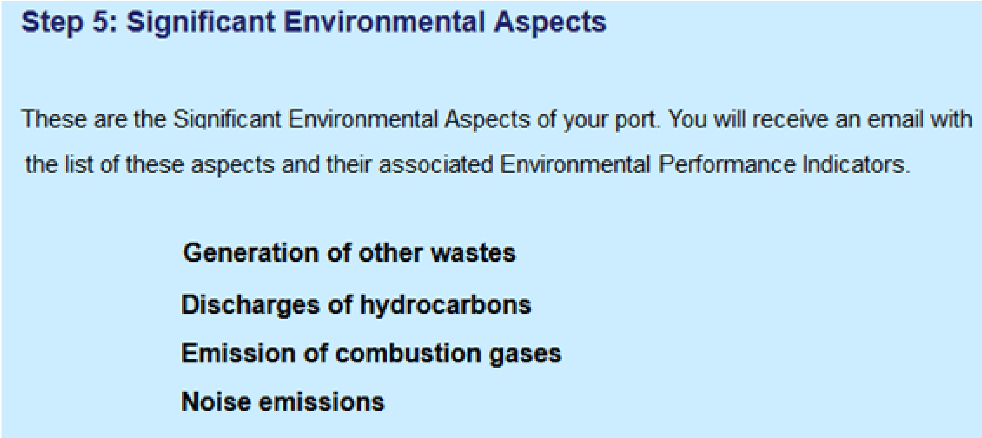
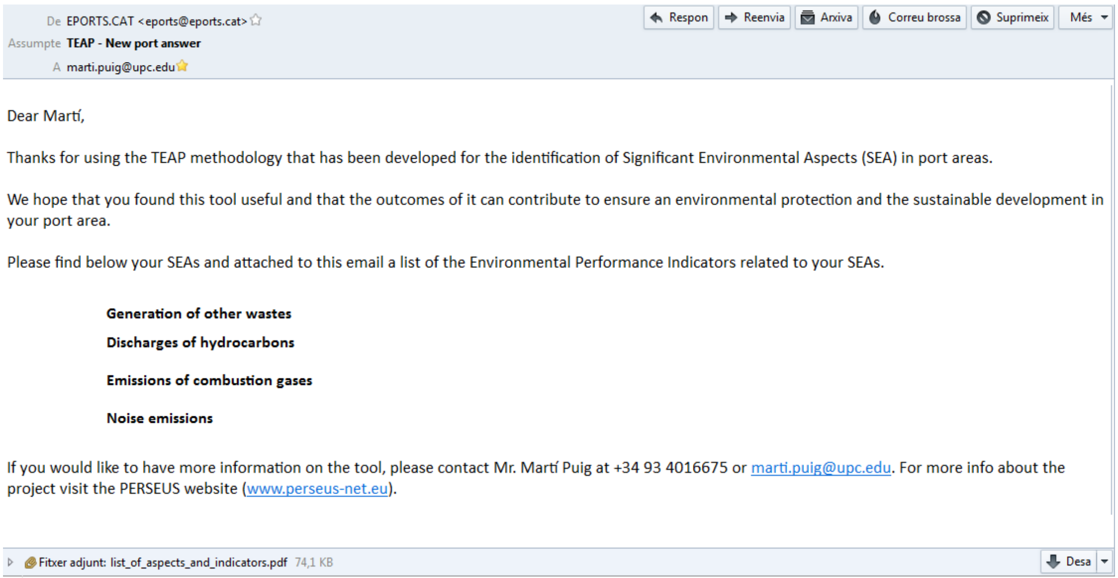


Figure 4.6: Screenshot of TEAP Step 5: Significant Environmental Aspects

In the same step, an email is sent to the user with the results obtained. An screenshot of the email is showed in figure 4.7 below.


De EPORTS.CAT <eports@eports.cat>
Assumpte **TEAP - New port answer**
A marti.puig@upc.edu

Respon | Reenvia | Arxiva | Correu brossa | Suprimeix | Més

Dear Martí,

Thanks for using the TEAP methodology that has been developed for the identification of Significant Environmental Aspects (SEA) in port areas.

We hope that you found this tool useful and that the outcomes of it can contribute to ensure an environmental protection and the sustainable development in your port area.

Please find below your SEAs and attached to this email a list of the Environmental Performance Indicators related to your SEAs.

Generation of other wastes
Discharges of hydrocarbons
Emissions of combustion gases
Noise emissions

If you would like to have more information on the tool, please contact Mr. Martí Puig at +34 93 4016675 or marti.puig@upc.edu. For more info about the project visit the PERSEUS website (www.perseus-net.eu).

Fitxer adjunt: list_of_aspects_and_indicators.pdf 74,1 KB Desa

Figure 4.7: Screenshot of the TEAP email

It is very important that the resulting list of SEAs should be taken into account within the management system of the port. A good way to treat this issue is to include the SEAs as part of the policy, goals or voluntary commitments of the port authority, so that they can be better controlled and, therefore, the impact generated may decrease. For example, many companies have established energy use, water use, or waste reduction goals and targets as a part of their policy, which allow not only to control this aspect, but also to reduce the costs.

It is suggested that the identification and assessment of the aspects should be conducted on a yearly basis or when some changes are made in relation with the port operations.

Chapter 5. TOOL FOR THE IDENTIFICATION AND IMPLEMENTATION OF ENVIRONMENTAL INDICATORS IN PORTS (TEIP)

This chapter aims at developing the second part of the method (EPORTS.CAT) elaborated in this thesis, which focusses on selecting environmental indicators for port authorities (TEIP). This selection is based on the environmental aspects obtained from the TEAP tool as well as other inputs of the port.

The chapter is divided into four sections: the first three constitute the background for developing the TEIP and the last one presents the TEIP itself. In the first three, an identification of all the existing indicators in ports is carried out, the criteria to assess this large amount of indicators is defined, and the filtering process of the indicators is conducted.

5.1 Research on port environmental indicators

It has been observed that there is a wide range of studies that confirm that ports report their performance through the use of Environmental Performance Indicators (EPIs). An extensive research has been carried out in order to identify and compile a very broad inventory of EPIs that are being used and reported in the industrial sector, with especial emphasis to the port sector. A vast list of references was researched, and each single new indicator that was identified within these references was added to the inventory, which contains a total number of 648 different indicators. It may be considered as the largest compilation of environmental indicators for the port sector that is known.

The final list of indicators, along with their sources, are provided in the Annex IX of this thesis. Eleven different sources of information were used, being these ones classified in eight categories, listed in table 5.1:

Table 5.1: Sources of information used for the identification of indicators

<table>
<tr><th>Categories</th><th colspan="2">Sources</th></tr>
<tr><td>Global Reporting Initiative (GRI)</td><td colspan="2">Global Reporting Initiative (GRI)</td></tr>
<tr><td rowspan="4">Research projects</td><td rowspan="2">ECOPORTS</td><td>EPI ECOPORTS</td></tr>
<tr><td>Self-Diagnosis Method (SDM)</td></tr>
<tr><td colspan="2">INDAPORT</td></tr>
<tr><td colspan="2">PPRISM</td></tr>
<tr><td>ESPO Questionnaire</td><td colspan="2">ESPO Questionnaire</td></tr>
<tr><td>Research studies</td><td colspan="2">Research studies</td></tr>
<tr><td>Legislation</td><td colspan="2">Legislation</td></tr>
<tr><td>Port environmental reports</td><td colspan="2">Port environmental reports</td></tr>
<tr><td>Port organisations</td><td colspan="2">Port organisations</td></tr>
<tr><td>EMS standards</td><td colspan="2">EMS standards</td></tr>
</table>

In the paragraphs below, the different categories are explained, as well as the type and the number of indicators found in each one.

i) Global Reporting Initiative

The Global Reporting Initiative (GRI) is a non-profit organisation, founded in 1997, that promotes sustainability reporting as a way for organisations to contribute to sustainable development (GRI, 2015a). Although the GRI is an independent organisation, it collaborates with the United Nations Environment Programme (UNEP) and works in cooperation with the United Nations Global Compact (UNGC).

GRI develops and disseminates globally applicable Sustainability Reporting Guidelines for voluntary use by organisations, reporting on the economic, environmental, and social dimensions of their activities, products and services (ACCA, 2001). In 1999, an ‘exposure draft’ of these Guidelines was released, and in 2000 the full version was completed (ACCA, 2001). Four further revisions of these guidelines have been carried out, in order to provide the best and most up-to-date guidance for effective sustainability reporting. The second revision was launched in 2002 (GRI, 2002), the third generation (referred to as the GRI G3 Guidelines) was released in 2006 (GRI, 2006) and, finally, the fourth update (known as G4) was presented in 2013 (GRI, 2013).

GRI Guidelines are widely used worldwide. In 2015, more than 5,000 organisations used these guidelines for their sustainability reporting across more than 90 countries; more than 20,000 reports were registered in GRI’s Sustainability Disclosure Database and 23 countries reference the Guidelines in policies (GRI, 2015b). These Guidelines may apply to corporate businesses, public agencies, small and medium enterprises, NGOs, industry groups and other organisations.

Environmental transparency is one of the main priorities of the scope of the GRI, so that the users of these Guidelines are encouraged to report on their environmental performance. To facilitate the reporting, the latest Guidelines (G4) suggest the monitoring of 34 Environmental Performance Indicators (EPIs), covering impacts related to inputs (such as energy and water) and outputs (such as emissions, effluents and waste). In addition, it covers biodiversity, transport, and product and service-related impacts, as well as environmental compliance and expenditures. All these indicators have already been included in the present inventory of indicators.

Apart from providing the Guidelines applicable to all types of companies, the GRI has developed Sector Supplements, allowing them to report according to their specific needs. For instance, in 2011, a report on the GRI Guidelines exclusively for the airport operators sector was released (GRI, 2011). Since environmental matters are significant concerns for airports and their stakeholders, several amendments were made to the G3 Guidelines to make them more applicable to this sector. Noise was considered as the main environmental concern from the airport sector that was not addressed by the GRI Guidelines, and for this reason, it was included as a new aspect in this airport supplement. However, from this report any additional indicator was obtained for the current research.

Unfortunately, this specific GRI guidance has not yet been developed for the port sector. Nevertheless, a study from Maigret (2014) investigated the current state of sustainability reporting in the port sector, by studying the GRI G3 environmental indicators that could be included or deleted for the development of a Sector Supplement, and providing potential additional indicators not covered under G3. These indicators have been taken also into consideration in the present research, although all they were already included in the database obtained from other sources.

ii) Research projects

As seen in section 2.1.2, the EU port sector has undertaken several research projects aimed at developing practical tools and methodologies to assist port managers to deliver compliance with legislation and to implement best practices in environmental management (Wooldridge and Stojanovic, 2004). There is no doubt that the development of these research projects contributed to enhance further the research cooperation between the port industry on one hand and the academia and research institutes on the other.

In addition, the development of several research projects has contributed to define and consider sets of environmental indicators for ports. In this research, the outcomes of major international and collaborative research projects have been examined, namely ECOPORTS (2002-2005), INDAPORT (2002-2004), PEARL (2005-2008) and PPRISM (2010 - 2011).

Firstly, in the framework of the ECOPORTS project there were two major outcomes that provided performance indicators for ports. The first one consisted of a document that compiled a set of approximately 50 indicators. The second outcome was the Self-Diagnosis Method (SDM) (Darbra et al., 2004), a tool already presented in section 2.1.2.

The SDM is a questionnaire that aims at providing an overview of the environmental situation and performance of the respondent ports. It contains a set of Yes / No questions that can be considered as qualitative environmental management indicators and, as a consequence, they have been taken into account for this research. A total number of 62 useful environmental indicators were provided in the field of management performance. This method was designed to help port environmental managers to continuously assess their performance and the progress achieved through time.

The methodology followed for the selection of indicators in the project Port Environmental Indicator System (INDAPORT) has already been explained in section 3.3.2. This study concluded with a final list of 17 indicators, obtained as a result of a research of the port activities and impacts in the Port of Valencia (Peris-Mora et al., 2005), already included in the final list (Annex IX).

With regards to PPRISM project, a comprehensive inventory of more than 300 existing EPIs in use in the seaport sector was identified for monitoring performance of operational, managerial and environmental condition. These indicators were filtered against specific criteria and were assessed and evaluated by port stakeholders in order to obtain a final set of indicators suitable to be implemented at EU level. In this research, all the 312 indicators identified within PPRISM have been included in the compilation.

The project PEARL studied the main environmental monitoring needs of ports. The resulting needs were related to marine issues (information on currents, waves and tides), water quality (the monitoring of different parameters such as salinity, water temperature, nutrient levels and dissolved oxygen), and meteorological parameters (data on atmospheric pressure, humidity, rainfall and temperature from meteorological stations located throughout the port area). Although this research did not provide any additional indicator to the compilation, it was useful to ensure that a wide range of indicators was already taken into account.

iii) ESPO Questionnaire

A very important source of indicators for this research has been the results obtained in the *ESPO/Ecoports Port Environmental Review 2009* (ESPO, 2010b) (see section 2.1.1). This questionnaire asked whether 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 ports of 20 different European Maritime states, obtaining a total number of 95 port environmental indicators. Data collection benefited from the development of a web based tool that facilitated online submission by interested ports and improved analysis and interpretation of results. The indicators obtained in this questionnaire have been incorporated in this compilation list, although the individual sources were kept anonymously.

iv) Research studies

The literature review demonstrated that there is a wide representation of research studies that provide environmental indicators. For the focus of this thesis, both, research reports carried out within the port sector and other studies not strictly related with ports were studied.

On one hand, reports related to ports were analysed in detail: the report prepared by the Postgraduate Course in Environmental Management (EPCEM) in the courses 2002 -2003 (De Leffe et al., 2003) and 2004-2005 (Berends et al., 2005), the research developed by Osorio and Quintana (2010), and a report carried out by the Economic and Social Commission for Asia and the Pacific (ESCAP) (UN, 1992). As a result the first report, called *Environmental Performance Indicators in European Ports*, a collection of 115 EPIs for ports was established, based mainly on a research of eight European port authorities. The second report was titled *Evaluation of Environmental Performance Indicators for European Ports & Impacts of the ECOPORTS Project* and developed a set of guidelines containing 49 validated EPIs for use in European ports. The research developed by Osorio and Quintana (2010) identified 128 indicators based on an analysis of nine Colombian ports, classified in six categories: water quality (61 indicators), sediments quality (29), soil quality (8), air quality (7), biology (14), social indicators (9). The last report, called *Assessment of the Environmental Impact of Port Development. A Guidebook for EIA of Port Development*, proposed 16 water related indicators, 14 bottom contamination indicators, and 11 air related indicators.

On the other hand, other examples of studies that provide lists of environmental indicators were taken into consideration, although they are not specifically for the port sector. These are the report *OECD Key Environmental Indicators* from the Organisation for Economic Development and Co-operation (OEDC, 2008) that defines 44 environmental indicators; the report *Environmental Performance Indicators Guideline for Organisations (Fiscal Year 2002 Version)* published by the Japan Ministry of the Environment which includes 80 indicators (Japan Government, 2003); the report *Summary of Proposed Indicators for Terrestrial and Freshwater Biodiversity* (Ministry for the Environment of New Zealand, 1999) which proposes 20 biodiversity indicators; or the *UK Biodiversity Indicators in Your Pocket 2010* (DEFRA, 2010) that also proposes 18 indicators related to biodiversity. These indicators are all listed in Annex IX.

v) Legislation

International and European legislation has also been taken into account in this study. Research into conventions from the International Maritime Organisation (IMO) as well as directives and other regulations from the European Commission provided further indicators that have been included in the broad inventory. Although the main pieces of legislation with regards to ports and the environment have already been presented in section 2.2 of this thesis, table 5.2 shows, in a chronological order, the nine international conventions that have been researched, along with the number of indicators that are mentioned in each one. A total number of 50 indicators is provided from international conventions.

Table 5.2: Number of indicators obtained from international conventions

International conventions	Acronym	Year	Number of indicators
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties	INTERVENTION	1969	0
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	London Convention	1972	22
International Convention for the Safety of Life at Sea	SOLAS	1974	0
International Convention for the Prevention of Pollution from Ships	MARPOL	1973 /178	8
International Convention on Standards of Training, Certification and Watchkeeping	STCW	1978	0
International Convention on Oil Pollution Preparedness, Response and Co-operation	OPRC	1990	0
International Convention on the Control of Harmful Anti-fouling Systems on Ships	AFS	2001	2
International Convention for the Control and Management of Ships' Ballast Water and Sediments	BWM	2004	5
International Convention for the Safe and Environmentally Sound Recycling of Ships	Hong Kong Convention	2009	13

The same exercise was carried out for the case of European Directives. The ESPO Green Guide (ESPO, 2012) provides a list of directives that affect ports and environment. A total of 22 Directives were researched, obtaining a total number of 168 indicators, as demonstrated in table 5.3. Out of the 22 directives, only there are five of them that do not provide any EPI.

Table 5.3: Number of indicators obtained from European directives

European Directives	Reference	Year	Number of indicators
Conservation of Wild Birds Directive (BIRDS)	79/409/EEC	1979	3
Environmental Impact Assessment (EIA) Directive	85/337/EEC	1985	2
Conservation of Natural Habitats and of Wild Flora and Fauna Directive (HABITATS)	92/43/EEC	1992	1
Volatile Organic Compound (VOC) Emissions Directive	94/63/EC	1994	1
Ambient Air Quality Assessment and Management Directive (Air Quality)	96/62/EC	1996	7
Integrated Pollution Prevention and Control (IPPC) Directive	96/61/EC	1996	25

Waste Incineration Plants Directive (WIPD) Directive	00/76/EC	2000	13
Framework for Community action in the field of water policy (Water Framework Directive)	00/60/EC	2000	28
Port reception facilities for ship-generated waste and cargo residues Directive	00/59/EC	2000	7
National Emission Ceiling (NEC) Directive	01/81/EC	2001	6
Large Combustion Plants Directive (LCP) Directive	01/80/EC	2001	3
Strategic Environmental Assessment (SEA) Directive	01/42/EC	2001	0
Assessment and Management of environmental Noise (Noise Directive)	02/49/EC	2002	15
Community vessel traffic monitoring and information system Directive	02/59/EC	2002	0
Public Access Environmental Information Directive	03/04 EC	2003	0
Emission Trading System (ETS) Directive	03/87/EC & 09/29/EC	2003	3
Environmental liability with regard to the prevention and remedying of environmental damage (Environmental Liability Directive)	04/35/EC	2004	0
Sulphur content of marine fuels Directive	05/33/EC	2005	2
Marine Strategy Framework Directive	08/56/EC	2008	8
Environmental quality standards in the field of water policy Directive	08/105/EC	2008	35
Waste Framework Directive	08/98/EC	2008	0
Eco-Management and Audit Scheme (EMAS III)	1221/09/EC	2009	9

Apart from the above-mentioned international conventions and European Directives, there are other six European regulations affecting ports and the environment, provided in table 5.4, which have also been considered. From these regulations, six indicators were obtained.

Table 5.4: Number of indicators obtained from other European regulations

Other European regulations	Reference	Year	Number of indicators
Pollution from ships (COSS) Regulation	2099/2002	2002	0
Regulation on Shipment of waste	1013/06/EC	2006	0
Green House Gases Decision	406/09/EC	2009	1
Maritime Spatial Planning	--	2010	2
Integrated Coastal Zone Management	--	2011	0
Estuary guidelines	--	2011	3

vi) Port environmental reports

This source includes an evaluation of numerous environmental reports and reviews from a large number of port authorities. Usually, when a port authority makes efforts towards the environment, it is keen to show it and publish its performance for its 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.

A research on the provision of indicators from the organisations used in section 3.3.1 (51 European port authorities, 39 non-European port authorities, 17 marinas and 13 port operators) was also conducted. Annex IV provides the names of the organisations with the number of indicators reported in each one, along with the name of the document that provides this information. Although a total number of 1360 indicators were compiled only from this source, there were many indicators that were repeated and reported several times by numerous ports. For instance, the monitoring of SO_2 emissions is a very common indicator and it appeared regularly in the reports of the ports. It allowed to reduce it to a shorter list of 253 different port environmental indicators, which were added into the inventory (see Annex IX), in case they were missing.

vii) Port organisations

The indicators suggested for monitoring by international port organisations also were taken into consideration. Although most of the researched port organisations make reference to environmental protection and sustainable development, only very few currently provide a list of EPIs to recommend to their port members. Most of the common actions that these organisations suggest are the development of an Environmental Management System (EMS) and the monitoring of the environmental performance. The associations that have been reviewed and the number of indicators found in each one are showed in table 5.5 below. The research included both national and regional port organisations, from all the five continents, as well as the International Association of Ports and Harbours (IAPH) from a worldwide perspective.

Table 5.5: Number of indicators obtained from port organisations

Continent	Organisation	Number of indicators
Worldwide	International Association of Ports and Harbours (IAPH)	26
Oceania	Ports Australia	3
	Papua New Guinea Ports Corporation (PNG ports)	0
Europe	European Sea Ports Organisation (ESPO)	0*
	Baltic Ports Organisation (BPO)	17
	Puertos del Estado (Spanish Ports)	35
	Associated Danish Ports (ADP)	0
	Union des Ports de France (UPF)	0

	British Ports Association (BPA)	1
	Finnish Port Association	0
	Bulgarian Ports Infrastructure Company	0
	Ports de la Generalitat (Catalan Ports)	5
America	Ports America	0
	American Association of Port Authorities (AAPA)	0
	U.S. States & Ports Association (USSPA)	0
	Association of Pacific Ports (APP)	0
	American Great Lakes Ports Association (AGLPA)	3
	California Association of Port Authorities	0
	Gulf Ports Association of the Americas	0
	Association of Canadian Port Authorities (ACPA)	0
Asia	China ports	0
	Indian Ports Association (IPA)	0
	Association of South East Asian Nations ports association (ASEAN)	0
Africa	Port Management Association for West and Central Africa (PMAWCA)	0
	Port Management Association of Eastern and Southern Africa (PMAESA)	0

* Although ESPO does not propose operational performance indicators, this organisation propose indicators regarding environmental management through the EcoPorts tools of SDM and PERS, which are fully integrated in the ESPO structure since 2011 (see section 5.1 for more information).

The International Association of Ports and Harbours (IAPH) has an entire branch dedicated to the environmental management, titled World Port Climate Initiative (WPCI). Among the different initiatives conducted by this organisation, a set of 26 performance indicators are proposed and included in the current compilation list.

As demonstrated in table 5.5, the number of indicators provided by each organisation vary between them, obtaining a total number of 90 indicators from this source. In the case of the organisations that does not report any indicator, on the basis alone of this research, it cannot be concluded that appropriate indicators have not been identified or selected. There may be several reasons why such information is not already in the public domain, such as political, policy, IT, culture, language, or resources available, among others.

viii) EMS standards

Finally, the indicators that are proposed for monitoring in the different EMS standards also were studied carefully. Although it is known that the standards do not oblige the use of any specific indicator, they do suggest several examples of EPIs. This is the case of ISO 14031 document (ISO, 1999), which provides more than 100 indicators. It is a very broad compilation, including indicators that are out of the scope of the port sector because they refer to industrial processes. Therefore, the indicators that were not considered applicable to ports were not included in this research.

The EMAS protocol (EC, 2009a) supplies a shorter list of EPIs. This standard provides nine core environmental indicators that are suggested for monitoring and reporting as a tool for sustainable development and continual improvement. The standard recognises that there is flexibility in their application and the organisation may decide not to report on a specific core indicator and may also report on the basis of additional relevant Environmental Performance Indicators. These indicators also were included in the compilation.

The third main standard to establish an EMS in the port sector is the Port Environmental Review System (PERS). This standard provides the list of 30 indicators (ESPO, 2011) as examples of EPIs related to the environmental quality, efforts and effects, which were included in the compilation.

5.2 Classification of the researched indicators

As mentioned in the previous chapter, Annex IX contains all the indicators and the sources of each one. It is interesting to note that several indicators appeared in more than one source, sometimes with exactly the same term and in other cases with similar names. For this reason, it was necessary to review the list and to avoid the repeated indicators.

After this, the literature review led to the creation of an inventory 648 environmental indicators. These indicators were classified under the seven categories of environmental aspects that were identified for the creation of TEAP tool (see table 4.1). The indicators that did not fit in the aforementioned classification were included in a new category, for instance the environmental management indicators or the port development indicators.

The following paragraphs provide the number of indicators located within each environmental aspect. They are presented below following the mentioned categories of aspects.

Environmental management

Environmental management indicators is one of the three categories of indicators, as defined by the standard ISO 14031: Environmental Performance Evaluation (see section 3.1.2 of this thesis) (ISO, 1999). This category embraces all the indicators collected that provides information on the issues of environmental management. This category of aspects was not included in TEAP.

This category has the highest number of indicators, 238 in total, representing a 37% of the total number of indicators collected. Management performance indicators may be allocated into 14 subcategories all related to the efforts made by the port authority towards the implementation of an effective environmental management within the organisation. Most of the subcategories are the components required in the establishment of an Environmental Management System, which are shown in the following table:

Table 5.6: Number of environmental management indicators

Subcategory	Number of indicators
Environmental Management System	10
Environmental Policy	14
Objectives and targets	10
Environmental Monitoring Plan	8
Significant Environmental Aspects	4
Management organisation & personnel	16
Environmental training and awareness	23
Environmental communication	22
Emergency planning and response	41
Environmental audit	10
Environmental legislation	19
Environmental complaints	15
Environmental budget	25
Other environmental management	21
Total number of environmental management indicators	**238**

Most of these indicators were obtained from the PPRISM project. In this way, from the 238 indicators listed in the management indicators, 132 are provided by this project. It is also interesting to note that from the environmental reports of port authorities, a total number of 65 indicators of management were identified, often being overlapped with indicators from the PPRISM project. The Self-Diagnosis Method (SDM) is also a significant source in this category, contributing with 62 indicators.

Emissions to air

As seen previously, air quality is a major environmental priority among European ports (ESPO, 2016). This category includes 66 indicators, mostly on the environmental monitoring, divided into six subcategories, as shown in table 5.7.

Table 5.7: Number of emissions to air indicators

Subcategory	Number of indicators
Emissions of combustion gases	28
Emissions of other gases	15
Emissions of particulate matter	5
Odour emissions	9
Other emissions	2
Meteorological data	7
Total number of emissions to air indicators	**66**

The subcategory *Emissions of combustion gases* is the one that has more indicators, 28 in total. They are related to the gases emitted during combustion of fossil fuels, and include both qualitative indicators (which mostly refer to footprint and to the efforts to reduce it) and quantitative indicators (which refer to emissions of greenhouse gases). *Emissions of other gases* refers to the monitoring of other air quality indicators, for instance, hydrocarbons or Polychlorinated biphenyl (PCB). The *Emissions of particulate matter* refers to the dust and other particulate matter (PM10 and PM2.5) emissions. The subcategory *Odour* includes indicators related to any release of gas that produces unpleasant smell. *Other emissions* includes the emissions of radiation, heat, vibration and light. Finally, *Meteorological data* includes meteorological indicators (e.g. temperature or wind speed). These last two subcategories were not identified as aspects and, therefore, they have been added.

The main sources of the indicators in this category are the environmental reports conducted by port authorities, the project PPRISM and the European legislation.

Discharges to water / sediments

As mentioned in section 4.2, the contamination of the sediments was also included in this category because any discharge to water may reach the bottom of the sea and then affect the sediments. However, there was not any aspect called *Sediments quality*, and since there are specific indicators on the quality of sediments, a new subcategory has been created. Discharges to water and sediments is divided into five subcategories, as shown in table 5.8. In total, 83 indicators are included.

Table 5.8: Number of discharges to water / sediments indicator

Subcategory	Number of indicators
Discharges of wastewaters	36
Discharges of hydrocarbons	2
Discharges of other chemicals	14

Discharges of particulate matter	4
Sediments quality	27
Total number of discharges to water / sediments indicators	**83**

Discharges of wastewaters has the major number of indicators, 36 in total. It includes water quality parameters, such as the indicators Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), pH and dissolved oxygen. The subcategory of *Discharges of hydrocarbons* collects the indicators related to spills in the port waters of crude oil and other petroleum products. *Discharges of other chemicals* contains the indicators that relate to concentrations of pollutants such as Polycyclic Aromatic Hydrocarbons (PAHs), tributyltin (TBT) and biocides. The fourth subcategory is the *Discharges of particulate matter* and includes four indicators, namely Total Dissolved Solids (TDS), Total Suspended Solids (TSS), settleable solids and turbidity. Finally, the subcategory *Sediments quality*, as its name suggests, covers the indicators identified in the research that relate to the quality parameters of the sediments, such as concentrations of contaminants and physical characteristics of the sediments themselves.

The main source of the indicators in this category are the environmental reports from ports, followed by research studies, the project PPRISM and the European legislation. As seen, most of these indicators aim at monitoring the environmental situation of ports.

Emissions to soil

Soil emissions indicators aim at assessing the past and present emissions made on the soil. A total number of 17 indicators was identified related to this aspect, without being divided into any subcategory. Examples of indicators are the soil pH, water content or the soil porosity. The main source of information of soil emissions indicators has been PPRISM project. The concentration of heavy metals, the soil occupation efficiency, the soil pH and availability of a soil pollution map are the indicators that have been cited by more sources.

Resource consumption

The indicators that have been collected related to the aspects of resource consumption are a total of 93. These are mostly operational indicators, although there are some management indicators. As shown in table 5.9, this category is divided into five subcategories. Three of those (water, electricity and fuel consumption) were already identified as environmental aspects in section 4.1, whereas *Energy consumption* and *Other resources consumption* have been added when the indicators were compiled.

Table 5.9: Number of resource consumption indicators

Subcategory	Number of indicators
Energy consumption	25
Water consumption	25

Electricity consumption	14
Fuel consumption	18
Other resources consumption	11
Total number of resource consumption indicators	**93**

Energy and water consumption have the same number of indicators: 25 each one. The first subcategory, *Energy consumption*, includes the indicators compiled that refer to the overall energy consumption in the port (e.g. total energy consumption by source, percentage of annual variation in energy consumption, or consumption of renewable energy). *Water consumption* refers to the indicators related to the amount of water consumed by the port authority or within the port area.

Electricity consumption indicators basically include the power consumption of the port authority and initiatives related to the supply of electricity to ships. The subcategory of fuel consumption refers to indicators related to the amount of fossil fuels consumed in the harbor. Finally, the *Other resources consumption* subcategory includes indicators that refer to the use of consumables such as paper, printer toners or lubricants.

The main source of information of these indicators is the research carried out on environmental reports of port authorities, followed by the project PPRISM and the latest Guidelines for environmental reporting developed by GRI.

Waste production

Ports are characterised for being a key connection point for the traffic of passenger and for hosting a wide range of industrial activities. All these practices may generate a variety of waste, both hazardous and non-hazardous, which ports must manage properly (ESPO, 2012). A total of 65 environmental indicators aiming at management waste production were identified. These include operational and management indicators, being divided into four subcategories, as shown in table 5.10.

Table 5.10: Number of waste production indicators

Subcategory	Number of indicators
Generation of waste	34
Generation of solid urban waste	7
Generation of hazardous waste	14
Generation of other waste	10
Total number of waste production indicators	**63**

Only the subcategory *Generation of waste* was not identified as an environmental aspect in table 4.1. This subcategory includes indicators that relate to waste in a generic way, without distinguishing what type they are. *Generation of solid urban waste* includes indicators regarding waste fractions: organic waste, paper and cardboard, plastics and glass. The following one is dedicated to hazardous waste, which includes oils, batteries and fluorescents, among others. Finally, the subcategory *Generation of other waste* includes non-hazardous industrial waste such as metal, wood, oil filters and electronic waste.

The two main sources of the waste production indicators were obtained from environmental reports conducted by port authorities and from the PPRISM project.

Noise

A total number of 22 indicators were identified related to noise and all of them are classified under the same category. These indicators involve mainly the levels of noise in different time zones and the measures implemented to control and reduce these levels. The main sources of this category are the project PPRISM and port authorities' reports.

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). Although port development was defined as a port activity (in section 4.3) and not as an environmental aspect, this category collects the indicators related to the port development, either at sea or on land due to their importance. It includes 21 indicators, grouped under the same category, which refer mostly to dredging operations and the location of dredging sediments. The main source of information of this category is the PPRISM project.

Effects on biodiversity

This category includes the indicators related to the monitoring of the fauna and flora inside the port area, the protection of natural habitats and the status of the soil. This category of aspects was not included in TEAP. 43 indicators were identified and classified into a single category, obtained mainly from the PPRISM project and reports from the port authorities consulted (e.g. Port of Valencia or Port of Cartagena).

5.3 Selection of criteria for the assessment of EPIs

As it has been demonstrated in the previous sections, a research was conducted and compiled a broad number of existing environmental indicators, almost 650 different EPIs. For this reason, it was found necessary to filter this large amount of indicators to a shorter list, more suitable to be potentially applied in port areas.

In order to carry out this filtering process in a methodological way, each indicator was assessed through a set of criteria. Then, the indicators that complied with more criteria were selected and the ones that obtained a poor performance were rejected. This section aims at defining the criteria used to assess the environmental indicators.

In order to establish the set of criteria to evaluate the extensive number of indicators, a literature review was conducted on the already existing criteria. A total number of 11 different sources were consulted. The nature of these sources was very broad, including scientific articles (Dale and Beyeler, 2001; Peris - Mora et al., 2005; Donnelly et al., 2007); reports from governments (EC, 1998 and Ministry for the Environment of New Zealand, 1999) and from public institutions (EEA, 2005; and UNEP, 2003); reports generated by other agencies (OECD, 1993; and Verfaillie and Bidwell, 2000); on-line publications (Jakobsen, 2008) and even the results of an investigation carried out in the framework of an environmental management course (De Leffe et al., 2003).

From this 11 sources, a set of 84 different names of criteria used to assess performance indicators was obtained. Annex X shows a table containing the criteria and their sources. By analysing these resulting 84 criteria, it was found that although some of them were written differently, the concept and the meaning was the same or, at least, similar. For this reason, the criteria that had the same purpose were grouped under the same name. This process allowed the reduction from the 84 criteria identified in the sources until the final number of 22 criteria. Table 5.11 below shows this resulting list of 22 criteria, along with their definition.

Table 5.11: Initial list of criteria to assess the indicators with definitions

Criteria	Definitions
1. Reliable	The source of the indicator is contrasted and scientifically robust
2. Limited	The indicator has well-defined limits and provides information about its own limitations
3. Practical	The indicator is easy to implement
4. Updated regularly	The indicator is determined at regular intervals for the purpose of actively pursue and influence the desired data
5. Understandable	The meaning of the indicator is easy to understand
6. Informative	The indicator enhances the port performance communication
7. Clearly defined	The meaning of the indicator is clear
8. Relevant	The indicator must be oriented and focused on the port priorities
9. Trend representative	The indicator allows to observe trends on the port performance
10. Specific	The indicator takes into account the particularities of the port

11. Measurable	The indicator can be measured in a quantitative way
12. Cost effective	The implementation of the indicator is feasible in terms of time and money with respect to the outcome obtained
13. Comparable	The indicator leads to potential performance comparisons
14. Standard	The indicator is equivalent for a wide spatial and temporal scale/range
15. Progress towards targets	The indicator allows to evaluate an activity in a way that targets linked to objectives are accomplished
16. Legislative priority	The indicator is defined (as a priority) in well-recognized legislations/ directives
17. Sensitive	The indicator is sensitive to the particularities of the system
18. Available	The indicator is available for all the stakeholders
19. Broadly accepted	The indicator is included in most of the sources consulted
20. Anticipative	The indicator predicts potential modifications in the system configuration
21. Integrative	The indicator is a part of a bigger set of indicators which describes a system
22. Adaptable	The indicator is adapted to other indicators, models and prediction systems

The 22 criteria listed in the table above were studied in more detail. It was found that some criteria could be further merged because they represent the same idea, and others could be discarded because they are out of the scope of this research. This second assessment made a reduction from the 22 to 10 criteria. Table 5.12 shows the ones that were merged, the ones that were kept as they were, and the three criteria that were discarded.

Table 5.12: Merging process of criteria

Previous criteria	New criteria
1. Reliable 2. Limited	1. Reliable
3. Practical 4. Updated regularly	2. Practical
5. Understandable 6. Informative 7. Clearly defined	3. Understandable
8. Relevant 9. Trend representative	4. Suitable

10. Specific	
11. Measurable 12. Cost effective	5. Cost effective
13. Comparable 14. Standard 15. Progress towards targets	6. Comparable
16. Legislative priority	7. Legislative priority
17. Sensitive	8. Sensitive
18. Available	9. Available
19. Broadly accepted	10. Broadly accepted
20. Anticipative 21. Integrative 22. Adaptable	(discarded)

The three indicators that were discarded were *Anticipative* (20), *Integrative* (21) and *Adaptable* (22). Since the focus of this research is to determine useful indicators to assess the current environmental situation and to monitor progress towards targets, the criterion *Anticipative* was refused because it is out of the scope of this thesis of predicting potential adverse environmental impacts and situations through indicators. The criterion *Integrative* needs to be applied to a set of indicators. In this research, the indicators are evaluated individually and, therefore, it is difficult to choose a criterion that evaluates all them together. Finally, the criteria *Adaptable* is related to the ability of an indicator to adapt to other indicators, models or forecasting systems. Since in this research this aspect is not measured, this criterion was also discarded.

The ten resulting indicators are listed and defined in table 5.13 below. The indicators that were merged are more comprehensive than the previous, since they involve several criteria and therefore the definition is broader.

Table 5.13: Resulting list of criteria with definitions

Criteria	Definition
1. Reliable	The source of the indicator is contrasted and scientifically robust. The information provided by the indicator is trustworthy and objective
2. Practical	The indicator is easy to implement and to monitor. The method is well-defined scientifically
3. Understandable	The meaning of the indicator is clear and easy to understand. The indicator enhances the port performance communication

4. Suitable	The indicator is focussed and oriented towards the priorities and policies of the port
5. Cost effective	The implementation of the indicator is financially sound with regards to the expected result
6. Comparable	The indicator leads to potential performance comparisons between ports and allows to observe the trends over the years
7. Legislative priority	The indicator is regulated by well-recognized legislations / directives
8. Sensitive	The indicator is sensitive to the particularities of the system
9. Available	The indicator is available for both port stakeholders and general public
10. Broadly accepted	The indicator is included in more than 50% of the sources consulted

Once decided that these would be the initial criteria used to assess indicators, a first attempt to apply them into the category of environmental management indicators was done. By doing this, it was found out that in order to apply some of these criteria, a deeper research of the indicator was needed. This was the case of the criteria *Cost effective* and *Legislative priority*, which required further information on the indicator in order to be evaluated, in terms of costs and legislative issues, respectively. It was also found that other criteria, namely *Practical* and *Sensitive*, only were applicable to quantitative indicators. For these reasons, it was agreed that these four criteria would be applied lately in a second filter. It was also observed that the criteria *Suitable* and *Available* evaluate issues that depend on the port policies, which provide a different answer in each port. As a result, the first one was redefined into a more applicable criterion, called *Useful* and the second was discarded.

In this way, the previous ten criteria were divided into two groups in order to assess the indicators in two phases. The criteria provided in the first filter was considered to be more generic and applicable to all the indicators. In contrast, the second filter was considered to be more specific in which a previous research on the indicators' characteristics was needed and in which these criteria may not be applicable to all the indicators.

The first filter consisted of five criteria and although four of them maintained the same name from the table 5.13, they had a more comprehensive definition. The criterion *Suitable* was replaced for *Useful* and therefore also its definition. Table 5.14 below shows the resulting criteria to be applied in the first filter.

Table 5.14: List of criteria with definitions to be applied in the first filter

Criteria	Definition
1. Reliable	This criterion refers to whether it is possible to corroborate the information provided by the indicator independently from the port. In other words, through own ways and without asking for information at the port authority
2. Understandable	This criterion refers to whether the statement of the indicator is clear, easy to understand, and it neither raises doubts nor allows different interpretations
3. Useful	This criterion refers to whether the indicator is relevant and useful to assess the environmental management
4. Comparable	This criterion evaluates the comparability of indicator itself and over the time, regardless whether the information provided is reliable or not
5. Broadly accepted	This criterion determines if an indicator is recommended for more than half of the sources consulted

Once the criteria for the first filter were determined, the next step was to select the criteria that would constitute the second filter. As mentioned, the second filter comprised criteria that imply a deeper research on the characteristics of the indicators.

In the second filter, three criteria maintained the same nomenclature, namely the criteria *Cost effective*, *Legislative priority* and *Sensitive*. However, their definition was modified from the initial one provided in table 5.13, in order to facilitate their applicability in the assessment of the indicators. The criterion *Practical* was split into two criteria: *Clearly defined method* and *Easy to monitor*. This separation was done because in order to carry out a more detailed analysis these two concepts should be evaluated separately. Finally, it was considered necessary to have a criterion in the second filter that evaluate the importance of indicators, and for this reason a new criterion was proposed. This is the criterion *Significant*, which had not appeared before although it is related to the criterion *Relevant*, which appeared in the very initial list of criteria (see table 5.11). Table 5.15 lists the criteria selected for the second filter along with their updated definitions

Table 5.15: List of criteria with definitions to be applied in the second filter

Criteria	Definition
1. Cost effective	The cost of the implementation of the indicator is financially sound with regards to the expected result. For qualitative indicators, it is considered the time invested to reply the indicator. For instance, indicators that may be quickly replied comply with the criteria, whereas management indicators that need more information, do not comply. For quantitative indicators it is considered the approximated cost of the cheapest method.
2. Legislative priority	The indicator is regulated by well-recognized national and international legislations / directives.

	If the indicator is not clear whether it is regulated or not, it is considered that this criterion does not apply to this indicator.
3. Sensitive	The indicator is sensitive to the particularities of the system. It changes at short term when there is an external change (there is a cause-effect relationship).
4. Clearly defined method	For qualitative indicators, the criterion applies to those indicators that a research on its method can be conducted. For the indicators that it is not possible to figure out how each port implements the indicator, it is considered that this indicator does not apply to this criterion. For quantitative indicators, the method is scientifically well-defined and it is based on well-established and well-known techniques.
5. Easy to monitor	There is a simple and practical procedure to measure the indicator. This procedure must contain few steps and must provide a value in a simple way. For qualitative indicators, it is considered that they are 'easy to monitor' if they provide a value (number) easily. Descriptions are not considered. Quantitative indicators are easy to monitor when they have an easy procedure.
6. Significant	For qualitative indicators, this criterion evaluates whether the indicator is relevant within its category of indicators. In order to determine which are the most significant, a comparison is carried out between all the indicators of the category. For quantitative indicators, it evaluates whether the indicator is relevant and if it makes sense to measure this indicator in a specific compartment (e.g. air, water, soil or sediment) of the port area. The relevance is determined by carrying out a research.

As it is observed in table 5.15, most of these criteria evaluate the indicators differently, depending if they are qualitative or quantitative indicators. In some of the cases, some of the criteria cannot be applied to all the indicators. Generally, qualitative indicators are from the categories of environmental management, resources consumption, waste production and port development (seen in section 5.2). Contrarily, quantitative indicators mainly belong to the indicators' categories of air, water, soil and sediments emissions, noise and biodiversity. Nevertheless, there are some exceptions, and within the qualitative categories there may be some quantitative indicators, and vice versa.

This section has described the criteria that were applied in both filters to assess the indicators. In the following chapter, the methodology used to carry out this process is explained.

5.4 Filtering process of the indicators

This section details the methodology that was followed in order to filter the large number of indicators against the criteria selected and defined in the previous section. The filtering process consisted of three steps: i) the first filter, ii) a regrouping of the indicators and iii) the second filter of the indicators, as shown in figure 5.1 below:

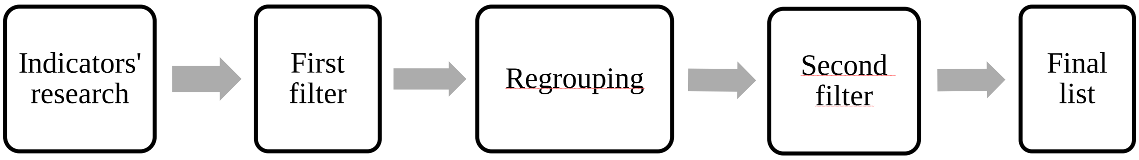


Figure 5.1: Filtering process of the indicators

These three steps are presented more in detail below:

5.4.1 First filter

The first filter consisted of analysing the complete broad list of indicators that were compiled. To do that, the criteria defined for the first filter were used. These criteria have been presented and defined in the previous table 5.14 (see section 5.3) and are the following: *Reliability*, *Understandable*, *Useful*, *Comparability*, and *Broad acceptance.*

The evaluation of the indicators against these five criteria was carried out by three researchers, with the objective of applying the filter in a contrasted way. Each evaluator, independently from the others, analysed the criteria met by each indicator. Table 5.16 shows an example of the assessment process of the first filter, dividing it in three main columns. The first column of this table contains the names of the indicators. The central column shows the assessments of the criteria for each indicator (this example corresponds to the results of the evaluator A2) and the third column summarizes the results of each evaluator (A1, A2 and A3).

If the indicator met a criterion, it was coloured with a green dot and if it did not comply, with a red dot. It was considered that an indicator was accepted by an evaluator when the result of the division between the accomplished criteria (green dot) and the total number of evaluated criteria was higher than 0.5. In other words, since in this first filter all the five criteria were applied, the indicators that met three or more criteria were accepted. A green tick (✓) indicates that the evaluator accepted this indicator, and a red cross (✗) that the indicator did not pass the first filter. All those indicators that were selected by at least two of the three evaluators were accepted. If there was only one green tick or any of them, then it was rejected.

Table 5.16: Example of the first filter assessment

Indicators	Criteria (A2)					A1	A2	A3	Accepted?
	1	2	3	4	5				
Total annual port waste sent to controlled landfill	🔴	🟢	🔴	🟢	🔴	✗	✗	✗	No
Total annual port waste stored in situ	🔴	🟢	🔴	🟢	🔴	✗	✗	✓	No

Existence of separate containers for the collection of port wastes	🟢	🟢	🟢	🟢	🟢	✓	✓	✓	Yes
Frequency of cleaning the port area	🔴	🟢	🟢	🟢	🔴	✓	✓	✗	Yes

As it is demonstrated in the example of table 5.16, the first two indicators were not accepted since the first one was not admitted by any reviewer and the second indicator was affirmed only by one (A3). The third and fourth indicators were both accepted since they were selected by, at least, two evaluators.

In this way, a first list of selected indicators was obtained. From the total number of 648 indicators, 354 were accepted through the first filter and 294 were rejected. The indicators that were rejected in this first filter are coloured in red in the compilation list of Annex IX.

5.4.2 Regrouping the indicators

The indicators that passed the first filter were regrouped. In some cases, there were some indicators that were normalized against different references, and they were unified in one more generic indicator. This is the example provided below in table 5.17, where three indicators related to electricity consumption were expressed in different ways. Consequently, they were grouped into a generic indicator called 'Total annual electricity consumption'. Nevertheless, it is important to mention that the information provided from the indicators that were regrouped (these three in the example below) was not lost; it was taken into consideration on the guidelines for the implementation of the indicator.

Table 5.17: Example of regrouping the indicators on 'annual electricity consumption'

Regrouped indicators	Resulting indicator
Total annual electricity consumption	Total annual electricity consumption
Electricity consumption per cargo handled	
Electricity consumption per number of employees	

In other cases, there were some indicators very similar, or that the response of one already implies the response of the other indicator. This is the case provided in the example of the table 5.18, which deals with the waste disposal methods. There is one indicator about the percentage of recycled waste, and another indicator on the percentage of all disposal methods. It is obvious that the result of the second indicator allows answering the first one. Therefore, they were grouped into one indicator as well.

Table 5.18: Example of regrouping the indicators on 'waste production'

Regrouped indicators	Resulting indicator
Percentage of disposal methods of port waste	Percentage of disposal methods of port waste
Percentage of recycled waste	

Annex IX shows in orange the indicators that were sent to the regrouping process, 148 in total. Annex XI compiles these 148 indicators and regroups them, resulting in 39 accepted indicators. In other words, the regrouping process eliminated 109 indicators from the compilation list and reduced it from 354 (first filter) to 245 indicators (as it can be seen in figure 5.2).

5.4.3 Second filter

The second filtering process of indicators consisted of six criteria that evaluated individually the indicators that remained after the first and the regrouping process (245 indicators). As presented in table 5.15 of section 5.3, the criteria for this second filter were *Cost effective, Legislative priority, Sensitive, Clearly defined method, Easy to monitor* and *Significant*. These criteria evaluated more specific issues of the indicators and, in many cases, it was necessary to conduct a previous research in order to determine if a particular indicator fulfilled a criterion.

In the same way as in the first filter, it was considered that an indicator was accepted when it met more than half of the criteria; in other words, the ratio between the accepted criteria and all the evaluated criteria had to be over 50%. In this second filter there was a major difference compared to the first one, because the total number of criteria evaluated was not always the same. Due to the different nature of the indicators, and considering that the criteria of the second filter are more specific, not always all criteria were applicable to all the indicators. It was also possible that, for certain indicators, not enough information was available to assess a specific criterion. In both cases, these criteria were not summed up in the total number of criteria assessed. An evaluation system was designed that took into account these particularities. This system is governed by the following formula:

$$\frac{Number\ of\ criteria\ fulfilled}{6-(Not\ applicable\ criteria+criteria\ with\ not\ enough\ information)} > 0{,}5 \quad \text{(Eq. 2)}$$

In the numerator, there is the number of criteria that are accomplished for a specific indicator. The number 6 in the denominator refers to the total number of existing criteria. From this value, it is deducted the number of criteria that are considered not applicable to this indicator and the number of criteria that do not provide enough available information for this indicator. In this way, the number of evaluated criteria is obtained. This value may vary between 1 and 6, and it be different for each indicator. The ratio should be greater than 0.5 in order to accept the indicator.

Table 5.19 shows a screenshot of the table used to evaluate the second filter. On the left there are the names of indicators to be assessed and on the right there is a table to evaluate the six criteria for each indicator. In the same way as in the evaluation of the first filter, a red dot indicates that the indicator does not meet the criteria and a green dot indicates that it does. In this second filter, as mentioned above, there are two more possibilities: i) a criterion may not apply to a particular indicator (grey dot), and ii) there is not enough information to assess a criterion for a specific indicator (blue dot).

Table 5.19: Example of the second filter assessment

Indicators	**Criteria 1**	**2**	**3**	**4**	**5**	**6**	**Accepted?**
Biological Oxygen Demand (BOD)	green	green	green	green	red	green	✓
Annual amount of recovered rainwater	blue	green	green	grey	green	red	✓
Percentage of the port area that has a system for the collection and treatment of rainwater	blue	red	green	grey	red	red	✗

For example, as shown in the table, the indicator *Biological Oxygen Demand* fulfilled five of the six criteria and it was accepted because, by applying the equation (2), a ratio of 0.83 was obtained (which is higher than 0.5). The indicator *Total annual rainwater recovered* fulfilled three out of four criteria (for criterion 1 not enough information was found and criterion 4 did not apply to this indicator and, therefore, these two criteria were not counted). The ratio was 0.75, passing the second filter. Finally, the indicator *Percentage of the port area that has a system for the collection and treatment of rainwater* fulfilled just one of four criteria that were evaluated, by applying the formula a ratio of 0.25 was obtained and therefore it did not overcome the filter.

Due to the complexity of this method and the fact that it was necessary to find information for each indicator, this process was done by one researcher, instead of three as in the first filter. A total number of 72 indicators were rejected in this second filter, and they are coloured in yellow in the tables of Annex IX. As a result, the initial number of 245 indicators was reduced to a list of 173.

The figure below summarizes the three main steps followed to filter the indicators and mentions the total number of indicators that resulted after the application of each filtering process.

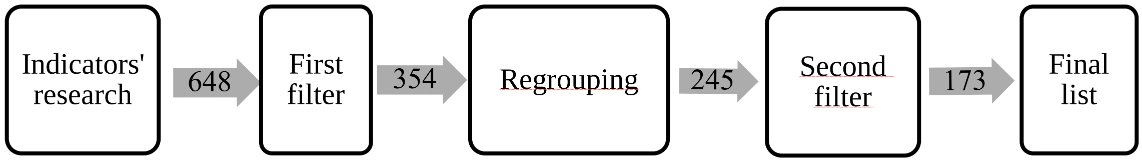


Figure 5.2: Number of indicators resulting after each filtering process

The final list of the 173 indicators is provided in Annex XII. For each of these resulting indicators, a guideline or recommendation on how to implement this indicator was created. The structure of these guidelines and recommendations are presented in the following section.

5.5 Structure of the guidelines

The main objectives of the TEIP tool are not only to provide ports with the list of indicators suggested for monitoring, but also to supply them with guidelines and recommendations for the proper implementation of these indicators. This section aims at presenting initially the structure of the guidelines and secondly of the recommendations.

The different nature of the indicators prevented to define a single structure of the guidelines for all the indicators. For this reason, two different structures were established. On one hand, a model was created for management and operational indicators (see section 3.1.2), which are focussed on issues related to the elements of an Environmental Management System and on port operations. On the other hand, another template was designed for the environmental condition indicators, which measure physical and chemical parameters of the environment and, therefore, they require quantitative methods and measuring equipment. Next, the two templates of guidelines for indicators and the one for recommendations are displayed.

5.5.1 Structure of the guidelines for management and operational indicators

The template of the guidelines used for management and operational indicators is presented in table 5.20 below. These indicators belong mainly to the categories of environmental management, resource consumption, waste production, and port development, which can be found in Annex XII. In addition, although most of the indicators on air emissions and effects on biodiversity are mainly condition indicators, some of them are management and operational indicators, such as Carbon Footprint and total port area protected indicator. These also follow this structure.

Table 5.20: Template of the guidelines for management and operational indicators

<table>
<tr><td>Indicator's name</td><td colspan="3"></td></tr>
<tr><td>Category</td><td></td><td>Indicator's code</td><td></td></tr>
<tr><td>Sub category</td><td colspan="3"></td></tr>
<tr><td>Definition</td><td colspan="3"></td></tr>
<tr><td>Importance</td><td colspan="3"></td></tr>
<tr><td>Units of measurement</td><td colspan="3"></td></tr>
<tr><td>Frequency</td><td colspan="3"></td></tr>
<tr><td>Level of effort</td><td colspan="3"></td></tr>
<tr><td>Notes</td><td colspan="3"></td></tr>
<tr><td>References</td><td colspan="3"></td></tr>
</table>

The first two elements of the template are the name of the indicator and its identification code, which is provided in order to have a specific reference of the indicator in each guideline. Then, the category and subcategory to which this indicator belongs is given (see the classification of the indicators in section 5.2), in order to place the indicator in context. After this, a definition of the indicator can be found and the reasons why this indicator is important are highlighted.

Then, three more technical elements of the indicator are detailed, which are the units of measurement, the frequency of monitoring (which defines how often the indicator should be monitored) and the level of effort involved to carry out this monitoring. This parameter may be obtained using the following legend:

Table 5.21: Level of efforts

Effort	Description
Low level	The information requested by the indicator is easily obtained.
Intermediate level	The information required by the indicator is not very complex, but it requires certain research to be obtained.
High level	The information required by the indicator is specific and it may require a deep research to be obtained.

Finally, the last two elements required in the structure for the management and operational indicators template are the notes (if needed) and the references used in that guideline.

5.5.2 Structure of the guidelines for condition indicators

The second template was developed considering the environmental condition indicators. These indicators require standardised methods and tools, such as laboratory instruments, probes, or complex equipment. The environmental condition indicators belong mainly to the categories of air emissions, water and sediments discharges and soil emissions. The template for this type of indicators is presented in table 5.22:

Table 5.22: Template of the guidelines for condition indicators

Indicator's name			
Category		**Indicator's code**	
Sub category			
Definition			
Importance			
Units of measurement			
Description of the methodology			
Detection limits			
Limit values			
Monitoring locations			
Frequency			
Approximate cost			
Level of effort			
Notes			
References			

The first elements that define the nature of the indicator are common to the previous template, from the indicator's name to the units of measurement. Some new elements are introduced: the description of the methodology used for the monitoring, the detection limits of the methodology, the limit values that are provided by the legislation (if any), the possible monitoring locations, and the approximate cost of the equipment needed to carry out the recommended method. Finally, there are four elements common to the template of the guidelines for management and operational indicators, which are the frequency of monitoring, the level of effort, the notes concerning any issue of this indicator and the references used for creating the guideline.

The whole set of guidelines for all the output indicators are provided in Annex XIII of this thesis.

5.5.3 Structure of the recommendations

As mentioned at the beginning of this section, apart from the guidelines for the implementation of the indicators, the TEIP tool also provides the users with a set of recommendations for environmental improvement. The template of the environmental recommendations is provided below:

Table 5.23: Template of the environmental recommendations

Recommendation name		**Recommendation code**	
Definition			
Contents			
Suggested indicators			
References			

This template consists of six main sections. Initially, the name and code of the recommendation are listed. Following it, the definition of the recommendation is provided. Then, there is the contents section, which refers to the information and the knowledge that this recommendation includes. The suggested indicators section contains the indicators from TEIP that are related to this recommendation. Finally the list of references used to create this recommendation is given.

The set of recommendations are all attached in the Annex XIV of this thesis.

5.6 Development of the TEIP tool

5.6.1 Classification of the final indicators

Based on the indicators that remained until the end in the filtering process, the final list of indicators that constitutes the TEIP tool was compiled (173 indicators). This list is was constituted from the remaining 134 ‘green’ indicators from the compilation list of Annex IX and the 39 indicators that resulted from the regrouping process in Annex XI. As mentioned in the previous chapter, all these final 173 indicators are provided on the Annex XII.

When the final list of indicators was analysed in order to develop the TEIP tool, it was found out that there were both quantitative and qualitative indicators. On one hand, the quantitative indicators were clearly identified as the output indicators of the tool (e.g. the number of environmental objectives defined). On the other hand, it was considered that qualitative indicators would be very helpful in two ways: i) to demonstrate existence or inexistence of a specific environmental topic (e.g. 'Has the port defined objectives for environmental improvement?') and ii) to identify issues that could be given as recommendations to the port authorities (e.g. 'Does the port have quantitative objectives?'). In addition, as a result of the suggestions provided by the TEIP reviewers (see section 6.2.2 for more information), two indicators were not included in the final list of TEIP indicators. According to this, the final indicators were categorized in the following four groups, each one in a specific colour in the Annex XII:

1. Quantitative indicators used as output indicators in the TEIP tool (green colour).
2. Qualitative indicators used as a question in the TEIP tool in order to demonstrate existence or inexistence of a specific environmental topic (yellow colour).
3. Qualitative indicators used as issues to take into account in the provision of recommendations to ports (blue colour).
4. Indicators rejected in the application of the TEIP tool (red colour).

These four possible options and the number of indicators that are derived to each option is schematized in figure 5.3 below:

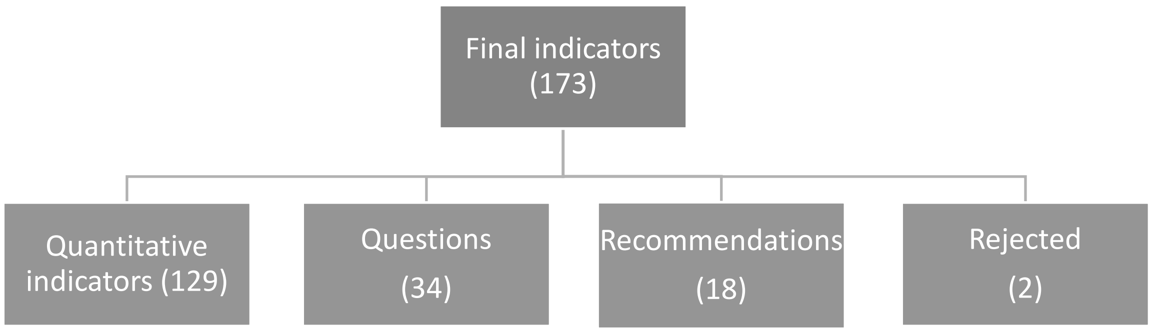


Figure 5.3: Classification of the final indicators

5.6.2 Interrelations aspects - indicators

The TEIP tool selects the indicators based on the significance of the aspects for the port. In other words, when an aspect is considered significant, its related indicators are suggested for monitoring. The following tables show the connections between each one of the 17 environmental aspects identified in TEAP (see section 4.1, table 4.1) and the related quantitative indicators (highlighted in green). There may be some questions (highlighted in yellow) on some aspects which, depending on the answer ('if yes' or 'if no'), further indicators and recommendations (highlighted in blue) are provided. This arrangement of the colours is based on the previous classification of indicators (see section 5.6.1). When two dashes (--) are provided, it means that there is not any related indicator or recommendation. In brackets, next to each indicator, the 'indicator number' is mentioned. This is the reference number that each indicator has, as stated in each indicator guideline (See Annex XIII).

Table 5.24: Indicators related with emissions of combustion gases

<table>
<tr><th>Aspect</th><th colspan="2">Emissions of combustion gases</th></tr>
<tr><td>Related indicators</td><td colspan="2">- Carbon monoxide (CO) (G.1.1)
- Nitrogen oxides (NO_x) (G.1.2)
- Sulphur dioxide (SO_2) (G.1.3)</td></tr>
<tr><td rowspan="2">Does the port measure or estimate its Carbon Footprint?</td><td>If YES:</td><td>- Total annual Carbon Footprint by scope (G.1.4)
- Frequency of monitoring the Carbon Footprint in the port area (G.1.5)
- Percentage of each energy source contributing to the Carbon Footprint (G.1.6)
- Percentage of annual change in the Carbon Footprint (G.1.7)</td></tr>
<tr><td>If NO:</td><td>- Carbon Footprint Recommendation (R.1.1)</td></tr>
<tr><td rowspan="2">Does the port differentiate dues for 'Greener' vessels?</td><td>If YES:</td><td>-- (no related indicators)</td></tr>
<tr><td>If NO:</td><td>- Differentiate dues for 'Greener' vessels recommendation (R.1.2)</td></tr>
</table>

Table 5.25: Indicators related with emissions of other gases

Aspect	**Emissions of other gases**
Related indicators	- Ammonia (NH_3) (G.2.1) - Dioxins (G.2.2) - Heavy metals (G.2.3) - Ozone (G.2.4) - Volatile Organic Compounds (VOCs) (G.2.5) - Benzene (G.2.6) - Polychlorinated biphenyl (PCB) (G.2.7) - Frequency of photochemical smog events (G.2.8) - Persistent Organic Pollutants (POPs) (G.2.9) - Polycyclic Aromatic Hydrocarbons (PAHs) (G.2.10)

Table 5.26: Indicators related with emissions of particulate matter

Aspect	Emissions of particulate matter
Related indicators	- Dust (G.3.1) - PM10 (G.3.2) - PM2.5 (G.3.3)

Table 5.27: Indicators related with odour emissions

Aspect	Odour emissions
Related indicators	- Hydrogen sulphide (H_2S) (G.4.1) - Percentage of respondents that perceive odour (G.4.2)

Table 5.28: Indicators related with discharges of wastewaters

Aspect	Discharges of wastewaters
Related indicators	- Chlorophyll-a (G.5.1) - Biological Oxygen Demand (BOD) (G.5.2) - Chemical Oxygen Demand (COD) (G.5.3) - Algal Growth Potential (AGP) (G.5.4) - Dissolved Oxygen (DO) (G.5.5) - Inorganic ions (G.5.6) - Nutrients (in water) (G.5.7) - Nutrients (in sediments) (G.5.8) - Bacterial content (G.5.9) - Water pH (G.5.10) - Redox potential (in water) (G.5.11) - Redox potential (in sediments) (G.5.12) - Total hardness (G.5.13) - Total Organic Carbon (TOC) (in water) (G.5.14) - Total Organic Carbon (TOC) (in sediments) (G.5.15) - Total Oxygen Demand (TOD) (G.5.16) - Water colour (G.5.17) - Water temperature (G.5.18) - Plankton (G.5.19)

Table 5.29: Indicators related with discharges of hydrocarbons

Aspect	Discharges of hydrocarbons
Related indicators	- Oil Content (Hydrocarbons) (G.6.1) - Volatile Organic Compounds (VOCs) (in water) (G.6.2) - Volatile Organic Compounds (VOCs) (in sediments) (G.6.3)

Table 5.30: Indicators related with discharges of other chemicals

Aspect	**Discharges of other chemicals**
Related indicators	- Halogen content (G.7.1) - Conductivity (G.7.2) - Heavy metals (in water) (G.7.3) - Heavy metals (in sediments) (G.7.4) - Surfactants (G.7.5) - Tributyltin (TBT) (in water) (G.7.6) - Tributyltin (TBT) (in sediments) (G.7.7) - Persistent Organic Pollutants (POPs) (in sediments) (G.7.8) - Polychlorinated biphenyl (PCB) (in sediments) (G.7.9) - Polycyclic Aromatic Hydrocarbons (PAHs) (in sediments) (G.7.10)

Table 5.31: Indicators related with discharges of particulate matter

Aspect	**Discharges of particulate matter**
Related indicators	- Solid content in water (G.8.1) - Turbidity (water transparency) (G.8.2)

Table 5.32: Indicators related with emissions to soil and groundwater

Aspect	**Emissions to soil and groundwater**
Related indicators	- Electrical conductivity (G.9.1) - Soil pH (G.9.2) - Macronutrients (G.9.3) - Total Organic Carbon (TOC) (G.9.4) - Total port area with soil pollution (G.9.5) - Heavy metals (G.9.6) - Redox potential (G.9.7)

Table 5.33: Indicators related with water consumption

Aspect	**Water consumption**
Related indicators	- Total annual water consumption (G.10.1) - Annual amount of recovered rainwater (G.10.2) - Percentage of the annual variation in the water consumption (G.10.3) - Percentage of water recycled per total water consumption (G.10.4)

Table 5.34: Indicators related with electricity consumption

Aspect	**Electricity consumption**	
Related indicators	- Total annual electricity consumption (G.11.1)	
Is Onshore Power Supply (OPS) available at one or more of the berths?	**If YES:**	- Annual number of vessels connected to shore-side electricity (G.11.2)
	If NO:	- Provision of Onshore Power Supply recommendation (R.11.1)

Table 5.35: Indicators related with fuel consumption

Aspect	**Fuel consumption**	
Related indicators	- Total annual fuel consumption (G.12.1)	
Is Liquefied Natural Gas (LNG) bunkering available in the port today?	**If YES:**	--
	If NO:	- Provision of Liquefied Natural Gas (LNG) recommendation (R.12.1)

Table 5.36: Indicators related with generation of solid urban waste

Aspect	**Generation of recyclable garbage**	
Is the port monitoring the solid urban waste?	**If YES:**	- Amount of solid urban waste collected by type (G.13.1) - Amount of solid urban waste recycled by type (G.13.2)
	If NO:	- Solid urban waste monitoring recommendation (R.13.1)

Table 5.37: Indicators related with generation of hazardous waste

Aspect	**Generation of hazardous waste**	
Is the port monitoring the port hazardous waste?	**If YES:**	- Amount of port hazardous waste collected by type (G.14.1) - Amount of port hazardous waste recycled by type (G.14.2)
	If NO:	- Hazardous waste monitoring recommendation (R.14.1)

Table 5.38: Indicators related with generation of other waste

Aspect	**Generation of non-hazardous waste**	
Is the port monitoring the other waste?	**If YES:**	- Amount of port other waste collected by type (G.15.1) - Amount of port other waste recycled by type (G.15.2)
	If NO:	- Other waste monitoring recommendation (R.15.1)

Table 5.39: Indicators related with noise emissions

<table>
<tr><th>Aspect</th><th colspan="4">Noise emissions</th></tr>
<tr><td>Related indicators</td><td colspan="4">- Noise levels in housing area around the port (G.16.1)
- Percentage of survey respondents that perceive noise (G.16.2)
- Number of noise claims from authorities (G.16.3)</td></tr>
<tr><td rowspan="4">Does the port monitor noise?</td><td rowspan="3">If YES:</td><td colspan="3">- Level of noise in terminal and industrial areas (G.16.4)
- Maximum level of noise in terminals and industrial areas (G.16.5)
- Frequency of noise measurements (G.16.6)</td></tr>
<tr><td rowspan="2">Does the port have a noise-zoning map?</td><td>If YES:</td><td>--</td></tr>
<tr><td>If NO:</td><td>Noise-zoning map recommendation (R.16.1)</td></tr>
<tr><td>If NO:</td><td colspan="3">- Noise monitoring recommendation (R.16.2)</td></tr>
</table>

Table 5.40: Indicators related with effects on biodiversity

<table>
<tr><th>Aspect</th><th colspan="2">Effects on biodiversity</th></tr>
<tr><td>Related indicators</td><td colspan="2">- Percentage of algae coverage at particular port sites (G.17.1)
- Percentage of large fish (G.17.2)
- Heavy metals in fish samples (G.17.3)
- Area of contaminated land returned to productive use (G.17.4)</td></tr>
<tr><td rowspan="2">Is the port located in, or does it contain a designated protected area?</td><td>If YES:</td><td>- Total port area protected (G.17.5)
- Number of bird species protected (G.17.6)
- Number of flora species protected (G.17.7)</td></tr>
<tr><td>If NO:</td><td>-- (no related recommendation)</td></tr>
</table>

There are other categories of environmental indicators that only appear when specific aspects (from the previous list of 17) are significant. Although they are related to the aspects presented before, they are not present in TEAP. This is the case of meteorological data, sediments quality, energy consumption, other resources, and waste production indicators.

In the tables below, these categories of indicators are presented, along with the aspects that make them appear, named as ‘related aspects’ and coloured in grey colour. For instance, the category of indicators ‘meteorological data’ will be selected when any of the related aspects (emissions of combustion gases, other gases, particulate matter or odour emissions) is significant. In this case, the related question ‘Does the port have a meteorological station?’ is asked. Depending on the response (‘if yes’ or ‘if no’) further indicators or recommendations are provided.

Table 5.41: Indicators related with meteorological data

Indicators' category	**Meteorological data**	
Related aspects	• Emissions of combustion gases • Emissions of other gases • Emissions of particulate matter • Odour emissions	
Does the port have a meteorological station?	**If YES:**	- Meteorological data indicators (G.18.1)
	If NO:	- Meteorological station recommendation (R.18.1)

Table 5.42: Indicators related with sediments quality

Indicators' category	**Sediments quality**	
Related aspects	• Discharges of waste waters • Discharges of hydrocarbons • Discharges of other chemicals	
Does the port monitor sediments quality?	**If YES:**	- Sediments particle size distribution (G.19.1)
	If NO:	- Monitor sediments quality recommendation (R.19.1)

Table 5.43: Indicators related with energy consumption

Indicators' category	**Energy consumption**	
Related aspects	• Electricity consumption • Fuel consumption	
Does the port monitor the energy consumption?	**If YES:**	- Total annual energy consumption (G.20.1) - Percentage of the annual variation in the energy consumption (G.20.2) - Percentage of renewable energy per total energy consumed (G.20.3)
	If NO:	- Energy consumption monitoring recommendation (R.20.1)

Table 5.44: Indicators related with other resources

Indicators' category	**Other resources**	
Related aspects	• Water consumption • Electricity consumption • Fuel consumption	
Does the port monitor the annual paper consumption?	**If YES:**	- Total annual paper consumption (G.21.1)
	If NO:	- Annual paper consumption monitoring recommendation (R.21.1)

Table 5.45: Indicators related with waste production

Indicators' category	**Waste production**	
Related aspects	• Generation of recyclable garbage • Generation of hazardous waste • Generation of non-hazardous waste	
Is the port monitoring all the waste generated within the port area?	**If YES:**	- Total annual port waste collected (G.22.1) - Total annual port waste recycled (G.22.2) - Percentage of disposal methods of port waste (G.22.3) - Annual waste collected on port surface water (Anthropogenic debris) (G.22.4)
	If NO:	- Waste monitoring recommendation (R.22.1)
Does the port have separate containers for the collection of port wastes?	**If YES:**	--
	If NO:	- Existence of separate containers for the collection of port wastes recommendation (R.22.2)
Does the port have ship waste reception facilities?	**If YES:**	- Annual amount of ship waste collected by type of MARPOL annex (G.22.5)
	If NO:	- Existence of ship waste reception facilities recommendation (R.22.3)

5.6.3 Indicators on management and development

Apart from the previous categories of indicators, there are also two types of environmental indicators that should be considered for monitoring and that are not directly related to SEAs. These categories are the environmental management and the port development indicators. In this case, in order to introduce these categories in the TEIP tool, some questions are asked to the user, and depending on the responses, some indicators or recommendations are provided.

Table 5.46: Indicators related with environmental management (I)

Environmental management		
Has the port received any environmental complaint?	**If YES:**	- Total annual number of environmental complaints received (G.23.1) - Total annual number of environmental complaints resolved (G.23.2)
	If NO:	--
Does the port have a budget specifically for environmental protection?	**If YES:**	- Total annual budget allocated to environmental protection (G.23.3) - Percentage of the budged allocated to environmental protection out of the total budget (G.23.4) - Percentage of annual variation in the environmental budget (G.23.5)
	If NO:	- Environmental budged recommendation (R.23.1)
Does the Port have a certified Environmental Management System (EMS)?	**If YES:**	- Number of environmental objectives defined (G.23.6) - Percentage of environmental objectives achieved (G.23.7) - Number of environmental indicators monitored (G.23.8) - Number of Significant Environmental Aspects identified (G.23.9) - Percentage of employees working on environmental issues (G.23.10) - Frequency of environmental training sessions for port employees (G.23.11) - Percentage of port employees that received environmental training (G.23.12) - Annual number of training hours per employee (G.23.13) - Annual number of environmental reports published (G.23.14) - Annual number of press articles published concerning environment (G.23.15) - Annual number of conferences that the port authority has organised or participated in (G.23.16) - Number of environmental educational programmes or materials provided for the community (G.23.17) - Number of times that the Emergency Response Plan has been activated (G.23.18) - Total number and volume of (significant) oil and chemical spills (G.23.19) - Annual number of environmental accidents (G.23.20) - Annual number of environmental incidents (G.23.21)

		- Number of EMS audits completed versus planned (G.23.22) - Number of EMS audit findings (G.23.23) - Number of EMS audit nonconformities addressed versus found (G.23.24) - Number of fines received for non-compliance with environmental legislation (G.23.25) - Number of times that the daily limit value of a certain environmental parameter has been exceeded (G.23.26)
	If NO:	- EMS recommendation (R.23.2)

In case that the respondent answered 'No' to the previous question on the existence of an EMS, the following questions are also asked:

Table 5.47: Indicators related with environmental management (II)

Does the port have an Environmental Policy?	**If YES:**	--		
	If NO:	- Environmental Policy recommendation (R.23.3)		
Has the port defined objectives for environmental improvement?	**If YES:**	- Number of environmental objectives defined (G.23.6) - Percentage of environmental objectives achieved (G.23.7)		
		Have management programmes and action plans been prepared to achieve each objective?	**If YES:**	--
			If NO:	- Environmental management programme recommendation (R.23.4)
	If NO :	- Environmental objectives recommendation (R.23.5) - Environmental management programme recommendation (R.23.4)		
Has the port identified environmental indicators to monitor trends in environmental performance?	**If YES:**	Does the port have an environmental monitoring plan?	**If YES:**	- Number of environmental indicators monitored (G.23.8)
			If NO:	- Number of environmental indicators monitored (G.23.8) - Environmental monitoring plan recommendation (R.24.6)

<table>
<tr><td></td><td>If NO:</td><td colspan="3">- Environmental monitoring plan recommendation (R.23.6)</td></tr>
<tr><td rowspan="4">Does the port have an inventory of Significant Environmental Aspects?</td><td rowspan="3">If YES:</td><td colspan="3">- Number of Significant Environmental Aspects identified (G.23.9)</td></tr>
<tr><td rowspan="2">Are there procedures to maintain and update the inventory of SEA?</td><td>If YES:</td><td>--</td></tr>
<tr><td>If NO:</td><td>- SEA inventory recommendation (R.23.7)</td></tr>
<tr><td>If NO:</td><td colspan="3">- SEA inventory recommendation (R.23.7)</td></tr>
<tr><td rowspan="2">Does the port have a representative responsible for managing environmental issues?</td><td>If YES:</td><td colspan="3">- Percentage of employees working on environmental issues (G.23.10)</td></tr>
<tr><td>If NO:</td><td colspan="3">- Environmental manager recommendation (R.23.8)</td></tr>
<tr><td rowspan="2">Does the port authority have an environmental training programme for its employees?</td><td>If YES:</td><td colspan="3">- Frequency of environmental training sessions for port employees (G.23.11)
- Percentage of port employees that received environmental training (G.23.12)
- Annual number of training hours per employee (G.23.13)</td></tr>
<tr><td>If NO:</td><td colspan="3">- Environmental training programme recommendation (R.23.9)</td></tr>
<tr><td rowspan="2">Are there procedures to communicate environmental information internally and externally?</td><td>If YES:</td><td colspan="3">- Annual number of environmental reports published (G.23.14)
- Annual number of press articles published concerning environment (G.23.15)
- Annual number of conferences that the port authority has organised or participated in (G.23.16)
- Number of environmental educational programmes or materials provided for the community (G.23.17)</td></tr>
<tr><td>If NO:</td><td colspan="3">- Environmental communication recommendation (R.23.10)</td></tr>
<tr><td rowspan="2">Does the port have an Emergency Response Plan?</td><td>If YES:</td><td colspan="3">- Number of times that the Emergency Response Plan has been activated (G.23.18)
- Total number and volume of (significant) oil and chemical spills (G.23.19)
- Annual number of environmental accidents (G.23.20)
- Annual number of environmental incidents (G.23.21)</td></tr>
<tr><td>If NO:</td><td colspan="3">- Emergency Response Plan recommendation (R.23.11)</td></tr>
</table>

<table>
<tr><td rowspan="2">Has an external EMS audit been conducted?</td><td>If YES:</td><td colspan="3">- Number of EMS audits completed versus planned (G.23.22)
- Number of EMS audit findings (G.23.23)
- Number of EMS audit nonconformities addressed versus found (G.23.24)</td></tr>
<tr><td>If NO:</td><td colspan="3">- EMS audit recommendation (R.23.12)</td></tr>
<tr><td rowspan="3">Does the port have an inventory of relevant environmental legislation and regulations related to its liabilities and responsibilities?</td><td rowspan="2">If YES:</td><td rowspan="2">Is the port in complianc e with legislation legal limits?</td><td>If YES:</td><td>--</td></tr>
<tr><td>If NO:</td><td>- Number of fines received for non-compliance with environmental legislation (G.23.25)
- Number of times that the daily limit value of a certain environmental parameter has been exceeded (G.23.26)</td></tr>
<tr><td>If NO:</td><td colspan="3">- Environmental legislation inventory recommendation (R.23.13)</td></tr>
</table>

Table 5.48: Indicators related with port development

<table>
<tr><th colspan="3">Port development</th></tr>
<tr><td rowspan="2">Is dredging carried out in your port?</td><td>If YES:</td><td>- Annual quantity or volume of dredged sediment (G.24.1)
- Frequency of dredging (G.24.2)
- Percentage of dredged sediment going to beneficial use (G.24.3)
- Percentage of polluted dredging sediments (G.24.4)</td></tr>
<tr><td>If NO:</td><td>--</td></tr>
<tr><td rowspan="2">Has the port authority carried out an Environmental Impact Assessment (EIA) during the last 5 years?</td><td>If YES:</td><td>--</td></tr>
<tr><td>If NO:</td><td>Development of an EIA recommendation (R.24.1)</td></tr>
</table>

TEIP tool compiles all the indicators that are obtained directly from the aspects that are significant for the port, and the indicators and recommendations obtained as a result of the questions that have been asked to the user. These indicators are gathered internally by the tool and they are displayed and provided in the last step. In addition, a set of guidelines for the implementation of the indicators and with some recommendations are also provided. The following section shows the application of the tool, the several steps that compose it and the connections with TEAP tool.

5.7 TEIP application

This section aims at presenting how the TEIP tool is applied from the point of view of the user. In general terms, the output indicators are linked with the environmental aspects that are considered significant for the port. The Significant Environmental Aspects (SEAs) of the port may be obtained from two different ways, as it can be seen in figure 5.4:

1. As a result of the application of the TEAP tool. In this case, the TEIP tool selects the environmental indicators directly, based on the results obtained in the previous tool.
2. By introducing the significant aspects manually in the TEIP tool. This occurs when the port authority already knows its significant aspects, and it considers that there is no need to apply the TEAP tool previously.

In the first case, the user starts applying the TEAP tool. After implementing the five steps of TEAP (see section 4.4), the user is asked whether he or she would like to continue to TEIP tool. If so, the resulting environmental aspects are kept internally in the system and the user has only to follow three steps more to complete TEIP:

- Step 1: Questions on SEAs
- Step 2: Questions on management and development
- Step3: Environmental Performance Indicators

The first step consists of specific questions on the aspects that resulted significant on TEAP. The second step provides further questions on environmental management and port development, since these two issues are not strictly related to any environmental aspect. Finally, the third step of TEIP provides the list of environmental indicators that are suggested for monitoring.

In the second case where the user starts directly through the TEIP tool (option 2), there are five steps to follow:

- Step 1: Port contact details
- Step 2: Significant Environmental Aspects
- Step 3: Questions on SEAs
- Step 4: Questions on management and development
- Step 5: Environmental Performance Indicators

The two additional steps that are added in this second case are the provision of the port contact details and the list of SEAs. These are asked because the respondent has not interacted before with the tool and therefore these details are needed to proceed. Figure

5.4 below displays the steps that conform the TEAP and TEIP tools, and the different pathways that the user may follow.

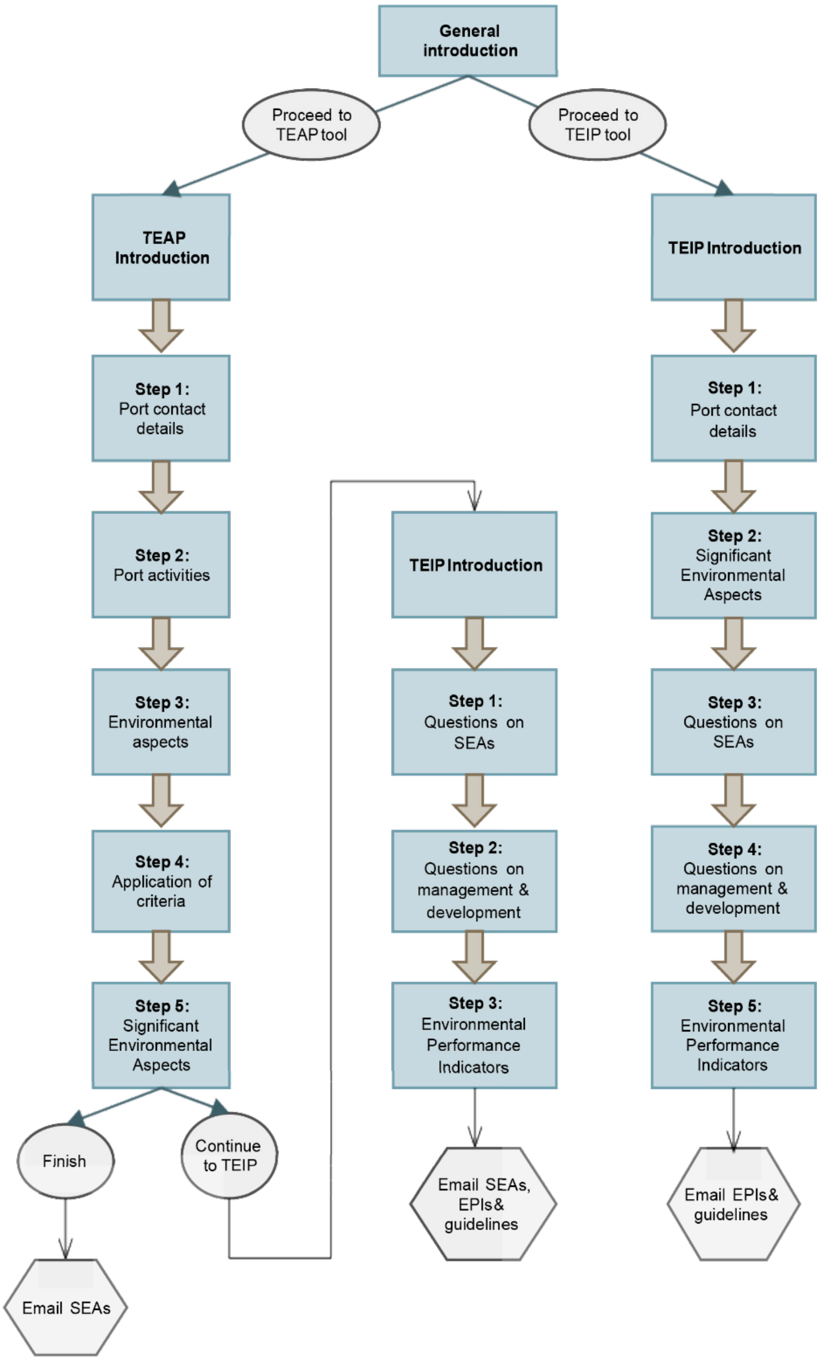


Figure 5.4: Overview of TEAP and TEIP steps

It is important to mention that at the end of each possible pathway, an email is sent to the user with the resulting outputs of the tools. The possible outputs are:

- In case of using only the TEAP tool: the list of SEAs
- In case of using only the TEIP tool: the list of EPIs and guidelines

- In case of using both TEAP and TEIP tools: the list of SEAs, EPIs and guidelines

Below, the general introduction and the steps developed for TEIP tool are presented, with a screenshot of the interface in each one, in line with the application of TEAP presented in the section 4.4 of this thesis. It is also relevant to note that this is not the final version of the tool, these pictures just illustrate the tool when it was submitted to the reviewers. The final version is presented in chapter 6, after undertaking the amendments proposed by the reviewers. TEIP is available at www.eports.cat.

General introduction

The general introduction page presents both tools and provides the links to either TEAP (Option 1) or TEIP (Option 2).

Figure 5.5: Screenshot of the general introduction section

Below, the screenshots that are shown are the ones from the Option 2 of figure 5.5; in other words, the complete TEIP.

5.7.1 TEIP introduction

The introduction presents the several steps that compose the TEIP tool, as well as a link to the PORTOPIA project that provides more information on this project. The time to complete the tool is estimated in 20 minutes, and the confidentiality is ensured.

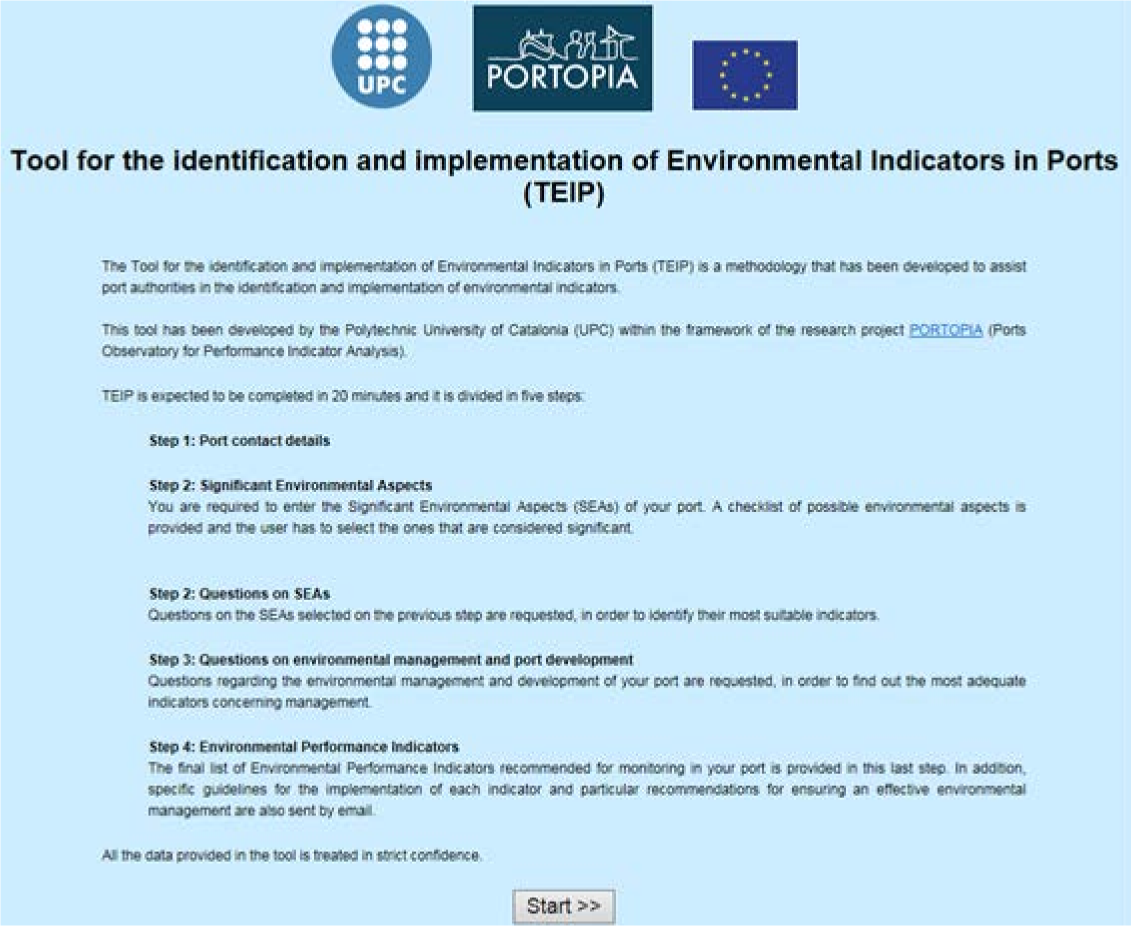


Figure 5.6: Screenshot of the TEIP introduction

5.7.2 Step 1: Port contact details

Following the same format as TEAP, in the Step 1 the contact details of the TEIP user are asked. It contains the name and country of the port, and the name, position and email of the respondent.

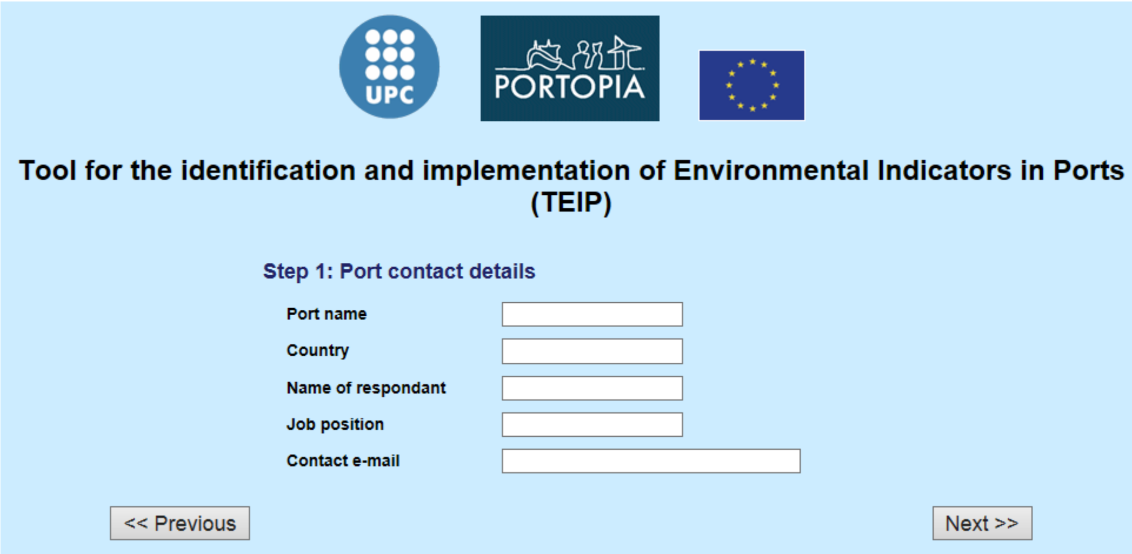


Figure 5.7: Screenshot of TEIP Step 1: Port contact details

5.7.3 Step 2: Significant Environmental Aspects

As explained before, in the Step 2 the respondent has to select the aspects that are considered significant in his/her port, in case that they have already been identified without the use of TEAP.

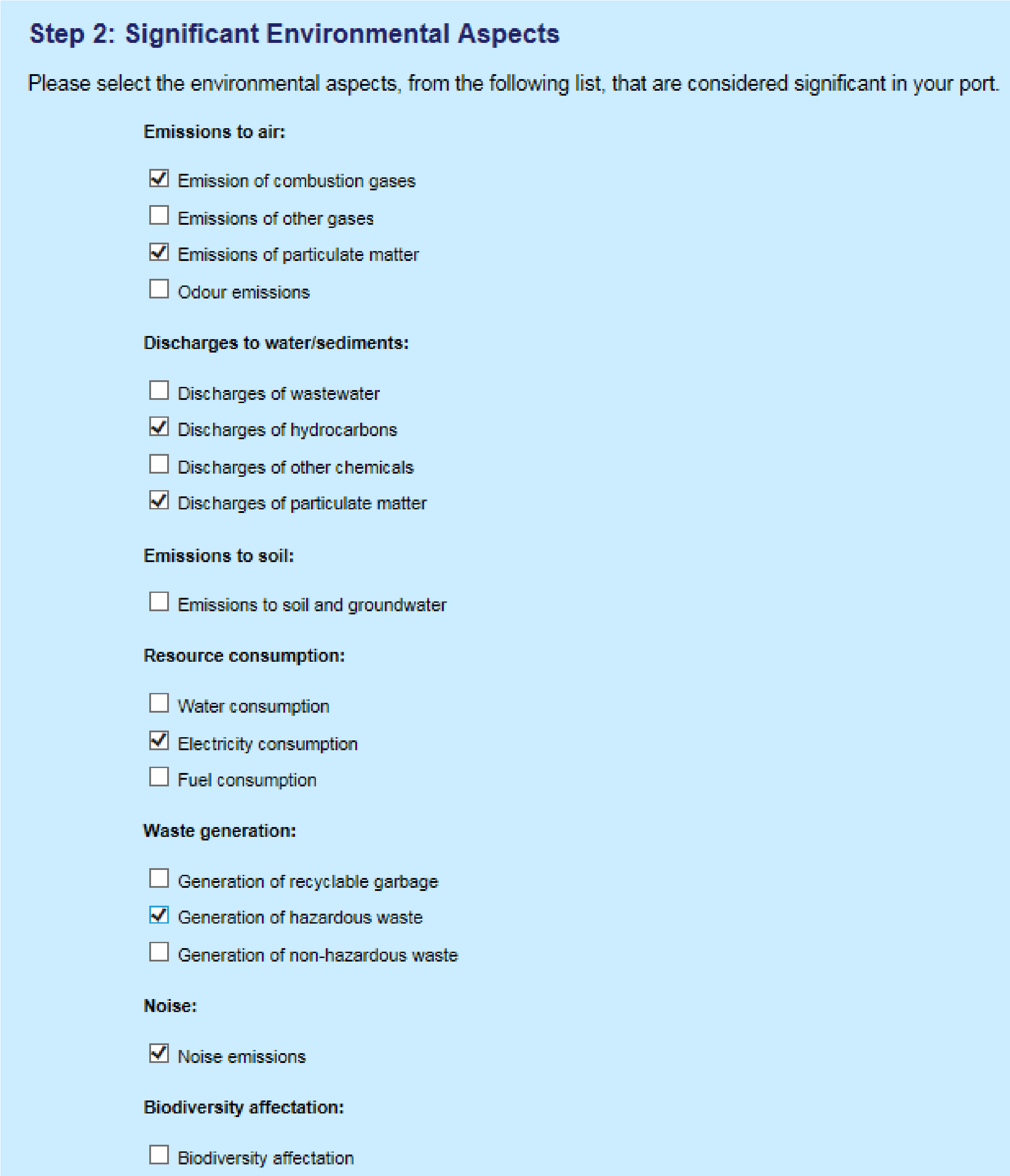


Figure 5.8: Screenshot of TEIP Step 2: Significant Environmental Aspects

The aspects are classified in categories as in TEAP and the user has to select them. This selection activates a set of questions presented in the next step.

5.7.4 Step 3: Questions on SEAs

Step 3 is composed of a set of questions on the aspects that were chosen as significant in the previous step. The structure is the following, as it can be seen in figure 5.9: the environmental aspect is mentioned and under it there is/are the related question(s). All the questions are Yes/No responses.

Figure 5.9: Screenshot of TEIP Step 3: Questions on SEAs

Ports that have completed TEAP start the TEIP tool at this point. Therefore, the previous Step 3 (from the complete TEIP) is equivalent to the Step 1 of the short version of TEIP. The system keeps the results of TEAP and the port does not have to select the aspects and enter the contact details.

5.7.5 Step 4: Questions on management and development

The Step 4 comprehends a set of questions on environmental management and port development. All the questions are Yes/No responses. Depending on the answer, additional questions are displayed. For example, although it is not shown in figure 5.10, if the respondent selects 'No' in the first question of EMS, further questions on the EMS elements (e.g. environmental policy, objectives, monitoring plan) appear.

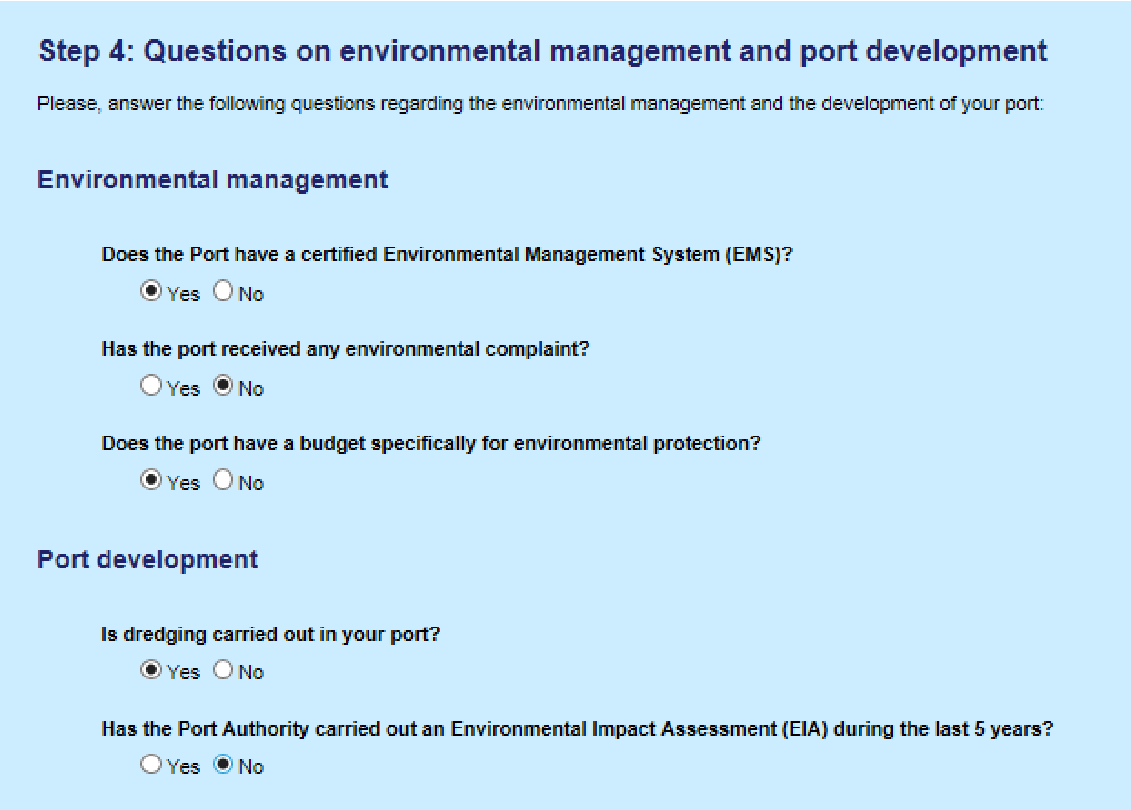


Figure 5.10: Screenshot of TEIP Step 4: Questions on management and development

Again, Step 4 of the long version of TEIP is the same as the Step 2 of the short version of TEIP.

5.7.6 Step 5: Environmental Performance Indicators

Finally, the last step presents all the indicators that resulted, in this case, recommended for monitoring in the port. The user can click over the indicator or recommendation in order to obtain the guidelines for implementation of the indicators or recommendations. Figure 5.11 shows a screenshot of this final step of the tool.

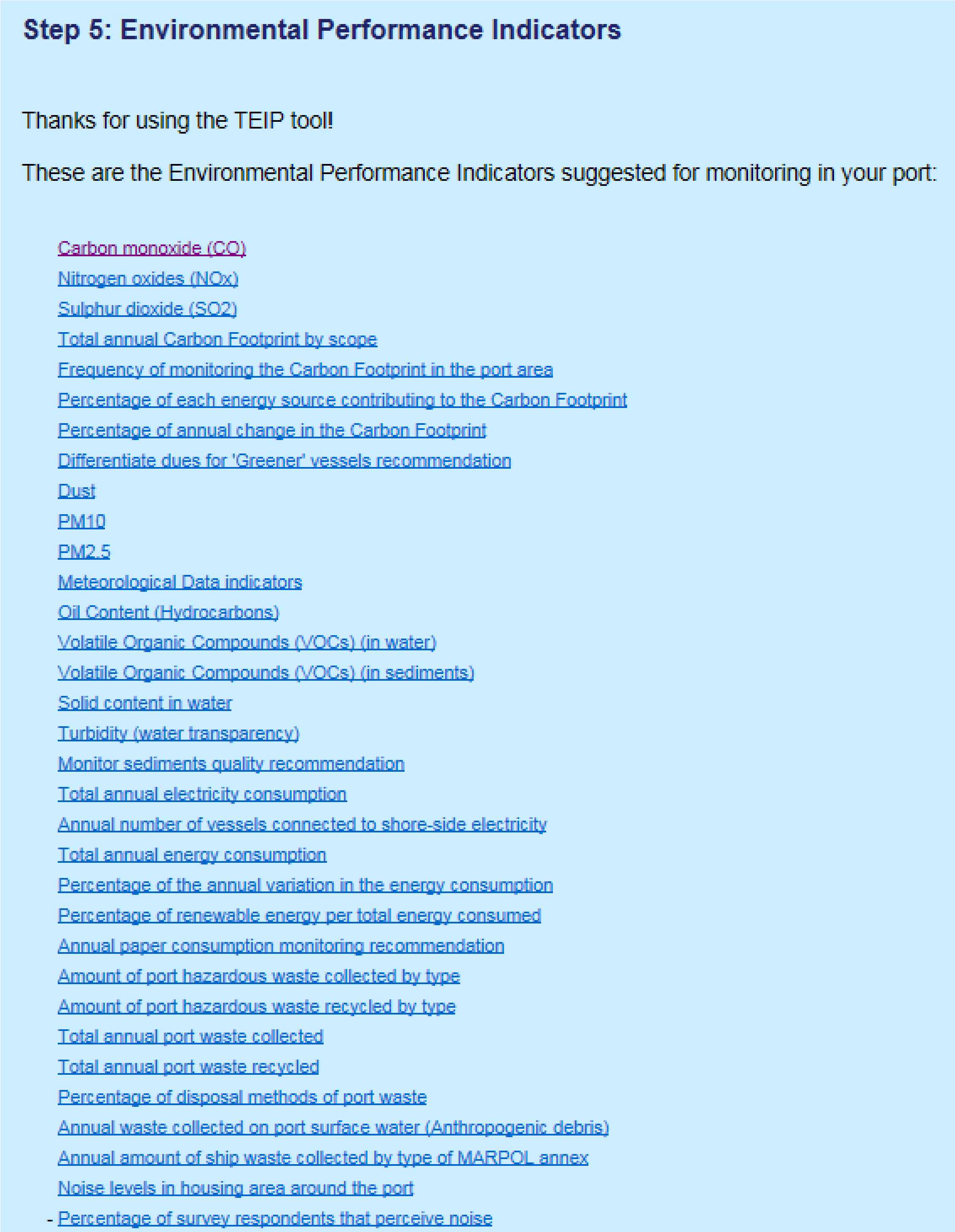
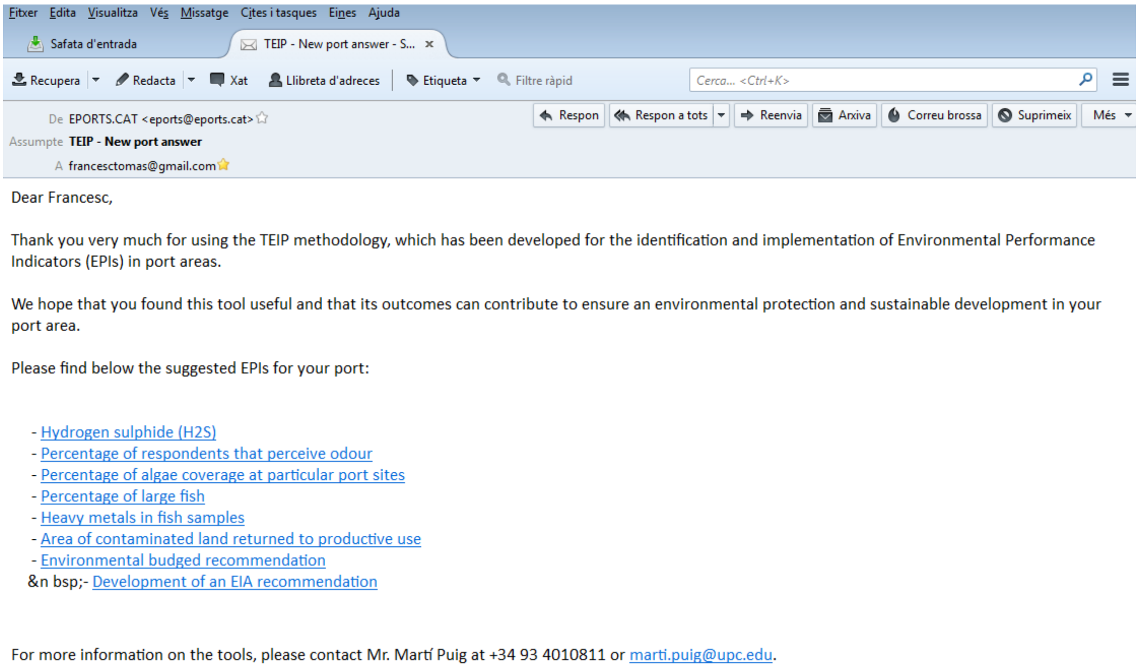


Figure 5.11: Screenshot of TEIP Step 5: Environmental Performance Indicators

Following the same structure as before, Step 5 is the same as the Step 3 of the TEIP reduced version (coming from TEAP tool). At the same time, in the last step, an email is sent to the user containing the same information as provided in the website: the list of indicators and recommendations, with the link to the guidelines.


Fitxer Edita Visualitza Vés Missatge Cites i tasques Eines Ajuda

Safata d'entrada | TEIP - New port answer - S...

Recupera | Redacta | Xat | Llibreta d'adreces | Etiqueta | Filtre ràpid | Cerca... <Ctrl+K>

De EPORTS.CAT <eports@eports.cat>

Assumpte **TEIP - New port answer**

A francesctomas@gmail.com

Respon | Respon a tots | Reenvia | Arxiva | Correu brossa | Suprimeix | Més

Dear Francesc,

Thank you very much for using the TEIP methodology, which has been developed for the identification and implementation of Environmental Performance Indicators (EPIs) in port areas.

We hope that you found this tool useful and that its outcomes can contribute to ensure an environmental protection and sustainable development in your port area.

Please find below the suggested EPIs for your port:

- Hydrogen sulphide (H2S)
- Percentage of respondents that perceive odour
- Percentage of algae coverage at particular port sites
- Percentage of large fish
- Heavy metals in fish samples
- Area of contaminated land returned to productive use
- Environmental budged recommendation

&n bsp;- Development of an EIA recommendation

For more information on the tools, please contact Mr. Martí Puig at +34 93 4010811 or marti.puig@upc.edu.

Figure 5.12: Screenshot of the TEIP email

Chapter 6. VALIDATION AND FINAL METHODOLOGY

This section aims at validating EPORTS.CAT method, by multiple ways and perspectives. The first section of this chapter provides the validation for the TEAP tool, and the second one, for the TEIP tool. Thirdly, the final version of the methodology is presented, showing the main improvements and its resulting interface.

6.1 TEAP validation

This subsection is structured in two parts. Initially, the three procedures that were used to validate the TEAP tool are presented. In the second section, the comments from the reviewers are listed together with an answer to each of them. Most of the feedback received was introduced in the tool through different amendments. Those comments that were not implemented were justified accordingly.

6.1.1 Validation procedures

The TEAP tool has been validated through the feedback obtained via three main procedures: i) reviews from port professionals, ii) reviews from attendants of port conferences, and iii) reviews from scientific publications. These three methods are explained in more detail below:

i) Reviews from port professionals

Once the first version of the tool was already available on-line and working properly, several experts on environmental port management were contacted. For instance, the tool was sent through the European Federation on Inland Ports (EFIP) to all its members.

In all these cases, the experts were encouraged to access to the TEAP website and to test the tool within their port authority, since most of they are port environmental managers.

These port professionals were contacted by email and, in most of the cases, the feedback was also provided in this way. In other cases, the reviewer provided the feedback either personally or via telephone.

ii) Reviews from attendants of port conferences

It was also considered interesting to disseminate the tool among other stakeholders, not only port professionals but also to marine and environmental-related professionals. This was useful in order to obtain further feedback and proposals for improvement. For this reason, the tool was presented to as many conferences as possible, where attendants could provide a direct and concise feedback to the presenter. The conferences and events in which the tool was presented were all related to the sustainable development of ports, seas or oceans, being the following:

- Green Infrastructure and Sustainable Societies / Cities (Izmir, May 2014)
- PERSEUS 2nd Scientific Workshop (Marrakesh, December 2014)
- European Maritime Day (Piraeus, May 2015)
- GreenPort Congress 2015 (Copenhagen, October 2015)
- International Black Sea Day Celebration (Istanbul, October 2015)
- PERSEUS & MareFrame Joint Stakeholders' Meeting (Constanta, November 2015)
- Integrated Marine Research in the Mediterranean and the Black Sea (Brussels, December 2015)
- 1st Research Seminar ETSEIB (Barcelona, February 2016)

iii) Reviews from scientific publications

The third dissemination procedure was through the publication of communications in conferences and a scientific article (Puig et. al 2015). Before publishing a paper in a conference or journal, it needs to be accepted and validated by a group of international reviewers. Usually, a set of amendments to the paper is provided, giving the opportunity to improve the output. Then, if a piece of research is accepted for publication, it demonstrates that it is considered interesting for the scientific community and that this set of reviewers validate the work done and the results obtained. This is the case of the TEAP paper (Puig et al., 2015b), where some minor amendments where suggested before it was accepted. An article on the TEAP tool also was published on the GreenPort journal (Seguí et al., 2015). This is a journal that provides business information on environmental best practice, focusing on ports and terminals, including shipping, transport and logistics. Having the opportunity to publish in this journal provided the chance to disseminate the existence of the tool (along with the website link and the methodology followed) to a wide range of port professionals and stakeholders of the sector.

6.1.2 Feedback obtained and actions taken

The feedback obtained from the aforementioned procedures has been compiled and classified according to the TEAP's steps. There are also some general comments that are provided at the end. Below each comment, the actions taken are also explained. When possible, the comments are classified according to their nature (e.g. changes on the activities' name or modifications of the activities' description) and on the action taken (accepted, rejected, or no action needed). The answers of comments that were accepted are coloured in green; the comments that were rejected are coloured in red; and finally the comments that did not need any action are coloured in blue. They are presented below:

Step 1: Port contact details

- It was suggested that at the beginning, there should be an introductory section where the framework of this research is explained and the five steps that compose the tool are presented.
    - The research team had this idea in mind at the time of testing the tool but it was not implemented yet. Therefore, this section was added, which included an overview of the TEAP steps, the time that it is expected to complete it, a link to the PERSEUS project and a statement mentioning that the results are treated in strict confidence.
- It was proposed that the Step 1 should also contain the contact details of the tool developer (email and telephone) in order to facilitate the contact with the research team, if needed.
    - It was agreed and the contact details were added, not only in this section, but also at the bottom of each tool step.
- It was suggested that the tool should be available to all ports and, therefore, the response of the 'country' should be open. The question on the 'country' was restricted to European ports since the possible answer of the port was given in a drop down list where only EU ports were included.
    - It was agreed to carry out this amendment and to give the opportunity to any port to use the tool. A blank space was provided where the user could introduce the country's name of the port.
- It was commented that the Step 1 (port contact details) was user-friendly and easy to fill in.
    - This is a positive comment and confirms the user-friendliness of this section.

Step 2: Port activities

Modify the name of the activity

- It was suggested that the information that it is in brackets in the name of some activities could be reduced because it is not needed. This is the case of the activities *Marine-based cargo transport (Shipping/navigation)*, *Land-based cargo transport (train, truck, car)*, *Passengers transportation (ferry & cruise ships*) and *Aggregate industry (sand, gravel, cement).*
    - This suggestion was accepted and the final names of these activities resulted as *Marine-based cargo transport (Shipping), Land-based cargo transport*, *Passengers' transportation* and *Aggregate industry*.
- It was suggested that the port activity *Ship waste management* should be reworded as *Ship waste reception*.
    - It was agreed that *Ship waste reception* is actually a more appropriate term because all the EC Directives (several amendments and modifications) refer to (Port) Reception Facilities (PRF), therefore the amendment was done.
- A respondent suggested that the term 'agro' should be deleted from the activity *Port based industry: Agro food industries* because it was considered as a limitation. This activity should consider the complete food industry.
    - The research team agreed to delete this term and modified the activity name as *Food industry*.
- It was suggested to add the terms 'gas' and 'storage' in the name of the activity *Port based industry: Oil refineries*.
    - This proposal was also accepted and therefore the final name of this activity resulted as *Port based industry: Oil / Gas refineries and storage.* The new term is broader and includes the gas refineries in the port area. As a result, the definition provided in the information button (*i*) was also updated and included the concept of gas refineries (See Annex VI).

Modify the definition of the activity

- It was proposed that the definition of the activity *Passengers transportation* should be re-defined in order to make clear that this activity refers to the transport of passengers and not to the shipping activities of cruises and ferries.
    - The previous definition was: 'The existence of ferry and cruise ships for the passengers' transportation'. This proposal was considered an interesting point and the definition was re-worded. The shipping activity

is already included in the activity of *Marine-based cargo transport*, and therefore it is important to make clear that this one does not involve the transfer of passengers, whereas passenger transportation does. The updated definition is: ‘This activity refers to the movement of passengers in the port due to their arrival/departure through ferries or cruises. It involves all the issues generated in the transfer and stay of people at the vessels’ and it is also compiled in Annex VI.

- It was suggested that the definition of the activity *Ship building, repair and maintenance* should be reworded in order to make this definition easier to understand.
  - o The previous definition was: ‘It includes all those operations carried out to ensure the navigable conditions of the vessels. Among other activities, it includes the cleaning of ships, the possible reparations, and the construction of ships itself’. A new definition was proposed: ‘Ship building, repair and maintenance include all those operations carried out to ensure the sea worthiness of the vessels. Among other activities, it includes the cleaning, repair and construction of the vessel’. It is more concise and provides examples of the activity.
- It was suggested to include the ‘development of new buildings in the existing port area’ under the *Port development* activity.
  - o This consideration was taken into account and for this reason this sentence was explicitly included in the definition of the *Port development* activity, as it is seen in Annex VI.
- It was suggested that the definition of the activity *Port waste management* should make clear that it involves the collection and management of waste generated within the port area as well as the port street cleaning.
  - o The previous definition only considered the waste generated by the port authority, which was: ‘This activity means that the port authority manages the waste generated within the port area’. An updated definition of this activity was accepted and included in the glossary of the TEAP tool: ‘This activity refers to the collection and management of the waste generated within the port area as well as the port street cleaning'.

Add or delete activities

- Five new activities were suggested for inclusion, namely *On-shore power supply*, *Provision of water to vessels*, *Waste treatment plant*, *General cargo* and *General manufacturing.*
  - o This comment was much appreciated and these five further activities that were proposed by the reviewers were included in an updated version of

the tool. The relationships between the new activities and the existing environmental aspects were created and they were introduced to TEAP, as well as their definition (as shown in Annex VI).

- One respondent suggested to add 'aggregates' as a separate activity than *Dry bulk*.
    - After studying the convenience or not of adding 'aggregates' as a separate activity, it was considered that the environmental aspects associated to aggregates are very similar to the ones associated with the activity of dry bulk, and therefore there is no need to differentiate them. Otherwise, this could create confusion among the users of the tool.
- It was suggested to divide the activity *Dredging* in two different activities 'Dredging – Grab and Suction' and 'Dredging – Water Injection / dispersion' because they are two types of dredging that may have different impacts.
    - In this case, this proposal was rejected for two main reasons. Initially because the resulting aspects related to these two dredging activities are very similar, and secondly because there may be more types of dredging and just offering these two may offer limitations to the respondent. It was considered more interesting to have a generic activity of *Dredging* and then another activity on *Disposal of dredged material*.
- One suggestion was to have the opportunity to add extra activities by the user when completing the tool (apart from the existing list of 35 port activities).
    - It was answered to the reviewer that it was not possible to add a new activity in the moment of applying the tool by a user. The main reason is because each activity is related to specific environmental aspects and by adding new activities the relation with the aspects would not exist and the new activities would not count to obtain the resulting port aspects. In any case, the reviewer was encouraged to mention the activities that he/she considered that were missing, in order to incorporate them in an updated version of the tool.
- One reviewer mentioned that the activity *Water sports* is not carried out in ports, and therefore he/she suggested to delete this activity from the list.
    - This proposal was also not accepted. Although this activity is forbidden in most of the big commercial ports, it may be carried out in other small ports or marinas, and/or in areas adjacent to the port waters. For this reason, and in order to be conservative and to expect the worst scenario, it was considered to maintain this activity as an option.

Other amendments

- Several reviewers mentioned that it is important to clarify and make a distinction between the activities that the port authority has the practical and legal power to control (that generate direct aspects) and the ones that the port authority has not the direct control (that generate indirect aspects).
    - Since this concern about the activities that the port can control directly and their related aspects was expressed by more than one reviewer, it was taken into account and actions were done regarding this issue. It was considered that a suitable way to differentiate the activities in which the port authority has control and the ones in which not was to ask this in Step 2 and provide different weights to their related aspects. For this reason, based on several examples of port authorities in assessing the significance (e.g. Environmental Declaration of Port of Livorno), in the final version, the indirect aspects are affected by a coefficient that reduces their weighting, and therefore are less likely to be significant compared to the aspects derived from the controlled activities. In the TEAP tool, this coefficient of reduction was established with the value of 0,5. This means that a direct aspect accounts for the double of an indirect aspect.
    - In order to facilitate the understanding by the user when completing the tool, a definition of directly controlled activity and not directly controlled was provided in the Step 2 of the TEAP tool.
- It was suggested to include as an activity the term 'tenant / operator control', which refers to the control that the port authority has on port tenants and operators in order to ensure that they meet the requirements and standards of the port.
    - This comment was very relevant and interesting. After analysing it, it was considered that adding it as an activity would not provide environmental aspects since there is no connexion between this activity and the environmental aspects. For this reason, it was found more pertinent to relate this comment with the preceding idea (previous bullet point) of assessing the grade of control from the port authority that each activity has. In this way, not all the aspects have the same weight in the moment of identifying the activities of the port. They are weighted according to their nature (direct or indirect).
- It was suggested that there are some port activities that deal with the provision of port services and they could be grouped under a new category of activities.
    - It was considered as an interesting idea and it was accepted. This new category was called *Provision of port services* and the activities that were included are: *Bunkering*, *Pilotage*, *Towing*, *Mooring*, *Ship waste reception*, *On-shore Power Supply* and *Provision of water to vessels*.

- It was suggested that the activities related to 'cargo handling and/or storage of' should be differentiated according to the amount handled in each activity. The reason to distinguish them is because most of the ports may handle and storage a wide range of the cargoes but in different percentage. If there was no differentiation, the tool would not be so realistic with the port aspects. Therefore, this distinction should be reflected on the tool.
    - It was considered an interesting proposal. A solution to deal with this concern was to introduce a ranking in the tool where the respondents can list the cargoes that are handled by priority, in terms of annual amount of cargo handled (being 1 the most handled). The weights associated to each aspect are modified based on corrective factors, where the cargoes that are handled the most receive a major weight.
- One reviewer expressed that from his point of view, the page of port activities presents too much information and he suggested to place the section 'cargo handling and/or storage of' as a new step.
    - Although the section may appear tight, as stated by the reviewer, it was considered to keep it in one step, in order to not discourage the respondent. Otherwise, it could seem to be too long.

<u>Step 3: Environmental aspects</u>

Change in the name of the aspect

- It was suggested that the aspect *Generation of other waste* should have another wording, because the respondent was not sure which type of waste this category included.
    - This proposal was accepted and it was reworded as *Generation of non-hazardous waste*. The types of waste that are included in this aspect are listed in its definition in order to avoid confusions among the users (see Annex V).
- It was suggested that the aspect *Generation of solid urban waste* should have another wording, because the word urban is generally related with a city. However, the reviewer did not provide any other alternative term for it.
    - It was agreed that an alternative term could be found. After a research, it was agreed that the term 'recyclable garbage' may be an appropriate name. This term is mentioned in the Annex V of the MARPOL Convention, and although the convention refers to ship-produced waste, it is a fact that in a port area garbage may be produced by port activities and urban/industrial activities. The word 'recyclable' was added because garbage also includes non-recyclable wastes and they are not included in this category. As a

result, the resulting aspect was re-worded as *Generation of recyclable garbage*.

Change in the definition of the aspect

- It was mentioned that the aspect *Effects on biodiversity* needed to be redefined. This aspect should be linked only to the activities that directly act over this aspect, not to those activities that may generate an aspect (such as emissions of particulate matter) that latter may impact on the biodiversity.
    - This comment was accepted and the definition of this aspect was amended. The interactions between port activities and the aspect *Effects on biodiversity* were reassessed (see Annex VII) in order to ensure that this aspect appears when the activity has a direct actuation over this aspect, and it does not appear as an impact. This activities are *Port development, Dredging, Disposal of dredged material* or *Fishing & aquaculture activities.*
- It was commented that the definition of all the aspects related to the discharges to water / sediments (namely discharges of wastewaters, hydrocarbons, other chemicals and particulate matter) should include that the fact that pollutant may reach the sediments, since it was not mentioned.
    - This proposal was accepted and therefore the definition of all these four aspects was modified, adding that the emissions may deposit afterwards to the sediments.

Other amendments

- The interactions between the port activities and the environmental aspects, as well as the weighting provided to each one, were analysed in detail by some respondents. Some proposals for improvement concerning the related aspects and the weightings were suggested.
    - The proposals for inclusion of aspects that were missing or the suggestions to delete aspects that were in excess were much appreciated in order to have these relations as complete as possible. Some amendments on the weightings of each particular aspect were also well received. The feedback provided by the professionals and specialists of the sector was very welcome and acknowledged. For this reason, the table 'interactions between port activities and environmental aspects, and the associated weights' was updated. The final table is provided in Annex VII of this thesis.
- It was suggested that the ranking of environmental aspects provided in Step 3 should be listed in numbers, in descending order, with the aim of demonstrating the priority list.

  - It was accepted and the numbers were incorporated in this step of the tool next to each aspect, from top priority aspects to less priority.

- It was suggested that all the aspects that were obtained as a result of the activities could be taken to the next step and be assessed through the criteria, without making the selection of 50%.

  - After analysing this proposal, it was discarded because if the user had to assess all the aspects against the criteria, it would take too long to complete TEAP and the first filter of port activities would be irrelevant.

- It was mentioned that it was not clear enough whether the aspect *Resource consumption* refers only to the port authority or also the whole port community.

  - As mentioned previously, the aspects may be generated as a result of both, port authority and other port stakeholders' activities. A distinction between them has already been introduced in Step 2. If the aspect is considered significant (no matter the origin of the activities), the port authority will have to take it into account as a matter of priority action and take steps on the proper management of this issue.

- The same comment was suggested for the aspect *Waste production*, because the respondent was not sure if it included only the wastes generated in the quay, port authority, MARPOL or port services.

  - The aspect *Waste production* as it is defined, includes the urban solid, non-hazardous and hazardous waste. The tool does not make reference to MARPOL annexes.

  - As before, this aspect can come from the activities controlled by the port or the ones under stakeholders' control. In any case, if it appears as SEA, it must be taken into account.

- One reviewer suggested that he/she would like to see the connection between Step 2 and Step 3 in order to better understand the result obtained in Step 3.

  - The methodology followed in order to proceed from one step to the other was explained accurately to the reviewer, as required. However, it was agreed that this internal process would not be publicly available on-line since it would not facilitate the understanding of the interface by the user.

<u>Step 4: Application of criteria</u>

- It was suggested that it would be easier that the criteria are presented in the format of a question, instead of a sentence. It was also suggested to summarise the possible answers, in order to make the response easier for the user.

  - It was agreed that, in order to implement the criteria, a question would be more adequate than a sentence because it would be easier to understand. For instance, the criterion *Frequency* was initially proposed as 'the number of times that the port activities can generate this aspect' and it was modified by 'How often is this aspect generated?' The possible responses were also summarized. For instance, the answer 'The aspect is generated continuously' was summarised as merely 'continuously'. The final questions and responses are provided in Annex VIII.

- It was suggested that the aspects that are ranked in Step 4 should be listed following the same number obtained in the ranking of Step 3.
  - It was accepted and the amendment was done to the tool. In the amended version, the aspects are listed in descending order, following the ranking obtained in the previous step.
- It was suggested that the criterion *Aspect duration* should have as a possible response option the term 'continuously'.
  - It was accepted, in order to be in consonance with the criterion *Frequency*, which also have a possible response as 'continuously'. Therefore, this response option was added to this criterion.
- In the criterion *Extent of the impact*, one of the possible responses refers to the term 'sensitive' place. The reviewer asked what is considered to be 'sensitive'.
  - It was answered that a sensitive place may refer to an area that includes either people (city), nature (protected area), or patrimony (heritage). In order to make it easier to understand for the respondent, these concepts were added next to the word 'sensitive', with an information button (*i*).
- In the response 'the effects are spread only within the port boundaries' of the criterion *Extent of the impact*, it was mentioned that although the effect is only within port boundary it could still be devastating, for instance spills of hazardous cargo containers in ferry port during tourist season.
  - It was mentioned that this criterion specifically evaluates the extension of the impact and not the severity of the impact. The severity is already evaluated by another criterion. However, in order to integrate this comment into the tool, the points associated to this response of this criterion were increased from 2 to 3. The other weighting for the rest of the responses were not modified. The final points for each response are provided in Annex VIII of this thesis.
- One respondent mentioned that the criterion *Extent of the impact* was considered very difficult to answer because sometimes it may be challenging for a port to know whether the effects are spread outside the port boundaries or not.

  - It was agreed with the reviewer that this criterion may be difficult to be assessed, especially in the aspect *Emissions of combustion gases*, because the effects on the environment are global and it is hard to differentiate the limits of these emissions. For this reason, this criterion was removed for this specific aspect.

- It was mentioned that in the criterion *Severity of impact*, the possible responses of high, moderate, or low impact should include a guideline criteria in order to assess better the significance.

  - It was totally agreed with this suggestion because those three possible responses (high, moderate or low impact) were too subjective. Guidelines criteria were included next to each possible response in order to facilitate the proper completion by the user.

- There was another comment referred to the criterion *Stakeholders' complaints*. The possible responses of this criterion are 1 complaint and no complaints per year on an aspect, between 2 and 4, or more than 5 complaints. The reviewer asked whether these numbers are based on actual reporting events or they are arbitrary.

  - These values were established based on examples of port authorities that report their annual number of complaints. Although few examples of ports were found, in most of the cases the number of complaints vary between 2 and 5. For this reason, these values were established.

- Concerning the criterion *Legal compliance*, it was suggested that when rules are not in place on a specific aspect, then the compliance is non-negotiable.

  - The research team totally agreed with that comment. It was considered that when an aspect is affected by legal requirements and those permissible levels are exceeded, then the aspect should be considered directly significant. This was amended in the tool in order to incorporate this proposal.

- It was suggested that the questions of the criteria *Quantity of waste* and *Consumption of natural resources* should be reworded, in order to be more generic and applicable to the aspects that apply to these criteria.

  - This suggestion was accepted and implemented in the tool. The question on the quantity of waste was modified from: 'Which is the scale of hazardous waste / solid urban waste generated in your port according to the table below?' to 'Which is the relation between the waste generated on the current year (Q_1) compared to the generated on the previous one (Q_0)?
  - The question on the criterion natural resources consumption was also modified from the initial version of 'Which is the significance of the

consumption of water, electricity and fuel, based on the table below?' to 'Which is the relation between this resource consumption on the current year (Q_1) compared to the consumption on the previous one (Q_0)?

- The responses of the criterion *Quantity of waste* (high, medium, low impact) were not representative of the whole port sector. The fact that a large port has a bigger amount of waste than a small one does not mean that the large port is not taken actions to reduce its waste.
  - The reviewer was totally right. Realistically, it is not fair to establish the same scale of hazardous waste and urban solid waste for the whole port sector. It is a very broad sector and therefore it is challenging to define a limit on these issues that are valid for all the ports. The idea of establishing levels based on comparisons year over year from the same ports appeared satisfactory and it was implemented in the tool. For this reason, a new response to this criterion was established, based on the relation Q_1/Q_0.
- Another question was the fact that the aspects *Generation of hazardous waste* and *Generation of solid urban waste* had the same criterion *Quantity of waste*, which assessed the significance in both hazardous and solid urban waste. This means that the aspect *Generation of hazardous waste* was also evaluated in terms of solid urban waste, and the aspect *Generation of solid urban waste* could be assessed in terms of hazardous waste, which had no sense.
  - The reviewer also was totally right with this comment. The same criterion was applied twice. With the amendment done in the previous comment (apply the criterion based on the percentage of annual performance and not on absolute value), this problem was also fixed.
- In the criterion *Consumption of natural resources*, it was defined that if the increase between years is higher than 10% the significance is considered high. One reviewer suggested that an increase of 10% is too much and it should be considered significant with a lower percentage of increase.
  - Following the reviewer's suggestion, the percentage of increase between the consumption of the current year and the consumption of the previous one was re-established at 5% in order to be significant.
- It was suggested that, at the end of Step 4, it should be asked whether the respondent is sure that he/she has finished, before proceeding to Step 5. This would allow the respondent to modify anything if he/she considers so.
  - It was found an interesting idea and it was implemented in the tool. After clicking the button 'next' at the end of Step 4, it appears a box asking 'Are you sure you have finished?' If the respondent clicks 'yes', it proceeds to

Step 5, if he/she clicks 'no' it remains in Step 4 and further amendments can be done.

- It was mentioned that there are some criteria that may be difficult to be assessed because it is not mentioned to which activity the aspect is referred to.
    - It is true that in this methodology the aspects are assessed without being explicitly related to the activities. This means that there may be some criteria, namely the *frequency*, *aspect duration*, *extent of the impact*, and *severity*, that are complicated to be evaluated if the activity is not known. For this reason, it has been detailed at the beginning of the Step 4 that these criteria should be evaluated bearing in mind the activity that generates the worst scenario. This is a way to be conservative but practical at the same time; otherwise, if the responded had to reply for each activity and related aspect, the process would be very long.
    - Related to this point, it was found necessary to move the criterion 'severity of impact' under the criterion 'extent of the impact' in order to have all these criteria together, since before they were separated.
- One reviewer highlighted that when no answer is replied, the message "You have not answered all required fields" is shown next to each possible response. The reviewer suggested to place this message only once at the side of the question rather than appear several times on the answers side.
    - The research team agreed with this suggestion: one advice of answering the required fields would be enough and it is not necessary that this message appears repeated. However, due to technical limitations, it was not possible to be carried out.
- The same respondent mentioned that the aspects *Discharges of hydrocarbons* and *Discharges of wastewaters* are also complicated to assess in terms of the criterion *Extent of the impact*.
    - In this case, since the discharges are on the water, it may be considered that in this situation it is easier to assess whether the emissions (of hydrocarbons or wastewaters) are spread only within the port waters or also outside them. Chemical analysis can be made to prove this. For this reason, this criterion was kept for these aspects.
- One reviewer suggested that the length of Step 4 might scare the user since it may result in a long page. He suggested having several short pages (e.g. one page for each aspect) rather than just one page.
    - The proposal of introducing the criteria's page separately in different pages by aspects is a good idea in order to not scare the user when she or

he sees all the criteria. However, in the development of TEAP, a minimum number of steps was pursued, in order not to create an extensive tool. For this reason, this amendment was not finally implemented.

Step 5: Significant Environmental Aspects

- It was suggested that another step after obtaining the Significant Environmental Aspects (Step 5) could be linking them to performance indicators.
    - This is exactly what was already thought as a way to proceed with the results obtained in TEAP. It demonstrates that the initial idea of linking port activities with environmental aspects and performance indicators is supported by port professionals. For this reason, the TEIP tool was conceived.
- It was mentioned that the list of aspects and indicators is very helpful.
    - This response shows the positive feedback that the results of the tool generate among the port professionals.
- Concerning the list of environmental aspects – indicators, it was remarked that the reviewer found the suggested indicators very interesting. However, the indicators provided should be only the ones related to the SEAs of each port.
    - In the testing period, the respondents received a comprehensive list of indicators, not only the ones related to their SEAs. For this reason, this reviewer considered that the other indicators that did not apply to his/her SEAs were not relevant. With the development of TEIP, this issue has been solved because the users only obtain the indicators that are applicable to their port.

Email

- It was mentioned that the email with the results that receives the user of the tool should also have the contact details of the tool developer (email and telephone).
    - This idea was considered very interesting and the contact details were incorporated in the e-mail, in order to obtain comments, suggestions or criticisms from the users in a direct and straightforward way, if needed.

General comments on TEAP

- It was suggested that the tool should keep/save the results or the data introduced in case the respondent has to go back to the previous steps.
    - It was considered indeed an interesting idea and it was implemented in the interface of the tool. In this way, the website keeps the data introduced in case that the user goes back and forward of the online tool.

- It was mentioned that the interface of the website was superb and the respondent expressed his/her willingness to use the tool as a worker of the port.
    - The positive feedback from the port stakeholders is always welcome and demonstrates that the tool gives an added value to the sector.
- One respondent mentioned that it was not easy for him/her to answer correctly each step because he/she did not have the full overview about all the information and complaints of the port authority.
    - It is true that sometimes the user may not have all the information required to implement the tool properly in the port. For this reason, it is recommended that, if needed, it may be implemented by more than one port worker and involve all the parties that are required.
- Another respondent remarked that the tool is user-friendly and places users mind in the right track. He/she mentioned that the degree of usefulness for the ports will depend a bit on how familiarized they are with the whole structured environmental management approach. According to the reviewer, the tool can definitely guide beginners and maybe also add perspectives to people with EMS experience.
    - It is agreed that the degree of usefulness of the tool would vary depending on the degree of familiarisation of the port authority with the whole environmental management approach. For beginners, it is expected that the tool could easily assist them in identifying aspects and indicators as a starting and essential point in the implementation of any EMS standard. For more experienced ports, it is expected that the tool could confirm that they are in the right way, and can be used to justify the SEA's identification to environmental certificates (ISO, EMAS).

6.2 TEIP validation

6.2.1 Validation procedure

A comprehensive validation of the TEIP tool was also carried out. The link was sent to a broad list of port professionals and stakeholders in order to obtain their feedback and opinion about the format and content of the tool. The feedback obtained from the reviewers was highly considered and much appreciated.

6.2.2 Feedback obtained

Below, the comments obtained from the reviewers and the actions taken are listed, also categorised by the steps of the tool. Again, when a suggestion has been incorporated in the tool, the answer is coloured in green, when it has been rejected, the answer is coloured in red, and when no action is needed, it is coloured in blue.

General introduction

- In the general introduction, it was suggested to add the logos of the projects that funded the research and, therefore, that allowed the development of both tools.
    - At the beginning, the general introduction only presented the EU and the UPC logos since it was a shared page between both projects. Following the recommendation of a project member, both logos were included in the main page. The other pages of the TEAP tool continued with the PERSEUS logo, and the TEIP tool with the PORTOPIA logo, according to the project in which each tool has been developed.
- A reviewer proposed to modify one of the paragraphs of the general introduction, in order to not repeat several words.
    - The previous text was: 'It is recommended that the user starts by implementing the TEAP tool, which will provide a set of environmental aspects considered as significant in the port. Then, it is recommended to continue with the TEIP tool, in order to obtain a set of Environmental Performance Indicators (EPIs) related to the previous aspects and suggested for monitoring in the port area'. The resulting paragraph is: 'It is recommended that the user starts by implementing the TEAP tool, which will provide a set of environmental aspects considered as significant for the port. Then, it is suggested to continue with the TEIP tool, in order to obtain a set of Environmental Performance Indicators (EPIs) related to the previous aspects and recommended for monitoring in the port area'.

TEIP Introduction

- In the TEIP introduction, one user advised to include a link of TEAP to be able to identify the SEAs.
    - It was considered as a positive contribution, especially in case that the user opted for option 2 (Proceed to TEIP tool) and afterwards he /she realised that his/her SEAs are not known. For this reason, a link to TEAP is provided in the introduction of the TEIP tool.

Step 1: Port contact details

Any comment was received in this step, probably because this section was already improved in the TEAP validation.

Step 2: Significant Environmental Aspects

- It was commented that, in the description of Step 2, it should be clearly mentioned that the aspects that have to be selected make reference to the whole port area, not only to the port authority.

  - It was agreed with the reviewer that this should be stated previously. In this step, the respondents have to select the aspects that are considered significant, and if it is not mentioned, it may create some confusions. In TEAP, it is already mentioned since the activities that are selected involve the whole port area. For this reason, the final sentence has been modified to: 'Please select the environmental aspects, from the following list, that are considered significant in your port (including the whole port area)'.

- It was also suggested to add the following text in the first paragraph of Step 2, to make clearer the functions of the tool to the user: 'Each environmental aspect is associated to several environmental indicators. When an aspect is selected, the related environmental indicators are activated'.
  - Following this suggestion, this sentence was added to the first paragraph of Step 2 of TEIP.
- It was suggested that the Step 2 of TEIP, which deals with the selection of Significant Environmental Aspects, should have the option for the respondent to introduce new aspects, in case that the port has other SEAs not mentioned in the available list.
  - It was agreed to include the opportunity to introduce new aspects under the category of 'other'. An empty space was provided to introduce additional environmental aspects.
- In the same step of TEIP, it was suggested to include the definition of the aspects to help the users, in line with the definitions provided in the TEAP tool.
  - It was agreed and the button *i* was added next to each aspect with its definition. In this way, the user can get a better insight of the aspect before selecting it.

<u>Step 3: Questions on SEAs</u>

- It was suggested that the question on *Meteorological data* 'Does the port have a meteorological station?' should be transformed to 'Does the port have access to meteorological data?' to avoid the situation where a port does have access to relevant data but does not own a station, and therefore would answer 'no'.
  - The reviewer was acknowledged for providing this suggestion. The research team agreed with this proposal and the question was modified.
- It was suggested to not include the paper consumption question in Step 3 and therefore to eliminate the related indicator. The reviewer commented that the consumption of paper is not a priority issue in a port authority and, for this reason; it was suggested to be deleted, since it is out of the scope of this sector.

  - Since this comment was obtained by a professional port auditor, it was agreed to not include this question and indicator. Initially, this question was introduced in Step 3 because there is not any environmental aspect related to the paper consumption.

- One respondent commented that the topic of ballast water does not appear on the TEIP tool.

  - It was replied that the issue of ballast water (together with bilge water or sewage) is part of the discharges to water and sediments (see page 86 of this thesis). For this reason, although the term 'ballast water' does not appear directly on the tool, it is already included on the aspects category 'Discharges to water/sediments'. To make it clearer and to avoid misunderstandings, shipping was included in the definition of the aspect *Discharges of wastewaters* as a possible source of emissions.

- One reviewer requested why the questions asked in Step 3 only concern to some SEAs and not to all of them.

  - It was explained to this reviewer that there are some SEAs that already have related indicators and therefore any question is needed. These indicators are kept internally and displayed at the last step. On the contrary, there are some aspects that need the answers to some questions in order to incorporate further indicators.

- It was mentioned that underwater noise is an issue that will be regulated in the future. For this reason, it was suggested that this topic could be added in the tool.

  - Noise is already included in the tool as an environmental aspect, and it has several indicators related to it. It was replied that underwater noise is too specific for being included in TEIP since this tool aims at providing a general overview of indicators for each specific port. However, it may be included or considered in a future version of the tool, if needed.

<u>Step 4: Questions on management and development</u>

- It was suggested that the budget question could be integrated within the EMS set of questions, when the user replies 'No' to the EMS certified.

  - It was rejected because the issues that are included in the set of questions related to the EMS are components of a management system. Although the existence of a budget for environmental protection is essential for the development of an EMS, it is not a requirement for its development.

- It was commented that several of the questions on monitoring and environmental impact assessment are already obligatory in some ports. The reviewer suggested to make a distinction between obligatory and voluntary environmental monitoring/actions.

- o This comment was acknowledged to the reviewer. However, it was not accepted, since in each country may be different in terms of regulations, it cannot be established which actions are compulsory and which are optional in a generic way. For this reason, this suggestion was not included.

<u>Step 5: Environmental Performance Indicators</u>

- It was suggested that the results of the tool, which are the indicators and recommendations, should be presented in bullet points in both, the Step 5 of the tool and in the output email, since the reviewer expressed his difficulties to read them.
    - o This comment was accepted because, in this way, a nicer format of the interface is given and it is more user-friendly.
- In addition, it was also commented that the results of the tool should be distinguished between the indicators and the recommendations.
    - o Initially, the tool provided the indicators and the recommendations all together. The proposal of differentiating them was very welcomed and therefore it was carried out. A title was added before each group in order to introduce what was presented.
- It was also commented that it should be written in the interface that the user has to click on the hyperlink of the indicators and recommendations to have access to the guidelines that are provided.
    - o It was agreed that this should be mentioned since otherwise the user could miss the information provided in the guideline or recommendations. For this reason, a sentence specifying this aspect was added previously to the final indicators as well as in the output email where a summary of the indicators and recommendations is provided.
- The three aspects *Generation of recyclable garbage*, *Generation of hazardous waste* and *Generation of non-hazardous waste* had a common recommendation on waste monitoring. It was suggested that each aspect should have its own recommendation, being more specific for each case.
    - o This proposal was accepted and three specific recommendations were created, one for each category of waste generation. With this amendment, the user of the TEIP tool receives a specific recommendation for monitoring recyclable garbage, hazardous waste and non-hazardous waste.

- It was suggested that the indicator *Annual waste collected on surface water (Anthropogenic debris)* should contain the word 'port' in order to clarify that this refers to the anthropogenic debris collect within the area of the port.
  - It was accepted and the resulting indicator was re-called *Annual waste collected on port surface water (Anthropogenic debris).* It was agreed that with this amendment, it is clear that the indicator is limited to the port area.
- In the same line as in the previous comment, it was suggested that the indicator *Total area protected* should include the word 'port' in order to make clear that it refers to the area limited by the port.
  - This proposal was also accepted and therefore this amendment was carried out. The final indicator was called *Total port area protected.*
- The recommendation *Existence of facilities for the treatment and cleaning of the dredged sediments* was suggested to be deleted since it is not compulsory for a port to have a treatment plant.
  - The research team agreed with the reviewer that it is not a relevant recommendation and therefore it does not have to appear as an output. Ports may have (or not) facilities for the treatment and cleaning of dredged sediments, but this existence will depend on the characteristics of the port. It is not a common recommendation that ports should have facilities aiming at that.
- It was suggested that the indicator *Percentage of employees participating in environmental issues* should modify the verb 'participating in' to 'working on' because the second one demonstrates a major active role of the port employees towards the environment.
  - This amendment was incorporated to the tool and the resulting indicator was written as the *Percentage of employees working on environmental issues.*
- It was suggested that the indicator *Number of port locations with soil pollution declared* should be re-written. It was mentioned that reporting the total port area that has soil pollution provides better information than the number of port locations with soil pollution.
  - As a result of this suggestion, this indicator was modified as *Total port area with soil pollution.*
- It was mentioned that in the indicator *Percentage of respondents that perceive noise* the word 'respondents' was not clear to whom it was referring to.

  - The concern of the reviewer was understood by the research team and therefore the indicator was modified as following: *Percentage of survey respondents that perceive noise*. This indicator is related to a potential survey on noise that the port may undertake.

- It was also commented that the indicator *Number of times that the daily limit value has been exceeded* was not very concise as to which parameter the indicator was referring to.

  - This comment also was taken into account and the name of the indicator was slightly amended. The final name of the indicator resulted as: *Number of times that the daily limit value of a certain environmental parameter has been exceeded.*

- Since the aspect *Generation of solid urban waste* was suggested to be modified to *Generation of recyclable garbage*, it was commented that the indicators related to this aspect also should be modified following this proposal.

  - It was agreed that the indicators related to this aspect should be modified accordingly. Therefore the new indicators were *Amount of port recyclable garbage collected by type* and *Amount of port recyclable garbage recycled by type*.

- Since the aspect *Generation of other waste* was suggested to be modified to *Generation of non-hazardous waste*, it was commented that the indicators related to this aspect also should be modified following this proposal.

  - It was agreed that the indicators related to this aspect should be modified accordingly. Therefore the new indicators were *Amount of port non-hazardous waste collected by type* and *Amount of port non-hazardous waste recycled by type*.

- It was proposed that the list of resulting indicators should be presented in a more structured way in both the website and the email. It was suggested to present them in categories, in order to be better organised.

  - The research team recognised that the way that the indicators appear is not user friendly. Providing the indicators classified by categories at the last step of the tool would facilitate the understanding to the user.

- Due to the fact that the handling of bulk products may generate the release of particles into the air, the reviewer suggested that the indicators on *Meteorological data* should be activated for the ports that load and unload dry bulk. In particular, wind is a very important parameter to monitor to avoid the possible dispersion of particles into the air.

- The concern of the reviewer was understood. However, this action would be related to the selection of activities, which is done in TEAP, not in TEIP. In addition, dry bulk is not the only activity that may generate particles, there are other activities that contributes to it, such as the fuel combustion. Moreover, meteorological data is also relevant for other aspects, namely, *Emissions of combustion gases*, *Emissions of other gases*, *Emissions of particulate matter*, and *Odour emissions*. For these reasons, this indicator is only activated in relation to these four aspects.

- The tool was reviewed by a noise specialist. This specialist proposed several noise indicators to be included in the tool.
  - The noise indicators provided by this reviewer were analysed and it was found that they were already included in the broad compilation of indicators (See Annex IX). Since these indicators did not pass either the first or the second filter, they were not included in the final list of indicators.

Email

- It was proposed that the guidelines of the indicators and recommendations could be attached to the email in a PDF format, instead of providing a hyperlink (as it is now).
  - The research team studied this proposal and agreed that it would be more user-friendly to have all the guidelines attached in the email. However, due to IT limitations, this proposal was not accepted. On one hand, it was seen that an email with a large amount of PDFs attached and with the unknown sender ('eports.cat') would be categorised as 'spam' and therefore the user would not receive it on its main inbox. On the other hand, to do so, a dynamic PDF generator was required since the responses from the users are different and therefore the guides attached vary each time. This would complicate the functioning of the tool and it was discarded.

Guidelines of the indicators and recommendations

- It was suggested that the template of the guidelines for the condition indicators (see section 5.5 of this thesis) should include a section containing the equivalences between the different units of measurement.
  - This proposal was accepted and, therefore, a new section, called 'Equivalence', was introduced to the indicators' guidelines that required it.

- There was also a suggestion for improving the structure of the recommendations, by introducing an example of a best practice. This was considered helpful to understand better the recommendations.

    - This proposal was also accepted. An example was added to each recommendation. In addition, the examples that are provided are from best practices of European ports, in order to make easier the application of the specific recommendation.

- One reviewer asked to include best practices for indicators, since it was already done for the TEIP 'recommendations'.
    - The proposal of providing a best practice (current example implemented in a port) for each indicator' guidelines is an interesting fact and it would definitely provide added value to the guidelines. However, realistically, for the matter of time and large amount of existing guidelines, it is not feasible to develop, at least in this stage of the tool.

- A reviewer mentioned that the inclusion of reference documents in the guidelines is interesting. He suggested that an added value could be to provide an online repository with these documents and hyperlinks.
    - This proposal would definitely reduce the amount of references that are included in the guidelines. The main inconvenience to delete and incorporate them into an online repository is that the user does not have access to this repository when the guidelines are downloaded and printed out. Therefore, the references have to be included in the same guideline, and, for this reason, they cannot be transferred to an online repository.

- It was commented that the section on the 'level of effort' is useful, but may need to be elaborated a bit more. An example was proposed by the reviewer, for instance, in the indicator percentage of large fish, it is indicated that some effort is necessary, but not in a concrete way. In this case, the necessary amount of fish needed to come to sound results could be added.
    - It was accepted that the 'level of effort' section is very generic, providing only three possible options: low, intermediate or high effort. It is recognised that extra information specifically on each indicator may provide high benefit to the guidelines. Unfortunately, due to the time restrictions and the large number of guidelines, in the version of the tool that is presented in this thesis, it is not feasible to be amended.

General comments on TEIP

- Respondents that answered TEAP but not TEIP suggested that it would be interesting to provide a link of the TEIP tool on the email that is sent to the respondent when the TEAP tool is completed. This would give a second opportunity to the respondent to easily proceed to complete the indicators' tool, if he or she wishes that.

  - It was agreed that providing a link to the TEIP tool would be very interesting because, in this case, the user always may have direct access to the tool in the email provided by TEAP.

- It was asked if the tool will be validated by a panel of environmental managers/experts since it would give validity and consistence to the tool.

  - It was answered that the research team provided the link of the tool to several port environmental managers and stakeholders and that their feedback was received. With this feedback, some amendments were implemented in order to obtain a validated and updated tool.

- The same stakeholder asked whether the tool is designed to generate data in itself in order to analyse the results, such as the type of ports accessing the tool, number of hits per indicator/recommendation, among others.

  - It was replied that the research team have access to the results. However, there is not any program that analyses them. This analysis can be done manually if this information is required. In any case, the information is confidential.

- A question was raised concerning the connections between the TEIP tool with the PORTOPIA platform, whether system-to-system communication was established or it was in mind to be done.

  - It was said that at this moment, TEIP tool is placed at eports.cat website. In the future, a link of the eports.cat website may be introduced into the PORTOPIA platform.

- Another point was raised on the future management of the tool. It was asked if the idea is that ESPO after the PORTOPIA project take up these tools.

  - It was mentioned that both tools are linked as part of one methodology. One option for future management could be that this method could be part of ECOPORTS toolbox. However, this still needs to be discussed with ESPO.

- It was suggested to include social and economic indicators in the compilation of environmental indicators.

  - Although it was regarded as a very interesting proposal, it was considered that, for the time being, it was out of the scope of this research and tool. Including port social and economic indicators may well be taken into account in future research or further development of the tool.

6.3 Final EPORTS. CAT method

As a result of all the amendments presented and justified above, updated versions of TEAP and TEIP tools were carried out. The final screenshots of EPORTS.CAT are displayed below along with a description of the main modifications undertaken, presenting firstly TEAP and then TEIP. This final version of the tool can be compared with the one provided in section 4.4 and 5.7 and observe the amendments done as a consequence of the reviewers' suggestions.

General introduction

The welcome page that the user finds in accessing to www.eports.cat is showed in figure 6.1 below. It presents the TEAP and TEIP tools and provides the links to enter to both tools. The PERSEUS and PORTOPIA logos are displayed since these two projects have funded this research. A paragraph was modified, as suggested by one reviewer.

Figure 6.1: Final screenshot of the Welcome page to eports.cat

6.3.1 TEAP final tool

TEAP introduction

Initially, as suggested by the reviewers, an introduction section to TEAP was created and the contact details (email and telephone) were added (see figure 6.2). This introduction presents the several steps that compose TEAP, a link to the PERSEUS project, a statement mentioning that the results are treated in strict confidence and the approximate time of completion (30 minutes).

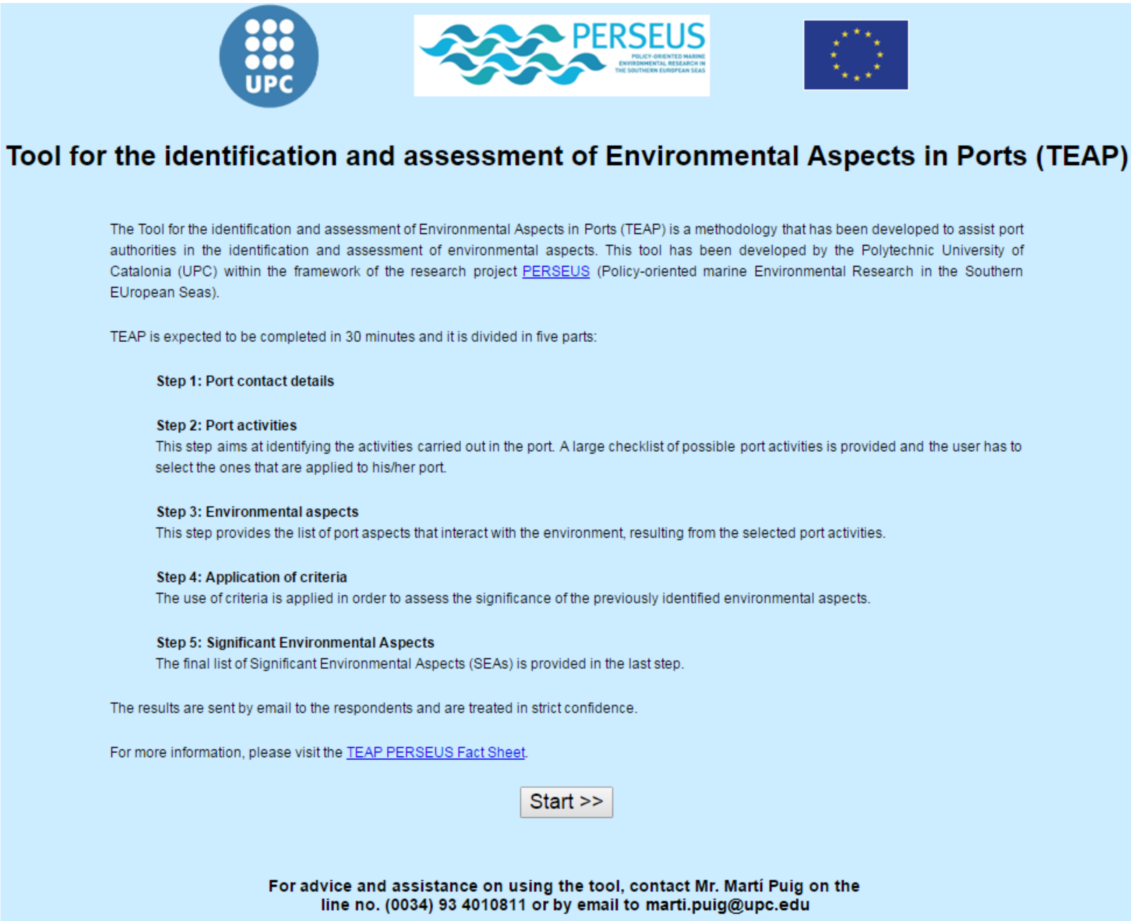


Figure 6.2: Final screenshot of the TEAP introduction

Step 1: Port contact details

The main amendment in the Step 1: Port contact details was to delete the list of EU countries and a blank space was provided. In this way, the restriction of country was removed and therefore all international ports are able to use the tool.

Figure 6.3: Final screenshot of TEAP Step 1: Port contact details

Step 2: Port activities

Several amendments were undertaken in Step 2 of TEAP. The final interface of this section is displayed in figure 6.4 below. These amendments include the re-writing of several port activities, the inclusion of new activities (and its related environmental aspects), and the insertion of the ‘provision of port services’ section that gathers several activities of service-providers.

A major change in this section is the introduction of ‘Direct control’ and ‘No direct control’ when an activity is selected. In this way, the user can differentiate the activities that generate direct aspects (controlled by the port authority) from the activities that generate indirect aspects (not directly controlled). A definition of what is considered directly controlled and not directly controlled is provided in the first line.

A second major change is the possibility offered to the user of ordering by priority the cargo handled and stored, as it can be seen at the bottom right side of figure 6.4. By establishing this differentiation, a better distribution of the related environmental aspects is created.

In addition, although it cannot be observed in the figure 6.4, the definitions of some activities (symbol *i*) were modified (See Annex VI for the final definitions), following the suggestions of the reviewers.

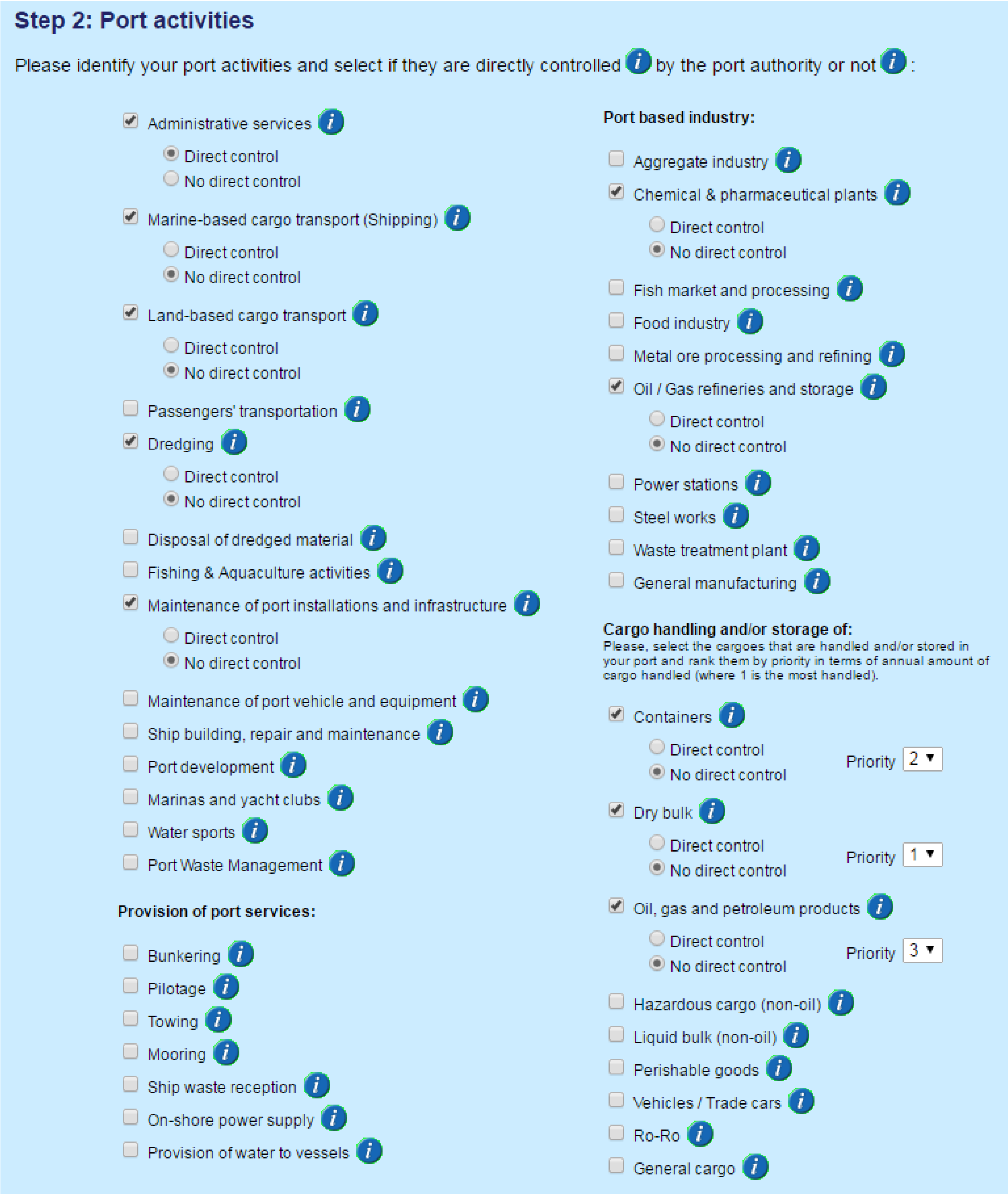


Figure 6.4: Final screenshot of TEAP Step 2: Port activities

Step 3: Environmental aspects

In this step, the amendments were the modifications in the name of some aspects, namely *Generation of non-hazardous waste* and *Generation of recyclable garbage*. The definition of other aspects were also improved.

In this process of improving the tool, the resulting ranking of environmental aspects was listed in numbers, so that the priority aspects are easily identified (in red colour), as seen in the example of figure 6.5.

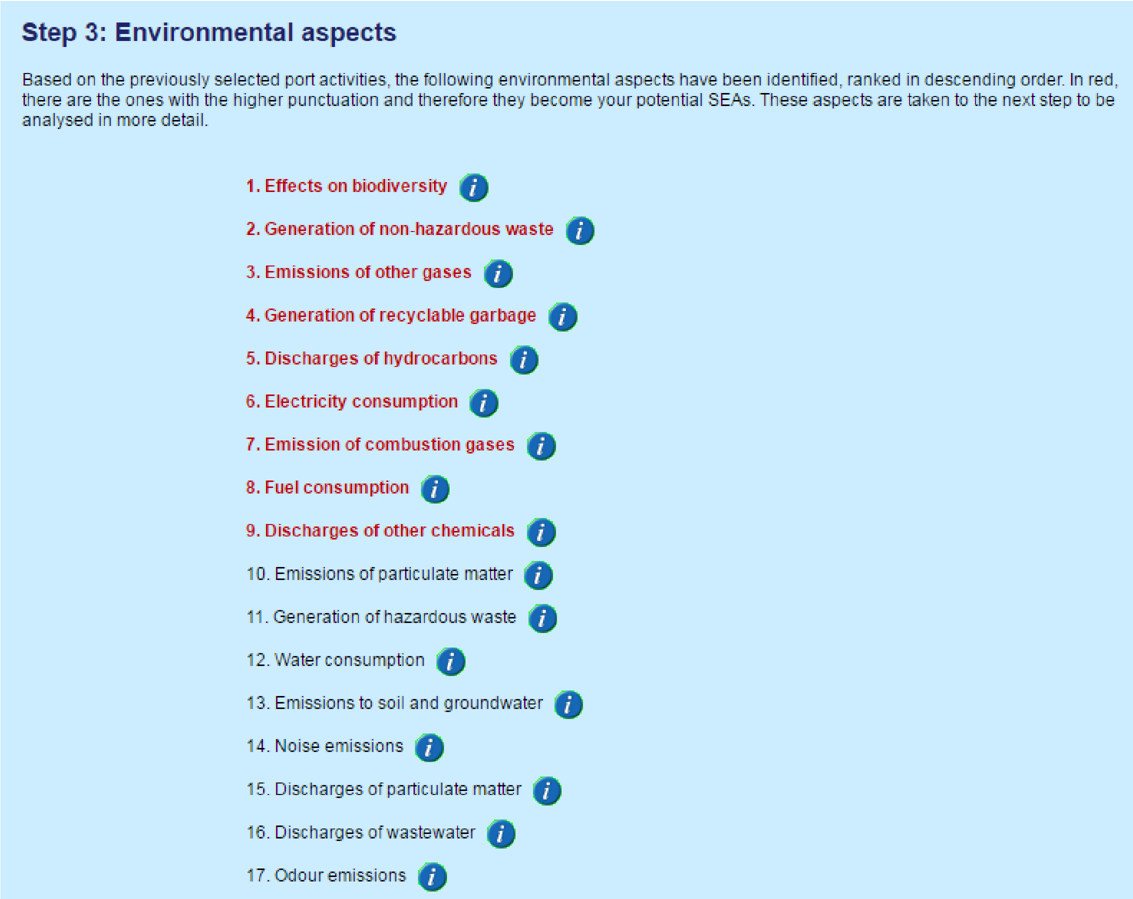
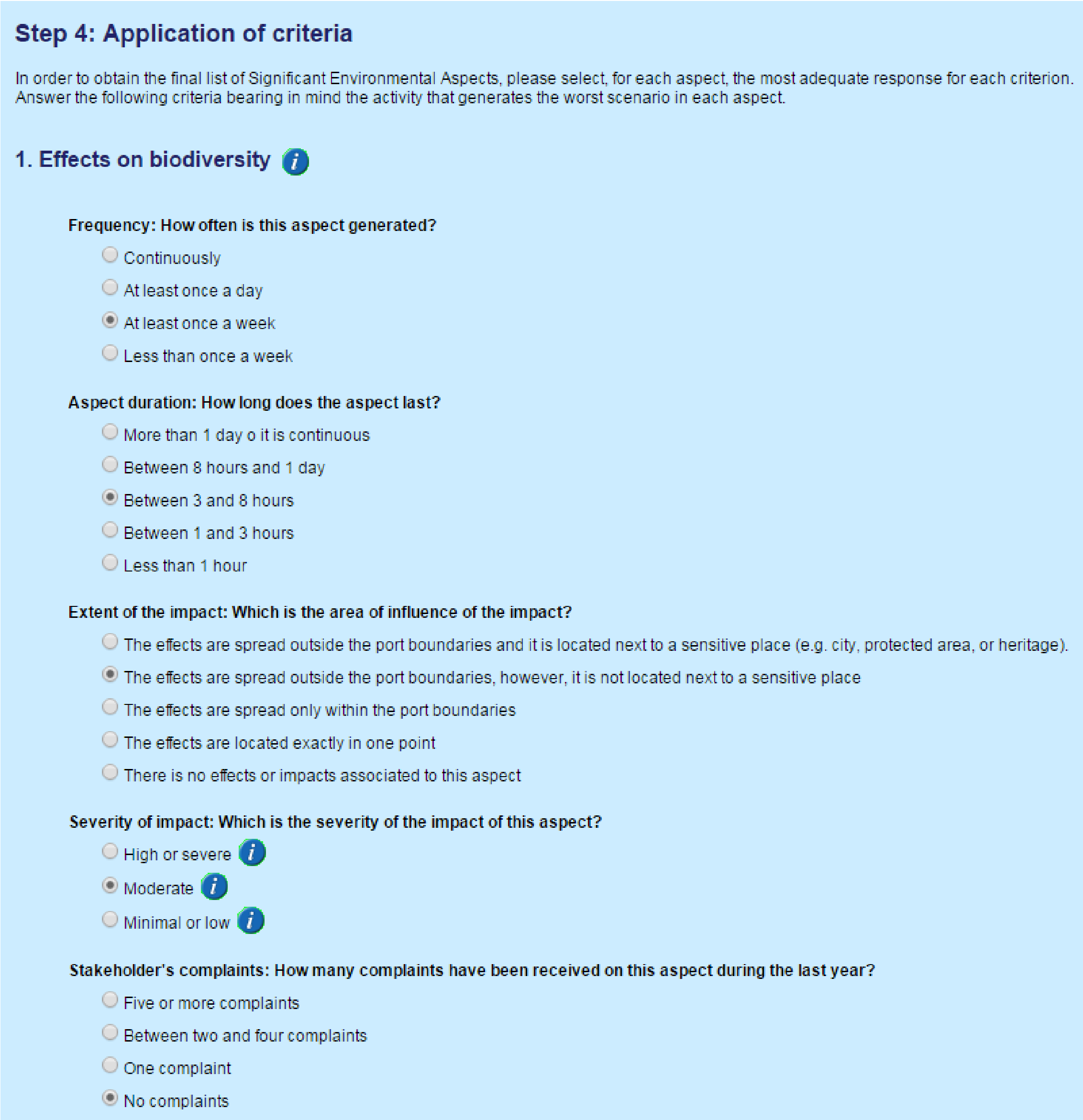


Figure 6.5: Final screenshot of TEAP Step 3: Environmental aspects

Step 4: Application of criteria

This step also experienced some amendments. The criteria were presented as questions instead of long sentences. The responses also were shortened, so that it is easier for the user to reply.

Another modification was to list the aspects following the same number as the previous step. A definition was added to the possible responses of the criterion *Severity of impact*, a new response option was provided in the criterion *Quantity of waste*, in order to be a standard response to all ports. An example of the application of criteria is shown in figure 6.6:



Step 4: Application of criteria

In order to obtain the final list of Significant Environmental Aspects, please select, for each aspect, the most adequate response for each criterion. Answer the following criteria bearing in mind the activity that generates the worst scenario in each aspect.

1. Effects on biodiversity

Frequency: How often is this aspect generated?

- ( ) Continuously
- ( ) At least once a day
- (•) At least once a week
- ( ) Less than once a week

Aspect duration: How long does the aspect last?

- ( ) More than 1 day o it is continuous
- ( ) Between 8 hours and 1 day
- (•) Between 3 and 8 hours
- ( ) Between 1 and 3 hours
- ( ) Less than 1 hour

Extent of the impact: Which is the area of influence of the impact?

- ( ) The effects are spread outside the port boundaries and it is located next to a sensitive place (e.g. city, protected area, or heritage).
- (•) The effects are spread outside the port boundaries, however, it is not located next to a sensitive place
- ( ) The effects are spread only within the port boundaries
- ( ) The effects are located exactly in one point
- ( ) There is no effects or impacts associated to this aspect

Severity of impact: Which is the severity of the impact of this aspect?

- ( ) High or severe
- (•) Moderate
- ( ) Minimal or low

Stakeholder's complaints: How many complaints have been received on this aspect during the last year?

- ( ) Five or more complaints
- ( ) Between two and four complaints
- ( ) One complaint
- (•) No complaints

Figure 6.6: Final screenshot of TEAP Step 4: Application of criteria

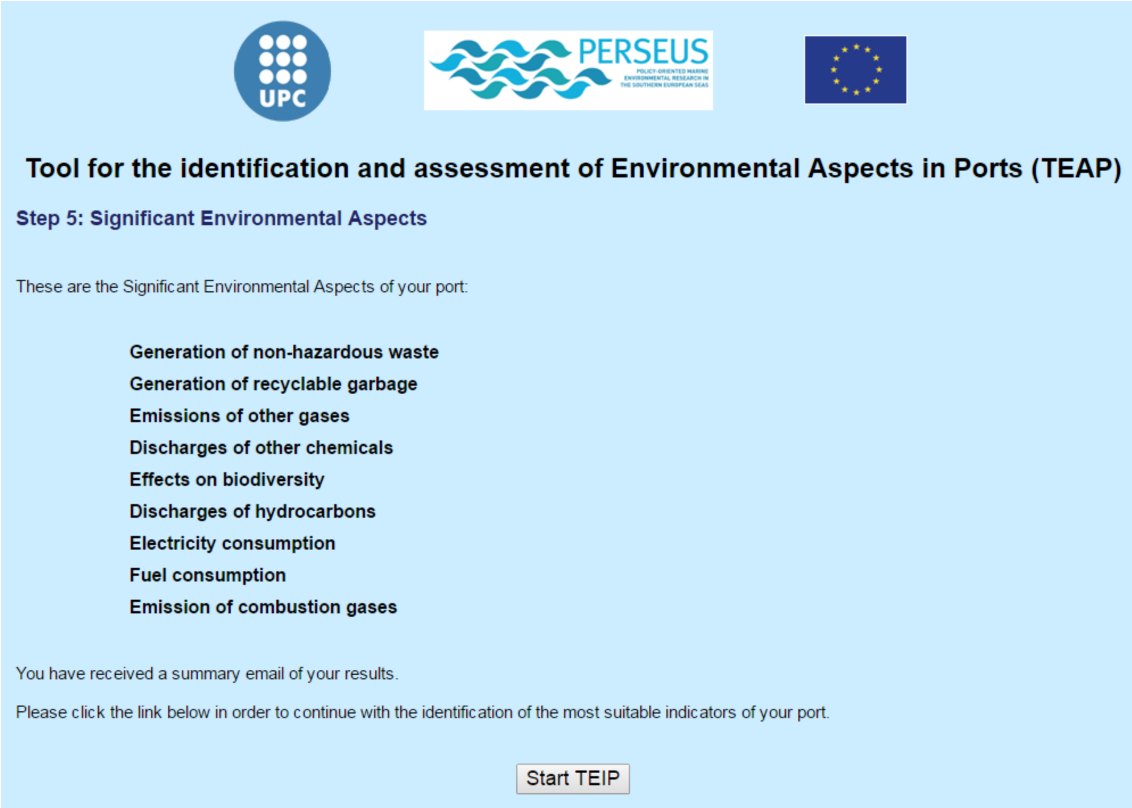
In addition, the relationships between the aspects and the criteria were slightly modified, being the final version the table below:

Environmental Aspects	Frequency	Aspect duration	Extent of the impact	Severity of impact	Stakeholders' complaints	Legal compliance	Quantity of waste	Consumption of resources
Normal and abnormal conditions								
Emisions to air								
Emissions of combustion gases								
Emissions of other gases								
Emissions of particulate matter								
Odour emissions								
Discharges to water								
Discharges of wastewaters								
Discharges of hydrocarbons								
Discharges of other chemicals								
Discharges of particulate matter								
Emissions to soil								
Emissions to soil and groundwater								
Resource consumption								
Water consumption								
Electricity consumption								
Fuel consumption								
Waste production								
Generation of recyclable garbage								
Generation of hazardous waste								
generation of non-hazardous waste								
Noise								
Noise emissions								
Biodiversity affectation								
Biodiversity affectation								

Figure 6.7: Final connections between aspects and criteria

Step 5: Significant Environmental Aspects

The main modifications in the Step 5 of TEAP was to link it to TEIP, to provide the option to continue to the user. As it is shown in figure 6.8 below, after providing the list of SEAs, a link to proceed to TEIP tool was incorporated.



Tool for the identification and assessment of Environmental Aspects in Ports (TEAP)

Step 5: Significant Environmental Aspects

These are the Significant Environmental Aspects of your port:

Generation of non-hazardous waste
Generation of recyclable garbage
Emissions of other gases
Discharges of other chemicals
Effects on biodiversity
Discharges of hydrocarbons
Electricity consumption
Fuel consumption
Emission of combustion gases

You have received a summary email of your results.

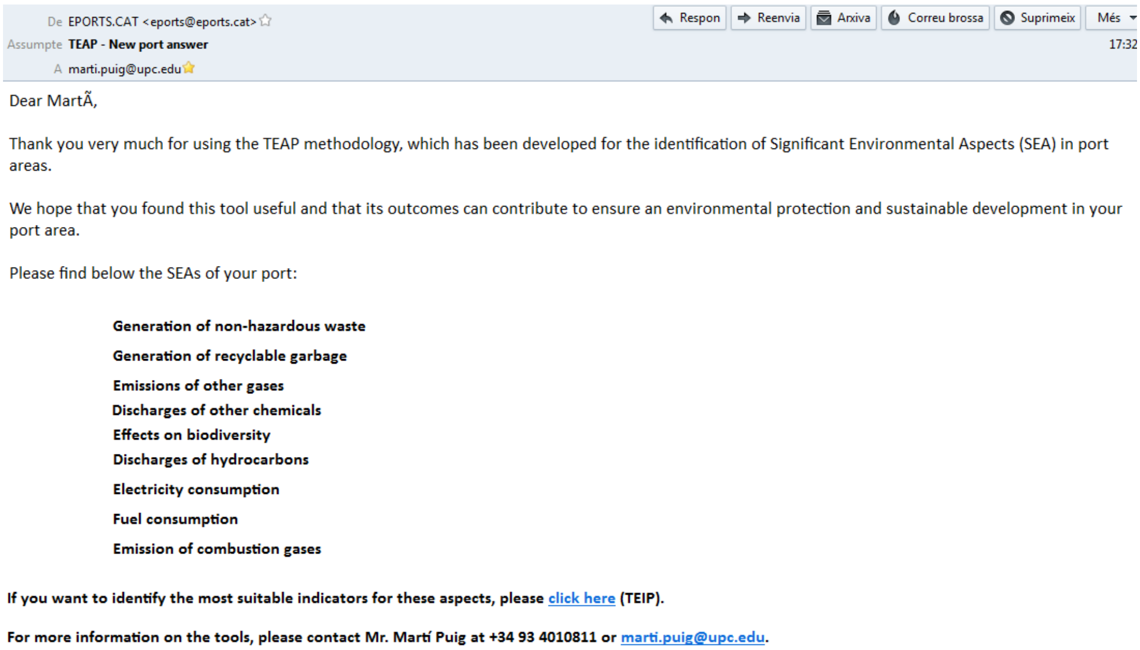
Please click the link below in order to continue with the identification of the most suitable indicators of your port.

Start TEIP

Figure 6.8: Final screenshot of TEAP Step 5: Significant Environmental Aspects

Email

Finally, a link to the TEIP tool was also added in the email sent to the user (see figure 6.9).



De EPORTS.CAT <eports@eports.cat>
Assumpte **TEAP - New port answer**
A marti.puig@upc.edu
Respon | Reenvia | Arxiva | Correu brossa | Suprimeix | Més
17:32

Dear MartÃ,

Thank you very much for using the TEAP methodology, which has been developed for the identification of Significant Environmental Aspects (SEA) in port areas.

We hope that you found this tool useful and that its outcomes can contribute to ensure an environmental protection and sustainable development in your port area.

Please find below the SEAs of your port:

Generation of non-hazardous waste
Generation of recyclable garbage
Emissions of other gases
Discharges of other chemicals
Effects on biodiversity
Discharges of hydrocarbons
Electricity consumption
Fuel consumption
Emission of combustion gases

If you want to identify the most suitable indicators for these aspects, please click here (TEIP).

For more information on the tools, please contact Mr. Martí Puig at +34 93 4010811 or marti.puig@upc.edu.

Figure 6.9: Final screenshot of TEAP email

6.3.2 TEIP final tool

This section presents the final snapshots of the TEIP tool in the complete version, by following the five steps of TEIP (Option 2).

TEIP introduction

As mentioned, the main amendment undertaken in the TEIP introduction section was the inclusion of the link to TEAP, to be able to identify the SEAs if it is needed. This link is showed in figure 6.10 below.

Figure 6.10: Final screenshot of the TEIP introduction

Step 1: Port contact details

Since any further amendment was undertaken in the Step 1 of TEIP, the final version remains as it has already been presented in section 5.7 of this thesis, and also provided below:

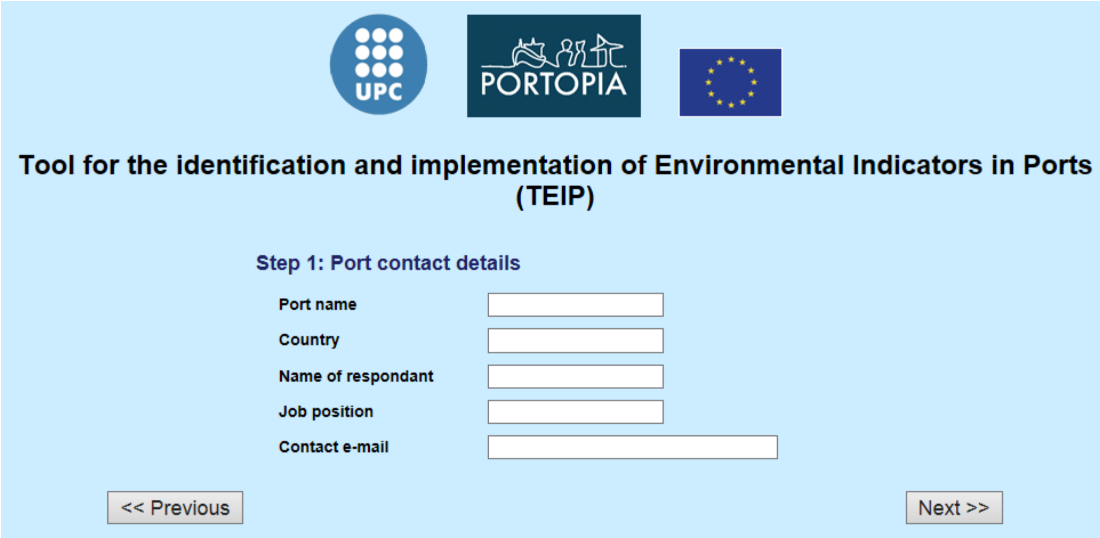


Figure 6.11: Final screenshot of TEIP Step 1: Port contact details

Step 2: Significant Environmental Aspects

The main amendments undertaken in this section were the inclusion of the definition of each aspect (with the symbol *i*) and the provision of a blank space to add further aspects, if it is the case.

In the updated version, it is explicitly mentioned that the aspects that are considered significant include the activities generated on the whole port area. In addition, a new sentence explaining that aspects are associated to indicators has been added. These amendments may be seen in figure 6.12.

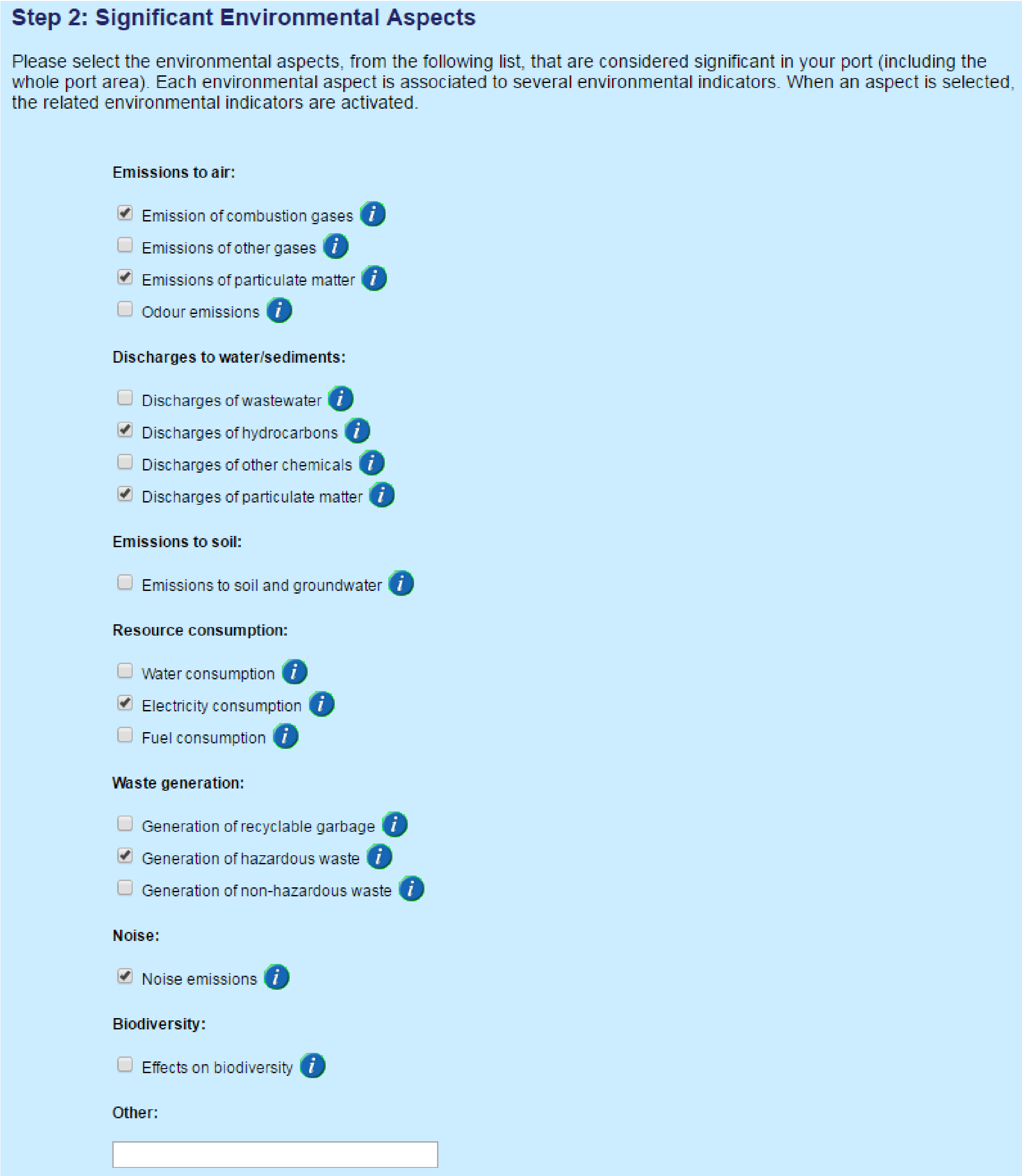
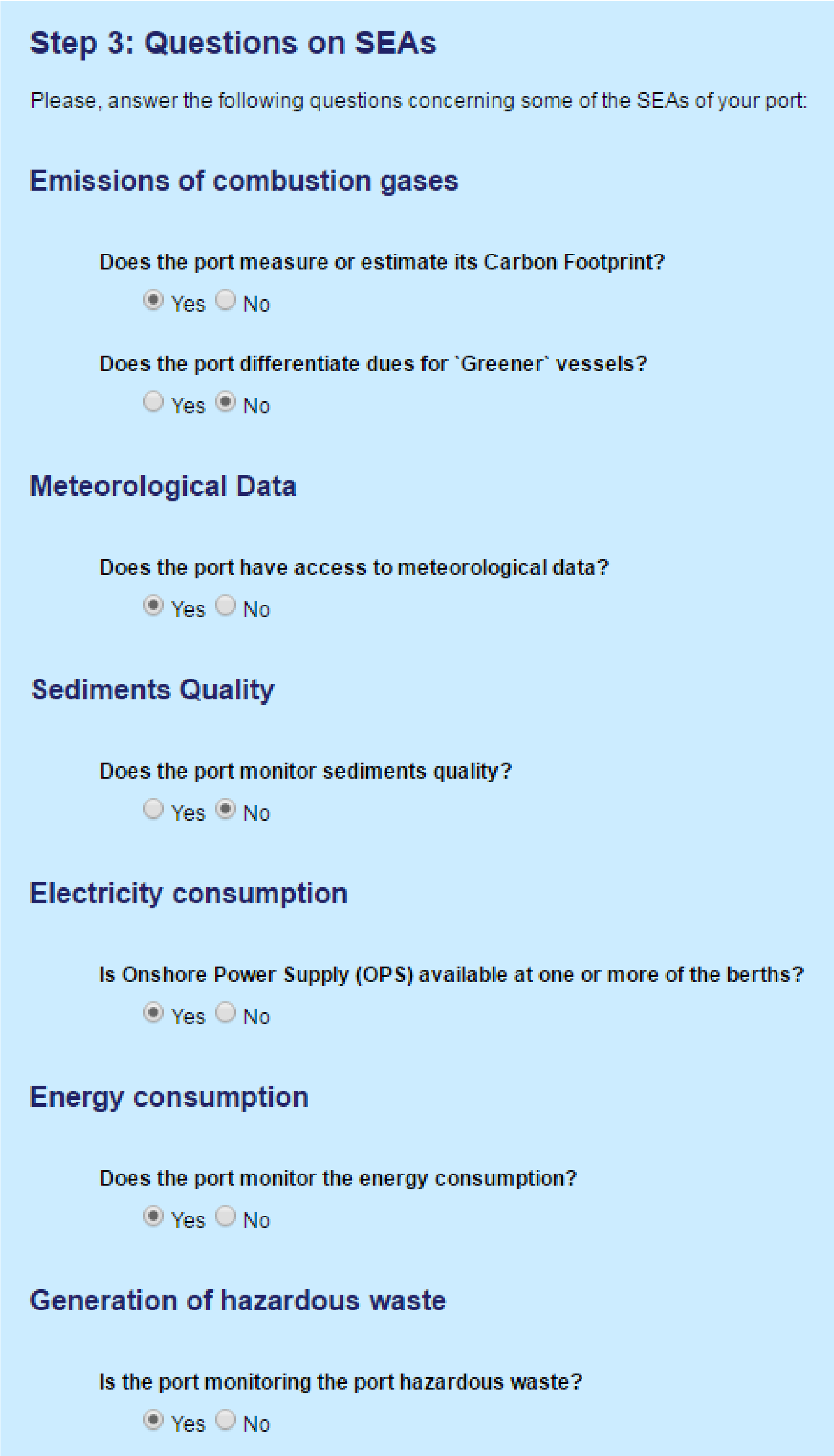


Figure 6.12: Final screenshot of TEIP Step 2: Significant Environmental Aspects

Step 3: Questions on SEAs

The question on meteorological data was modified and the question on paper consumption was deleted, as suggested by the reviewers. An example of the final screenshot of the Step 3 is displayed in the figure below:



Step 3: Questions on SEAs

Please, answer the following questions concerning some of the SEAs of your port:

Emissions of combustion gases

Does the port measure or estimate its Carbon Footprint?

Yes No

Does the port differentiate dues for `Greener` vessels?

Yes No

Meteorological Data

Does the port have access to meteorological data?

Yes No

Sediments Quality

Does the port monitor sediments quality?

Yes No

Electricity consumption

Is Onshore Power Supply (OPS) available at one or more of the berths?

Yes No

Energy consumption

Does the port monitor the energy consumption?

Yes No

Generation of hazardous waste

Is the port monitoring the port hazardous waste?

Yes No

Figure 6.13: Final screenshot of TEIP Step 3: Questions on SEAs

Step 4: Questions on environmental management and port development

Step 4 also was not modified as a result of the validation process. The final screenshot of this step is provided below in figure 6.14.

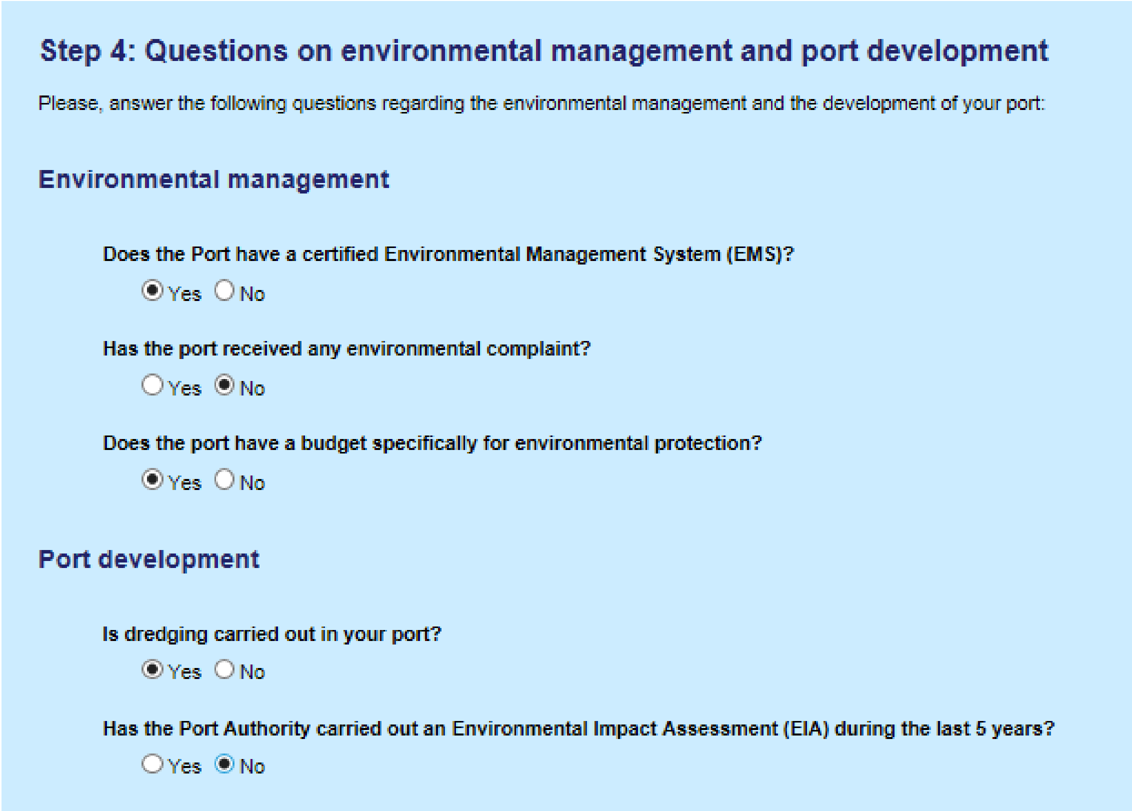


Figure 6.14: Final screenshot of TEIP Step 4: Questions on management and development

Step 5: Environmental Performance Indicators

In the last step of TEIP several amendments were suggested and they were incorporated in the final version. After the changes, the indicators are listed separately from the list of recommendations, and they are presented classified by categories. In addition, the resulting list of indicators and recommendations is presented in bullet points, since it gives a nicer presentation. It was added that to access to the guidelines, it is needed to click over the name of the indicators and recommendations. Some indicators were re-written, following the comments of the reviewers. An example of the indicators and recommendations provided in the last step is displayed below in figure 6.15

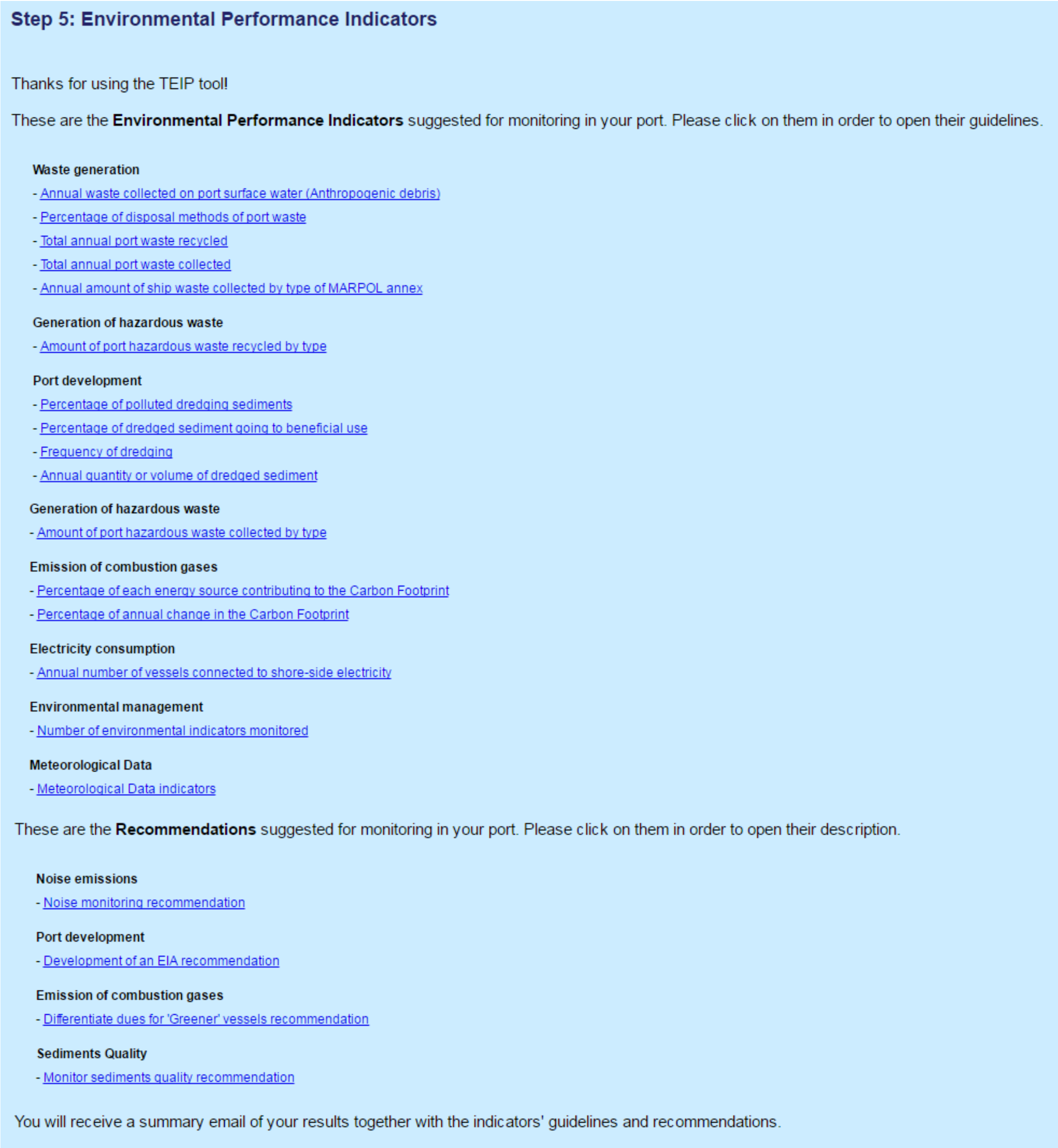
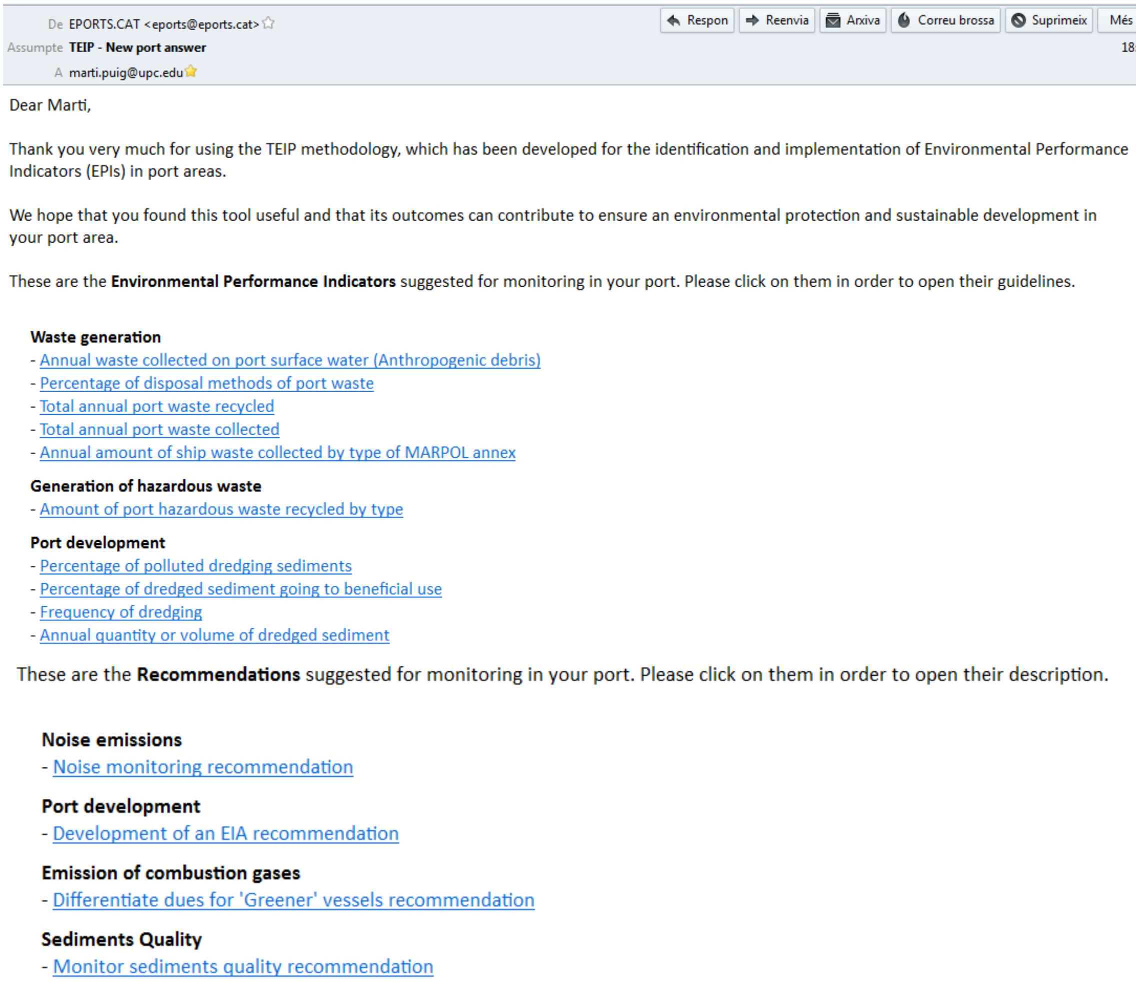


Figure 6.15: Final screenshot of TEIP Step 5: Environmental Performance Indicators

Email

Finally, similar amendments (e.g. adding bullet points, separating indicators and recommendations, classifying them by categories, mentioning to click over them) were also undertaken on the final email that is sent to the user, showing an example of it in the figure 6.16 below.



De EPORTS.CAT <eports@eports.cat>
Assumpte TEIP - New port answer
A marti.puig@upc.edu

Respon | Reenvia | Arxiva | Correu brossa | Suprimeix | Més

18

Dear Marti,

Thank you very much for using the TEIP methodology, which has been developed for the identification and implementation of Environmental Performance Indicators (EPIs) in port areas.

We hope that you found this tool useful and that its outcomes can contribute to ensure an environmental protection and sustainable development in your port area.

These are the **Environmental Performance Indicators** suggested for monitoring in your port. Please click on them in order to open their guidelines.

Waste generation
- Annual waste collected on port surface water (Anthropogenic debris)
- Percentage of disposal methods of port waste
- Total annual port waste recycled
- Total annual port waste collected
- Annual amount of ship waste collected by type of MARPOL annex

Generation of hazardous waste
- Amount of port hazardous waste recycled by type

Port development
- Percentage of polluted dredging sediments
- Percentage of dredged sediment going to beneficial use
- Frequency of dredging
- Annual quantity or volume of dredged sediment

These are the **Recommendations** suggested for monitoring in your port. Please click on them in order to open their description.

Noise emissions
- Noise monitoring recommendation

Port development
- Development of an EIA recommendation

Emission of combustion gases
- Differentiate dues for 'Greener' vessels recommendation

Sediments Quality
- Monitor sediments quality recommendation

Figure 6.16: Final screenshot of TEIP email

Guidelines of the indicators and recommendations

Since the guidelines of the indicators and recommendations also received proposals for improvement, the final version is provided below. The template for condition indicators required the provision of the equivalences of the units of measurement. The final version containing this section is provided in table 6.1 below:

Table 6.1: Final template of the guidelines for condition indicators

Indicator's name			
Category		**Indicator's code**	
Sub category			
Definition			
Importance			
Units of measurement			

Equivalence	
Description of the methodology	
Detection limits	
Limit values	
Monitoring locations	
Frequency	
Approximate cost	
Level of effort	
Notes	
References	

The template of the recommendations required the provision of an example of a best practice. The final version is provided in table 6.2 below.

Table 6.2: Final template of the environmental recommendations

Recommendation		**Recommendation code**	
Definition			
Contents			
Suggested indicators			
Example			
References			

Chapter 7. CONCLUSIONS

It has been widely reported that although ports around the world are major centres for the economic development of the areas where they are located, port and shipping activities also pose negative externalities and impacts to their surrounding areas. In particular, ports and harbours may be located in highly valuable and vulnerable natural areas, hosting endangered habitat and species, and being, some of them, protected under EU, national, regional, or local nature conservation legislation. For this reason, a broad mix of measures have to be applied for the effective management of potential environmental impacts.

Port authorities have already put in place a wide range of instruments to limit negative environmental impacts. These measures may be adopted either in marine-based cargo transport (shipping), in the cargo handling, or in the land-based cargo transport. For instance, the sulphur content of fuels may be limited in the shipping activities; noise levels may be restricted in the handling of goods in berth; and, the emissions from vehicles in the hinterland transport may be reduced. The types of measures also may differ very much, including soft measures, such as information provision or economic incentives (e.g. differentiated port dues); to stricter measures, such as bans on certain activities (e.g. on the use of antifouling containing biocides) or technologies to be applied (e.g. double-hulls on tankers).

This thesis has demonstrated that there are two common elements that are key in ensuring environmental protection and sustainable development in any organisation. These elements are the Significant Environmental Aspects (SEAs) and the Environmental Performance Indicators (EPIs).

On one hand, the identification of Significant Environmental Aspects is essential to guarantee an effective environmental management in port areas. Ports, and in general all industrial organisations, are encouraged to identify their SEAs in order to be aware of the issues that pose more threats on the environment. On the other hand, Environmental Performance Indicators are another strategic component that provide organisations with real and updated data and information of their environmental performance. In order to demonstrate the advantage of using both elements, aspects and indicators, a research on their role in the EMS standards was carried out in this thesis.

The three major standards for the achievement of an Environmental Management System are ISO 14001, EMAS and PERS. These standards recognise that the SEAs identification is a fundamental process and it has to be carried out carefully in order to ensure environmental protection and sustainable development. However, these standards do not detail any specific methodology for this selection. Although EMAS standard proposes four major steps to follow, the final decision on the methodology used is taken by the port authority. These three standards also recognise the importance of using indicators and encourage organisations to establish a method to periodically evaluate the performance through indicators. Some examples of indicators are provided by these standards, for instance, EMAS provides a list of nine core indicators. However, they do not define any specific procedure.

Another interesting issue studied in this thesis was the existing methods for the identification and assessment of aspects and indicators. Concerning aspects, the research provided the two most common methodologies at EU level (namely ECOPORT and SOSEA), as well as the methods developed by individual ports. For this purpose, a literature review was undertaken to research on the broad number of techniques that are already in place, especially focused on the port sector. Unfortunately, the research demonstrated that there is a minority of ports using either one of the sector methodologies or its own method and make it publicly available. Concerning indicators, the research demonstrated that there is a small number of procedures developed aiming at obtaining a system of indicators. The level of implementation of these methods among ports was studied, and it was found that they are not currently in place among the sector.

Based on the aforementioned reasons, it was detected that that a new methodology, available to all European ports was needed, to be broadly implemented among ports, so that they are able to identify their aspects and the most adequate indicators with a scientific procedure behind it. Based on the existing techniques and on the considerations from the EMS standards, a new methodology was developed: EPORTS.CAT. This method includes two tools: a Tool for the identification and assessment of Environmental Aspects in Ports (TEAP) and a Tool for the identification and implementation of Environmental Indicators in Ports (TEIP).

To develop the TEAP methodology, a wide range of environmental activities and aspects existing in ports were identified and described through an extensive research and review. Since the impacts generated on the environment are largely determined by the activities that are carried out in a port, the interactions between them were identified. The user has to select the activities undertaken in a port, and the aspects that may affect the environment are compiled. Then, through the definition of criteria and the provision of weighting to the possible responses, the final list of Significant Environmental Aspects is generated. TEAP was tested with several pilot ports and their suggestions for improvement were included in its final version.

It is interesting to point out that the procedure for identifying SEAs should follow an on-going review process, where the significance of environmental aspects should be continuously re-assessed. Those aspects identified as not significant should be reviewed regularly in order to consider changing circumstances. For this reason, it is highly recommended to use TEAP yearly to keep this information up-to-date.

To develop the TEIP tool, firstly an inventory of existing environmental indicators in ports was created. Research on the Global Reporting Initiative (GRI) guidelines, outcomes of research projects and studies, information from ESPO environmental reviews, pieces of legislation, port environmental reports, and EMS standards contributed to the identification of almost 650 indicators that are in use in ports. All the proposed indicators are real (existing), which proves that they are 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.

Since a large number of EPIs was compiled, it was required to reduce the extensive list of indicators to a shorter list, more appropriate to be implemented in ports. The filtering process consisted of three main steps: a first filter against a set of five criteria, a regrouping process, and a second filter against of six criteria. The criteria were established through a research of several different sources containing examples of criteria used. The indicators that complied with more criteria were selected and the ones that obtained a poor performance were rejected. After evaluating all the indicators, a total number of 172 indicators were selected to be incorporated into the TEIP tool.

This tool was developed using as a basis the aspects that were considered significant for the port. The interrelations between aspects and indicators were created. In TEIP, the list of significant aspects of the port may be obtained from two ways: as a result of applying the TEAP tool or by introducing the aspects manually. Some indicators are obtained straightaway when the aspect is selected as significant and other indicators are activated after answering a set of related questions. In any case, the user receives a set of indicators suggested for monitoring in the port, along with a guideline for its implementation. A set of recommendations are also provided.

The EPORTS.CAT method is applicable to all types of ports (e.g. seaport, inland port), no matter their country, geographical location, size or commercial profile since it provides specific results for each one. It is suggested that this method could assist port managers in identifying the SEAs and EPIs of their own port area in a user-friendly, practicable and time-effective manner. In addition, the use of EPORTS.CAT is beneficial not only for individual port authorities but also for the whole port sector. Since individual ports are engaged in the objective of continual improvement of their environmental performance, the sector as a whole would be able to demonstrate evidence of progress in the environmental performance. The adoption and application of TEAP and TEIP have the potential to enhance further the exchange of knowledge and experience throughout the sector and with its wide range of stakeholders.

It is important to mention that the aims of the implementation of an Environmental Management System are not only to control the activities that are carried out in the port but also to ensure a continuous improvement of the environmental performance. The environmental aspects that have been identified as significant and the environmental indicators selected for monitoring should be incorporated into the Environmental Management System of the port. It is highly recommended that the resulting aspects should be associated with the Environmental Policy and objectives and targets of the port authority, so that it will undoubtedly improve the credibility of the entire EMS of the port.

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Annex I: PERSEUS Environmental questionnaire

Policy – oriented marine Environmental Research in the Southern European Seas (PERSEUS)

Start the questionnaire

Please enable macros to ensure the proper functionality of the form

For advice and assistance on using the questionnaire, contact Mr. Marti Puig Duran on the UPC-CERTEC line no. (0034) 93 4016675 or by email to marti.puig@upc.edu

Introduction

The port sector and the shipping industry are crucial for maintaining the global economy and the welfare of the current society. The expansion of port facilities and their associated operations can contribute significantly to the growth of maritime transport and economic development. However, port operations and activities may also create adverse environmental impacts on air, water, soil and sediment, affecting both the terrestrial and marine environments.

Framework of the project and aim

The 'Policy-oriented marine Environmental Research in the Southern EUropean Seas' (PERSEUS) research project (www.perseus-net.eu) aims at identifying the interacting patterns of natural and human-derived pressures on the Mediterranean and Black Seas and assessing their impact on marine ecosystems.

The Center for Technological Risk Studies (CERTEC), within the Universitat Politècnica de Catalunya (UPC), contributes to this project by analysing the environmental risk assessment of ports. The main aim of this questionnaire is to assess the environmental performance of ports, identify their major port activities, their related environmental impacts and their key Environmental Performance Indicators (EPIs) that may be implemented to prevent, manage and mitigate those impacts on the environment.

Your participation in this questionnaire is a valuable contribution to the development of the next steps of the project and your collaboration will be much appreciated. Contributing ports will receive an analysis of their environmental performance compared with the European benchmark and will be able to participate in the test of a tool to select effective Environmental Performance Indicators (EPIs) for port operations and development.

Ethics and confidentiality

All data provided by participants will be treated in strict confidence and it will be used in the context of this research project. The analysis of the results will not reveal any personal details that could lead to the identification of participants.

Guidelines for use

Please, use the buttons 'Back', 'Homepage' and 'Forward' to move within the questionnaire. Respondents are asked to provide the contact details of their Port Authority in the first section. In most of the questions, you are required to tick (☑) the appropriate answer or to choose one option from a list; however, in specific questions you have to write some words. The symbol links you to a brief definition of the adjacent word. To return to the previous sheet, just click on the button .

Several information sources have contributed to the development of this questionnaire, namely the Self-Diagnosis Method (SDM) developed by the EcoPorts Foundation (www.ecoports.com), the European Sea Ports Organisation (ESPO) Environmental Review 2009 and the PPRISM research project about Port Performance Indicators.

ETHICS AND CONFIDENTIALITY

All data provided by participants will be treated in strict confidence and it will be used in the context of this research project. The analysis of the results will not reveal any personal details that could lead to the identification of participants.

Port contact details

Name of the port	**Country**

Name of respondent	**Job Position**	**Contact e-mail**

Port Profile

Please indicate the size of your port in terms of cargo handled, passengers, TEUs and vessels by selecting one option from the list in each case:

Annual tonnes of cargo handled	< 1 million	☐
	1 – 10 million	☐
	10 – 25 million	☐
	> 25 million	☐
Annual passengers	< 100.000	☐
	100.000 – 1.000.000	☐
	1.000.000 – 5.000.000	☐
	> 5.000.000	☐
Annual TEUs (containerised cargo)	< 150.000	☐
	150.000 – 200.000	☐
	200.000 – 1.000.000	☐
	> 1.000.000	☐
Annual number of vessels entering the port	<1.000	☐
	1.000 – 10.000	☐
	10.000 – 25.000	☐
	> 25.000	☐

Concerning the port surroundings, your port is located:

Inside urban areas	☐
Next to urban areas	☐
Outside urban areas	☐

Is your port located within a site with special conservation designations? Y / N

Port activities

Please identify and select your major port activities by ticking the appropriate box:

Port Activities	
Administrative services	☐
Bunkering *i*	☐
Cargo handling and/or storage: Containers	☐
Cargo handling and/or storage: Dry bulk (e.g. coal or grain)	☐
Cargo handling and/or storage: Hazardous cargo	☐
Cargo handling and/or storage: Liquid bulk (non-Oil)	☐
Cargo handling and/or storage: Oil, gas and petroleum products	☐
Cargo handling and/or storage: Perishable goods *i*	☐
Cargo handling and/or storage: Vehicles / Trade cars	☐
Cargo handling: Ro-Ro	☐
Cargo transport: Shipping (sea traffic)	☐
Cargo transport: Land-based (lorry, train, car)	☐
Dredging *i*	☐
Fisheries & Aquaculture *i*	☐
Maintenance of port installations and infrastructure	☐
Passengers transportation (ferry & cruise ships)	☐
Port based industry: Aggregate industry (sand, gravel, cement)	☐
Port based industry: Chemical & pharmaceutical plants	☐
Port based industry: Fish market and processing	☐
Port based industry: Agro food Industries	☐
Port based industry: Metal ore processing and refining	☐
Port based industry: Oil refineries	☐
Port based industry: Power stations	☐
Port based industry: Steel works	☐
Port expansion (land) *i*	☐
Port expansion (sea) *i*	☐
Port services: pilotage	☐
Port services: towing *i*	☐
Port services: mooring *i*	☐
Recreation and tourism: Water sports	☐
Recreation and tourism: Marinas *i*	☐

Ship building and repair	☐
Waste Management: Port	☐
Waste Management: Ship	☐
Other, please specify:	☐

Port environmental aspects

Please identify and select the Significant Environmental Aspects (i) that are relevant for your port by ticking the appropriate boxes. Please also rank them according to their relative importance (where 1 is most important):

Port environmental aspects			PRIORITY
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		☐	
Other (please specify):		☐	
Other (please specify):		☐	

Port Environmental Management

Please identify and select the elements that your port has by ticking the appropriate boxes.

Environmental Policy?	☐
If so, is the environmental policy publicly available on the port's website?	Y/N?
Inventory of Significant Environmental Aspects (SEA)?	☐
Inventory of relevant environmental legislation?	☐
Environmental objectives and targets?	☐
Environmental Programme?	☐
Environmental Training Programme?	☐
Environmental Report?	☐
Emergency Response Plan?	☐
Environmental Monitoring Programme?	☐
Internal environmental revision?	☐
External environmental audit?	☐
Environmental Management System (EMS)?	☐

If so, please indicate which one:	Y/N?

Does the port have a budget for environmental monitoring?	
Does the port have its own Environmental Manager?	
Does the port have procedures to communicate environmental information internally?	
Does the port website show environmental information?	
Has the port received any environmental complaint?	
If so, please indicate the main environmental aspect affected by the complaint:	
If so, please indicate who issued the complaint:	
Has the port received any fine for non-compliance with environmental legislation?	
If so, please indicate which level of legislation is broken:	

Has your port identified and implemented Environmental Performance Indicators (EPIs) to monitor trends in environmental performance?

YES NO

Port Environmental Performance Indicators

Environmental Performance Indicators (EPIs) are categorised into two sections: Operational Performance Indicators and Environmental Condition Indicators. Please ☑ tick the Environmental Performance Indicators (EPIs) that have been implemented or monitored within your port and, if known, introduce their value with units:

Operational Performance Indicators

Issue	Indicator	
Resource consumption	Total annual energy consumption by energy source	☐
	Amount of energy saved due to energy-efficiency improvements	☐
	Number of energy-efficiency initiatives implemented	☐
	Number of vessels using shore-side electricity	☐
	Percentage of renewable energy per total energy consumed	☐
	Total annual water consumption	☐
	Percentage of water recycled per total water consumption	☐
Carbon Footprint	Total annual greenhouse gas (GHG) emissions (Carbon Footprint)	☐
	Percentage of annual variation in the greenhouse gas (GHG) emissions	☐
	Number of initiatives implemented to reduce GHG emissions	☐
Noise	Existence of a noise-zoning map	☐
	Level of noise in terminals and industrial areas (Lden: overall day-evening-night)	☐
	Maximum level of noise in terminals and industrial areas (Lmax)	☐
	Compliance with limits at day, evening, and night time for noise level	☐
	Number of measures implemented to reduce noise levels	☐

	Annual number of noise complaints	☐
Waste Management	Existence of separate containers for the collection of port waste	☐
	Annual amount of port waste collected	☐
	Annual amount of port waste recycled by type	☐
	Annual amount of ship waste recycled (MARPOL Convention annexes I, II, III, IV and V)	☐
	Hazardous waste reduced by pollution prevention	☐
	Frequency of cleaning the port area	☐
	Number of initiatives implemented to reduce, recycle or reuse waste	
Port development	Annual quantity or volume of dredged sediment	
	Annual amount of time and money spent on dredging activities	
	Frequency of dredging	
	Percentage of clean/contaminated dredged material	☐
	Number of measures implemented to reduce negative ecological effects of dredging	☐
	Percentage of dredged sediment going to beneficial use	☐
	The existence of facilities for the treatment and cleaning of the dredged material	☐
	Number of environmental licenses withdrawn or refused for dredging disposal	☐
	Chemical quality of the dredged material	☐
	Frequency of monitoring dredging material in disposal sites	☐
Other:		☐
Other:		☐
Other:		☐
Other:		☐

Environmental Condition Indicator

Issue	Indicator	
Air quality	Sulphur Oxides (SOx)	☐
	Nitrogen Oxides (NOx)	☐
	Carbon Monoxide (CO)	☐
	Suspended Particulate Matter (SPM)	☐
	Dust	☐
	Volatile Organic Compounds (VOCs)	☐
Water quality	Chemical Oxygen Demand (COD)	☐
	Biological Oxygen Demand (BOD)	☐
	Dissolved Oxygen (DO)	☐
	Water pH	☐
	Coliform Bacteria (microbiology)	☐
	Oil Content (Hydrocarbons)	☐
	Anthropogenic debris	☐
	Heavy metals	☐

☐

	Turbidity (water transparency)	
	Water temperature	☐
	Electrical conductivity	☐
Soil quality	Soil pH	☐
	Organic contaminants	☐
	Macronutrients	☐
	Water content	☐
	Soil Organic Matter	☐
	Cost related to the treatment of contaminated soil	☐
	Availability of a soil pollution map	☐
Sediment Quality	Halogenated hydrocarbons	☐
	Polycyclic Aromatic Hydrocarbons	☐
	Nutrients	☐
	Heavy metals	☐
	Organic Matter	
Ecosystems and habitats	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	☐
	Benthic fauna monitoring: quantity and variety of benthic fauna found in seabed sediments	☐
	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	☐
	Butterflies monitoring: quantity and variety of generalists (wider countryside) and specialists species of butterflies	☐
	Number of widely established (more than 50 per cent) invasive species in freshwater, marine and terrestrial environments	☐
	Amount of time that citizens spend volunteering in biodiversity conservation of the port	☐

Please identify the major difficulties experienced in using Environmental Performance Indicators in your port:

Identifying the Authority responsible for their implementation / monitoring	☐
Lack of budget	☐
Lack of trained personnel	☐
Lack of experience / good practice	☐
No problems	☐
Other (please specify):	☐
Other (please specify):	☐

How did you select the above-mentioned indicators? Did you follow any methodology for their selection? If so, please explain it in the box below:

Does your port publish the results of the indicators in a publicly available Environmental Report?

Does your port assess its environmental performance year over year?

Do you think that your port would need more environmental indicators to be monitored?

If so, please indicate which ones:

Reasons for not implementing EPIs

Please identify the reasons for not using Environmental Performance Indicators in your Port Authority:

Identifying the most suitable indicators to be implemented / monitored		☐
Identifying the Authority responsible for their implementation / monitoring		☐
Lack of budget		☐
Lack of trained personnel		☐
Lack of experience / good practice		☐
Other (please specify):		☐
Other (please specify):		☐
Other (please specify):		☐

Glossary of terms

Bunkering	The act or process of supplying a ship with fuel.
Special conservation designations	A conservation designation site considers the status of an area of land in terms of conservation or protection. For example, in a European Union level, it includes 'Special Area of Conservation' (SAC) which is a designation under the European Union's Habitats Directive (92/43/EEC) and the 'Special Protection Area' (SPA) which is a designation under the European Union Directive on the Conservation of Wild Birds (2009/147/EC). In a national level, it includes National Parks, National Nature Reserves, Marine Nature Reserves, Areas of Outstanding Natural Beauty, Local Designations, among others.
Perishable goods	Food that will decay rapidly if not refrigerated, such as fresh meat, seafood, and ripe fruits.
Dredging	Dredging consists of removing a certain amount of sediment from the bottom of the sea in order to keep the navigation depth (maintenance dredging),

	make it deeper (capital dredging), sell the material (commercial dredging) or to improve the environmental quality (remedial dredging).
Port expansion (land)	The lack of space and the increasing number of industries located in the port area can create a necessity for expansion towards the surroundings. Land development refers to the occupation and alteration of the terrestrial space and may generate several consequences: destruction of some natural areas close to the port (e.g. wetlands, dune systems), disturbance of the flora and fauna or relocation of some installations which can generate social conflicts.
Port expansion (sea)	The increase in the maritime transport around the world has contributed to the expansion of ports (e.g. new docks, new facilities) in order to provide maximum surface to the port users.
Aquaculture	Aquaculture is the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants.
Towing	To use a boat to pull another boat along.
Mooring	To make fast a boat by attaching it by a cable or rope to the shore or to an anchor.
Marina	A specially designed harbour with moorings for pleasure yachts and small boats.
Inventory of Significant Environmental Aspects	A list of the Significant Environmental Aspects identified by the port: elements of the port authority’s activities, products or services that have or can have a significant impact on the environment.
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.
Inventory of legislation	A list of legislation and regulations relevant to the port’s liabilities and responsibilities.
Environmental objectives and targets	An environmental 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.
Environmental Programme	A description of the means of achieving environmental objectives and targets.
Environmental Training Programme	A planned process to provide employees with the skills to do their work more efficiently, make them more aware of their roles and responsibilities and modify attitude, knowledge or skill behaviour through a learning experience.
Environmental Report	An Environmental Report gives information about the environmental activities, achievements and results that a port authority has carried out throughout the preceding year.
Emergency Response Plan	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.

Environmental Monitoring Programme	Activity involving repeated periodic observation and measurement of one or more selected parameters, allowing a port to establish the current status of environmental quality and being an essential tool to track its environmental performance.
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 Management System	The part of the overall management system that includes organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy.
Environmental complaint	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.
Environmental Performance Indicator	An information tool that summarises data on complex environmental issues to show overall status and trends of those issues.
Suspended Particulate Matter (SPM)	Amount of soot from combustion processes or dust sources. It generally concerns particulates with a diameter of 10 µm or less.
Dust	Amount of fine powder or other particles greater than 10 µm in the atmosphere
Volatile Organic Compounds	Vapours produced by the volatilisation of low boiling point liquids, released by storage venting, spilling or traffic.
Chemical Oxygen Demand	Amount of oxygen required to oxidise the organic and inorganic compounds in water.
Biological Oxygen Demand	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.
Dissolved Oxygen	The concentration of oxygen dissolved in water.
Water 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.
Coliform Bacteria (microbiology)	The number of Coliform bacteria such as Escherichia coli in water, expressed as most probable number in 100 ml (MPN/100ml).
Oil Content (Hydrocarbons)	The amount of oil in the water column or a sediment sample.

Anthropogenic debris	Amount of waste collected yearly from the water surface of the port.
Heavy metals	Concentration of the various metal ions in a sample, such as copper, lead, cadmium or chromium.
Turbidity	Turbidity is a measure of the cloudiness of a liquid caused by fine suspended particles, bubbles, silt and organic matter such as microbes.
Soil pH	Degree of soil acidity or alkalinity by measuring the amount of hydrogen ions present in the soil solution.
Macronutrients	Essential elements used for plant growth. The major macronutrients are nitrogen (N), phosphorous (P), and potassium (K).
Water content	The ratio of the weight of water to the weight of solids in a given volume of soil.
Soil Organic Matter (SOM)	Soil organic matter (SOM) is the organic matter component of soil.
Halogenated hydrocarbons	A group of chemicals which are very resistant to decay, such as DDT and PCBs. They were extensively used in electrical fittings and paints and although they are no longer manufactured, they are extremely persistent.
Polycyclic Aromatic Hydrocarbons	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 human

Annex II: Weightings' criteria applied to assess the significance in the ECOPORT method

The weightings applied to the three criteria (frequency or probability, control of the impact, and severity) used in the ECOPORT method for assessing and recording environmental aspects are described in this annex.

1. Frequency or probability:C1

	Frequency	Probability	Value
Very low	Less than once a year	< once a year	1
Low	A few times a year	From 2 to 12 times a year	2
Average	A few times a month	From 12 to 47 times a year	3
High	A few times a week	From 48 to 200 times a year	4
Very high	Daily or continually	> 200 times a year	5

2. Control of the impact: C2

Control	Description	Value
Low	When the aspect is produced, the potential impact also occurs and nothing can be done to avoid it. (E.g.: emissions to air, wastewater deposits, resource consumption without applying good practices or good environmental purchasing criteria)	4
Average	When the aspect is produced but the impact can be reduced. (E.g.: Noise, controlled filtered air emissions, waste removed to a dump, resource consumption in accordance with good practices and environmental purchasing criteria)	2
High	Although the aspect is produced the impact does not occur (E.g.: Waste is recycled, resource consumption in accordance with good practices and purchasing criteria.	1

3. Severity: C3

Combination of risk and quantity in accordance with the table:

Quantity	Risk					
	High		*Average*		*Low*	
High	Very high	16	High	8	Average	4
Average	High	8	Average	4	Moderate	2
Low	Average	4	Moderate	2	Low	1

3.1 Risk

High	Average	Low
• Hazardous waste • Escapes and leaks of dangerous products • Toxic product consumption	• Combustion gases • Volatile products • Dust • Deposits in water • Waste which is neither dangerous • Escapes and leaks of products which are not dangerous • Electricity consumption • Fuel consumption	• Inert waste • Water consumption • Consumption of paper and packaging • Noise • Vibrations • Smells

3.2 Quantity (Note: To be adapted to the activity sector and production level of the company)

Aspect	Low	Average	High
Paper/cardboard (Tons/year) (writing paper, packaging, advertising material	X<6	6<X<18	X>18
Plastic (Tons/year)	X<6	6<X<18	X>18
Cans and metals (Tons/year)	X<6	6<X<18	X>18
General mixed waste (Tons/year)	X<6	6<X<18	X>18
Waste from batteries and batteries used in electrical equipment(Tons/year)	X<0,004	0,004<X<0,013	X>0,013
Used fluorescents (units/year)	X<13	13<X<39	X>39
Used toners (Tons/year)	X<6	6<X<18	X>18
Obsolete electrical and computing equipment (Tons/year)	X<6	6<X<18	X>18
Other special waste (Correction fluid, Paints, Solvents, Tin, Clearing products) (Tons/year)	X<0,340	0,340<X<1,030	X>1,030
Out of date medicines (Tons/year)	X<0,0003	0,0003<X<0,0009	X>0,0009
Waste from renovations and contraction works (Tons/year)	X<6	6<X<18	X>18
Waste from fire (Tons/year)	X<1,2	1,2<X<3,7	X>3,7
Waste from human and animal sanitary sharps (Tons/year)	X<0,0003	0,0003<X<0,0009	X>0,0009
Cardboard consumption (Tons/year)	X<6	6<X<18	X>18
Electrical energy consumption (kwh/year)	X<74.000	74.000<X<224.000	X>224.000
Water consumption (m3/year)	X<1.250	1.250<X<3.850	X>3.850
Writing paper consumption (Tons/year)	X<6	6<X<18	X>18
Consumption of cleaning products (Tons/year)	X<0,730	0,730<X<2,235	X>2,235
Consumption of plastic bin liners (Tons/year)	X<6	6<X<18	X>18
Consumption of vehicle fuel (Tons/year)	X<17,5	17,5<X<53	X>53
Consumption of paints (Tons/year)	X<0,530	0,530<X<1,610	X>1,610
Correction fluid consumption (Tons/year)	X<0,530	0,530<X<1,610	X>1,610
Distilled water consumption (m3/year)	X<1.250	1.250<X<3.850	X>3.850
Consumption of alcohol or solvents (Tons/year)	X<0,080	0,080<X<0,240	X>0,240

Annex III: Aspects Specific Strategic Questions (SOSEA questions)

This set of 12 questions are asked on the second part of the SOSEA procedure. It consists of two different kinds of questions: i) about the current situation (A1-A8) and ii) about current actions (B1-B4).

- A1: Which are the regulations that afect the port's significant environmental aspects?
- A2: Which organisation(s) is/are legally responsible for the enforcement of the regulations related to the Port's Significant Environmental Aspects (SEA)?
- A3: Does the port authority have any difficulties complying with the regulations related to its SEAs?
- A4: Do any of the port's SEAs or any of the regulations related to them affect the development plans of the port?
- A5: Are the ports' SEAs especially important for the port's image?
- A6: Are the Ports' SEAs especially important for the port users?
- A7: Have been reported any incidents in the port related to SEA during the last year?
- A8: Have there been there any complaints during the last year concerning the port's SEAs?
- B1: Are the port SEAs regularly monitored?
- B2: Does the port authority have special procedures for its own employees regarding its SEA?
- B3: Does the port authority have special procedures for the port users (e.g. port operators) regarding its SEA?
- B4: Are there management programes or actions plans dealing with the Port's SEAs at the present?

Annex IV: Results of the aspects and indicators research

	Legend
The list of aspects/indicators and the methodology is provided	(green)
The list of aspects/indicators is provided	(yellow)
Neither the list of aspects/indicators nor the methodology is provided	(red)

1- European port authorities

Name	Country	Size[2]	Aspects	Indicators	Document
Puerto de A Coruña	Spain	M	23 N/A[3] 25E	94	Env. Declaration 2012 / Memoria de sostenibilidad 2011
Puerto de Vigo	Spain	S	42N/A 27 E	66	Environmental Declaration 2010
Puerto de Valencia	Spain	L	14 N/A	62	Memoria ambiental 2013
Port of Roses	Spain	S	13 N/A 6 E	62	EMAS Environmental Declaration 2012
Puerto Bahía de Algeciras	Spain	L	4 N/A	43	Memoria Ambiental 2014
Port of Cartagena	Spain	M	30 N/A	36	EMAS Environmental Declaration 2010 & 2011
Port of Livorno	Italy	L	19 N/A	20	Dichiarazione ambientale 2012 - 2015
Autoridad Portuaria de Santander	Spain	M	8 N/A	102	Memoria annual 2013
Puerto de Gijón	Spain	M	7 N/A	45	Memoria de Sostenibilidad 2013
Port of Koper	Slovenia	M	37 N/A	23	Environmental Report 2012
Antwerp Port Authority	Belgium	L	9 N/A	21	Sustainability report
Port de Ceuta	Spain	S	10 N/A	15	Memoria de Sostenibilidad 2008
Port of Belfast	UK	M	10 N/A	12	Environment Report 2013
Peterhead Port Authority	UK	S	18 N/A	12	EMS 2011
Port of Helsinki	Finland	M	7 N/A	9	Web-site / Annual report 2013
Alacant Port	Spain	S	6 N/A	9	Environmental best practices / Report Alacant port 2013
Port of Felixstowe	UK	S	6 N/A	8	Environmental Report 2011-12
Ghent Port Authority	Belgium	L	6 N/A	8	PERS: Environmental report 2013
Freeport of Riga Authority	Latvia	L	10 N/A	7	Environment Report 2012
Ports of Bremen / Bremerhaven	Germany	L	10 N/A	6	Environmental Report 2010
Port of Cork	Ireland	M	7 N/A	11	Port of Cork. Environmental Report
Port Authority of Cagliari	Italy	L	-	51	Rapporto ambientale 2010

[2] Size: L (large) ports handle more than 25 annual million tonnes; M (medium) ports handle between 25 million tonnes and 5 million tonnes; and S (small) ports handle less than 5 million tonnes annually.
[3] *N/A* stands for Normal and Abnormal conditions. *E* stands for Emergency conditions.

Port of Moerdijk	Netherlands	M	-	11	Port Environmental Review System (PERS) 2014
Port of Dover	United Kingdom	M	-	7	Environmental Bulletin 2013
Piraeus Port Authority S.A.	Greece	L	-	1	Annual financial report 2011
Port of Tallinn	Estonia	L	-	0	-
Port of Gothenburg	Sweden	L	-	30	Sustainability report
Port of Barcelona	Spain	L	-	29	Annual report 2011
Hamburg Port Authority	Germany	L	-	14	Sustainability report 2011/201
Ports of Stockholm	Sweden	M	-	12	Annual Report 2013
Grand Port Maritime de Nantes St-Nazaire	France	L	-	11	Environmental report 2014
Port of Odense	Denmark	M	-	8	Environmental report 2013-2014
Dublin Port Company	Ireland	L	-	7	Report 2013
Port of Rotterdam	Netherlands	L	-	4	Annual Report 2009
Grand Port Maritime du Havre	France	L	-	3	Port website
Port of Oslo	Norway	M	-	3	Port website
Port Authority of Genoa	Italy	L	-	1	Port website
Bruges-Zeebrugge Port Authority	Belgium	L	-	1	Port website
Cyprus Ports Authority	Cyprus	M	-	0	-
Klaipeda State Seaport Authority	Lithuania	L	-	0	-
Port of Setubal	Portugal	L	-	0	-
Patras Port Authority	Greece	S	-	0	-
Authority for Transport in Malta	Malta	S	-	0	-
Port Authority of Civitavecchia	Italy	M	-	0	-
Zeeland SeaPorts	Netherlands	L	-	0	-
Port of Gdynia Authority	Poland	M	-	0	-
Port Authority of Piombino	Italy	M	-	0	-
Port of Amsterdam	Netherlands	L	-	0	-
Administraţia Porturilor Maritime S.A. Constanţa	Rumania	L	-	0	-
Port of Kalundborg	Denmark	S	-	0	-

Port of Split Authority	Croatia	S	-	0	-

2. Non-European port authorities

Name	Country	Size	Aspects	Indicators	Document
Esperance	Australia	M	4 N/A	5	Annual marine sediment monitoring report 2014 Annual ambient air quality monitoring report 2014
Dakar	Senegal	M	6 N/A	4	Environmental and social management plan summary
Melbourne	Australia	L	-	7	Sustainably managing Factsheet September 2011. Safety and Environment Management Plan. October 2014
Sidney	Australia	L	-	7	Green Port Guidelines 2006 Ship Noise Monitoring Report 2015 Sustainability report 11/12.
Durban	South Africa	L	-	3	NPA Sustainability Report 2003
Montevideo	Uruguay	M	-	0	Comunicación proyecto nº7. Terminal granelera. Puerto de Montevideo. 2008.
Los Angeles	USA	L	-	19	Air quality report card 2009 Summary of Sediment Quality Conditions in the Port of Los Angeles 2010
Singapore	Singapore	L	-	15	Annual report 2014
Karachi	Pakistan	S	-	13	Website (www. http://kpt.gov.pk/)
Kuantan	Malaysia	M	-	11	Surface Water Contamination Due To Industrial Activities in Gebeng Area, Kuantan, Malaysia.
Abbot point	Australia	M	-	10	Cumulative assessment of the air emissions at the Abbot Point coal terminals. October 2012 Technical report marine water quality. August 2012
Santos	Brazil	L	-	10	Dados da coleta. Resultados analíticos
Manatee	USA	M	-	5	Port Manatee Master Plan 2009
Long Beach	USA	L	-	5	Air Quality Monitoring 2013 Annual report 2005
Buenos Aires	Argentina	M	-	5	Tercera conferencia hemisférica sobre gestión del medio ambiente portuario. 2012.
Shangai	China	L	-	5	Ship emissions inventory, social cost and eco-efficiency in Shanghai Yangshan port.
New York/ New Jersey	USA	L	-	4	A Clean Air Strategy For The Port of New York and New Jersey 2009
Cape Town	South Africa	M	-	4	Air Quality Specialist Report 2014.
Jacksonville	USA	M	-	3	Dames Point Marine Terminal Intermodal Container Transfer Facility (ICTF). Draft Environmental Assessment. 2012

Dubai	United Arab Emirates	L	-	3	Modeling Selected Water Quality Parameters at Jebel Ali Harbour, Dubai- UAE; Maraqa et al., 2007
Jeddah	Saudi Arabia	L	-	3	Determination of Heavy Metals in Four Common Fish, Water and Sediment Collected from Red Sea at Jeddah Isalmic Port Coast
Digna	Sudan	S	-	3	Environmental Impact Assessment (EIA) in Osman Digna (Suakin) Harbour. 2007
Hong Kong	Hong Kong	L	-	2	Website (www.mardep.gov.hk)
Port Klang	Malaysia	L	-	2	Distribution and Contamination of Heavy Metal in the Coastal Sediments of Port Klang, Selangor, Malaysia
Balboa	Panama	L	-	1	Studies of the Carbon Footprint for a Port in the Panama Canal
Chennai	India	S	-	1	Chenai port trust 2012
Papetee	French Polynesia	S	-	1	Coral and fish communities in a disturbed environment: Papetee harbor (Tahiti), 2000
Tangier	Morocco	L	-	1	Website (http://www.tmpa.ma)
Cartagena	Colombia	L	-	0	-
Cozumel	Mexico	S	-	0	-
Aguirre	Bolivia	S	-	0	-
Khor Fakkan/ Shargah	United Arab Emirates	L	-	0	-
Hilo	USA	S	-	0	-
Freeport	USA	S	-	0	-
Shenzhen	China	L	-	0	-
Da Nang	Vietnam	M	-	0	-
Tamjung Pelepas	Malaysia	L	-	0	-
Alexandria	Egypt	S	-	0	-
Malborought	New Zealand	S	-	0	-

3. Port Operators

Name	Country	Aspects	Indicators	Document
Terminal de Contenidors de Barcelona (TCB)	Spain	13 N/A	19	Declaración Ambiental EMAS III 2011
Terminal de Contenedores de Gijón (TCG)	Spain	11 N/A	9	Declaración Ambiental EMAS III 2012
Terminal Carbón del Puerto de Ferrol	Spain	30 N/A 11 E	22	Environmental Declaration 2012
TEPSA. Terminal de Bilbao	Spain	3 N/A	13	Environmental Declaration 2011
SAGGAS (Planta de Regasificación de Sagunto, S.A.)	Spain	14 N/A	21	Declaración Ambiental 2011
Decal España S.A. Terminal de Barcelona	Spain	10 N/A 4 E	23	Environmental Declaration 2012
Cosco Group	China	-	34	Sustainability report 2013

Maersk Group	Netherlands	-	11	Sustainability report 2014
DP World	United Arab Emirates	-	2	Annual Report and Accounts 14
PSA International	Singapore	-	0	Annual report 2014
Gdynia Container Terminal	Poland	-	0	-
Barcelona Europe South Terminal	Spain	-	0	-
Europe Containers Terminal	Netherlands	-	0	-

4. Marinas

Name	Country	Aspects	Indicators	Document
Club de Mar Mallorca	Spain	55 N/A 33 E	27	Declaración Ambiental 2011
Club Náutico Portosín	Spain	6 N/A	10	Declaración Ambiental 2012
Puerto Deportivo Bayona	Spain	4 N/A 12 E	28	Environmental declaration 2011
Marina Coruña	Spain	16 N/A	28	Declaración medioambiental 2012
Marina Port Vell Barcelona	Spain	31 N/A 7 E	11	Declaración ambiental 2013
Marina Port de Mallorca	Spain	7 N/A	13	Declaración ambiental Enero – Diciembre 2013
Puerto A Pobra do Caramiñal	Spain	41 N/A 8 E	22	Environmental Declaration 2006
Port ginesta	Spain	8 N/A	51	Declaració ambiental 2013
Marinas del Mediterráneo	Spain	-	0	-
Port Tarraco (marina)	Spain	-	0	-
Premier Marinas	United Kingdom	-	0	-
MDL Marinas	United Kingdom	-	0	-
Royal Ramsgate Marina	United Kingdom	-	0	-
Port Edgar Marina	United Kingdom	-	0	-
Port Ellen Marina	United Kingdom	-	0	-
Port Bannatyne Marina	United Kingdom	-	0	-
Port Dinorwic Marina	United Kingdom	-	0	-

Annex V: Compilation of port environmental aspects

This annex provides the comprehensive list of port environmental aspects in normal and abnormal conditions (120), the environmental aspects related to emergency situations (75), and the reduced list of aspects and their definition (17).

Comprehensive list of port environmental aspects (in normal and abnormal conditions)

Extensive list port environmental aspects (120)
Emissions to air (15)
Emissions of combustion gases
Emissions of combustion gases from the vehicles of the port authority
Emissions of combustion gases from propane boiler
Emissions of combustion gases from Diesel oil boiler
Emissions of combustion gases from machinery
Emissions of combustion gases from vessels
Emissions of combustion gases from transportation in the port area
Emissions of dust
Emissions of dust from port development / construction activities
Emissions of gases
Emissions of gases from paint spraying
Emissions of particulate matter
Emissions of Ozone Depleting Substances
Emissions of Volatile Organic Compounds
Emissions of smog from the kitchen
Discharges to water /sediments (9)
Discharges of wastewaters
Discharges of wastewaters produced by the machinery washing facility and run offs
Discharges of polluted waters
Discharges of hydrocarbons and their derivatives
Discharges of rainwater
Discharges of ballast water
Discharges of particulate matter
Quality of the ground water
Release of contaminants from dredging
Emissions to soil (6)
Quality of the soil

Emissions to soil and groundwater
Hydrocarbons stains in car park
Hydrocarbons stains in fuel pump
Paint stains
Sediment disposal from dredging
Resource consumption (18)
Water consumption
Water consumption in control tower
Water consumption for vessels
Water consumption in the port area
Electricity consumption
Electricity consumption in control tower
Paper consumption
Fuel consumption
Fuel consumption for clients
Energy consumption in the port area
Raw materials consumption in the port area
Chemical products consumption
Natural gas consumption
Gasoline consumption for the port authority
Gasoline provided to vessels
Diesel consumption for the port authority
Diesel provided to vessels
Batteries consumption
Waste production (46)
Generation of paper and cardboard
Generation of glass
Generation of plastic packages
Generation of organic matter
Generation of garbage
Generation of used batteries
Generation of empty packages of chemical products
Generation of aerosols
Generation of button batteries
Generation of alkaline batteries
Generation of used oil filters

Generation of used oil
Generation of polluted oil
Generation of oily waters
Generation of fluorescents, lights and tubes
Generation of fluorescents, lights and tubes that contain mercury
Generation of metal containers with rests of paint and solvent
Generation of fire-extinguishers
Generation of butane cylinders
Generation of contaminated absorbent material
Generation of absorbent material used after hydrocarbon spillage on land
Generation of expired flare
Generation of contaminated metal containers
Generation of contaminated plastic containers
Generation of chlorofluorocarbon (CFC)
Generation of painting residues
Generation of pruning and garden cleaning waste
Generation of outdated medicine
Generation of toner and ink cartridges
Generation of electrical, electronic, and computer equipment out of use
Generation of scrap metal
Generation of obsolete furniture
Generation of used tyres
Generation of dredging materials
Generation of wood and pallets
Generation of nets
Generation of vegetable oil
Generation of asbestos fibers used in pipelines
Presence of flotsam (floating debris)
Generation of waste from building works contracted by the port authority
Generation of waste from building works carried out within the port area
Generation of waste from loading and unloading of vessels
Generation of solid waste from ships (MARPOL Annex V) (Garbage)
Generation of bilge water from ships (MARPOL, Annex I type C)
Generation of sewage from ships (MARPOL Annex IV)
Generation of waste in the port area
Noise (10)

Noise emissions from port activities
Noise emissions from maintenance operations
Noise emissions from ship repair
Noise emissions from port development/construction activities
Noise emissions from the roads of the port area
Noise emissions from nightclub
Noise emissions at the morning
Noise emissions at the afternoon
Noise emissions at the evening
Affection for noise emissions in the bordering areas of the port
Odours (1)
Odour emissions
Ecosystems and habitats (2)
Ecosystems and habitats
Effects on the marine environment
Light pollution (1)
Light pollution
Other (12)
Visual impact
Managing internal transport reliant on fossil fuel
Managing electrically powered internal transport
Seabed dredging and deposition of marine sediments
Electromagnetic radiation
Radioactive radiation
Climate change
Heritage
Nature conservation objectives
Environmental performance of the concessions
Environmental performance of the contractor
Environmental performance of the supplier

Environmental aspects related to emergency situations (75)

Emergency situation	Emergency Environmental Aspects
Discharges to water (37)	
Accidental spillage of fuel during the provision to vessels from tanks	Discharges of hydrocarbons and their derivatives
Accidental spillage of fuel during the provision to vessels from ship or barge	Discharges of hydrocarbons and their derivatives
Accidental spillage of fuel during the loading of tanks	Discharges of hydrocarbons and their derivatives
Spillage of fuel from an inflatable boat	Discharges of hydrocarbons and their derivatives
Breakage of a fuel tank	Discharges of hydrocarbons and their derivatives
Spillage of bilge water from boats	Discharges of bilge water
Accidental spillages during loading and unloading of vessels	Discharges of chemical products
Breakage of tanks containing chemical products	Discharges of chemical products
Breakage of tanks containing mineral oil	Discharges of mineral oil
Breakage of tanks containing vegetable oil	Discharges of vegetable oil
Breakdown in the system of collection and treatment of waste waters	Discharges of untreated sewage (waste waters)
Overflow of industrial or municipal effluent	Discharges of untreated sewage (waste waters)
Shipwreck or abandon of vessels	Discharges of non-hazardous solid waste in the water body
Shipwreck or abandon of vessels	Discharges of hazardous solid waste in the water body
Shipwreck or abandon of vessels	Discharges of hydrocarbons and their derivatives
Shipwreck or abandon of vessels	Discharges of untreated sewage (waste waters) without affecting the marine environment
Shipwreck or abandon of vessels	Discharges of untreated sewage (waste waters) affecting the marine environment
Shipwreck or abandon of vessels	Discharge of oily waters
Shipwreck or abandon of vessels	Sinking of the vessel
Fire or explosion (facilities)	Discharges of chemical products
Fire or explosion (facilities)	Discharges of untreated sewage (waste waters)
Fire or explosion (facilities)	Discharges of mineral oil
Fire or explosion (facilities)	Discharges of vegetable oil
Fire or explosion (facilities)	Discharges of cooling water
Fire or explosion (facilities)	Discharge of substances used to extinguish the fire

Fire or explosion (boat)	Discharges of hydrocarbons and their derivatives
Fire or explosion (boat)	Discharges of oily waters
Fire or explosion (boat)	Discharge of substances used to extinguish the fire
Maritime accidents	Discharges of chemical products
Maritime accidents	Spills of hydrocarbons and their derivatives
Accidental spillage of harmful or toxic substances in low concentration	Discharges of non-hazardous solid waste in the water body
Accidental spillage of harmful or toxic substances in low concentration	Discharges of hazardous solid waste in the water body
Accidental spillage of harmful or toxic substances in high concentration	Discharges of non-hazardous solid waste in the water body
Accidental spillage of harmful or toxic substances in low concentration	Discharges of hazardous solid waste in the water body
Accidental spillage as a result of watering the port area	Discharges of hazardous solid waste in the water body
Accidental spillage as a result of watering the port area	Discharges of non-hazardous solid waste in the water body
Accidental spillage as a result of watering the port area	Discharges of particulate matter in the water body
Emissions to air (9)	
Accidental emissions of dry bulk during loading and unloading of vessels	Emissions of particulate matter affecting the port facilities
Accidental emissions of dry bulk during loading and unloading of vessels	Emissions of particulate matter affecting the local community
Fire or explosion (facilities)	Emissions of combustion gases
Fire or explosion (boat)	Emissions of combustion gases
Gas leak	Emissions of gases
Breakage of tanks containing chemical products	Emissions of gases
Mixture of chemicals	Emissions of gases
Accidental spillage of fuel during the provision to vessels	Emissions of VOC
Accidental spillage of fuel during the loading of tanks	Emissions of VOC
Emissions to soil (11)	
Overfilling of tanks	Spills of hydrocarbons and their derivatives
Overfilling of tanks	Spills of chemical products
Breakage of tanks containing chemical products	Spills of chemical products

Breakage of tanks containing petroleum products	Spills of hydrocarbons and their derivatives
Breakdown in the water system	Spills of untreated sewage (waste waters)
Fire or explosion (facilities)	Spills of hydrocarbons and their derivatives
Fire or explosion (facilities)	Spills of chemical products
Fire or explosion (facilities)	Spills of untreated sewage (waste waters)
Traffic accidents involving dangerous goods	Spills of chemical products
Traffic accidents	Spills of hydrocarbons and their derivatives
Spills from vehicles	Spills of hydrocarbons and their derivatives
Resource consumption (3)	
Fire or explosion (facilities)	Water consumption
Fire or explosion (boat)	Water consumption
Breakdown in the water system	Water consumption
Changes in marine ecosystems (2)	
Idem as 'discharges to water'	Discharges of hydrocarbons and their derivatives
Spillage of bilge water from boats	Discharges of bilge water
Waste production (13)	
Breakage of tanks containing chemical products	Generation of contaminated absorbent material
Breakage of tanks containing mineral oil	Generation of contaminated absorbent material
Breakage of tanks containing vegetable oil	Generation of contaminated absorbent material
Fire or explosion (facilities)	Generation of waste
Fire or explosion (boat)	Generation of waste
Fire or explosion (boat)	Generation of waste from used hydrocarbons barrier
Breakage of a fuel tank	Generation of waste from used hydrocarbons barrier
Shipwreck or abandon of vessels	Generation of waste from used hydrocarbons barrier
Accidental spillage of fuel during the provision to vessels	Generation of waste from used hydrocarbons barrier
Accidental spillage of fuel during the loading of tanks	Generation of waste from used hydrocarbons barrier
Maritime accidents	Generation of waste
Spill during the handling and storage of hazardous waste	Generation of contaminated absorbent material
Merchant and fishing vessels, and recreational boats	Generation of flare

Reduced list of aspects in normal conditions and their definition (17)

Aspects	Definition
Emissions to air (4)	
Emissions of combustion gases	This aspect refers to the gases emitted as a result of the combustion of fuels. Typical pollutants are CO2 (it is neither toxic nor noxious, but it is recognized as a greenhouse gas that contributes to global warming), CO (from incomplete combustion), HC/VOCs (from unburnt fuel), NOx (from excessive combustion temperatures), PM (mostly soot, impure carbon particles resulting from the incomplete combustion of hydrocarbons), ground level ozone (formed when NOx and VOCs react in the presence of sunlight), and SOx (mainly emitted by marine fuels).
Emissions of other gases	This aspect refers to the gases emitted as a result of the evaporation of hydrocarbons (Volatile Organic Compounds (VOCs)) or chemicals (chemical vapours).
Emissions of particulate matter	This aspect refers to the emissions of dust and other suspended particulate matter.
Odour emissions	Any release that produce unpleasant smell.
Discharges to water/sediments (4)	
Discharges of wastewaters	This aspect refers to the discharges of wastewaters into the water, which may deposit afterwards to the sediments. Wastewater is any water that has been adversely affected in quality by anthropogenic influence from domestic or industrial establishments.
Discharges of hydrocarbons	This aspect refers to the discharges of crude oil and other oil-related products into the water, which may deposit afterwards to the sediments.
Discharges of other chemicals	This aspect refers to the discharges of chemicals into the water, which may deposit afterwards to the sediments.
Discharges of particulate matter	It includes the discharges of dust into the water, which may deposit afterwards to the sediments.
Emissions to soil (1)	
Emissions to soil and groundwater	This aspect considers any spillage to the soil or groundwater, either hydrocarbons or chemicals.
Resource consumption (3)	
Water consumption	The amount of water that is consumed by a port authority or within a port area. Main water consumption sources in a port are cleaning and maintaining green areas, watering bulk cargo areas, cleaning machinery and vehicles, and the consumption in offices and toilets.
Electricity consumption	The amount of electricity that is consumed by a port authority. Main electricity consumption sources in a port are harbour lightning and port buildings’ heating and lightning, and electricity usage for cranes or lighthouses.
Fuel consumption	The amount of fuel that is consumed by a port authority. Main fuel consumption sources are stationary sources such as operational machines, cranes, heating or cooling; and mobile sources essentially company-owned vehicles such as cars or vessels.
Waste production (3)	

Generation of solid urban waste	Recyclable garbage is considered as the solid urban wastes, which include organic, cardboard and paper, plastics and glass.
Generation of hazardous waste	Hazardous wastes include, among others, liquid chemicals, ink cartridges, used oil, fluorescents, and batteries.
Generation of other waste	Non-hazardous industrial wastes include, among others, scrap metal, wood, electronic waste, oil filters, and tires.
Noise (1)	
Noise emissions	Noise is defined as unwanted sound. The majority of noise generated in a port is from ships and cargo handling. Since port operations both vessel and land based are ongoing 24 hours per day and 7 days a week, they generate noise that can disturb adjacent neighbours.
Effects on biodiversity (1)	
Ecosystems and habitats	Port activities may have direct influence on the existing biodiversity, in both terrestrial and marine environments. It is crucial to know which are the port activities that directly affect the habitat of the species and their natural behaviour

Annex VI: Description of the port activities

This annex provides the final description of the port activities (after the amendments suggested by the reviewers).

Activity	Description
Administrative services	This activity is based on the administrative services that the port develops, including staff working on the financial and commercial departments.
Marine-based cargo transport (Shipping)	Shipping involves the action of transporting cargo by sea with any type of vessel. This activity involves the shipping operations that are carried out within the port.
Land-based cargo transport	This activity concerns the land-based cargo transport operations that are carried out within the port, for the transportation of passengers, port workers, or products. It includes cars, trucks, train, among others.
Passengers transportation	This activity refers to the movement of passengers in the port due to their arrival/departure through ferries or cruises. It involves all the issues generated in the transfer and stay of people at the vessels.
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).
Disposal of dredged material	Dredged material is a resource that have to be disposed of in an environmentally sound manner. Beneficial use of dredged material includes beach and coastal-wetland nourishment, seagrass restoration, shoreline protection, and mangrove and saltmarsh wetland creation. If dredged material cannot be used beneficially, it should be placed in existing placement areas or on upland sites where levees can be used to contain the material.
Fishing & Aquaculture activities	Fishing is the activity of catching fish and aquaculture is the cultivation of freshwater and marine resources, both plant and animal, for human consumption or use.
Maintenance of port installations and infrastructure	Maintenance of port installations and infrastructure include the maintenance activities carried out on port buildings, gardens, roads, grounds, docks, among others.
Maintenance of port vehicle and equipment	Maintenance of port vehicle and equipment include the maintenance activities carried out on vehicles owned by the port authority and also on the port equipment. It includes mobile harbour cranes, container cranes, and straddle carriers, among others.
Ship building, repair and maintenance	Ship building, repair and maintenance include all those operations carried out to ensure the sea worthiness of the vessels. Among other activities, it includes the cleaning, repair and construction of the vessel.
Port development	Port development refers to the activities carried out either on land or at sea that involve construction works. The on land port development activities include building demolition, construction of new infrastructures for transferring cargo (e.g. wharves and berths), development of new buildings in the existing port area, cargo transfer facilities (e.g. gantry crane), storage facilities (e.g. silos), rails, pipelines, roads, installation or removal of pavement, and utility construction. At sea, port development

	includes the installation or replacement of navigation marks, piles, lights, vessel traffic schemes, flood defence and wave screens, among others
Marinas and yacht clubs	A marina is a dock or basin with moorings and supplies for yachts and small boats. A marina differs from a port in that a marina does not handle large passenger ships or cargo from freighters.
Water sports	There are a large number of sports involving water that may be carried out within or next to the port boundaries. The sports included in this section are the ones that use motorised vehicles, such as motorboat or a watercraft. Examples of sports are barefoot skiing, boat racing, or water skiing.
Port Waste Management	This activity refers to the collection and management of the waste generated within the port area as well as the port street cleaning.
Provision of port services:	
Bunkering	Bunkering is the action of supplying a ship with fuel.
Pilotage	Pilotage is guiding the captain to enter the ship into the port. A harbour pilot provides local navigation advice to the captain, since he/she has special local knowledge of the channels and how currents and winds can affect ships. When the ship is at sea, pilots usually use a boat to get on board, although in some places they may use helicopters.
Towing	Ships usually are slow to turn and take a long time to stop. When they are using only their own power, ships risk at damaging the dock and the ship itself. Towing is assisting a ship by one or more tug boats, which bring it towards the dock, so that it can berth safely. Although tugs are small, they have powerful engines, which can push a ship as well as use lines to pull it.
Mooring	Mooring is the act of making fast a vessel, by a cable or an anchor. Any ship has to be secured to the wharf or it will move, possibly damaging the ship and the wharf. The mooring line ties the ship to the wharf, and it may be reached by a mooring boat or by throwing the line at each end of the ship to the wharf. The end of the mooring rope is placed over a bollard on the wharf.
Ship Waste Reception	This activity includes the collection and management of the residues generated by ships. Regulations set by MARPOL (73/78) and the EC Directive 2000/59 on port reception facilities for ship-generated waste and cargo residues stipulate that ports should provide reception facilities for vessels to safely dispose and manage various types of wastes.
Provision of water to vessels	This activity consists of providing water to vessels that are moored at the port.
On-shore power supply	It is the provision of shore side electrical power to a ship at berth while its main and auxiliary engines are shut down. It improves the air quality in ports and port cities and reduces emissions of carbon dioxide and noise.
Port based industry:	
Aggregate industry	Aggregate industry is a broad category of particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world.
Chemical & pharmaceutical plants	A chemical plant is an industrial process plant that manufactures or processes chemicals, usually on a large scale. The general objective of a chemical plant is to create new material wealth via the chemical or biological transformation and/or separation of materials. Chemical plants use specialized equipment, units, and technology in the manufacturing process. Pharmaceutical plants are the ones that manufacture or process medicines.

Fish market and processing	The term fish processing refers to the processes associated with fish, from the time fish is caught or harvested to the time the final product is delivered to the customer.
Food Industry	The food industry is defined as the large-scale production, processing, and packaging of food using modern equipment and methods.
Metal ore processing and refining	Metal ore processing is the process of separating commercially valuable minerals from their ores. Refining consists of purifying an impure material, in this case a metal.
Oil/gas refineries and storage	This activity refers to the existence of oil and gas refineries and storage facilities within the port area. An oil refinery is an industrial process plant where crude oil is processed and refined into more useful products such as naphtha and diesel, among others. Gas refineries purifies and converts raw natural gas into residential, commercial and industrial fuel gas, and also recovers natural gas liquids (NGL) such as butanes and pentanes.
Power stations	A power station is an industrial facility for the generation of electric power. Most of the power stations burn fossil fuels (such as coal, oil, and natural gas) to generate electricity; however, other may use nuclear power or cleaner renewable sources such as solar, wind, wave and hydroelectric.
Steel works	Steel industry is the business of processing iron ore into steel which, in its simplest form, is an iron-carbon alloy. This industry also is responsible for turning that metal into partially finished products or for recycling scrap metal into steel.
Waste treatment plant	Existence of a plant within the port area aiming at the treatment of waste.
General manufacturing	Manufacturing industry refers to any business that transforms raw materials into finished or semi-finished goods using machines, tools and labour. This category includes any other industry not mentioned before, such as the production of textiles, machines and equipment.
Cargo handling and/or storage of:	
Containers	A shipping container is a large steel or aluminium container that may be filled with many types of small goods. It should have the strength enough to resist shipment, storage, and handling. Containers are stacked on top of each other in the ship’s holds and on the deck. A large proportion of the world's long-distance freight generated by international trade is transported in shipping containers.
Dry bulk	Dry bulk is solid cargo that is transported unpacked in large quantities. The major bulks are iron ore, grain, coal, phosphates, and bauxite. Other dry bulk commodities are cement, gypsum, or sulphur.
Oil, gas and petroleum products	This activity involves the transport of crude oil, refined products and LNG, carried through oil tankers. Crude oil is often transported from oil-producing countries to oil refineries.
Hazardous cargo (non-oil)	Hazardous cargo is any substance or material that can harm people, other living organisms, property, or the environment. It includes liquid chemical products (e.g. caustic soda, sulphuric acid, nitric acid, phosphoric acid, ammonia); liquefied gases; minerals (e.g. coal, sulfur, mineral concentrates), products of animal or vegetable origin (e.g. fishmeal, pressed cakes of oleaginous seeds and cotton, which can cause spontaneous combustion, fire or explosions); and radioactive materials. Although oily products are also regarded as hazardous products, there is a port activity exclusively for them.

Liquid bulk (non-oil)	Liquid bulk is liquid cargo that is transported unpacked in large quantities, excluding oil-derivative products and hazardous products. Examples of liquid bulk are water, cooking oil, fruit juices, and vegetable oil.
Perishable goods	Perishable goods are the ones that may decay, such as fish and fruit. As a result, perishable goods have to be refrigerated in order to be kept in good conditions.
Vehicles / Trade cars	This activity deals with the transport and storage of commercial vehicles.
Ro-Ro	Roll-on/roll-off (ro-ro) is wheeled cargo, such as automobiles, trucks, semi-trailer trucks, or trailers that are driven on and off the ship on their own wheels or using a platform vehicle.
General cargo	General cargo is any other type of cargo not mentioned before that a ship or barge might bring. It can include packaged or semi-packaged products (bags, boxes, pallets, bindings) from coffee or rice to steel, pipes or wind turbines.

Annex VII: Interactions between port activities and environmental aspects

This annex provides the interactions between the port activities and their related environmental aspects, as well as the points and the justification associated to each aspect.

ACTIVITY	ASPECTS	Points	JUSTIFICATION
Administrative services	Electricity consumption	5	From electricity usage in offices, lighting, computers, heating and cooling units, among others
	Fuel consumption	5	From heating and cooling units, among others
	Generation of recyclable garbage	3	Generation of paper and cardboard
	Generation of non-hazardous waste	3	Generation of toner and ink cartridges; electrical, electronic, and computer equipment out of use
	Water consumption	3	Water consumption in the offices and toilets
	Discharges of wastewaters	3	Discharges of wastewaters from sanitary waters and from the air cooling systems
Marine-based cargo transport (Shipping)	Emissions of combustion gases	5	From the fuel consumed by ships
	Discharges of hydrocarbons	5	From bilge water and from motor fuel leakage from ships
	Noise emissions	3	Noise generated by the engine of the vessels
	Discharges of wastewaters	3	Wastewaters from ships
	Discharges of other chemicals	3	Anti-fouling paints, garbage, and other residues
	Generation of hazardous waste	3	Production of different types of hazardous waste by ships that need to be managed according to the MARPOL convention
	Generation of recyclable garbage	3	Ships generate solid waste
	Generation of non-hazardous waste	3	Other wastes may be generated by ships such as electronic waste or oil filters
	Fuel consumption	1	Fuel is needed for the propulsion of the vessels
Land-based traffic	Emissions of particulate matter	3	During the transport of dry bulk particulate matter can be released. In addition, vehicle traffic rise the dust accumulated in dirty roads.
	Emissions of combustion gases	3	The use of cars and trucks for land-based transportation emit combustion gases such as CO_2, or NOx

	Fuel consumption	3	Land-based transportation needs the consumption of fuel
	Noise emissions	1	Noise may be generated by heavy trucks and other land-traffic in high sensitive areas
	Emissions to soil and groundwater	1	Spills or leaks of fuel from land traffic
	Generation of hazardous waste	1	Generation of waste such as batteries and generation of used oil
Passengers	Generation of recyclable garbage	5	Cruise and ferry vessels generate recyclable garbage such as paper, plastics, organic matter.
	Emissions of combustion gases	3	Emissions generated due to the secondary engines that are working while moored
	Discharges of other chemicals	3	Anti-fouling paints, detergents, and other residues
	Noise emissions	3	Noise is generated from secondary engines and passengers
	Discharges of wastewaters	3	Passengers may generate big amount of wastewaters that discharged from ships
	Water consumption	3	Cruises and ferries require a higher consumption of water
	Discharges of hydrocarbons	1	Oil of bilge and motor fuel leakage from ships
	Fuel consumption	1	Fuel is needed for the propulsion of the vessels
	Generation of non-hazardous waste	1	Other non-hazardous wastes may be generated by cruises and ferries
Dredging	Effects on biodiversity	5	Dredging activity may pose a direct affectation to biodiversity since it creates an immediate impact on the living organisms
	Discharges of particulate matter	5	Dredging operations remove the seabed and generate particulate matter at sea
	Discharges of other chemicals	3	Other chemicals may be released when dredged sediments are polluted by chemicals
	Discharges of hydrocarbons	3	From the HC accumulated in the sediments of the port area due to port activities
	Noise emissions	3	From the use of dredging equipment and power tools
	Fuel consumption	1	From the use of dredging equipment, vessels and power tools
	Emissions of combustion gases	1	Generated by the fuel consumption of the dredging equipment
	Generation of non-hazardous waste	1	For instance, sludge is generated by dredging operations

Disposal of dredged material	Effects on biodiversity	5	The disposal of dredged material on land may affect the biodiversity (e.g. communities of species have to be displaced)
	Discharges of particulate matter	3	The disposal of dredged material at sea generate the discharges of particulate matter
	Emissions to soil and groundwater	3	Polluted dredged material may leach and contaminate the soil
	Emissions combustion gases	1	The use of equipment to dispose dredged material generates emissions of combustion gases
Fishing & Aquaculture	Generation of recyclable garbage	5	Typical waste generated includes organic matter and packaging to transport fish
	Discharges of wastewater	3	From potential releases of water with high content of organic matter
	Odour emissions	3	Generation of odours originated in the fish handling or residues
	Effects on biodiversity	3	Fishing activities can affect the biodiversity (e.g. reduction of fish communities)
	Electricity consumption	3	Electricity consumption is increased due to this activity, for example by the use of cooling systems to storage fish
	Water consumption	1	Water consumption in the cleaning of boats and installations
	Emissions to soil and groundwater	1	Leached material from storage of waste from fishing activities
	Generation of hazardous waste	1	Oil filters and used oil from ships and refrigerated trucks
	Noise emissions	1	Originated from trucks and vessels
	Fuel consumption	1	Fuel is needed for the propulsion of the fishing boats
Maintenance of port installations and infrastructure	Generation of recyclable garbage	3	Such as plastics or rests of gardening
	Generation of non-hazardous waste	3	Such as scrap metal or building materials
	Electricity consumption	1	Consumption of electricity from the machinery
	Fuel consumption	1	From port vehicles used for cleaning and for maintenance operations
	Noise emissions	1	Generation of noise from the civil works and other machinery
	Emissions of combustion gases	1	From the machinery used to the tasks of cleaning and maintenance
	Generation of hazardous waste	1	From different activities such as painting, use of pesticides, batteries, fluorescent

			tubes, electric equipment. It also can include the packaging of toxic products and polluted building rubber
	Emissions to soil and groundwater	1	Soil may be polluted from spills or leaks of dangerous liquids (paints, solvent, oils, HC)
	Emissions of other gases	1	From chemical products, paints, … used in the maintenance of port installations
	Water consumption	1	From the tasks of cleaning the installations and maintenance of the green areas
Maintenance of port vehicle and equipment	Generation of hazardous waste	3	Waste generated in the maintenance activities, such as used oils, filters, paints, lubricants, or batteries
	Generation of non-hazardous waste	3	Waste generated in the maintenance activities, such as oil filters or tires
	Discharges of other chemicals	1	Other chemicals may be released from cleaning the machinery, tanks or polluted working surfaces
	Emissions to soil and groundwater	1	Soil may be polluted from spills or leaks of dangerous liquids (HC, paints, solvent, oils)
	Discharges of wastewaters	1	Wastewaters can be released when cleaning the port facilities
	Water consumption	1	Water is consumed in cleaning machinery and vehicles
	Electricity consumption	1	Electricity can be consumed when repairing equipment
	Fuel consumption	1	Fuel can be consumed when repairing equipment
	Discharges of hydrocarbons	1	In the replacement of the engines' oil of port vehicles or in adding lubricants to the equipment there may be spillages of hydrocarbons
Ship building, repair and maintenance	Generation of hazardous wastes	5	During this activity waste may be generated, such as used oils, filters, packaging of toxic products, batteries, fluorescent tubes, paint and solvent containers, contaminated absorbent material.
	Generation of non-hazardous waste	3	Waste is generated, such as building materials, scrap metal, or packaging.
	Noise emissions	3	Machinery used for vessel repairing and construction emit noise
	Odour emissions	3	Paints and other chemical products used to repair and maintain ships may emit odour
	Emissions of particulate matter	3	In the operations of repairing and constructing the vessels PM can be emitted
	Emissions of other gases	1	Emissions to air due to painting and other products

	Emissions of combustion gases	1	From the machinery used in the tasks of construction and reparation of vessels
	Discharges of other chemicals	1	Leakages of painting and solvents in the cleaning of the vessels' hull
	Water consumption	1	Water is consumed for the cleaning of boats
	Electricity consumption	1	Electricity is consumed in the use of the machinery used in the tasks of ships' building and repairing
Port development	Emissions of particulate matter	5	Construction works may generate emissions of particulate matter
	Discharges of particulate matter	5	The particulate matter that is generated may be discharged to water
	Effects on biodiversity	5	Construction activities generate direct effects to the biodiversity (displacement or extinction of species, …)
	Noise emissions	3	Large levels of noise may be generated from the construction works
	Generation of non-hazardous waste	3	Large amount of construction waste may be generated by port development activities
	Emissions of combustion gases	3	Combustion gases are generated by the machinery used for port construction
	Fuel consumption	1	Fuel is needed by the machinery that carries out the main operations for the port expansion
	Electricity consumption	1	Electricity is also needed to carry out other operations for the port expansion
Marinas and yatch clubs	Discharges of hydrocarbons	3	Discharges of fuel can be generated by daily refuelling and oil leaks from pleasure crafts
	Generation of hazardous waste	3	Oil and oily residues may be generated by boats and yachts
	Generation of non-hazardous waste	3	Other wastes may be also generated in marinas, such as wood and pallets, nets, flotsam.
	Fuel consumption	3	Consumption of fuel provided to vessels
	Emissions of combustion gases	3	The use of yachts and recreative vessels generate emissions of combustion gases
	Electricity consumption	1	In marinas, electricity is provided to small boats and yachts
	Noise emissions	1	The use of yachts and recreative vessels may generate noise
	Generation of recyclable garbage	1	Solid urban waste is generated in marinas
Watersports	Discharges of hydrocarbons	3	Gasoline and diesel oil leakages from water sports motors

	Emissions of combustion gases	3	Emissions generated from the consumption of fuel
	Fuel consumption	3	Fuel is needed in the motorized water sports
	Noise emissions	3	Noise is also generated in motorized water sports
Port Waste Management	Discharges of wastewaters	3	In cleaning the port streets and roads, waste waters may be generated and discharged
	Odour emissions	3	Waste management processes generate odour
	Discharges of other chemicals	3	Detergents and other products may be used to clean port installations, streets. And they may be discharged at sea
	Noise emissions	3	Noise is generated in the collection and management of the waste
	Fuel consumption	1	Fuel is needed in the port waste management, especially for the trucks that collect rubbish
	Electricity consumption	1	Electricity is needed to carry out processes for the port waste management
	Water consumption	1	In these processes, water is consumed to clean the containers
	Emissions to soil and groundwater	1	Due to potential infiltration of wastewater or other chemicals used in the street cleaning
	Emissions of combustion gases	1	Combustion gases are emitted from the fuel consumed for this activity
Provision of port services:			
Bunkering	Discharges of hydrocarbons	5	This activity is highly likely to produce leakages of fuel, introducing hydrocarbons into the sea
	Emissions of other gases	3	Volatile Organic Compounds are emitted in this activity
	Fuel consumption	1	The bunkering process requires fuel in order to pump the combustible to the ships
	Emissions of combustion gases	1	Combustion gases are generated related to the fuel consumption
	Noise emissions	1	Noise is generated during the bunking process due to the machinery used to provide fuel to ships
Pilotage	Emissions of combustion gases	1	From the fuel consumed by the pilot boat
	Noise emissions	1	From pilotage activities
	Discharges of hydrocarbons	1	Bilge water and motor fuel leakage from the pilot boat

	Fuel consumption	1	Fuel is needed for the propulsion of the pilot boat
Towing	Emissions of combustion gases	1	From the fuel consumed by the tug boat
	Noise emissions	1	From the towing the activities
	Discharges of hydrocarbons	1	Bilge water and motor fuel leakage from the tug boat
	Fuel consumption	1	Fuel is needed for the propulsion of the tug boat
Mooring	Emissions of combustion gases	1	From the fuel consumed by the ship in the process of mooring
	Fuel consumption	1	Fuel is needed by the ship while it is mooring
Ship Waste Reception	Odour emissions	3	Odour is generated in the ship waste management processes
	Water consumption	1	Water is used in the processes in the waste management in order to clean the facilities
	Fuel consumption	1	Fuel is needed by the vehicles that carry out the processes for the ship waste management (collection, distribution of garbage)
	Emissions of combustion gases	1	Combustion gases are emitted from the fuel consumed for this activity
Provision of water to vessels	Water consumption	5	In the activity of provision of water to vessels, water is definitely consumed within the port area
On-shore power supply	Electricity consumption	5	The activity of providing shore side electricity to vessels implies an extra consumption of electricity within the port area
Port based industry:			
Aggregate industry	Emissions of particulate matter	5	Particulate matter are typical emissions generated from the aggregate industry such as cement production, gravel or sand.
	Discharges of particulate matter	5	The particulate matter that is generated may be discharged to water
	Noise emissions	3	Noise may be generated derived from this industrial activity
	Electricity consumption	3	Electricity is consumed to carry out the development of this industry
	Water consumption	1	It is known that aggregate industry requires water for its development
Chemical & pharmaceutical plants	Emissions of other gases	5	Chemical and pharmaceutical plants may release chemical products to the atmosphere
	Discharges of other chemicals	5	Chemicals may be discharged to water originated from chemical industries

	Generation of hazardous waste	3	These plants may generate hazardous waste related to chemical processes
	Emissions to soil	3	Emissions to soil may be generated due to spills of chemical products from the plant
	Fuel consumption	3	Fuel is consumed to carry out the development of this activity
	Emission of combustion gases	3	The consumption of fuel produces emissions of combustion gases
	Water consumption	1	Water is needed for the development of these industrial activities
	Electricity consumption	1	Like in most of the industries, electricity is consumed to carry out the development of this activity
Fish market and processing	Odour emissions	5	Fish market and processing industry is highly likely to generate odour emissions
	Discharges of wastewater	3	Discharges of water with high content of organic matter can be derived from this activity
	Generation of recyclable garbage	3	Recyclable garbage can include for example organic matter and packaging used to transport fish
	Water consumption	3	Water is needed for the development of these industrial activities
	Electricity consumption	1	Electricity is consumed to carry out the development of this activity
Food industry	Odour emissions	5	Food industries are likely to produce odour emissions
	Generation of recyclable garbage	3	It is expected that the food industry may generate recyclable waste, especially organic waste and plastics
	Water consumption	3	Water is needed for the development of these industrial activities
	Discharges of wastewaters	3	The processes generated in the food industries may generate discharges of wastewaters
	Fuel consumption	1	Fuel is consumed to carry out the development of this activity
	Electricity consumption	1	Electricity is consumed to carry out the development of this activity
	Emission of combustion gases	1	The consumption of fuel produces emissions of combustion gases
	Noise emissions	1	Although it is in a lower level compared to other industries, noise may be generated derived from this industrial activity

Metal ore processing and refining	Emissions of combustion gases	5	The consumption of fuel produces emissions of combustion gases
	Emissions of particulate matter	5	It generates emissions of particulate matter from the metal ore to the atmosphere
	Discharges of particulate matter	5	The particulate matter may be discharged to the water
	Discharges of wastewaters	3	Wastewaters may be discharged as a result of this industrial activity
	Noise emissions	3	This kind of industry generates high levels of noise emissions
	Fuel consumption	3	Fuel is needed and consumed in this type of industry
	Electricity consumption	1	Electricity is another resource required to carry out the operations related to metal ore processing and refining
	Water consumption	1	Water is consumed in this type of industry
Oil/gas refineries and storage	Emissions of other gases	5	VOCs are likely to be generated since this activity deals with petroleum products
	Discharges of hydrocarbons	5	Discharges of hydrocarbons are highly likely to be generated in refineries
	Generation of hazardous waste	5	Hazardous waste (related to oily products) are likely to be generated in oil refineries
	Emissions of combustion gases	5	The consumption of fuel generates the emission of combustion gases
	Emissions to soil and groundwater	3	Spills of hydrocarbons from oil refineries may generate emissions to soil and groundwater
	Fuel consumption	3	Fuel is consumed to carry out the operations of the refineries
Power stations	Emissions of combustion gases	5	Power stations generate electricity and in most of the cases large amount of combustion gases are emitted
	Fuel consumption	3	Fuel is consumed to generate electricity in the power stations
	Water consumption	1	Water is needed for the development of these industrial activities
Steel works	Emissions of combustion gases	5	This type of industry typically generates a large amount of combustion gases due to the high consumption of fuel
	Noise emissions	5	Noise emissions are particularly high in this activity
	Emissions of particulate matter	5	Steel industry is considered to have a high rate of particulate matter emissions
	Discharges of particulate matter	3	The particular matter that are generated can be discharged into the port waters

	Generation of non-hazardous waste	3	Steel industry can generate large amounts of other wastes, such as scrap metal
	Fuel consumption	3	Fuel is needed and consumed in this type of industry
	Water consumption	1	Water is a resource indispensable to carry out the processes
	Electricity consumption	1	Electricity is needed to carry out the normal development of the industry
Waste treatment plant	Odour emissions	5	Odour emissions is the main aspect associated to this activity
	Emissions of combustion gases	3	Combustion gases are also generated in this industry, since energy is consumed
	Noise emissions	1	Noise is emitted, although it is not the main related aspect of this activity
	Fuel consumption	1	Fuel is needed to carry out these processes
	Water consumption	1	Although, it is not the most important related aspect, water may be consumed in this activity
General manufacturi ng	Emissions of combustion gases	3	Combustion gases are generated in this industry and they are one of the main aspects
	Noise emissions	1	Noise are emitted, although it is not the main related aspect
	Fuel consumption	1	Fuel is needed to carry out these processes, like in the other industries
	Water consumption	1	In general manufacturing, water is also consumed in order to carry it out
Cargo handling and/or storage of:			
Containers	Electricity consumption	3	From cranes that load and unload the containers. Reefer containers have an increased consumption
	Noise emissions	3	Generation of noise from the machinery of the containers' handling
	Emissions of combustion gases	1	From loading and unloading machines and other activities related to containerized merchandise
	Fuel consumption	1	From the machines and vehicles that transport containers
Dry bulk	Emissions of particulate matter	5	Particulate matter may be emitted from runoff, spills, or leakages during the cargo loading, unloading or storing in piles at the open air
	Discharges of particulate matter	5	Runoff from material storage, spills from bulk cargo handling, and wind-blown dust may contaminate port waters

	Fuel consumption	1	Consumption of fuel from the vehicles that transport the dry bulk from/to the silo or outside the port
	Emissions of combustion gases	1	Combustion gases are originated from the vehicles that transport goods and from the machinery used to load and unload the cargo
	Noise emissions	1	Generation of noise from the machinery used for the cargo handling
	Water consumption	1	Water may be used to prevent the spreading of the bulk cargo by watering it
	Electricity consumption	1	Consumption of electricity used by the cranes that load and unload the dry bulk
Oil, gas and petroleum products	Odour emissions	3	Odours may be generated in the activities of loading and unloading petroleum products
	Discharges of hydrocarbons	3	There may be spillages of hydrocarbons in the activities of loading and unloading petroleum products, from vessels to storage tanks, and vice versa
	Emissions of other gases	3	Emissions of VOC's are produced in the loading and unloading of petrochemicals in a port
	Emissions to soil and groundwater	3	The handling or storage of petrochemicals may generate leached materials, which affect the soil and groundwater
	Emissions of combustion gases	3	From vehicles that transport petroleum products and from machinery used to load and unload the cargo
	Electricity consumption	1	Electricity is consumed by the cranes that carry out the loading and unloading of this cargo
	Generation of hazardous waste	1	Polluted wastes may be generated in developing this activity, for instance in cleaning the tanks that storage this products
	Fuel consumption	1	Consumption of fuel used by the vehicles that transport the oil products
Hazardous cargo (non-oil)	Generation of hazardous waste	5	The handling of hazardous cargo may generate hazardous waste. Hazardous waste may be also generated in the cleaning of tanks that contain hazardous cargo
	Emissions to soil and groundwater	3	From leached material of the storage area to the soil or groundwater
	Discharges of other chemicals	3	Discharges of hazardous cargo may introduce chemicals to the port waters and well as in the cleaning of tanks
	Emissions of other gases	3	Hazardous cargo, such as liquid chemical products or liquefied gases, may release vapours

	Fuel consumption	1	Consumption of fuel used by the vehicles that transport the hazardous products from/to the tank or outside the port
	Electricity consumption	1	Consumption of electricity used by the cranes that carry out the loading and unloading of goods
	Emissions of combustion gases	1	From the vehicles that transport goods and from the machinery used to load and unload the cargo
Liquid bulk (non-oil)	Emissions to soil and groundwater	3	The storage and handling of liquid bulk may produce leakages into the soil
	Discharges of other chemicals	1	The cleaning activities of tanks may release polluted waters
	Generation of hazardous waste	1	The cleaning of the tanks were these products are stored may generate hazardous waste
	Electricity consumption	1	Consumption of electricity used by the cranes that carry out the loading and unloading of goods
	Fuel consumption	1	Consumption of fuel used by the vehicles that transport these liquid bulk products from/to the tank or outside the port
	Water consumption	1	Water is consumed for cleaning the tanks
	Emissions of combustion gases	1	From the vehicles that transport the liquid bulk and from the machinery used to load and unload this cargo
Perishable goods	Odour emissions	3	Perishable goods are more likely to produce odour emissions
	Electricity consumption	3	Perishable goods have an extra consumption of electricity to keep them refrigerated
	Fuel consumption	1	Consumption of fuel used by the vehicles that transport goods
	Emissions of combustion gases	1	Emission of combustion gases and particles originated from the vehicles that transport goods and from the machinery used to load and unload the cargo
	Generation of recyclable garbage	1	Perishable goods may generate organic matter and wastes from the packaging
Vehicle / trade cars	Emissions of combustion gases	5	From the vehicles that transport goods and from the machinery used to load and unload the cargo
	Noise emissions	3	Noise is generated in the traffic of the vehicles
	Discharges of hydrocarbons	1	Leakages of hydrocarbons from the vehicles may be generated

Ro-ro	Noise emissions	5	Noise is generated by the ro-ro vehicles
	Emissions of combustion gases	5	Carbon emissions are generated from the fuel consumed by the ro-ro vehicles
	Emissions of particulate matter	3	Ro-ro vehicles can emit particulate matter in case they are bringing dry bulk cargo (e.g. gravel, sand)
	Discharges of hydrocarbons	1	Leakages of hydrocarbons from the vehicles may be generated
General cargo	Emissions of combustion gases	3	Combustion gases are generated due to the loading and unloading of general cargo
	Noise emissions	3	Cranes and machinery that is used to carry out this activity may generate noise
	Generation of recyclable garbage	3	General cargo involves a wide range of products, and it is highly likely to generate plastics from packaging
	Fuel consumption	1	Fuel is needed in order to load and unload general cargo
	Electricity consumption	1	The development of this activity requires electricity (e.g. cranes, elevators)

Annex VIII: Criteria for evaluating environmental aspects

1. Comprehensive list of criteria (23)

Frequency (aspect/impact)
Extent of the impact
Local context
Reversibility of the impact
Hazardous profile of the substance
Persistence and the transport on the environment
Stakeholders' concerns
Legal compliance
Compliance difficulties
Organisation responsible
Environmental prosecutions
Quantity
Toxicity
Detection
Degree of operational control
Duration
Treatment
Economic concerns
Gas leakage
Aspect scope
Severity of impact
Noise, odours, visual impact, and lighting pollution
Consumption of natural resources

2. Reduced list of criteria (8) and their possible responses and weight

Final version after the validation of the methodology

Frequency: How often is this aspect generated?
- Continuously (5)
- At least once a day (4)
- At least once a week (3)
- Less than once a week (1)

Aspect duration: How long does the aspect last?

- More than 1 day or it is continuous (5)
- Between 8 hours and 1 day (4)
- Between 3 and 8 hours (3)
- Between 1 and 3 hours (2)
- Less than 1 hour (1)

Extent of the impact: Which is the area of influence of the impact?

- The effects are spread outside the port boundaries and it is located next to a sensitive place (e.g. city, protected area) (5)
- The effects are spread outside the port boundaries, however, it is not located next to a sensitive place (4)
- The effects are spread only within the port boundaries (3)
- The effects are located exactly in one point (1)
- There is no effects or impacts associated to this aspect (0)

Severity of impact: Which is the severity of the impact of this aspect?

- High or severe (5)
- Moderate (3)
- Minimal or low (1)

Stakeholders' complaints: How many complaints have been received on this aspect during the last year?

- Five or more complaints (5)
- Between two and four complaints (3)
- One complaint (1)
- No complaints (0)

Legal compliance: Is the aspect affected by legal requirements?

- Yes, and permissible levels are exceeded, receiving fines for this (5)
- Yes, and permissible levels are exceeded, but no fine has been received for this (4)
- Yes, and permissible levels are not exceeded (1)
- No (0)

Quantity of waste: Which is the relation between this waste generated on the current year (Q_1) compared to the generated on the previous one (Q_0)?

$Q_1/Q_0 > 1.05$	High (5)
$1 \leq Q_1/Q_0 < 1.05$	Medium (3)
$Q_1/Q_0 < 1$	Low (1)

Consumption of natural resources: Which is the relation between this resource consumption on the current year (Q1) compared to the consumption on the previous one (Q0)?

$Q_1/Q_0 > 1.05$	High (5)

$1 \leq Q_1/Q_0 < 1.05$	Medium (3)
$Q_1/Q_0 < 1$	Low (1)

Annex IX: List of indicators collected and their sources

The table below shows the sources of the indicators with their corresponding number, as they appear later in the tables of indicators.

Sources	Number
PPRISM	1
ESPO Questionnaire	2
Global Reporting Initiative (GRI)	3
SDM	4
EPI ECOPORTS	5
Research studies	6
Legislation	7
Port environmental reports	8
Port organisations	9
EMS standards	10
INDAPORT	11

The indicators provided below include already the amendments provided by the TEAP and TEIP reviewers. The total number of indicators identified is 648. It is distributed in the following way:

	Indicators rejected in the application of the first filter	294
	Indicators regrouped	148*
	Indicators rejected in the application of the second filter	72
	Resulting indicators	134

*This total amount of 148 indicators are regrouped into a list of 39 (Annex XI), which are added to the resulting indicators (134) to obtain a final list of 173 (see Annex XII).

Environmental management

Environmental management indicators		Sources										
		1	2	3	4	5	6	7	8	9	10	11
Environmental Management System	Does the Port have a certified Environmental Management System (EMS)?	1							1			
	Number and type of EMS certifications	1				1	1	1	1			
	Year(s) of certification (number of years and year)	1				1						
	Is the port EMS re-certified?								1			
	Has the port completed the environmental review Self Diagnosis Method?	1										
	Have any customers requested the port to be EMS certified?	1										
	Is there a procedure to review the port's EMS program?				1							
	Number of tenants with an EMS								1			
	Number of suppliers with an EMS								1			
	Level of implementation of EMS in port facilities (% of third parties certified)									1		

Environmental Policy	Does the port have an Environmental Policy?	1			1				1			
	Is the policy signed by the Chief Executive / senior management?	1			1							
	Is the policy communicated to all relevant stakeholders?	1			1				1			
	Is the policy communicated to all employees?	1			1				1			
	Is the policy publicly available on the port's website?	1			1				1			
	Does the policy include reference to major objectives?	1			1							
	Does the policy include reference to publication of an Environmental Report?	1			1							
	Does the policy include reference to the identification and control of the port's Significant Environmental Aspects?	1			1							
	Does the policy include reference to introduction / maintenance of an Environmental Management System?	1			1							
	Does the policy aim to improve environmental standards beyond those required by legislation?	1			1							
	Does the policy include reference to reduction of resource consumption?				1							
	Does the policy refer to sustainable development?				1							
	Does the policy refer to Corporate Social Responsibility (social integration)?				1							
	Does the policy include reference to ESPO Code of Practice (2003)?	1										
Objectives and targets	Has the port defined objectives for environmental improvement?	1	1		1							
	Has the port defined targets for its objectives?	1			1							
	Have the objectives and targets been communicated?	1			1							
	Does the port have quantitative objectives?	1			1		1					
	Number of environmental objectives defined	1							1			
	Number of environmental objectives and targets achieved	1					1		1		1	
	Number of organisational units involved in achieving the objectives and targets						1				1	
	Percentage of environmental targets achieved	1							1			
	Percentage of environmental objectives achieved								1			
	Have management programmes and action plans been prepared to achieve each objective?	1										
Environmental Monitoring Plan	Does the port have an environmental monitoring plan?	1			1				1			
	Has the port identified environmental indicators to monitor trends in environmental performance?	1			1							
	Which environmental issues addresses the monitoring program?		1						1			
	Number of environmental indicators monitored	1							1			
	Frequency of monitoring each parameter	1				1						
	Number of monitoring locations for each parameter	1										
	Is the port environmental management monitored?				1							
	Description of the measures implemented by de port authority in order to put in place the monitoring program									1		
	Does the port have an inventory of Significant Environmental Aspects?	1			1							

Significant Environmental Aspects	Does the inventory consider aspects from the activities of tenants and operators?	1			1							
	Are there procedures to maintain and update the inventory of SEA?				1							
	Number of Significant Environmental Aspects identified	1							1			
Management organisation & personnel	Does the port have a representative responsible for managing environmental issues?	1			1							
	Are all personnel aware of the responsibilities and authority of this representative?	1										
	Does the representative report to senior management?				1							
	Does the representative coordinate environmental management throughout the port?				1							
	Does the representative ensure compliance with environmental policy?				1							
	Does the representative have responsibility for implementation/maintenance of an EMS?				1							
	Does the representative monitor current environmental issues and legislation?				1							
	Are the environmental responsibilities of this representative documented?	1			1							
	Are the environmental responsibilities of other key personnel documented?	1			1							
	Which methods are used to document the environmental responsibilities of other key personnel (e.g. job descriptions, written procedures)?				1							
	Number of levels of management with specific environmental responsibilities	1					1				1	
	Number of employees who have requirements of professional competence on environmental matters in their jobs	1					1		1			
	Number of employees who have obtained reward and recognition in comparison to the total number of employees who participated in the programme										1	
	Percentage of employees working on environmental issues										1	
	Number of environmental improvement suggestions from employees										1	
	Number of suppliers and contractors queried about environmental issues										1	
Environmental training and awareness	Does the port authority have an environmental training programme for its employees?	1			1							
	Existence of training (crane drivers, lift truck operators) with regard to noise						1					
	Is the environmental training fitted to employees' activities and responsibilities?	1			1							
	Have all the personnel whose work may create an impact on the environment received appropriate training?	1										
	Are environmental issues included in introduction programmes for new employees?	1			1							
	Has the port authority established procedures for identifying training needs?	1										
	Annual number of environmental training courses for port employees	1				1			1	1		

	Number of employees who have requirements of professional competence on environmental matters in their jobs	1					1				1	
	Number of port employees trained in environmental issues	1	1			1	1		1			
	Number of suppliers and contractors that require environmental training						1					
	Annual number of hours invested on environmental training for port employees	1					1		1			
	Frequency of environmental training sessions for port employees	1				1						
	Percentage of port employees that received environmental training	1					1		1	1	1	
	Number of trained people working with hazardous cargo	1										
	Are all employees aware of the importance of compliance with environmental policy?	1			1							
	Are all employees aware of the potential environmental impacts of their work activities?	1			1							
	Are all employees aware of their responsibility to conform to the environmental policy and management objectives?	1			1							
	Are all employees aware of the objectives, actions and programmes carried out by the port in order to improve its environmental performance?	1			1							
	Annual number of training courses carried out / Annual number of training courses scheduled								1			
	Annual number of training hours per employee								1			
	Number of contracted individuals trained										1	
	Levels of knowledge obtained by training participants										1	
	Results of employee surveys on their knowledge of the organisation's environmental issues										1	
Environmental communication	Does the port publish a publicly available Environmental Report?	1	1		1	1	1					
	Does the port publish factual data by which the public can assess the trend of its environmental performance?	1										
	Are there procedures to communicate environmental information internally between the key environmental personnel?	1			1		1					
	Are there procedures to exchange port environmental information with stakeholders including external parties?	1			1		1					
	Which communications are used to communicate environmental information internally between the key environmental personnel?				1							
	Which communications are used to exchange port environmental information with stakeholders including external parties?				1							
	Are there procedures to consult with the Local Community on the port's environmental programme?	1			1		1					
	Frequency of meetings and consultations with external stakeholders	1					1		1			

	Number of internal meetings with key environmental personnel								1			
	Frequency of internal meetings with key environmental personnel	1										
	Annual number of environmental reports published	1				1				1		
	Annual number of press articles published concerning environment	1				1					1	
	Does the port website show environmental information?	1				1						
	Number of hours invested on environmental presentations given to stakeholders or interest groups	1	1			1	1					
	Annual number of conferences that the port authority has organized or participated in	1				1	1					
	Annual number of congresses and conferences attended by port employees concerning environment	1				1	1					
	Number of universities and research institutes co-operating with the port in the field of environment	1				1						
	Annual number of groups and students visiting the port for environmental education purposes	1					1					
	Number of environmental educational programmes or materials provided for the community										1	
	Favourable rating from community surveys										1	
	Port environmental impact score attributed by the local community								1			
	Port satisfaction survey: % of respondents that consider that the port is already taking serious measures for sustainability								1			
Emergency planning and response	Does the port have an Emergency Response Plan?	1			1	1			1	1		
	Does the port have an Emergency Response Plan specially designed for handling hazardous cargo?	1										
	Does the port have a Cargo Handling Plan to avoid accidents?	1										
	Does the port have an Oil Spill Response Plan?	1				1		1				
	Does the port have a Water Leakage Response Plan?		1		1							
	Number of response instructions defined for each emergency situation						1					
	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 (yes/no)?	1			1							
	Does the Emergency Response Plan specify the responsibility and role of each body: port authority, tenants and operators, ship agents, and external agencies?	1			1							
	Does the plan specify the communication, control and containment procedures?				1							
	Does the plan specify the location and type of equipment (on and off site)?				1							
	Does the plan specify the location and skills of trained personnel (on and off site)?				1							
	Does the plan specify the communication procedures with government departments, NGOs, local community, media and other interested parties?				1							
	Does the plan specify the responsibility for follow-up links?				1							

	Number of times that the Emergency Response Plan has been activated								1			
	Number of times that the Emergency Response Plan has been activated due to an on-land fire								1			
	Number of times that the Emergency Response Plan has been activated due to an off-shore fire								1			
	Amount of annual hazardous cargo handled	1							1			
	Total number and volume of (significant) oil and chemical spills	1	1	1		1		1	1			1
	Annual number of environmental accidents reported	1	1				1		1			
	Annual number of accidents at the port sea area								1			
	Annual number of bunkering-related pollution accidents	1				1		1				
	Annual number of vessel-related pollution accidents	1				1		1				
	Annual number of cargo-related pollution accidents	1				1		1				
	Annual number of environmental incidents reported		1					1	1		1	1
	Annual number of incidents with the need for intervention								1			
	Annual number of incidents with no need for intervention								1			
	Annual number of gas alarm incidents								1			
	Annual number of incidents related with the on land illegal dumping by third parties								1			
	Average response time in case of environmental accidents	1									1	
	Average response and correction time in case of environmental accidents	1					1					
	Maximum response time in case of environmental accidents	1										
	Frequency of safety equipment revisions	1										
	Does the port have a representative responsible for managing safety issues?	1										
	Are the responsibilities of this representative documented?	1										
	Are all the employees familiarised with safety regulations?	1										
	Has the port authority carried out an Environmental Risk Assessment during the last 5 years?	1					1					
	Number of Seveso II sites (sites containing large quantities of dangerous substances defined by the Directive 2003/105/EC)	1										
	Annual number of emergency drills	1									1	
	Annual number of emergency drills carried out / Annual number of emergency drills scheduled								1			
	Percentage of emergency preparedness and response drills demonstrating planned readiness										1	
	Number of hours of preventive maintenance to equipment per year										1	
Environmental audit	Has an external EMS audit been conducted?	1			1							
	Number of EMS audits conducted	1				1	1	1				
	Number of EMS audits completed versus planned										1	
	Number of nonconformities found in EMS audits	1	1									
	Number of nonconformities addressed	1										
	Time spent on addressing nonconformities	1										

	Number of identified environmental corrective actions that have been resolved or that are unresolved										1	
	Number of EMS audit findings										1	
	Frequency of review of operation procedures										1	
	Number of stakeholders audited								1			
Environmental legislation	Does the port have an inventory of relevant environmental legislation and regulations related to its liabilities and responsibilities?	1										
	Are there procedures to maintain and update the inventory of environmental legislation?	1										
	Are there methods to deal with non-compliance with internal and external standards?	1										
	Number of prosecutions received for non-compliance with environmental legislation	1										
	Number of fines received for non-compliance with environmental legislation	1					1	1			1	
	Monetary value of significant fines for non-compliance with environmental laws and regulations			1			1		1		1	
	Total number of non-monetary sanctions for non-compliance with environmental laws and regulations			1					1			
	Percentage of compliance with environmental legal requirements	1				1	1				1	
	Number of times that the daily limit value of a certain environmental parameter has been exceeded								1			
	Number of days in a year that the limit value is exceeded	1							1			
	Compliance with discharges of wastewaters legal limits		1						1			
	Compliance with discharges of oil legal limits		1									
	Compliance with discharges of other chemicals legal limits		1									
	Compliance with discharges of particulate matter legal values		1									
	Compliance with discharges of sediments legal limits		1									
	Compliance with limits at day, evening, and night time for noise level	1									1	
	Annual Number of environmental inspections	1							1			
	Total number of environmental licenses obtained	1										
	Total number of environmental licenses withdrawn or refused	1										
Environmental complaints	Total annual number of environmental complaints received	1	1						1	1		
	Annual number of environmental complaints received from NGOs	1										
	Annual number of environmental complaints received from people working in port area	1										
	Annual number of environmental complaints received from the Local Community	1										
	Annual number of environmental complaints received from port authority' employees	1										
	Annual number of dust-related complaints					1		1	1			
	Annual number of odour-related complaints		1									
	Annual number of noise-related complaints	1	1					1	1	1		
	Annual number of dredging-related complaints						1					
	Number of inquiries or comments about environmentally related matters										1	

	Total annual number of environmental complaints logged and investigated	1					1		1			
	Annual number of environmental complaints resolved where further action was necessary	1										
	Number of environmental complaints filed, addressed, and resolved through formal complaints mechanism			1								
	Annual number of environmental complaints resolved where no further action was necessary	1										
	Does the port have an environmental complaint registration system for following-up complaints from residents in the area?		1							1		
Environmental budget	Does the port have a budget specifically for environmental protection?	1										
	Total annual budget allocated to environmental protection	1	1	1					1			
	Amount of funding allocated to environmental training of employees	1			1							
	Amount of funding allocated to control environmental impacts	1			1							
	Amount of funding allocated to emergency response and prevention	1			1		1					
	Amount of funding allocated to environmental monitoring	1	1		1				1	1		
	Amount of funding allocated to stakeholder engagement and outreach activities	1			1							
	Amount of funding allocated to environmental reporting	1			1					1		
	Amount of funding allocated to biodiversity protection	1								1		
	Amount of funding allocated to waste collection and disposal								1			
	Amount of funding allocated to environmental liability insurance								1			
	Amount of funding allocated to external environmental management service								1			
	Amount of funding allocated to personnel engaged in comprehensive environmental management activities								1			
	Amount of funding allocated to the implementation and certification of an Environmental Management System								1			
	Amount of funding allocated to projects with environmental significance										1	
	Amount of funding allocated to support community environmental programmes										1	
	Amount of funding allocated to monitoring water quality										1	
	Amount of funding allocated to the treatment of contaminated soil	1				1		1			1	
	Investment costs of waste reception facility										1	
	Percentage of each environmental expense out of the total environmental budget								1			
	Percentage of the budget allocated to environmental protection out of the total budget	1							1			

	Percentage of annual variation in the environmental budget	1										
	Return on investment for environmental improvement projects										1	
	Savings achieved through reductions in resource usage, prevention of pollution or waste recycling										1	
	Environmental liabilities that may have a material impact on the financial status of the organisation										1	
Other Environmental management	Are copies of ESPO Environmental Review (2001) available in the port?	1										
	Are there procedures to involve all port users in the development of the environmental programme?	1										
	Are there initiatives to mitigate environmental impacts?			1					1			
	Number of significant environmental impacts of transporting products and other goods and materials for the organisation's operations, and transporting members of the workforce			1								
	Percentage of products sold and their packaging materials that are reclaimed			1								
	Significant negative environmental impacts in the supply chain			1								
	Percentage of new suppliers that were screened using environmental criteria			1								
	Number and description of initiatives implemented to prevent pollution	1					1				1	
	Number of solutions implemented to reduce pollution	1										
	Number of travel cards provided to port employees								1			
	Land use efficiency: percentage of the port area that is occupied by active installations								1		1	
	Number and frequency of specific environmental activities (e.g. audits)										1	
	Description of the conditions established for environmental-related aspects on the requirement form for port services under tender and concession companies									1		
	Longevity data for the population living around the port										1	
	Incidence of specific diseases, particularly among sensitive populations, from epidemiology studies in the port surroundings										1	
	Rate of population growth in the port surroundings										1	
	Population density in the port surroundings										1	
	Levels of lead in blood of the population living in the port surroundings										1	
	Measure of the condition of sensitive structures										1	
	Measure of the surface integrity of historical buildings in the port area										1	
	Involvement in Short Sea Shipping promotion										1	
	Total number of environmental management indicators: 238	132	21	10	62	24	32	12	65	13	48	2

Emissions to air

Emissions to air indicators	Sources										
	1	2	3	4	5	6	7	8	9	10	11

Emissions of combustion gases	Does the port measure or estimate its Carbon Footprint?	1										
	Does the port take measures to reduce its Carbon Footprint?	1										
	Total annual greenhouse gas (GHG) emissions	1		1			1	1	1	1	1	1
	Annual greenhouse gas (GHG) emissions from direct emissions (scope 1)	1		1					1			
	Annual greenhouse gas emissions (GHG) from energy indirect emissions (scope 2)	1		1					1			
	Annual greenhouse gas emissions (GHG) from other indirect emissions (scope 3)	1		1					1			
	Percentage of each scope contributing to the total emissions	1							1			
	Frequency of monitoring the Carbon Footprint in the port area					1						
	Percentage of each energy source contributing to the Carbon Footprint								1			
	Percentage of annual change in the Carbon Footprint	1							1			
	GHG emissions per TEU								1			
	GHG emissions per number of employees								1			
	Direct CO_2e emissions per number of employees								1			
	Indirect CO_2e emissions per number of employees								1			
	Kilometres driven by port vehicles	1	1			1		1				
	Number of vehicles in fleet with pollution-abatement technology										1	
	Number and description of initiatives implemented to reduce greenhouse gas emissions	1		1		1				1	1	
	Does the port differentiate dues for 'Greener' vessels?				1				1			
	Number of cargo movements by rail								1			
	Number of cargo movements by road								1			
	Ratio of truck to non-truck (rail, barge) cargo moves								1	1		
	Carbon monoxide (CO)	1				1	1	1	1	1	1	1
	Nitrogen oxides (NO_x)	1	1	1		1	1	1	1	1	1	1
	Sulphur dioxide (SO_2)	1	1	1		1	1	1	1	1	1	1
	Number of vessels participating in the Sulphur programme (aiming at reducing sulphur emissions)								1			
	Environmental benefits of the sulphur programme (emission reduction of SOx, NOx, PM, CO_2)								1			
	Description of the port activities that suppose the main sources of air emission									1		
	Schematic description of the operational teams available to the PA for monitoring air quality									1		
Emissions of other gases	Ammonia (NH3)	1						1				
	Halogenated compounds	1					1	1				
	Dioxins							1				
	Hydrocarbons (HC)	1	1					1	1	1		
	Heavy metals	1						1	1	1		
	Photochemical oxidant (Ox)	1					1	1				
	Ozone						1	1	1	1		1
	Ozone depleting substances (CFCs)			1			1	1	1		1	
	Volatile Organic Compounds (VOCs)	1	1				1	1	1			1
	Benzene								1			
	Polychlorinated biphenyl (PCB)							1				
	Frequency of photochemical smog events							1				
	Persistent Organic Pollutants (POPs)	1						1				
	Other harmful air pollutants (HAP)	1						1				

	Polycyclic Aromatic Hydrocarbons (PAHs)							1	1			
Emissions of particulate matter	Dust	1	1			1		1	1	1		
	PM10	1	1			1	1	1	1	1	1	1
	PM2.5	1	1			1	1	1	1	1	1	
	Mineral fibre particulate							1				
	Dust monitoring related to coal handling operations		1						1			
Odour emissions	Acetaldehyde	1										
	Ammonia	1										
	Hydrogen sulphide (H_2S)	1							1			
	Methyl disulphide	1										
	Methyl mercaptan	1										
	Methyl sulphide	1										
	Styrene	1										
	Trimethylamine	1										
	Percentage of respondents that perceive odour								1			
Other emissions	Quantity of radiation released										1	
	Amount of heat, vibration, or light emitted										1	
Meteorological data	Temperature									1		
	Humidity									1		
	Surface wind pattern (direction, speed, intensity, frequency)						1			1		
	Rainfall						1					
	Atmospheric pressure						1					
	Solar Radiation						1					
	Cloudiness						1					
	Total number of air emissions indicators: 66	32	9	8	0	9	16	23	33	17	11	7

Discharges to water/sediments

	Discharges to water/sediments indicators	Sources										
		1	2	3	4	5	6	7	8	9	10	11
Discharges of wastewaters	Percentage of reports with satisfactory results on water quality								1			
	Chlorophyll	1										
	Biological Oxygen Demand (BOD)	1	1				1	1	1			
	Chemical Oxygen Demand (COD)	1	1				1	1	1			
	Algal Growth Potential (AGP)	1					1	1	1			
	Dissolved Oxygen (DO)	1					1	1	1	1	1	
	Dissolved oxygen in surface waters								1			
	Dissolved oxygen in bottom waters								1			
	Number of ecological studies conducted in the port area	1										
	Inorganic ions	1						1	1			
	Sulphate						1					
	Total Phosphorus						1					
	Orthophosphates (dissolved inorganic phosphorus)						1					
	Total Nitrogen						1					
	Ammonium						1					
	Ammonia								1		1	
	Nitrite						1					
	Nitrate						1					
	Sulphide						1					
	Total coliform bacteria	1	1				1	1	1		1	
	Escherichia coli (E. coli)						1		1			
	Faecal coliforms						1		1			

	Faecal Streptococcus								1		1	
	Salmonella										1	
	Water pH	1	1				1	1	1		1	
	Redox potential	1						1	1			
	Total hardness						1					
	Total Organic Carbon (TOC)	1						1				
	Total Oxygen Demand (TOD)	1						1	1			
	Water colour	1					1	1	1			
	Water temperature	1	1				1	1	1	1	1	
	Zooplankton						1					
	Bacterioplankton						1					
	Phytoplankton						1	1	1			
	Description of the main sources of wastewater discharges in the port								1			
	Description of the main measures implemented by the port authority to control the discharges of wastewaters								1			
Discharges of hydrocarbons	Oil Content (Hydrocarbons)		1			1	1	1	1			
	Existence of water treatment system for oil spills					1						
Discharges of other chemicals	Organohalogenated substances							1				
	Halogen content	1						1				
	Complex organics	1						1	1			
	Conductivity	1	1				1	1	1			
	Water salinity	1	1				1	1	1		1	
	Specific simple organics	1						1				
	Heavy metals	1	1				1	1	1			
	Surfactants	1					1	1	1			
	Tributyltin (TBT)								1			
	Polycyclic Aromatic Hydrocarbons (PAHs)								1			
	Volatile Organic Compounds (VOCs)								1			
	Biocides								1			
	Other water pollutants	1										
	Inhibitory substances								1			
Discharges of particulate matter	Total Dissolved Solids (TDS)	1	1				1	1	1			
	Total Suspended Solids (TSS)	1	1				1	1	1		1	
	Settleable solids						1		1			
	Turbidity (water transparency)	1	1				1	1	1	1		
Sediments quality	Cyanogen compounds	1										
	Halogenated Hydrocarbon	1						1				
	Persistent Organic Pollutants (POPs)											
	Polychlorinated biphenyl (PCB)		1					1	1			
	Polycyclic Aromatic Hydrocarbons (PAHs)	1	1					1	1			
	Tributyltin (TBT)		1					1	1			
	Redox potential								1			
	Total Organic Carbon (TOC)						1		1			
	Organic Carbon						1		1			
	Amount of organic matter	1							1			
	Volatile Organic Compounds (VOCs)								1			
	Biocides								1			
	Total phosphorus						1		1			
	Orthophosphates (dissolved inorganic phosphorus)						1					
	Total Nitrogen						1					
	Nitrite						1					
	Nitrate						1					
	Kjeldahl nitrogen						1		1			

	Ammonium						1					
	Calcium						1					
	Nutrients	1	1					1	1			
	Sulphide (acid volatile sulphides)						1					
	Heavy metals	1	1				1	1	1			
	Sediments particle size distribution	1							1			
	Benthal oxygen demand						1					
	Number of FEPA (Food and Environmental Protection Act) sediments analysis		1									
	Percentage of reports with satisfactory results on sediment quality	1						1				
	Total number of discharges to water and sediment indicators: 83	33	18	0	0	3	44	33	51	3	9	0

Emissions to soil

Emissions to soil indicators		Sources										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Emissions to soil and groundwater	Electrical conductivity	1					1					
	Soil pH	1					1	1				
	Organic contaminants	1						1				
	Macronutrients	1						1				
	Water Content	1										
	Soil porosity	1										
	Bulk density	1										
	Soil Organic Matter	1					1					
	Total Organic Carbon (TOC)	1						1				
	Particulate organic matter	1										
	Soil occupation efficiency	1							1	1		1
	Total port area with soil pollution						1		1			
	Heavy metals	1	1				1	1				
	Land area rehabilitated in the port area										1	
	Redox potential						1					
	Hydrocarbons						1					
	Availability of a soil pollution map	1				1		1				
	Total number of emissions to soil indicators: 17	13	1	0	0	1	7	6	2	1	1	1

Resource consumption

Resource consumption indicators		Sources										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Energy consumption	Total annual energy consumption								1		1	1
	Total annual energy consumption by energy source	1					1	1	1		1	
	Percentage of each energy source	1					1					
	Energy consumption within the port authority			1								
	Energy consumption outside the port authority			1								
	Percentage of energy consumption by use								1			
	Energy consumption per cargo handled								1		1	
	Energy consumption per number of employees								1			
	Energy intensity			1								
	Direct energy consumption by primary energy source			1					1			
	Indirect energy consumption by primary energy source			1					1			
	Percentage of the annual variation in the energy consumption			1					1			

	Variation in the energy requirements of products and services			1								
	Energy saved due to conservation and efficiency improvements			1			1				1	
	Initiatives to provide renewable energy-based products and services			1					1			
	Number of energy-efficiency initiatives implemented	1										
	Initiatives to reduce indirect energy consumption and reductions achieved			1								
	Does the port have a programme to increase energy efficiency?	1										
	Does the port produce any form of renewable energy?	1							1			
	Total annual renewable energy generated								1			
	Total annual renewable energy consumed	1					1		1			
	Percentage of renewable energy per total energy consumed	1							1	1	1	
	Installed capacity of renewable energy								1			
	Installed capacity cogeneration								1			
	Annual energy use for port lighting										1	
Water consumption	Total annual water consumption	1	1				1	1	1	1		1
	Total annual water withdrawal by source			1			1	1	1			
	Percentage of water withdrawal by source								1			
	Total annual water consumption by use								1			
	Percentage of water consumption by use								1			
	Total annual water consumption per cargo handled								1			
	Total annual water consumption per number of employees								1			
	Daily average water consumption for cleaning de port area								1			
	Water sources significantly affected by withdrawal of water			1			1					
	Volume of unnacounted (lost) water								1			
	Water consumption from port's sources per number of employees								1			
	Annual rainwater used for cleaning de port area								1			
	Annual amount of recovered rainwater								1			
	Percentage of the port area that has a system for the collection and treatment of rainwater								1			
	Percentage of the annual variation in the water consumption								1			
	Total annual non-drinking water consumption								1			
	Total annual drinking water consumption		1						1			
	Cost per unit of water consumed		1				1					
	Total annual water recycled and reused	1						1				
	Percentage of water recycled per total water consumption	1		1								
	Total annual water consumption / square meters of the port service area			1					1	1		
	Annual number of water leakages		1									
	Percentage of showers and toilets with a water-saving system								1			
	Efficiency of the water distribution network: percentage for those Port Authorities that undertake the direct management of such distribution network									1		
	Change in groundwater level										1	

Electricity consumption	Total annual electricity consumption	1	1					1	1	1		1
	Average daily electricity consumption in port buildings								1			
	Electricity consumption per cargo handled								1			
	Electricity consumption per number of employees								1			
	Percentage of electricity consumption by use								1			
	Cost per unit of electricity consumed		1									
	Amount of electricity saved due to energy-efficiency improvements	1										
	Is Onshore Power Supply (OPS) available at one or more of the berths?	1			1							
	Annual number of vessels connected to shore-side electricity	1	1						1			
	Percentage of vessels calling at the port that connect to shore-side electricity								1			
	Amount of electricity provided to vessels (shore-side electricity)								1			
	Environmental benefits of shore-side electricity (emission reduction of SOx, NOx, PM, CO_2)								1			
	Percentage of low consumption lights compared to total number of lights	1	1									
	Total annual electrical energy consumption per square meters of the port service area									1		
Fuel consumption	Total annual fuel consumption by type	1	1						1			
	Percentage of fuel consumption by type								1			
	Percentage of fuel consumption by use								1			
	Annual fuel consumption per number of employees								1			
	Annual fuel consumption per travelled kilometre							1				
	Annual fuel consumption per cargo handled								1			
	Annual fuel consumption per square meters of the service area								1	1		
	Total annual gas consumption (NG, propane, …)								1			
	Total annual petrol consumption								1			
	Total annual gas oil consumption								1			
	Total annual fuel provided to port authority vessels								1			
	Total annual fuel provided to port authority vehicles								1		1	
	Annual natural gas consumption in port buildings								1			
	Average daily natural gas consumption in port buildings								1			
	Cost per unit of fuel consumption		1									
	Monthly Diesel oil consumption		1					1	1			
	Amount of fuel saved due to energy-efficiency improvements	1										
	Is Liquefied Natural Gas (LNG) bunkering available in the port today?				1				1			
Other Resources	Total annual paper consumption								1			
	Paper consumption per number of employees								1			
	Rechargeable batteries consumption / number total of batteries								1			
	Total annual consumption of lubricants								1			
	Total annual consumption of ink cartridges								1			
	Total annual consumption of tonners								1			
	Total annual consumption of batteries per number of employees								1			
	Material efficiency: Annual mass-flow of different materials used (excluding energy carriers and water)										1	

	Amount of hazardous materials used by contracted service providers										1	
	Amount of cleaning agents used by contracted service providers										1	
	Amount of recyclable and reusable materials used by contracted service providers										1	
	Total number of resource consumption indicators: 93	17	11	14	0	0	8	7	64	7	13	3

Waste production

Waste production indicators		Source										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Generation of waste	Amount of materials used by weight or volume			1			1		1			
	Surface percentage of the port service area provided with waste water collection and treatment			1			1	1		1		
	Total annual port waste collected	1	1	1		1	1	1	1		1	
	Total annual port waste generated								1		1	
	Total annual port waste recycled								1		1	
	Percentage of disposal methods of port waste	1	1				1	1				
	Percentage of recycled waste						1		1			
	Total annual port waste sent to incineration								1			
	Total annual port waste sent to controlled landfill						1		1		1	
	Total annual port waste stored in situ						1					
	Existence of separate containers for the collection of port wastes	1		1		1	1					
	Frequency of cleaning the port area	1				1		1				
	Percentage of waste handled per total cargo handled	1	1					1	1			
	Number of operations with high level of waste (>0,19% of total cargo handling)	1	1					1				
	Number of port stakeholders with a Waste Management Plan	1				1		1	1			
	Existence of waste processing facilities					1						
	Existence of ship waste reception facilities	1						1	1			
	Total annual amount of ship waste collected	1						1	1			
	Number and description of initiatives implemented to reduce, recycle or reuse waste	1				1		1				
	Number and description of initiatives implemented to improve port waste management								1			
	Percentage of recovered waste						1		1	1		
	Percentage of annual variation in the port waste generation		1									
	Annual cost of waste treatment	1						1				
	Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel convention Annex I, II, III and VIII, and percentage of transported waste shipped internationally			1				1				
	Annual waste collected on port surface water (Anthropogenic debris)	1				1		1	1	1		
	Annual total amount of ship waste collected in ship waste reception facilities (Annexes of MARPOL convention)	1										
	Number of vessels that provided MARPOL ship waste								1			

	Amount or type of wastes generated by contracted service providers										1	
	Description of the main activities or sources of waste generation within the port								1	1		
	Total annual wastewater treated in the waste water treatment plant								1			
	Total annual wastewater discharges by quality and destination			1					1	1		
	Amount of effluent water from treatment of sludge		1									
	Existence of a wastewater treatment plant	1				1		1				
	Percentage of the port area that has a system for the collection and treatment of wastewaters								1			
Generation of recyclable garbage	Existence of separate containers for the collection of port recyclable garbage	1										
	Annual amount of port recyclable garbage collected by type	1					1		1			1
	Percentage of each type of port recyclable garbage collected		1						1			
	Annual amount of port recyclable garbage recycled by type	1	1				1		1	1		
	Percentage of each type of port recyclable garbage recycled								1			
	Number and description of initiatives implemented to reduce, recycle or reuse port recyclable garbage	1				1				1		
	Time spent on litter collection		1									
Generation of hazardous waste	Existence of separate containers for the collection of port hazardous waste	1										
	Annual amount of port hazardous waste collected by type	1					1	1	1	1	1	1
	Percentage of each type of port hazardous waste collected		1						1			
	Annual amount of port hazardous waste collected per number of employees								1			
	Annual amount of port hazardous waste collected per cargo handled								1			
	Annual amount of port hazardous waste reduced by pollution prevention initiatives	1										
	Annual amount of port hazardous waste eliminated by changes in materials						1					
	Annual amount of port hazardous waste recycled by type	1	1				1		1	1		
	Percentage of each type of port hazardous waste recycled		1						1			
	Annual amount of oil collected and recycled	1	1					1	1			
	Annual amount of ship waste MARPOL annex I (oil) collected	1	1					1	1			
	Annual amount of ship waste MARPOL annex II (noxious liquid substances carried in bulk) collected	1	1					1	1			
	Annual amount of ship waste MARPOL annex III (harmful substances) collected	1						1				
	Existence of an oil spillage treatment plant	1										
Generation of non-hazardous waste	Existence of separate containers for the collection of port non-hazardous waste	1										
	Annual amount of port non-hazardous waste collected by type	1					1		1			
	Percentage of each type of port non-hazardous waste collected	1	1									

	Annual amount of port non-hazardous waste recycled by type	1	1				1		1	1		
	Percentage of each type of port non-hazardous waste recycled	1	1									
	Amount of port non-hazardous waste collected per cargo handled								1			
	Amount of port non-hazardous waste collected per number of employees								1			
	Annual amount of port non-hazardous waste reduced by pollution prevention initiatives	1										
	Annual amount of ship waste MARPOL annex IV (sewage) collected	1	1					1	1			
	Annual amount of ship waste MARPOL annex V (garbage) collected	1							1			
	Total number of waste production indicators: 65	34	17	6	0	8	16	19	36	10	6	2

Noise

Noise indicators		Sources										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Noise emissions	Level of noise in terminals and industrial areas Lden (overall day-evening-night)	1					1	1	1	1	1	1
	Level of noise in terminals and industrial areas Lday (7:00 – 19:00 hrs)	1						1	1			
	Level of noise in terminals and industrial areas Levening (19:00-23:00 hrs)	1						1	1			
	Level of noise in terminals and industrial areas Lnight (23:00 – 7:00 hrs)	1						1	1			
	Level of noise in terminals and industrial areas Lday (7:00 - 22:00 hrs)								1			
	Level of noise in terminals and industrial areas Lnight (22:00 - 7:00 hrs)								1			
	Average noise exposure during an 8-hour working day	1										
	Maximum level of noise in terminals and industrial areas	1										
	Frequency of noise measurements	1										
	Existence of a noise-zoning map	1	1			1		1	1	1		
	Frequency of verification the noise-zoning map	1										
	Existence of a noise model		1									
	Level of noise in water due to vessels bunkering		1									
	Number of measures implemented to reduce noise levels	1					1			1		
	Noise levels in housing area around the port										1	
	Number of local residents affected by noise from port area operations	1										
	Percentage of survey respondents that perceive noise								1			
	Description of the port's main sources of noise emission								1	1		
	Existence of licence on noise issues for each terminal						1					

	The level of control on noise licence by authorities						1					
	Number of noise claims from authorities		1						1			
	Control of applying noise instructions						1					
	Total number of noise indicators: 22	11	4	0	0	1	6	5	10	4	2	1

Port development

Port development indicators		Sources										
		1	2	3	4	5	6	7	8	9	10	11
Port development	Has the port authority carried out an Environmental Impact Assessment (EIA) during the last 5 years?	1										
	Is the port involved with other organisations in the development of coastal or estuary management plans?	1										
	Has the port authority experienced, or does it anticipate any restrictions on development / expansion due to environmental planning controls?	1										
	Annual quantity or volume of dredged sediment	1	1						1			
	Annual amount of time and money spent on dredging activities	1				1						
	Frequency of dredging	1										
	Quantity of dredged sediment per fuel consumed	1										
	Number of research projects undertaken to evaluate both the short and the long term effects of dredging	1				1						
	Number of measures implemented to reduce negative ecological effects of dredging	1					1					
	Number of turtles harmed by dredging	1										
	Beneficial use of dredged material (definition and description of practices)	1							1			
	Percentage of dredged sediment going to beneficial use	1				1	1				1	
	Existence of facilities for the treatment and cleaning of the dredged sediments	1				1	1					
	Number of researchers and projects carried out concerning dredging disposal	1				1						
	Number of environmental licenses withdrawn or refused for dredging disposal	1	1									
	Frequency of monitoring in contaminated dredging material disposal sites	1	1				1					
	Measures dealing with the dredging disposal (storage, treatment, avoidance of pollution): definition of the measures and of the expected and current results	1										
	Measures to reduce negative ecological effects of dredging: definition of the measures and of the expected and current results.	1										
	Monitoring of the affected area after a capital dredging		1									
	Alteration of the sea floor											1
	Percentage of polluted dredging sediments								1	1	1	
	Total number of port development indicators: 21	18	4	0	0	5	4	0	3	1	2	1

Effects on biodiversity

Effects on biodiversity indicators		Sources 1	2	3	4	5	6	7	8	9	10	11
Effects on biodiversity	Is the port located in, or does it contain a designated protected area?	1										
	Area of land and water owned, leased, or (co)managed within designated protected areas	1	1	1			1		1			
	Description of significant impacts or activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas			1						1		
	Total area protected								1			
	Number of habitats protected or restored	1	1	1				1	1	1		
	Percentage of protected area								1			
	Area of Natura 2000 sites								1			
	Number of bird species protected								1			
	Number of flora species protected								1			
	Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organisation's discharges of water and runoff			1						1		
	Strategies, current actions, and future plans for managing impacts on biodiversity			1						1		
	Percentage of algae coverage at particular port sites	1	1					1	1			
	Percentage of change in the size of algae blooms at particular sites	1										
	Change of species diversity at particular sites	1										
	Other aquatic flora monitoring: quantity and variety of aquatic flora species	1						1				
	Trawling monitoring: quantity and variety of fish, crustaceans and other species which live on the seabed and within the water column	1					1		1			
	Benthic fauna monitoring: quantity and variety of benthic fauna found in sediments samples within the seabed	1	1			1		1				
	Birds monitoring: quantity and variety of farmland birds, woodland birds, water and wetland birds, and seabirds	1	1			1		1				
	Butterflies monitoring: quantity and variety of generalists (wider countryside) and specialists species of butterflies	1				1						
	Plant diversity: number of plant species per survey plot in arable land, woodland and grassland, and boundary habitats	1	1			1		1	1			
	Area of mangroves (various kinds of trees that grow in saline coastal sediment habitats)	1						1	1			
	Percentage of large fish	1	1			1		1				
	Annual number of fish deaths in a specific watercourse	1						1				
	Population of a specific animal species within a defined area	1							1			
	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	1		1								

	Area of sensitive habitats exceeding critical loads for acidification and eutrophication	1										
	Number of widely established (more than 50 per cent) invasive species in freshwater, marine and terrestrial environments	1										
	Existence of a Special Protection Areas (SPA) monitoring scheme		1									
	Annual amount of time that people spend volunteering in biodiversity conservation	1										
	Heavy metals in fish samples							1	1			
	Number and description of initiatives implemented to protect and regenerate the natural environment								1			
	Area of contaminated land returned to productive use									1		
	Constructed on-land port area								1		1	
	Area of port water surface								1			
	Landscaped port area								1			
	Area dedicated to landfill, tourism or wetlands in the port area										1	
	Paved and non-fertile area in the port area										1	
	Measure of the erosion of topsoil in the port area										1	
	Crop yield over time from fields on the surrounding port area										1	
	Specific measures of the quality of habitat for specific species in the port area (fauna and flora)										1	
	Specific measures of the quantity of vegetation in the port area										1	
	Specific measures of the quality of vegetation in the port area										1	
	Number of total fauna species in the port area										1	
	Total number of effects on biodiversity indicators: 43	20	8	6	0	5	2	10	17	5	9	0

Annex X: Criteria to assess indicators

Source	Criteria		
OECD (1993)	Policy relevance	Analytical soundness	Measurability
Ministry for the environment of New Zealand (1998)	Policy relevance Simple and easily understood	Measurable and analytically valid	Cost effective
De Leffe, et al (2003)	Policy relevant Practical	Informative Representative	Measurable
Verafaille, et al (2000)	Relevant and meaningful Inform decision makers Support benchmarking and monitoring	Clearly defined, measurable, transparent Be understandable and meaningful to stakeholders Recognize relevant and meaningful issues	Recognize the inherent diversity of business Based on the evaluation of operations, products and services
Dale, et al (2001)	Easily measured Integrative Respond to stress in a predictable manner	Sensitive to stresses Have low variability in response Predict changes	Have a known response to disturbances, anthropogenic stresses, and changes over time Be anticipatory
Jakobsen (2008)	Easy to understand Based on accessible data	Relevant	Reliable
EEA (2005)	Available and routinely collected data Understandability of indicators Policy relevance	Progress towards targets Methodologically well founded EU priority policy issues	Spatial and temporal coverage National scale and representativeness of data
UNEP (2003)	Policy relevant and meaningful Affordable modelling Broad acceptance	Biodiversity relevant Small number Sensitive Representative	Scientifically sound Affordable monitoring Aggregation and flexibility
EC (1998)	Be based on data adequately documented and of known quality Be sensitive to the changes in the environment Give early warning about irreversible trends	Be based on readily available data or be available at reasonable cost Be capable of being updated at regular intervals Representative	Be simple and easy to interpret Scientifically valid Show trends over time

Donnelly, et al (2007)	Be easily understandable to decision makers and the public	Well founded in technical and scientific terms	Cover a range of environmental receptors
	Policy relevant	Shows trends	Adaptable
	Relevant to the plan	Identify conflict	Prioritise key issues and provide early warning
Peris-Mora, et al (2005)	Representativeness	Conciseness	Purpose
	Adaptability	Comparability	Sensitivity
	Easy to obtain	Continuity	Regularity
	Cost-effectiveness	Scientific verification	Clarity
	Usefulness Reliability and objectivity	Relevance	Well-defined limits

Annex XI: Regrouped indicators

This annex presents the indicators that were grouped. It shows the category where these indicators are categorized, the indicators that were rejected and the indicator obtained as a result of joining the previous ones.

Management

Category	Regrouped indicators	Resulting indicators
Environmental training & awareness indicators	Does the port authority have an environmental training programme for its employees?	Does the port authority have an environmental training programme for its employees?
	Existence of training (crane drivers, lift truck operators) with regard to noise	
Environmental communication indicators	Are there procedures to communicate environmental information internally between the key environmental personnel?	Are there procedures to communicate environmental information internally and externally?
	Are there procedures to exchange port environmental information with stakeholders including external parties?	
Emergency planning & response indicators	Does the port have an Emergency Response Plan?	Does the port have an Emergency Response Plan?
	Does the port have an Emergency Response Plan specially designed for handling hazardous cargo?	
	Does the port have a Cargo Handling Plan to avoid accidents?	
	Does the port have an Oil Spill Response Plan?	
	Does the port have a Water Leakage Response Plan?	
	Annual number of environmental accidents reported	Annual number of environmental accidents
	Annual number of accidents at the port sea area	
	Annual number of environmental incidents reported	Annual number of environmental incidents
	Annual number of incidents with the need for intervention	
EMS audits indicators	Number of EMS audits conducted	Number of EMS audits completed versus planned
	Number of EMS audits completed versus planned	
	Number of nonconformities found in EMS audits	Number of EMS audit nonconformities addressed versus found
	Number of nonconformities addressed	
Environmental legislation indicators	Compliance with discharges of wastewaters legal limits	Is the port in compliance with legislation legal limits?
	Compliance with discharges of oil legal limits	
	Compliance with discharges of particulate matter legal values	
	Compliance with discharges of sediments legal limits	
	Compliance with limits at day, evening, and night time for noise level	
Environmental complaints indicators	Total annual number of environmental complaints received	Total annual number of environmental complaints received
	Annual number of dust-related complaints	
	Annual number of odour-related complaints	
	Annual number of noise-related complaints	
	Annual number of dredging-related complaints	
	Number of inquiries or comments about environmentally related matters	
	Annual number of environmental complaints resolved where further action was necessary	Total annual number of environmental complaints resolved
	Number of environmental complaints filed, addressed, and resolved through formal complaints mechanism	

Air

Category	Regrouped indicators	Resulting indicators
Emissions of combustion gases	Total annual greenhouse gas (GHG) emissions	Total annual Carbon Footprint by scope
	Percentage of each scope contributing to the total emissions	
	GHG emissions per TEU	
	GHG emissions per number of employees	
Meteorological Data	Temperature	Meteorological Data
	Humidity	
	Surface wind pattern (direction, speed, intensity, frequency)	
	Rainfall	
	Atmospheric pressure	
	Solar Radiation	
	Cloudiness	

Water and sediments

Category	Regrouped indicators	Resulting indicators
Discharges of wastewaters	Dissolved Oxygen (DO)	Dissolved Oxygen (DO)
	Dissolved oxygen in surface waters	
	Dissolved oxygen in bottom waters	
	Inorganic ions	Inorganic ions
	Sulphate	
	Total Phosphorus	Nutrients
	Orthophosphates (dissolved inorganic phosphorus)	
	Total Nitrogen	
	Ammonium	
	Ammonia	
	Nitrite	
	Nitrate	
	Total coliform bacteria	Bacterial content
	Escherichia coli (E. coli)	
	Faecal coliforms	
	Faecal Streptococcus	
	Salmonella	
	Zooplankton	Plankton
	Bacterioplankton	
	Phytoplankton	
Discharges of other chemicals	Conductivity	Conductivity
	Water salinity	
Discharges of particulate matter	Total Dissolved Solids (TDS)	Solid content in water
	Total Suspended Solids (TSS)	
	Settleable solids	
Sediments Quality	Amount of organic matter	Total Organic Carbon (TOC)
	Total Organic Carbon (TOC)	
	Organic Carbon	
	Total Phosphorus	Nutrients
	Orthophosphates (dissolved inorganic phosphorus)	
	Total Nitrogen	
	Nitrite	
	Nitrate	
	Kjeldahl nitrogen	
	Ammonium	

	Calcium	
	Nutrients	

Soil

Category	Regrouped indicators	Resulting indicators
Emissions to soil and groundwater	Soil Organic Matter	Total Organic Carbon
	Total Organic Carbon	

Resource consumption

Category	Regrouped indicators	Resulting indicators
Energy consumption	Total annual energy consumption	Total annual energy consumption
	Total annual energy consumption by energy source	
	Percentage of each energy source	
	Percentage of energy consumption by use	
	Energy consumption per cargo handled	
	Energy consumption per number of employees	
Water consumption	Total annual water consumption	Total annual water consumption
	Total annual water withdrawal by source	
	Percentage of water withdrawal by source	
	Total annual water consumption by use	
	Percentage of water consumption by use	
	Total annual water consumption per cargo handled	
	Total annual water consumption per number of employees	
	Daily average water consumption for cleaning de port area	
Electricity consumption	Total annual electricity consumption	Total annual electricity consumption
	Electricity consumption per cargo handled	
	Electricity consumption per number of employees	
	Percentage of electricity consumption by use	
	Annual number of vessels connected to shore-side electricity	Annual number of vessels connected to shore-side electricity
	Percentage of vessels calling at the port that connect to shore-side electricity	
Fuel consumption	Total annual fuel consumption by type	Total annual fuel consumption
	Percentage of fuel consumption by type	
	Percentage of fuel consumption by use	
	Annual fuel consumption per number of employees	
	Annual fuel consumption per cargo handled	
	Total annual gas oil consumption	
Other resources	Total annual paper consumption	Total annual paper consumption
	Paper consumption per number of employees	

Waste production

Category	Regrouped indicators	Resulting indicators
Generation of waste	Percentage of disposal methods of port waste	Percentage of disposal methods of port waste
	Percentage of recycled waste	
	Existence of separate containers for the collection of port wastes	Existence of separate containers for the collection of port wastes
	Existence of separate containers for the collection of port recyclable garbage	

	Existence of separate containers for the collection of port hazardous waste	
	Existence of separate containers for the collection of port non-hazardous waste	
	Annual total amount of ship waste collected in ship waste reception facilities (Annexes of MARPOL convention)	Annual amount of ship waste collected by type of MARPOL annex
	Annual amount of ship waste MARPOL annex I (oil) collected	
	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	
Generation of recyclable garbage	Annual amount of port recyclable garbage collected by type	Amount of port recyclable garbage collected by type
	Percentage of each type of port recyclable garbage collected	
	Annual amount of port recyclable garbage recycled by type	Amount of port recyclable garbage recycled by type
	Percentage of each type of port recyclable garbage recycled	
Generation of hazardous waste	Annual amount of port hazardous waste collected by type	Amount of port hazardous waste collected by type
	Percentage of each type of port hazardous waste collected	
	Annual amount of port hazardous waste collected per number of employees	
	Annual amount of port hazardous waste collected per cargo handled	
	Annual amount of oil collected and recycled	
	Annual amount of port hazardous waste recycled by type	Amount of port hazardous waste recycled by type
	Percentage of each type of port hazardous waste recycled	
	Annual amount of oil collected and recycled	
Generation of non-hazardous waste	Annual amount of port non-hazardous waste collected by type	Amount of port non-hazardous waste collected by type
	Percentage of each type of port non-hazardous waste collected	
	Annual amount of port non-hazardous waste recycled by type	Amount of port non-hazardous waste recycled by type
	Percentage of each type of port non-hazardous waste recycled	

Noise

Category	Regrouped indicators	Resulting indicators
Noise emissions	Level of noise in terminals and industrial areas Lden (overall day-evening-night)	Level of noise in terminal and industrial areas
	Level of noise in terminals and industrial areas Lday (7:00 – 19:00 hrs)	
	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)	
	Level of noise in terminals and industrial areas Lday (7:00 - 22:00 hrs)	
	Level of noise in terminals and industrial areas Lnight (22:00 - 7:00 hrs)	
	Average noise exposure during an 8-hour working day	

Biodiversity

Category	Regrouped indicators	Resulting indicators
Effects on biodiversity	Is the port located in, or does it contain a designated protected area?	Total port area protected
	Area of land and water owned, leased, or (co)managed within designated protected areas	
	Total area protected	
	Number of habitats protected or restored	
	Percentage of protected area	
	Area of Natura 2000 sites	

Annex XII: Final list of indicators

This annex presents all the indicators that remained until the end after the filtering process being already amended by the comments of the reviewers. They are classified according to the categories of environmental aspects (see table 4.1). These resulting indicators are the ones that are coloured in green in Annex IX (134) plus the ones that resulted from the regrouping process (39) (Annex XI), making a total of 173 indicators.

For the development of the TEIP tool, the resulting indicators were divided into four types of indicators:

(yellow)	Qualitative indicators used as a question in the TEIP tool in order to demonstrate existence or inexistence of a specific environmental topic	24
(blue)	Qualitative indicators used as issues to take into account in the provision of recommendations	18
(green)	Quantitative indicators used as output indicators of the TEIP tool	129
(red)	Indicators rejected in the application of the TEIP tool.	2

Environmental management indicators	
Environmental Management System	Does the Port have a certified Environmental Management System (EMS)?
	Has the port completed the environmental review Self Diagnosis Method?
	Is there a procedure to review the port's EMS program?
Environmental Policy	Does the port have an Environmental Policy?
	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?
Objectives and targets	Has the port defined objectives for environmental improvement?
	Does the port have quantitative objectives?
	Number of environmental objectives defined
	Percentage of environmental objectives achieved
	Have management programmes and action plans been prepared to achieve each objective?
Environmental monitoring plan	Does the port have an environmental monitoring plan?
	Has the port identified environmental indicators to monitor trends in environmental performance?
	Number of environmental indicators monitored
Significant Environmental Aspects	Does the port have an inventory of Significant Environmental Aspects?
	Are there procedures to maintain and update the inventory of SEA?
	Number of Significant Environmental Aspects identified
Management organisation & personnel	Does the port have a representative responsible for managing environmental issues?
	Does the representative ensure compliance with environmental policy?
	Are the environmental responsibilities of this representative documented?
	Percentage of employees working on environmental issues
Environmental training & awareness	Does the port authority have an environmental training programme for its employees?
	Has the port authority established procedures for identifying training needs?
	Frequency of environmental training sessions for port employees
	Percentage of port employees that received environmental training
	Annual number of training hours per employee
	Does the port publish a publicly available Environmental Report?

Environmental communication	Are there procedures to communicate environmental information internally and externally?
	Annual number of environmental reports published
	Annual number of press articles published concerning environment
	Does the port website show environmental information?
	Annual number of conferences that the port authority has organized or participated in
	Number of environmental educational programmes or materials provided for the community
Emergency planning & response	Does the port have an Emergency Response Plan?
	Does the plan specify the communication, control and containment procedures?
	Does the plan specify the location and type of equipment (on and off site)?
	Does the plan specify the location and skills of trained personnel (on and off site)?
	Number of times that the Emergency Response Plan has been activated
	Total number and volume of (significant) oil and chemical spills
	Annual number of environmental accidents
	Annual number of environmental incidents
	Does the port have a representative responsible for managing safety issues?
	Has the port authority carried out an Environmental Risk Assessment during the last 5 years?
EMS audits	Has an external EMS audit been conducted?
	Number of EMS audits completed versus planned
	Number of EMS audit findings
	Number of EMS audit nonconformities addressed versus found
Environmental legislation	Does the port have an inventory of relevant environmental legislation and regulations related to its liabilities and responsibilities?
	Are there procedures to maintain and update the inventory of environmental legislation?
	Are there methods to deal with non-compliance with internal and external standards?
	Number of fines received for non-compliance with environmental legislation
	Number of times that the daily limit value of a certain environmental parameter has been exceeded
	Is the port in compliance with legislation legal limits?
Environmental complaints	Total annual number of environmental complaints received
	Total annual number of environmental complaints resolved
Environmental budget	Does the port have a budget specifically for environmental protection?
	Total annual budget allocated to environmental protection
	Percentage of the budget allocated to environmental protection out of the total budget
	Percentage of annual variation in the environmental budget

Emissions to air indicators	
Emissions of combustion gases	Does the port measure or estimate its Carbon Footprint?
	Total annual Carbon Footprint by scope
	Frequency of monitoring the Carbon Footprint in the port area
	Percentage of each energy source contributing to the Carbon Footprint
	Percentage of annual change in the Carbon Footprint
	Does the port differentiate dues for 'Greener' vessels?
	Carbon monoxide (CO)
	Nitrogen oxides (NO_x)
	Sulphur dioxide (SO_2)
Emissions of other gases	Ammonia (NH_3)
	Dioxins
	Heavy metals
	Ozone

	Volatile Organic Compounds (VOCs)
	Benzene
	Polychlorinated biphenyl (PCB)
	Frequency of photochemical smog events
	Persistent Organic Pollutants (POPs)
	Polycyclic Aromatic Hydrocarbons (PAHs)
Emissions of particulate matter	Dust
	PM10
	PM2.5
Odour emissions	Hydrogen sulphide (H_2S)
	Percentage of respondents that perceive odour
Meteorological data	Meteorological Data

Discharges to water/sediments indicators	
Discharges of wastewaters	Chlorophyll
	Biological Oxygen Demand (BOD)
	Chemical Oxygen Demand (COD)
	Algal Growth Potential (AGP)
	Dissolved Oxygen (DO)
	Inorganic ions
	Nutrients
	Bacterial content
	Water pH
	Redox potential
	Total hardness
	Total Organic Carbon (TOC)
	Total Oxygen Demand (TOD)
	Water colour
	Water temperature
	Plankton
Discharges of hydrocarbons	Oil Content (Hydrocarbons)
	Volatile Organic Compounds (VOCs)
Discharges of other chemicals	Halogen content
	Conductivity
	Heavy metals
	Surfactants
	Tributyltin (TBT)
Discharges of particulate matter	Solid content in water
	Turbidity (water transparency)
Sediments quality	Persistent Organic Pollutants (POPs)
	Polychlorinated biphenyl (PCB)
	Polycyclic Aromatic Hydrocarbons (PAHs)
	Tributyltin (TBT)
	Redox potential
	Total Organic Carbon (TOC)
	Volatile Organic Compounds (VOCs)
	Nutrients
	Heavy metals
	Sediments particle size distribution

Emissions to soil indicators	
Emissions to soil and groundwater	Electrical conductivity
	Soil pH
	Macronutrients
	Total Organic Carbon (TOC)
	Total port area with soil pollution
	Heavy metals

	Redox potential

Resource consumption	
Energy consumption	Total annual energy consumption
	Percentage of the annual variation in the energy consumption
	Percentage of renewable energy per total energy consumed
Water consumption	Total annual water consumption
	Annual amount of recovered rainwater
	Percentage of the annual variation in the water consumption
	Percentage of water recycled per total water consumption
Electricity consumption	Total annual electricity consumption
	Is Onshore Power Supply (OPS) available at one or more of the berths?
	Annual number of vessels connected to shore-side electricity
Fuel consumption	Total annual fuel consumption
	Is Liquefied Natural Gas (LNG) bunkering available in the port today?
Other resources	Total annual paper consumption

Waste production indicators	
Waste generation	Total annual port waste collected
	Total annual port waste recycled
	Percentage of disposal methods of port waste
	Existence of separate containers for the collection of port wastes
	Existence of ship waste reception facilities
	Annual waste collected on port surface water (Anthropogenic debris)
	Annual amount of ship waste collected by type of MARPOL annex
Generation of recyclable garbage	Amount of port recyclable garbage collected by type
	Amount of port recyclable garbage recycled by type
Generation of hazardous waste	Amount of port hazardous waste collected by type
	Amount of port hazardous waste recycled by type
Generation of non-hazardous waste	Amount of port non-hazardous waste collected by type
	Amount of port non-hazardous waste recycled by type

Noise indicators	
Noise emissions	Level of noise in terminal and industrial areas
	Maximum level of noise in terminals and industrial areas
	Frequency of noise measurements
	Existence of a noise-zoning map
	Noise levels in housing area around the port
	Percentage of survey respondents that perceive noise
	Number of noise claims from authorities

Port development indicators	
Port Development	Has the port authority carried out an Environmental Impact Assessment (EIA) during the last 5 years?
	Annual quantity or volume of dredged sediment
	Frequency of dredging
	Percentage of dredged sediment going to beneficial use
	Existence of facilities for the treatment and cleaning of the dredged sediments
	Percentage of polluted dredging sediments

Effects on biodiversity indicators	
Effects on biodiversity	Total port area protected
	Number of bird species protected
	Number of flora species protected
	Percentage of algae coverage at particular port sites
	Percentage of large fish
	Heavy metals in fish samples

	Area of contaminated land returned to productive use

Annex XIII: Guidelines of indicators

<table>
<tr><th>Indicator's name</th><td colspan="3">Carbon monoxide (CO)</td></tr>
<tr><th>Category</th><td>Emissions to air</td><th>Indicator's code</th><td>G.1.1</td></tr>
<tr><th>Sub category</th><td colspan="3">Emissions of combustion gases</td></tr>
<tr><th>Definition</th><td colspan="3">Carbon monoxide (CO) gas is odourless, colourless and tasteless. The main source of emission of CO is produced by incomplete combustion in internal combustion engines of cars, trucks and airplanes. Other major sources of emissions are energy production, industrial processes or fires [1].</td></tr>
<tr><th>Importance</th><td colspan="3">CO is an important component of urban air pollution and pollution inside buildings as it has harmful effects on human health in short term. Additionally, although the CO is not a greenhouse gas, its oxidation to CO_2 may have adverse effects on the global climate [1].</td></tr>
<tr><th>Units of measurement</th><td colspan="3">• Milligrams of CO per cubic meter of air (mg/m^3) [2]
• Parts per million (ppm) [2]</td></tr>
<tr><th>Equivalence</th><td colspan="3">$$ppm \cdot \frac{M}{24{,}4} = mg/m^3$$
where:
M: Molecular mass of the substance (28 g/mol for CO)
24,4: volume of a mol (l/mol) of an ideal gas at 1 atm and 25ºC [2]</td></tr>
<tr><th>Description of the methodology</th><td colspan="3">Below, a method is presented for determining the concentration of CO in the ambient air through the nondispersive infrared (NDIR) absorption [3].
Basis:
The NDIR technique is a method designed for the continuous monitoring and it is based on the absorbance of the infrared radiation characteristic of the CO molecule at $\lambda = 4.6$ µm. This absorbance may be used to measure the concentration of CO even in the presence of other gases.
Equipment needed:
• Sampling system: it is necessary to collect samples of air from the atmosphere and lead them to the analyser, without altering their composition. It consists of the following elements:
    • Sampling probe
    • Suction tube
    • Pipes (tubes)
    • Pump for the air suction
• Analysis system: it is composed of the following elements:
    • NDIR analyser (measures the CO absorbance at $\lambda = 4.6$ µm)
    • Humidity control system (e.g. Nafion® drying column [4])
    • Particulate filter (to prevent suspended particulates to enter to the cell detection)
    • Flowmeter (to know the volume of sample)
• Data recording system: system capable of recording data in a standard format.</td></tr>
<tr><th>Limit values</th><td colspan="3">10 mg / m^3, maximum average concentration for 8 hours [5].</td></tr>
<tr><th>Monitoring locations</th><td colspan="3">Usually, measuring stations are located at a height of 3 to 10 meters, in a point sufficiently far from the source of emission of the pollutant [6].</td></tr>
<tr><th>Frequency</th><td colspan="3">Monitoring 24 hours a day throughout the year (see note) [3].</td></tr>
<tr><th>Approximate cost</th><td colspan="3">Sampling system: 500 € [7]
NDIR analyser: 5.400 € [8]
Data recording system: 97 € [9]</td></tr>
<tr><th>Notes</th><td colspan="3">During the monitoring, it is frequent to have a loss of 5 to 10% of the data at the end of the year (for maintenance, breakdowns, etc.) [3].</td></tr>
<tr><th>References</th><td colspan="3">[1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002.</td></tr>
</table>

	[2] A. RAÑA. *Unidades de medición empleadas en Calidad del Aire*. La Coruña, 2002 [3] BVSDE. Chapter 02, Analytical Methods for Monitoring Carbon Monoxide. Washington, Organización Panamericana de la Salud, 2005. [4] CHROMSERVIS. *Dryer Nafion, 1 tube 0.07", 144" length, SS shell/fittings* [https://www.chromservis.eu/p/dryer-nafion-1-tube-0-07-144-length-ss-shell-fittings, 6th of March 2016] [5] EUROPEAN COMMISSION (EC). *Directive 2000/69/EC of the European Parliment and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air*. Brussels, Official Journal of the European Communities, 2000. [6] INDIAN INSITITUTE OF TECHNOLOGY GUWAHATI. QUALITY IMPROVEMENT PROGRAMME. *Air Pollution Sampling and Analysis*. Guwahati, Departmen of Civil Engineering, 2009. [7] LABX. *Air sampling listings.* 2016. [http://www.labx.com/air-sampling, 6th of March 2016] [8] THERMOCIENTIFIC. *NDIR Model 60 Multi-Gas Analyzer*. 2015 [http://www.thermoscientific. com/en/product/ndir-model-60-mult-gas-analyzer.html, 6th of March 2016] [9] LABJACK. MEASUREMENT & AUTOMATION. *U3 Series*. 2015 [https://labjack.com/ products/u3, 6th of March 2016]

Indicator's name	Nitrogen oxides (NOx)		
Category	Emissions to air	**Indicator's code**	G.1.2
Sub category	Emissions of combustion gases		
Definition	This indicator measures the concentration of the nitrogen oxides (NO_X) in the air. The parameter NO_X mainly includes the gases NO and NO_2 (nitrogen monoxide and nitrogen dioxide, respectively). Nitrogen monoxide is a colourless gas, and nitrogen dioxide is a brownish gas that gives off a strong odour. The main source of NO emissions are the combustion processes at high temperature and the main source of NO_2 is the oxidation of NO. NO_2 is also created in the combustion process, but in very small quantities compared to the emissions of NO [1].		
Importance	Nitrogen oxides have adverse effects on the environment: they are precursors of ozone (the main component of photochemical smog) and nitric acid, one of the substances that cause acid rain. Additionally, both NO and NO_2 reduce stratospheric ozone.		
Units of measurement	• Microgram of NO_2 per cubic meter of air ($\mu g/m^3$) • Parts per billion (ppb) [2]		
Equivalences	$$ppb \cdot \frac{M}{24{,}4} = \mu g/m^3$$ where: *M*: Molecular mass of the substance (46 *gr/mol* for NO_2) *24,4:* volume of a mol (*l/mol*) of an ideal gas at a pressure of 1 atm and a temperature of 25ºC [2]		
Description of the methodology	The standard method proposed by the European Committee for Standardization (CEN) to determine the concentration of nitrogen dioxide and nitrogen monoxide in ambient air is based on the chemiluminescence technique [3]. Basis: The principle of chemiluminescence is based on the fact that NO is a relatively unstable molecule that is oxidized to NO_2 in the presence of ozone (O_3). This reaction produces an exact amount of light for each molecule of NO that reacts. The light emitted can be measured. By controlling the volume of the sample and the excess O_3, the level of luminescence in the reaction chamber is directly proportional to the concentration of NO in the sample. Since the device only detects NO, in order to determine the concentration of NO_2 or total nitrogen oxides (NO_X), there must be a previous reduction to NO [4]. Equipment and specifications:		

	The equipment APNA-370 Ambient NOx Monitor [5] is able to determine the concentration of nitrogen oxides in the atmosphere using the CEN standard method. Specifications of the equipment [5] • This device has a single detector to determine the amounts of NO, NO_2 and NO_x continuously. • The standard equipment of the device includes a drying unit with an automatic air recycling device to provide dry ambient air and a constant source of ozone. • The equipment includes a silicon photodiode as a sensor light radiation.
Limit values	• 200 $\mu g/m^3$, maximum concentration of NO_2 in 1 hour [6] • 40 $\mu g/m^3$, annual average concentration of NO_2 [6]
Monitoring locations	Usually, measuring stations are located at a height of 3 to 10 meters, at a point sufficiently far from the source of emission of the pollutant [7].
Frequency	Monitoring 24 hours a day throughout the year
Approximate cost	APNA-370 Ambient NO_X Monitor: 10.890 € [5]
References	1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002. [2] A. RAÑA. *Unidades de medición empleadas en Calidad del Aire*. La Coruña, 2002 [3] *CEN. EUROPEAN COMMITTE FOR STANDARIZATION. EN 14211:2012. Ambient air - Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence.* 2012 [http://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT: 31489&cs=121328E210D839441159216341115917E, 6th March 2016] [4] K2BW. *Chemiluminescent Measurement of NO/NOx in Gas Analysers*. New York, 2013.[http://www.k2bw.com/chemiluminescence.htm, 6th of March 2016] [5] HORIBA. PROCESS & ENVIRONMENTAL. *APNA-370 Ambient NOx Monitor*. 2016. [http://www.horiba.com/process-environmental/products/ambient/details/apna-370-ambient-nox-monitor-274/, 6th of March 2016] [6] EUROPEAN COMMISSION (EC). *Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air*. Brussels, Official Journal of the European Communities, 1999. [7] INDIAN INSITITUTE OF TECHNOLOGY GUWAHATI. QUALITY IMPROVEMENT PROGRAMME. *Air Pollution Sampling and Analysis*. Guwahati, Departmen of Civil Engineering, 2009.

Indicator's name	Sulphur dioxide (SO_2)		
Category	Emissions to air	**Indicator's code**	G.1.3
Sub category	Emissions of combustion gases		
Definition	This indicator measures the concentration of sulphur dioxide (SO_2) in the air. Sulphur dioxide is a colourless gas that presents taste from a concentration of 0.3 ppm and smell from 0.5 ppm. Some of the major sources of SO_2 emissions are coal thermal power plants, shipping and volcanic eruptions [1].		
Importance	It is a significant indicator because the SO_2 is a precursor of sulfuric acid (H_2SO_4), which is an important component of acid rain and has effects on global warming and on the ozone layer [1].		
Units of measurement	• Micrograms of SO_2 per cubic meter of air ($\mu g/m^3$) • Parts per billion (ppb) [2]		
Equivalence	$$ppb \cdot \frac{M}{24{,}4} = \mu g/m^3$$ where: *M*: Molecular mass of the substance (64 *gr/mol* for SO_2) *24,4:* volume of a mol (*l/mol*) of an ideal gas at a pressure of 1 atm and a temperature of 25ºC [2]		

Description of the methodology	The standard method proposed by the European Committee for Standardization (CEN) to measure the concentration of sulphur dioxide in ambient air is a method based on fluorescent ultraviolet (UV) [3]. Basis: This method is based on fluorescence that is released by the molecule SO_2 when it is irradiated with ultraviolet light with a wavelength within the range of 190-230 nm. Sulphur dioxide absorbs radiation in this region of the spectrum without receiving any attenuation from the air or other gases present in polluted air. The only potential source of interference is water vapour (atmospheric moisture). The radiation emitted (fluorescence) by the gas becomes a voltage that can be directly measured and correlated with the concentration of SO_2 in the sample [4]. Equipment and specifications: The equipment APSA-370 SO2 Monitor Environment [6] is able to determine the concentration of sulphur dioxide in the atmosphere using the CEN standard method. Specifications of the equipment [5] • This device uses the principle of UV fluorescence and allows the continuous monitoring of SO_2. • The design of the fluorescence camera allows measurements with a minimum interference from water vapour.
Limit values	• 350 $\mu g/m^3$, maximum concentration of SO_2 in 1 hour [6] • 125 $\mu g/m^3$, daily average concentration of SO_2 [6]
Monitoring locations	Usually, measuring stations are located at a height of 3 to 10 meters, at a point sufficiently far from the source of emission of the pollutant [6].
Frequency	Monitoring 24 hours a day throughout the year.
Approximate cost	APSA-370 Ambient SO_2 Monitor: 10.890 € [5]
References	1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002. [2] A. RAÑA. *Unidades de medición empleadas en Calidad del Aire.* La Coruña, 2002 [3] CEN. EUROPEAN COMMITTE FOR STANDARIZATION. *EN 14212:2012. Ambient air - Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence.* 2012. [http://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT :31490&cs=133752E37BA80F54C0A4868B3F5AE1D44, 6th of March 2016] [4] STATE OF ALASKA. DEPARTMENT OF ENVIRONMENTAL CONSERVATION. *Standard Operating Procedures for Sulfur Dioxide (SO_2) Monitoring by Ultraviolet Fluorescence*. Anchorage, Air Monitoring and Quality Assurance Section, 2012. [5] HORIBA. PROCESS & ENVIRONMENTAL. *APSA-370 Ambient Sulfur Dioxide Monitor*. 2016 [http://www.horiba.com/process-environmental/products/ambient/details/apsa-370-ambient-sulfur-dioxide-monitor-272/, 6th of March 2016] [6] EUROPEAN COMMISSION (EC). Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. Brussels, Official Journal of the European Communities, 1999. [7] INDIAN INSITITUTE OF TECHNOLOGY GUWAHATI. QUALITY IMPROVEMENT PROGRAMME. *Air Pollution Sampling and Analysis*. Guwahati, Departmen of Civil Engineering, 2009.

Indicator's name	Total annual Carbon Footprint by scope		
Category	Emissions to air	**Indicator's code**	G.1.4
Sub category	Emissions of combustion gases		

<table>
<tr><td>Definition</td><td>This indicator monitors the Carbon Footprint of the port area. The Carbon Footprint is the total amount of Greenhouse Gas (GHG) emissions generated as a result of the port activities. The main gases contributing to the GHG effect are [1]:

Carbon dioxide (CO_2)
Methane (CH_4)
Nitrogen oxide (N_2O)
Hydrofluorocarbons (HCFs)
Perfluorocarbons (PFCs)
Sulphur hexafluoride (SF_6)

To measure its Carbon Footprint, the port authority must carry out an assessment of its Greenhouse Gas emissions and must use a method of calculation. There are international standards in order to certify the methods for measuring the Carbon Footprint that an organisation is using. The most commonly used internationally are the GHG Protocol [2] and the ISO 14064-1 [3].
The emissions that are considered in the calculation of the Carbon Footprint are divided into three categories, as defined in the GHG Protocol standard [2]:

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).
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.
</td></tr>
<tr><td>Importance</td><td>Climate change is one of the major environmental, social and economic threats of our time [1]. According to the Intergovermental Panel on Climate Change (IPCC), global warming is unequivocal, and the emission of Greenhouse Gases of anthropogenic origin is one of the main causes [4]. Therefore, it is important to have an indicator that improves decision making regarding sustainability considerations [5].</td></tr>
<tr><td>Units of measurement</td><td>The Carbon Footprint is expressed as the percentage of each scope contributing to the total Carbon Footprint. It is obtained by calculating the tonnes of carbon dioxide equivalent (t CO2e) (see Notes below) for each scope. To express the results provided by the indicator, the following table may be used:
<table>
<tr><th>Category</th><th>t CO_2e</th><th>%</th></tr>
<tr><td>Scope 1</td><td></td><td></td></tr>
<tr><td>Scope 2</td><td></td><td></td></tr>
<tr><td>Scope 3</td><td></td><td></td></tr>
<tr><td>Total Carbon Footprint</td><td></td><td>100 %</td></tr>
</table></td></tr>
<tr><td>Frequency</td><td>An annual monitoring is recommended.</td></tr>
<tr><td>Level of effort</td><td>High level: The information required by the indicator is specific and it may require a deep research to be obtained.</td></tr>
<tr><td>Notes</td><td>In order to obtain the value of the carbon dioxide equivalent, the emissions gases (other than CO_2) are weighted according to their Global Warming Potential (GWP). The GWP is a measure of the ability of a given gas to contribute to the global warming over a period of 100 years in relation to CO_2, which has a value equal to one [1]. The following table shows an example on how the different gas emissions are weighted by the GWP factor:
<table>
<tr><th>Gas</th><th>Emissions (t)</th><th>GWP</th><th>Equivalent emissions (t CO_2e)</th></tr>
<tr><td>CO_2</td><td>1000</td><td>1</td><td>1000</td></tr>
<tr><td>CH_4</td><td>12</td><td>25</td><td>300</td></tr>
<tr><td>N_2O</td><td>2</td><td>298</td><td>596</td></tr>
<tr><td>SF_6</td><td>0,05</td><td>22800</td><td>1140</td></tr>
</table>
The HFCs and PFCs comprise a large number of different gases with different GWP which can be found in reference [6].</td></tr>
</table>

References	[1] EUROPEAN ENVIRONMENTAL AGENCY (EEA). *Total greenhouse gas (GHG) emission trends and projections.* Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-5, 27th of March of 2016]. [2] GREENHOUSE GAS PROTOCOL. *Calculation Tools*. Geneva, 2012. [http://www.ghgprotocol.org/calculation-tools, 27th of March of 2016]. [3] ISO. *ISO 14064-1:2006. Greenhouse gases -- Part 1: Specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals*. Geneva, 2006. [http://www.iso.org/iso/catalogue_detail?csnumber=38381, 27th of March of 2016]. [4] INTERGOVERNAMENTAL PANEL ON CLIMATE CHANGE (IPCC). *Climate Change 2007: Synthesis Report. Summary for Policymakers*. Valencia, IPCC Plenary XXVII, 2007. [5] FUNDACIÓN VALENCIAPORT. *La Huella de Carbono, un indicador clave en la sostenibilidad de los puertos y sus actividades*. Valencia, Newsletter, 2014. [6] INTERGOVERNAMENTAL PANEL ON CLIMATE CHANGE (IPCC). *2.10.2 Direct Global Warming Potentials.* Geneva, 2014. [http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14, 27th of March 2016].

Indicator's name	Frequency of monitoring the Carbon Footprint in the port area		
Category	Emissions to air	**Indicator's code**	G.1.5
Sub category	Emissions of combustion gases		
Definition	This indicator monitors how often the port authority calculates the emissions of the port's greenhouse gases. The Carbon Footprint is a measure of the total amount of Greenhouse Gas (GHG) emissions that is directly and indirectly caused by an activity [1].		
Importance	Climate change is one of the major environmental, social and economic threats of our time [2]. According to the *Intergovernmental Panel on Climate Change (IPCC)*, global warming is unequivocal, and the emission of Greenhouse Gases of anthropogenic origin is one of the main causes [3]. It is important that port authorities monitor the Carbon Footprint generated as a result of their activities at least once a year.		
Units of measurement	Units of frequency (times / year).		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] Carbon Trust. 2010. Carbon Footprinting. The next step to reduce your emissions. London: The Carbon Trust. [2] EUROPEAN ENVIRONMENTAL AGENCY (EEA). *Total greenhouse gas (GHG) emission trends and projections.* Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-5, 27th March 2016] [3] INTERGOVERNAMENTAL PANEL ON CLIMATE CHANGE (IPCC). *Climate Change 2007: Synthesis Report. Summary for Policymakers*. València, IPCC Plenary XXVII, 2007.		

<table>
<tr><td>Indicator's name</td><td colspan="3">Percentage of each energy source contributing to the Carbon Footprint</td></tr>
<tr><td>Category</td><td>Emissions to air</td><td>Indicator's code</td><td>G.1.6</td></tr>
<tr><td>Sub category</td><td colspan="3">Emissions of combustion gases</td></tr>
<tr><td>Definition</td><td colspan="3">This indicator monitors the percentage of the main energy sources of the greenhouse gases emissions of the port. The main sources of emissions are stationary combustion (natural gas, oil or coal), mobile combustion (diesel or gasoline) [1].</td></tr>
<tr><td>Importance</td><td colspan="3">Climate change is one of the major environmental, social and economic threats of our time [2]. According to the Intergovernmental Panel on Climate Change (IPCC), global warming is unequivocal, and the emission of Greenhouse Gases of anthropogenic origin is one of the main causes [3]. This indicator contributes to find out which are the main sources of GHG emissions and, therefore, it is a useful tool for setting goals to reduce them.</td></tr>
<tr><td>Units of measurement</td><td colspan="3">In order to express the percentage of each energy source, the following table may be used:
<table>
<tr><th>Category</th><th>%</th></tr>
<tr><td>Natural Gas</td><td></td></tr>
<tr><td>Coal</td><td></td></tr>
<tr><td>Gasoline</td><td></td></tr>
<tr><td>Diesel</td><td></td></tr>
<tr><td>Other sources</td><td></td></tr>
<tr><td>Total</td><td>100 %</td></tr>
</table></td></tr>
<tr><td>Frequency</td><td colspan="3">An annual monitoring is recommended.</td></tr>
<tr><td>Level of effort</td><td colspan="3">High level: The information required by the indicator is specific and it may require a deep research to be obtained.</td></tr>
<tr><td>References</td><td colspan="3">1] BOLES S. What are the differences between Scope 1, 2 and 3 Greenhouse Gas emissions? Shelton, EUA, iCompli Sustainability. [http://www.icomplisustainability.com/index.php/ask-the-expert/ghg-management/item/63-what-are-the-differences-between-scope-1-2-and-3-greenhouse-gas-emissions/63-what-are-the-differences-between-scope-1-2-and-3-greenhouse-gas-emissions, 20th of March 2016]
[2] EUROPEAN ENVIRONMENTAL AGENCY (EEA). Total greenhouse gas (GHG) emission trends and projections. Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-5, 27th of March 2016]
[3] INTERGOVERNAMENTAL PANEL ON CLIMATE CHANGE (IPCC). Climate Change 2007: Synthesis Report. Summary for Policymakers. València, IPCC Plenary XXVII, 2007.</td></tr>
</table>

<table>
<tr><td>Indicator's name</td><td colspan="3">Percentage of annual change in the Carbon Footprint</td></tr>
<tr><td>Category</td><td>Emissions to air</td><td>Indicator's code</td><td>G.1.7</td></tr>
<tr><td>Sub category</td><td colspan="3">Emissions of combustion gases</td></tr>
<tr><td>Definition</td><td colspan="3">This indicator expresses the annual variation in the emissions of the port's Greenhouse Gas (GHG). In order to calculate this variation, the annual CO_2e emissions (see Guideline G.1.4 for more information) are required. To carry out the calculation, the following formula may be used:
$$\% \, variation = \frac{t\,CO_2e\ current\ year - t\,CO_2e\ previous\ year}{t\,CO_2e\ previous\ year} \cdot 100$$
A positive percentage means an increase on the emissions and a negative percentage, a decrease.</td></tr>
<tr><td>Importance</td><td colspan="3">The annual variation of the GHG emissions is useful for setting targets for reducing the Carbon Footprint of the port.</td></tr>
</table>

Units of measurement	Percentage
Frequency	Annually
Level of effort	Intermediate level: the information required by the indicator is not very complex, but it requires certain research to be obtained.

Indicator's name	Ammonia (NH_3)		
Category	Emissions to air	**Indicator's code**	G.2.1
Sub category	Emissions of other gases		
Definition	Ammonia (NH_3) is a very common alkaline gas, less dense than air, with a high reactivity. It is a colourless gas and gives off a very characteristic and strong odour. It is used in various industrial processes: as a disinfectant and bleaching agent, in the production of fertilizers, plastics, pharmaceutical and petrochemical products, and in the recent years it has been established as an alternative to chlorinated and fluorinated refrigerants (prohibited by the Montreal protocol [1]). Ammonia is released into the environment by both natural and anthropogenic sources, being agriculture the largest emitter [2, 3].		
Importance	It is important to monitor the concentration of ammonia in the air because, at higher concentrations, it can affect the vegetation and become toxic to humans and aquatic animals, such as fish [3]. Additionally, at very low concentrations, its unwanted odour is detected.		
Units of measurement	• Milligrams of NH_3 per cubic meter of air (mg/m^3) [4] • Parts per million (ppm) [3]		
Equivalence	$$ppm \cdot \frac{M}{24{,}4} = mg/m^3$$ where: *M*: Molecular mass of the substance (17 *g/mol* for NH_3) *24,4:* volume of a mol (*l/mol*) of an ideal gas at a pressure of 1 atm. and a temperature of 25ºC [5]		
Description of the methodology	Below, a method based on the absorption [5] is presented for the determination of the concentration of ammonia. **Basis:** This method uses as a principle the fact that the rate of diffusion of gases and solid particles through a liquid are very different. In other words, the rate of diffusion of gases is much higher than that of the solid particles. This enables to separate and remove the solid particles in suspension, which are the main interference in the determination of the concentration of ammonia gas in the atmosphere. **Preparation of the equipment:** • The absorption system consists of a glass tube (Pyrex), whose inner wall is coated with oxalic acid, a chemical substance that absorbs ammonia. • The tube should be 50 cm long and 3 mm in diameter, approximately. • The coating layer is applied by introducing to the tube a solution of ethanol with 1.5% by volume of oxalic acid. • Immediately after the aspiration of the solution, dry air is passed free of ammonia (see Notes) through the tube for 3 seconds. • Once applied the coating, the tube may be stored in a closed environment (room) as long as both ends are covered with film. Sampling: • The tube coated with oxalic acid is placed vertically and connected in one end to a funnel for proper aspiration, and the other end to a flow meter and pump suction. • The sample is collected for 24 hours, once the session is finished, it is recommended to analyze the sample in the laboratory as soon as possible. Analysis:		

	• The analytical procedure is based on dissolving the layer of oxalic acid of the tube with a solvent and analyzing the ammonia content, which will be fully as ammonium ion ($NH4^+$). • The dissolution of the layer of oxalic acid is achieved by suctioning through the tube 2 ml of a solution of sodium hydroxide (NaOH), 0.1 M. • The dissolution is collected in a beaker and magnetic agitation is applied. To measure the concentration of ammonium ions a specific electrode (Orion 95-10) is used.
Limit values	*Time-Weighted Average* (TWA) 25 ppm (18 mg/m^3) [6] Short Term Exposure Limit (STEL) 35 ppm (27 mg/m^3) [6]
Approximate cost	Air collecting system: 500 € [7] Laboratory equipment: 300 € [8] Orion electrode: 150 € [9]
Notes	The easiest way to remove ammonia from the dry air is passing it through a filter impregnated with oxalic acid [5].
References	[1] UNITED NATIONS ENVIRONMENTAL PROGRAMME. *The Montreal Protocol on Substances that Deplete the Ozone Layer*. Nairobi, Ozone Secretariat, 2000. [2] SEPA. SCOTTISH POLLUTANT RELEASE INVENTORY. *Ammonia.* [http://apps.sepa.org.uk/spripa/Pages/SubstanceInformation. aspx?pid=1, 7th of March 2016] [3] ASPIS. AIR POLLUTION INFORMATION SYSTEM. *Ammonia.* [www.apis.ac.uk/overview/pollutants/overview_NH3.htm, 7th of March 2016] [4] A. RAÑA. *Unidades de medición empleadas en Calidad del Aire.* La Coruña, 2002 [5] FERM M. *Method for determination of atmospheric ammonia. Atmospheric environment.* Vol. 13, 1979, p. 1385-1393. [6] NATIONAL TECHNICAL INFORMATION SERVICE. DEPARTMENT OF HEALTH AND HUMAN SERVICES. *NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 2005-149 First.* Pittsburgh, Centers for Disease Control and Prevention National Institute for Occupational Safety and Health, 2007. [7] LABX. *Air sampling listings.* 2016. [http://www.labx.com/air-sampling, 6th of March 2016] [8] IBDCIENCIA. *Instrumentos y utensilios de laboratorio.* 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016] [9] THERMOCIENTIFIC. *Orion™ Ammonia Gas Sensing ISE Electrodes*. 2015 [http://www.thermoscientific.com/en/product/orion-ammonia-gas-sensing-ise-electrodes.html, 6th of March 2016]

Indicator's name	Dioxins		
Category	Emissions to air	**Indicator's code**	G.2.2
Sub category	Emissions of other gases		
Definition	Dioxins are a group of toxic chemicals that are created in the combustion processes, such as waste incineration, and in certain industrial processes, such as bleaching paper pulp and manufacturing herbicides. The most toxic chemical in this group is the 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD). The highest concentrations of dioxins are usually found in soil and sediment. In air and water, the concentrations are usually much lower. They are persistent substances that accumulate in the food chain. The main source of exposure to these toxic for humans is eating contaminated food [1].		
Importance	Dioxins are highly toxic and can cause problems in the reproduction, damage the immune system, interfere with hormones and even they may cause cancer. Due to the high toxic potential of these pollutants, efforts should be made to reduce exposure levels to a minimum [2].		
Units of measurement	• Nanograms per cubic meter of air (ng/m^3) [3] • g-TEQ (Toxic Equivalent Units) [4]		

Description of the methodology	The European standard method for the determination of dioxins in the environment is the EN-1948 [5]. **Basis:** In order to obtain an air sample suitable for the analysis of the dioxins, an air flow is circulated along a system that contains polyurethane foam (PUF), which retains the substances to be analyzed. The sample is extracted from the foam using a solvent such as n-hexane. Finally, the sample is analyzed with gas chromatography, followed by a mass spectrometry to determine the concentration of dioxins. **Material:** • Sampling system [6] - polyurethane foam: ORBO PUF-1000 Sampler - resin: Amberlite XAD-2 • Gas chromatography [6] - P-2331 - SPB-Octyl - SLB-5ms See reference [5] for more information on the sampling method, the analysis of the sample or on the interpretation of results.
Limit values	The maximum concentration of dioxins is: $14{,}8 \cdot 10^{-12}$ g TEQ/m^3 [6]
Frequency	At least once a year [7]
Approximate cost	Analysis of a sample in the laboratory (in g-TEQ): 500-750 € [7]
References	[1] USGS. ENVIRONTMENTAL HEALTH - TOXIC SUBSTANCES. *Dioxins.* 2015. [http://toxics.usgs.gov/definitions/dioxins.html, 7th of March 2016] [2] WORLD HEALTH ORGANIZATION. MEDIA CENTRE. *Dioxins and their effects on human health.* 2014. [http://www.who.int/mediacentre/factsheets/fs225/en/, 7th of March 2016] [3] A. RAÑA. *Unidades de medición empleadas en Calidad del Aire.* La Coruña, 2002. [4] STATE OF WASHINGTON. DEPARTMENT OF ECOLOGY. *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors.* Washington, 2007. [5] BRITISH STANDARD INSTITUTION. *BS EN 1948-1:2006.* 2006. [http://shop.bsigroup.com/ProductDetail/?pid=000000000030105220, 7th of March 2016]. [6] SIGMA-ALDRICH. SUPELCO ANALYTICAL. *Dioxin & PCB Analysis.* Saint Louis, 2007. [7] UNITED NATIONS ENVIRONMENTAL PROGRAMME. *Guidance on the Global Monitoring Plan* for Persistent Organic Pollutants, *preliminary version.* Geneva, Secretariat of the Stockholm Convention on Persistent Organic Pollutants, 2007.

Indicator's name	Heavy metals		
Category	Emissions to air	**Indicator's code**	G.2.3
Sub category	Emissions of other gases		
Definition	Heavy metals are emitted during industrial processes that require high temperatures, such as waste incineration, foundries, cement industry or the production of electricity in power plants. In these cases, heavy metals vaporise at high temperatures and they are condensed in the ash particles that are emitted. The main metals present in the ashes are: arsenic (As), cadmium (Cd), cobalt (Co), copper (Cu), iron (Fe), mercury (Hg), nickel (Ni), lead (Pb) and zinc (Zn) [1].		
Importance	The most dangerous metals for the human health are lead, cadmium, mercury and arsenic. The main adverse effects of heavy metals have been extensively studied. For example, the exposure to low concentrations of cadmium affects the kidney and weakens the bones; and the exposure to lead is especially harmful to children because it has neurotoxic effects even at low concentrations [2].		

Units of measurement	• Micrograms per cubic meter of air (μg/m^3) [3]. • Nanograms per cubic meter of air (ng/m^3) [3].
Description of the methodology	Below, a method is presented for determining the concentration of the metals As, Cd, Co, Cu, Pb and Ni in ambient air through the technique of Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) [4]. Material and equipment: • Mixed Cellulose Ester (MCE) filters • Prefabricated capsules of polystyrene 37 mm • Mass Spectrometer with inductively coupled plasma (e.g. *Perkin-Elmer Elan 6100*) • Laboratory microwave (e.g. *A CEM MARS-5*) • Centrifugal machine (e.g. *Thermo IEC Centra CL3*) • Plastic pipes for the centrifuge of 50 ml. • Cellulose nitrate filters (e.g. *Whatman* with pore size 0.45 μm and 47 mm diameter) Sampling: A known volume of ambient air is conducted, using an air suction pump, through the MCE filter contained in a capsule of polystyrene. Procedure: • Place the polystyrene capsule into the sampling device and connect it to the suction pump. • Vacuum directly the ambient air to be analysed. • After collecting air sample, turn off the suction pump and remove the capsule. • Record the collected air volume (litres), the sampling time (min) and sampling flow (l / min). Sample preparation: • Transfer the MCE filter from the polystyrene capsule to a test tube to introduce it to the centrifugal machine. • Add 2 ml of nitric acid (70% by vol.) and 0.2 ml of hydrogen peroxide (30% vol.). • Place the tube in the microwave oven at 104 °C. • Remove the sample from the oven, and when it is cold, add 0.5 ml of HCl (aq.) (38% by vol.) and re-enter the tube in the oven at 86 °C. Analysis: • The analysis is carried out by Inductively Coupled Plasma - Mass Spectrometry (ICP-MS). • Follow the specific instructions of the manufacturer. • Calibrate it with the appropriate standards.
Limit values	Maximum annual average concentrations. Lead: 0,5 μg/m^3 [5] Arsenic: 6 ng/m^3 [6] Cadmium: 5 ng/m^3 [6] Nickell: 20 ng/m^3 [6]
Approximate cost	Perkin-Elmer Elan 6100 : 26.000 € [7] Laboratory microwave: 5.400 € [8] Centrifugal machine: 2.700 € [9]
References	[1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002. [2] JARÜP L. *Hazards of heavy metal contamination. British Medical Bulletin*. Vol. 68(1), 2003, p. 167-182. [3] RAÑA A. *Unidades de medición empleadas en Calidad del Aire*. La Coruña, 2002. [4] UNITED STATES DEPARTMENT OF LABOUR. OSHA. *Arsenic, Cadmium, Cobalt, Copper, Lead, and Nickel (Open Vessel Microwave Digestion/ICP-MS Analysis).* Sandy, OSHA Salt Lake Technical Center, 2005. [5] EUROPEAN COMMISSION (EC). *Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air*. Brussels, Official Journal of the European Communities, 1999.

	[6] EUROPEAN COMMISSION (EC). *Directive 2004/107/EC of the European Parliment and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air*. Brussels, Official Journal of the European Union, 2004. [7] CONQUER SCIENTIFIC. *Perkin Elmer Sciex Elan 6100 ICP-MS System.* San Diego, 2016. [https://conquerscientific.com/product/perkin-elmer-sciex-elan-6100-icp-ms-system/, 7th of March 2016] [8] CEM. *MARS Microwave system*. Matthews, 2015. [http://cem.com/content-cat662.html, 6th of March 2016] [9] LABX. *Centrifuge - Benchtop Listings.* 2016. [http://www.labx.com/centrifuge-benchtop, 7th of March 2016

Indicator's name	Ozone		
Category	Emissions to air	**Indicator's code**	G.2.4
Sub category	Emissions of other gases		
Definition	Ozone is a colourless gas at typical concentrations close to the Earth surface. However, in high concentrations it appears lilac. Tropospheric ozone is not emitted directly, it is a secondary pollutant: it is the major product of complex chemical reactions, involving NO_X and Volatile Organic Compounds (VOCs). Tropospheric ozone is considered an environmental concern and it is regulated in many countries. However, in the stratosphere, ozone provides a protective layer for the life of the Earth through the absorption of part of the UV radiation from the sun. Although stratospheric ozone is considered positive and tropospheric ozone harmful, in both cases the chemical composition of ozone is the same [1].		
Importance	Ozone contributes to the urban smog and it is considered an important air pollutant because of the damage it can cause in humans (irritation to the eyes and skin), animals, vegetation and materials [1].		
Units of measurement	• Micrograms of O_3 per cubic meter of air (μg/m^3) • Parts per billion (ppb) [2].		
Equivalence	$$ppb \cdot \frac{M}{24{,}4} = \mu g/m^3$$ where: *M* Molecular mass of the substance (48 *g/mol* for O_3) *24,4* volume of a mol (*l/mol*) of an ideal gas at a pressure of 1 atm and a temperature of 25ºC [1]		
Description of the methodology	The standard method proposed by the European Committee for Standardization (CEN) to determine the concentration of ozone in ambient air is based on the ultraviolet photometry principle [3]. **Basis:** The method of UV photometry is based on leading a sample of ambient air through a cell which measures the absorption of ultraviolet radiation of the sample at 254 nm. The strong absorption of ozone at this wavelength generates a detectable signal when the ozone is present in the sample. Based on this signal, comparing it with the signal detected in the absence of ozone, it is possible to determine the concentration of ozone in the sample [4]. **Equipment** To determine the concentration of ozone in the atmosphere through the CEN standard method, the device APOA-370 (Ambient Ozone Monitor) may be used [5].		
Limit values	The maximum average concentration for 8 hours is 120 μg/m^3 [6].		
Monitoring locations	Usually, measuring stations are located at a height of 3 to 10 meters, in a point sufficiently far from the source of emission of the pollutant [7].		
Approximate cost	APOA-370 Ambient Ozone Monitor: 10.890 € [5]		
References	[1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002.		

	[2] RAÑA A. Unidades de medición empleadas en Calidad del Aire. La Coruña, 2002 [3] CEN. EUROPEAN COMMITTE FOR STANDARIZATION. EN 14625:2012. Ambient air - Standard method for the measurement of the concentration of ozone by ultraviolet photometry. 2012. [http://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT: 31491&cs=1EB159F37D8E51D3A0AD1AA3B49CADF93, 6th March 2016] [4] HASSLER B. et al. Past changes in the vertical distribution of ozone – Part 1: Measurement techniques, uncertainties and availability. Atmos. Meas. Tech. Vol. 7, 2014, p. 1395-1427. [5] HORIBA. PROCESS & ENVIRONMENTAL. APOA-370 Ambient Ozone Monitor. 2016 [http://www.horiba.com/process-environmental/products/ambient/details/apoa-370-ambient-ozone-monitor-276/, 6th March 2016] [6] EUROPEAN COMMISSION (EC). Directive 2002/3/EC of the European Parliment and of the Council of 12 February 2002 relating to ozone in ambient air. Brussels, Official Journal of the European Union, 2003. [7] INDIAN INSITITUTE OF TECHNOLOGY GUWAHATI. QUALITY IMPROVEMENT PROGRAMME. Air Pollution Sampling and Analysis. Guwahati, Department of Civil Engineering, 2009.

Indicator's name	Volatile Organic Compounds (VOCs)		
Category	Emissions to air	**Indicator's code**	G.2.5
Sub category	Emissions of other gases		
Definition	Volatile Organic Compounds (VOCs) are a group of organic compounds that in normal conditions are gaseous or have facility to evaporate. Although they have very different chemical compositions, they show a similar behaviour when they are in the atmosphere. VOCs are emitted into the atmosphere from several sources, such as combustion processes, use of solvents and other industrial processes [1].		
Importance	Volatile Organic Compounds contribute significantly to the formation of tropospheric ozone, with its negative effects (see guideline G.2.4). Additionally, some VOCs species or groups of species, such as benzene and 1,3-butadiene are harmful to human health, and even carcinogenic [1].		
Units of measurement	• Micrograms of VOCs per cubic meter of air (μg/m^3) • Parts per million (ppm) [2]		
Description of the methodology	Below, a method for determining the concentration of VOCs using an electronic device through Photo Ionization Detection (PID) is presented. **Basis:** The PID method uses ultraviolet light to ionize gas molecules. It is used routinely for the determination of VOCs. The Photo Ionization consists in ionizing a gas through an ultraviolet radiation field, generated by a lamp with an inert ionizable gas inside, when this one is located in a space between two electrodes with a known and stable potential. The electrons released in the process of ionization are captured by electrodes, creating a current flow, the magnitude of which can be correlated with the concentration of ionized gas [3]. **Equipment:** • UltraRAE 3000 (Benzene Specific Monitor), from the Manufacturer RAE® Systems Inc, is a portable device for measuring the concentration of VOCs *in situ*, using the previously described method [2, 4]. It also allows the determination of specific compounds, such as benzene and 1,3-butadiene.		
Limit values	Directive 1999/13/EC [5] specifies emission limit values in gases for various industrial activities.		
Monitoring locations	Usually, measuring stations are located at a height of 3 to 10 meters, in a point sufficiently far from the source of emission of the pollutant [6].		

Approximate cost	UltraRAE 3000 - Benzene Specific Monitor: 4.500 € [7]
References	[1] EUROPEAN ENVIRONMENTAL AGENCY. *Non-methane volatile organic compounds (NMVOC) emissions*. Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/eea-32-non-methanevolatile-1, 8th of March 2016] [2] RAE SYSTEMS. *UltraRAE 3000. Portable Handheld Compound-Specific VOC Monitor*. San Jose, 2015 [3] CHOU J. *Hazardous Gas Monitors*. Irvine, CA, McGraw-Hill, 1999, Chapter 6. [4] RAE SYSTEMS. *UltraRAE 3000 User's Guide*. San Jose, 2010 [5] EUROPEAN COMMISSION (EC). *Council Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations*. Brussels, Official Journal of the European Communities, 1999. [6] INDIAN INSITITUTE OF TECHNOLOGY GUWAHATI. QUALITY IMPROVEMENT PROGRAMME. *Air Pollution Sampling and Analysis*. Guwahati, Departmen of Civil Engineering, 2009. [7] RAE SYSTEMS. SURVEY MONITORS. *UltraRAE 3000. Portable, wireless advanced VOC monitor with benzene-specific technology*. San Jose, 2015

Indicator's name	Benzene		
Category	Emissions to air	**Indicator's code**	G.2.6
Sub category	Emissions of other gases		
Definition	Benzene (C_6H_6) is a Volatile Organic Compound (VOCs) with a very stable ring structure. This compound has its own guidelines due to its hazardousness. It is the base of the family of aromatic hydrocarbons. It is a natural component of crude oil and it is found in various refined products, such as the gasoline.		
Importance	Benzene is known for its ability to cause cancer; it is classified as a Class 1 carcinogen [1].		
Units of measurement	• Microgram of C_6H_6 per cubic meter of air (µg/m^3) [2]. • Parts per million (ppm) [2].		
Equivalence	$ppm \cdot \frac{M}{24{,}4}\frac{1}{1000} = \mu g/m^3$ where: *M* Molecular mass of the substance (78 *g/mol* for C_6H_6) *24,4* volume of a mol (*l/mol*) of an ideal gas at a pressure of 1 atm and a temperature of 25ºC [1]		
Description of the methodology	Below, the method OSHA No. 12 is presented, which determines the concentration of benzene in air samples [3]. **Basis:** 1. A known volume of air is led through an absorption column with active carbon to capture the organic vapors present in the air sample (including benzene). 2. The active carbon of the column is transferred to a sealed vial where benzene is extracted by adding carbon disulfide. 3. An aliquot of the extracted sample is analyzed with gas chromatography. 4. The peak area is calculated and it is compared with the area obtained from standard solutions in order to obtain the concentration of benzene in the air sample. **Material:** • Air suction pump to obtain the air samples. • Active carbon columns. • Equipment of gas chromatography. • Electronic Integrator to measure the peak area. • Laboratory equipment. **Other methods:**		

	The device described in the guideline G.2.5 for determining VOCs (UltraRAE - Specific Benzene Monitor) can be also used for the direct determination of benzene. For further information see references [2] and [4].
Limit values	The limit value for the protection of the human health is 5 µg/m^3 (annual average concentration) [5].
Approximate cost	UltraRAE 3000 - Benzene Specific Monitor: 4.500 € [6]
References	[1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002. [2] RAE SYSTEMS. *UltraRAE 3000. Portable Handheld Compound-Specific VOC Monitor*. San Jose, 2015 [3] UNITED STATES DEPARTMENT OF LABOUR. OSHA. *Sampling and analytical methods for Benzene monitoring and measurement procedures.* Washington, Occupational Safety & Health Administration. [https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table =STANDARDS&p_id=10046, 8th of March 2016] [4] RAE SYSTEMS. *UltraRAE 3000 User's Guide*. San Jose, 2010 [5] EUROPEAN COMMISSION (EC). *Directive 2000/69/EC of the European Parliament and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air*. Brussels, Official Journal of the European Communities, 2000. [6] RAE SYSTEMS. SURVEY MONITORS. *UltraRAE 3000. Portable, wireless advanced VOC monitor with benzene-specific technology*. San Jose, 2015.

Indicator's name	Polychlorinated biphenyl (PCB)		
Category	Emissions to air	**Indicator's code**	G.2.7
Sub category	Emissions of other gases		
Definition	PCBs are a group of 209 chlorinated organic substances which were widely used as an insulator in electrical equipment manufactured until the mid-1980s, when they were banned due to their toxicity and persistence in the environment. Other minor uses of PCBs are as hydraulic fluid, lubricants, dyes, adhesives and insecticides. PCBs are very persistent in the environment, and they take many years to degrade. They are still being emitted into the environment from landfills, which were deposited long time ago and have become a global contaminant because air currents transport them over long distances across the globe. [1].		
Importance	The exposure to PCBs can cause permanent damage to the nervous system, the reproductive system and the immune system of humans. Additionally, they are recognized as carcinogenic substances and links between these pollutants and skin cancer and liver have been found [1].		
Units of measurement	• Nanograms per cubic meter of air (ng/m^3) [2] • g-TEQ (Toxic Equivalent Units) [3]		
Description of the methodology	The European standard method for the determination of PCBs in the environment is the method EN-1948 [4]. Out of all the existing PCB, it is recommended to analyze and determine seven congeners individually [5]. The following list shows the seven recommended		

Name of the PCB	Number of the congener
2,4,4'-Trichlorobiphenyl	28
2,2',5,5'-Tetrachlorobiphenyl	52
2,2',4,5,5'-Pentachlorobiphenyl	101
2,3',4,4',5-Pentachlorobiphenyl	118
2,2',3,4,4',5'-Hexachlorobiphenyl	138
2,2',4,4',5,5'-Hexachlorobiphenyl	153
2,2',3,4,4',5,6-Heptachlorobiphenyl	180

	substances, with the number of associated congener for an easier identification. The number of the congener may be found in the reference [6]. **Sample preparation** • Before analyzing the PCBs, these should be extracted through absorption solid / liquid with a solvent. • The samples are extracted through a Soxhlet extractor [7], using acetone or a mixture of acetone and n-hexane as a solvent. • To analyze the different PCBs, the extracted sample is divided in a silica gel column. **Analysis** The determination of the PCBs concentration is done through gas chromatography (GC) with Electron Capture Detectors (ECD) or mass spectrometry (MS). **Material** • Sampling Systems [8] o polyurethane foam: ORBO-1000 PUF Sampler - resin: Amberlite XAD-2 • Gas chromatography [8] - SP-2331 - SPB-Octyl - SLB-5ms
Frequency	A sample of 24 hours should be taken every 5 or 7 days (this represents around 50 or 70 samples in a year) [2].
Approximate cost	Analysis of the 7 congeners in the laboratory: 800€ / sample [2].
References	[1] EUROPEAN ENVIRONMENTAL AGENCY. *Environmental Terminology and Discovery Service (ETDS).* Copenhagen. [http://glossary.eea.europa.eu/terminology/concept_html?term=pcb, 8th of March 2016] [2] OSPAR COMISSION. *Guidance note on the sampling and analysis of PCBs in air and precipitation, Ref. No: 1997-9*. London, Monitoring guidelines, 2012. [3] STATE OF WASHINGTON. DEPARTMENT OF ECOLOGY. *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors.* Washington, 2007. [4] BRITISH STANDARD INSTITUTION. *BS EN 1948-1:2006.* 2006. [http://shop.bsigroup.com/ProductDetail/?pid=000000000030105220, 7th of March 2016] [5] UNITED NATIONS ENVIRONMENTAL PROGRAMME. *Guidance on the Global Monitoring Plan* for Persistent Organic Pollutants, *preliminary version.* Geneva, Secretariat of the Stockholm Convention on Persistent Organic Pollutants, 2007. [6] US ENVIRONMENTAL PROTECTION AGENCY. *Table of PCB Species by Congener Number.* Washington, 2003. [http://www3.epa.gov/epawaste/hazard/tsd/pcbs/pubs/congeners.htm, 8th of March 2016] [7] ROYAL SOCIETY OF CHEMISTRY. *Classic Kit: Soxhlet extractor*. London, 2007. [http://www.rsc.org/chemistryworld/Issues/2007/September/ClassicKit SoxhletExtractor.asp, 6th March 2016] [8] SIGMA-ALDRICH. SUPELCO ANALYTICAL. *Dioxin & PCB Analysis.* Saint Louis, 2007.

Indicator's name	Frequency of photochemical smog events		
Category	Emissions to air	**Indicator's code**	G.2.8
Sub category	Emissions of other gases		
Definition	The photochemical smog pollution is derived from the reactions that take place, with the presence of sunlight, between the primary pollutants (from internal combustion engines and certain industrial processes) to create		

	secondary pollutants, especially ozone (O_3). The air pollution levels in some cities are aggravated by the temperature inversion that traps pollutants near the ground level without possibility to dissipate them [1].
Importance	The smog is often highly toxic to humans and it can cause diseases, decrease life expectancy and even cause the death [1]. Additionally, it is harmful to animals and plants and it can damage the buildings [1].
Units of measurement	Frequency units, such as number of photochemical smog events that have taken place in a day or in a month.
Frequency	Every three months, to observe the seasonality of this phenomenon.
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research to be obtained.
References	[1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002.

<table>
<tr><td>Indicator's name</td><td colspan="3">Persistent Organic Pollutants (POPs)</td></tr>
<tr><td>Category</td><td>Emissions to air</td><td>Indicator's code</td><td>G.2.9</td></tr>
<tr><td>Sub category</td><td colspan="3">Emissions of other gases</td></tr>
<tr><td>Definition</td><td colspan="3">Persistent Organic Pollutants (POPs) are chemical substances that persist in the environment, they have the ability to bioaccumulate along the food chain and pose a risk to human health and to the environment. This group of pollutants includes by-products of chemical processes, such as Polycyclic Aromatic Hydrocarbons (PAHs) (see G.2.10), Dioxins (see G.2.2), pesticides (such as DDT) and industrial chemicals (such as PCBs (see G.2.7)) [1].</td></tr>
<tr><td>Importance</td><td colspan="3">POPs accumulate gradually at the top of the food chain (human and predatory animals), where concentrations that can be potentially harmful are reached. They are also a matter of concern for its high toxicity and its ability to cause cancer, affect the reproductive system and the immune system of humans [1].</td></tr>
<tr><td>Units of measurement</td><td colspan="3">• Nanograms per cubic meter of air (ng/m^3) [2]
• g-TEQ (Toxic Equivalent Units) [3]</td></tr>
<tr><td>Description of the methodology</td><td colspan="3">Below, a method for the determination of POPs in the air is presented [4]. Because of the difficulty to analyze all the congeners of the family of pollutants, the analysis of the following substances are recommended:
<table>
<tr><td>Aldrin</td><td>Chlordane</td><td>DDT</td><td>Dieldrin</td></tr>
<tr><td>Endrin</td><td>HCB</td><td>Heptachlor</td><td>Mirex</td></tr>
<tr><td>PCBs</td><td colspan="3">Dioxins (PCCD and PCDF)</td></tr>
</table>
Sampling:
There are two types of sampling:
1) Active sampling (high volume)
• The sample is collected using a suction volume between 0.5 and 1 m^3/min.
• A session of 24 hours represents a sample of air collected between 720 and 1440 m^3.
• It is recommended to filter the air sample through fiberglass filters in order to separate solid particles and gases.
• Two absorbent gas particle filters are placed. There are three possible configurations:
- 2 absorbents of polyurethane foam (PUF)
- 1 polyurethane foam (PUF) and 1 resin XAD-2
- 1 polyurethane foam (PUF) followed by active carbon
2) Passive sampling (diffusive)
• Passive sampling systems use an absorbent with a great capacity to absorb POPs, such as polyurethane foam (PUF) or resin XAD-2.
• The absorber is located inside a cylindrical stainless steel chamber.</td></tr>
</table>

	• The ratios of sample collection are usually 3 or 4 m^3/day. • In three months of passive sampling, a volume estimated of 270-360 m^3 may be collected. **Extraction:** • The samples are extracted using a Soxhlet extractor [5], using as a solvent n-hexane or dicloroethane. • The key elements for a good extraction are allowing an enough exposure time to achieve a good performance and limiting the steps that involve a direct manipulation of the sample. • Steps of separation: the aim is to remove other substances that are extracted together with POPs and to separate the more polar PCBs from the other non-polar POPs. These steps are carried out on a column of silica gel or Florisil. • After the separation steps, the extract vials for the gas chromatography are prepared. **Analysis:** • POPs are analyzed traditionally using techniques of gas chromatography (GC) with the electron capture detectors (ECD) method [4]. • However, recently the separation step has been improved using capillary techniques, and with the use mass spectrometry (MS).
Frequency	At least once a year
Approximate cost	The cost of the facilities and equipment to carry out this analysis is very high. In order to analyze all the recommended POPs, it is necessary a laboratory, with the following estimated costs [4]: Laboratory instruments: 400 € Laboratory equipment: € 45,000 Specialist staff: € 45,000 / year In addition, the approximated cost of a complete analysis of POPs is: 850€ [4].
References	[1] EUROPEAN ENVIRONMENTAL AGENCY. *Persistent organic pollutant emissions*. Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/eea32-persistent-organic-pollutant-pop-emissions-1/assessment-5, 8th March 2016] [2] RAÑA A. *Unidades de medición empleadas en Calidad del Aire.* La Coruña, 2002 [3] STATE OF WASHINGTON. DEPARTMENT OF ECOLOGY. *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors.* Washington, 2007. [4] UNITED NATIONS ENVIRONMENTAL PROGRAMME. *Guidance on the Global Monitoring Plan* for Persistent Organic Pollutants, *preliminary version.* Geneva, Secretariat of the Stockholm Convention on Persistent Organic Pollutants, 2007. [5] ROYAL SOCIETY OF CHEMISTRY. *Classic Kit: Soxhlet extractor*. London, 2007. [http://www.rsc.org/chemistryworld/Issues/2007/September/ClassicKit SoxhletExtractor.asp, 6th March 2016]

Indicator's name	Polycyclic Aromatic Hydrocarbons (PAHs)		
Category	Emissions to air	**Indicator's code**	G.2.10
Sub category	Emissions of other gases		
Definition	The Polycyclic Aromatic Hydrocarbons (PAHs) are a family of chemical compounds composed of carbon and hydrogen atoms, with a molecular structure constituted of two or more fused benzene rings. This family of chemicals includes more than 100 substances that are differentiated according to the number and position of the ring. They are non-polar substances and extremely hydrophobic. The PAHs emission sources are found mainly in urban areas (e.g. automobiles, oil refineries, power plants, or aluminium production processes) [1]. Although PAHs are already included in the		

	guideline of POPs (see G.2.9), they have their own guideline because they are considered as an important indicator.
Importance	The risk associated with the exposure to the PAHs present in the atmosphere is higher in cities due to the sources location. Additionally, some compounds of this group are highly carcinogenic and mutagenic, in particular the compound benzo (a) pyrene (B [a] P) [1]. These properties make them to be persistent on the environment.
Units of measurement	• Nanograms per cubic meter of air (ng/m^3) [2] • g-TEQ (Toxic Equivalent Units) [3]
Description of the methodology	Due to its toxicity and hazardousness to human health, the most important PAH to monitor and control is benzo(a)pyrene. The method UNE-EN 15549: 2008 specifies how to calculate the concentration of benzo(a)pyrene (B[a]P) in ambient air [4, 5]. **Background:** This sampling is done in conjunction with the analysis of PM10 particles. PAHs are extracted from the sample by absorbing liquid / liquid with an organic solvent. The analysis is carried out with a High Performance Liquid Chromatography (HPLC) with fluorescence detector (FLD) or with Gas Chromatography with Mass Spectrometry (GC / MS) detector. **Determination of PAHs:** In order to determine other PAHs, such as benzo(a)anthracene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, india(1,2,3-cd)pyrene and benzo(g,h,i)perilene, the method explained in [6] is available.
Threshold values	The annual average concentration of benzo(a)pyrene is 1 ng/m^3, (see note below) [7]
Notes	The limit value for PAHs is defined in terms of the concentration of benzo(a)pyrene, a substance used as a reference for the entire group of polycyclic aromatic hydrocarbons [8].
References	[1] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Polycyclic Aromatic Hydrocarbons (PAHs). Washington, Office of Solid Waste, 2008. [2] RAÑA A. *Unidades de medición empleadas en Calidad del Aire.* La Coruña, 2002 [3] STATE OF WASHINGTON. DEPARTMENT OF ECOLOGY. *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors.* Washington, 2007. [4] AENOR. *UNE-EN 15549:2008. Air quality - Standard method for the measurement of the concentration of benzo[a]pyrene in ambient air*. 2008. [http://www.ca.aenor.es/aenor/normas/normas/fichanorma.asp?tipo= N&codigo=N0041363#.Vt8CEykaz8h, 8th of March 2016] [5] AENOR. *UNE-EN 15549:2008. Método normalizado para la medición de la concentración de benzo(a)pireno en el aire ambiente.* Madrid, 2008 [6] CEN. EUROPEAN COMMITTE FOR STANDARIZATION. *CEN/TS 16645:2014. Ambient air - Method for the measurement of benz[a]anthracene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene and benzo[ghi]perylene.* 2014. [http://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT: 36712&cs=1D52ABA79F1E52A6828AF5BB067AB45A7, 6th of March 2016] [7] EUROPEAN COMMISSION (EC). *Directive 2004/107/EC of the European Parliment and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air*. Brussels, Official Journal of the European Union, 2004. [8] OSPAR COMISSION. *Guidance note on the sampling and analysis of PCBs in air and precipitation, Ref. No: 1997-9*. London, Monitoring guidelines, 2012.

Indicator's name	Dust		
Category	Emissions to air	**Indicator's code**	G.3.1
Sub category	Emissions of particulate matter		

Definition	Dust is defined as any particle of matter, solid or liquid, present in the air with a diameter smaller than 100 µm. The dust is generated and released into the atmosphere due to various industries, such as the cement industry, the processing of minerals or mining. It also may be released from other non-industrial sources, such as the internal combustion of vehicles or pollen.
Importance	When the dust is inhaled, it can create respiratory problems, damage lung tissue and aggravate the existing health problems. Moreover, the dust generated by various activities can reduce visibility, which can increase the risk of accidents.
Units of measurement	Micrograms per cubic meter of air ($\mu g/m^3$)
Description of the methodology	Below, a method is presented for determining the concentration of Total Suspended Particulates (TSP) through the device MiniVol™ TAS of Airmetrics [2]. This parameter includes all suspended matter in the air (from larger particles to PM10 and PM2.5 particles). **Basis:** The air is conducted through a filter. To determine the total amount of suspended particles, it is not needed a separation system, because the objective is to determine the total amount of suspended solids that are in the air, regardless their diameter. The amount of solids retained in the filter are determined by weighing the filter where they are retained. **Procedure:** • The system should be cleaned and lubricated every five readings. The frequency may be increased or decreases depending on the load of solid. • Once verified that the device is calibrated and it works properly, a filter should be placed in the appropriate support and the pump suction should be set to an appropriate flow. For more information see the manual of operations [3].
Monitoring locations	Usually, measuring stations are located at a height of 3 to 10 meters, in a point sufficiently far from the source of emission of the pollutant [7].
Approximate cost	MiniVol™ TAS: 3.050 € [5]
References	1] RAÑA A. *Unidades de medición empleadas en Calidad del Aire*. La Coruña, 2002 [2] AIRMETRICS. PRODUCTS & SERVICES. *MiniVol Portable Air Sampler*. Eugene, 2002. [http://www.airmetrics.com/products/minivol/index.html, 8th March 2008] [3] AIRMETRICS. MiniVol Portable Air Sampler. Operation Manual. Eugene, 2001. [4] INDIAN INSITITUTE OF TECHNOLOGY GUWAHATI. QUALITY IMPROVEMENT PROGRAMME. *Air Pollution Sampling and Analysis*. Guwahati, Departmen of Civil Engineering, 2009. [5] NRDF. *Community Air Monitors*. 2013.

Indicator's name	PM10		
Category	Emissions to air	**Indicator's code**	G.3.2
Sub category	Emissions of particulate matter		
Definition	The parameter PM10 provides the concentration of the particulate matter in suspension. More specifically, PM10 is the concentration of aerosol particles with an aerodynamic diameter smaller than 10 µm that are able to pass through a selective filter with a cut efficiency of 50%. The main sources of PM10 are particles of dust raised by the wind, emissions from agricultural or forestry, erosion particles caused by wind, and particles from combustion [1].		
Importance	Correlations have been found between the particles with a diameter less than 10 µm and asthma and chronic lung diseases [1].		
Units of measurement	Micrograms of PM10 per cubic meter of air ($\mu g/m^3$) [2]		

Description of the methodology	The PM10 concentration can be determined by using the device MiniVol™ TAS of Airmetrics [3] (see notes). **Basis:** The air is conducted through a particle separator, and then through a filter. The separation of particles by size is achieved by impact, larger particles fall, and smaller particles (PM10) are taken by the airflow and retained in the filter [4]. The flow of particles passing through the separator is a critical parameter for the proper separation. The optimal volumetric flow is 5 l/min. Finally, the amount of solid particles retained in the filter are determined by weighing it. **Procedure:** • The system should be cleaned and lubricated every five readings. The frequency may be increased or decreases depending on the load of solid. • Once it is verified that the device is calibrated and it works properly, a filter should be placed in the appropriate support and the pump suction should be set to an appropriate flow. For more information see the manual of operations [5]. **Other methods:** Another method is the standard method of the European Committee for Standardization (CEN) to measure the concentration of particles (PM10 and PM2.5) in ambient air [6].
Limit values	The maximum daily (24 hours) average concentration is 50 $\mu g/m^3$ [7]. The maximum annual average concentration is 40 $\mu g/m^3$ [7].
Monitoring locations	Usually, measuring stations are located at a height of 3 to 10 meters, in a point sufficiently far from the source of emission of the pollutant [8].
Approximate cost	MiniVol™ TAS: 3.050 € [9]
Notes	This device also allows the measurement of Total Suspended Particles and PM2.5
References	[1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002. [2] RAÑA A. *Unidades de medición empleadas en Calidad del Aire*. La Coruña, 2002 [3] AIRMETRICS. PRODUCTS & SERVICES. *MiniVol Portable Air Sampler*. Eugene, 2002. [4] COPELY SCIENTIFIC. *Andersen Cascade Impactor (ACI)*. Therwil, 2016. [5] AIRMETRICS. *MiniVol Portable Air Sampler. Operation Manual*. Eugene, 2001. [6] CEN. EUROPEAN COMMITTE FOR STANDARIZATION. *CEN/TC 264/WG 15 - Particulate Matter (PM10/PM2,5)*. 2016. [http://standards.cen.eu/dyn/www/f?p=204:32:0::::FSP_ORG_ID,FSP_LANG_ID:7836,25&cs=10857B0CC55007A65728F245D5370EFEB, 6th March 2016] [7] EUROPEAN COMMISSION (EC). Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. Brussels, Official Journal of the European Communities, 1999. [8] INDIAN INSITITUTE OF TECHNOLOGY GUWAHATI. QUALITY IMPROVEMENT PROGRAMME. *Air Pollution Sampling and Analysis*. Guwahati, Department of Civil Engineering, 2009. [9] NATURAL RESOURCES DEFENSE COUNCIL. *Community Air Monitors*. 2013.

Indicator's name	PM2.5		
Category	Emissions to air	**Indicator's code**	G.3.3
Sub category	Emissions of particulate matter		

Definition	The parameter PM2.5 is composed of particulate matter in suspension. In particular, PM2.5 is the concentration of aerosol particles with an aerodynamic diameter smaller than 2.5 µm that are able to pass through a selective filter with a cut efficiency of 50% [1].
Importance	Long periods of exposure to PM2.5 may cause cardiopulmonary problems, such as the decrease of the lung function, the increase in the number of respiratory diseases or the increase in mortality in both children and adults. Additionally, some studies have demonstrated that PM2.5 particles pose a greater risk to health than larger aerosol particles [1].
Units of measurement	Micrograms of PM2.5 per cubic meter of air (µg/m^3) [2]
Description of the methodology	The PM2.5 concentration can be determined by using the device MiniVol™ TAS of Airmetrics [3] (see Note 1). **Basis:** The air is conducted through a particle separator, and then through a filter. The separation of particles by size is achieved by impact, larger particles fall, and smaller particles (PM2.5) are taken by the airflow and retained in the filter [4]. The flow of particles passing through the separator is a critical parameter for the proper separation. The optimal volumetric flow is 5 l/min. Finally, the amount of solid particles retained in the filter are determined by weighing it. **Procedure:** • The system should be cleaned and lubricated every five readings. The frequency may be increased or decreases depending on the load of solid. • Once it is verified that the device is calibrated and it works properly, a filter should be placed in the appropriate support and the pump suction should be set to an appropriate flow. For more information see the manual of operations [5]. **Other methods:** Another method is the standard method of the European Committee for Standardization (CEN) to measure the concentration of particles (PM10 and PM2.5) in ambient air [6].
Limit values	The maximum annual average concentration for PM2.5 is 25 µg/m^3 [7] (see Note 2).
Monitoring locations	Usually, measuring stations are located at a height of 3 to 10 meters, in a point sufficiently far from the source of emission of the pollutant [8].
Approximate cost	MiniVol™ TAS: 3.050 € [6]
Notes	1. This device also allows the measurement of Total Suspended Particles and PM10 2. On the 1st January 2020 a new limit value will come into force. The annual average concentration will be 20 µg/m^3 [7].
References	[1] JACOBSON, M. Atmospheric pollution: History, science, and regulation. Cambridge, Cambridge University Press, 2002. [2] RAÑA A. Unidades de medición empleadas en Calidad del Aire. La Coruña, 2002 [3] AIRMETRICS. PRODUCTS & SERVICES. MiniVol Portable Air Sampler. Eugene, 2002. [http://www.airmetrics.com/products/minivol/index.html, 8th of March 2008] [4] COPELY SCIENTIFIC. Andersen Cascade Impactor (ACI). Therwil, 2016. [5] AIRMETRICS. MiniVol Portable Air Sampler. Operation Manual. Eugene, 2001. [6] CEN. EUROPEAN COMMITTE FOR STANDARIZATION. CEN/TC 264/WG 15 - Particulate Matter (PM10/PM2,5). 2016. [http://standards.cen.eu/dyn/www/f?p=204:32:0::::FSP_ORG_ID,FSP _LANG_ID:7836,25&cs=10857B0CC55007A65728F245D5370EFEB, 6th of March 2016] [7] EUROPEAN COMMISION (EC). Directive 2008/50/EC of the European Parliament and of the Council of of 21 May 2008 on ambient air quality and cleaner air for Europe. Brussels, Official Journal of the European Union, 2008. [8] INDIAN INSITITUTE OF TECHNOLOGY GUWAHATI. QUALITY IMPROVEMENT PROGRAMME. Air Pollution Sampling and Analysis. Guwahati, Department of Civil Engineering, 2009.

Indicator's name	Hydrogen sulphide (H_2S)		
Category	Emissions to air	**Indicator's code**	G.4.1
Sub category	Odour emissions		
Definition	The hydrogen sulphide is a toxic and flammable gas that gives off an unpleasant odour. It is formed naturally during the decomposition of organic matter. However, the main sources of emissions are the petroleum refining processes and the combustion of waste [1].		
Importance	The odour threshold of the hydrogen sulphide is very low (at concentrations of the order of ppb) and it is considered as the most persistent odorant substance. At higher concentrations, hydrogen sulphide may cause irritation, breathing difficulties, nausea, vomiting and even the death [1].		
Units of measurement	• Micrograms of H_2S per cubic meter of air ($\mu g/m^3$) • Parts per billion (ppb) [1].		
Equivalence	$$ppb \cdot \frac{M}{24,4} = \mu g/m^3$$ where: *M* Molecular mass of the substance (34 *g/mol* for H_2S) *24,4* Volume of a mol (*l/mol*) of an ideal gas at a pressure of 1 atm and a temperature of 25ºC [1]		
Description of the methodology	Below, a method is presented for determining the concentration of hydrogen sulphide in the air, through an independent monitoring system [2]. **Basis:** This method is based on an amperometric sensor. This sensor comprises three electrodes: the working electrode (anode), the reference electrode, and an electrode to close the circuit (cathode). The gas to be analysed is diffused through a membrane that removes the moisture and is led to the working electrode. The gas is oxidized or reduced between the anode and cathode, and the electrical signal generated is proportional to the concentration of hydrogen sulphide. **Equipment** The device CairSens [2], from the manufacturer CairPol, is an integrated system that includes an amperometric sensor for the calculation of H_2S, a dynamic air sampler, and a patented filter that allows real-time readings and recording these reads into a data logger. Specifications of the device: • Measurement range: from 0 to 1000 ppb of H_2S. • The readings should be comparable to reference methods [3] • Measures every minute, storage capacity readings from 10 to 20 days. • Maintenance and calibration once a year. • Cairtube: support for applications where the sensor is installed in a fixed location [4]		

Limit values	Time-Weighted Average (TWA) 1 ppm (1,4 mg/m^3) [1] Short Term Exposure Limit (STEL) 5 ppm (7,7 mg/m^3) [1] (See Notes)
Monitoring locations	Areas where H_2S can be generated, such as refineries and petrochemical plants, leather tanning industries, paper industry and wastewater treatment plants [1].
Notes	These limit values were adopted by the American Conference of Governmental Industrial Hygienist (ACGIH). Despite not being a regulatory body, the ACGIH is a globally recognized authority for establishing exposure limits for hazardous chemical agents, such as H_2S.
References	[1] DRÄGER. *Monitoring Hydrogen Sulfide (H2S) to meet new exposure standards*. Lübeck, 2013. [2] CAIRPOL. *Autonomous systems for low pollution levels survey*. La Roche Blanche, 2015. [http://www.cairpol.com/index.php?option=com_content&view=article&id=68&Itemid=155&lang=en, 8th March 2016] [3] ZAOUAK, O., et al. *High Performance Cost Effective Miniature Sensor for Continuous Network Monitoring of H_2S. Chemical Engineering Transactions*. Vol. 30, 2012. [4] CAIRPOL. *CairTub, Autonomous beacon for the measure "any ground"*. La Roche Blanche, 2015. [http://www.cairpol.com/index.php?option=com_content&view=article&id=47&Itemid=158&lang=en, 8th March 2016]

Indicator's name	Percentage of respondents that perceive odour		
Category	Emissions to air	**Indicator's code**	G.4.2
Sub category	Odour emissions		
Definition	This indicator aims at providing the opinion of the port stakeholders in relation with the odours generated in the port. The indicator demonstrates whether surveys related to this issue have been carried out and, if so, which are their results.		
Importance	To ensure an efficient environmental management, it is very important to integrate and have the involvement of all the port stakeholders. For example, knowing the perception that the neighbouring communities have on the odours generated in the port area is valuable information in order to apply mitigation measures. Odour can generate disturbances to the local community.		
Units of measurement	Percentage of respondents		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

Indicator's name	Chlorophyll-a		
Category	Emissions to water	**Indicator's code**	G.5.1
Sub category	Discharges of wastewaters		
Definition	Chlorophyll is the substance that gives the green colour to plants. It absorbs sunlight to perform the photosynthesis. The average annual concentration of chlorophyll in coastal waters is a measure of the phytoplankton abundance and biomass, and it is a common indicator of water quality [1].		
Importance	High levels of chlorophyll often indicate poor quality of water and low levels indicate good conditions. However, high concentrations of chlorophyll for short periods of time are not harmful. The high concentrations for a long period of time are a problem [1].		
Units of measurement	Micrograms of chlorophyll per litre of sample (µg/l) Milligrams of chlorophyll per cubic metre of sample (mg/m^3)		
Equivalences	1 µg/l = 1 mg/m^3		
Description of the methodology	Below, a method is presented for the spectrophotometric determination of chlorophyll concentration in seaweed [2]. **Equipment** • Vacuum filtration system • Fiberglass filters of 47 mm diameter • Laboratory mortar 30 ml of capacity • Spectrophotometer (e.g. Perkin Elmer LAMBDA 25/35/45 UV / Vis [3]) **Sampling** • Samples are collected in tinted bottles. • They are kept immediately in a container with ice. • They are filtered immediately when they are at the laboratory. • Once filtered, the filtered product is wrapped with aluminium foil and kept at -20 °C. **Procedure** 1. The sample is filtered under vacuum and preserved according to the previous point. 2. The filter is grinded with a mortar laboratory. 3. A solution of acetone at 90% is introduced to extract chlorophyll (note 1). 4. Once extracted, the solid waste is separated through centrifugation. 5. The absorbance of the centrifuged solution is measured with the spectrophotometer at wavelengths of 750, 665, 664, 647, 630 nm. 6. The sample is acidified with $HCl_{(aq)}$ and the absorbance is re-measured at the same wavelengths as above. **Results** The chlorophyll concentration in the sample is calculated using the following formula: $$Chlorophyll\left(\frac{\mu g}{l}\right) = \frac{26{,}7(664_B - 665_A)\cdot V_1}{V_2 \cdot L}$$		

	Where: *664*$_B$ absorbance at 664 nm previous to the acidification *665*$_A$ absorbance a 665 nm after the acidification V_1 Volume analyzed (acetone solution and chlorophyll) V_2 Volume of sample filtered *L* Optical path length (cm) See reference [2] to obtain more detailed information on this method
Monitoring locations	Port waters Saline waters
Approximated costs	Vacuum filtration system: 70€ [4] Laboratory mortar: 200€ [5] Spectrophotometer LAMBDA 35 : 14.500€ [6]
Notes	To prevent the degradation of the sample, the extraction and analysis with the spectrometer are carried out in a room with dim light (red light bulbs) [2].
References	[1] AUSTRALIAN GORVERNMENT. AUSTRALIAN ONLINE COASTATAL INFORMATION. *Chlorophyll a concentrations*. Marine & Coastal Environment Group, Canberra, 2015. [http://www.ozcoasts.gov.au/indicators/chlorophyll_a.jsp, 8 March 2016] [2] DEPARTMENT OF ENVIRONMENTAL PROTECTION. BUREAU OF LABORATORIES. *Spectrophotometric Determination of Corrected and Uncorrected Chlorophyll a and Phaeophytin*. Tallahassee, Biology Section, 2015. [3] PERKINELMER. *Technical Specifications for the LAMBDA 25/35/45 UV/Vis Spectrophotometers*. Shelton, PerkinElmer life and Analytical Sciencies, 2004. [4] IBDCIENCIA. *Instrumentos y utensilios de laboratorio.* 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7 March 2016] [5] WHEATON. *Tissue grinders.* 2012. [http://wheaton.com/lab/cell-culture/tissue-grinders.html, 8 March 2016] [6] VWR. LAMBDA™ 25/35 Series UV/Vis Spectrophotometers, PerkinElmer®. [https://us.vwr.com/store/catalog/product.jsp?product_id=4832209, 8th March 2016]

Indicator's name	Biological Oxygen Demand (BOD)		
Category	Emissions to water	**Indicator's code**	G.5.2
Sub category	Discharges of wastewaters		
Definition	Biological Oxygen Demand (BOD) is the amount of oxygen required for aerobic microorganisms to oxidize metabolically the organic matter present in the water sample. BOD provides information on the amount of biodegradable matter that is present in a sample. The BOD_5 is the variation of dissolved oxygen measured after five days from the beginning of the analysis, under standard conditions. It is the most common parameter for determining the BOD [1, 2].		

Importance	Its use for the monitoring of the biodegradable organic matter is widespread and researched.
Units of measurement	Milligrams of dissolved oxygen per litre of sample (mg/l)
Description of the methodology	Below, a method is presented in order to determinate the BOD of a water sample. **Equipment** • Material of laboratory. • Incubation containers, from 130 to 250 ml. • Incubator, regulated at 20 °C • Oxygen electrode (apparatus for measuring the dissolved oxygen) **Sampling** 1. The samples must be collected in glass or polyethylene containers. 2. The samples should be analysed as soon as possible. 3. If they are not analysed immediately, keep them between 0 and 4 °C, for 24 hours. **Procedure** 1. Neutralize the water sample to be analysed (for more information, see reference [3]). 2. Dilute it in a solution rich in dissolved oxygen and aerobic microorganisms. 3. Incubate for 5 days in the dark and at 20 ºC in a container completely filled and covered. 4. Calculate the concentration of dissolved oxygen before and after the incubation with an oxygen electrode. 5. Calculate the mass of oxygen consumed per litre of water. **Results** The BOD_5, as expressed in mg of O_2/l, is calculated through the following formula: $$DBO_5 = (OD_0 - OD_5) \cdot \frac{V_t}{V_m}$$ Where: OD_0 is the dissolved oxygen before the incubation OD_5 is the dissolved oxygen after the incubation V_t is the total volume after diluting the sample V_m is the volume of the sample
Threshold values	BOD_5 at 20 ºC: 25 mg/l O_2 [4]
Monitoring locations	Natural waters Wastewaters Treatment plants waters
Frequency	Every three months (as a maximum) [5]
Approximate cost	Commercial oxygen electrode: 300-1500 € [6] Laboratory equipment: 300 € [7] Incubator: 1250 € [8]

Notes	Often, it is needed to seed the dissolution with microorganisms. In this case, a blank test (without the sample) should be carried out in parallel. The BOD of the blank test (DBOblank) must be subtracted of the total [2]. $$DBO_5 = (OD_0 - OD_5) \cdot \frac{V_t}{V_m} - \left(OD_{0,blank} - OD_{5,blank}\right) \cdot \frac{V_{t-}V_m}{V_m}$$
References	[1] AZNAR, A. *Determinación de los parámetros fisico-químicos de calidad de las aguas. Gestión Ambiental 2000*. Vol. 2(23), 2000, pag. 12-19. [2] UNIVERSITAT POLITÈCNICA DE CATALUNYA. *Tecnologia del Medi Ambient. Llibre de transperències*. Barcelona, Departament d'Enginyeria Química de l'Escola Tècnica d'Enginyeria Industrial de Barcelona, 2014. [3] AENOR. *Calidad del agua. Medioambiente Tomo 1*. AENOR, Madrid, 1997. [4] EUROPEAN COMMISSION (EC). *Council Directive (91/271/EEC) of 21 May 1991 concerning urban waste water treatmen*t. Brussels, Official Journal of the European Communities, 1991. [5] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000. [6] GRAINGER. *Conductivity Meters*. 2016. [http://www.grainger.com/category/conductivity-meters/water-testing-equipment-and-meters/lab-supplies/ecatalog/N-kva, 8th March 2016] [7] IBDCIENCIA. *Instrumentos y utensilios de laboratorio*. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016] [8] ELICROM. INCUBADORA DE LABORATORIO CIRCULACION NATURAL 32 LITROS 414005-128. 2016. [http://www.elicrom.com/incubadora-de-laboratorio-circulacion-natural-32-litros-414005-128/, 8th of March 2016]

Indicator's name	Chemical Oxygen Demand (COD)		
Category	Emissions to water	**Indicator's code**	G.5.3
Sub category	Discharges of wastewaters		
Definition	Chemical Oxygen Demand (COD) is the amount of oxygen consumed by organic compounds (biodegradable or not) that are contained in a water sample. The value of COD always should be higher than the Biological Oxygen Demand (BOD), because all matter that is oxidizable chemically it is also oxidized biologically [1, 2].		
Importance	It is an indicator of organic matter present in contaminated waters [1].		
Units of measurement	Milligrams of dissolved oxygen per litre of sample (mg/l)		

<table>
<tr><td>Description of the methodology</td><td>Below, a method is presented in order to determinate the COD through the dichromate technique [3].
Equipment
• Material of laboratory.
• Reflux apparatus (glass container connected to a coolant to prevent loss of volatile substances).
• Thermal mesh to bring the sample to boil quickly (within 10 minutes).
• Precision burette (capacity of 10 ml, graduated with divisions of 0.02 ml).
Sampling
1. The samples must be collected in glass or polyethylene containers.
2. The samples should be analysed as soon as possible.
3. If they have to be kept, add 10 ml of sulphuric acid and keep them between 0 and 5 °C, up to 5 days.
Procedure
1. Add into the sample to be analysed, 5 ml of potassium dichromate 0.04 M (mol/liter) and homogenize it.
2. Bring to boil, add a few glass beads to regulate the boiling.
3. Add, slowly, silver sulphate - sulphuric acid 4 M, shaking the container carefully.
4. Connect the coolant with the reflux container and boil the sample for 2 hours.
5. Separate the coolant, dilute the sample with 75 ml of distilled water and let it cool.
6. Titrate the sample with iron sulphate (II) and ammonium 0.12 M, in the presence of ferroin (indicator that will change from teal to red-violet).
7. Perform a blank test following the same procedure and substituting the sample for 10 ml of distilled water.
Results
The COD, as expressed in mg of O_2/l, is calculated through the following formula:
$$COD = \frac{8 \cdot 10^3 \cdot c(V_1 - V_2)}{V_0}$$
where:
c is the concentration of the solution of iron sulphate (II) and ammonium (in mol/l).
V_0 is the volume of the original sample (in ml).
V_1 is the volume of the solution of iron sulphate (II) and ammonium used in the blank test (in ml).
V_2 is the volume of the solution of iron sulphate (II) and ammonium used in the assessment (in ml).
$8 \cdot 10^3$ is the molar mass, in mg/l of ½ O_2.</td></tr>
<tr><td>Limit values</td><td>125 mg/l O_2 [4]</td></tr>
<tr><td>Monitoring locations</td><td>Wastewaters
It is not valid for saline waters [3]</td></tr>
<tr><td>Frequency</td><td>Every three months (as a maximum) [5]</td></tr>
<tr><td>Approximate cost</td><td>Reagents: 30 € [6]
Laboratory equipment: 400 € [7]</td></tr>
</table>

References	[1] AZNAR, A. *Determinación de los parámetros fisico-químicos de calidad de las aguas. Gestión Ambiental 2000*. Vol. 2(23), 2000, pag. 12-19. [2] UNIVERSITAT POLITÈCNICA DE CATALUNYA. *Tecnologia del Medi Ambient. Llibre de transperències*. Barcelona, Departament d'Enginyeria Química de l'Escola Tècnica d'Enginyeria Industrial de Barcelona, 2014. [3] AENOR. *Calidad del agua. Medioambiente Tomo 1*. AENOR, Madrid, 1997. [4] EUROPEAN COMMISSION (EC). *Council Directive (91/271/EEC) of 21 May 1991 concerning urban waste water treatmen*t. Brussels, Official Journal of the European Communities, 1991. [5] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000. [6] IBDCIENCIA. *Ácido sulfúrico*. 2015. [http://www.ibdciencia.com/acido-sulfurico-c-191, 7th of March 2016] [7] IBDCIENCIA. *Instrumentos y utensilios de laboratorio*. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016]

Indicator's name	Algal Growth Potential		
Category	Emissions to water	**Indicator's code**	G.5.4
Sub category	Discharges of wastewaters		
Definition	This indicator determines the maximum amount of algae that can grow in a water sample, based on the amount of nutrients contained inside. This analysis is a good indicator of the algae blooms that can occur in a given body of water [1]. The availability of the nutrients nitrogen (N) and phosphorus (P) in water and the levels of nutrient absorbed previously by the sample are important factors that contribute to the growth of algae [2].		
Importance	This indicator provides an efficient indication of the possible proliferation of algae, better than the information provided by other chemical parameters. It also provides an indication of the concentration of nutrients that the algae need for growing, since not all the nutrients present in water can be used by algae.		
Units of measurement	Micrograms of chlorophyll per litre of sample (μg/l) Milligrams of chlorophyll per cubic metre of sample (mg/m^3)		
Equivalences	1 μg/l = 1 mg/m^3		
Description of the methodology	Below, a method is presented for determining the AGP. This test requires specialized equipment and most of the laboratories cannot carry it out [1].		

	The AGP is calculated through the chlorophyll concentration. Therefore, the first step is to determine the chlorophyll value through the guideline G.5.1. Once the value of chlorophyll is obtained, the AGP is calculated. The main actions that have to be developed are: • The determination of the parameter AGP consists of collecting samples of surface water that contain phytoplankton. • The samples are incubated in glass containers under controlled conditions of temperature and light for two weeks. • The maximum concentration of chlorophyll in the sample obtained in the incubation is the value of the AGP of the water body analysed [2]. • The growth of algae is calculated as the difference observed in the amount of chlorophyll in the sample before and after the incubation (see note).
Frequency	Every three months [2]
Approximate cost	Equipment for determining the concentration of chlorophyll: Vacuum filtering equipment: 70€ [3] Mortar tissue: 200€ [4] Spectrophotometer LAMBDA 35: 14.500€ [5]
Notes	To determine the chlorophyll concentration in a sample see G.5.1.
References	[1] FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION. Algal Bioassays. Florida, 2012. [http://www.dep.state.fl.us/labs/biology/aalimnut.htm, 8 March 2016] [2] UC DAVIS. TAHOE ENIRONMENTAL RESEARCH CENTER. Algal Growth Potential Bioassays. 2016. [http://terc.ucdavis.edu/research/nearshore/algal-growth.html, 8 March 2016] [3] IBDCIENCIA. *Instrumentos y utensilios de laboratorio.* 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016]. [4] WHEATON. *Tissue grinders.* 2012. [http://wheaton.com/lab/cell-culture/tissue-grinders.html, 8th March 2016]. [5] VWR. LAMBDA™ 25/35 Series UV/Vis Spectrophotometers, PerkinElmer®. [https://us.vwr.com/store/catalog/product.jsp?product_id=4832209, 8th of March 2016]

Indicator's name	Dissolved oxygen (DO)		
Category	Emissions to water	**Indicator's code**	G.5.5
Sub category	Discharges of wastewaters		
Definition	Dissolved oxygen is the amount of oxygen that is dissolved in water. Its solubility is small (limited to 10 mg/l) and it depends on the temperature and the dissolved salts. The solubility decreases with temperature: cold water supports more dissolved oxygen		

	than warm water [1]. The salinity also influences the dissolved oxygen. As saltier is the water, less dissolved oxygen.
Importance	It is an indicator of good water quality: more dissolved oxygen has less presence of microorganisms and other pathogenic forms of life [1].
Units of measurement	• The amount of oxygen (in milligrams) in a litre of water (mg/l). • Percentage of saturation: the amount of oxygen dissolved in a litre of water in relation to the maximum (saturation) that can be dissolved at a given temperature (% sat.). [2]
Description of the methodology	Below, a procedure is presented to calculate the dissolved oxygen. It uses an electronic device that converts the measurement of signal from a probe placed in the water into DO units (mg/l). Most of these DO devices also measure the water temperature [3]. **Equipment** • Oxygen electrode: measuring device equipped with a probe, calibrated according to manufacturer's instructions. • Device operations manual • Membrane and electrolyte for the probe **Procedure** Once the device is switched on, the membrane needs 15 minutes to reach the equilibrium. Then it can be calibrated. Once it is done, the device should not be shut down until the sample has been analysed. To use the probe, these steps should be followed: 1. Place the probe in the water stream below the surface. 2. Set the device to the temperature reading option and wait until the temperature is stabilized. Write down the temperature. 3. Change the mode of the device to read the dissolved oxygen. 4. Write down the reading of the device. **Results** DO measurement devices tend to give the reading in mg/l. If it is necessary, the percentage of oxygen saturation in water can be calculated based on the following formula [2]: $$\%\ sat. = \frac{d(O)}{d(O)_s} \cdot 100$$ where: d(O) is the concentration measured in mg/l $d(O)_s$ is the theoretical saturation concentration at the same temperature of the sample.
Limit values	Lower limit: >80% sat. Upper limit: <120% sat. [4]
Monitoring locations	Surface waters Sea-bottom waters
Frequency	Every 3 months [5]
Approximate cost	DO measuring device & probe: 450 - 1000 € [5]

Notes	The device should always be calibrated before carrying out the analysis of a set of samples, and even an intermediate calibration should be performed if many tests are being made [3].
References	[1] UNIVERSITAT POLITÈCNICA DE CATALUNYA. Tecnologia del Medi Ambient. Llibre de transperències. Barcelona, Departament d'Enginyeria Química de l'Escola Tècnica d'Enginyeria Industrial de Barcelona, 2014. [2] AENOR. Calidad del agua. Medioambiente Tomo 1. AENOR, Madrid, 1997. [3] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Water Resources. Washington, 2016. [http://www.epa.gov/learn-issues/water-resources#our-waters, 8th of March 2016] [4] STATE WATER RESOURCES CONTROL BOARD. DQM Information Paper 3.1.1. Dissolved Oxygen Measurement Principles and Methods. Clean Water Team Guidance Compedium for Watershed Monitoring and Assessment, 2004. [5] EUROPEAN COMMISSION (EC). Directive 2000/60/EC of the European Parliment and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Brussels, Official Journal of the European Communities, 2000.

Indicator's name	Inorganic ions		
Category	Emissions to water	**Indicator's code**	G.5.6
Sub category	Discharges of wastewaters		
Definition	The organic ions monitored by this indicator are nitrates (NO_3^-), nitrites (NO_2^-), the orthophosphate (PO_4^{3-}), sulphate (SO_4^{2-}), bromide (Br^-) and chloride (Cl^-). These substances come primarily from the agriculture industry.		
Importance	Although the inorganic ions are not toxic, they are considered pollutants because at high concentrations in the water they can cause algae blooms. This fact contributes to the decrease in the dissolved oxygen levels and in the eutrophication of the water body [1]. Additionally, some algae, generated due to the eutrophication, can produce toxins and bacteria that can be harmful for the human health [2].		
Units of measurement	Milligrams of NO_3^- per litre of sample (mg/l) (Nitrate) Milligrams of NO_2^- per litre of sample (mg/l) (Nitrite) Milligrams of PO_4^{3-} per litre of sample (mg/l) (Orthophosphate) Milligrams of SO_4^{2-} per litre of sample (mg/l) (Sulphate) Milligrams of Br^- per litre of sample (mg/l) (Bromide) Milligrams of Cl^- per litre of sample (mg/l) (Chloride)		
Description of the methodology	Below, a method for the determination of the ions: bromide, chloride, nitrate, nitrite, orthophosphate, and sulphate in wastewaters is presented, based on the ISO 10304-2: 1995 [3, 4]. **Basis**		

	The ion separation is carried out using a liquid phase chromatography through an ion exchange column. Conductimetric detectors and UV techniques are used. **Equipment** • Ion chromatography system • Columns solid phase extraction with nonpolar stationary phase • Drying stove • Membrane filtration system • Laboratory equipment
Detection limits of the method	Nitrate: 0,1 a 50 mg/l Nitrite: 0,05 a 20 mg/l Orthophosphate: 0,1 a 20 mg/l Sulphate 0,1 a 20 mg/l Bromide 0,05 a 20 mg/l Chloride: 0,1 a 50 mg/l [3]
Monitoring locations	Port waters Wastewaters
Approximate cost	Ion chromatography system: 6.600 - 10.000 € [5] Drying stove: 1.000€ [6] Laboratory equipment: 400€ [7]
References	[1] LENNTECH. WATER TREATMENT SOLUTIONS. Water Pollutant FAQ Frequently Asked Questions. Delft, 2016. [http://www.lenntech.com/water-pollutants-faq.htm#ixzz3o4Oc4XZT, 8th of March 2016]. [2] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Nutrient Pollution. Washington, 2016. [https://www.epa.gov/nutrientpollution/problem, 8th of March 2016] [3] AENOR. Calidad del agua. Medioambiente Tomo 1. AENOR, Madrid, 1997. [4] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Clean Water Act Analytical Methods. Washington, 2016. [https://www.epa.gov/cwa-methods/other-clean-water-act-test-methods-microbiological, 8th of March 2016] [5] LABX. Ion Chromatography Listings. 2016. [http://www.labx.com/ion-chromatography, 7th of March 2016] [6] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016] [7] IBDCIENCIA. Estufa de desecación 40 L. 2015. [http://www.ibdciencia.com/estufa-u, 7th of March 2016]

Indicator's name	Nutrients (in water)		
Category	Emissions to water	**Indicator's code**	G.5.7
Sub category	Discharges of wastewaters		

Definition	This indicator calculates the concentration of the two main elements that are used as nutrients: nitrogen (N) and phosphorus (P). These two nutrients are quantified as Total Nitrogen (TN) and Total Phosphorus (TP). TN is the sum of all the ways in which nitrogen is in the water, which include, basically, organic and inorganic substances. Additionally, inorganic species are divided into oxidized species (such as nitrates or nitrites) and reduced species (ammonia / ammonium and dissolved diatom gas). TP is the sum of all the ways in which the phosphorus is in the water, both organic and inorganic. The inorganic phosphorus exists in the form of orthophosphate and polyphosphates. The organic phosphorus is present in the water living organisms [1].
Importance	The overuse of nutrients done in the recent decades is causing significant health and environmental problems. The nutrients' pollution of water bodies creates an excess of algae, which consume significant amounts of oxygen. This reduces the oxygen to other aquatic organisms. This phenomenon is called eutrophication. Additionally, the proliferation of algae can emit toxic chemicals that can cause serious health problems for humans [1].
Units of measurement	Milligrams of nitrogen per litre of sample (mg/l) (Total nitrogen) Milligrams of phosphorus per litre of sample (mg/l) (Total phosphorus)
Description of the methodology	Below, a method is presented for the simultaneous determination of Total Nitrogen and Total Phosphorus, through a digestion with sodium persulfate followed by ion chromatography (IC) [1]. **Sampling** • Glass (preferably) or plastic containers are used, with closure made of polytetrafluoroethylene (PTFE). • Analyse the sample as soon as possible. If the immediate analysis is not possible, the sample should be kept at 4 °C or frozen at -20 °C. **Digestion** The process of digestion uses equimolar concentrations of persulfate ($S_2O_8^{2-}$) and hydroxide ions (OH^-) to achieve a pH of the sample over 12. In these alkaline conditions, all the nitrogen present in the sample is oxidized to nitrate. Since digestion takes place at temperatures of 120ºC, the persulfate decomposes bisulphate (HSO_4^-), which neutralizes and acidifies the reaction. When all the persulfate has been decomposed, the pH of the solution is 2. **Analysis** After the digestion, the mixture contains a considerable amount of bisulphate, which has the ability to interfere with the analysis of the orthophosphate. An effective analysis technique is the use of a high capacity anion exchange column which allows to separate effectively the orthophosphate from the bisulphate.
Limit values	Total phosphorus [2]: 1 mg/l Total nitrogen [2]: 10 mg/l
Monitoring locations	Port waters Wastewaters
Frequency	Every three months, as a maximum [3]

	Ion chromatography system: 6.600 - 10.000 € [4] Laboratory material: 400 € [5]
References	[1] THERMO FISHER SCIENTFIC. *Application Note 1103. Determination of Total Nitrogen and Phosphorus in Wastewaters by Alkaline Persulfate Digestion Followed by IC*. Sunnyvale, CA, Thermo Scientific, 2014. [2] EUROPEAN COMMISSION (EC). *Council Directive (91/271/EEC) of 21 May 1991 concerning urban waste water treatmen*t. Brussels, Official Journal of the European Communities, 1991. [3] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000. [4] LABX. *Ion Chromatography Listings*. 2016. [http://www.labx.com/ion-chromatography, 7th March 2016] [5] IBDCIENCIA. *Instrumentos y utensilios de laboratorio*. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016]

Indicator's name	Nutrients (sediments)		
Category	Emissions to water	**Indicator's code**	G.5.8
Sub category	Discharges of wastewaters		
Definition	This indicator calculates the concentration of the two main elements that are used as nutrients: nitrogen (N) and phosphorus (P). These two nutrients are quantified as Total Nitrogen (TN) and Total Phosphorus (TP). TN is the sum of all the ways in which nitrogen is in the sediments, which include, basically, organic and inorganic substances. Additionally, inorganic species are divided into oxidized species (such as nitrates or nitrites) and reduced species (ammonia / ammonium and dissolved diatom gas). TP is the sum of all the ways in which the phosphorus is in the sediments, which also includes organic and inorganic. The organic phosphorus is present in the water living organisms and the inorganic phosphorus exists in the form of orthophosphate and polyphosphates. [1].		
Importance	The overuse of nutrients done in the recent decades is causing significant health and environmental problems. The nutrients' pollution of water and sediment creates an excess of algae, which consume significant amounts of oxygen. This reduces the oxygen to other aquatic organisms. This phenomenon is called eutrophication. Additionally, the proliferation of algae can emit toxic chemicals that can cause serious health problems for humans [1].		
Units of measurement	Milligrams of nitrogen per litre of sample (mg/l) (Total nitrogen) Milligrams of phosphorus per litre of sample (mg/l) (Total phosphorus)		

Description of the methodology	Below, two standard methods are presented for determining total nitrogen and total phosphorus in sediment samples. A) The first method is from the ISO 13878 [2], which uses the technique of dry combustion to determine the total amount of elemental nitrogen in soil and sediment samples. The method is based on the combustion of the sample at 900ºC, to reduce all the nitrogen to elemental gas (N_2). This gas is injected into a stream of helium and the concentration is measured through its electrical conductance [3]. B) The second method is from the ISO 11263 [4]. This standard describes a method for extracting the phosphorus from soil or sediment, using digestion with a solution of 0.5 M sodium bicarbonate at a pH of 8.5. Then, the concentration of phosphorus is measured and quantified with a spectrophotometer [3].
Monitoring locations	Sediments of the port waters
References	[1] THERMO FISHER SCIENTFIC. Application Note 1103. Determination of Total Nitrogen andPhosphorus in Wastewaters by Alkaline Persulfate Digestion Followed by IC. Sunnyvale, CA, Thermo Scientific, 2014. [2] ISO. ISO 13878:1998. Soil quality -- Determination of total nitrogen content by dry combustion ("elemental analysis"). Geneva, 2015. [http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=23117, 27th of March 2016] [3] JANSEN E. Determination of total Phosphorus, total Nitrogen and Nitrogen Fractions. Horizontal, 2016. [4] ISO. ISO 11263:1994. Soil quality -- Determination of phosphorus -- Spectrometric determination of phosphorus soluble in sodium hydrogen carbonate solution. Geneva, 2016. [http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=19241, 27th of March 2016]

Indicator's name	Bacterial content		
Category	Emissions to water	**Indicator's code**	G.5.9
Sub category	Discharges of wastewaters		
Definition	This indicator includes the parameters total coliform bacteria, faecal coliforms (including E. coli) and faecal Streptococcus. Coliforms are bacteria that are present naturally in the environment and they are used as an indicator of the presence of other potentially harmful bacteria. Faecal coliforms and E. Coli are bacteria that indicate the water may be contaminated by viral and bacterial pathogens [1]. Streptococcus faecal bacteria are found in the intestinal tract of humans and warm-blooded animals. They are an indicator of the faecal contamination of water and may indicate the presence of enteric pathogens [5].		

Importance	The microorganisms present in wastewater may have harmful effects on human health in the short term, such as diarrhoea, nausea or other symptoms [1].
Units of measurement	Total number of colony forming units (CFU) per 100 ml of sample (see note) [1] (CFU / 100 ml)
Description of the methodology	Below, a summary is presented of the several methods used to assess the parameters that constitute this indicator. **Membrane filter method for the determination of total coliform bacteria [2]** A water sample is filtered through a membrane with a pore diameter of 0.45 µm, in order to capture the bacteria that are present. Subsequently, the membrane filter is placed in a selective medium for total coliforms, called m-Endo disk. The disk is incubated for 24 hours at 35 °C. The number of positive colonies (those with a colour from pink to dark red) are counted and recorded. **Membrane filter method for the determination of faecal coliforms [3]** A water sample is filtered through a membrane with a pore diameter of 0.45 µm, in order to capture the bacteria that are present. Subsequently, the membrane filter is placed in a selective medium for faecal coliforms, called mFC disk. The disk is incubated for 24 hours at 44.5 °C. The number of positive colonies (those with a blue colour) are counted and recorded. **Membrane filter method for the determination of Escherichia coli (E. coli) [4]** A water sample is filtered through a membrane with a pore diameter of 0.45 µm, in order to capture the bacteria that are present. Subsequently, the membrane filter is placed in a selective medium for E. Coli, called mTec disk. The disk is incubated for 2 hours at 35 °C and then transferred to an isothermal bath at 44.5 °C and left for 22 hours. After incubation, the filter is transferred to a container that is saturated of urea substrate. After 15 minutes in the urea substrate, the number of positive colonies (that have a yellowish-green colour) are counted and recorded. **Membrane filter method for the determination of faecal Streptococcus** A water sample is filtered through a membrane with a pore diameter of 0.45 µm, in order to capture the bacteria that are present. Subsequently, the membrane filter is placed in a selective medium for faecal bacteria Streptococcus, called mENT disk. The disk is incubated for 48 hours at 35 °C. The number of positive colonies (which appear in red colour) is counted and recorded.
Limit values	Faecal coliforms: 200 UFC/100 ml
Monitoring locations	Port waters Waste waters Treatment plant waters
Approximate cost	Incubator 600 € [6] m-Endo Disk 96 € mFC Disk 116 € mTEC Disk 185 € mENT Disk 154 €

Notes	Each type of bacteria is recorded separately, indicating the number of colony forming units for each specific type (e.g. 10 CFU / 100 mL of feacal coliforms)
References	[1] FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION. Algal Bioassays. Thallahassee, 2012. [http://www.dep.state.fl.us/labs/ biology/aalimnut.htm, 8th March 2016] [2] FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION. Standard Operating Procedure for: Membrane Filter Method for Total Coliforms. Thallahassee, Bureau of Laboratories, Biology Section, 2015. [3] FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION. Standard Operating Procedure for: Membrane Filter Method for Fecal Coliforms. Thallahassee, Bureau of Laboratories, Biology Section, 2014. [4] FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION. Standard Operating Procedure for: Membrane Filter Method for Escherichia coli (E. coli). Thallahassee, Bureau of Laboratories, Biology Section, 2015. [5] FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION. Standard Operating Procedure for: Membrane Filter Method for Fecal Streptococcus. Thallahassee, Bureau of Laboratories, Biology Section, 2015. [6] THERMO FISHER SCIENTFIC. Heratherm™ Advanced Protocol Microbiological Incubators. Sunnyvale, CA, Thermo Scientific, 2015. [http://www.thermoscientific.com/en/product/heratherm-advanced-protocol-microbiological-incubators.html, 27th March 2016]

Indicator's name	Water pH		
Category	Emissions to water	**Indicator's code**	G.5.10
Sub category	Discharges of wastewaters		
Definition	Water pH is a quantitative measure of the acidity or basicity of a solution. It is defined as the negative logarithmic value of the Hydrogen ion (H^+) concentration. The pH is determined using a scale from 0 to 14. pH=7 is called neutral and it is the value of pure water. Numbers lower than 7 indicate that the solution is acidic (e.g. nitric acid, acetic acid) and higher values indicate that it is basic (e.g. detergents, ammonia).		
Importance	pH has a decisive influence on the chemical and biological processes that occur in nature (e.g. redox reactions). It affects the vital functions of any living organism, from bacteria to human beings. For this reason, it is important to control its variation.		
Units of measurement	Logarithmic scale: 0 (acidic) to 14 (basic); 7 (neutral)		
Description of the methodology	Below, a procedure is presented to carry out *in situ* the measurement of pH [1]. **Equipment** pH meter **Sampling and procedure**		

	1. Previously, it is necessary to calibrate the device according to the manufacturer's instructions. 2. Collect the sample in a container of polyethylene and record the water temperature. 3. Immerse the probe of the pH meter into the sample, keeping it away from the walls and from the bottom of the container. Leave enough time in order to allow to balance the probe with the sample. 4. Take the reading of pH and write it down on the recording sheet. 5. Clean the probe with distilled water after each reading.
Monitoring locations	Surface waters Waste waters
Frequency	There is not a recommended frequency [2]
Approximate cost	pH meter: 330 € [3]
References	[1] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. *Operating procedure, Field pH measurement*. Athens, Science and Ecosystem Support Division 2013. [2] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliment and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000. [3] HACH LANGE. HQ40d Portable pH, Conductivity, Dissolved Oxygen, ORP, and ISE Multi-Parameter Meter. Loveland, 2015. [http://www.hach.com/hq40d-portable-ph-conductivity-dissolved-oxygen-orp-and-ise-multi-parameter-meter/product?id=7640501639, 8th of March 2016]

Indicator's name	Redox potential (in water)		
Category	Emissions to water	**Indicator's code**	G.5.11
Sub category	Discharges of wastewaters		
Definition	The redox potential is a parameter that represents the sum of the oxidation and reduction reactions that occur in the water sample. The presence of oxidizing agents, such as oxygen, increases the potential; however, the presence of reducing agents, such as Biological Oxygen Demand (BOD), diminish the value of the potential. It is not an indicator specific for a single element or specie [1].		
Importance	The redox potential can influence certain biological processes that can have effects on the environment [1].		
Units of measurement	Millivolts (mV) [1]		

Description of the methodology	Below, a procedure is presented to carry out an *in situ* measurement of the redox potential [1]. **Equipment** • A device for measuring redox potential [2]. **Sampling and procedure** 1. Previous to the calculation, it is necessary to calibrate the device according to the manufacturer's instructions. 2. The probe is directly immersed in the mass of water to be analysed (usually to a depth of 0.5 m). Some time is given in order to stabilize the probe with the sample. 3. The reading of the redox potential is taken and it is written down on the recording sheet. 4. The probe is rinse with distilled water after each reading.
Monitoring locations	Surface waters Waste waters Treatment plants waters
Approximate cost	Sensor: 150 € [2]
References	[1] NEIWPCC. *Oxidation-Reduction Potential and Wastewater Treatment*. Connecticut, 2008. [http://www.neiwpcc.org/iwr/reductionpotential.asp, 8th of March 2016. [2] HACH LANGE. HQ40d Portable pH, Conductivity, Dissolved Oxygen, ORP, and ISE Multi-Parameter Meter. Loveland, 2015. [http://www.hach.com/hq40d-portable-ph-conductivity-dissolved-oxygen-orp-and-ise-multi-parameter-meter/product?id=7640501639, 8th of March 2016]

Indicator's name	Redox potential (in sediments)		
Category	Emissions to water	**Indicator's code**	G.5.12
Sub category	Discharges of wastewaters		
Definition	The redox potential is a parameter that represents the sum of the oxidation and reduction reactions that occur in the sediments sample. The presence of oxidizing agents, such as oxygen, increases the potential; however, the presence of reducing agents, such as Biological Oxygen Demand (BOD), diminish the value of the potential. It is not an indicator specific for a single element or specie [1].		
Importance	The evolution in the redox potential of the sediments are an effective indicator to monitor the changes in aquatic flora and fauna. It is also important because it indicates which type of sediment it is. This has influence in which type of pollutant is adhered to the sediments [2].		
Units of measurement	Millivolts [1] (mV)		

Description of the methodology	Below, a procedure is presented in order to carry out the measurement of redox potential *in situ* in a sample of sediments [3]. **Material** • Device for measuring the redox potential [4] **Calibration** • To calibrate the platinum electrodes, they must be submerged in a solution of 4 M KCl at least 24 hours prior to the calibration. • Calibration techniques are specific to each type of electrode. For specific information, you can consult the manual of the device used [5]. • The electrodes should be cleaned with distilled water after each reading, and when they are not used, they should also be immersed into distilled water. **Sampling and procedure** • A sample of the sediments (100 g) is extracted. • The redox potential is read *in situ* directly from the sample of sediments. • The water that may be contained in the sample is drained and the probe is inserted into the sample (about 2 cm). • The probe is left within the sediments for 2 or 3 minutes, or until it reaches the equilibrium. • The reading of the redox potential should be done within the three hours after the extraction of the sample. If it is not possible, the sample should be kept in the dark and cold within 24 hours.
Monitoring locations	Sediments of the port waters
Approximate cost	Sensor: 150 € [4]
References	[1] NEIWPCC. Oxidation-Reduction Potential and Wastewater Treatment. Connecticut, 2008. [http://www.neiwpcc.org/iwr/reductionpotential.asp, 8th of March 2016. [2] BRAVO-LINARES C.M., MUDGE S.M. Analysis of volatile organic compounds (VOCs) in sediments using in situ SPME sampling. J. Environ. Monit. Vol. 9, 2007, p. 411–418. [3] GOVERNMENT OF CANADA. Additional Technical Guidance for Conducting Redox and Sulphide Measurements in Marine Sediments. Ottawa, Environmental Protection Branch, 2003. [4] HACH LANGE. HQ40d Portable pH, Conductivity, Dissolved Oxygen, ORP, and ISE Multi-Parameter Meter. Loveland, 2015. [http://www.hach.com/hq40d-portable-ph-conductivity-dissolved-oxygen-orp-and-ise-multi-parameter-meter/product?id=7640501639, 8th of March 2016] [5] HACH LANGE. HQd Portable Meter. Basic User Manual. Ref.: DOC022.97.80017. Loveland, 2013.

Indicator's name	Total hardness		
Category	Emissions to water	**Indicator's code**	G.5.13
Sub category	Discharges of wastewaters		
Definition	Total hardness is defined as the sum of the concentrations of calcium ions (Ca^{2+}) and magnesium (Mg^{2+}) in the water. The main cause of water hardness is dissolved salts of calcium and magnesium coming from the process of infiltration of surface water into the ground to become groundwater. The total hardness of fresh water is normally between 15 and 375 mg/l of $CaCO_3$. However, the hardness of seawater is approximately 6600 mg/l of $CaCO_3$ [1].		
Importance	Total hardness is an important environmental parameter. Calcium is an important element to marine organisms. Magnesium is an essential nutrient for plants and it is a component of chlorophyll. High levels of hardness are not considered a danger to human health. However, high levels of hardness may create deposits of $CaCO_3$ in piping systems, which reduce the effectiveness of detergents [1].		
Units of measurement	mg/l de $CaCO_3$ [1]		
Description of the methodology	Below, a procedure to determine the total hardness of a water sample is explained. The method involves an assessment of the water sample with EDTA (ethylenediaminetetraacetic acid), using *Calmagite* as an indicator [1]. **Equipment** • Sampling bottles • Lab material • Buffer solution (pH = 10) [2] • Indicator Calmagite [3] • EDTA solution (0.01 M) [4] • Distilled water **Sampling** • Collect at least 300 ml of sample • It is important to collect the water sample below the surface and as far as possible from the edge. **Procedure** 1. Fill a 25 ml burette with EDTA solution. 2. Preparation of the solution to value: a) Measure 50 ml of sample and add it into a 250 ml Erlenmeyer. b) Add 1 ml of buffer solution to set the pH to 10. c) Add indicator powder and stir it slightly to homogenize the solution, which will achieve a reddish hue. 3. Titrate the sample: a) Add the EDTA solution in an Erlenmeyer. Initially, add 1 ml each time.		

	b) Close to the equivalence point, the red color of the solution will begin to fade and become more lilac. At this point, the EDTA solution is added drop by drop and one second is left after each addition. c) The measurement ends when the solution reaches suddenly a blue colour. d) Write down the remaining volume of EDTA in the burette. 4. Repeat the above steps again. If the volume obtained is very different from the previous one, repeat the valuation until two consecutive results are obtained with similar volume. **Calculations**: The total hardness of the water can be determined using the following formula: $Total\ hardness = (Initial\ EDTA\ volume\ -\ Final\ EDTA\ volume)x20{,}0$
Monitoring locations	Surface waters
Approximate cost	Laboratory equipment: 300€ [2]
References	[1] VERNIER. *Total water hardness*. Vernier Software & Technology. Beaverton, EUA, 2012. [2] IBDCIENCIA. *Instrumentos y utensilios de laboratorio.* 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7 de març de 2016]

Indicator's name	Total Organic Carbon (TOC) (in water)		
Category	Emissions to water	**Indicator's code**	G.5.14
Sub category	Discharges of wastewaters		
Definition	The Total Organic Carbon (TOC) is a parameter that indicates the total amount of carbon in a sample of water. In comparison with the COD, this indicator is adapted to the continuous monitoring, providing results in a small interval of time, in the order of minutes [1].		
Importance	The value of this indicator reflects the organic pollution in the water [1].		
Units of measurement	Milligrams of carbon per litre of sample (mg/l)		
Description of the methodology	Below, a method is presented in order to determinate the TOC of a water sample through thermal oxidation and non-dispersive infrared detector (NDIR) [2]. **Equipment** • Material of laboratory. • Analyser of Total Organic Carbon **Sampling** 1. The samples must be collected in opaque containers. 2. The samples should be analysed as soon as possible.		

	3. If they are not analysed immediately, keep them between 0 and 4 °C, for 24 hours. **Procedure** 1. Acidify the samples with phosphoric acid until obtaining a pH approximately of 2. 2. Remove the inorganic carbon (CO2 dissolved in water and its ions) by passing nitrogen gas through the sample for 20 minutes. 3. Incinerate the samples in the presence of a catalyst (Ce5O2) at 850 °C in an oxygen atmosphere. 4. The CO2 formed in the combustion is determined quantitatively using a non-dispersive infrared detector (NDIR).
Limit values	Content of TOC in saline waters: 2 mg/l of C [2]
Monitoring locations	Port waters Wastewaters Treatment plants waters
Approximate cost	TOC analyser: 13000 € [3] Laboratory equipment: 300 € [4]
References	1] CHEMEUROPE. BOD, COD, TOC and TOD – sum parameters in environmental analysis. 2016. [http://www.chemeurope.com/en/whitepapers/126405/bod-cod-toc-and-tod-sum-parameters-in-environmental-analysis.html, 9th of March 2016] [2] E. Niemirycz, et al. *Variability of Organic Carbon in Water and Sediments of the Odra River and Its Tributaries. Polish J. of Environ. Stud*. Vol. 15, 2006, p. 557-563. [3] LABX. *TOC Analyzers Listings.* 2016. [http://www.labx.com/toc-analyzers, 7th of March 2016] [4] IBDCIENCIA. *Instrumentos y utensilios de laboratorio.* 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016]

Indicator's name	Total Organic Carbon (TOC) (in sediments)		
Category	Emissions to water	**Indicator's code**	G.5.15
Sub category	Discharges of wastewaters		
Definition	This indicator indicates the total amount of organic carbon present in a sediments sample, which reflects the organic pollution ([1] and [2]).		
Importance	The presence of organic matter into sediments facilitates the adsorption of organic contaminants. Therefore, this parameter provides information on the potential amount of organic pollutants that can be found in the sediments. As more organic matter, more organic pollutants will be retained [3].		

Units of measurement	Milligrams of carbon per kilogram of the sample (mg/kg)
Description of the methodology	Below, a method for determining the Total Organic Carbon (TOC) in a sediment sample is presented [4]. **Sampling** • A sample of the sediments (100 g) is extracted. • It is kept at 4 ºC in order to prevent the degradation of the sample and the loss of volatiles. • In the laboratory, the water of the sample is removed by using dry air. • The particles with a diameter greater than 2 mm are eliminated and they are homogenised by passing the sample through a sieve. • By adding few drops of concentrated HCl (1 to 4 M) and observing if there is an effervescence, it is determined whether the sample contains inorganic carbon, in the form of carbonates (see note). • To remove inorganic carbonates, 3 ml of H_2SO_4 2 M are added to the sample. **Sample extraction** • The Walkley-Black method is used, consisting on the rapid oxidation of organic matter using dichromate. • 0,5 g of potassium dichromate and 1 g of H_2SO_4 are added to the sample, previously dried. • The solution is stirred constantly and it is cooled (the reaction between sulphuric acid and dichromate is exothermic), before adding water to stop the oxidation. • The chemical reaction that takes place is the following: $2Cr_2O_7^{2-} + 3C^0 + 16H^+ = 4Cr^{3+} + 3CO_2 + 8H_2O$ **Quantification of the sample** • The sample is quantified by titrating the excess of $Cr_2O_7^{2-}$ through ammonium sulphate or ferric sulphate. • It is recommended a titration using a calomel or platinum electrode. • The electrode is placed in the digester and it is titrated until it reaches a stable electrical potential. • When the titration point has been reached, the TOC is calculated from the electric potential.
Monitoring locations	Sediments of the port waters
Approximate cost	Laboratory equipment: 400 € [5]
Notes	The main source of interference in the determination of TOC in sediment samples is the presence of inorganic carbonates (which lead to a wrong reading of the Organic Carbon). For further information see reference [4].
References	[1] CHEMEUROPE. BOD, COD, TOC and TOD – sum parameters in environmental analysis. 2016.

	[http://www.chemeurope.com/en/whitepapers/126405/bod-cod-toc-and-tod-sum-parameters-in-environmental-analysis.html, 9th March 2016] [2] AZNAR, A. Determinación de los parámetros fisico-químicos de calidad de las aguas. Gestión Ambiental 2000. Vol. 2(23), 2000, pag. 12-19. [3] BRAVO-LINARES C.M., MUDGE S.M. Analysis of volatile organic compounds (VOCs) in sediments using in situ SPME sampling. J. Environ. Monit. Vol. 9, 2007, p. 411–418. [4] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Methods for the determination of total organic carbon (TOC) in soils and sediments. Cincinnati, OH, Ecological Risk Assessment Support Center, 2002. [5] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016]

Indicator's name	Total Oxygen Demand (TOD) (in water)		
Category	Emissions to water	**Indicator's code**	G.5.16
Sub category	Discharges of wastewaters		
Definition	This parameter defines the Total Oxygen Demand of a water sample. It is based on the same principle as the parameter Chemical Oxygen Demand (see G.5.3); from the complete oxidation of all organic compounds, the oxygen demand required may be determined. However, the method used to determine TOD ensures that all organic matter is oxidized [1]. Additionally, this parameter also detects the carbon-free substances that contribute to oxygen consumption, such as ammonia and sulphites [2].		
Importance	It is a parameter well adapted for continuous monitoring and which allows to know in real time the COD and BOD [2].		
Units of measurement	Milligrams of oxygen per litre of sample (mg/l)		
Description of the methodology	Below, a method is presented for determining the TOD, based on the thermal oxidation of the sample at high temperature [1]. The determination of the TOD is standardized by the norm ASTM D6238-98 [3]. • A high purity alumina reactor is used, similar to the one used in the analysis of the parameter TOC (Total Organic Carbon, see G.5.14). • The furnace is continuously fed with a carrier gas (e.g. nitrogen) in a closed system containing oxygen. • The sample is added, avoiding any gas exchange with the ambient air that would generate erroneous readings. • Inside the oven, the water sample is evaporated immediately and all the organic compounds are completely oxidized at 1200 °C.		

	• The flue gas leaving the furnace is washed through absorption columns (scrubbers). • Once clean, the amount of oxygen of the carrier gas is measured through a carbon oxide detector based. • The decrease in the oxygen content is directly proportional to oxygen consumption. • The frequency measurement is from 3 to 5 minutes, making the method suitable for the continuous monitoring.
Limit values	100 – 100.000 mg/l [3]
Monitoring locations	Wastewaters Treatment plants waters
Frequency	Every three months [4]
References	[1] WATER ONLINE. *Total Oxygen Demand (TOD) – An Alternative Parameter For Real-Time Monitoring Of Wastewater Organics*. 2015. [http://www.wateronline.com/doc/total-oxygen-demand-tod-an-alternative-parameter-for-real-time-monitoring-of-wastewater-organics-0001, 9th of March 2016] [2] CHEMEUROPE. BOD, COD, TOC and TOD – sum parameters in environmental analysis. 2016. [http://www.chemeurope.com/en/whitepapers/126405/bod-cod-toc-and-tod-sum-parameters-in-environmental-analysis.html, 9th of March 2016] [3] ASTM INTERNATIONAL. *ASTM D5907 - 13. Standard Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water*, West Conshohocken 2011. [http://www.astm.org/Standards/D5907.htm, 9th of March 2016] [4] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliment and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000.

Indicator's name	Water colour		
Category	Emissions to water	**Indicator's code**	G.5.17
Sub category	Discharges of wastewaters		
Definition	The colour of a waterbody is the optical property that consists of modifying the spectral composition of visible light transferred through the body of water. The apparent colour of a water sample is caused by the dissolved substances and the suspended matter. The real colour of a water sample is generated only by the dissolved substances, and it is determined after the filtering of the sample through		

	a membrane of 0.45 μm [1]. The three main components that give colour to the water are phytoplankton, suspended solids and dissolved organic matter [2].
Importance	The concentrations of these three main components determine the specific colour of the water, and it is possible to recognize and classify the different types of natural waters from its specific colour. [2]
Units of measurement	It is measured as the intensity of the colour (e.g. colourless, pale, light, and dark) and the tone (e.g. yellow, yellowish brown), which gives an idea of the water pollution degree [1].
Description of the methodology	Below, a method is presented for the qualitative determination of a water sample by visual examination of apparent colour, in accordance with the ISO 7997 Section Two [1]. This method is used to determine the apparent colour of the water. **Equipment** Colourless bottle of 1 litre (at least), clean, preferably made of glass. **Sampling** 1. Clean the glass that will be in contact with the sample with a solution of hydrochloric acid (HCl (aq)) 2 M (mol/litre). 2. Rinse with distilled water. 3. Once the samples are taken, the procedure is made as soon as possible. If it is unavoidable to store the samples, it should be at 4° C and completely dark. **Procedure** The unfiltered water sample is placed in a container, and the intensity of the colour and tone is examined, under diffuse light on a white background. If the sample contains suspended matter, it is decanting before the visual examination. **Results** The intensity and tone of colour is recorded in the way as described above, according to visual examination.
Notes	There exist methods to determine the real colour of the water. For example, ISO 7887 Section Three [1].
References	[1] AENOR. *Calidad del agua. Medioambiente Tomo 1*. AENOR, Madrid, 1997. [2] CITCLOPS PROJECT. *Measuring water colour*. 2016. [http://www.citclops.eu/water-colour/measuring-water-colour, 9th of March 2016]

Indicator's name	Water temperature		
Category	Emissions to water	**Indicator's code**	G.5.18
Sub category	Discharges of wastewaters		
Definition	The temperature is an objective measure of heat and cold. From the point of view of thermodynamics, it is a measure related to the internal energy of a system.		
Importance	Water temperature is very important in the development of the various processes that take place in the aqueous medium. A rise of the temperature increases the solubility of dissolved solids and reduces the solubility of gases. It also reduces the dissolved oxygen, affecting therefore the living ecosystems. An abnormal increase		

	of the water temperature (not for climate reasons) usually has its origin in the discharges of water used in industrial processes of heat exchange.
Units of measurement	• Degrees Celsius (ºC) • Degrees Fahrenheit (ºF) [1]
Equivalence	1 ºF = 1,8 ºC + 32
Description of the methodology	Below, a method is explained for determining the temperature of a body through a temperature probe [1]. **Equipment** Temperature probe **Sampling and procedure** To measure the temperature, these steps should be followed: 1. Place the probe at least 10 cm below the water surface. 2. Wait until the temperature reading is stabilized before taking the measurement. 3. Write down the temperature on a record sheet. 4. Repeat this procedure for all the measurement points.
Monitoring locations	Along the water surface and at different depths (see Notes)
Approximate cost	Temperature probe: 50 € [2]
Notes	The temperature varies with the depth and along the surface of the water. The temperature readings should be made at different points on the surface and at different depths, in order to obtain the temperature profile [1].
References	[1] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Water Resources. Washington, 2016. [http://www.epa.gov/learn-issues/water-resources#our-waters, 8th March 2016] [2] HACH COMPANY. *SensION Temperature Probe, 5-pin connector*. Loveland, 2015. [http://www.hach.com/sension-temperature-probe-5-pinconnector/ product?id=7640488935, 9th March 2016]

Indicator's name	Plankton		
Category	Emissions to water	**Indicator's code**	G.5.19
Sub category	Discharges of wastewaters		
Definition	Plankton is a very diverse group of microscopic organisms that live in the upper water column of the seas. They represent a crucial source of food for many underwater species, such as fish and whales. In particular, the phytoplankton is a subgroup that includes plankton species that are able to perform photosynthesis. Phytoplankton is the basis of the food chain in the oceans. The two main types of phytoplankton are diatoms and dinoflagellates [1]. Other subgroups of plankton are the zooplankton (which		

	includes the animal species of plankton) and bacterioplankton (formed by bacteria that live suspended in inland and marine waters).
Importance	Plankton is sensitive to changes that occur in the environment. If the environment is contaminated, the presence of plankton is reduced. For this reason, the total biomass of plankton and many species of plankton (and more specifically, phytoplankton) are indicators used for monitoring the water quality [2].
Units of measurement	• Total number of units identified for water sample • Number of diatoms for water sample
Description of the methodology	Below, a method is presented for the identification and counting of algae in phytoplankton samples [2]. **Material** • Inverted microscope • Utermöhl chamber • Counter of laboratory **Sampling** • The samples are collected in tinted bottles • They are kept immediately in a container with ice. • Once at the laboratory, they are kept at -20 °C. **Procedure** 1. Homogenize the sample by inverting the test tube with caution 3 or 4 times. 2. Transfer the sample to the Utermöhl chamber, so that the liquid slightly exceeds the chamber walls. Cover the container so that no air bubbles remain inside. 3. Let the sample rest for a whole night. 4. After the rest period, observe the sample in the inverted microscope at 400 X. Count the number of units of algae present in 20 squares of the grid, chosen randomly. 5. Calculate the average according to the following expression: $\boldsymbol{Total\ number\ of\ units\ counted/Numberof\ squares}$ 6. There are three possibilities: A. If the average is below 5 per unit grid: the sample must be concentrated. B. If the average is between 5 and 10 units per grid: the sample has a density appropriate for the analysis. C. If the average is above 10 units per grid: the sample must be diluted. 7. Once the appropriated density is obtained, the dilution factor is calculated. For those samples that have not required dilution, the factor is equal to one. 8. Place the Utermöhl chamber in the inverted microscope. 9. To start counting, move the plate so that microscope shows the left side of the chamber. During the counting, move the plate from left to right. 10. Count the number of grids examined, the total number of units and the total number of diatoms algae. 11. Continue counting until completing all the squares of the grid or reaching the 300 units counted.

Monitoring locations	Saline waters
Frequency	Every six months (at a maximum) [3].
Approximate cost	Laboratory equipment: 300 € [4] Utermöhl chamber: 400 € [5] Inverted microscope: 2.200 € [6]
References	[1] US NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA). *What are phytoplankton?* Washington, 2014. [http://oceanservice.noaa.gov/facts/phyto.html, 27th march 2016] [2] MEDUPIN C. *Phytoplankton community and their impact on water quality: An analysis of Hollingsworth Lake, UK. J. Appl. Sci. Environ. Manage*. Vol. 15(2), 2011, p. 347-350. [3] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliment and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000. [4] IBDCIENCIA. *Instrumentos y utensilios de laboratorio*. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016] [5] AQUATIC RESEARCH INSTRUMENTS. *Utermoehl (Phytoplankton) Sedimentation Chambers*. Hope, ID, 2006. [http://www.aquaticresearch.com/sedimentation_chamber.htm, 27th March 2016] [6] OPTICS PLANET. *Motic Instruments Binocular Inverted 2000 100103800016 100103800016 w/ Free S&H*. Northbrook, IL, 2016. [http://www.opticsplanet.com/motic-instruments-binocular-inverted-2000-100103800016.html, 27th March 2016]

Indicator's name	Oil content (Hydrocarbons)		
Category	Emissions to water	**Indicator's code**	G.6.1
Sub category	Discharges of hydrocarbons		
Definition	Hydrocarbons are substances essentially composed by carbon and hydrogen atoms. They are usually divided into three groups: aliphatic, cyclic and aromatic. They are generated by anaerobic decomposition of organic matter at high pressure and temperature with the presence of microorganisms. Industrial processes and human activities contribute to release hydrocarbons on the environment. The natural degradation processes are not enough to eliminate them, and therefore they may accumulate [1].		
Importance	Hydrocarbons can affect the breathing of fish and adhere to the algae and phytoplankton to the point of destroying them. The food chain and the reproduction of some organisms may also be altered. In addition, hydrocarbons produce aesthetic		

	problems in the surface of the water, which may affect tourism and water activities [1].
Units of measurement	Milligrams of hydrocarbons per litre of sample (mg/l)
Description of the methodology	This section briefly describes the standard method ASTM D7575 for the determination of the content of oils and fats in a water sample [2]. **Equipment** • Infrared spectrometer • Sample containers • Ultrasonic bath: 1 litre of capacity, capable of reaching 40 °C • Syringes of 10 ml • Syringe pump • Capsules with extractor membrane • Air pressure system, free of lubricants **Sampling** • The sample is recollected in clean containers glass or polyethylene. • In order to stabilize the sample, it is acidified with $HCl_{(aq)}$ 12 M to reach a pH of 2. **Procedure** 1. Before the analysis, the samples are placed in a sonic bath at 40 °C for 20 minutes, in order to homogenize them. 2. Using a syringe and a syringe pump, the sample is injected to a capsule. 3. The cartridge is dried by passing compressed air through it with the air pressure system 4. The sample is analysed with the infrared spectrometer. 5. The absorbance of the sample is determined from the peak observed at 2920 cm^{-1}. **Results** With the assistance of a calibration line developed previously, the concentration of hydrocarbons in the sample (in mg/l) is observed, based on the absorbance obtained.
Monitoring locations	Port waters Waste waters Treatment plants waters
Approximate cost	• Infrared spectrometer: 13.200 € [3] • Ultrasonic bath: 420 € [4] • Syringe pump: 880 - 1.100 € [5]
Notes	For more information, you can consult the method ASTM D7575 [6].
References	[1] ARJAY ENGINEERING. Understanding and Monitoring Hydrocarbons in Water. Ontario, 2000. [2] THERMO SCIENTIFIC. Low-Level Measurement of Oil and Grease in Water Using Solvent-Free Infrared Analysis Method ASTM D7575. Madison, 2015.

	[3] COLE-PARMER. Espectrómetro FT-IR. 2010 [4] GRANT INSTRUMENTS. XUBA Analogue Ultrasonic Baths. Cambridge, 2015. [http://www.grantinstruments.com/xuba-ultrasonic-bath/, 9th March 2016] [5] CHEMYX. Fusion Classic Syringe Pumps. Stafford, 2016. [6] ASTM INTERNATIONAL. ASTM D7575 - 11. Standard Test Method for Solvent-Free Membrane Recoverable Oil and Grease by Infrared Determination. West Conshohocken, 2011. [http://www.astm.org/Standards/D7575.htm, 9th of March 2016]

Indicator's name	Volatile Organic Compounds (VOCs) (in water)		
Category	Emissions to water	**Indicator's code**	G.6.2
Sub category	Discharges of hydrocarbons		
Definition	Volatile Organic Compounds are a group of organic compounds that evaporate at ambient temperature and pressure, generating vapours that can be toxic. They are used in the manufacture of various products, such as petroleum products, adhesives, pharmaceuticals, paints and refrigerants. In addition, they are also used directly as solvents [1].		
Importance	VOCs released from the aforementioned activities can be deposited into the water. The water pollution from Volatile Organic Compounds is critical due to the fact that many of these compounds, such as benzene or 1,3-butadiene are harmful to human health and they may even be carcinogens [1 2].		
Units of measurement	Parts per billion (ppb) [3]		
Description of the methodology	Below, a method is presented for the analysis of Volatile Organic Compounds (VOCs) in water, through Static Headspace (SHS) and Gas Chromatography - Mass Spectrometry (GC-MS) [3]. **Basis** The SHS establishes a balance between the liquid phase and a gas phase located at the top of a sealed vial. A certain amount of the gas phase is transferred to the equipment of gas chromatography and mass spectrometry for the analysis of the sample. **Sampling** • The analysis is carried out using 10 ml of water samples. • The samples are placed in specific vials of 20 ml capacity and that contain 7g of sodium sulphate. • The vials are closed with an aluminum and polytetrafluoroethylene (PTFE) stopper. **Analysis** • This method does not require an extraction using solvents.		

	• The analysis is performed with a gas chromatograph, equipped with mass spectrometry detector (e.g. Agilent 7890A GC / 5975C MSD system).
Monitoring locations	Port waters Surface waters Waste waters Treatment plant waters
Approximate cost	GC-MS system (*Agilent 7890A GC/5975C MSD*): 62.000€ [4]
References	[1] UNIVERSITY OF STARTHCLYDE. Development of an Analytical Method and the Environmental Contamination of Tributyltin in the Forth and Clyde Canal, Scotland. Glasgow, Faculty of engineering, 2006. [2] EUROPEAN ENVIRONMENTAL AGENCY. Non-methane volatile organic compounds (NMVOC) emissions. Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/eea-32-non-methanevolatile-1, 8th th of March 2016] [3] AGILENT TECHNOLOGIES. Analysis of Volatile Organic Compounds in Water Using Static Headspace-GC/MS. Kortrijk, Research Institute for Chromatography, 2008. [4] LABX. Gas Analyzers / Detectors Listings. 2016. [http://www.labx.com/gas-analyzers-detectors, 7th of March 2016]

Indicator's name	Volatile Organic Compounds (VOCs) (in sediments)		
Category	Emissions to water	**Indicator's code**	G.6.3
Sub category	Discharges of hydrocarbons		
Definition	Volatile Organic Compounds are a group of organic compounds that evaporate at ambient temperature and pressure, generating vapours that can be toxic. They are used in the manufacture of various products, such as petroleum products, adhesives, pharmaceuticals, paints and refrigerants. In addition, they are also used directly as solvents [1].		
Importance	VOCs that are released to water may deposit to sediments. The sediments pollution from Volatile Organic Compounds is critical due to the fact that many of these compounds, such as benzene or 1,3-butadiene are harmful to human health and they may even be carcinogens [1 2].		
Units of measurement	Micrograms of COV per kilogram of sediment sample (µg/kg)		
Description of the methodology	Below, a method is presented for the analysis of Volatile Organic Compounds (VOCs) in sediments. **Sampling and *in situ* extraction** • A bowl-shaped inverted funnel of about 25 cm of height is used for the extraction. The wide part of the container is placed in contact with the surface of the sediments. The top		

	(narrow part) contains the fiber for the solid phase micro extraction (SPME). • Through a suction pump (flow of 100 ml/min), the fumes emitted by the sample are conducted to the fiber so that they remain absorbed. • In order to obtain the VOCs of the sediments, 500 µl of a solution of 4-bromofluor benzene in methanol are added, before starting the sampling. • This process is isolated of the atmospheric air. • About 2 cm are inserted into the sediments in the edge of the bottom of the funnel, in order to ensure a proper seal and to guarantee that the atmospheric air is not inhaled. • The fiber used is DVB-PDMS-carboxene, supplied by Supleco. • After the extraction, the fiber is sealed in a vial to avoid losses of analyte and it is kept cold. **Analysis** The sample is analysed by gas chromatography and mass spectrometry (GC-MS).
Monitoring locations	Sediments of the port waters
Approximate cost	Laboratory equipment: 300 € [4] GC-MS system (*Agilent 7890A GC/5975C MSD*): 62.000 USD [5]
References	[1] UNIVERSITY OF STARTHCLYDE. Development of an Analytical Method and the Environmental Contamination of Tributyltin in the Forth and Clyde Canal, Glasgow, Scotland. Glasgow, Faculty of engineering, 2006. [2] EUROPEAN ENVIRONMENTAL AGENCY. Non-methane volatile organic compounds (NMVOC) emissions. Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/eea-32-non-methanevolatile-1, 8th March 2016]. [3] BRAVO-LINARES C.M., MUDGE S.M. Analysis of volatile organic compounds (VOCs) in sediments using in situ SPME sampling. J. Environ. Monit. Vol. 9, 2007, p. 411–418. [4] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016]. [5] LABX. Gas Analyzers / Detectors Listings. 2016. [http://www.labx.com/gas-analyzers-detectors, 7th March 2016].

Indicator's name	Halogen content		
Category	Emissions to water	**Indicator's code**	G.7.1

Sub category	Discharges of other chemicals
Definition	This indicator determines the amount of organic substances that contain chlorine, bromine and iodine (halogen substances). These substances can be simple (e.g. chloroform) or complex organic molecules (such as dioxins and furans). One of the main worldwide sources of halogenated compounds is the paper industry. Other releases of chlorinated substances are the routine disinfection in swimming pools and in cooling waters [1].
Importance	Excessive exposure to these chemicals may affect the health, although the specific effects depend on each substance. In addition, low concentrations of some substances contained in this indicator are toxic to fish and to other aquatic organisms [1].
Units of measurement	This indicator determines the equivalent amount of chlorine, bromine and iodine, expressed as chlorides [2] • micrograms of chlorides per litre of sample (μg/l) • milligrams of chloride per litre of sample (mg/l)
Description of the methodology	Below, the method UNE-EN 1485 is presented for the determination of halogenated organic compounds (AOX) [2]. **Equipment** • Filtration system • Polycarbonate membrane filter • Conical flask • Mechanical stirrer • Oven capable of reaching 950 °C and a quartz container • Absorbent filling of sulphuric acid • Argentometric measuring device (e.g. microcoulombimeter) **Sampling** • Glass (preferably) or plastic containers are used, with a top of polytetrafluoroethylene (PTFE). • If the sample is believed to contain oxidizing agents, 10 ml of sodium sulphite solution are added. • The sample should be analysed as soon as possible. If the analysis is not possible immediately, the sample should be kept acidified at 4 °C or frozen at -20 °C. **Procedure** 1. The sample is homogenized by stirring in the container. 2. 100 ml of sample is transferred to a conical flask and 5 ml of nitrate solution are added. It is checked that the pH is less than 2. 3. 50 mg of active carbon are added, the flask is covered and the suspension is stirred for 1 hour. 4. The suspension is filtered and the residue retained on the filter is washed with about 25 ml of nitrate solution. 5. The wet filter and the retained residue are placed in the quartz container inside the oven. 6. The temperature of the combustion chamber should be 950 °C.

	7. The gas supply is connected to the combustion tube, and this tube to the absorbent. 8. The gas flow should be approximately 150 ml/min. 9. The reading given by the argentometric measuring device is written down. 10. The same procedure is followed to carry out a blank, with distilled water. **Results** The mass concentration of the halogen organic compounds that are absorbable, expressed as chlorides QCl (AOX), is determined by the following formula: $$Q_{Cl}(AOX) = \frac{N - N_0}{V} \cdot \frac{M \cdot a}{F} \cdot D$$ where: N_0 is the blank value of the absorbable organic halogen compounds, in Coulombs N is the average value of the absorbable organic halogen compounds, in Coulombs M is the molecular weight of chloride M = 35.45· 106 µg/mol V is the volume of sample used for adsorption, in litres F is Faraday's constant with a value of 96487 C/mol a is the correction factor D dilution factor, if applicable
Detection values of the method	10 µg/l - 1 g/l [2]
Monitoring locations	Saline waters Waste waters Treatment plants water
Approximate cost	Laboratory equipment: 300€ [3] Mechanical agitator 300 € [4] Oven: 2000€ [5] Microcoulombmeter: 90 € [6]
References	[1] EU EDUCATION AND CULTURE. LEONADRO DA VINCI. *Training Module for Environmental Pollution Control*. Rome, 2005. [http://leonardo.unibuc.ro/, 8th of March 2016] [2] AENOR. *Calidad del agua. Medioambiente Tomo 1*. AENOR, Madrid, 1997. [3] IBDCIENCIA. *Instrumentos y utensilios de laboratorio*. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7 th of March 2016] [4] TECNYLAB. *Agitador Mecanico Varilla 686··1, Ref. 50686001*. Valencia, 2016. [http://www.tecnylab.es/es/mecanicos/2559-agitador-mecanico-varilla-6861.html, 8 th of March 2016] [5] LAC. *Laboratory tube furnaces LT*. 2016. [http://www.lac.cz/en/produkty/katalogove-pece-susarny/laboratorni-pece-susarny/pece-laboratorni-trubkove-lt/, 8 th of March 2016] [6] EDU-LAB. *Digital Coulomb Meter. Product Code: 231-037*. 2016. [http://www.edulab.com/prod/digital-coulomb-meter, 8 th of March 2016]

Indicator's name	Conductivity		
Category	Emissions to water	**Indicator's code**	G.7.2
Sub category	Discharges of other chemicals		
Definition	Salinity is the amount of dissolved salts into a body of water. The main substances dissolved in seawater are: chlorine (Cl), sodium (Na), sulphate (SO_4^{2-}), magnesium (Mg), calcium (Ca) and potassium (K). In water analysis, the electrical conductivity can be taken as a measure of the concentration of ionisable substances (salts) present in the sample, in other words, the salinity of the analysed water [1].		
Importance	The conductivity is an important factor for understanding the aspects of the chemistry of natural waters and the biological processes that take place.		
Units of measurement	S/m at 25 ºC (S=Siemens) [1]		
Description of the methodology	Below, a method is presented for determining the electrical conductivity using a conductivity meter [2]. **Equipment** Measuring instrument equipped with induction electrodes of stainless steel. **Collection of samples** Samples are taken in polyethylene containers filling it completely and closing it immediately. The samples must be analyzed as soon as possible, particularly when there is the possibility of gas exchange with the atmosphere or the possibility of biological activity. **Procedure** 1. The conductivity meter should be properly calibrated. The manufacturer's instructions explain how to calibrate the device. 2. The protective cover should be removed, the device turned on and the probe should be immersed into the water sample (see Note 1). 3. The probe should reach the water temperature before reading the result (see Note 2). The temperature has a significant influence on the salinity. 4. After each sampling, the probe should be cleaned with distilled water and any excess of water should be wiped, in order to remove any trace of salt. **Results** The result is read directly from the measuring equipment. The correction method used should be indicated when the measure has not been done at 25 °C [1].		
Monitoring locations	Surface waters Waste waters Treatment plants waters		
Frequency	Every three months, at a maximum [3]		
Approximate cost	Conductivity meter: 300 – 1.500 € [4]		

Notes	1. It is important that there are no bubbles on the surface of the probe, if so scroll it up and down slightly. 2. The conductivity readings are normalized to 25 °C. Some conductivity meters correct automatically the reading to the water temperature of 25 °C. There are two possibilities: A) If the conductivity meter has automatically correction, wait 30 seconds before taking the reading. If the sample is at a very low temperature, wait for a longer period, up to two minutes if necessary. B) If the device has not automatic compensation, the salinity reading and the temperature of the sample should be recorded. Later on, the reading should be corrected with the appropriate correction factor. These factors are tabulated in tables for the conversion of conductivity from a temperature T to 25,0ºC [1].
References	[1] AENOR. *Calidad del agua. Medioambiente Tomo 1*. AENOR, Madrid, 1997. [2] STATE OF VICTORIA. AGRICULTURE VICTORIA. Measuring the Salinity of Water. LC0064. Melbourne, 1999. [http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/salinity/measuring-the-salinity-of-water, 8th March 2016] [3] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliment and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000. [4] GRAINGER. *Conductivity Meters*. 2016. [http://www.grainger.com/category/conductivity-meters/water-testing-equipment-and-meters/lab-supplies/ecatalog/N-kva, 8 de març de 2016]

Indicator's name	Heavy metals (in water)		
Category	Emissions to water	**Indicator's code**	G.7.3
Sub category	Discharges of other chemicals		
Definition	This indicator includes most of the metals with atomic number greater than 20, excluding the alkali metals (e.g. rubidium, cesium), the alkaline earth (e.g. calcium, strontium) and the lanthanides and actinic. The metals are introduced into aquatic systems as a result of the erosion of soils and rocks, from volcanic eruptions, and as a result of various human activities, such as mining, metals processing, and their use. The most common contaminants are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb) and mercury (Hg) [1].		
Importance	The main adverse effects of heavy metals have been extensively studied. For instance, the exposure to low concentrations of cadmium affect the kidney and weaken the bones; or the exposure to lead is especially harmful to children, which has neurotoxic effects even at low concentrations [2].		
Units of measurement	Milligrams of metal pollutant per litre of sample (mg/l) Micrograms of metal pollutant per litre of sample (μg/l)		

<table>
<tr><td>Equivalences</td><td>1 μg/l = 1000 mg/l</td></tr>
<tr><td>Description of the methodology</td><td>Below, a method is presented for determining the concentration of Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in sea water using Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) [3].
Basis
• The method only needs 12 ml of the water sample.
• All samples are irradiated with a low power UV system in order to destroy the organic ligands.
• Then the sample is acidified using ammonium acetate reaching a pH of 6.4.
• Then, there is a pre-concentration step using a chelating agent (e.g. the commercial resin: Toyopearl AF-Chelate-650).
• A solution of six isotopes is added to the acidified samples: Fe 57, Ni 62, Cu 65, Zn 68, Cd 111, and Pb 207, enriched above the natural abundance.
• The metals extracted in the step of pre-concentration are diluted using HNO_3 1M.
• Finally, its concentration is determined by using mass spectrometry.</td></tr>
<tr><td>Limit values</td><td>EQS Directive 2008/105/EC [4] defines two types of thresholds:
• AA: annual average concentration
• MAC: maximum allowable concentration
The following table lists the limit for four metals and compounds included in this directive:
<table>
<tr><th>Substance</th><th>AA</th><th>MAC</th></tr>
<tr><td>Cadmium and its compounds</td><td>0,2 μg/l</td><td>1,5 μg/l</td></tr>
<tr><td>Lead and its compounds</td><td>7,2 μg/l</td><td>Not applicable</td></tr>
<tr><td>Mercury and its compounds</td><td>0,05 μg/l</td><td>0,07 μg/l</td></tr>
<tr><td>Nickel and its compounds</td><td>20 μg/l</td><td>Not applicable</td></tr>
</table></td></tr>
<tr><td>Monitoring locations</td><td>Saline waters [3]
Wastewaters
Treatment plant waters</td></tr>
<tr><td>Frequency</td><td>Each month (as a maximum) [5].</td></tr>
<tr><td>Approximate cost</td><td>ICP-MS: 40.000 € [6]</td></tr>
<tr><td>References</td><td>[1] LENNTECH. WATER TREATMENT SOLUTIONS. Metals in aquatic freshwater. Delft, 2016. [http://www.lenntech.com/aquatic/metals.htm, 8th of March 2016]
[2] JARÜP L. Hazards of heavy metal contamination. British Medical Bulletin. Vol. 68(1), 2003, p. 167-182.
[3] MILNE, A., et al. Determination of Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in seawater using high resolution magnetic sector inductively coupled mass spectrometry (HR-ICP-MS). Analytical Chimica acta. Vol. 665(2), 2010, p. 200 - 207.
[4] EUROPEAN COMMISSION (EC). Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy. Brussels, Official Journal of the European Communities, 2008.</td></tr>
</table>

	[5] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000. [6] LABX. *ICP / ICPMS Listings.* 2016. [http://www.labx.com/icp-icpms, 7th of March 2016]

Indicator's name	Heavy metals (in sediments)		
Category	Emissions to water	**Indicator's code**	G.7.4
Sub category	Discharges of other chemicals		
Definition	This indicator includes most of the metals with atomic number greater than 20, excluding the alkali metals (e.g. rubidium, cesium), the alkaline earth (e.g. calcium, strontium) and the lanthanides and actinic. The metals are introduced into aquatic systems as a result of the erosion of soils and rocks, from volcanic eruptions, and as a result of various human activities, such as mining, metals processing, and their use. The most common contaminants are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb) and mercury (Hg) [1].		
Importance	The main adverse effects of heavy metals have been extensively studied. For instance, the exposure to low concentrations of cadmium affect the kidney and weaken the bones; or the exposure to lead is especially harmful to children, which has neurotoxic effects even at low concentrations [2].		
Units of measurement	Micrograms of metal pollutant per gram of sample (µg/g)		
Equivalences	1 µg/l = 1000 mg/l		
Description of the methodology	Below, a method is presented for determining the concentration of heavy metals in sediments, using Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES) [3]. This method allows to determine the concentration of zinc (Zn), cadmium (Cd), lead (Pb), nickel (Ni), chromium (Cr) and copper (Cu) [3]. **Equipment** • Precision scale • PFA containers (perfluoroalkoxy polymer) • Laboratory equipment • Microwave • Pressurized buckets for microwave • Spectrometer ICP-AES (e.g. Jobin-Yvon Spectrometer [4]) **Sampling** • A sample is extracted • In the laboratory, the sample is dried at 105 °C for 3 hours. **Sample preparation**		

	1. 0.2 g of the sample are weighted in a container of PFA and they are placed in a pressurized bucket for a microwave. 2. 4 ml of concentrated nitric acid and 0.5 ml of concentrated hydrofluoric acid are added. 3. The sample is digested applying microwave for 40 minutes. 4. Once the sample is back to room temperature, it is diluted to 100 ml with deionized water. **Analysis** The sample is analysed with Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES).
Monitoring locations	Sediments of the port water
Approximate cost	Balance precision: 500 - 2.000 € [5] PFA containers: 20 - 50 € [6] Laboratory equipment: 300 € [7] Microwave and pressurized buckets: 5.400 € [8] Spectrometer ICP-AES: 30.000 € [4]
References	[1] LENNTECH. WATER TREATMENT SOLUTIONS. *Metals in aquatic freshwater*. Delft, 2016. [http://www.lenntech.com/aquatic/metals.htm, 8th March 2016] [2] JARÜP L. *Hazards of heavy metal contamination.* British Medical Bulletin. Vol. 68(1), 2003, p. 167-182. [3] MILNE, A., et al. *Determination of Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in seawater using high resolution magnetic sector inductively coupled mass spectrometry (HR-ICP-MS). Analytical Chimica acta*. Vol. 665(2), 2010, p. 200 - 207. [4] EUROPEAN COMMISSION (EC). *Directive 2000/60/EC of the European Parliment and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. Brussels, Official Journal of the European Communities, 2000. [5] LABX. *ICP / ICPMS Listings.* 2016. [http://www.labx.com/icp-icpms, 7th March 2016]

Indicator's name	Surfactants		
Category	Emissions to water	**Indicator's code**	G.7.5
Sub category	Discharges of other chemicals		
Definition	The surfactant is the main element (active ingredient) of the most synthetic detergents. The most common type of surfactants are the anionic ones. The main anionic surfactants currently used are linear alkyl sulphates and sulfonated linear alkyl benzenes, being the latter group the most abundant and significant [1].		

Importance	Although some surfactants are biodegradable, most of them are not and they can contaminate water supplies. It is important to control this parameter because surfactants can be harmful to humans, aquatic organisms and vegetation. Additionally, the water containing surfactants can accumulate large amounts of toxic hydrophobic chemicals [1].
Units of measurement	Part per million of SDS (ppm)
Equivalences	1 ppm = 1 mg/l
Description of the methodology	Below, a method is presented for the spectrophotometric determination of anionic surfactants in wastewater, using acridine orange (pigment) [1]. **Equipment** • Flask decanter • Spectrophotometer • Acridine orange • Glacial acetic acid • Toluene **Sampling** 1. The samples must be collected in glass or polyethylene containers. 2. The samples should be analysed as soon as possible. 3. If they are not analysed immediately, they should be kept between 0 and 4 °C for 24 hours. **Procedure** 1. The content of sodium dodecyl sulphate (SDS) in 10 ml of sample is analysed. 2. 100 ml of acridine orange and 100 ml of glacial acetic acid $5 \cdot 10^3$ M are added. 3. Then, 5 ml of toluene are added. 4. The contents are agitated for 1 minute and let stand for 5 minutes, and then two phases are formed. 5. The aqueous phase is removed. 6. The organic phase (toluene) is collected and its absorbance is analysed with the spectrophotometer directly to the wavelength of 467 nm. **Results** The absorbance is directly related to the concentration of SDS sample. The following expression may be used: $A = 0{,}0629 \cdot C(ppm) - 0{,}045$
Detection limits of the method	0,1 - 6,0 ppm
Monitoring locations	Port waters Waste waters
Approximate cost	Spectrophotometer LAMBDA 35: 14.500 € [2] Glacial acetic acid (1000 ml): 32 € [3] Acridine orange (10 ml): 85 € [5]

	Toluene (1000 ml): 41 € [4]
References	[1] RAHMAN M., et al. Partitioning of dioxins (PCDDs/Fs) in ambient air at urban residential locations. International Journal of Environmental Science and Technology. Vol. 11(7), 2014, p. 1897-1910. [2] VWR. LAMBDA™ 25/35 Series UV/Vis Spectrophotometers, PerkinElmer®. [https://us.vwr.com/store/catalog/product.jsp?product_id=4832209, 8th March 2016] [3] IBDCIENCIA. Ácido acético. 2015. [http://www.ibdciencia.com/acido-acetico-c-189, 7th March 2016] [4] SIGMA-ALDRICH. Acridine Orange solution. 2016. [http://www.sigmaaldrich.com/catalog/product/sigma/a9231?lang=es& region=ES, 8th March 2016] [5] IBDCIENCIA. Tolueno 1000 ml. 2015. [http://www.ibdciencia.com/otros-compuestos-reactivos/5742-tolueno-1000-ml.html, 7th March 2016]

Indicator's name	Tributyltin (TBT) (in water)		
Category	Emissions to water	**Indicator's code**	G.7.6
Sub category	Discharges of other chemicals		
Definition	The tributyltin (TBT) is an organometallic compound that forms the basis of organotin pollutants. These are three butyl groups joined covalently to a central atom of tin (IV). Organic tin compounds have been used extensively worldwide since the 1960s as additives in paints for marine craft due to its excellent antifouling properties. Additionally, TBT is used in sintering fungicides, pesticides and biocides and as a stabilizing agent in polymers and catalysts [1].		
Importance	The TBT is an important parameter to monitor because of its potential to bioaccumulate, and its harmful effects to the environment, particularly on the aquatic environment [1].		
Units of measurement	Parts per billion (ppb) [1]		
Description of the methodology	Below, an analytical method is presented for the determination of tributyltin (TBT) in salty water, through the analysis technique Gas Chromatography - Flame Photometric Detector (GC-FPD) [1]. **Equipment** • GC-FDP detection equipment (e.g. Shimadzu GC-2010 Plus series) • SPE cartridges Lichorlit forisil of Sigma-Aldrich **Sampling** • Samples are taken in dark glass bottles and they are transported to the laboratory kept in ice. • Water samples are filtered with a filter paper of 90 mm, in order to remove suspended particles.		

	• 2 ml of $HCl_{(aq)}$ 1 M are added to each sample as a conservative agent. • The samples are kept in dark glass bottles, previously washed with acid, at 4 ºC. **Sample preparation** 1. For the extraction of the organotin compounds, 500 ml of the sample are used. They are taken to pH 2 using $HCl_{(aq)}$. 2. Cartridges for the Solid Phase Extraction (SPE) are used. 3. Previously to the extraction of the sample, 5 ml of toluene, 5 ml of methanol and 5 ml of deionized water are passed through each cartridge. Then, they are dried for 45 minutes. 4. After that, 500 ml sample are taken in order to extract the organotin compounds. 5. It uses a vacuum pump connected to the cartridge, through PTFE connections. 6. The analytes s'eludeixen cartridge with 10 ml of toluene and concentrated in 2 ml by passing nitrogen through the sample. **Analysis** • At this step, the samples are ready to be introduced into the analysis system. • The samples are analysed through the system Gas Chromatography – Flame Photometric Detector (GC-FPD)
Limit values	Annual average value: 0,0002 ppb [2] Maximum allowable concentration: 0,0015 ppb [2]
Monitoring locations	Saline waters [1]
Approximate cost	GC-FPD system (Shimadzu GC-2010 Plus): 28.000€ [3] SPE cartridges Lichorlit forisil: 130€ [4] Laboratory equipment: 300€ [5]
References	[1] H. K. Okoro, et al. *Development of an Analytical Method for Determining Tributyltin and Triphenyltin in Seawater, Sediment, and Mussel Samples using GC-FPD and GC-MS-TOF. Polish J. of Environ. Stud.* Vol. 21, 2012, p. 1743-1753. [2] EUROPEAN COMMISSION (EC). *Directive 2008/105/EC of the European Parliment and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council.* Brussels, Official Journal of the European Union, 2008. [3] SHIMADZU. ANALYTICAL AND MEASURMENT INSTRUMENTS. *GC-2010 Plus*. 2016. [http://www.shimadzu.com/an/gc/2010plus.html, 9 March 2016] [4] SIGMA-ALDRICH. *Supelclean™ LC-Florisil® SPE Tube*. 2016. [http://www.sigmaaldrich.com/catalog/product/supelco/57057?lang=es& region=ES, 8th of March 2016] [5] IBDCIENCIA. *Instrumentos y utensilios de laboratorio*. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016]

Indicator's name	Tributyltin (TBT) (in sediments)		
Category	Emissions to water	**Indicator's code**	G.7.7
Sub category	Discharges of other chemicals		
Definition	The tributyltin (TBT) is an organometallic compound that forms the basis of organotin pollutants. These are three butyl groups joined covalently to a central atom of tin (IV). Organic tin compounds have been used extensively worldwide since the 1960s as additives in paints for marine craft due to its excellent antifouling properties. Additionally, TBT is used in sintering fungicides, pesticides and biocides and as a stabilizing agent in polymers and catalysts [1].		
Importance	The TBT is an important parameter to monitor because of its potential to bioaccumulate, and therefore it poses harmful effects to the environment, particularly to the aquatic environment [1].		
Units of measurement	Micrograms of TBT per kilogram of the sample (µg/kg).		
Description of the methodology	Below, an analytical method is presented for the determination of tributyltin (TBT) in sediments, through the analysis technique Gas Chromatography - Flame Photometric Detector (GC-FPD) [1]. **Equipment** • GC-FDP detection equipment (e.g. Shimadzu GC-2010 Plus series) • SPE cartridges Lichorlit forisil of Sigma-Aldrich • Laboratory equipment **Sampling** • The samples are taken from the sediments. • In the laboratory, the sample is dried using air. **Sample preparation** 1. 10 g of the sediments sample are weighted, previously dried, in a container of 250 ml. 2. 10 g of NaCl are added, followed, in this order, by 20 ml of deionized water, 2 ml of concentrated HCl, 20 ml of tropolona (C_7H_6O) 0.02% in methanol, and 100 ml of n-hexane. 3. The bowl is covered and put in agitation for 12 hours. 4. The resulting suspension is filtered, and the sample that remained in the filter is recovered by adding anhydrous sodium sulphate (drying agent) to remove the remaining water. 5. The extract is transferred to a water bath at 100 ºC in order to concentrate the sample. 6. Once the sample is concentrated, it is cleaned in a column packed with silica gel. 7. 1 ml of sodium acetate is added, followed by 1ml of sodiumtetraethylborate (STEB) 1% dissolved with ethanol. 8. The solution is agitated for 10 minutes. **Analysis** • Before entering the sample to the measuring equipment, the sample is dried by applying a nitrogen gas stream and reconstituting the sample with 1 ml of n-hexane. • 1 µl is introduced to the GC-FDP for the analysis of the sample.		
Monitoring locations	Sediments of the port waters		
Approximate cost	GC-FPD system (Shimadzu GC-2010 Plus): 28.000€ [2] SPE cartridges Lichorlit forisil: 130€ [3] Laboratory equipment: 300€ [4]		
References	[1] H. K. Okoro, et al. *Development of an Analytical Method for Determining Tributyltin and Triphenyltin in Seawater, Sediment, and Mussel Samples using GC-FPD and GC-MS-TOF. Polish J. of Environ. Stud.* Vol. 21, 2012, p. 1743-1753. [2] SHIMADZU. ANALYTICAL AND MEASURMENT INSTRUMENTS. *GC-2010 Plus*. 2016. [http://www.shimadzu.com/an/gc/2010plus.html, 9th March 2016].		

	[3] SIGMA-ALDRICH. *Supelclean™ LC-Florisil® SPE Tube*. 2016. [http://www.sigmaaldrich.com/catalog/product/supelco/57057?lang=es& region=ES, 8th March 2016]. [4] IBDCIENCIA. *Instrumentos y utensilios de laboratorio.* 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016].

Indicator's name	Persistent Organic Pollutants (POPs) (in sediments)		
Category	Emissions to water	**Indicator's code**	G.7.8
Sub category	Discharges of other chemicals		
Definition	Persistent Organic Pollutants (POPs) are chemical substances that persist in the environment. Three important families of persistent pollutants are the polychlorinated dibenzo-p-dioxins (PCDD), the polychlorinated dibenzofurans (PCDF), and the polychlorinated biphenyls (PCBs). The substances of the first two families are obtained as a by-product in many chemical processes that include combustion and thermal treatments. PCBs are industrial chemicals that although they are currently banned, they are still released into the environment from landfills or due to accidental leakages [1].		
Importance	POPs have the ability to bioaccumulate along the food chain and pose a risk to human health and to the environment. They are also a matter of concern for its high toxicity and its ability to cause cancer, affect the reproductive system and the immune system of humans [1]. POPs tend to accumulate in sediments, due to their low solubility [2].		
Units of measurement	• Picogram (10^{-12} g) per gram of sediment (pg/g) [2] • Toxic Equivalent Units per gram of sediment (pg-TEQ/g) [3] (See notes)		
Description of the methodology	Below, a method for the determination of POPs in sediments is presented, where a representative sample of the three most important families is selected. The chosen substances are the different congeners of PCDD, PCDF and PCBs, all highly toxic and representative of the whole indicator [2]. **Equipment** • Sediment sampler *Haps* • Column *Soxtec Avanti* • Rotary evaporator • Laboratory equipment • Gas chromatograph with electron capture detector (GC-ECD) **Sampling** • A sample of sediment surface (0 to 10 cm) is extracted through a sediment sampler *Haps* [4]. • The sediment sample is passed through different sieves to obtain the particle size fraction with grain size <0.63 μm. • The samples are kept at -20 °C. **Sample preparation** 1. The selected POPs are extracted with a mixture of hexane and dichloromethane (1: 1 v/v), using the device *Soxtec Avanti* [5]. 2. The sample is introduced into a rotary evaporator to concentrate and remove the dichloromethane. 3. The sample is cleaned by adding sulphuric acid and centrifuging it. 4. Then, the sample is frozen, in order to separate the remaining solvent from the rest of extract. By removing the upper phase of the frozen, the solvent is removed. 5. The phase of sulfuric acid (containing the persistent pollutants) is frozen and it is extracted with hexane. 6. The element sulfur, which is a byproduct of the extraction, is eliminated by adding copper powder. **Analysis**		

	The combination of extracts is adjusted to a volume of 1 ml with deionized water. It is analyzed by a gas chromatography with electron capture detector (GC-ECD) system.
Monitoring locations	Sediments of the port waters
Approximate cost	Column *Soxtec Avanti* 600 € [6] Rotary evaporator 2.000 € [7] Laboratory equipment 400 € [8] GC-ECD device 8.000 - 15.000 € [9]
Notes	The calculation of the unit values in TEQ is carried out by weighing each pollutant concentrations obtained with the corresponding Toxic Equivalent Factor (TEF) [3]. The TEF factors for humans and fish were established by the World Health Organization (WHO) and they are calculated in relation with the toxicity of 2,3,7,8-TCCD species, being the equivalent factor this specie equal to one.
References	[1] EUROPEAN ENVIRONMENTAL AGENCY. Persistent organic pollutant emissions. Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/eea32-persistent-organic-pollutant-pop-emissions-1/assessment-5, 8th March 2016] [2] SZLINDER-RICHERT J. USYDUSA Z., DRGASB A. Persistent organic pollutants in sediment from the southern Baltic: risk assessment. J. Environ. Monit., Vol. 14, 2012, p. 2100-2107. [3] STATE OF WASHINGTON. DEPARTMENT OF ECOLOGY. Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors. Washington, 2007. [4] KC DENMARK. Haps Operated by hand. Silkeborg, 2015. [http://www.kc-denmark.dk/products/sediment-samplers/haps-corer/haps-operated-by-hand.aspx, 27th March 2016] [5] FOSS. Solvent extraction with fast and safe Soxtec™ systems. Hillerød, 2016. [http://www.foss.dk/industry-solution/chemical-analysis/solvent-extraction/, 27th March 2016] [6] FISHER SCIENTIFIC. PM Kit for Soxtec Avanti 2050. Ontorio, 2013. [https://www.fishersci.ca/itemDetails_TC10007350, 27th March 2016] [7] IKA. Rotavapores. Staufen, 2015. [http://www.ika.com/Products-Lab-Eq/Rotary-Evaporators-Rotary-Evaporators-Rotary-evaporator-distilling-distillation-csp-35-1/, 27th March 2016] [8] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016] [9] LABX. GC Systems Listings. 2016. [http://www.labx.com/gc-systems, 27th March 2016]

Indicator's name	Polychlorinated biphenyl (PCB) (in sediments)		
Category	Emissions to water	**Indicator's code**	G.7.9
Sub category	Discharges of other chemicals		
Definition	PCBs are one of the important families of Persistent Organic Pollutants (POPs, see G.7.8). Due to its importance, its calculation method is explained individually in this Guideline. PCBs are a group of 209 chlorinated organic substances which were widely used as an insulator in electrical equipment manufactured until the mid-1980s, when they were banned due to their toxicity and persistence in the environment. Other minor uses of PCBs are as hydraulic fluid, lubricants, dyes, adhesives and insecticides.		
Importance	PCBs are very persistent in the environment, and they take many years to degrade. PCBs are substances insoluble in water, therefore, when they are present in the aquatic environment, they tend to accumulate in sediments [1]. The exposure to PCBs can cause permanent damage to the nervous system, the reproductive system and the immune system of humans. Additionally, they are recognized as carcinogenic		

<table>
<tr><td></td><td>substances and links between these pollutants and skin cancer and liver have been found [2].</td></tr>
<tr><td>Units of measurement</td><td>Micrograms (10^{-6} g) per kilogram of sediments (µg/kg) [3]
Toxic Equivalent Units per gram of sediment (µg-TEQ/g) [4] (See notes)</td></tr>
<tr><td>Description of the methodology</td><td>Below, a method is presented for the determination of the seven congeners that are representative of the PCB pollutants in sediments. The following list shows the seven recommended substances, with the number of associated congener for an easier identification [5].
<table>
<tr><th>Name of the PCB</th><th>Number of the congener</th></tr>
<tr><td>2,4,4’-Trichlorobiphenyl</td><td>28</td></tr>
<tr><td>2,2’,5,5’-Tetrachlorobiphenyl</td><td>52</td></tr>
<tr><td>2,2’,4,5,5’-Pentachlorobiphenyl</td><td>101</td></tr>
<tr><td>2,3’,4,4’,5-Pentachlorobiphenyl</td><td>118</td></tr>
<tr><td>2,2’,3,4,4’,5’-Hexachlorobiphenyl</td><td>138</td></tr>
<tr><td>2,2’,4,4’,5,5’-Hexachlorobiphenyl</td><td>153</td></tr>
<tr><td>2,2’,3,4,4’,5,6-Heptachlorobiphenyl</td><td>180</td></tr>
</table>
Sampling
• A sample of sediment surface (0 to 10 cm) is extracted through a polycarbonate tube.
• The samples are kept wrapped in aluminium foil and sealed in polythene bags.
Sample preparation
1. The sediment samples are dried in the laboratory at room temperature.
2. The samples are passed through a sieve of 500µm to obtain fine particle fraction.
3. 2.0 g of the sample are weighted and they are added to a sonic bath for 3 h at 40 °C with 50 ml of a mixture (3:1) of acetone and n-hexane.
4. Once the sample is extracted from the sonic bath, it is concentrated up to 3 ml with a rotary evaporator.
5. The concentrate is cleaned with 2.0 g of Florisil adsorbent and 1.5 g of anhydrous sodium sulphate.
6. Next, the PCBs are extracted with 8 ml of n-hexane. The extract is reduced up to 0.5 ml in a rotary evaporator and the residue is recovered with 1.5 ml of ethyl acetate.
Analysis
The sample is introduced into the gas chromatograph equipped with electron capture detector (GC-ECD) and analyses the seven types. The conditions of the analysis can be found in reference [3].</td></tr>
<tr><td>Monitoring locations</td><td>Sediments of the port waters</td></tr>
<tr><td>Approximate cost</td><td>Laboratory equipment: 400 € [6]
rotary evaporator: 2.000 € [7]
GC-ECD device: 8.000 - 15.000 € [8]</td></tr>
<tr><td>Notes</td><td>The calculation of the unit values in TEQ is carried out by weighing each pollutant concentrations obtained with the corresponding Toxic Equivalent Factor (TEF) [3]. The TEF factors for humans and fish were established by the World Health Organization (WHO) and they are calculated in relation with the toxicity of 2,3,7,8-TCCD species, being the equivalent factor this specie equal to one.</td></tr>
<tr><td>References</td><td>[1] NET, S., et al. Overview of persistent organic pollution (PAHs, Me-PAHs and PCBs) in freshwater sediments from Northern France. Journal of Geochemical Exploration. Vol 148, 2015, pp. 181 - 188.
[2] EUROPEAN ENVIRONMENTAL AGENCY. Environmental Terminology and Discovery Service (ETDS). Copenhagen. [http://glossary.eea.europa.eu/terminology/concept_html?term=pcb, 8th of March 2016]
[3] Afful S., et al. Determination of indicator polychlorinated biphenyls (PCBs) by gas chromatography-electron capture detector. Chemosphere. Vol. 93, 2013, pp 1556-1560.</td></tr>
</table>

[4] STATE OF WASHINGTON. DEPARTMENT OF ECOLOGY. Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors. Washington, 2007.
[5] US ENVIRONMENTAL PROTECTION AGENCY. Table of PCB Species by Congener Number. Washington, 2003. [http://www3.epa.gov/epawaste/hazard/tsd/pcbs/pubs/congeners.htm, 8th of March 2016]
[6] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016]
[7] IKA. Rotavapores. Staufen, 2015. [http://www.ika.com/Products-Lab-Eq/Rotary-Evaporators-Rotary-Evaporators-Rotary-evaporator-distilling-distillation-csp-35-1/, 27th of March 2016]
[8] LABX. GC Systems Listings. 2016. [http://www.labx.com/gc-systems, 27th of March 2016]

Indicator's name	Polycyclic Aromatic Hydrocarbons (PAHs) (in sediments)		
Category	Emissions to water	**Indicator's code**	G.7.10
Sub category	Emissions of other chemicals		
Definition	The Polycyclic Aromatic Hydrocarbons (PAH) are a family of chemical compounds composed of carbon and hydrogen atoms, with a molecular structure constituted of two or more fused benzene rings. This family of chemicals includes more than 100 substances that are differentiated according to the number and position of the ring. The PAHs emission sources are found mainly in urban areas (e.g. automobiles, oil refineries, power plants, or aluminium production processes) [1]. Although PAHs are already included in the guideline of POPs (see G.7.8), they have their own guideline because they are considered as an important indicator.		
Importance	PAHs are non-polar substances and extremely hydrophobic, which make them to be persistent on the environment. Additionally, some compounds of this group are highly carcinogenic and mutagenic, in particular the compound benzo (a) pyrene (B [a] P) [1].		
Units of measurement	Micrograms of PAH per kilogram (µg/kg)		

Description of the methodology

Below, a method is presented for the determination of 10 relevant Polycyclic Aromatic Hydrocarbons in a sediment sample [2]. This method is capable of determining the concentration of the 10 PAHs shown in the following table:

PAH	Formula
Fluorene	$C_{13}H_{10}$
Phenanthrene	$C_{14}H_{10}$
Anthracene	$C_{14}H_{10}$
Fluoranthene	$C_{16}H_{10}$
Pyrene	$C_{16}H_{10}$
Benzo(a)anthracene	$C_{18}H_{22}$
Chrysene	$C_{18}H_{22}$
Benzo(e)pyrene	$C_{20}H_{12}$
Benzo(k)fluoranthene	$C_{20}H_{12}$
Benzo(a)pyrene	$C_{20}H_{12}$

Sampling

- A sample of the sediments is extracted *in situ*.
- In the laboratory, the sample is dried by air flow.

Extraction and sample preparation

1. The PAHs that are contained in 10 g of a sediment sample are extracted, by using an ultrasonic bath for 1 hour with 20 ml of a mixture of acetone and dichloromethane (1: 1).
2. Then, the solution containing the extract is centrifuged at 4000 rpm for 20 min.

	3. 5ml of the top layer of the liquid are removed and the analyte is extracted with 5 ml of solvent (mixture 1: 1 of acetone and n-hexane). 4. The solvent is removed by evaporation, and the sample is recovered with 2 ml of n-hexane. 5. The sample is passed through a column of silica gel with 11 ml of a mixture 1: 1 of n-hexane and dichloromethane. 6. The solvents are removed again by evaporation and the sample is recovered with 2 ml of methanol, specific for the High Performance Liquid Chromatography (HPLC) column. 7. Finally, the sample is filtered through a polytetrafluoroethylene (PTFE) filter of pore diameter of 0.22 mm, and it is kept is sealed sample vials. **Analysis** PAHs that are extracted from sediment samples are analyzed by HPLC liquid chromatography. The analyte solution (40 ml) is introduced to the column at a rate of 1 ml/min. The determination of the concentration of PAHs is carried out by UV detection.
Monitoring locations	Sediments of the port waters
Approximate cost	Ultrasonic bath (1l): 420 € [3] Laboratory equipment: 300 € [4] Filtering system: 70 € [4] HPLC column and UV detection system: 4.200 € [5]
References	[1] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Polycyclic Aromatic Hydrocarbons (PAHs). Washington, Office of Solid Waste, 2008. [2] CHEN B., et al. Distributions of polycyclic aromatic hydrocarbons in surface waters, sediments and soils of Hangzhou City, China. Water Research. Vol. 38, 2004, p. 3558–3568. [3] GRANT INSTRUMENTS. XUBA Analogue Ultrasonic Baths. Cambridge, 2015. [http://www.grantinstruments.com/xuba-ultrasonic-bath/, 9th of March 2016] [4] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016] [5] LABX. HPLC Detectors Listings. 2016. [http://www.labx.com/hplc-detectors, 7th of March 2016]

Indicator's name	Solid content in water		
Category	Emissions to water	**Indicator's code**	G.8.1
Sub category	Discharges of particulate matter		
Definition	This indicator includes various parameters. On one hand, there are the dissolved solids (dissolved ions in water, mainly salts) and the suspended solids (floating particles that although they are not dissolved, due to their size and density, they are not deposited). The sum of these two parameters is known as Total Solids (TS) [1]. Moreover, the solid content also includes the sedimentable solids, which are those ones that are deposed [2].		
Importance	It is important to monitor the solid content in the water because the dissolved and suspended matter provides support for the growth of microbial compounds and the sedimentable solids can create mud on the seabed and generate odours [2].		

Units of measurement	• Sedimentable solid: mg of solid that rest at the bottom for one litre of sample (mg/l) • Suspended solids: mg of dry residue for one litre of sample (mg/l) • Dissolved solids: mg of dry residue for one litre of sample (mg/l) [1]
Description of the methodology	Below, various methods are presented for determining the solid content in a sample of water. **Equipment** • Laboratory material • Cone Imhoff • Vacuum filtration system • Stove **Sampling** • Use glass or polyethylene bottles • If the samples have to be stored before the analysis, they should be kept under 6ºC and for 24 hours maximum. • The sample should reach the ambient temperature before beginning the determination. **Determination of sedimentable solids: decantation with cone Imhoff [3]** 1. Fill the Imhoff cone with the sample 2. Let it rest for 1 hour. After 45 minutes, shake slightly the cone in order to allow to fall the sediments that may have been left on the walls of the cone. 3. Read the volume of the settled solids that is marked on the regulated scale at the bottom of the cone. **Determination of suspended solids through gravimetry [4]** 1. A vacuum filtration system is used with borosilicate fiberglass filters with pore diameter of 0.45 microns. 2. A known volume of the sample is filtered and the solid residue obtained is dried in the oven at 105 °C. 3. The result is expressed as the weighting of the dry solid residue, in mg/l. **Determination of the dissolved solids [1]** 1. The filtered product from the determination of the suspended solids is evaporated. 2. The residue obtained is dried. 3. The result is expressed as the weighting of the dry solid residue, in mg/l.
Detection limit	Suspended solids: 4 mg/l - 20 g/l Dissolved solids: 10 mg/l – 15.000 mg/g [2]
Limit values	Total suspended solids: 35 mg/l [5]
Monitoring locations	Port waters and salt marshes Sewage Water from treatment plants [4]
Approximate cost	Laboratory equipment: 300€ [6] Cone Imhoff: 30€ [7]

	Vacuum filtering equipment: 70€ [6] Stove: 1000€ [8]
References	[1] AZNAR, A. Determinación de los parámetros fisico-químicos de calidad de las aguas. Gestión Ambiental 2000. Vol. 2(23), 2000, pag. 12-19. [2] ASTM INTERNATIONAL. ASTM D5907 - 13. Standard Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water, West Conshohocken 2011. [http://www.astm.org/Standards/D5907.htm, 9th of March 2016] [3] HACH COMPANY. Method 8165. Solids, Settleable Matter Ref.: DOC316.53.01202. Düsseldorf, 2015. [4] AENOR. Calidad del agua. Medioambiente Tomo 1. AENOR, Madrid, 1997. [5] EUROPEAN COMMISSION (EC). Council Directive (91/271/EEC) of 21 May 1991 concerning urban waste water treatment. Brussels, Official Journal of the European Communities, 1991. [6] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th of March 2016] [7] SIGMA-ALDRICH. BRAND® Imhoff sedimentation cone, SAN. 2016. [http://www.sigmaaldrich.com/catalog/product/sigma/z336807?lang=es&region=ES&gclid=CJvSj_y_wcgCFckSwwodYC8Oxg, 8th of March 2016] [8] IBDCIENCIA. Estufa de desecación 40 L. 2015. [http://www.ibdciencia.com/estufa-u, 7th of March 2016]

Indicator's name	Turbidity (water transparency)		
Category	Emissions to water	**Indicator's code**	G.8.2
Sub category	Discharges of particulate matter		
Definition	Turbidity in liquids is caused by the presence of suspension matter (not dissolved), small solid particles that are invisible to the naked eye. Turbidity can be determined by measuring the attenuation of a beam of light through the sample [1]. Although turbidity and suspended solids of a water body are interrelated, there is not any correlation that links these two parameters.		
Importance	Turbidity is a parameter that can be measured *in situ* and it even may be monitored continuously. Additionally, although there is not any universal correlation, there may be local correlations that relate the turbidity and the level of suspended solids. In this case, benthic organisms may be affected.		
Units of measurement	• FNU (formazine nephelometric Units) • NTU (nephelometric turbidity units)		
Description of the methodology	Below, a method is presented that uses a transparency test disk, suitable for *in situ* measurements of turbidity [1]. **Equipment**		

	Disk for the test of transparency (e.g. Secchi disk), made of bronze and covered with white plastic, attached to a chain or a graduated rope. **Operating procedure:** 1. Immerse the disk, attached to the chain, in the water until it is practically not visible from above (see note). 2. Measure the length of the chain or rope that is immersed. 3. Repeat the test several times. **Results** The average measured depth is recorded. • For values of less than 1 m, the result is rounded to the nearest centimetre (e.g. 0.87 m.) • For values greater than 1 m, the result is rounded to 0,1m (e.g. 1,3m). There are more precise methods that use the attenuation of a beam of light through to measure the turbidity. The most common method is the use of a nephelometric, which provides the FNU or NTU units [1, 2].
Monitoring locations	Port waters Waste waters (nephelometric method) [2]
Approximate cost	Secchi disk: 50€
Notes	When using a test disk transparency, the readings should be done near the water surface. They cannot be made from a high place, for example, a bridge.
References	[1] AENOR. Calidad del agua. Medioambiente Tomo 1. AENOR, Madrid, 1997. [2] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Other Clean Water Act Test Methods: Microbiological, Washington, 2016. [http://www.epa.gov/cwa-methods/other-clean-water-act-test-methods-microbiological, 8th of March 2016]

Indicator's name	Electrical conductivity		
Category	Emissions to soil	**Indicator's code**	G.9.1
Sub category	Emissions to soil and groundwater		
Definition	The electrical conductivity of a soil is a measure of its ability to conduct the electric current through it [1].		
Importance	The conductivity of soil is a good indicator of the amount of nutrients and dissolved salts present in it. It also provides information on the type of soil (e.g. particle size and texture, porosity, water content) [2 and 3].		
Units of measurement	dS/m at 25 ºC (dS = deciSiemens) [1]		
Description of the methodology	Below, a procedure for measuring the electrical conductivity of a soil is presented [4]. **Equipment** • Conductivity meter and probe		

	• Bottles for sampling **Procedure** 1. Add 50 ml of deionized water into a soil sample of 10 g, previously dried. 2. Shake the suspension mechanically at 15 rpm for 1 hour to dissolve the soluble salts. 3. Calibrate the conductivity meter following the manufacturer's instructions, with a reference solution in a known conductivity of KCl of 1.413 dS/m at 25 °C, in order to obtain the cell constant. 4. Clean the probe carefully with deionized water and measure the conductivity of a solution of 0.01 KCl, at the same temperature as the soil suspension. 5. Clean the probe carefully and measure the conductivity of the suspension of the soil sample. **Calculations and results** If the conductivity meter does not incorporate a temperature compensator, the following calculations should be carried out: $$EC_{25}(dS/m) = \frac{S\ x\ 1.413}{K}$$ where: S: electrical conductivity of the suspension K: electrical conductivity of the solution 0.01 M KCl
Approximate cost	Conductivity meter: 300 - 1.500 € [5]
References	[1] MICROBIAL LIFE. Water and Soil Characterization - pH and Electrical Conductivity. Carlenton, 2014. [http://serc.carleton.edu/microbelife/research_methods/environ_sampling/pH_EC.html, 27th of March 2016] [2] AGRICULTURE SOLUTIONS. The why and how to testing the Electrical Conductivity of Soils. 2016. [https://www.agriculturesolutions.com/resources/92-the-why-and-how-to-testing-the-electrical-conductivity-of-soils, 27th March 2016] [3] VIRIGINIA STATE UNIVERSITY. Precision Farming Tools: Soil Electrical Conductivity. Richmond, Virginia Cooperative Extension, 2009. [4] NSW GOVERNMENT. Soil survey standard test method. Electrical conductivity. Sidney, Department of Suitable Natural Resources. [5] GRAINGER. Conductivity Meters. 2016. [http://www.grainger.com/category/conductivity-meters/water-testing-equipment-and-meters/lab-supplies/ecatalog/N-kva, 8th of March 2016]

Indicator's name	Soil pH		
Category	Emissions to soil	**Indicator's code**	G.9.2

Sub category	Emissions to soil and groundwater
Definition	Soil pH is a quantitative measure of the acidity or basicity of the soil. It is defined as the negative logarithmic value of the Hydrogen ion (H^+) concentration. The pH is determined using a scale from 0 to 14, where a pH lower than 7 indicates that the substance is acidic, a pH higher indicates that it is basic, and a pH equal to 7 indicates that it is neutral.
Importance	pH develops a decisive influence on the chemical and biological processes that occur in nature, such as the chemical structure of the pollutants. It affects the vital functions of any living organism, from bacteria to human beings.
Units of measurement	Logarithmic scale: 0 (acidic) to 14 (basic); 7 (neutral)
Description of the methodology	Below, a procedure to measure the soil pH using a glass electrode [2] is presented. The soil sample is mixed with deionized water in order to carry out this method. **Equipment** • pH meter • Temperature probe (if the pH meter has no temperature compensation) • Container of 50 ml • Analytical scale (0.1 g sensitivity) **Calibration** Before measuring the pH of the samples, the device should be calibrated at two points in a pH range comprising the expected value of the samples to be analysed. **Sample preparation and reading** 1. 20 g of the sample are weighed and they are added to the 50 ml container. 2. 20 ml of deionized water are added, it is covered and stirred for 5 min. 3. The solution is let stand for 1 hour, in order to allow the non-dissolved suspended particles to settle down. To speed up the procedure, it is also possible to filter or centrifuge the suspension. 4. The pH probe is immersed into the solution. A proper contact between the electrode and the water should be ensured. The contact with the deposited particles from the bottom of the container should be avoided. 5. The probe should be cleaned with distilled water after each reading.
Approximate cost	pH meter: 330 € [3]
References	[1] MICROBIAL LIFE. *Water and Soil Characterization - pH and Electrical Conductivity*. Carlenton, 2014. [http://serc.carleton.edu/microbelife/research_methods/environ_sampling/pH_EC.html, 27th March 2016]. [2] UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. *Method 9045D. Soil and Waste pH*. Washington, 2004. [3] HACH LANGE. *HQ40d Portable pH, Conductivity, Dissolved Oxygen, ORP, and ISE Multi-Parameter Meter*. Loveland, 2015. [http://www.hach.com/hq40d-portable-ph-conductivity-dissolved-oxygen-orp-and-ise-multi-parameter-meter/product?id=7640501639, 8th of March 2016]

Indicator's name	Macronutrients		
Category	Emissions to soil	**Indicator's code**	G.9.3
Sub category	Emissions to soil and groundwater		
Definition	Macronutrients are nutrients that are required in greater quantities, which are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S), magnesium (Mg). They are essential elements that plants need for a proper growth and development. Synthetic fertilizers (that contain these elements) are used in agriculture in order to achieve high levels of production.		
Importance	An overuse of fertilizers implies an accumulation of inorganic substances in soil [1]. Excessive nutrients can cause adverse effects on plant growth and increase the potential for environmental contamination due to leaching. In particular, above optimum nitrogen and phosphorus levels can lead to excessive plant and algal growth in waterways that can degrade drinking water, fisheries, and recreational areas. High potassium can lead to an imbalance of base saturation levels as well as high soluble salts. High calcium and magnesium levels are commonly associated with pH values above 7.0 [2].		
Units of measurement	Milligrams of nitrogen per kilogram of sample (mg/kg) Milligrams of phosphorus per kilogram of sample (mg/kg)		
Description of the methodology	Below, two standard methods are presented for determining total nitrogen and total phosphorus in soil samples, which are the two most relevant macronutrients and have major adverse effects. A) The first method is from the ISO 13878 [3], which uses the technique of dry combustion to determine the total amount of elemental nitrogen in soil and sediment samples. The method is based on the combustion of the sample at 900ºC, to reduce all the nitrogen to elemental gas (N_2). This gas is injected into a stream of helium and the concentration is measured through its electrical conductance [4]. B) The second method is from the ISO 11263 [5]. This standard describes a method for extracting the phosphorus from soil or sediment, using digestion with a solution of 0.5 M sodium bicarbonate at a pH of 8.5. Then, the concentration of phosphorus is measured and quantified with a spectrophotometer [4].		
References	[1] MONTANA STATE UNIVERSITY BOZEMAN. Analytical Methods. Ecosystem restoration, EUA, 2004. [http://ecorestoration.montana.edu/mineland/guide/analytical/chemical/solids/macronutrients.htm, 20th March 2016] [2] Over-Fertilization of Soils: Its Causes, Effects and Remediation 2016. [https://soiltest.umass.edu/fact-sheets/over-fertilization-soils-its-causes-effects-and-remediation, 20th March 2016] [3] ISO. ISO 13878:1998. Soil quality -- Determination of total nitrogen content by dry combustion ("elemental analysis"). Geneva, 2015.		

	[http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=23117, 27th March 2016] [4] JANSEN E. Determination of total Phosphorus, total Nitrogen and Nitrogen Fractions. Horizontal, 2016. [5] ISO. ISO 11263:1994. Soil quality -- Determination of phosphorus -- Spectrometric determination of phosphorus soluble in sodium hydrogen carbonate solution. Geneva, 2016. [http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=19241, 27th March 2016]

Indicator's name	Total Organic Carbon		
Category	Emissions to soil	**Indicator's code**	G.9.4
Sub category	Emissions to soil and groundwater		
Definition	This indicator indicates the total amount of organic carbon present in a soil sample, which can be an indicator the organic pollution. The soil organic matter includes all forms of life existing in the soil and the remains of living organisms that are in various states of decomposition.		
Importance	The soil organic matter has influence on many physical, chemical and biological properties of the soil. Some of these properties are related with the organic pollutants that are distributed in the soil and its activity [2]. For example, if there is a high level of organic matter, the organic pollutants tend to be trapped in the soil for a longer period of time.		
Units of measurement	Milligrams of carbon per kilogram of the sample (mg/kg)		
Description of the methodology	Below, a procedure is presented for calculating the organic matter content in a soil, based on the mass loss of the sample by ignition [3]. **Equipment** • Oven capable of reaching 650 ºC • Crucibles (pots that resist high temperatures) • Precision scale (0,001g sensitivity) **Procedure** 1. Weight 10 g of soil sample, previously dried, and place them in a crucible, previously calibrated. 2. Dry for 2 hours at 105 °C. 3. Annotate the mass with an accuracy of 0.001 g. 4. Place the crucible in an oven at 360 °C for 2 hours. 5. Cool to 150 ºC. 6. Weight again the crucible. **Calculations and determining the amount of organic matter** The mass loss by ignition is calculated from the following expression: $$Mass\ loss\ (\%) = \frac{Mass\ at\ 105\ ºC\ - Mass\ at\ 360ºC}{Mass\ at\ 105\ ºC} x100$$ In order to estimate the organic matter, a regression analysis is carried out. Additional samples of soil containing more and less organic matter than the analysed one are selected. The amount of organic matter is determined by the Walkley-Black method (see [3]) and by the mass loss by ignition. The regression line is calculated and the amount of organic matter in the sample is determined by interpolation.		
Approximate cost	Oven: 1.300 € [4] Crucibles: 52 € [5] Laboratory material: 300 € [6]		

References	[1] TASMANIAN GOVERNMENT. AGRICULTURE. *Soil Organic Matter*. Tasmania, 2014. [http://dpipwe.tas.gov.au/agriculture/land-management-soils/soil-management/soil-organic-matter, 27th of March 2016]. [2] AGVISE. *Soil Organic Matter (A choice of methods)*. Northwood ND, 2014. [http://www.agvise.com/educational-articles/soil-organic-matter-a-choice-of-methods/, 27th March 2016] [3] UNIVERSITY OF DELAWARE. *Recommended Soil Testing Procedures for the Northeastern United States*. Dover, The Northeast Coordinating Committee for Soil Testing, 2011. [4] DIRECT INDUSTRY. *Carbolite®.* 2016. [http://www.directindustry.com/prod/carbolite/product-28278-169498.html, 27th March 2016] [5] SIGMA-ALDRICH. Coors™ high alumina combustion boat. 2016. [https://www.sigmaaldrich.com/catalog/product/aldrich/z561754?lang=es&region=ES, 27th March 2016] [6] IBDCIENCIA. *Instrumentos y utensilios de laboratorio.* 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016]

Indicator's name	Total port area with soil pollution		
Category	Emissions to soil	**Indicator's code**	G.9.5
Sub category	Emissions to soil and groundwater		
Definition	This indicator monitors the total number of locations, within the port area, that present soil pollution. A contaminated soil is that one that its characteristics have been altered negatively by the presence of hazardous chemical components [1]. Some of the major pollutants that can affect soil are [2]: • Heavy metals: lead, copper, chromium, nickel, cadmium, zinc and mercury • Aromatic hydrocarbons: benzene, toluene, ethylbenzene or phenols • Chlorinated solvents: chloromethanes, chloroethanes, chlorobenzenes or chlorophenols • Polycyclic Aromatic Hydrocarbons (PAHs) • Polychlorinated biphenyls (PCBs) • Pesticides: organochlorines, triazines or N-methylcarbamates. • Other compounds such as cyanide, thiocyanate, styrene, or phthalates.		
Importance	A large number of organic substances (such as benzene, dioxins, PCBs or PAHs) contribute to pollute the soil. These substances are harmful to living organisms and to human health. Moreover, many metals, present in soil in high concentrations, are toxic to wildlife and can enter the food chain, affecting humans. Additionally, soil pollution is not only an environmental and public health problem, but it also has an adverse effect on the economy, representing a negative impact due to its loss of productivity [3].		
Units of measurement	Number of locations with soil pollution		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] GOVIERNO DE ESPAÑA. Guía Técnica de aplicación del RD 9/2005, de 14 de enero, por el que se establece la relación de actividades potencialmente contaminantes del suelo y los criterios y estándares para la declaración de suelos contaminados. Madrid, Ministerio del Medio Ambiente, 2007.		

	[2] UNIVERSITAT POLITÈCNICA DE CATALUNYA. Tecnologia del Medi Ambient. Llibre de transperències. Barcelona, Departament d'Enginyeria Química de l'Escola Tècnica d'Enginyeria Industrial de Barcelona, 2014. [3] BINI C. From soil contamination to land restoration. Venice, Università Ca' Foscari di Venezia, 2009.

Indicator's name	Heavy metals		
Category	Emissions to soil	**Indicator's code**	G.9.6
Sub category	Emissions to soil and groundwater		
Definition	This indicator includes most of the metals with atomic number greater than 20, excluding the alkali metals (e.g. rubidium, cesium), the alkaline earth (e.g. calcium, strontium) and the lanthanides and actinic. The metals are introduced into the soil as a result of various human activities, such as mining, metals processing and their use, or agriculture. The most common contaminants are cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb) and mercury (Hg) [1].		
Importance	The main adverse effects of heavy metals have been extensively studied. For instance, the exposure to low concentrations of cadmium affect the kidney and weaken the bones; or the exposure to lead is especially harmful to children, which has neurotoxic effects even at low concentrations [2].		
Units of measurement	Micrograms of metal pollutant per gram of sample (μg/g)		
Description of the methodology	Below, a method is presented for determining the concentration of heavy metals in soil, using Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES) [3]. This method allows to determine the concentration of zinc (Zn), cadmium (Cd), lead (Pb), nickel (Ni), chromium (Cr) and copper (Cu) [3]. **Equipment** • Precision scale • PFA containers (perfluoroalkoxy polymer) • Laboratory equipment • Microwave • Pressurized buckets for microwave • Spectrometer ICP-AES (e.g. Jobin-Yvon Spectrometer [4]) **Sampling** • A sample is extracted. • In the laboratory, the sample is dried at 105 °C for 3 hours. **Sample preparation** 1. 0.2 g of the sample are weighed in a container of PFA and they are placed in a pressurized bucket for a microwave. 2. 4 ml of concentrated nitric acid and 0.5 ml of concentrated hydrofluoric acid are added. 3. The sample is digested applying microwave for 40 minutes. 4. Once the sample is back to room temperature, it is diluted to 100 ml with deionized water. **Analysis** The sample is analysed with Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES).		
Monitoring locations	Polluted soils		
Approximate cost	Balance precision: 500 - 2.000 € [5] PFA containers: 20 - 50 € [6] Laboratory equipment: 300 € [7] Microwave and pressurized buckets: 5.400 € [8] Spectrometer ICP-AES: 30.000 € [4]		

Notes	The method presented in this guideline is the same as the method presented in the G.7.4 for the determination of heavy metals in sediments.
References	[1] LENNTECH. WATER TREATMENT SOLUTIONS. Metals in aquatic freshwater. Delft, 2016. [http://www.lenntech.com/aquatic/metals.htm, 8th March2016] [2] JARÜP L. Hazards of heavy metal contamination. British Medical Bulletin. Vol. 68(1), 2003, p. 167-182. [3] MOOR C., LYMBEROPOULOU T., DIETRICH V.J. Determination of Heavy Metals in Soils, Sediments and Geological Materials by ICP-AES and ICP-MS. Mikrochim. Acta. Vol. 136, 2001, p. 123-128. [4] HORIBA SCIENTIFIC. ICP-OES Spectrometers - A Platform for the Future. Kyoto, 2016. [http://www.horiba.com/us/en/scientific/products/atomic-emission-spectroscopy/icp-oes-spectrometer/, 27th March 2016] [5] STARTORIUS. Balanzas de precisión. Madrid, 2015. [https://www.sartorius.es/es/productos/laboratorio/balanzas-de-laboratorio/balanzas-de-precision/, 27th March 2016] [6] SAVILLEX. Containers/Trays. Eden Prairie, MN, 2013. [http://www.savillex.com/CategoryDetail.aspx?CategoryName =Containers-and-Trays, 27th March 2016] [7] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016] [8] CEM. MARS Microwave system. Matthews, 2015. [http://cem.com/content-cat662.html, 6th March 2016]

Indicator's name	Redox potential		
Category	Emissions to soil	**Indicator's code**	G.9.7
Sub category	Emissions to soil and groundwater		
Definition	The redox potential is a parameter that represents the sum of the oxidation and reduction reactions that occur in the sediments sample. The presence of oxidizing agents, such as oxygen, increases the potential; however, the presence of reducing agents, such as Biological Oxygen Demand (BOD), diminish the value of the potential. It is not an indicator specific for a single element or specie, but it may be related to the species and processes that are taking place in the soil sample [1].		
Importance	The redox potential is particularly useful to monitor and explain complex processes and reactions that take place in contaminated soil areas that are being recovered by means of biological degradation of the contaminants [2].		
Units of measurement	Millivolts [1] (mV)		
Description of the methodology	Below, a procedure is presented in order to carry out the measurement of redox potential *in situ* in a sample of soil. **Material** • Microelectrode to measure the redox potential in soils [2]. **Calibration** • To calibrate the platinum electrodes, they must be submerged in a solution of 4 M KCl, at least 24 hours prior to the calibration.		

	• Calibration techniques are specific to each type of electrode. For specific information, you can consult the reference [2]. **Sampling and procedure** • The microelectrodes allow the measurement of redox potential in situ [2]. • The probe is inserted into the soil to make a direct reading. • The probe is stabilized for one minute before recording the measure.
References	[1] NEIWPCC. Oxidation-Reduction Potential and Wastewater Treatment. Connecticut, 2008. [http://www.neiwpcc.org/iwr/reductionpotential.asp] 8th March 2016. [2] JANG A., et al. Miniaturized Redox Potential Probe for In Situ Environmental Monitoring. Environ. Sci. Technol. Vol. 39, 2005, p. 6191-6197.

Indicator's name	Total annual water consumption		
Category	Resource consumption indicators	**Indicator's code**	G.10.1
Sub category	Water consumption		
Definition	This indicator expresses the total annual volume of water consumed by the port authority.		
Importance	Water is essential for life on Earth and for the development of the human activities. Although it is a renewable source, fresh water available for human consumption only accounts for 0.15% of the total fresh water [1] and, therefore, it is a scarce resource. It should be added to this fact that its distribution is unequal to the different regions of the world and, in general, there is an excessive use of water.		
Units of measurement	The water consumption is expressed as m^3/year. It may also be expressed as a relative value, by dividing the consumption by: • the number of port authority employees (m^3 / number of employees · year) • the total annual cargo handled (m^3 / tonnes· year)		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] UNIVERSITAT POLITÈCNICA DE CATALUNYA. *Tecnologia del Medi Ambient. Llibre de transperències*. Barcelona, Departament d'Enginyeria Química de l'Escola Tècnica d'Enginyeria Industrial de Barcelona, 2014.		

Indicator's name	Annual amount of recovered rainwater		
Category	Resource consumption indicators	**Indicator's code**	G.10.2
Sub category	Water consumption		
Definition	This indicator indicates the amount of rainwater recovered in the port area. Rainwater is captured on the roofs of the buildings of the port authority and it is stored [1]. Rainwater can be used in various applications, being the most common: • Irrigation of green areas • Cleaning of public areas • Cleaning of port authority buildings • Water tanks		

Importance	The rainwater that is collected, filtered and stored properly represent an alternative source of water that may replace drinking water in certain applications which do not harm human health. As a result, it contributes to save this natural resource [1].
Units of measurement	Cubic metres per year (m^3/year)
Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	1] AQUA ESPAÑA. *Guía Técnica de aprovechamiento de aguas pluviales en edificios*. Barcelona, Grupo de Trabajo de Gestión y Aprovechamiento de aguas pluviales, 2015.

Indicator's name	Percentage of the annual variation in the water consumption		
Category	Resource consumption indicators	**Indicator's code**	G.10.3
Sub category	Water consumption		
Definition	This indicator expresses the annual change in the total water consumption of the port authority. In order to calculate this parameter, the values of annual water consumption (see G.10.1 for more information) of the current and the previous years are required. To carry out the calculation, the following formula may be used: $$Annual\ variation\ (\%) = \frac{Current\ year - previous\ year}{Previous\ year\ consumption} \cdot 100$$ A positive percentage means an increase in the energy consumption, and a negative percentage a reduction in the consumption.		
Importance	Knowing the variation in the water consumption between one year and the previous one is useful to establish objectives of reduction and to check their achievement.		
Units of measurement	Percentage of variation		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

Indicator's name	Percentage of water recycled per total water consumption		
Category	Resource consumption indicators	**Indicator's code**	G.10.4
Sub category	Water consumption		
Definition	Recycled waters are those grey waters (e.g. from showers or bathroom sinks) that are treated by two simple treatments: solid particle filtration and disinfection with hypochlorite in the installation itself [1]. Reused waters can be used in various applications, being the most common: • Irrigation of green areas • Cleaning of public areas • Cleaning of port authority buildings • Toilet tanks		
Importance	Recycled waters represent an alternative source of water that may replace drinking water in certain applications. As a result, it contributes to save this natural resource [1].		
Units of measurement	Percentage of recycled water		

Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	[1] J. RODRÍGUEZ. *Reutilizar el agua*. Segòvia, Centro Nacional de Educación Ambiental (CENEAM), 2006.

Indicator's name	Total annual electricity consumption		
Category	Resource consumption indicators	**Indicator's code**	G.11.1
Sub category	Electricity consumption		
Definition	This indicator expresses the total annual electrical energy consumption, consumed by the port authority.		
Importance	The production of electricity still depends heavily on fossil fuels (coal, oil and natural gas). Their consumption contributes to the global warming. Additionally, the production of electricity has other significant environmental impacts. On one hand, the use of coal in power plants to generate electricity involves the release of toxic substances that cause acid rain, damaging and destroying forests and other ecosystems. On the other hand, the use of radioactive nuclei in nuclear power plants for obtaining electricity generate radioactive waste, which pose a constant threat to the environment due to the current incapacity to eliminate them [1].		
Units of measurement	The electricity consumption is expressed in MWh/year. It may also be expressed as a relative value, by dividing the consumption by: • the number of port authority employees (MWh/number of employees · year) • the total annual cargo handled (MWh/tonnes· year)		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] INSTITUTO SINDICAL DE TRABAJO, AMBIENTE Y SALUD (ISTAS). Problema ambiental del consumo de energía. València, 2016. [http://www.istas.net/web/index.asp?idpagina=2207, 20th March 2016]		

Indicator's name	Annual number of vessels connected to shore-side electricity		
Category	Resource consumption indicators	**Indicator's code**	G.11.2
Sub category	Electricity consumption		
Definition	On-shore Power Supply (OPS), consists in connecting the vessels to the electricity grid during their stay in port. This indicator reports the number of vessels that have connected to shore-side electricity in one year.		

Importance	Ships require electricity when they are berthed to support activities like loading, unloading, heating, lighting and other on-board activities. Today, this power is generally provided by auxiliary engines that emit carbon dioxide (CO_2), air pollutants and noise, affecting local air quality and ultimately the health of both port workers and nearby residents [1]. As an alternative to reduce these emissions, vessels can be connected to the local electricity grid, in what is known as Onshore Power Supply (OPS). In this way, ships' operations can proceed uninterrupted and the negative environmental effects, such as noise and air pollution are reduced, since the ships' auxiliary engines can be switched off [1].
Units of measurement	The common way to report this indicator is the following one: • Number of vessels that used the On-shore Power Supply in a year (number of vessels /year). Another way to express the OPS performance in a port is the following one: • Percentage of vessels calling at the port that connect to shore-side electricity: $\% \, OPS = \frac{Number\ of\ vessels\ that\ used\ OPS}{Total\ number\ of\ vessels} x100$
Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	[1] WPCI. 2015. What is OPS? [Online]. Available at: http://www.ops.wpci.nl/what-is-ops-/what-is-ops--1/

Indicator's name	Total annual fuel consumption		
Category	Resource consumption indicators	**Indicator's code**	G.12.1
Sub category	Fuel consumption		
Definition	This indicator shows the amount and type of fuel consumed by the port authority. The main types of fuel consumed are [1, 2]: • Diesel A (for land vehicles) • Diesel B (for heating and vessels) • Gasoline (for land vehicles) • Natural Gas (for heating and other applications) • LPG (Liquefied Petroleum Gas) (for vessels) • Fuel-oil • Other renewable sources (e.g. biomass)		
Importance	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 [3], 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 [4]. The consumption of fossil fuels also contributes to the exhaustion of non-renewable resources.		
Units of measurement	The units of the fuel consumption are expressed in litres (if they are liquid), in m^3 (if they are gas) or in tons (if they are solid). In addition, they are also reported in MWh, in order to compare them and to obtain each percentage (see Notes for the change of units).		

Source	Consumption (litres/kg/m^3)	Consumption (MWh)	%
Diesel A			
Diesel B			
Gasoline			
Natural Gas			
LPG			
Fuel-oil			
Other renewable sources			

	Total | | | **100%** It also may be expressed as a relative value, by dividing the consumption by: • the number of port authority employees (m^3/number of employees · year) • the total annual cargo handled (m^3/tonnes· year).
Frequency	Annually
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research to be obtained.
Notes	To convert the liquid fuels from m^3 to MWh, the following expression is used: $$consumption\ [MWh] = Consumption\ [l] \cdot \rho_{comb.} \left[{}^{kg}/_{l}\right] \cdot LCV_{comb.} \left[{}^{MWh}/_{kg}\right]$$ where: ρcomb is the density of the combustible LCV_{comb} is the Lower Calorific Value (LCV), which is the heat that the fuel releases and may be consulted in the reference [5]. To convert solid fuels, it is not required to multiply by the density. In the case of gaseous fuels the LCV is expressed as MWh / m^3.
References	[1] PORT DE BARCELONA. Declaración Ambiental de la Autoridad Portuaria de Barcelona. Barcelona, Autoritat Portuaria de Barcelona, 2014. [2] VALENCIAPORT. Memoria Ambiental 2013. València, Autoridad Portuaria de Valencia, 2014. [3] Kiehl, J.T., and Trenberth, K. 1997. Earth's Annual Global Mean Energy Budget. Bulletin of the American Meteorological Society 78 (2), pp. 197 – 208. [4] Twerefou, D. K. 2009. Mineral Exploitation, Environmental Sustainability and Sustainable Development in EAC, SADC and ECOWAS Regions. African Trade Policy Centre. Economic Commission for Africa. [5] INSTITUTO PARA LA DIVERSIFICACIÓN Y AHORRO DE ENERGÍA (IDAE). *Poderes Caloríficos*. Madrid, 2015. [http://www.idae.es/, 20 de marҫ de 2016]

Indicator's name	Amount of port recyclable garbage collected by type		
Category	Waste production indicators	**Indicator's code**	G.13.1
Sub category	Generation of recyclable garbage		
Definition	This indicator reports the amount of recyclable garbage collected in the port area in a year. The most common recyclable garbage are: • Packaging • Cardboard • Glass • Organic matter		
Importance	Recyclable garbage may create negative impacts on the environment, affecting the groundwater, air, soil, or generating simply an aesthetic impact [1]. Monitoring the amount of each type of waste collected is useful to monitor the efficiency of collection systems in the port.		
Units of measurement	This indicator may be expressed as the amount (tonnes/year) of each type of recyclable garbage collected. In addition, the percentage (contribution to the total) of each type of waste may be also calculated.		

Recyclable garbage	Amount (t/year)	% of the total
Packaging		
Cardboard		
Glass		
Organic matter		
Total recyclable garbage collected		**100 %**

Frequency	Annually
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research to be obtained.
References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva.

<table>
<tr><th>Indicator’s name</th><td colspan="3">Amount of port recyclable garbage recycled by type</td></tr>
<tr><th>Category</th><td>Waste production indicators</td><th>Indicator’s code</th><td>G.13.2</td></tr>
<tr><th>Sub category</th><td colspan="3">Generation of recyclable garbage</td></tr>
<tr><th>Definition</th><td colspan="3">This indicator reports the amount of recyclable garbage that have been recycled in the port area in a year. The most common recyclable garbage are:
Packaging
Cardboard
Glass
Organic matter</td></tr>
<tr><th>Importance</th><td colspan="3">The recycling of waste is a very important solution in order to prevent the high impact that they have on the environment (e.g. emissions of toxic substances or greenhouse gases to the environment). Additionally, producing goods from recycled materials reduces the amount of raw materials and the energy required in industry for the production of products. Therefore, all this contributes to preserve the natural resources.</td></tr>
<tr><th>Units of measurement</th><td colspan="3">This indicator may be expressed as the amount (tonnes/year) of each type of recyclable garbage recycled. In addition, the percentage (contribution to the total) of each type of waste may be also calculated.<table><tr><th>Recyclable garbage</th><th>Amount (t/year)</th><th>% of the total</th></tr><tr><td>Packaging</td><td></td><td></td></tr><tr><td>Cardboard</td><td></td><td></td></tr><tr><td>Glass</td><td></td><td></td></tr><tr><td>Organic matter</td><td></td><td></td></tr><tr><td>Total recyclable garbage recycled</td><td></td><td>100 %</td></tr></table></td></tr>
<tr><th>Frequency</th><td colspan="3">Annually</td></tr>
<tr><th>Level of effort</th><td colspan="3">High level: the information required by the indicator is specific and it may require a deep research to be obtained.</td></tr>
</table>

<table>
<tr><th>Indicator’s name</th><td colspan="3">Amount of port hazardous waste collected by type</td></tr>
<tr><th>Category</th><td>Waste production indicators</td><th>Indicator’s code</th><td>G.14.1</td></tr>
<tr><th>Sub category</th><td colspan="3">Generation of hazardous waste</td></tr>
<tr><th>Definition</th><td colspan="3">This indicator monitors the amount of hazardous waste that are collected annually in the port area, classified by type of waste. The classification between hazardous and non-hazardous waste is based on the classification and labelling of hazardous substances, regulated in Annex III of Directive 2008/98/EC [1]. In addition, Decision 2000/523/EC [2] establishes a list of hazardous pollutants [3]. Typical examples of hazardous waste that may be generated in ports include ink cartridges, used oil, fluorescents, aerosols, automotive filters, waste, electrical and electronic equipment, and batteries</td></tr>
<tr><th>Importance</th><td colspan="3">Hazardous wastes imply a greater risk to the environment and to human health compared with recyclable garbage. Therefore, a tighter control on these types of waste is required [3]. Monitoring the hazardous waste collected regularly in the port area helps to apply a more strict control and to improve their management, avoiding risky situations and accidents.</td></tr>
</table>

<table>
<tr><td>Units of measurement</td><td>This indicator may be expressed as the amount (tonnes/year) of each type of hazardous waste collected. In addition, the percentage (contribution to the total) of each type of waste may be also calculated.
<table>
<tr><th>Hazardous waste</th><th>Amount (t/year)</th><th>% of the total</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Total hazardous waste collected</td><td></td><td>100 %</td></tr>
</table></td></tr>
<tr><td>Frequency</td><td>Annually</td></tr>
<tr><td>Level of effort</td><td>High level: the information required by the indicator is specific and it may require a deep research</td></tr>
<tr><td>References</td><td>[1] EUROPEAN COMMISSION (EC). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. Brussels, Official Journal of the European Union, 2008.
[2] EUROPEAN COMMISSION (EC). Comission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste. Brussels, Official Journal of the European Union, 2000.
[3] EUROPEAN COMMISSION (EC). Hazardous Waste. Brusel·les, 2016. [http://ec.europa.eu/environment/waste/hazardous_index.htm, 20 de març de 2016]</td></tr>
</table>

<table>
<tr><td>Indicator's name</td><td colspan="3">Amount of port hazardous waste recycled by type</td></tr>
<tr><td>Category</td><td>Waste production indicators</td><td>Indicator's code</td><td>G.14.2</td></tr>
<tr><td>Sub category</td><td colspan="3">Generation of hazardous waste</td></tr>
<tr><td>Definition</td><td colspan="3">This indicator monitors the amount of hazardous waste that are recycled annually in the port area, classified by type of waste. The classification between hazardous and non-hazardous waste is based on the classification and labelling of hazardous substances, regulated in Annex III of Directive 2008/98/EC [1]. In addition, Decision 2000/523/EC [2] establishes a list of hazardous pollutants [3]. Typical examples of hazardous waste that may be generated in ports include ink cartridges, used oil, fluorescents, aerosols, automotive filters, waste, electrical and electronic equipment, and batteries.</td></tr>
<tr><td>Importance</td><td colspan="3">Hazardous wastes imply a greater risk to the environment and to human health compared with recyclable garbage. Therefore, a tighter control on these types of waste is required [3]. Monitoring the hazardous waste recycled can assist in setting objectives and in checking their compliance.</td></tr>
<tr><td>Units of measurement</td><td colspan="3">This indicator may be expressed as the amount (tonnes/year) of each type of hazardous waste recycled. In addition, the percentage (contribution to the total) of each type of waste may be also calculated.
<table>
<tr><th>Hazardous waste</th><th>Amount (t/year)</th><th>% of the total</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Total hazardous waste recycled</td><td></td><td>100 %</td></tr>
</table></td></tr>
<tr><td>Frequency</td><td colspan="3">Annually</td></tr>
</table>

Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research
References	[1] EUROPEAN COMMISSION (EC). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. Brussels, Official Journal of the European Union, 2008. [2] EUROPEAN COMMISSION (EC). *Comission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste*. Brussels, Official Journal of the European Union, 2000. [3] EUROPEAN COMMISSION (EC). *Hazardous Waste*. Brusel·les, 2016. [http://ec.europa.eu/environment/waste/hazardous_index.htm, 20th March 2016]

Indicator's name	Amount of port non-hazardous waste collected by type		
Category	Waste production indicators	**Indicator's code**	G.15.1
Sub category	Generation of non-hazardous waste		
Definition	This indicator monitors the amount of other solid waste (non-hazardous waste) that are collected in the port area, classified by type of waste. Examples of non-hazardous waste are metals, wood, rubble or gravel.		
Importance	Non-hazardous waste may create negative impacts on the environment, affecting the groundwater, air, soil, or generating simply an aesthetic impact [1]. Monitoring the amount of each type of waste collected is useful to monitor the efficiency of collection systems in the port.		
Units of measurement	This indicator may be expressed as the amount (tonnes/year) of each type of non-hazardous waste collected. In addition, the percentage (contribution to the total) of each type of waste may be also calculated.		
Frequency	Annually		
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research		
References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva.		

Non-hazardous waste	**Amount (t/year)**	**% of the total**
Total non-hazardous waste collected		**100 %**

Indicator's name	Amount of port non-hazardous waste recycled by type		
Category	Waste production indicators	**Indicator's code**	G.15.2
Sub category	Generation of non-hazardous waste		
Definition	This indicator monitors the amount of other solid waste (non-hazardous and non-recyclable garbage) that are recycled in the port area, classified by type of waste. The type of industrial waste generated in each port depends on the type of industries located in the port area. Examples of non-hazardous waste are metals, wood, rubble or gravel.		

Importance	Industries generate lots of wastes, being most of them recyclable. Producing goods from recycled materials reduces the amount of raw materials and the energy required in industry for the production of products. Therefore, all this contributes to preserve the natural resources.
Units of measurement	This indicator may be expressed as the amount (tonnes/year) of each type of non-hazardous waste recycled. In addition, the percentage (contribution to the total) of each type of waste may be also calculated.
Frequency	Annually
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research

Non-hazardous waste	Amount (t/year)	% of the total
Total non-hazardous waste recycled		**100 %**

Indicator's name	Noise levels in housing area around the port		
Category	Noise indicators	**Indicator's code**	G.16.1
Sub category	Noise emissions		
Definition	Noise is often defined as 'unwanted sound'. This indicator monitors the levels of noise that are recorded in the housing area around the port. The inhabitants of residential areas close to ports can be affected by noise pollution caused by port activities. These activities (and the associated noise emissions) normally are be carried out 24 hours a day, 7 days a week.		
Importance	It is important to monitor the noise levels in the port area because they can affect the quality of life and the health of the neighbouring population. Specifically, the World Health Organization (WHO) warns that excessive levels of noise can seriously damage the human health and can interfere with the daily activities of the population. Additionally, they can cause sleep disorders, cardiovascular effects, reduced performance and change in the social behaviour of people [2].		
Units of measurement	Intermediate level of annual noise: dB (A), applying the A-weighted decibels (See Notes).		
Description of the methodology	The measurement of noise levels can be realised according to the international standards, such as the ISO 1996-2:2007 [3]. This standard describes how the sound levels may be measured from direct measurement, by extrapolating the results of the direct measurements, or by theoretical calculations to assess environmental noise. When the noise levels are measured from direct measurement, sound level measuring devices are used. These devices must comply with the international standard IEC: 62672 to ensure that they meet all specifications and tolerance levels and that their reading is reliable [4]. A device suitable for measuring noise levels at the port area is the equipment *Pulsar Nova Range* [5] from the manufacturer Pulsar Instruments Plc.		
Limit values	The noise limits are regulated in a national level. In Spain, for instance, they are described in the RD 1367/2007 [6]. The average annual noise limits applicable in port areas are shown in the following table:		
Approximate cost	Device for measuring the noise level: 50€ [5]		

Noise	Interval time	Limit value (db(A))
L_{day}	7:00h a 19:00h	65
$L_{evening}$	19:00h a 23:00h	65
L_{night}	23:00h a 7:00h	55

Notes	The auditory sense of human beings responds well in a range of sound frequencies between 500 Hz and 8000 Hz, and it is less sensitive to grave or high-pitched noises. The frequency weightings (used in sound measuring devices) are used to adapt the measurement of the devices to what actually perceives the human ear. The A-weighted decibels is the most common one and it is used to the average levels of noise. Other existing weightings are C and Z [7].
References	[1] PORT METRO VANCOUVER. Noise monitoring. Vancouver, 2016. [http://www.portmetrovancouver.com/port-dashboard/noise-monitoring/, 25th March 2016] [2] WORLD HEALTH ORGANIZATION (WHO). Noise. Copenhagen, 2016. [http://www.euro.who.int/en/health-topics/environment-and-health/noise/noise, 25th March 2016] [3] INTERNATIONAL ORGANIZATION FOR STADARDIZATION (ISO). ISO 1996-2:2007. Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels. Geneva, 2016. [http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm? csnumber=41860, 25th March 2016] [4] INTER NOISE 2008. New IEC Standards and Periodic Testing of Sound Level Meters. Lindfield (Australia), National Measurement Institute, 2008. [5] PULSAR INSTRUMENTS. Pulsar Nova Range. Scarborough, 2016. [http://pulsarinstruments.com/range-product/the-nova-range/, 25th March 2016] [6] BOLETÍN OFICIAL DEL ESTADO. REAL DECRETO 1367/2007, de 19 de octubre, por el que se desarrolla la Ley 37/2003, de 17 de noviembre, del Ruido, en lo referente a zonificación acústica, objetivos de calidad y emisiones acústicas. Madrid, Ministerio de la Presidencia, 2007 [7] NOISE METERS INC. Frequency Weightings - A-Weighted, C-Weighted or Z-Weighted. Berkley, 2015. [https://www.noisemeters.com/help/faq/frequency-weighting.asp, 25th March 2016]

Indicator's name	Percentage of survey respondents that perceive noise		
Category	Noise indicators	**Indicator's code**	G.16.2
Sub category	Noise emissions		
Definition	This indicator monitors the results of the surveys carried out by the port authority on noise emissions. These surveys are developed to know the opinion of the port stakeholders regarding the noise emissions generated in the port, as a result of the port activities.		
Importance	In order to ensure an efficient environmental management, it is very important to integrate all the port stakeholders and to have their involvement. For example, knowing the perception that neighbouring communities have on the noise emissions originated in the port area is a valuable information when applying mitigation measures.		
Units of measurement	Percentage of respondents that perceive noise		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

Indicator's name	Number of noise claims from authorities		
Category	Noise indicators	**Indicator's code**	G.16.3
Sub category	Noise emissions		
Definition	This indicator provides information on the number of claims or requirements that apply to the port authority regarding the environmental issue of noise.		

Importance	This indicator is relevant because it provides information on the number of demands that the relevant authorities (local, regional, national or European) have brought to the port authority regarding the noise issue. This indicator, although it is very specific for noise, provides information on how controversial this issue is for the port.
Units of measurement	Number of claims per year
Frequency	Annually
Level of effort	**Low level:** the information requested by the indicator is easily obtained.

<table>
<tr><td>Indicator's name</td><td colspan="3">Level of noise in terminal and industrial areas</td></tr>
<tr><td>Category</td><td>Noise indicators</td><td>Indicator's code</td><td>G.16.4</td></tr>
<tr><td>Sub category</td><td colspan="3">Noise emissions</td></tr>
<tr><td>Definition</td><td colspan="3">Noise is often defined as 'unwanted sound'. This indicator monitors the levels of noise that are recorded in the port terminals and its industrial areas. In the ports, noise can be generated by vehicle traffic, trucks and trains, engines of large vessels, alarms and other signals, or construction works that may be carried out in the port area [1].</td></tr>
<tr><td>Importance</td><td colspan="3">It is important to monitor the noise levels in the port area because they can affect the quality of life and the health of the neighbouring population. Specifically, the World Health Organization (WHO) warns that excessive levels of noise can seriously damage the human health and can interfere with the daily activities of the population. Additionally, they can cause sleep disorders, cardiovascular effects, reduced performance and change in the social behaviour of people [2].</td></tr>
<tr><td>Units of measurement</td><td colspan="3">• Intermediate level of annual noise: dB (A), applying the A-weighted decibels (see Notes)
• Maximum level of annual noise: dB (C) applying the C-weighted decibels (see Notes)</td></tr>
<tr><td>Description of the methodology</td><td colspan="3">The measurement of noise levels can be realised according to the international standards, such as the ISO 1996-2:2007 [3]. This standard describes how the sound levels may be measured from direct measurement, by extrapolating the results of the direct measurements, or by theoretical calculations to assess environmental noise.
When the noise levels are measured from direct measurement, sound level measuring devices are used. These devices must comply with the international standard IEC: 62672 to ensure that they meet all specifications and tolerance levels and that their reading is reliable [4]. A device suitable for measuring noise levels at the port area is the equipment Pulsar Nova Range [5] from the manufacturer Pulsar Instruments Plc.</td></tr>
<tr><td>Limit values</td><td colspan="3">The noise limits are regulated in a national level. In Spain, for instance, they are described in the RD 1367/2007 [6]. The average annual noise limits applicable in port areas are shown in the following table:
<table><tr><th>Noise</th><th>Interval time</th><th>Limit value (db(A))</th></tr><tr><td>L_{day}</td><td>7:00h a 19:00h</td><td>65</td></tr><tr><td>$L_{evening}$</td><td>19:00h a 23:00h</td><td>65</td></tr><tr><td>L_{night}</td><td>23:00h a 7:00h</td><td>55</td></tr></table>The maximum noise levels cannot exceeded by 5 dB the average annual levels indicated in the table above.</td></tr>
<tr><td>Approximate cost</td><td colspan="3">Device for measuring the noise level: 50€ [5]</td></tr>
<tr><td>Notes</td><td colspan="3">The auditory sense of human beings responds well in a range of sound frequencies between 500 Hz and 8000 Hz, and it is less sensitive to grave or high-pitched noises. The frequency weightings (used in sound measuring devices) are used to adapt the measurement of the devices to what actually perceives the human ear. The A-weighted decibels is used to the average levels of noise, whereas the C-weighted decibels are used to determine the maximum levels of noise [7].</td></tr>
</table>

References	[1] PORT METRO VANCOUVER. Noise monitoring. Vancouver, 2016. [http://www.portmetrovancouver.com/port-dashboard/noise-monitoring/, 25th March 2016] [2] WORLD HEALTH ORGANIZATION (WHO). Noise. Copenhagen, 2016. [http://www.euro.who.int/en/health-topics/environment-and-health/noise/noise, 25th March 2016] [3] INTERNATIONAL ORGANIZATION FOR STADARDIZATION (ISO). ISO 1996-2:2007. Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels. Geneva, 2016. [http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm? csnumber=41860, 25th March 2016] [4] INTER NOISE 2008. New IEC Standards and Periodic Testing of Sound Level Meters. Lindfield (Australia), National Measurement Institute, 2008. [5] PULSAR INSTRUMENTS. Pulsar Nova Range. Scarborough, 2016. [http://pulsarinstruments.com/range-product/the-nova-range/, 25th March 2016] [6] BOLETÍN OFICIAL DEL ESTADO. REAL DECRETO 1367/2007, de 19 de octubre, por el que se desarrolla la Ley 37/2003, de 17 de noviembre, del Ruido, en lo referente a zonificación acústica, objetivos de calidad y emisiones acústicas. Madrid, Ministerio de la Presidencia, 2007 [7] NOISE METERS INC. Frequency Weightings - A-Weighted, C-Weighted or Z-Weighted. Berkley, 2015. [https://www.noisemeters.com/help/faq/frequency-weighting.asp, 25th March 2016]

Indicator's name	Maximum level of noise in terminal and industrial areas		
Category	Noise indicators	**Indicator's code**	G.16.5
Sub category	Noise emissions		
Definition	Noise is often defined as 'unwanted sound'. This indicator monitors the maximum level of noise that is recorded in the port terminals and in its industrial areas. In the ports, noise can be generated by vehicle traffic, trucks and trains, engines of large vessels, alarms and other signals, or construction works that may be carried out in the port area [1].		
Importance	It is important to monitor the maximum level of noise in the port area because it shows the upper limit that these emissions have reached. Noise emissions can affect the quality of life and the health of the neighbouring population. Specifically, the World Health Organization (WHO) warns that excessive levels of noise can seriously damage the human health and can interfere with the daily activities of the population. Additionally, they can cause sleep disorders, cardiovascular effects, reduced performance and changes in the social behaviour of people [2].		
Units of measurement	• Intermediate level of annual noise: dB (A), applying the A-weighted decibels (see Notes) • Maximum level of annual noise: dB (C) applying the C-weighted decibels (see Notes)		
Description of the methodology	The measurement of noise levels can be realised according to international standards, such as the ISO 1996-2:2007 [3]. This standard describes how the sound levels may be measured: i) direct measurement, ii) by extrapolating the results of the direct measurements, or iii) by theoretical calculations to assess environmental noise. When the noise levels are measured from direct measurement, sound level measuring devices are used. These devices must comply with the international standard IEC: 62672 to ensure that they meet all specifications and tolerance levels and that their reading is reliable [4]. A device suitable for measuring noise levels at the port area is the equipment *Pulsar Nova Range* [5] from the manufacturer Pulsar Instruments Plc.		
Limit values	The noise limits are regulated in a national level. In Spain, for instance, the maximum noise levels are described in the RD 1367/2007 [6]. The maximum limit values vary on the interval time applied: **Interval time** | **Max. limit value (dB)**		

	7:00h a 19:00h — 70 19:00h a 23:00h — 70 23:00h a 7:00h — 60
Approximate cost	Device for measuring the noise level: 50€ [5]
Notes	The auditory sense of human beings responds well in a range of sound frequencies between 500 Hz and 8000 Hz, and it is less sensitive to grave or high-pitched noises. The frequency weightings (used in sound measuring devices) are used to adapt the measurement of the devices to what actually perceives the human ear. The A-weighted decibels is used to the average levels of noise, whereas the C-weighted decibels are used to determine the maximum levels of noise [7].
References	[1] PORT METRO VANCOUVER. Noise monitoring. Vancouver, 2016. [http://www.portmetrovancouver.com/port-dashboard/noise-monitoring/, 25th March 2016] [2] WORLD HEALTH ORGANIZATION (WHO). Noise. Copenhagen, 2016. [http://www.euro.who.int/en/health-topics/environment-and-health/noise/noise, 25th March 2016] [3] INTERNATIONAL ORGANIZATION FOR STADARDIZATION (ISO). ISO 1996-2:2007. Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels. Geneva, 2016. [http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm? csnumber=41860, 25th March 2016] [4] INTER NOISE 2008. New IEC Standards and Periodic Testing of Sound Level Meters. Lindfield (Australia), National Measurement Institute, 2008. [5] PULSAR INSTRUMENTS. Pulsar Nova Range. Scarborough, 2016. [http://pulsarinstruments.com/range-product/the-nova-range/, 25th March 2016] [6] BOLETÍN OFICIAL DEL ESTADO. REAL DECRETO 1367/2007, de 19 de octubre, por el que se desarrolla la Ley 37/2003, de 17 de noviembre, del Ruido, en lo referente a zonificación acústica, objetivos de calidad y emisiones acústicas. Madrid, Ministerio de la Presidencia, 2007 [7] NOISE METERS INC. Frequency Weightings - A-Weighted, C-Weighted or Z-Weighted. Berkley, 2015. [https://www.noisemeters.com/help/faq/frequency-weighting.asp, 25th March 2016]

Indicator's name	Frequency of noise measurements		
Category	Noise indicators	**Indicator's code**	G.16.6
Sub category	Noise emissions		
Definition	This indicator monitors how often the port authority has made measurements on environmental noise levels in the port area and in its surroundings.		
Importance	The frequency of noise measurements is important for the calculation of the annual noise levels and for meeting their evaluation principles, according to the International Standard ISO 1996-2:2007 [1] and ISO 1996-1:2016 [2].		
Units of measurement	Frequency units, such as number of noise measurements that have taken place in a year.		

Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	[1] INTERNATIONAL ORGANIZATION FOR STADARDIZATION (ISO). ISO 1996-2:2007. Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels. Geneva, 2016. [http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=41860, 25th March 2016]. [2] INTERNATIONAL ORGANIZATION FOR STADARDIZATION (ISO). ISO 1996-1:2016. Acoustics -- Description, measurement and assessment of environmental noise -- Part 1: Basic quantities and assessment procedures. Geneva, 2016. [http://www.iso.org/iso/home/store/catalogue_ics/catalogue_detail_ics.htm?csnumber=59765, 25th March 2016].

Indicator's name	Percentage of algae coverage at particular port sites		
Category	Effects on biodiversity indicators	**Indicator's code**	G.17.1
Sub category	Effects on biodiversity		
Definition	This indicator monitors the amount of algae that cover the seabed in certain areas of the port waters. The evolution of the percentage of the seabed covered in seaweed can assist port managers to track trends and identify when these natural tendencies are not being met.		
Importance	Algae grow in any body of water that is reached by sunlight. This growth is done in proportion to the amount of nutrients available. Many of the species that live in a port feed on algae, and therefore they are an important element in an ecosystem as a whole. However, a higher amount of algae can have a negative effect on the environment because they would eliminate the large amount of oxygen available in the water, reducing the capacity of the port waters to sustain life.		
Units of measurement	Percentage of algae coverage		
Description of the methodology	In order to monitor the percentage of algae that cover the seabed of the harbour, it is recommended to follow this method [1]: - The locations where algae are measured should be marked with two crosses painted on the walls of the docks. - It is important to analyse always the same locations to monitor the changes over time. - A boat takes pictures of the seabed in each monitoring location. - Once in the office, by knowing the width of the area analysed and observing the photographs, the scale can be determined. - Then, it is possible to estimate the surface area of each portion of the seabed analysed. - Finally, the percentage of algae coverage is calculated in each location.		
Frequency	Seasonally (4 times per year)		
Cost	Submersible camera: 150€		
References	[1] PORT OF DOVER. *Official site of the Dover Harbour Board*. Dover, UK, 2016. [http://www.doverport.co.uk/, 28th March 2016]		

Indicator's name	Percentage of large fish		
Category	Effects on biodiversity indicators	**Indicator's code**	G.17.2

Sub category	Effects on biodiversity
Definition	This indicator monitors the proportion of fish longer than 40 cm. The length of the fish is related to its size. It is considered that the size is a parameter with a good correlation with the processes relevant to the integrity of marine ecosystems (such as the predatory strategies or the migration). It is recommended that the proportion of fish longer than 40 cm should be higher than 30% [1].
Importance	Fishing by trawling tends to reduce the average size of fish in the fishing areas. It happens because larger fish are easier to catch than small ones. Given that larger fishes are usually predators that occupy the top of the food chain, there is concern that commercial fishing is altering the normal trophic functioning of marine ecosystems. The indicators based on the length of the fish can properly monitor structural changes in the size of the fish [1].
Units of measurement	Percentage of fish longer than 40 cm. (See Notes) This percentage is obtained by measuring the total weight of large fish (≥40 cm) and compare it with the total weight of fish. To calculate this indicator, the following formula may be used: $$\% \, (\geq 40cm) = \frac{\sum weight_{fish \geq 40cm}(kg)}{\sum weight_{total\ fish}(kg)}$$
Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
Notes	Some of the information needed for this indicator may be already available, because generally fishery industry monitors the size and weight of its production [1].
References	[1] CEFAS. Marine Ecosystem Integrity: Development of a Marine Trophic Index for UK waters and recommendations for further indicator development. Lowestoft, UK, Natural Environmental Group, Defra, 2008

Indicator's name	Heavy metals in fish samples		
Category	Effects on biodiversity indicators	**Indicator's code**	G.17.3
Sub category	Effects on biodiversity		
Definition	This indicator monitors the concentration of heavy metals present in fish species that inhabit the harbour. Metals are introduced into aquatic systems as a result of the erosion of soils and rocks, from volcanic eruptions, and as a result of various human activities such as mining, processing of metals and their use. The heavy metals that monitors this indicator are cadmium (Cd), lead (Pb), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn).		
Importance	In the marine environment, pollutants can potentially accumulate in aquatic organisms and sediments, and consequently be transferred to humans through the food chain. For this reason, it is important to determine the chemical quality of marine organisms, specifically the content of heavy metals in order to assess the risk that the consumption of fish represents for human health [1].		
Units of measurement	Micrograms of metal per gram of dry sample (μg/g).		
Description of the methodology	Below, a method for the determination of Cd, Pb, Cu, Fe, Mn and Zn in samples of fish is presented. This method uses the technique of Atomic Absorption Spectrometry (AAS) with graphite furnace [1]: **Equipment** • Atomic absorption spectrometer (e.g. Variant Model Spectra AA 220) • Graphite furnace (e.g. Variant GTA-110) • Laboratory equipment • Pump digestion [4] **Sampling** • The fish samples are washed with distilled water		

	• Then, fish samples are dried on filter paper and homogenized • They are stored in polyethylene bags • They are kept at -20 °C. **Digestion of the samples:** 1. For the analysis, the samples are dried at 110 °C until they have a constant weight (all the water content should be removed). 2. 1 g of the dry sample is added in a teflon container 3. 5 ml of concentrated nitric acid (HNO_3) are added 4. The system is heated to 130ºC for 90 minutes. 5. Finally, the sample is diluted in 25 ml of distilled water. **Analysis** • The concentration of metals in the sample is determined with atomic absorption spectrometer. • As a transport gas, argon (Ar) is used, with a flow of 250 ml/min.
Approximate cost	Atomic absorption spectrometer and graphite furnace: 7.000 € [2] Laboratory equipment: 300 € [3] Pump digestion : 600 € [4]
References	[1] Tüzen M. Determination of heavy metals in fish samples of the middle Black Sea (Turkey) by graphite furnace atomic absorption spectrometry. Food Chemistry. Vol. 80, 2003, pp. 119-123. [2] LABX. Atomic Absorption. 2016. [http://www.labx.com/product/varian-spectraa, 26th March 2016]. [3] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016]. [4] PARR INSTRUMENT COMPANY. Acid Digestion. Moline, EUA, 2016. [http://www.parrinst.com/products/sample-preparation/acid-digestion/, 26th March 2016].

Indicator's name	Area of contaminated land returned to productive use		
Category	Effects on biodiversity indicators	**Indicator's code**	G.17.4
Sub category	Effects on biodiversity		
Definition	This indicator monitors the total area of contaminated land that has been recovered and returned to productive use. The soil can be altered negatively with the presence of hazardous chemical components in such concentrations that involve an unacceptable risk to human health or the environment [1]. Some of the major pollutants that can affect soil are [2]: • Heavy metals: lead, copper, chromium, nickel, cadmium, zinc and mercury • Aromatic hydrocarbons (monocyclics): benzene, toluene, ethylbenzene or phenols • Chlorinated solvents: Chloromethane, chloroethane, chlorobenzenes or chlorophenols • Polycyclic Aromatic Hydrocarbons (PAHs) • Polychlorinated biphenyls (PCBs) • Pesticides: organochlorines, triazines or n-methylcarbamate		

	• Other compounds, such as cyanide, thiocyanate, styrene, phthalates
Importance	A large number of organic substances (such as benzene, dioxins, PCBs or PAHs) may contribute to soil pollution and can contaminate groundwater. These substances are harmful to living organisms and human health. Moreover, heavy metals, when they are present in high concentrations in soil, are toxic to wildlife and can enter into the food chain affecting humans. Additionally, soil pollution is not only an environmental and public health problem, but also has an adverse effect on the economy, representing a negative impact due to the loss of productivity [3].
Units of measurement	Soil hectares recovered
Equivalences	1 ha = 10.000 m^2
Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	[1] GOVIERNO DE ESPAÑA. *Guía Técnica de aplicación del RD 9/2005, de 14 de enero, por el que se establece la relación de actividades potencialmente contaminantes del suelo y los criterios y estándares para la declaración de suelos contaminados*. Madrid, Ministerio del Medio Ambiente, 2007. [2] UNIVERSITAT POLITÈCNICA DE CATALUNYA. *Tecnologia del Medi Ambient. Llibre de transperències*. Barcelona, Departament d'Enginyeria Química de l'Escola Tècnica d'Enginyeria Industrial de Barcelona, 2014. [3] BINI C. *From soil contamination to land restoration*. Venice, Università Ca' Foscari di Venezia, 2009.

Indicator's name	Total port area protected		
Category	Effects on biodiversity indicators	**Indicator's code**	G.17.5
Sub category	Effects on biodiversity		
Definition	Ports are often located in coastal areas and in estuaries (transition zones between the rivers and the coast) with a high natural value. The economic development that these areas are subject to, such as the port development and the freight traffic, represents a risk to the biodiversity and to the natural balance of these areas [1]. An instrument to combat the loss of		

	biodiversity and the conservation of these areas is the creation of protected areas. This indicator monitors the total area of protected areas within the port area.
Importance	The establishment of protected areas is a direct response to the concerns about the loss of biodiversity in Europe [2]. An indicator on the coverage of protected areas is a useful indicator of the existing commitment to preserve biodiversity. Additionally, the indicator provides information that can be used at different scales (e.g. local, or national) and can be a demonstration of the improvements made over time.
Units of measurement	Total hectares protected
Equivalences	1 ha = 10.000 m^2
Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	[1] NEW! DELTA. Creation and restoration of coastal and estuarine habitats. Final Report, 2007. [2] EUROPEAN ENVIRONMENTAL AGENCY (EEA). Nationally designated protected areas. Copenhagen, 2015. [http://www.eea.europa.eu/data-and-maps/indicators/nationally-designated-protected-areas/nationally-designated-protected-areas-assessment-3, 27th March 2016]

Indicator's name	Number of birds species protected		
Category	Effects on biodiversity indicators	**Indicator's code**	G.17.6
Sub category	Effects on biodiversity		
Definition	This indicator reports the total number of protected bird species in the port area.		
Importance	Europe hosts more than 500 species of wild birds. Unfortunately, 32% of these species are not currently in an adequate state of conservation [1]. Although there are laws and European directives (being the most significant the Wild Birds Directive [2]), it is important, for the conservation of local species present in the port area, that the port authority registers the total number of bird species that inhabit in the protected areas of the port.		
Units of measurement	Number of birds species protected		

Frequency	Annually
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research to be obtained.
References	[1] EUROPEAN COMMISSION (EC). ENVIRONMENT. *The Birds Directive*. Brussels, 2016. [http://ec.europa.eu/environment/nature/legislation/birdsdirective/index _en.htm, 27th March 2016] [2] EUROPEAN COMMISSION (EC). *Directive 2009/147/EC of the European Parliment and of the Council of 30 November 2009 on the conservation of wild birds*. Brussels, Official Journal of the European Communities, 2009.

Indicator's name	Number of flora species protected		
Category	Effects on biodiversity indicators	**Indicator's code**	G.17.7
Sub category	Effects on biodiversity		
Definition	This indicator reports the total number of protected flora species in the port area.		
Importance	Europe has a great diversity of species of flora and fauna, many of which are found only in this continent. Unfortunately, wild species of Europe are increasingly subject to more pressures and dangers [1]. Although there are laws and European directives (being the most significant the Habitats Directive [2]), it is important, for the conservation of local species present in the port area, that the port authority registers the total number of flora species that inhabit within the protected areas of the port.		
Units of measurement	Number of flora species protected		
Frequency	Annually		
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research to be obtained.		
References	[1] EUROPEAN COMMISSION (EC). ENVIRONMENT. The Habitats Directive. Brussels, 2016. [http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index _en.htm, 27th March 2016]		

	[2] EUROPEAN COMMISSION (EC). Council Directive 92 / 43 / EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Brussels, Official Journal of the European Communities, 1992.

Indicator's name	Meteorological data indicators		
Category	Air emissions	**Indicator's code**	G.18.1
Sub category	Meteorological data indicators		
Definition	This indicator includes monitoring of the following meteorological parameters: • Temperature • Relative humidity • Pattern of surface winds (speed and direction) • Rainfall • Atmospheric pressure • Solar radiation There exist compact weather stations that allow the monitoring of all the parameters included in this indicator, such as the weather station HD52, from the manufacturer Delta OHM [1].		
Importance	The atmosphere is the environment where air pollutants are released. The meteorological parameters are important because the transport and dispersion of these pollutants depend largely on the weather conditions.		
Units of measurement	• Temperature: ºC • Relative humidity: % RH • Pattern of surface winds: Wind speed: m / s Wind direction: 0 - 360 ° • Rainfall: mm • Atmospheric pressure: hPa • Solar radiation: W/m^2		
Frequency	Daily		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] DELTA OHM. *HD 52.3D 2 Axes ultrasonic anemometer*. Madrid, Alava Ingenieros, 2016. [http://www.alava-ing.es/ingenieros/productos/sensores-adquisicion-de-datos-y-calibracion/sensores-y-acondicionadores-de-senal/ parametros-meteorologicos/estaciones-meteorologicas/documentos/, 20th March 2016]		

Indicator's name	Sediments particle size distribution		
Category	Sediments Quality	**Indicator's code**	G.19.1
Sub category	Sediments Quality		
Definition	The particle size of the sediment is an index that determines the distribution in terms of the size of sediments. This index indicates the size of the particles that are present and in which proportion (the relative amount of particles of a certain size with respect to the amount of particles). The particle size is divided into different intervals depending on the spherical diameter (e.g. 0.5 – 1; 1 – 2 mm.). Each interval has a percentage of the total allocated to it (100%) [1].		

Importance	The particle size determines which type of contaminants may be adhered to the sediments. The thinner the sediments are, more contaminants they would retain [2].
Units of measurement	Percentage of the total for each interval (e.g. 0.25 – 0.50 mm.) [2].
Description of the methodology	Below, a method for determining the particle size of a sample of sediments is presented [2]. **Laboratory equipment** • Set of sieves of different sizes (in mm): 63; 2; 1; 0.50; 0.25; 0.125 and 0.063 • Rotary shaker • Filtering system and N11 Whatman filter paper **Operating procedure** 1. Approximately 100 g of wet sediment sample are passed through the sieve of 63 mm. 2. The fraction obtained is filtered through a N11 Whatman filter paper. 3. The filtered product is dried in an oven at 90 ºC and weighed. 4. The dry fraction is passed through sieves of 2, 1, 0.50, 0.25, 0.125 and 0.063 mm, respectively, using a rotary shaker for 10 minutes. 5. The various factions that have been obtained at the different sieves are weighed, in order to determine the amount of particles in each interval. 6. The percentage of each interval can be calculated with the following expression: $$\%\ of\ the\ interval\ i = \frac{weight_{sieve\ i}}{weight_{total}}$$
Monitoring locations	Sediments of the port waters
Approximate cost	Laboratory equipment: 300 € [3] Set of sieves: 200 € [4
References	[1] SHIMADZU. ANALYTICAL AND MEASURMENT INSTRUMENTS. Particle Size Distribution Dependent on Principle of Measurement. 2016. [http://www.shimadzu.com/an/powder/support/practice/p01/lesson02.html, 9th March 2016] [2] BRAVO-LINARES C.M., MUDGE S.M. Analysis of volatile organic compounds (VOCs) in sediments using in situ SPME sampling. J. Environ. Monit. Vol. 9, 2007, p. 411–418. [3] IBDCIENCIA. Instrumentos y utensilios de laboratorio. 2015. [http://www.ibdciencia.com/instrumentos-y-utensilios-de-laboratorio-c-69, 7th March 2016] [4] GILSON COMPANY. ASTM Test Sieves. 2016. [http://www.globalgilson.com/astm-test-sieves, 9th of March 2016]

Indicator's name	Total annual energy consumption		
Category	Resource consumption indicators	**Indicator's code**	G.20.1
Sub category	Energy consumption		
Definition	This indicator comprises the total energy consumption of the port authority, also specifying the origin of the energy source. Possible energy sources are both non-renewable energy sources (fossil fuels and natural gas) and renewable. This indicator also includes the consumption of electricity, a secondary source of energy, produced mainly from fossil fuels (e.g. coal, natural gas).		
Importance	The burning of fossil fuels creates emissions of carbon dioxide (CO_2), which is the greenhouse gas (GHG) that contributes the most to the global warming [1], 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		

<table>
<tr><td></td><td>environment [2]. The consumption of fossil fuels also contributes to the exhaustion of non-renewable resources.
By controlling the sources of the energy consumed in the port, the authority can move towards the use of more sustainable sources.</td></tr>
<tr><td>Units of measurement</td><td>The consumption of all energy sources is expressed in MWh / year (see note) or as the percentage of the each energy source:
<table>
<tr><th>Energy source</th><th>Consumption (MWh/year)</th><th>% of the total</th></tr>
<tr><td>Electricity</td><td></td><td></td></tr>
<tr><td>fossil fuels</td><td></td><td></td></tr>
<tr><td>Natural Gas</td><td></td><td></td></tr>
<tr><td>Renewable sources</td><td></td><td></td></tr>
<tr><td>Other</td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td></tr>
</table>
In addition, this indicator also may be expressed as a relative value, by dividing the consumption by the number of port authority employees or by the total annual cargo handled.</td></tr>
<tr><td>Frequency</td><td>Annually</td></tr>
<tr><td>Level of effort</td><td>High level: the information required by the indicator is specific and it may require a deep research to be obtained.</td></tr>
<tr><td>Notes</td><td>In the case of fossil fuels (such as diesel or gasoline) the consumption value should be converted from m^3 to MWh, based on the following expression:
$$consumption\ [MWh] = Consumption\ [l] \cdot \rho_{comb.} \left[{}^{kg}/_{l}\right] \cdot LCV_{comb.} \left[{}^{MWh}/_{kg}\right]$$
where:
$\rho_{comb.}$: is the density of the combustible
$LCV_{comb.}$: is the Lower Calorific Value (LCV), which is the heat that the fuel releases and may be consulted in the reference [3].</td></tr>
<tr><td>References</td><td>[1] Kiehl, J.T., and Trenberth, K. 1997. Earth’s Annual Global Mean Energy Budget. Bulletin of the American Meteorological Society 78 (2), pp. 197 – 208.
[2] Twerefou, D. K. 2009. Mineral Exploitation, Environmental Sustainability and Sustainable Development in EAC, SADC and ECOWAS Regions. African Trade Policy Centre. Economic Commission for Africa.
[3] INSTITUTO PARA LA DIVERSIFICACIÓN Y AHORRO DE ENERGÍA (IDAE). Poderes Caloríficos. Madrid, 2015. [http://www.idae.es/, 20th March 2016]</td></tr>
</table>

Indicator’s name	Percentage of the annual variation in the energy consumption		
Category	Resource consumption indicators	**Indicator’s code**	G.20.2
Sub category	Energy consumption		
Definition	This indicator expresses the annual change in the total energy consumption of the port authority. In order to calculate this parameter, the volumes of annual energy consumption (see G.20.1 for more information) of the current and the previous years are required. To carry out the calculation, the following formula may be used: $$Annual\ variation\ (\%) = \frac{Current\ year - previous\ year}{Previous\ year\ consumption} \cdot 100$$ A positive percentage means an increase in the energy consumption, and a negative percentage a reduction in the consumption.		
Importance	Knowing the variation in the energy consumption between one year and the previous one is useful to establish objectives of reduction and to check their achievement.		
Units of measurement	Percentage of variation		

Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.

Indicator's name	Percentage of renewable energy per total energy consumed		
Category	Resource consumption indicators	**Indicator's code**	G.20.3
Sub category	Energy consumption		
Definition	Renewable energy is defined as energy derived from resources that are regenerated naturally, such as solar, wind, tidal and geothermal energy. Renewable energy sources are mainly used for generating electricity, thermal energy and transport. This indicator shows the percentage of the total energy consumed (see G.20.1) that is obtained from renewable sources: $\% \, renewable \; energy = \frac{energy \; from \; renewable \; sources}{Total \; energy \; consumption} \cdot 100$		
Importance	Energy consumption is one of the main causes of global warming and the depletion of natural resources, since many of the sources currently used are not renewable (e.g. fossil fuels). This indicator is useful to know the progress towards the use of sustainable energy sources and minimize the impact of the port.		
Units of measurement	Percentage of renewable energy from the total		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

Indicator's name	Total annual port waste collected		
Category	Waste production indicators	**Indicator's code**	G.22.1
Sub category	Waste generation		
Definition	This indicator includes the total amount of waste collected by the port authority in a year, regardless their origin or type. The port authority manages the collection of waste in the port. Port waste may have different origins: the port authority itself, vessels that call to the port, the port industry, or the construction works that are being carried out. The different types of waste generated in a port (and therefore that are likely to be collected by the port authority) are: • Recyclable garbage such as organic waste, cardboard or plastic. • Hazardous waste such as ink cartridges, batteries, waste oils or chemicals. • Non-hazardous waste, such as scrap metal, wood or gravel.		
Importance	It is important to maintain an effective port waste collection to avoid environmental impacts to the port area and its surroundings, which are, very often, sensitive. For example, industries located in the port area can generate different types of waste that, without the existence of a proper management, they may deposit in the port area and at the sea. This waste can introduce organic pollutants into the environment and degrade water quality, causing negative impacts such as oil pollution, odours or unsanitary conditions.		
Units of measurement	Tonnes of waste collected per year (tonnes/year)		

Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.

Indicator's name	Total annual port waste recycled		
Category	Waste production indicators	**Indicator's code**	G.22.2
Sub category	Waste generation		
Definition	This indicator monitors the total amount of recyclable waste managed by the port authority, collected selectively in order to be recycled.		
Importance	The recycling of waste is a very important solution in order to prevent the high impact that garbage may have on the environment (e.g. emissions of toxic substances or greenhouse gases to the environment). Additionally, producing goods from recycled materials reduces the amount of raw materials and the energy required in industry for the production of products and, therefore, it contributes to preserve the natural resources.		
Units of measurement	Tonnes of waste recycled per year (tonnes/year)		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

Indicator's name	Percentage of disposal methods of port waste		
Category	Waste production indicators	**Indicator's code**	G.22.3
Sub category	Waste generation		
Definition	This indicator monitors the disposal methods of the waste collected at the port area, based on the percentage of waste destined to each method. The main methods of waste treatment are [1]: • Controlled landfills • Composting • Recycling • Incineration • Uncontrolled landfills • Other methods		
Importance	Not all the methods of waste disposal have the same impact on the environment. For example, recycling of waste and composting have a lower environmental impact in comparison to controlled landfills or incineration. At the same time, these two latter methods are more environmentally friendly than uncontrolled landfills.		
Units of measurement	This indicator is expressed as the percentage of each disposal method. In order to obtain this result, the amount (tonnes/year) for each method is needed.		

Disposal method	Amount (t/year)	% of the total
Controlled landfills		
Composting		

	Recycling | | Incineration | | Uncontrolled landfills | | Other methods | | **Total** | | **100%**
Frequency	Annually
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research to be obtained.
References	[1] WORLD BANK. *What a Waste: A global review of solid waste management*. Urban Development Series - Knowledge Series. [http://siteresources.worldbank.org/INTURBANDEVELOPMENT/ Resources/336387-1334852610766/Chap6.pdf, 20th of March 2016]

Indicator's name	Annual waste collected on port surface water (Anthropogenic debris)		
Category	Waste production indicators	**Indicator's code**	G.22.4
Sub category	Waste generation		
Definition	This indicator monitors the amount of solid waste collected in the surface of port waters, by specialized vessels.		
Importance	Debris floating on the surface of the port waters pollute the water and generate opacity and loss of light available for photosynthesis of aquatic organisms [1]. In addition, floating wastes generate serious visual and aesthetic impact in the port.		
Units of measurement	Kg/year		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] GREENPEACE. *Plastic Debris in the World's Oceans*. Amsterdam, Greenpeace International.		

Indicator's name	Annual amount of ship waste collected by type of MARPOL annex		
Category	Waste production indicators	**Indicator's code**	G.22.5
Sub category	Waste generation		
Definition	The International Convention for the Prevention of Pollution from Ships, MARPOL [1], is the main international convention on the prevention and reduction of maritime pollution caused by ships, whether accidentally or as a result of operations in normal conditions. Ports are obliged to have MARPOL waste reception facilities. Currently MARPOL wastes are classified into six technical annexes [2]: • Annex I: Regulations for the Prevention of Pollution by Oil. • Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. • Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form • Annex IV: Prevention of Pollution by Sewage from Ships		

	• Annex V: Prevention of Pollution by Garbage from Ships • Annex VI: Prevention of Air Pollution from Ships (see note).
Importance	It is important to monitor and control the amount of collected waste reception facilities in ports. If the wastes generated by vessels are not properly deposited in these facilities, they may end up dumped directly into the ocean or harbour waters, causing a strong environmental impact.
Units of measurement	This indicator is expressed as the annual amount of each MARPOL annex that has been collected, in tonnes for solid waste and in cubic metres for liquid waste. It may be reported in a table, such as:
Frequency	Annually
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research to be obtained.
References	[1] INTERNATIONAL MARITIME ORGANIZATION. *Pollution Prevention*. London, 2016.

Table within "Units of measurement":

MARPOL Annex	Annual amount (t/year or m^3/year)
Annex I	
Annex II	
Annex III	
Annex IV	
Annex V	

Indicator's name	Total annual number of environmental complaints received		
Category	Management performance indicators	**Indicator's code**	G.23.1
Sub category	Environmental complaints indicators		
Definition	This indicator monitors the number of complaints that the port authority received during the past year, regarding environmental issues.		
Importance	An environmental complaint is a critical and documented observation about any environmental aspect of the port, in which an improvement action or a response by the port authority is requested. The number of environmental complaints that the different port stakeholders (such as neighbours, public authorities, NGOs, port workers, among others) send to the port authority is a relevant indicator. It provides information on the main environmental problems or environmental issues that generate more discomfort among these groups of people.		
Units of measurement	Number of complaints / year		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Total annual number of environmental complaints resolved		
Category	Management performance indicators	**Indicator's code**	G.23.2
Sub category	Environmental complaints indicators		

Definition	This indicator measures the annual number of environmental complaints were resolved correctly.
Importance	An environmental complaint is a critical and documented observation about any environmental aspect of the port, in which an improvement action or a response by the port authority is requested. The number of environmental complaints that have been resolved correctly is an indicator on how the port authority management reacts regarding the main problems or concerns of the port stakeholders (such as neighbours, public authorities, NGOs, port workers, among others).
Units of measurement	Number of complaints resolved / year
Frequency	Annually
Level of effort	**Low level:** the information requested by the indicator is easily obtained.

Indicator's name	Total annual budget allocated to environmental protection		
Category	Management performance indicators	**Indicator's code**	G.23.3
Sub category	Environmental budget indicators		
Definition	This indicator aims to inform about the annual budget allocated to the environment by the port authority.		
Importance	The environmental budget refers to the amount of money devoted to environmental protection by the port authority. This indicator is important because it provides information about the priority given and the financial efforts made by the port authority towards the environment.		
Units of measurement	€ / year		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Percentage of the budget allocated to environmental protection out of the total budget		
Category	Management performance indicators	**Indicator's code**	G.23.4
Sub category	Environmental budget indicators		
Definition	This indicator shows the percentage of the budget allocated to the environment out of the total budget of the port authority. The formula for this calculation is the following: $Percentage = \frac{Budget\ allocated\ to\ environment}{Total\ budget} \cdot 100$		
Importance	The environmental budget refers to the amount of money devoted to environmental protection by the port authority. This indicator monitors the percentage that the environmental protection has in comparison to the total annual budget of the port authority. This indicator is important because it provides information about the priority given and the financial efforts made by the port authority towards the environment.		
Units of measurement	Percentage		

Frequency	Annually
Level of effort	**Low level:** the information requested by the indicator is easily obtained.

Indicator's name	Percentage of annual variation in the environmental budget		
Category	Management performance indicators	**Indicator's code**	G.23.5
Sub category	Environmental budget indicators		
Definition	This indicator shows the variation of the budget allocated to the environmental protection between the current year and the previous one. The formula for this calculation is the following: $$Variation = \frac{Budget\ current\ year - budged\ previous\ year}{Budget\ previous\ year} \cdot 100$$		
Importance	The environmental budget refers to the amount of money devoted to environmental protection by the port authority. This indicator monitors the annual variation of the budget allocated to the environment. It is an interesting indicator because it shows whether the percentage of the budget allocated to the protection of the environment increases or, conversely, it decreases. If it decreases, less resources are available to allocate potential environmental issues.		
Units of measurement	Percentage		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Number of environmental objectives defined		
Category	Management performance indicators	**Indicator's code**	G.23.6
Sub category	Objectives and targets indicators		
Definition	An objective is an overall environmental goal that a port authority sets itself to achieve [1]. This indicator determines the number of environmental objectives that were defined by the port authority.		
Importance	The definition of environmental objectives are important for several reasons [2]: • To translate the environmental policy to a more specific, tangible and measurable basis for its implementation. • To provide performance indicators for guiding the organization in planning and developing the environmental programmes in a focused manner. • To provide clear benchmarks against which to measure the progress and success of the environmental programmes over time. • To provide a basis for external and internal reporting of achievements.		
Units of measurement	Number of objectives		

Frequency	Annually
Level of effort	**Low level:** the information requested by the indicator is easily obtained.
References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [2] Environmental Protection Department. 2005. A Simple Guide to Set Up an Environmental Management System. [Online]. Available at: http://www.epd.gov.hk/epd/english/how_help/tools_ems/ems_6.html#01

Indicator's name	Percentage of environmental objectives achieved		
Category	Management performance Indicators	**Indicator's code**	G.23.7
Sub category	Objectives and targets indicators		
Definition	An objective is an overall environmental goal that a port authority sets itself to achieve [1]. This indicator determines the percentage of environmental objectives that have been achieved in relation to the total number of environmental objectives that were defined by the port authority. This value is obtained by dividing the total number of achievements between the total number objectives that were defined, as indicated by the following formula: $\% \, objectives = \frac{Number\ of\ environmental\ objectives\ achieved}{Number\ of\ environmental\ objectives\ defined} \cdot 100$		
Importance	The importance of this indicator lies in the fact that it is not only important to monitor the number of annual environmental objectives defined by the port authority, but also it is even more important to know which percentage of these objectives has been finally achieved. This will help to improve the port environmental performance.		
Units of measurement	Percentage		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		
References	[1] ISO (International Organization for Standardization). *ISO 14001: Environmental management systems. Requirements with guidance for use*. Geneva, ISO, 2004.		

Indicator's name	Number of environmental indicators monitored		
Category	Management performance indicators	**Indicator's code**	G.23.8
Sub category	Environmental monitoring plan indicators		
Definition	An Environmental Performance Indicators (EPI) is defined as 'an information tool that summarises data on complex environmental issues to show overall status and trends of those issues' [1]. This indicator provides information on the number of indicators that the port authority is monitoring.		
Importance	The advantages of using performance indicators have been widely reported. Firstly, indicators monitor progress and provide a picture of trends and changes over time [2]. The second reason is that indicators provide simplified data that clearly show not only how an individual authority is performing, but also assess the national and regional benchmark performance of the sector [3]. Thirdly, indicators may be used to evaluate the effectiveness of policies implemented, by measuring the progress towards environmental targets [4] and to provide a firm basis for future objectives [5]. In addition, 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 [3]. Finally, environmental indicators may be used as a powerful tool to raise public awareness on environmental issues [6].
Units of measurement	Number of indicators
Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	[1] UN (United Nations). United Nations Environment Programme (UNEP), 1997. Recommendations for a core set of indicators of biological diversity. United Nations, Montreal. [2] Lehane, M., Le Bolloch, O., Crawley, P. (Eds.), 2002. Environment in Focus, Key Environmental Indicators for Ireland. Environmental Protection Agency, Dublin, Ireland. [3] De Leffe, A.; Luk'yanchuk, S.; Michail, A.; Panasevich, S.; Shelest, K.; Shevchenko, N.; van Duursen, J. 2003. Environmental Performance Indicators in European Ports. European Postgraduate Course in Environmental Management (EPCEM): Amsterdam. [4] DEFRA (Department for Environment, Food and Rural Affairs). 2003. Sustainable Development: The UK Governments Approach, Quality of Life Counts. Sustainable Development Unit, DEFRA, London. [5] Dantes, 2003. Environmental Performance Indicators. http://www.dantes.info/ Tools&Methods/Environmentalinformation/enviro_info_spi_epi.html (accessed 06.05.13). [6] Gautam, R. and Singh, A. 2010. Critical environmental indicators used to assess environmental performance of business. Glob. Bus. Manage. Res.: Int. J. 2 (2–3).

Indicator's name	Number of Significant Environmental Aspects identified		
Category	Management performance indicators	**Indicator's code**	G.23.9
Sub category	Significant environmental aspects indicators		
Definition	An environmental aspect is an element of an organisation's activities, products and services that can interact with the environment [1]. Examples of them are water discharges, emissions to air, waste generation or noise emissions. Port authorities should select the aspects that are most significant, called the Significant Environmental Aspects (SEAs).		
Importance	An effective port environmental management requires awareness and knowledge of its environmental aspects in order to know what is required to be properly managed from the environmental point of view [2]. Port environmental managers should identify and evaluate all the aspects associated with the port's activities, products or services that can interact with the environment. It is highly recommended that port authorities select the most significant aspects, called the Significant Environmental Aspects (SEAs), in order to focus their time, efforts and resources on those issues with major potential for environmental impact, providing the greatest assurance that the environment will be protected [3].		
Units of measurement	Number of aspects		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		
References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva.		

	[2] ESPO (European Sea Ports Organisation). 2011. Port Environmental Review System (PERS). A port-sector specific methodology to start implementing an environmental management system. ESPO: Brussels. [3] Puig, M. 2012. Identification and selection of Environmental Performance Indicators (EPIs) for use in the management of European Seaports. MPhil Thesis. School of Earth and Ocean Sciences. Cardiff University.

Indicator's name	Percentage of employees working on environmental issues		
Category	Management performance Indicators	**Indicator's code**	G.23.10
Sub category	Management organization & personnel indicators		
Definition	This indicator monitors the percentage of the port authority employees that are working on environmental issues. This percentage is calculated based on the following formula: $\% \; of \; employees = \frac{Number \; of \; employees \; working \; on \; env. issues}{Total \; number \; of \; employees} \cdot 100$		
Importance	It is important that each port monitors and publishes the number of workers of the organization that are working on issues related to the environment, either through an environmental department, specific working groups, committees, among others.		
Units of measurement	Percentage		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Frequency of environmental training sessions for port employees		
Category	Management performance Indicators	**Indicator's code**	G.23.11
Sub category	Environmental training and awareness indicators		
Definition	This indicator monitors how often port employees receive environmental training sessions.		
Importance	Environmental training and awareness indicators are very important, since the port authority must ensure that their employees are trained on those issues and are able to carry out the environmental tasks and responsibilities that have been assigned to them. Implementing a program on environmental training for workers and carrying out environmental awareness activities contributes to the continuous improvement of environmental management of the port. This training provides the skills necessary for employees to perform their jobs more efficiently and makes them more aware of their duties and responsibilities. Port authorities should identify their training needs and should provide training or take measures in order to meet them [1].		
Units of measurement	Frequency units, such as number of training sessions that have taken place in a year.		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] ISO (International Organization for Standardization). *ISO 14001: Environmental management systems. Requirements with guidance for use*. Geneva, ISO, 2004.		

Indicator's name	Percentage of port employees that received environmental training

Category	Management performance indicators	**Indicator's code**	G.23.12
Sub category	Environmental training and awareness indicators		
Definition	This indicator monitors the port authority workers that received training on environmental issues. It is expressed as the percentage of employees who received environmental training, compared to the total number of employees of the organization. The percentage is calculated based on the following formula: $\% \ of \ employees = \frac{Employees \ that \ received \ env. training}{Total \ number \ of \ employees} \cdot 100$		
Importance	Environmental training and awareness indicators are very important, since the port authority must ensure that their employees are trained on those issues and are able to carry out the environmental tasks and responsibilities that have been assigned to them. Implementing a program on environmental training for workers and carrying out environmental awareness activities contributes to the continuous improvement of environmental management of the port. This training provides the skills necessary for employees to perform their jobs more efficiently and makes them more aware of their duties and responsibilities. The port authority should identify its training needs and should provide training or take measures in order to meet these needs for their workers [1]		
Units of measurement	Percentage		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] ISO (International Organization for Standardization). *ISO 14001: Environmental management systems. Requirements with guidance for use*. Geneva, ISO, 2004.		

Indicator's name	Annual number of training hours per employee		
Category	Management performance Indicators	**Indicator's code**	G.23.13
Sub category	Environmental training and awareness indicators		
Definition	This indicator calculates the annual number of hours that the port authority's employees spend, on average, on environmental training. This indicator is calculated as follows: $Average \ hours \ dedicated \ on \ training = \frac{\sum annual \ hours \ on \ env. training}{Number \ of \ employees}$		
Importance	Environmental training and awareness indicators are very important, since the port authority must ensure that their employees are trained on those issues and are able to carry out the environmental tasks and responsibilities that have been assigned to them. Implementing a program on environmental training for workers and carrying out environmental awareness activities contributes to the continuous improvement of environmental management of the port. This training provides the skills necessary for employees to perform their jobs more efficiently and makes them more aware of their duties and responsibilities. The port authority should identify its training needs and should provide training or take measures in order to meet these needs for their workers [1].		
Units of measurement	Number of hours / employee · year		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

References	[1] ISO (International Organization for Standardization). *ISO 14001: Environmental management systems. Requirements with guidance for use*. Geneva, ISO, 2004.

Indicator's name	Annual number of environmental reports published		
Category	Management performance indicators	**Indicator's code**	G.23.14
Sub category	Environmental communications indicators		
Definition	This indicator monitors the number of annual environmental publications published by the port authority. This indicator includes the publication of the annual port environmental report or review, and other reports and studies published in both digital and paper format.		
Importance	The publication of environmental documents constitutes a part of the external communication of the port. This type of communication is very important and must be taken into account since it informs stakeholders on the port's progress in environmental issues. The publications provide information about environmental activities, results or achievements of the port. Although conducting an environmental report implies investing time, effort and budget, it is also well known that its implementation brings benefits to the port. For example, reporting on the environmental performance is a good opportunity not only to improve the reputation by demonstrating transparency, but also it serves to identify impacts, set goals, and to explore ways to reduce costs and risks.		
Units of measurement	Number of environmental publications / year		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Annual number of press articles published concerning environment		
Category	Management performance indicators	**Indicator's code**	G.23.15
Sub category	Environmental communication indicators		
Definition	This indicator monitors the number of articles published in newspapers (in both digital and paper format) related to the port and the environment.		
Importance	The publication of press articles related to the environment is part of the external communication port. This type of communication is very important and must be taken into account since it informs port stakeholders on its progress in environmental issues The press articles published in relation with the environment provide information to the general public on environmental port performance. For this reason, it is considered important to monitor this indicator.		
Units of measurement	Number of papers published / year		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

Indicator's name	Annual number of conferences that the port authority has organized or participated in		
Category	Management performance indicators	**Indicator's code**	G.23.16

Sub category	Environmental communication indicators
Definition	This indicator aims to inform about the number of annual conferences which have been organized by the port authority or which its employees have attended. The conferences can be both national and international and they should deal with the environment.
Importance	The importance of this indicator lies in the willingness of sharing environmental information with other port environmental managers or with employees of port and shipping companies. Examples of this information are the new techniques that have been developed or examples of best practices that ports are implementing. The attendance and organization of conferences that deal with the environment is also considered as a training activity for environmental managers. This is a part of the external communication of the port, which is very important because it informs port stakeholders on its progress in environmental issues.
Units of measurement	Number of conferences / year
Frequency	Annually
Level of effort	**Low level:** the information requested by the indicator is easily obtained.

Indicator's name	Number of environmental educational programmes or materials provided for the community		
Category	Management performance indicators	**Indicator's code**	G.23.17
Sub category	Environmental communication indicators		
Definition	This indicator aims at informing about the number of environmental education programs that the port authority offers to its surrounding community, including schools, social or civic centres, and libraries, among others.		
Importance	Increasingly, large companies and corporations are contributing to the Corporate Social Responsibility (CSR). This concept aims at participating, in an active and voluntarily way, to improve the social, economic and environmental performance of the company. This indicator belongs to the external communication of the port and it may be integrated as part of the Corporate Social Responsibility of the port.		
Units of measurement	Number of educational programmes / year		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Number of times that the Emergency Response Plan has been activated		
Category	Management performance indicators	**Indicator's code**	G.23.18
Sub category	Emergency planning & response indicators		
Definition	This indicator aims to inform about the number of times the emergency plan has been activated in one year in the port.		
Importance	An emergency plan is a document which identifies the possible emergencies that may occur, studies the potential effects, and details, step by step, the procedures that should be followed in case of an emergency [1].		

	Emergencies may arise from many different causes, such as fires, explosions, collisions, floods, spills or leakage of chemicals or oil products [2]. This indicator is important because it provides information on the number of times that there have been emergencies in the port.
Units of measurement	Number of times the plan is activated / year
Frequency	Annually
Level of effort	**Low level:** the information requested by the indicator is easily obtained.
References	[1] BUSINESS DICTIONARY. *Emergency action plan*. 2011 [http://www.businessdictionary.com/definition/ emergency-action-plan.html, 10 de març de 2016] [2] ECOPORTS FOUNDATION. *Guidelines for Self-Diagnosis Method SDM. Version 1.4*. 2004.

Indicator's name	Total number and volume of (significant) oil and chemical spills		
Category	Management performance indicators	**Indicator's code**	G.23.19
Sub category	Emergency planning & response indicators		
Definition	This indicator monitors the annual number of spills occurred within the port area, from both chemicals and oil products, and the total volume that has been spilled.		
Importance	The spills of chemical and / or oil products are a major source of contamination in ports. These spills affect not only the quality of the water and sediments, but they also affect seriously the flora and fauna inhabiting in these compartments. Therefore, it is very important that the ports monitor the number and the volume of the spills produced annually within the port area.		
Units of measurement	Number of spills / year and volume of spilled product / year (m^3 / year).		
Frequency	Annually		
Level of effort	**High level:** The information required by the indicator is specific and it may require a deep research to be obtained.		

Indicator's name	Annual number of environmental accidents		
Category	Management performance indicators	**Indicator's code**	G.23.20
Sub category	Emergency planning & response indicators		
Definition	This indicator monitors the number of accidents that occurred during the year within the port area, as an undesired result of the port routine activities.		
Importance	An accident is defined as an unwanted event or sequence of events that cause physical harm to people, economic loses and / or affects the environment [1]. It is important to monitor the number of accidents that occur inside the port area in order to study their causes and prevent them to happen again. This indicator takes into account the accidents that happened with effects to the environment.		
Units of measurement	Number of accidents / year		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

References	[1] MEYER, T., RENIERS, G. *Engineering risk management*. Walter de Gruyter. 2013

Indicator's name	Annual number of environmental incidents		
Category	Management performance indicators	**Indicator's code**	G.23.21
Sub category	Emergency planning & response indicators		
Definition	This indicator monitors the number of incidents (dangerous situations without serious consequences) that occurred during the year within the port area, as an undesired result of the port routine activities.		
Importance	An incident is defined as an unwanted event or sequence of events that could have led to physical harm to people, economic loses and / or effects over the environment [1]. The main difference between an accident and an incident is on their consequences on the environment. In other words, accidents involve serious damage, but not the incidents. It is important to monitor the number of incidents that occur inside the port area in order to study their causes and prevent them to happen again. This indicator takes into account the incidents that have happened with effects to the environment.		
Units of measurement	Number of incidents / year		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] MEYER, T., RENIERS, G. *Engineering risk management*. Walter de Gruyter. 2013		

Indicator's name	Number of EMS audits completed versus planned		
Category	Management performance indicators	**Indicator's code**	G.23.22
Sub category	EMS audits indicators		
Definition	This indicator monitors the number of EMS audits conducted, compared with the total number of EMS audits that were planned.		
Importance	An environmental audit is a systematic evaluation that is carried out to measure current environmental performance of the port against a set of requirements and goals. Audits assess the compliance with the environmental legislation, internal policies of the company and the requirements of the Environmental Management System standard. This indicator is important in order to know the number of environmental audits that have been carried out at the port in a year and to know if there exist a relevant difference between the number of audits that were conducted and the ones that were planned. If this is the case, the port should take action to correct this.		
Units of measurement	Number of audits conducted and audits planned		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Number of EMS audit findings

Category	Management performance indicators	**Indicator's code**	G.23.23
Sub category	EMS audits indicators		
Definition	This indicator aims to monitor the number of findings that are obtained at the EMS audits.		
Importance	An environmental audit is a systematic evaluation that is carried out to measure current environmental performance of the port against a set of requirements and goals. Audits assess the compliance with the environmental legislation, internal policies of the company and the requirements of the Environmental Management System standard. This indicator is important because it monitors the number of corrections to make that have been detected in the development of the audit. The finding are small amendments that have to be carried out in order to approve the audits.		
Units of measurement	Number of audits findings		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Number of EMS audit nonconformities addressed versus found		
Category	Management performance indicators	**Indicator's code**	G.23.24
Sub category	EMS audits indicators		
Definition	This indicator aims to monitor the number of the nonconformities found in the development of the EMS audits and the ones that were addressed.		
Importance	An environmental audit is a systematic evaluation that is carried out to measure current environmental performance of the port against a set of requirements and goals. Audits assess the compliance with the environmental legislation, internal policies of the company and the requirements of the Environmental Management System standard. If these requirements are not accomplished, the audit identifies it as a nonconformity, and therefore, corrective actions have to be taken to overcome this undesired situation. This indicator is significant because it provides information on the number of times that the EMS requirements have not been reached and on the nonconformities that have been amended.		
Units of measurement	Number of nonconformities found and nonconformities addressed		
Frequency	Annually		
Level of effort	**Low level:** the information requested by the indicator is easily obtained.		

Indicator's name	Number of fines received for non-compliance with environmental legislation		
Category	Management performance indicators	**Indicator's code**	G.23.25
Sub category	Environmental legislation indicators		

Definition	This indicator monitors the number of annual fines received by the port authority for not complying with environmental legislation.
Importance	This indicator is significant as it provides information on the number of fines received by the port authority for not complying with the environmental legislation. This compliance is an indispensable requirement for any company or organization. Therefore, the fact of receiving fines for non-compliance is considered as a parameter that indicates that the port authority should act quickly to correct this situation.
Units of measurement	Number of fines / year
Frequency	Annually
Level of effort	**Low level:** the information requested by the indicator is easily obtained.

Indicator's name	Number of times that the daily limit value of a certain environmental parameter has been exceeded		
Category	Management performance indicators	**Indicator's code**	G.23.26
Sub category	Environmental legislation indicators		
Definition	This indicator monitors the number of times that the daily legal limit of an environmental parameter (e.g. the concentration of ozone) has been exceeded and, therefore, the legislation has been broken.		
Importance	This indicator is important because it gives a numerical value of the times that a specific parameter has exceeded its threshold value. It is also relevant because it demonstrates the parameters that should improve their performance and therefore the areas where the port should invest more efforts.		
Units of measurement	Number of non-compliances / year		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		

Indicator's name	Annual quantity or volume of dredged sediment		
Category	Port development indicators	**Indicator's code**	G.24.1
Sub category	Port development		
Definition	This indicator monitors the amount of sediments (sand and silt) extracted in dredging works that have been carried out at the port in a year. These works are necessary to remove the sediments deposited naturally in the channels to enter to the port, and to maintain the adequate depth for boats [1].		
Importance	Dredging works may cause a negative environmental impact on marine ecosystems and water quality, and they can have harmful effects on human health. For example, increased turbidity caused by the alteration of the seabed may harm the species that inhabit it. In addition, changes in the chemical composition of the water may be produced since toxic substances attached to sediments (such as heavy metals) may be released. Additionally, nutrients (mainly nitrogen and phosphorus) also could be released, by increasing the risk of a toxic algal bloom [2].		
Units of measurement	Tonnes or cubic metres of dredged sediments per year (t/year, m^3/year)		

Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	[1] VALENCIAPORT. Memoria Ambiental 2013. Valencia, Autoridad Portuaria de Valencia, 2014. [2] VICTORIA STATE GOVERNMENT. Dredging. Melbourne, 2015. [http://www.depi.vic.gov.au/forestry-and-land-use/coasts/marine/bays-inlets-estuaries-and-lakes/dredging, 25th March 2015].

Indicator's name	Frequency of dredging		
Category	Port development indicators	**Indicator's code**	G.24.2
Sub category	Port development		
Definition	This indicator informs about the frequency in which the dredging works are carried out at the port. Dredging is an activity that involves removing sand and silt from the seabed in order to maintain an adequate depth to access to the channels of the port or to build new docks or channels [1].		
Importance	Dredging works can cause severe environmental impacts to marine ecosystems and to the quality of the water, and they may have harmful effects on human health [2]. Controlling the frequency of this activity may prevent the negative impacts associated with that [2].		
Units of measurement	Frequency units, such as number of dredging sessions that have taken place in a year.		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] VALENCIAPORT. Memoria Ambiental 2013. Valencia, Autoridad Portuaria de Valencia, 2014. [2] VICTORIA STATE GOVERNMENT. Dredging. Melbourne, 2015. [http://www.depi.vic.gov.au/forestry-and-land-use/coasts/marine/bays-inlets-estuaries-and-lakes/dredging, 25th March 2015]		

Indicator's name	Percentage of dredged sediments going to beneficial use		
Category	Port development indicators	**Indicator's code**	G.24.3
Sub category	Port development		
Definition	This indicator monitors the percentage of the sediments having a beneficial use. This is using them as a raw material for certain applications. In some of these applications, the dredged material can be used for the following uses [1]: • Creation of land (for building new areas in ports) • Covering landfills • Recovery of beaches • Creation and recovery of natural habitats		
Importance	A high percentage of sediments that are obtained from dredging are not contaminated and, therefore, they do not have to be deposited in special facilities. These facilities are expensive to manufacture and maintain. In order not to unnecessarily overfill these installations with uncontaminated material, some applications where these material may be useful are sought [1].		
Units of measurement	Percentage of sediments		

Frequency	Annually
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.
References	[1] UNIVERSITY OF WISCONSIN SEA GRANT INSTITUTE. Beneficial Use of Dredged Material. Wisconsin, 2013. [http://www.seagrant.wisc.edu/Home/Topics/PortsHarborsandMarinas/Details.aspx?PostID=641, 25th March 2016]

Indicator's name	Percentage of polluted dredging sediments		
Category	Port development indicators	**Indicator's code**	G.24.4
Sub category	Port development		
Definition	In general, there is a certain percentage of dredged sediments that are polluted. The most common pollutants found in dredged sediments are heavy metals, oil derivatives, some pesticides, PCBs and TBT [1].		
Importance	It is important to store and treat the polluted sediments separately in order to avoid the release of pollutants. The release of these contaminants could cause severe impacts on the chemical composition of the water column and it could bio accumulate on aquatic fauna and flora. It could be lately transferred through the food chain and affect human health [1]. The contaminated sediments are confined in facilities specifically designed for this purpose [2].		
Units of measurement	Percentage of sediments polluted		
Frequency	Annually		
Level of effort	**Intermediate level:** the information required by the indicator is not very complex, but it requires certain research to be obtained.		
References	[1] UK MARINE SAC PROJECT. *Dredging and disposal: Contaminated sediments*. United Kingdom, 2001. [http://www.ukmarinesac.org.uk/activities/ports/ph5_2_5.htm, 25th March 2016] [2] UNIVERSITY OF WISCONSIN SEA GRANT INSTITUTE. *What is Dredging?*. Wisconsin, 2013. [http://www.seagrant.wisc.edu/Home/Topics/PortsHarborsandMarinas/Details.aspx?PostID=640, 25th March 2016]		

Annex XIV: Recommendations

Recommendation	To monitor the GHG emissions (Carbon Footprint)	**Recommendation code**	R.1.1
Definition	The Carbon Footprint is a measure of the total amount of greenhouse gas (GHG) emissions caused directly and indirectly by an individual, organisation, event or product. 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). The results are given in tonnes of carbon dioxide equivalent (CO_2e). This is the unit of measurement which allows different greenhouse gases to be compared on a like for like basis relative to one unit of CO_2. CO_2e emissions are calculated by multiplying the emissions of each of the six greenhouse gases by its 100 year global warming potential (GWP) [1]. For example, the 100 year GWP of methane is 34, so it means that methane emissions are multiplied by 34 in order to convert them into CO_2e.		
Contents	The calculation of the Carbon Footprint of an organisation encompasses a wide range of emissions sources. The Greenhouse Gas Protocol (GHG Protocol) classifies the GHG emissions by the level of control an organisation has over them. On this basis, there are three main types, known as scopes [1]: **Scope 1: Direct emissions that result from the activities that the organisation controls** These include stationary sources (operational machines and cranes, heating or cooling) and mobile sources (company owned vehicles such as cars or vessels). **Scope 2: Emissions from electricity usage** It includes electricity used for harbour lightning, and for the heating and lightning of the buildings. It also includes electricity usage by cranes, lighthouses, or electricity usage for other purposes. Although the organisation is not directly in control of the emissions, by using the electricity it is indirectly responsible for the release of CO_2. **Scope 3: Indirect emissions from sources that the organisation does not directly control** Examples of scope 3 include the employees' commuting and the employees' business travel. With regards to the calculation of the Carbon Footprint, all Scope 1 and Scope 2 emissions should be included in the calculation, but the authority can choose which Scope 3 emissions includes, if any, because it is considered as 'voluntary' by the GHG Protocol. An increasing number of port authorities are committing themselves to calculating, quantifying and reporting their Carbon Footprint. There are two main reasons for calculating the Carbon Footprint [1]: • To identify the 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. • To report the footprint accurately to a third party. Companies are calculating their carbon footprint in order to share the information with other organisations (for public disclosure), to report emissions as part of a Corporate Social Responsibility (CSR) programme or for marketing purposes, to respond to requests from business, customers and investors or to ascertain what level of emissions are needed to offset in order to become 'carbon neutral'. This calculation also may be independently verified to ensure that the methodology has been correctly used and that the results are accurate.		

Recommended indicators	There are four quantitative indicators related to the monitoring of the Carbon Footprint recommended in TEIP: • Total annual greenhouse gas (GHG) emissions by scope (Carbon Footprint) • Frequency of monitoring the GHG emissions (Carbon Footprint) in the port area • Percentage of each energy source contributing to the carbon footprint • Percentage of annual change in greenhouse gas (GHG) emissions In addition, the indicator 'Total annual greenhouse gas (GHG) emissions by scope' could be reported in a standardised common ground: • Greenhouse gas emissions by annual tonnes of cargo handled • Greenhouse gas emissions by annual TEUs • Greenhouse gas emissions by number of port employees Another indicator that was regrouped was the following one: • Percentage of each scope contributing to the total emissions
Example	The Environmental Report 2014 of the Port of Valencia details the methodology followed to calculate its Carbon Footprint and the total annual CO_2e emissions [2].

Objective No. 45. Calculating the Port of Valencia's carbon footprint

The carbon footprint for the Port of Valencia was calculated for 2010 and 2012, and was validated using the method established in the Climeport project, which was also used to calculate the port's carbon footprint for 2008. The method was validated by a certification body, in accordance with the requirements set out in ISO 14064.

The calculation was based on the following scopes:

Scope 1: The PAV's direct GHG emissions

Scope 2: The PAV's indirect GHG emissions

Scope 3: Other PAV indirect GHG emissions

- Indirect emissions from diesel consumption by concessionaires at the port.
- Indirect emissions from natural gas consumption by concessionaires at the port.
- Indirect emissions from fuel consumption deriving from goods transport within the port facility.
- Indirect emissions from fuel consumption deriving from ships' calls

Thus, the data obtained so far in kilos of CO_2 equivalent per tonne of goods throughput are as follows:

- 2008: 3.12
- 2010: 2.78
- 2012: 2.66

References	[1] Carbon Trust. 2012. *Carbon Footprinting. The next step to reduce your emissions.* [Online]. Available at: https://www.npower.com/idc/groups/wcms_content/@wcms/documents/digitalassets/eskh_pdf_carbon_footprinting.pdf [2] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To differentiate dues for 'Greener' vessels	**Recommendation code**	R.1.2
Definition	It consists that the port authority provides environmentally differentiated port fees as a financial incentive to support and encourage shipping companies to try and reduce environmental impact themselves [1].		
Contents	More and more, port authorities apply environmentally differentiated port fees to encourage shipping companies to take environmental measures that go beyond the legal requirements. The main objective is to reduce both the local air pollution from ships (primarily related to emissions of NO_X, SO_2, particles, noise and chemicals and oils to water) and the pollution with global impact (primarily related to emissions of CO_2 and particles) [1].		

<table>
<tr><td></td><td>To motivate and encourage ship owners to reduce their environmental impact, ports are introducing new environmental discounts for ‘greener’ vessels, such as:
Vessels that are able to connect to electricity at the quayside (Onshore Power Supply), since it is demonstrated that connecting vessels to shore side electricity reduces noise pollution and emissions to the atmosphere [2]
Vessels fuelled with LNG, since they do not emit SO_2 or particles into the atmosphere. In addition, these vessels emit reduced emissions of CO_2 and NO_x,(85% less) [2]
Vessels that comply with a voluntary speed limit in the port authority’s waters as a way to reduce ships’ emissions [3].
Vessels that report good environmental performance, for instance on the Environmental Ship Index (ESI) [4], the Clean Shipping Index (CSI) [5] or on the Green Award [6].</td></tr>
<tr><td>Example</td><td>Ports of Stockholm has applied environmentally differentiated port fees since the 1990s. The discounts that this port authority provides to shipping companies are described below [7]:</td></tr>
<tr><td colspan="2"><h1>Prices for services/tariffs</h1> From 2015 Ports of Stockholm will apply new environmentally differentiated fees to encourage shipping companies to implement environmental initiatives over and above the legal requirements. In summary the environmental rebates are the following: A funding contribution of SEK 1 million will be offered to every vessel that carries out restructuring work to enable the vessel to connect to electricity at the quayside. This applies for the quays where Ports of Stockholm offers quayside electricity connection capabilities.
The port fee for LNG vessels will be discounted by 5 öre per unit of gross tonnage. For a vessel of the size of Viking Grace, calling at Stockholm daily, this amounts to a rebate of around SEK 1 million annually. For a vessel calling at Stockholm every second day the rebate will be around SEK 500 thousand annually.
The discount for reduced emission of nitrous oxide will follow the seven-level scale applied by the Swedish Maritime Administration. For a normal-sized vessel operating daily calls this will mean a discount of between SEK 3 million to SEK 4 million annually, depending on the amount of nitrous oxide emissions.</td></tr>
<tr><td>References</td><td>[1] CLEANSHIP. 2013. Clean Baltic Sea Shipping. Project Report.
[2] GREEN4SEA. 2014. Ports of Stockholm applies differentiated port fees for LNG vessels [Online] Available at: http://www.green4sea.com/ports-of-stockholm-applies-differentiated-port-fees-for-lng-vessels/
[3] OECD, 2011.
[4]: http://www.environmentalshipindex.org/Public/Home
[5] http://www.cleanshippingindex.com/
[6] http://www.greenaward.org/greenaward/
[7] Ports of Stockholm. 2015. Prices for services / tariffs. [Online] Available at: http://www.portsofstockholm.com/about-us/prices-for-servicestariffs/</td></tr>
</table>

Recommendation	To provide Onshore Power Supply (OPS)	**Recommendation code**	R.1 1.1
Definition	Onshore Power Supply (OPS) is one strategy that consists of connecting vessels into the electricity grid in order to reduce the exhaust emissions of seagoing vessels in ports.		
Contents	Ships require electricity when they are berthed to support activities like loading, unloading, heating, lighting and operation of other on-board activities. Today, this power is generally provided by auxiliary engines that emit carbon dioxide (CO_2), air pollutants and noise, affecting local air quality and ultimately the health of both port workers and nearby residents [1]. Governments have therefore set air quality standards for air pollutants, which many port cities have problems to meet [2]. The European Union directive on low sulphur fuel (2005/33/EC) limits the sulphur content in marine fuel to 0.1% (from 1%) for ships at berth in order to reduce the emissions discharge from vessels [3]. As an alternative to reduce these emissions, vessels can be connected to the local electricity grid, in what is known as Onshore Power Supply (OPS). In this way, ships' operations can proceed uninterrupted and the negative environmental effects, such as noise and air pollution are reduced, since the ships' auxiliary engines can be switched off [1]. Nowadays, ports are not normally equipped to supply vessels with electricity from the dockside, and vessels are usually not equipped to receive power in this way. Nevertheless, around the world, many activities in this direction are now underway and interest in the technology is growing rapidly. This technology is encouraged by the fact of having more restrictive environmental legislation and the rise of fuel prices [1]. Using OPS could be profitable for regular shipping lines that commonly berth at the same dock. On this assumption, most of the technological developments will take place at berths for ferries and RoRo ships. Consequently, ports with many regular shipping lines are more interested in implementing OPS facilities. At container terminals, where vessels do not always dock at the same position, there is a need for more connection points, which makes the implementation of OPS facilities more complicated [2]. In addition, another disadvantage of OPS is the voltage and frequency variations in different parts of the world. For instance, North America and Japan operate on 60 Hz and the rest of the world on 50Hz. Electrical frequencies also differ among vessel categories and sizes. Ocean-going vessels calling at European ports tend to have 60 Hz electrical systems on-board, whereas smaller vessels (not sailing to other continents) have 50 Hz systems. Depending on the particular local situation, a frequency converter and/or an on-board transformer are needed. The difference in the voltages also has to be considered. Small vessels require low-voltage systems (typically 400-480 V) for lighting, heating and for charging batteries. However, large ships require high-voltage systems (6.6 -11 kV) and they would need an on-board transformer [4]. It is recommended that ports interested in establishing this methodology should find out which vessel fleet of the port would be the most suitable for OPS, preferably frequent-calling vessels with long port stays and offering the greatest emission reduction potential. The port should determine the best technical approach by collecting data on electrical systems, voltages, frequencies, fuel quality and fuel consumption on the vessels in question [2].		

	This issue is being researched at ports by several working groups. For example, the World Ports Climate Initiative (WPCI) established a working group on Onshore Power Supply (OPS). This group aims at providing practical information about OPS to port authorities, terminal operators and shipping companies considering introduction or expansion of this technology [5].
Recommended indicators	There is one indicator related to the provision of Onshore Power Supply, which is the following one: • Annual number of vessels connected to shore-side electricity Another way to express the OPS performance in a port is the following one: • Percentage of vessels calling at the port that connect to shore-side electricity
Example	In 2000, the Port of Gothenburg was the first port in the world to offer onshore high voltage power for commercial shipping. In 2013, the Port of Gothenburg reduced its carbon dioxide emissions by 6400 tonnes thanks to the OPS [6]. According to the Sustainability Report of Gothenburg Port Authority 2015, 32% of vessel calls had the capacity to connect to OPS in 2015 [7], as showed in the picture below.

	2012	2013	2014	2015	Measurement and calculation method/notes
Percentage of vessel calls that can connect to quayside onshore power supply	34	30	37	32	The percentage is produced using calling statistic for vessels that have been equipped for quayside onshore power supply.

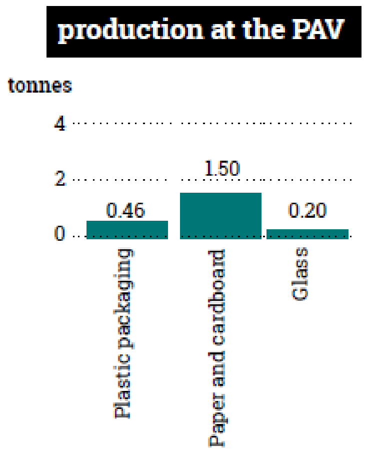
References	[1] WPCI. 2015. What is OPS? [Online]. Available at: http://www.ops.wpci.nl/what-is-ops-/what-is-ops--1/ [2] CLEANSHIP. 2013. Clean Baltic Sea Shipping. Project Report. [3] European Comission. 2005. Directive 2005/33/EC of the European Parliament and of the Council of 6 July 2005 amending Directive 1999/32/EC as regards the sulphur content of marine fuels. [4] WPCI. 2015. Implement and solutions. [Online]. Available at: http://www.ops.wpci.nl/implementation-1/equipment-and-solutions/ [5] WPCI. 2015. Onshore Power Supply. [Online]. Available at: http://wpci.iaphworldports.org/onshore-power-supply/ [6] Port of Gothenburg. 2013. Sustainability Report of Gothenburg Port Authority 2013. [7] Port of Gothenburg. 2015. Sustainability Report of Gothenburg Port Authority 2015.

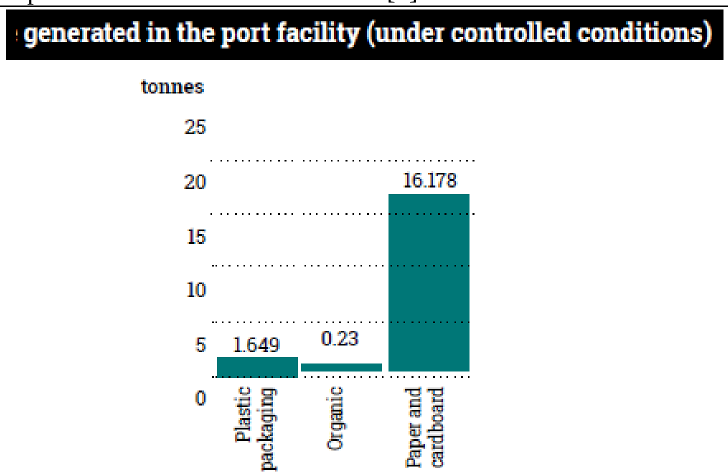
Recommendation	To provide Liquefied Natural Gas (LNG) bunkering	**Recommendation code**	R.12.1
Definition	LNG is an alternative fuel for seagoing vessels, inland vessels and trucks. The use of Liquefied Natural Gas as a fuel emits fewer polluting substances than other fuels [1]. If a port provides LNG bunkering, it is considered as a green initiative.		
Contents	The new regulations from the International Maritime Organization (IMO) demand a decrease of sulphur content in maritime fuel in the Sulphur Emission Control Area (SECA) from 1.0% to 0.1%. Therefore, ship owners and other stakeholders have to consider new solutions to develop competitiveness of shipping and to avoid the modal shift from ships to land-based transport. One established possible alternative to meet this demand is the use of Liquefied Natural Gas (LNG) [2]. Natural gas is widely used around the world by industries, power plants, for heating purposes and for transportation on land and sea. By cooling it down to a temperature of -163°C at atmospheric pressure, the natural gas becomes liquid, containing more energy (600 times more) per litre, and is easier to deliver in the transportation chain, including storage and bunkering. It primarily consists of methane (typically at least 90%), is odourless, colourless, non-corrosive and non-toxic. The flammability range limits are 5 -		

	15% in the air. LNG is the cleanest fossil fuel available and when compared to conventional diesel engines it has potential to reduce emissions as follows [3]: • NO_x – 92% • CO_2 – 23% • SO_2 – 100% • Particulate matter – 100% For this reason, when fuelling a ship with LNG no additional reduction measures are needed in order to meet the SECA requirements. Other advantages of using LNG as a fuel are [1]: • LNG-powered engines require less maintenance • LNG-powered engines are much quieter • LNG is cheaper than other petroleum-based fuels • LNG has a higher energy value than other fossil fuels • Port authorities may give incentives or reduced fees to LNG propelled vessels. However, there are also some disadvantages. A LNG-fuelled ship requires purpose built or modified engines and a sophisticated system of special fuel tanks, a vaporiser, and double insulated piping, making this alternative costly in a short-time perspective. For practical reasons, LNG as marine fuel is most convenient for vessels which can refuel relatively often, that is, port service vessels and short sea shipping vessels (trading between fixed ports where LNG fuel is available). It also should be noted that the methane (CH_4) that has an incomplete combustion generates further emissions of greenhouse gases. Methane is more than 20 times more powerful than CO_2 as a greenhouse gas. Engine manufactures are aware of this challenge and research is being carried out to minimize the methane slip [2]. It is expected that both the number of merchant ships using LNG and the number of ports where LNG is available will increase significantly in the coming years. Around one hundred vessels in the world used LNG as a fuel in 2014, and the number of new-build LNG-fuelled ships is increasing rapidly [4]. According to the European Commission's Clean Fuel Strategy, there will be even more focus on LNG, since the Commission is proposing that LNG refuelling stations should be installed in all maritime ports of the TEN-T core network by end 2025 and at all inland ports of the TEN-T core network by end 2030 [5]. Focusing on the use of LNG as a marine fuel, the World Ports Climate Initiative (WPCI) (as part of the International Association of Ports and Harbours, IAPH) has established a LNG Fuelled Vessels Working Group. The Working Group has developed guidelines on safe procedures for LNG bunkering operations, providing ports around the world with implementation guidelines to pursue this technology [4].
Example	In March 2013, Ports of Stockholm became one of the first ports in the world to offer a bunkering infrastructure solution for the provision of LNG to a larger passenger ferry (Viking Grace) [2]. Other ports where LNG is currently available as a bunker fuel for maritime and inland shipping are Antwerp, Amsterdam, Rotterdam, or Zeebrugge. Many other ports are planning to implement LNG bunkering in the next years [4]. Below, an example of the LNG provisions of the Port of Rotterdam is displayed [6].
Liquefied natural gas in the port of Rotterdam • LNG terminal with a capacity of 12 billion m3 for import and re-export • The adjacent LNG break bulk terminal will be operational from mid-2016 • Large investments in LNG infrastructure • LNG as a cleaner fuel for shipping and road transport • Bunkering of LNG is permitted, facilitated and encouraged	
References	[1] Port of Rotterdam. 2015. LNG as a fuel for vessels and trucks [Online]. Available at: https://www.portofrotterdam.com/en/cargo-industry/lng-liquefied-natural-gas/lng-as-a-fuel-for-vessels-and-trucks [2] CLEANSHIP. 2013. Clean Baltic Sea Shipping. Project Report.

	[3] DNV 2010. Greener Shipping in the Baltic Sea. [Online]. Available at: http://www.dnv.fi/Binaries/Greener%20Shipping%20in%20the%20Baltic%20Sea_tcm146-429433.pdf [4] World Ports Climate Initiative. 2015. LNG fuelled vessels. [Online]. Available at: http://www.lngbunkering.org/ [5] European Commission. 2015. Clean transport, Urban transport [Online]. Available at: http://ec.europa.eu/transport/themes/urban/cpt/index_en.htm [6] Port of Rotterdam. 2015. LNG: import, export and bunkering. [Online]. Available at: https://www.portofrotterdam.com/en/cargo-industry/lng-import-export-and-bunkering

Recommendation	To monitor the recyclable garbage generated within the port area	**Recommendation code**	R.13.1
Definition	Recyclable garbage includes materials that are collected in the port and that can be recycled. It is recommended to monitor the amount of recyclable garbage that is generated directly by the port authority and indirectly by other tenants and operators.		
Contents	The recyclable garbage that may be generated in a port are organic waste, paper and cardboard, plastic and glass.		
Recommended indicators	There are two indicators related to the generation of port waste that are recommended for monitoring: • Amount of recyclable garbage collected by type • Amount of recyclable garbage recycled by type These two indicators also include the following two: • Percentage of each type of port recyclable garbage collected • Percentage of each type of port recyclable garbage recycled		
Example	The examples below display firstly the types of recyclable garbage generated in the Port Authority of Valencia (PAV), and secondly the recyclable garbage generated in the port facility under controlled conditions. These two graphs are reported in the Environmental Report 2014 of the Port of Valencia [1].		

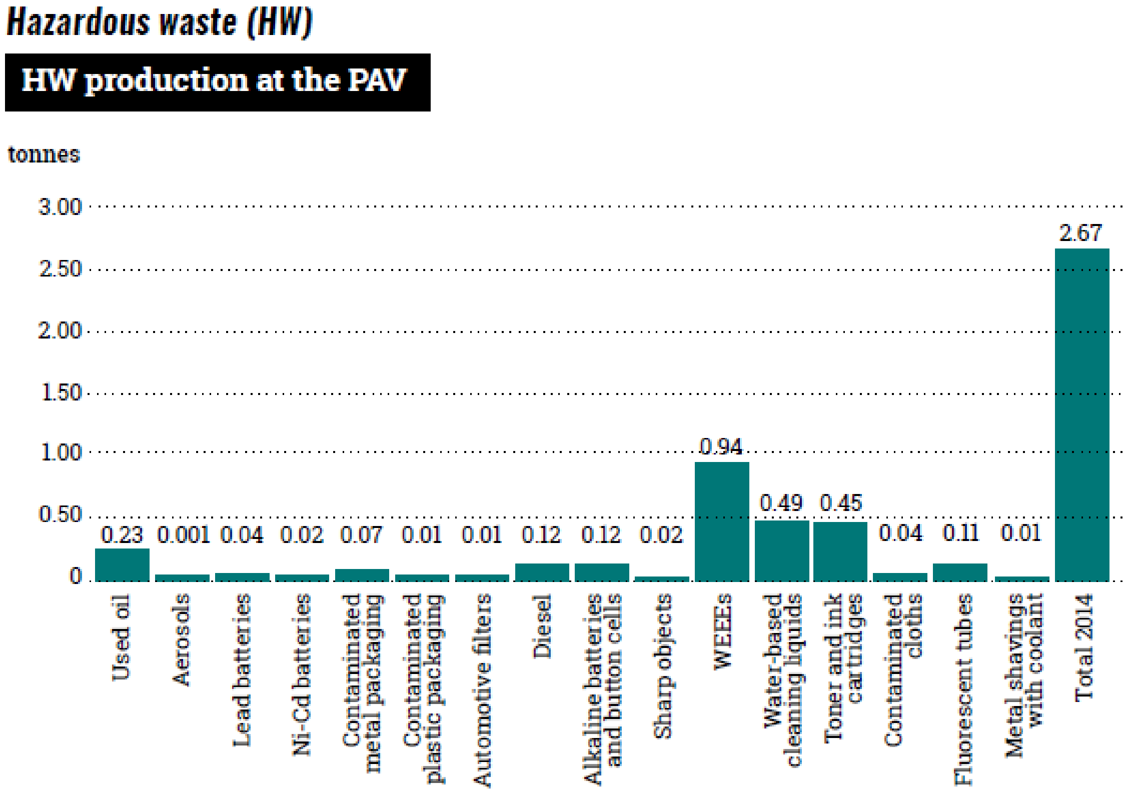


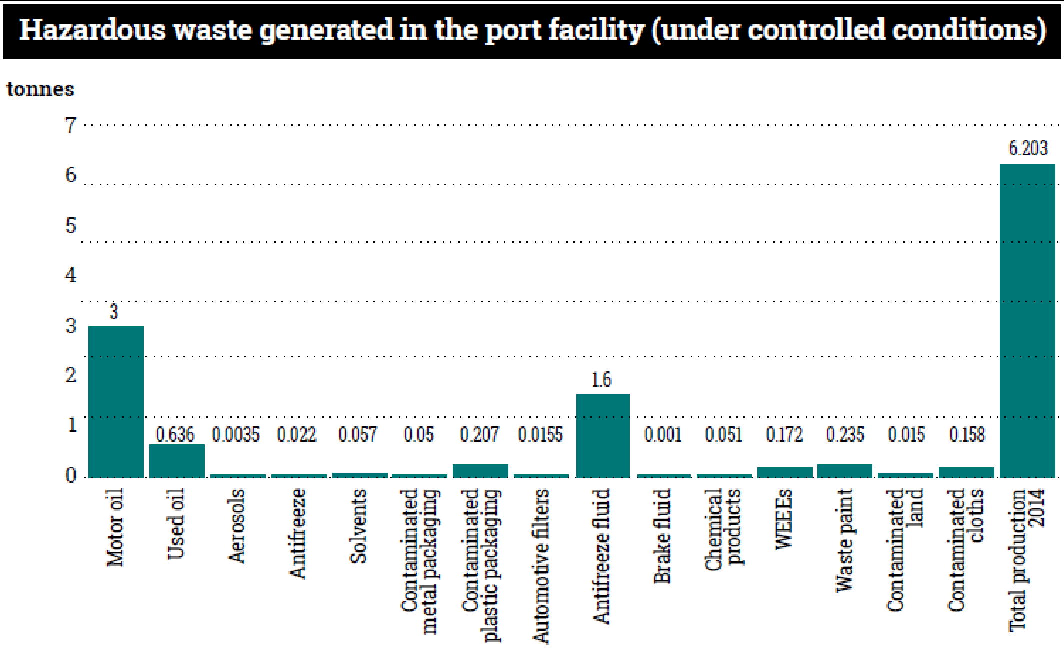


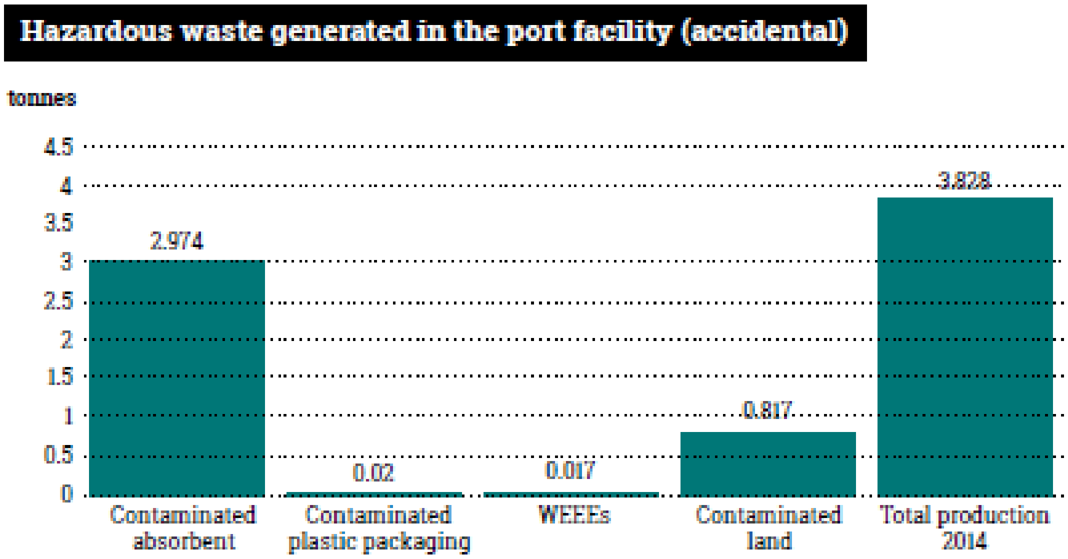
References	[1] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To monitor the hazardous waste generated within the port area	**Recommendation code**	R.14.1
Definition	Hazardous waste is defined as a used or discarded material that can damage the environment and can be harmful to health [1]. It is recommended to monitor the amount of hazardous waste that is generated directly by the port authority and indirectly by other tenants and operators.		
Contents	Typical examples of hazardous waste that may be generated in ports include ink cartridges, used oil, fluorescents, aerosols, automotive filters, waste, electrical and electronic equipment, and batteries.		

Recommended indicators	There are two indicators related to the generation of port hazardous waste that are recommended for monitoring in the TEIP tool: • Amount of port hazardous waste collected by type • Amount of port hazardous waste recycled by type These indicators also may be expressed as: • Annual amount of port hazardous waste collected per number of employees • Annual amount of port hazardous waste collected per cargo handled • Percentage of each type of port hazardous waste collected • Percentage of each type of port hazardous waste recycled • Annual amount of oil collected and recycled
Example	The examples below display firstly different types of hazardous waste generated in the Port Authority of Valencia (PAV), secondly the hazardous wastes generated in the port facility under controlled conditions and, finally, the hazardous wastes generated in the port facility under accidental conditions. These three graphs are reported in the Environmental Report 2014 of the Port of Valencia [2].



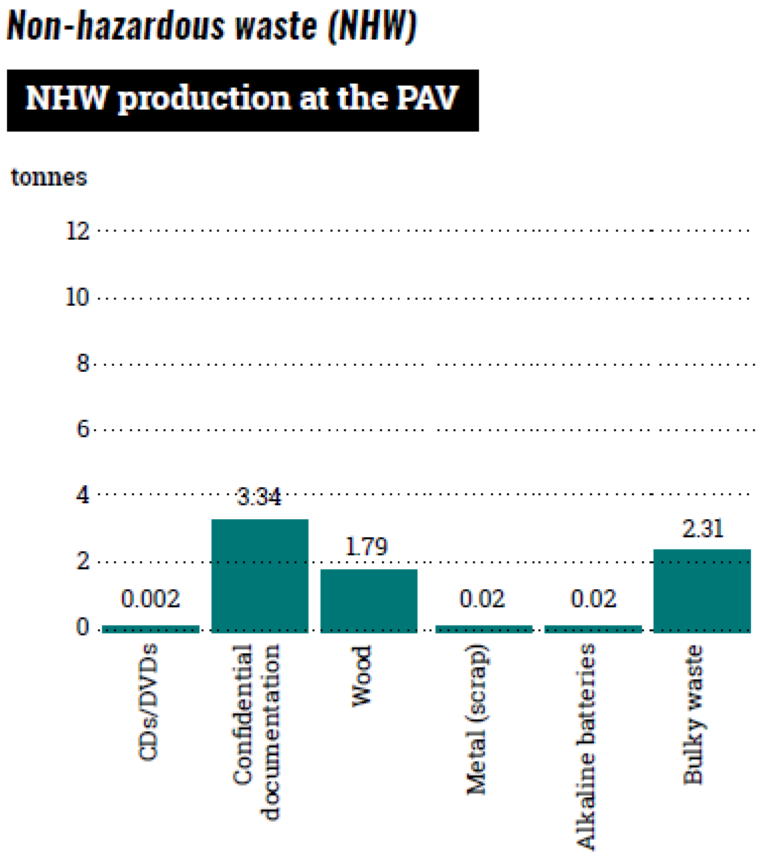


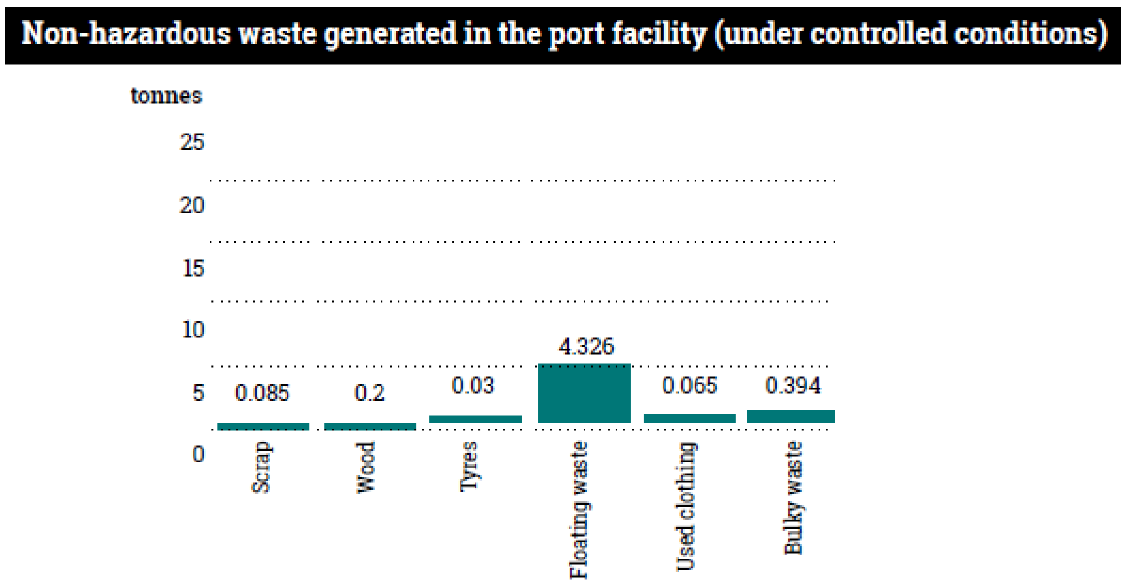


References	[1] Dictionary.com. Hazardous waste. [Online]. Available at: http://www.dictionary.com/browse/hazardous-waste [2] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

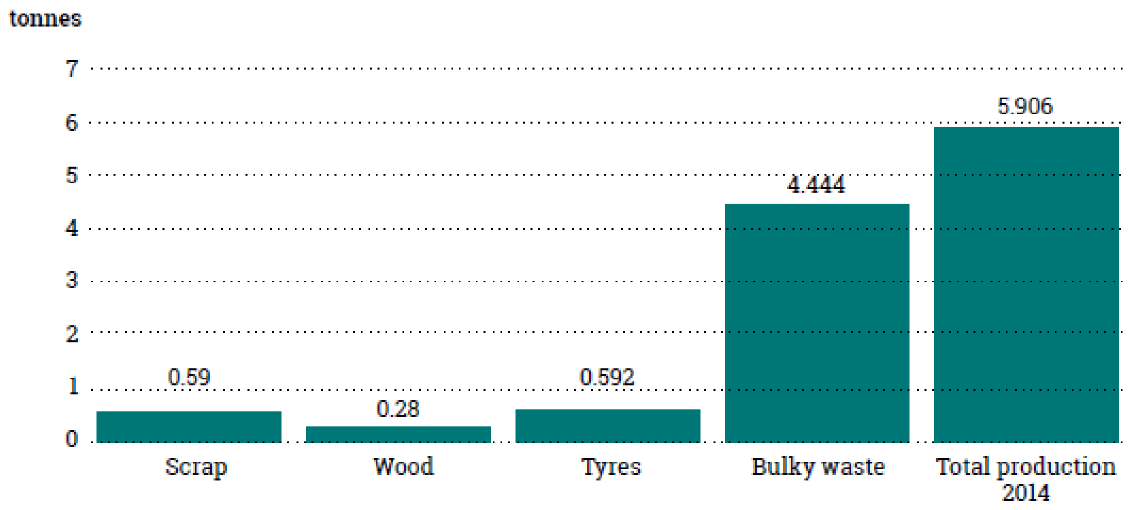
Recommendation	To monitor the non-hazardous waste generated within the port area	**Recommendation code**	R.15.1
Definition	Non-hazardous waste includes the waste that it is neither recyclable garbage (paper, plastic and glass) nor hazardous waste. It is recommended to monitor the amount of non-hazardous waste that is generated directly by the port authority and indirectly by other tenants and operators.		
Contents	Typical examples of non-hazardous waste that may be generated in ports include wood, metal scrap, alkaline batteries and bulky waste.		
Recommended indicators	There are two indicators related to the generation of port non-hazardous waste that are recommended for monitoring: • Annual amount of port non-hazardous waste collected by type • Annual amount of port non-hazardous waste recycled by type These two indicators also include the following two:		

	• Percentage of each type of port non-hazardous waste collected • Percentage of each type of port non-hazardous waste recycled
Example	The examples below display firstly the types of non-hazardous waste generated in the Port Authority of Valencia (PAV), secondly the non-hazardous wastes generated in the port facility under controlled conditions and, finally, the non-hazardous wastes generated in the port facility under accidental conditions. These three graphs are reported in the Environmental Report 2014 of the Port of Valencia [2].



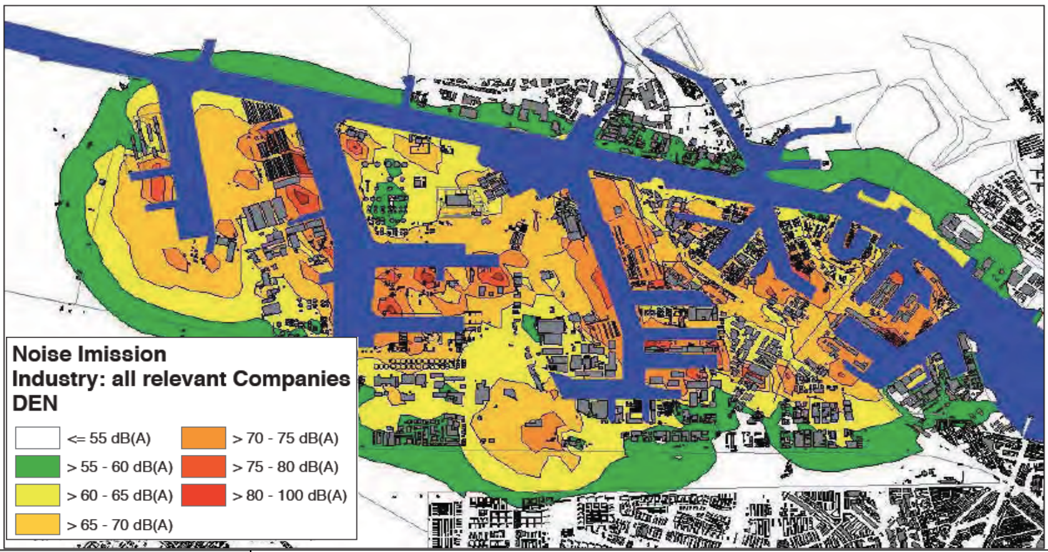


Non-hazardous waste generated in the port facility in 2014 (accidental)



References	[1] EcoPorts Foundation. 2004. *Guidelines for Self-Diagnosis Method SDM*. Version 1.4. [2] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To have a noise zoning map	**Recommendation code**	R. 16 .1
Definition	This recommendation aims at having a noise zoning map in the port area		
Contents	Noise mapping is the geographic presentation of data related to outdoor noise levels and noise exposure with associated information on impact to the affected population [1]. Noise mapping provides port authorities with the basic information necessary to identify sources of noise generated in the port area that cause the greatest impact. There is a wide range of noise potential sources, including industrial activities and transport operations such as road, rail and air [2]. For this reason, a noise map shows the areas where mitigation is needed [1]. Noise management tools may be used by port authorities to select the best location in the port area for a particular activity. Action plans provide a tool for planning future port development in terms of implications of noise issues related to expansion, investment and compliance with legislation. Further information on how to set up a noise zoning map is provided in the report Good Practice Guide on Port Area Noise Mapping and Management [2], which was published as a result of the research project Noise Management in European Ports (NoMEPorts) (2005-2008).		
Recommended indicators	Although the TEIP programme provides several indicators on the noise monitoring, it does not provide any specific indicator related to noise-zoning maps.		
Example	Below, a noise map of the Port of Amsterdam is provided. This map was provided as an example of best practice on the NOMEPORT Project report [2].		



References	[1] METRANS. 11-26 Noise Mapping of Container Terminals at the Port of Los Angeles. Los Angeles, 2011. [https://www.metrans.org/research/11-26-noise-mapping-container-terminals-port-los, 25th of March 2016] [2] NOMEPORTS PROJECT. 2008. *Good Practice Guide on Port Area Noise Mapping and Management*. Amsterdam, Port of Amsterdam.

Recommendation	To monitor noise in port areas	**Recommendation code**	R.16.2
Definition	Noise is defined as unwanted sound [1].		
Contents	Noise is generated mainly by mechanical and industrial activities. 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 [2]. Road traffic includes passenger cars, trucks and heavy vehicles. Cargo operations refer to noise from machinery such as quay-crane, pumps, among others [2]. 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 [1]. 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 [3]. Since noise pollution has become an increasingly significant environmental issue for many port authorities [4], 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. Research projects on noise have been conducted to investigate more about this issue. In particular, in ports 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 [5].		
Recommended indicators	There are three indicators specifically related to noise monitoring suggested in the TEIP tool: • Level of noise in terminal and industrial areas • Maximum level of noise in terminals and industrial areas • Frequency of noise measurements The first one 'Level of noise in terminal and industrial areas' is obtained as a result of joining several noise indicators:		

	• Level of noise in terminals and industrial areas Lden (overall day-evening-night) • Level of noise in terminals and industrial areas Lday (7:00 – 19:00 h) • Level of noise in terminals and industrial areas Levening (19:00-23:00h) • Level of noise in terminals and industrial areas Lnight (23:00 – 7:00 h) • Level of noise in terminals and industrial areas Lday (7:00 - 22:00 h) • Level of noise in terminals and industrial areas Lnight (22:00 - 7:00 h) • Average noise exposure during an 8-hour working day
Example	The Port Authority of Valencia has three sound level meters to carry out the monitoring of the noise emissions in the port area. These three meters are strategically sited on the port-city interface and enable noise quality to be analysed practically in real time (). The sites of the noise monitoring terminals are shown in the figure below, along with the 2014 annual average noise levels in each station for daytime, evening and night [6]:

Daytime 7:00-19:00	2014
IMMISSION STATION	68 dBA
TUNNEL	68 dBA
RIVER TURIA STATION	63 dBA

Evening 19:00-22:00	2014
IMMISSION STATION	63 dBA
TUNNEL	64 dBA
RIVER TURIA STATION	61 dBA

Nighttime 23:00-06:00	2014
IMMISSION STATION	57 dBA
TUNNEL	55 dBA
RIVER TURIA STATION	54 dBA

References	[1] EcoPorts Foundation. 2004. *Guidelines for Self-Diagnosis Method SDM*. Version 1.4. [2] Trozzi, C. and Vaccaro, R. 2000. Environmental impact of port activities. In: Brebbia, C.A. and Olivella, J. Eds. Maritime engineering and ports II. Sothampton, Boston: WIT Press, pp. 151 – 161. [3] OECD (Organisation for Economic Co-operation and Development). 2011. Environmental Impacts of International Shipping: The Role of Ports. OECD Publishing. [4] Puig, M., Wooldridge, C., Michail, A., Darbra, R.M. 2015. Current status and trends of the environmental performance in European ports. Environmental Science and Policy 48, pp. 57-66. [5] NoMEPorts. 2008. Good Practice Guide on Port Area Noise Mapping and Management. Amsterdam: Port of Amsterdam [6] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To have a meteorological station	**Recommendation code**	R.18.1
Definition	Meteorological stations measure a large variety of different meteorological parameters, including air temperature; atmospheric pressure; rainfall; wind speed and direction, and humidity [1].		
Contents	Since air pollutants are released to the atmosphere, the meteorological parameters are important because they influence on the transport and dispersion of these pollutants. The information provided by these stations is extremely useful for decision-making in a range of port operations, for instance solid bulk operations, where handling has to be stopped when winds reach a specific speed to avoid the possible release of particles into the air [2]. In the market, there are compact weather stations that allow monitoring of all parameters included in this indicator, such as the weather station HD52 manufacturer Delta OHM [3].		

Recommended indicators	The recommended indicator is the Meteorological Data indicator. It includes these seven indicators:
	• Temperature (ºC)
	• Relative Humidity (%)
	• Surface wind pattern
	  - Wind speed (m/s)
	  - Wind direction (0 - 360º)
	• Rainfall (mm)
	• Atmospheric pressure (hPa)
	• Solar Radiation (W/m^2)
	• Cloudiness		

Example	An example of weather data is provided by the Port of Valencia in its Environmental Report 2014 [2]. It is mentioned that The Port Authority of Valencia currently has eight strategically sited weather stations: five at the Port of Valencia, two at the Port of Sagunto and one at the Port of Gandia. The example below shows monthly statistical data on three parameters (wind speed, temperature and relative humidity) recorded at one measuring station of the port authority.		

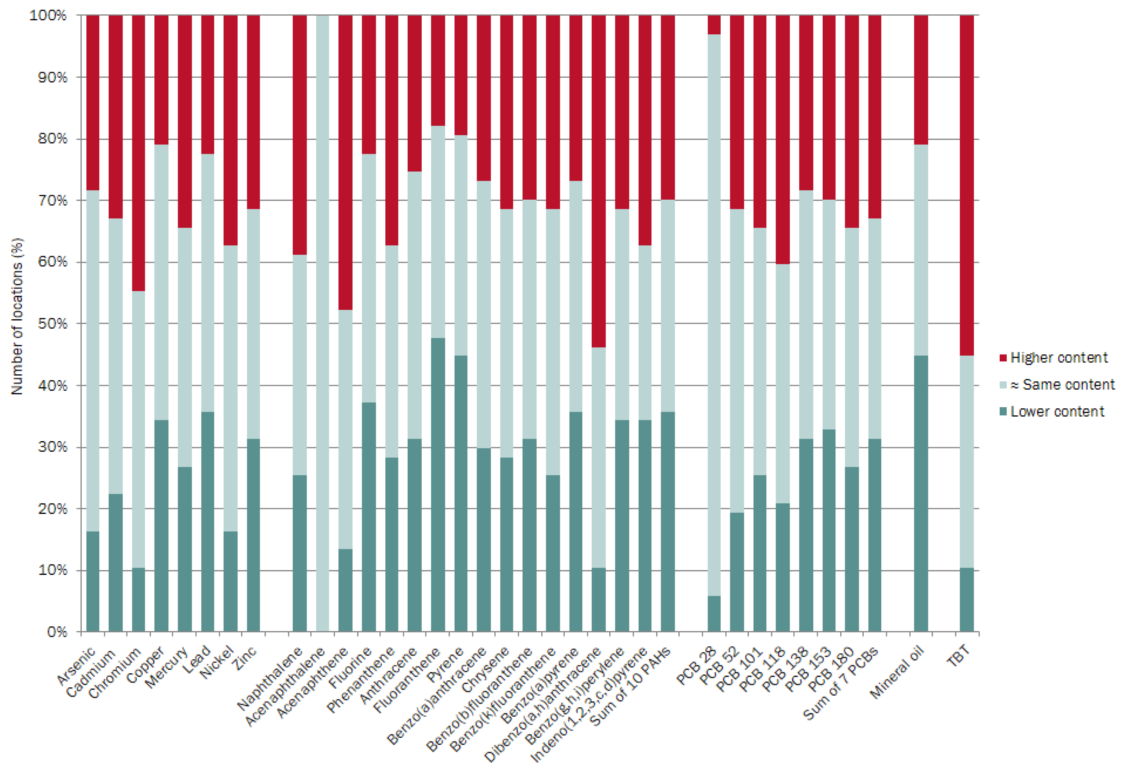
Monthly statistics from the station MA.V.7.PRINCIPE FELIPE. EM6 - 2014

	WS (M/S)				TMP (ºC)				RH (%)			
	Samples	Average	Max.	Min.	Samples	Average	Max.	Min.	Samples	Average	Max.	Min.
January	30	4.05	9.28	0.77	30	13	17.8	10.3	30	43.1	66.3	26.3
February	28	4.34	9.18	1.33	28	13	19.1	9.9	28	40.7	59.6	21.2
March	19	4.53	10.8	1.49	19	14	17.1	11.8	19	44.8	63.6	21.4
April	30	3.13	5.27	1.46	30	17	21.6	14.2	30	48.1	68.5	21.9
May	31	3.23	5.98	1.38	31	19	21.5	17.8	31	45.7	58.0	20.2
June	30	2.58	4.47	1.15	30	23	25.8	19.9	30	49.5	59.5	36.5
July	31	3.01	6.00	1.67	31	25	28.6	22.8	31	47.9	63.6	21.7
August	27	2.75	4.91	1.45	27	26	27.8	24.8	27	51.2	55.9	35.7
September	30	2.28	3.80	1.13	30	25	28.7	20.6	30	48.9	59.3	30.9
October	31	2.25	5.57	0.99	31	22	24.7	19.3	31	44.1	57.1	26.2
November	30	3.30	6.79	0.67	30	16	20.2	11.6	30	45.2	60.8	22.9
December	18	2.11	8.64	0.72	18	11	16.7	6.38	18	42.7	63.4	18.8

References	[1] Met Offices. Weather station. [Online]. Available at: http://www.metoffice.gov.uk/learning/science/first-steps/observations/weather-stations [2] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia. [3] Alava Ingenieros, 2016. [Online]. Available at: http://www.alava-ing.es/ingenieros/productos/sensores-adquisicion-de-datos-y-calibracion/sensores-y-acondicionadores-de-senal/parametros-meteorologicos/estaciones-meteorologicas/documentos/

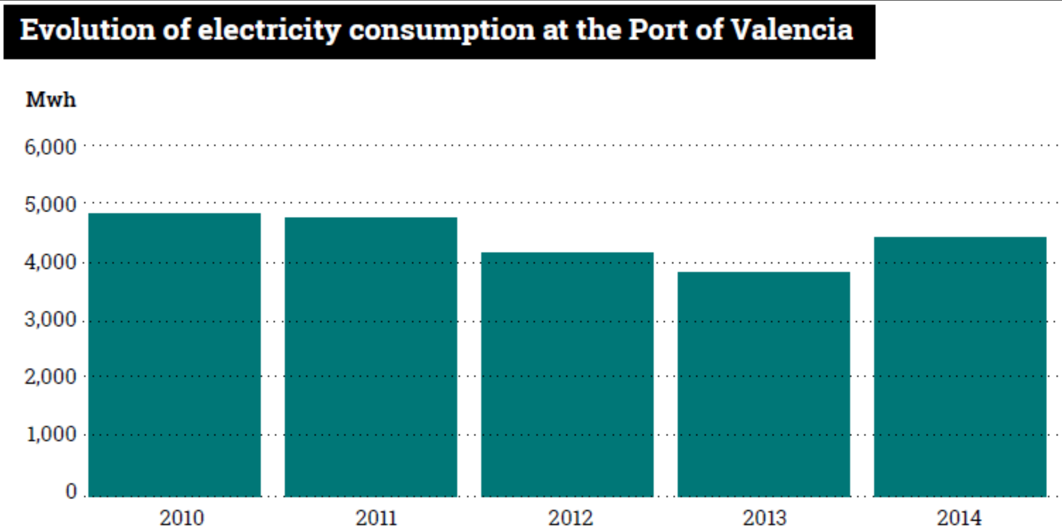
Recommendation	To monitor sediments quality	**Recommendation code**	R.19.1
Definition	Water sediments are fragmented materials that originate from erosion of rocks and are transported by, suspended in, or deposited by water [1]. Sediment emissions include any kind of liquid discharge such as fuel, or solid product such as waste, that reaches the bottom of the sea [2]. This recommendation aims at monitoring the quality of the sediments located within the port waters.		
Contents	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. Dredging activities, which are carried out in a port to maintain its navigation channels, also may contribute to re-suspend the sediments. 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 [3]. For all the above-mentioned reasons, it is highly recommended to monitor the quality of the sediments. The main measure to prevent bottom contamination is, first of all, avoiding discharges with contaminants to water.		
Recommended indicators	In the TEIP tool, there is one recommended indicator that is related to the physical characteristics of the sediments. This indicator is: • Sediments particle size distribution In addition, there are 9 indicators related to the monitoring of pollutants in the sediments. These indicators are: • Nutrients • Redox potential		

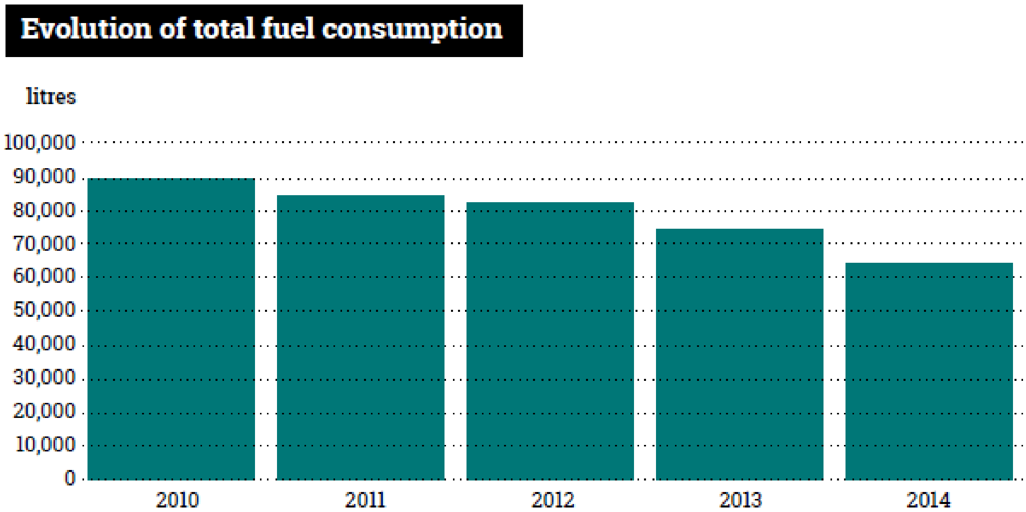
	• Total Organic Carbon (TOC) • Volatile Organic Compounds (VOCs) • Heavy metals • Tributyltin (TBT) • Persistent organics • Polychlorinated biphenyl (PCB) • Polycyclic aromatic hydrocarbons (PAHs)
Example	In the port of Antwerp, the overall sediment quality was mapped in the period from November 2014 to February 2015, and it was compared with the results of the same indicators measured in 2010. In the Sustainability Report 2015 of the Port of Antwerp [4] the content of sediments' pollutants at 67 sites of the port were studied. The following graph shows the percentage of variations of these pollutants from 2010 to 2015 for each indicator. As an example, the concentration of arsenic increased in almost 30% of the locations, it had the same content in around 50% of the locations and it had a lower content in almost 20% of the sites. It is demonstrated that chromium, the polyaromatic hydrocarbons acenaftheen and dibenzo (a, h) anthracene, PCB118 and tributyltin (TBT) have higher values at more than 40% of the locations. On the other hand, fluoranthene, pyrene and mineral oil have lower values at more than 40% of the locations. The lower levels of mineral oil may be a result of dredging carried out and the changed approach regarding resolving oil spills.



References	[1] United States Environmental Protection Agency. 2011a. Water: Contaminated Sediments, Overview [Online]. Available at: http://water.epa.gov/polwaste/sediments/cs/index.cfm [2] EcoPorts Foundation. 2004. Guidelines for Self-Diagnosis Method SDM. Version 1.4. [3] United States Environmental Protection Agency. 2011b. Water: Contaminated Sediments, Basic Information [Online]. Available at: http://water.epa.gov/polwaste/sediments/cs/aboutcs.cfm [4] Port of Antwerp. Sustainability report 2015. [Online]. Available at: http://www.duurzamehavenvanantwerpen.be/sites/default/files/Sustainability_Report_2015_def.pdf

<table>
<tr><td>Recommendation</td><td>To monitor the energy consumption</td><td>Recommendation code</td><td>R.20.1</td></tr>
<tr><td>Definition</td><td colspan="3">This recommendation aims at monitoring the total annual energy consumption of the port authority.</td></tr>
<tr><td>Contents</td><td colspan="3">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 [1], 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 [2]. The consumption of fossil fuels also contributes to the exhaustion of non-renewable resources.
The energy consumption of the port authority comprises several sources. It includes the consumption of electricity, non-renewable energy sources (e.g. fossil fuels and natural gas) and the energy obtained from renewable sources. It is strongly recommended that authorities control and monitor the percentages of the energy sources consumed in the harbour, in order to move towards the use of more sustainable sources.
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 [3].
In addition, in order to reduce the consumption and to have a more efficient management, it is also recommended to monitor the final uses of the energy, A port authority, in general, applies energy for these uses:
• Public lighting or in the port area
• Consumption in port authority's buildings (lighting, air conditioning and power equipment)
• Fleet of terrestrial vehicles
• Fleet of vessels</td></tr>
<tr><td>Recommended indicators</td><td colspan="3">The TEIP tool suggests three indicators related to the energy consumption. These indicators are:
• Total annual energy consumption
• Percentage of the annual variation in the energy consumption
• Percentage of renewable energy per total energy consumed
The first one compiles, at the same time, other indicators:
• Total annual energy consumption by energy source
• Percentage of each energy source
• Percentage of energy consumption by use
• Energy consumption per cargo handled
• Energy consumption per number of employees</td></tr>
<tr><td>Example</td><td colspan="3">The Port of Valencia monitors the annual amount electricity (MWh) and fuel (litres) consumed by the port authority [4]. In this way, it allows to draw the evolution of these consumptions year over year.</td></tr>
</table>

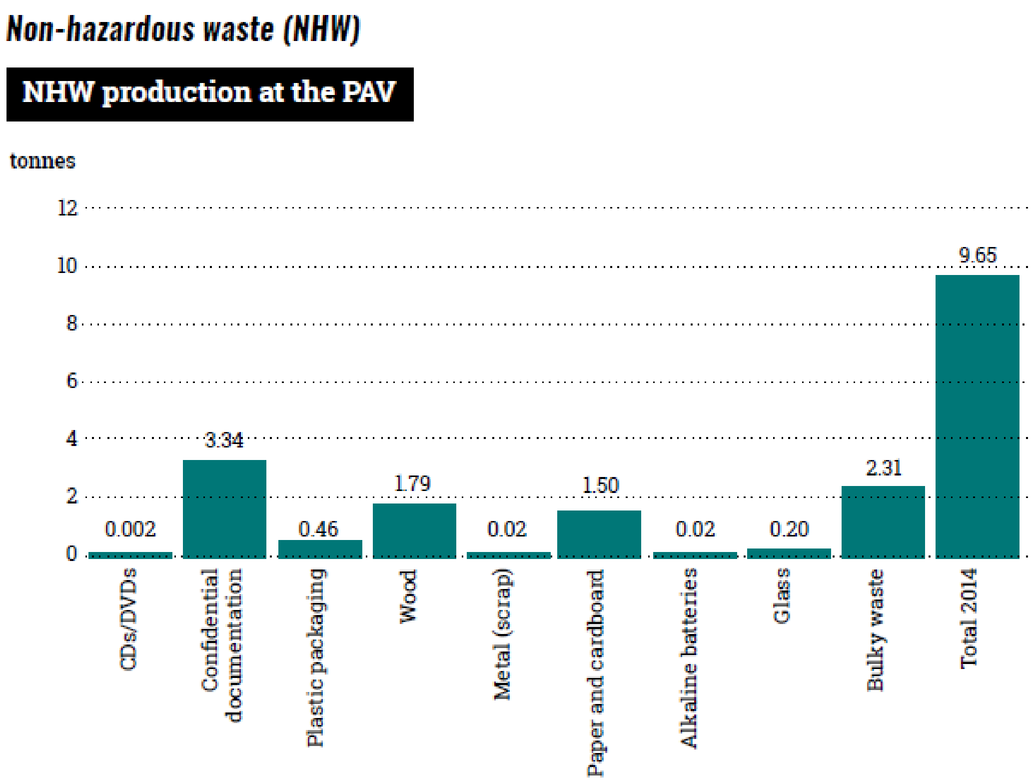


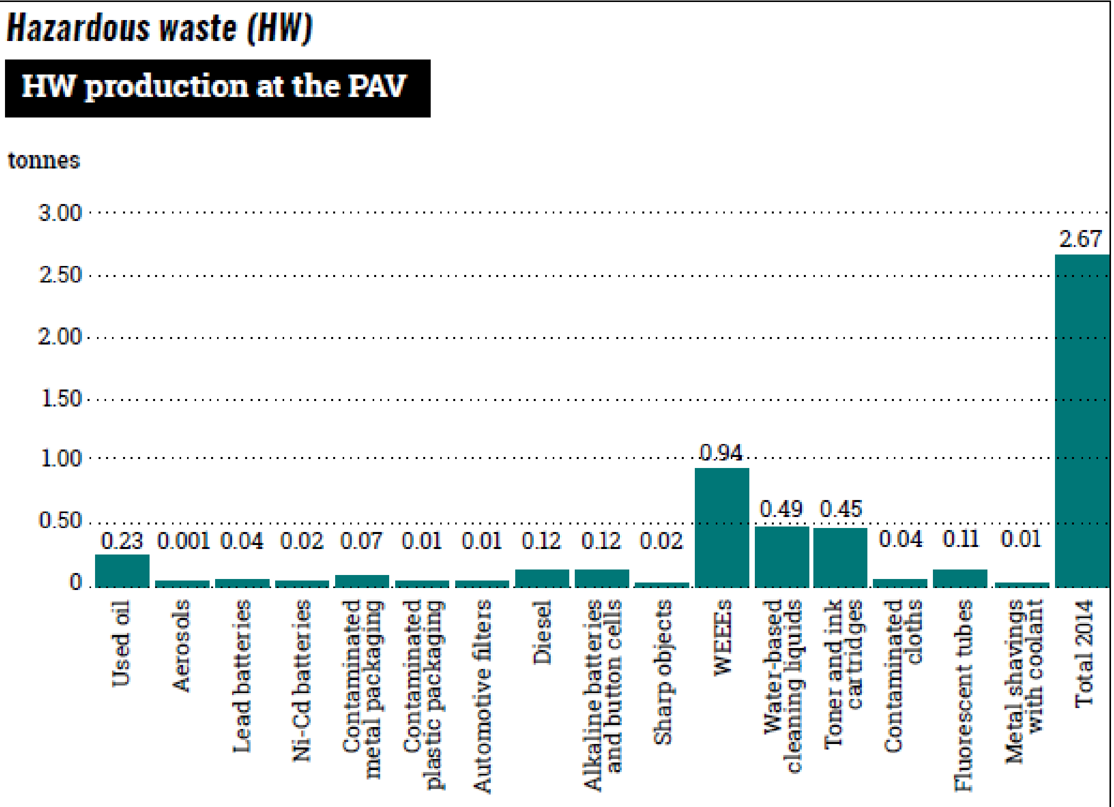


References	[1] Kiehl, J.T., and Trenberth, K. 1997. Earth's Annual Global Mean Energy Budget. Bulletin of the American Meteorological Society 78 (2), pp. 197 – 208. [2] Twerefou, D. K. 2009. Mineral Exploitation, Environmental Sustainability and Sustainable Development in EAC, SADC and ECOWAS Regions. African Trade Policy Centre. Economic Commission for Africa. [3] OECD (Organisation for Economic Co-operation and Development). 2011. Environmental Impacts of International Shipping: The Role of Ports. OECD publishing. [4] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To monitor the waste generated within the port area	**Recommendation code**	R.22.1
Definition	Waste is defined as any substance, either liquid or solid, that the holder intends to or is required to discard [1]. It is recommended to monitor the amount of waste that is generated directly by the port authority and indirectly by other tenants and operators.		
Contents	The port authority and industries located in the port area may classify the port waste as: • Solid waste, such as organic waste, paper and cardboard, plastic and glass; • Non-hazardous industrial waste, such as scrap metal, wood, remains of nets, aerosols, electronic waste or oil filters;		

	• Hazardous waste, such as ink cartridges, used oil, fluorescents and batteries. Port waste is a 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).
Recommended indicators	There are four indicators related to the monitoring of port waste generation that are recommended for monitoring: • Total annual port waste collected • Total annual port waste recycled • Percentage of disposal methods of port waste • Annual waste collected on surface water (Anthropogenic debris)
Example	The examples below display the non-hazardous and hazardous waste generated in the Port Authority of Valencia (PAV), as reported in the Environmental Report 2014 of the Port of Valencia [2].





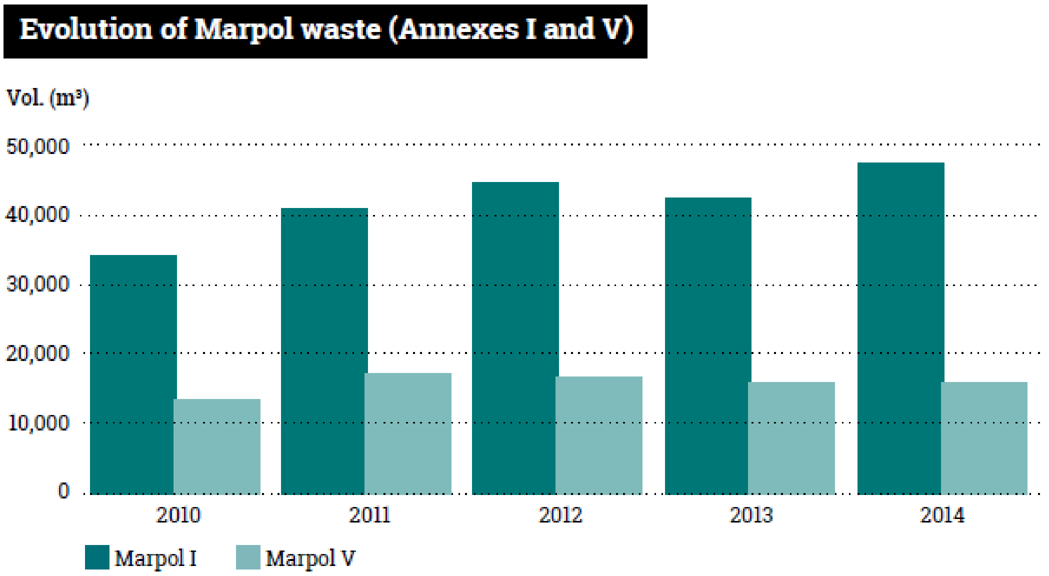
References	[1] EcoPorts Foundation. 2004. *Guidelines for Self-Diagnosis Method SDM*. Version 1.4. [2] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To have separate containers for the collection of port wastes	**Recommendation code**	R.22.2
Definition	This recommendation is referred to the provision of specific bins for the separate collection of waste generated within the port area.		
Contents	The port authority and the companies located in port areas should correctly handle the waste they generate. In order to assist companies to manage their waste, port authorities should have a 'green point' that collects and stores the waste generated before it is transported to its final destination, where it is recycled, recovered or disposed of. By implementing this 'green point', it is expected that it will facilitate the collection and management of the waste generated at the port and it would contribute to maintain the port facilities in harmony with its environment. The containers or facilities that should be available in ports in order to collect the wastes separately include • Recyclable garbage (organic waste, cardboard and paper, plastics, and glass) • Non-hazardous industrial waste (e.g. scrap metal, wood, remains of nets, electronic waste, aerosols, oil filters, floating debris, contaminated rags, contaminated drums, polystyrene and tires) • Hazardous waste (e.g. ink cartridges, used oil, fluorescents, alkaline batteries, button batteries or other batteries)		
Example	An example of a waste collection point is provided in the annual environmental report of the Port of Valencia [1], as showed in the picture below.		

References	[1] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To have ship waste reception facilities	**Recommendation code**	R.22.3
Definition	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 1973/78) [1].		
Contents	MARPOL is the main international convention covering prevention and minimisation of pollution of the marine environment by ships. It contains six technical annexes that provide guidance on the products that are requested to be discharged in the port and not dumped at sea [1]: • **Annex I.** Oil: it covers prevention of pollution by oil from operational activities as well as from accidental discharges. It includes sludge, bilge water, oily cleaning materials, oily cloths, and oil and fuel filters. • **Annex II**. Noxious liquid substances in bulk: it details the discharge criteria and measures for the control of pollution by around 250 noxious liquid substances carried in bulk. • **Annex III:** Harmful substances: it contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications. • **Annex IV:** Sewage: it contains requirements to control pollution of the sea by sewage. • **Annex V:** Garbage: it deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of. Examples of garbage include: plastic, food waste, municipal waste, cooking oil, incinerator ash, operational waste, cargo residues, or fishing nets. • **Annex VI:** Air pollution from ships: it sets limits on sulphur oxide and nitrogen oxide emissions as well as particulate matter and prohibits deliberate emissions of ozone depleting substances.		

	It is recognised that the provision of proper reception facilities in ports is crucial for the effective implementation of the MARPOL Convention. Ports are obliged to provide adequate reception facilities for wastes generated during the normal operation of ships.
Recommended indicators	There is one indicator regarding the ship waste collected in the port reception facilities, which is: • Annual amount of ship waste collected by type of MARPOL annex
Example	An example of the annual amount of MARPOL waste collected is provided in the Environmental Report 2014 of the Port Authority of Valencia [2].



References	[1] IMO. 2016. International Convention for the Prevention of Pollution from Ships (MARPOL). [Online]. Available at: http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx [2] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To establish a budget specifically defined for environmental protection	**Recommendation code**	R.23.1
Definition	The environmental budget is the amount of money allocated to the protection of the environment.		
Contents	The establishment of a budget allocated to the environmental protection is crucial in order to ensure the continual improvement of the environmental quality. The amount of money allocated to the environmental protection is a significant parameter because it provides information about the priority given and the economic efforts made by the port authority towards the environment.		
References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [2] Annual Environmental Report. 2011. Valencia Port Authority.		
Recommended indicators	• Total annual budget allocated to environmental protection • Percentage of annual variation in the environmental budget		
Example	An example of the resources allocated to the environmental protection (environmental budged) is provided below. It is obtained from the Annual Environmental Report 2011 of the Valencia Port Authority [2]		

11 GREEN ACCOUNTING

The resources allocated to environmental protection in the three ports managed by the Valencia Port Authority; Sagunto, Valencia and Gandía totalled 1,494,537.62 € in 2011. This sum includes Environmental Costs totalling 1,481,581.03 € and Environmental Investments of 12,956.59 €.

11.1 ENVIRONMENTAL COSTS

In 2010, costs incurred by the VPA in protecting and improving the environment amounted to 1,481,581.03 €, as detailed on the table below:

COSTS ASSOCIATED WITH ENVIRONMENTAL MANAGEMENT	COST (€)
REPAIR AND CONSERVATION	212.239,84 €
INDEPENDENT PROFESSIONAL SERVICES	393.850,12 €
SUPPLIES AND CONSUMPTION	5.695,94 €
OTHER SERVICES AND COSTS	336.681,93 €
STAFF	250.790,79 €
DEPRECIATION OF FIXED COSTS	282.322,41 €
TOTAL COST	1.481.581,03 €

11.2 ENVIRONMENTAL INVESTMENT

In 2010, the Valencia Port Authority made environmental investments totalling 12.956,59 € as detailed on the following table:

INVESTMENT ASSOCIATED WITH ENVIRONMENTAL MANAGEMENT	COST (€)
Material for tackling pollution	7.406,59 €
Other (Guide to Fishing Resources)	5.550,00 €
TOTAL INVESTMENT	12.956,59 €

<table>
<tr><th>Recommendation</th><td>To implement a certified Environmental Management System (EMS)</td><th>Recommendation code</th><td>R.23.2</td></tr>
<tr><th>Definition</th><td colspan="3">An Environmental Management System (EMS) is a set of management processes and procedures that allows an organisation to analyse, control, and reduce the environmental impact of its activities, products and services and operate with greater efficiency and control [1].</td></tr>
<tr><th>Contents</th><td colspan="3">An EMS is merely a system that if used properly will enable a company to continually improve its environmental performance. It follows an established Plan-Do-Check-Act management system cycle for continual improvement (also known as Deming or Shewhart cycle). These steps are repeated over and over again so that the last step, conducting a management review, leads to new ideas, targets and recommendations that then become the starting point for the renewed management commitment.
Within the Plan step the objectives and targets (or goals) are established. In the Do step, the plan is implemented. In Check, the actual results are studied and compared against the expected results (targets or goals defined in the Plan) to ascertain any differences. If the results show that there is an improvement to the prior baseline, then that becomes the new baseline in Act, ensuring in this way the continual improvement. If the Check shows that there is not an improvement, then the existing baseline remains in place and the EMS continues working to achieve these goals [2].
The key elements that compose an EMS are the following:
• Environmental policy
• Environmental aspects
• Legal and other requirements
• Objectives, targets and programmes
• Resources, roles, responsibility and authority
• Competence, training and awareness
• Communication</td></tr>
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- Documentation
- Control of documents
- Operational control
- Emergency preparedness and response
- Monitoring and measurement
- Evaluation of compliance
- Nonconformity, corrective action and preventive action
- Control of records
- Internal audit
- Management review

With all these elements in place, the port authority can certify the EMS. The main standards within the European port sector are the International Organisation for Standardisation (ISO) 14001 and the Eco-Management and Audit Scheme (EMAS) Regulation. In addition to those elements, the EMAS regulation also requires an environmental review (an initial analysis of the port environmental performance) and the publication of an annual environmental declaration (a public description of the activities and targets for future improvement and the environmental performance of the organisation when the analysis is completed).
Several tools and methodologies have been developed as a first step to assist ports in achieving these standards. These tools are the Port Environmental Review System (PERS) and the Self-Diagnosis Method, which assists ports in identifying environmental risk and establishing priorities for action and compliance [3].
</td>
</tr>
<tr>
<td>Example</td>
<td>Two examples of EMS certifications from two different port authorities are provided below. These certifications are the ISO 14001 from the Port Authority of Valencia [4] and the EMAS Certification from the Port Authority of Bilbao [5].</td>
</tr>
<tr>
<td colspan="2">

Lloyd's Register LRQA

CERTIFICADO DE APROBACIÓN

Certificamos que el Sistema de Gestión Medioambiental de:

AUTORIDAD PORTUARIA DE VALENCIA
Muelle del Turia, s/n
46024 Valencia
España

ha sido aprobado por Lloyd's Register Quality Assurance, de acuerdo con la siguiente Norma del Sistema de Gestión Medioambiental:

ISO 14001:2004

El Sistema de Gestión Medioambiental es aplicable a:

Gestión de servicios e infraestructuras en los puertos de Sagunto, Valencia y Gandía.

Aprobación Certificado No: SGI 3050282

Aprobación Original: 28 de Abril 2006
Certificado en Vigor: 13 de Octubre 2014
Caducidad del Certificado: 12 de Octubre 2017

Emitido por: LRQA España, S.L.
For y en nombre de: Lloyd's Register Quality Assurance Limited

ERREGISTRO-ZIURTAGIRIA
CERTIFICADO DE REGISTRO

Eusko Jaurlaritzako Ingurumen eta Lurralde Politika Saileko Ingurumen Sailburuordetzak erakunde hau erregistratua izan dela egiaztatzen du:

La Viceconsejería de Medio Ambiente del Departamento de Medio Ambiente y Política Territorial certifica que la organización:

AUTORIDAD PORTUARIA DE BILBAO

Edificio de Oficinas Generales, Muelle ampliación acceso Ugaldebieta – 48980 Santurtzi (Bizkaia)

Erregistro-zenbakia hau da / ha sido registrada con el número:

EMAS

Ingurumen kudeaketa eta ikuskaritzaren arloko erkidegoko erregistroaren gaineko erregelamenduak ezartzen duenaren arabera (EMAS).

De acuerdo con lo que se establece en el Reglamento relativo al registro comunitario de gestión y auditoría medioambientales (EMAS).

Erregistro-data / Fecha de Registro: 2014/09/19

José Antonio Galera Carrillo

EUSKO JAURLARITZA GOBIERNO VASCO
</td>
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<td>References</td>
<td>[1] Peer Center. [No date]. What is an EMS? [Online]. Available at: http://www.peercenter.net/about/index.cfm. [Accessed: 12 June 2015].
[2] IACBE, 2015. [Online]. Available at: http://iacbe.org/qa-cqi.asp [Accessed: 12 June 2015].
[3] EcoPorts Foundation, 2004)
[4] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.</td>
</tr>
</table>

	[5] Bilbao Port. Management Policy. [Online]. Available at: http://www.bilbaoport.es/wNS/docs/en/inicio/autoridad/responsabilidad/ Registro_EMAS.pdf Accessed: 08 April 2016.

Recommendation	To define and implement an Environmental Policy	**Recommendation code**	R.23.3
Definition	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 port activities [1].		
Contents	The environmental policy is the driver for implementing and improving an organisation's Environmental Management System so that it can maintain and potentially improve its environmental performance. The main requirements that a complete environmental policy should contain are listed below [2]: • The policy should be appropriated to the nature, scale and environmental impacts of its activities, products and services. • The policy should contain a commitment to continual improvement and to the prevention of pollution. • The policy should contain a commitment to comply with relevant environmental legislation, regulations and other requirements to which the port subscribes. • The policy should provide the framework for setting and reviewing environmental objectives and targets. • The policy should be documented, implemented and maintained. • The policy should be communicated to all persons working for or on behalf of the company. • The policy should be available to the public. • The policy should be signed by the Chief Executive or the top management. • The policy should include reference to the introduction / maintenance of an Environmental Management System (EMS). • The policy should be clear, concise and written in non-technical language interpretable by internal and external parties and it should include the date. • The policy should be regularly reviewed and rewritten, as necessary, to reflect changes in activities or services. Other considerations that an environmental policy may include are the following: • The policy may include reference to the reduction of resource consumption • The policy may aim to improve environmental standards beyond those required by legislation • The policy may include reference to publication of an Environmental Report • The policy may include reference to the identification and control of the port's Significant Environmental Aspects • The policy may refer to sustainable development • The policy may refer to Corporate Social Responsibility (social integration) • The policy may include reference to the ESPO documents, such as the ESPO Green Guide 2012 [3] • The policy may be publicly available on the port's website		
References	[1] McCormick, J. 2001. *Environmental Policy in the European Union. The European Series.* Palgrave. p. 21. [2] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva.		

	[3] ESPO (European Sea Ports Organisation), 2012. ESPO Green Guide; Towards Excellence in Port Environmental Management and Sustainability. ESPO, Brussels. [4] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.
Example	Below, an example of the environmental policy of the Port Authority of Valencia is provided [4].

ENVIRONMENTAL POLICY
OF THE PORT AUTHORITY OF VALENCIA

Shipping is an essential element in the flow and exchange of goods. Modern port management and market competition have led port companies to concentrate and increase the volume of their activities and accordingly, they use ever larger amounts of resources, which makes the inclusion of ecoefficient management criteria increasingly more important. One of the business strategy priorities of the Port Authority of Valencia, as the managing body of one of the main port areas in the Mediterranean, is sustainable development, combining respect for the environment with the economic and social growth of port activities in the facilities it manages.

The PAV is committed to developing an environmental management system which, in addition to making all the members of its organisation aware of the responsibilities of sustainable management, also publicises and extends the need to adopt this ethical commitment to all the companies that operate on public port land, and involves customers, suppliers, official bodies, and other companies in the sector in this Environmental Policy. This commitment is specifically reflected in:

- The incorporation of environmental considerations into public port land planning, organisation, management, and conservation processes.
- Regular systematic analysis and assessment of the activities, products, and services of companies that may interact with the environment, in order to be aware of and manage the environmental risks they may create.
- Streamlining the use of natural resources and energy, including eco-efficiency criteria in general, and energy efficiency criteria in particular.
- Compliance with applicable environmental legislation and requirements, aiming to go further than the demands required by law, whenever possible.
- Prevention and minimisation of emissions, discharges, noise, and waste produced as a result of its activities, aiming to recover as much as possible of the waste generated.
- Using and encouraging the implementation of the best, most viable technologies in each activity.
- The provision of suitable training and information for employees to encourage awareness and take-up of this policy.

As part of the voluntary commitments taken on to encourage environmental sustainability in the facilities it manages, the PAV supports a number of initiatives in its port community:

- Providing a forum where port companies can participate to establish common environmental initiatives and objectives, facilitate training for port company employees, and share concerns and needs linked to projects, communication and regulatory aspects which help to improve the environmental performance of all the participating firms.
- Encourage port community companies to adopt the best technologies available to them through their participation in projects.
- Regularly assess and measure the impact of activities that take place in port facilities by calculating their carbon footprint.

Similarly, regular reports including a review of environmental initiatives will be drawn up and circulated to customers, suppliers, industry firms, members of the organisation and other stakeholders.
This Environmental Policy will be made public and sent to all the members of the PAV. It will be updated when appropriate through a process of continuous improvement.

Approved by the Port of Valencia's Board of Directors, on 12th April 2000, and last amended on 14th May 2015.

Rafael Aznar Garrigues

Chairman of the Port Authority of Valencia

Recommendation	To establish environmental management programmes to achieve the objectives	**Recommendation code**	R.23.4

Definition	An environmental management programme (action plan) establishes the time-frame and the means by which the objectives will achieved [1].
Contents	Management programmes should be established, implemented and maintained for achieving the objectives and targets. For this reason, objectives and targets must be set out in environmental management programmes specifying the steps to be taken, the time scales, necessary resources, and personnel responsible for achieving them. The programme identifies how the targets will be met, who is responsible for each of the activities required to meet that target, when those activities will be completed and how much money is allocated to each one. If a target is met, its correlating objective will similarly be achieved and the environmental policy will satisfy its stated intention. The programmes should be documented, controlled and kept in the EMS manual and they should be regularly reviewed (targets, activities, budgets, responsibilities, means, time-frame, among others.)
Example	Two examples of environmental management programmes are provided below. The first example specifies the port activity and the environmental aspect that is associated with the environmental objective, and then it specifies the different targets that have been established to meet this objective, along with the time, the means (economic resources allocated to it) and the person responsible to carry out this task. The second one is another example of an Environmental Management Programme from a real company and it shows the targets, the responsible and the deadlines [2].

Activity	Ship building and repair		
Environmental aspect	Discharges to water		
Objective	Reduce emissions to water to allowed levels		
Targets	**Time**	**Means**	**Responsible**
1. Research on legislation	2 months	5000 €	Research assistant
2. Environmental monitoring of water compounds	1 month	10000 €	Environmental manager
3. Establishing limits of discharges and percentage of reduction required	1 month	5000 €	Environmental manager
4. Research on methods to reduce discharges	2 months	10000 €	Research assistant
5. Selection of methodology and implementation	5 months	80000 €	Environmental manager
6. Verification of the improvement	1 month	10000 €	Environmental manager
TOTAL	**12 months**	**120000 €**	**-**

References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [2] Roberts, H. and Robinson, G. (1998). ISO 14001 EMS Implementation Handbook. Butterworth Heinemann. United Kingdom.

<table>
<tr><th>Recommendation</th><td>To define objectives for environmental improvement</td><th>Recommendation code</th><td>R.23.5</td></tr>
<tr><th>Definition</th><td colspan="3">An environmental objective is an overall environmental goal, consistent with the Environmental Policy, that a Port Authority sets itself to achieve [1].</td></tr>
<tr><th>Contents</th><td colspan="3">The port authority should establish, implement, and maintain documented environmental objectives, at relevant functions and levels within the organisation. In addition, targets should be defined to achieve each objective.
An environmental target is a detailed performance guideline, quantified where possible, that needs to be set and met in order to achieve the objectives [1]. For example, an objective could be ‘better management for water runoff’, and a target ‘to reduce the amount of water used by 20% by 2016’.
The objectives and targets should [1]:
• Be specific, realistic, easy to understand and measurable
• Cover short and long term issues
• Be consistent with the environmental policy, including the commitments to prevention of pollution and continual improvement
• Consider the legal requirements and other requirements that the port authority subscribes
• Include the Significant Environmental Aspects of the port authority
• Take into account the technological options, its financial, operational and business requirements, and the views of the interested parties
• Be communicated internally and externally
• Be reviewed and documented with the endorsement of the top management
• Be supported with sufficient human and financial resources required for their achievement
Furthermore, management programmes and actions plans should be established, implemented and maintained for achieving the objectives and targets.</td></tr>
<tr><th>Recommended indicators</th><td colspan="3">• Number of environmental objectives defined
• Percentage of environmental objectives achieved</td></tr>
<tr><th>Example</th><td colspan="3">An example of the objectives established by the port of Valencia is provided below [2].</td></tr>
</table>

The following objectives were planned in 2014:

Objective established in previous years that has not yet been met.

Objective planned in the current year, which is linked to objectives established in previous years.

New objective established in the current year.

Objective No. 40. Implementation of a computer tool to manage the EMS

In 2014, the contents of the tool were defined to ensure their compliance with the demands of the ISO 14001 and the EMAS standards. In addition, the tool's design included a component which can be exported to any other management system, as well as a subject-specific component. Both the content and the operational aspects of the local design of the tool have been completed. It is awaiting inclusion in the PAV framework, which is expected to take place in 2015.

Objective No. 43. Updating the noise map at the Port of Valencia to include the North Extension

The tender process has begun to update the Port of Valencia's noise maps, and include the North Extension on this occasion. The specifications have been drawn up and the tender is expected to be put out in 2015.

Objective No. 44. Improving environmental quality in bulk handling at the Port of Sagunto

A meteorological profiling study is being carried out in Sagunto to develop the prediction tool and help control emissions in bulk handling operations at the Port of Sagunto. The study is expected to be completed in 2015.

Objective No. 45. Calculating the Port of Valencia's carbon footprint

The carbon footprint for the Port of Valencia was calculated for 2010 and 2012, and was validated using the method established in the Climeport project, which was also used to calculate the port's carbon footprint for 2008. The method was validated by a certification body, in accordance with the requirements set out in ISO 14064.

Objective No. 46. Implementation of a computer application for port authority staff to car share at the Port of Valencia

As a result of the actions undertaken as part of the PAV's Sustainability Mobility Plan, a web application entitled CARSHARING has been designed to promote joint use of cars by port community company employees.

The tool has been developed and is pending inclusion in the Valenciaport framework. It is expected to be made available in 2015.

References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [2] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To develop and implement an environmental monitoring plan	**Recommendation code**	R.23.6
Definition	An environmental monitoring plan consists of repeated periodic observations and measurements of selected parameters of the environment, according to a pre-determined schedule, allowing a port to establish the current status and trends of environmental quality and being an essential tool to track its environmental performance [1].		
Contents	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 [2]. The port authority should ensure that the monitoring and measurement equipment is calibrated and maintained, and should retain associated records. The results of the monitoring are expressed though Environmental Performance Indicators (EPIs). Port authorities should identify EPIs to monitor trends in environmental performance. It is important that each port identifies the most adequate indicators, since depending on the activities and operations that it is developing, the indicators to be monitored and measured would vary. Data collected from monitoring and measurement can be analysed to identify patterns and obtain information. Knowledge gained from this information can be used to implement corrective and preventive actions. Monitoring and measuring generate records. These records should be used to track progress towards stated objectives and targets. The records should be documented and controlled. They should be referenced in the EMS manual.		
Recommended indicators	Number of environmental indicators monitored		
Example	The Port Authority of Valencia provides in its environmental report [3] the Air Quality Monitoring Plan. It includes the location of the various stations for monitoring the air quality and well as the average concentrations of different pollutants obtained in each station. The location of the stations and the results obtained are provided below.		

STATION	SO_2 MG/m³	NO MG/m³	NO_2 MG/M³	NOx MG/M³	O_3 MG/M³	CO µg/m³	PM_{10} MG/M³	$PM_{2.5}$ MG/M³
AVDA. FRANCIA	2	8	27	39	48	0.2	13	8
BOULEVARD SUR	2	13	30	50	46	-	-	-
MOLÍ DEL SOL	2	9	27	41	50	0.1	14	11
PISTA DE SILLA	4	23	45	81	46	0.2	15	8
POLITÉCNICO	1	7	26	38	53	-	16	11
VIVEROS	2	8	26	38	49	-	-	-
PORT OF VALENCIA IMMISSION STATION	2	7	33	25	-	0.1	12	-
PORT OF VALENCIA RIVER TURIA STATION	-	-	-	-	-	-	13	9

References	[1] EcoPorts Foundation. 2004. Guidelines for Self-Diagnosis Method SDM. Version 1.4. [2] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [3] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To identify an inventory of Significant Environmental Aspects	**Recommendation code**	R.23.7
Definition	An environmental aspect is an element of the activities, products and services of the port that can interact with the environment [1], such as the generation of waste or the noise emissions.		
Contents	An effective port environmental management requires awareness and knowledge of its environmental aspects in order to know what is required to be properly managed from the environmental point of view [2].		

	Each port has different environmental aspects depending on activities that are carried out within the port area. Port environmental managers should identify and evaluate all the aspects associated with the port's activities, products or services that can interact with the environment. These may be associated not only with the productive process and auxiliary operations, but also with the products and services realised by the company's own employees or contractors [3]. Examples of environmental aspects are the emissions of combustion gases or the discharges of wastewaters. It is highly recommended that port authorities select the most significant aspects, called the Significant Environmental Aspects (SEAs), in order to focus their time, efforts and resources on those issues with major potential for environmental impact, providing the greatest assurance that the environment will be protected [4]. The aspects have to be considered when setting the objectives and targets. Port should establish a procedure not only to identify its aspects and to determine those that can have a significant impact on the environment, but also to maintain and update the inventory of SEA. It is recommended that the list of aspects is reviewed and updated every year. The identification of SEAs commits ports for continuous environmental improvement since they have to be constantly aware of the impacts that may be generated. In addition, determining the SEAs allows a port to know which are the main stakeholders' concerns and the issues that should be reported to them. The Tool for the identification and assessment of Environmental Aspects in Ports (TEAP) is a specific tool that has been developed to assist ports in this identification and evaluation. The tool is available online at www.eports.cat. Environmental aspects may be classified as direct and indirect. Direct aspects are associated with activities, products and services of the organisation itself over which it has direct management control, whereas indirect aspects can result from the interaction of an organisation with third parties (EC, 2009a). In addition, environmental aspects may be generated in normal conditions, abnormal conditions and in emergency situations. Normal conditions refer to routine working conditions (e.g. provision of services or production), abnormal conditions are related to conditions which can be controlled but are considered 'special' (e.g. maintenance or cleaning) and emergency situations concern uncontrolled situations such as incidents and accidents (Valenciaport et al., 2003). This inventory should contain the direct and indirect aspects, as well as the ones obtained in normal and abnormal conditions, and emergency situations.
Recommended indicators	Number of Significant Environmental Aspects identified
Example	The environmental aspects that were published in the Environmental Report 2014 of the Port of Valencia [5] are provided below. They are divided in direct and indirect aspects, and they are related to the environmental objectives that the port set itself to achieve. In addition, the aspects that resulted as significant also are listed below.

DIRECT	OBJ.	INDIRECT	OBJ.
Generation of waste	No. 48	Generation of waste in the port facility	No. 48
Air emissions	No. 47	Emissions from transport used in the port facility	No. 44 No. 47
Water quality	No. 49	Environmental performance of concessions	No. 44 No. 47
Noise and visual impact	No. 43	Noise on roads in the port facility	No. 43
Water consumption		Water consumption in the port facility	
Energy consumption		Energy consumption in the port facility	
Raw material consumption		Raw material consumption in the port facility	

The table below shows the significant environmental aspects in line with the assessment criteria established in the "Procedure to identify and assess environmental aspects".

SIGNIFICANT ENVIRONMENTAL ASPECTS			
DIRECT	**OBJ.**	**INDIRECT**	**OBJ.**
Energy consumption	No. 47	Environmental performance of concessions	No. 44 No. 47

References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [2] ESPO (European Sea Ports Organisation). 2011. Port Environmental Review System (PERS). A port-sector specific methodology to start implementing an environmental management system. ESPO: Brussels. [3] Valenciaport, IPEC, EUROPHAR, 2003. Procedure 3: Procedure for assessing and recording environmental aspects. EMS Project. [4] Puig, M. 2012. Identification and selection of Environmental Performance Indicators (EPIs) for use in the management of European Seaports. MPhil Thesis. School of Earth and Ocean Sciences. Cardiff University. [5] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To define a representative responsible for managing environmental issues	**Recommendation code**	R.23.8
Definition	Environmental managers are responsible for overseeing the environmental performance of private, public and voluntary sector organisations. They develop, implement and monitor environmental strategies, policies and programmes that promote sustainable development [1].		
Contents	The top management of the organisation should appoint a specific environmental manager or representative [2]. This manager will be responsible mainly for: • Coordinating environmental management throughout the port • Developing and implementing environmental strategies and action plans that ensure sustainable development • Ensuring compliance with the Environmental Policy • Ensuring that an Environmental Management System is established, implemented and maintained • Responding to internal and external enquiries		

	• Monitoring current environmental issues and legislation and ensuring compliance to them • Coordinating all aspects of pollution control, waste management, recycling, environmental health, conservation and renewable energy • Liaising with relevant bodies such as local authorities, public bodies and competent bodies • Auditing, analysing and reporting environmental performance to internal and external clients and regulatory bodies • Carrying out impact assessments to identify, assess and reduce an organisation's environmental risks and financial costs • Promoting and raising awareness, at all levels of an organisation, of the impact of environmental issues • Training staff at all levels in environmental issues and responsibilities • Writing environmental reports, assuming the lead responsibility with the company • Setting environmental objectives and targets, and developing plans to meet them • Managing relations with the board of directors, senior management and internal staff • Reporting to top management on the performance of the Environmental Management System for review, including recommendations for improvement The responsibilities of this representative should be clearly defined, documented and communicated to all the port personnel. The port authority should hire enough employees in the environmental section of the port in order to carry out the environmental programme of the port. The environmental responsibilities of the environmental manager as well as the responsibilities of other key personnel should be defined, documented and communicated in order to facilitate effective environmental management.
Recommended indicators	Percentage of employees participating in environmental issues
Example	An example is provided below of the environmental management structure in the Port of Brisbane (Australia) [3].

References	[1] Prospects. [Online]. Available at: https://www.prospects.ac.uk/job-profiles/environmental-manager. Accessed: 05/04/2016 [2] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [3] Environmental Performance Report 1999. Port of Brisbane Corporation.

Recommendation	To implement an environmental training programme for port employees	**Recommendation code**	R.23.9
Definition	Training is defined 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		

<table>
<tr><td></td><td>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 [1].</td></tr>
<tr><td>Contents</td><td>The port authority should ensure that any person performing tasks for it or on its behalf (and that have the potential to cause significant environmental impacts) is competent on the basis of appropriate education, training or experience. The port should identify training needs associated with its environmental aspects and its Environmental Management System. It should provide training or take other actions to meet these needs, and should retain associated records. Top management should determine the level of experience, competence and training necessary to ensure the capability of personnel, especially those carrying out specialised tasks [2].
Implementing a training programme and awareness-raising activities is expected to deliver continuous improvement in environmental performance because it provides 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.
The environmental training programme should be fitted to employees' activities and responsibilities. Procedures should be established for identifying training needs. In addition, environmental issues should be included in introduction programmes for new employees.
The port authority needs to ensure that contractors have the appropriate training with respect to the EMS requirements. The training records must be documented and kept in the EMS manual.
Roberts and Robinson considered three levels of training [3]:
The 1st level of training is the Environmental Awareness Training and it is provided to ensure that all personnel are aware of EMS development and the existence and importance of the environmental policy
The 2nd level of training is the Aspects and Impacts Training and it is provided to ensure that all personnel whose work is associated to any significant impact receives appropriate training
The 3rd level of training is the EMS Training and it is provided to the personnel with identified roles and responsibilities within the EMS
All the port employees should:
Be aware of the importance of compliance with environmental policy.
Be aware of their responsibility to conform to the environmental policy and management objectives.
Be aware of the objectives, actions and programmes carried out by the port in order to improve its environmental performance.
Be aware of the potential environmental impacts of their work activities.</td></tr>
<tr><td>Recommended indicators</td><td>Number of port employees trained in environmental issues
Frequency of environmental training sessions for port employees
Percentage of port employees that have received environmental training
Annual number of training hours per employee</td></tr>
<tr><td>Example</td><td>As an example it is shown below the commitment of the Port Authority of Valencia with the environmental training. It is obtained from the Environmental Report 2014 of the port [4].</td></tr>
</table>

8.4 TRAINING

The PAV aims to provide the necessary environmental training and awareness, as set out in its environmental policy. This is understood not only as a way of improving staff skills, but also as a means to acquire new knowledge and abilities that will make the ports of Sagunto, Valencia and Gandia more competitive. Thus, training courses and sessions are scheduled every year to enhance knowledge in line with the environmental activities carried out. As far as possible, and as set out in the ECOPORT II project, these activities are carried out in conjunction with the rest of the port community.

Various training documents on environmental aspects were drawn up, as part of the Ecoport II project's training plan. In September 2014, the environmental aspects document on bulk goods was presented to all the companies in the Ecoport group.

References	[1] The Manpower Services Commission. 1981. *A Glossary of Training Terms*. London: Training Services, Manpower Services Commission, HMSO [2] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [3] Roberts, H. and Robinson, G. 199). ISO 14001 EMS Implementation Handbook. Butterworth Heinemann. United Kindgom. [4] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To communicate environmental information internally and externally	**Recommendation code**	R.23.10
Definition	Environmental communication is to inform about environmental affairs internally to port employees and externally to other port stakeholders.		
Contents	The Environmental Management System standards specify that a set of procedures should be established to ensure that internal and external communication is carried out properly. Internal communication contributes to keep employees updated with the progress being made towards the environment, and external communication to ensure that stakeholders are kept informed of the port's environmental progress. Methods of internal communication include regular work group meetings, bulletin boards and intranet sites; and for external communication annual environmental reports, newsletters, websites, visits, workshops, and community meetings [1]. One of the most efficient ways to communicate environmental information is to publish an environmental report because it provides information about the environmental activities, achievements and results that a port 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'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. The contents that a comprehensive environmental report should include are: • Chief Executive Officer's (CEO) statement • Port authority's Environmental Policy • A port profile specifying the size, location and its main operations and functions • A description of any recognised standard of Environmental Management System implemented 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 • Data on Environmental Performance Indicators being monitored by the port • Environmental best practices and initiatives implemented		

	• Future projects As far as the format to report is concerned, there are three common ways to report: i. To publish a stand-alone environmental report. The main advantage is that it may be more easily disseminated to a target audience and the disadvantage is that it is difficult to serve the needs of all audiences in one document ii. 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 iii. More and more, ports are preparing sustainability reports as a form of environmental communication, which also includes their economic and social impacts [2]. The reports may be distributed on-line as a web-based report or printed out as a hard-copy. The positive points of the first option 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. For this reason, it is recommended that the best option is a combination of both: uploading the report on-line and at the same time having hard-copies printed out to give in hand to the stakeholders whenever it is needed. An example of best practices in environmental reporting is the Global Reporting Initiative (GRI). It is a non-profit organization that promotes sustainability reporting as a way for organizations to contribute to sustainable development [3]. GRI develops and disseminates globally applicable Sustainability Reporting Guidelines for voluntary use by organisations, reporting on the economic, environmental, and social dimensions of their activities, products and services [4]. Apart from the environmental report, it is important not to forget the other methods of communication. It is recommended that the port authority should have a regular and fluent communication with port stakeholders on environmental issues, because it will allow both sides to share the concerns and will avoid future misunderstandings or disputes. Regular work group meetings are a decisive way to keep the port employees, tenants and operators, and customers updated with the progress. Workshops and community meetings are also important in order to get in touch with port stakeholders, such as local community and neighbours, as well as other pressure groups, such as NGOs and media. The port websites are one of the main external communication platforms of the port. It is recommended that the port website should contain not only the port environmental report but also a comprehensive environmental section. This will provide credibility and demonstrate that the port is taking the environmental communication and transparency seriously. There are some port authorities that organise port visits for students, either from school or universities, in order to show them the actions taken by the port in terms of the environment. Another example of external communication is to participate and give presentations in national and international congresses and conferences about the environment in relation to ports. This allows the port representatives to explain issues related to new techniques or development, data on port performance, etc. to a wider and specialised audience. Finally, the authority also may publish other documents, apart from the annual environmental report, such as leaflets, newsletters, environmental guides, among others. It is recommended that these documents are also updated on the port website.
Recommended indicators	• Annual number of environmental reports published • Annual number of press articles published concerning environment • Annual number of national and international conferences organized by the port authority • Number of environmental educational programmes or materials provided for the community

Example	A screenshot of the contents of the Environmental Report 2014 [5] of the port authority of Valencia is provided below. It is shown as an example of best practice in environmental reporting. In addition, examples of other environmental publications from the port of Valencia are displayed below.

Contents

Living the Port Environmentally Guide

In the Living the Port Environmentally Guide, the Port Authority of Valencia sets out the environmental activities it carries out on a daily basis, some of which are carried out in conjunction with companies in the port, and others as an independent public company that takes responsibility for inherent environmental aspects. Thus, the Port Authority of Valencia complies with one of the premises of its management system included in its environmental policy: dissemination of its environmental activities.

Environmental Risk Assessment in Port Facilities Guide

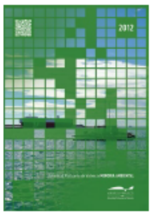
This guide aims to be an efficient, user-friendly tool for companies in the ports of Sagunto, Valencia and Gandia that wish to carry out their own environmental risk assessment, according to the UNE 150.008 standard.

Best Environmental Practice Guide

In 2000, a series of Best Environmental Practice guides began to be compiled in the framework of the Ecoport project, in order to raise awareness among the groups working in the port facilities about the importance of applying environmentally friendly criteria in the workplace. Each guide focuses on a specific port activity and provides useful tips to be applied in the standard procedures corresponding to their particular field, as well as the legislation applicable to each case. The guides published so far include:

- Offices (published in 2000, reprinted in 2006 and 2009)
- Workshops (published in 2000, reprinted in 2006 and 2009)
- Road haulage (published in 2004 and reprinted in 2009)
- Solid bulk handling and storage (published in 2005 and reprinted in 2009)

Port Authority of Valencia's Environmental Report (annual since 2001)



In 2002, the publication of Authority of Valencia's Envi Report (the first Spanish port detailed all the environmental carried out in 2001, and aime the lead in informing society its continuous improvement p

Since then, the Port Authority of Valencia has published these reports on a yea highlighting the organisation's special interest in respecting and protecting the env The reports set out the main environmental protection activities carried out in th Sagunto, Valencia, and Gandia, as well as the main environmental parameters and associated with them. They also provide a detailed description of the results obtain

Port of Valencia Birdlife Guide

Through the publication of the Port of Valencia Birdlife Guid aims to disseminate the wide variety of birds that can be s port environment, providing experts with basic knowledge use to study and monitor these species, whilst helping th public to identify the birds that fly over our ports during th seasons.

The idea for this guide came from the Ecoport projec publication meets two objectives, firstly, to respond to societ for information on the biodiversity of our port, and secondly, with the commitment to "promote awareness and provid training for employees, thus encouraging the developme policy", as stated in the PAV's Environmental Policy.

References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva.

	[2] GRI (Global Reporting Initiative), 2015. About Sustainability Reporting. [Online]. Available at: https://www.globalreporting.org/information/ sustainability-reporting/Pages/default.aspx [3] GRI (Global Reporting Initiative), 2015a. Introduction. About GRI. [Online]. Available at: https://www.globalreporting.org/information/about-gri/Pages/default.aspx [Accessed: 20 April 2015]. [4] ACCA (Association of Chartered Certified Accountants). 2001. An Introduction to Environmental Reporting. [Online]. [5] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To define and implement an Emergency Response Plan	**Recommendation code**	R.23.11
Definition	An Emergency Response Plan is a written plan which should detail step-by-step procedures to follow in case of emergencies such as fire, chemical spill, or a major accident [1].		
Contents	An Emergency Response Plan specifies procedures for handling sudden or unexpected situations. The objective is to be prepared to: [2] • Prevent fatalities and injuries. • Reduce damage to buildings, stock, and equipment. • Protect the environment and the community. • Accelerate the resumption of normal operations. Although emergencies by definition are sudden events, their occurrence can be predicted with some degree of certainty. The first step is to find which hazards pose a threat to any specific enterprise. Hazards include both technological and natural. Examples of technological hazards are a fire, explosion, building collapse, spills of flammable liquids, or the release of toxic substances. Natural hazards include floods, earthquakes, or tornados. The development of the plan begins with a vulnerability assessment. The results of this study will show: • How likely a situation is to occur • What means are available to stop or prevent the situation • What is necessary for a given situation From this analysis, appropriate emergency procedures can be established. In ports, the areas that handle or store the flammables, explosives, or chemical products should be considered as the most likely place for a technological hazard emergency to occur. The elements that an Emergency Response Plan should contain are the following: [2] • **Objective:** it is a brief summary of the purpose of the plan; which is to reduce human injury and damage to property and environment in an emergency. It also specifies those staff members who may put the plan into action. • **Organization:** personnel on site during an emergency are key in ensuring that prompt and efficient action is taken to minimize loss. Detailed lists of personnel, including their home telephone numbers, their duties, responsibilities, authority, and resources must be clearly defined in the plan. The responsibility and role of each body (e.g. port authority, tenants and operators, ship agents, and external agencies) should also be defined. • **Procedures:** there are several procedures that should provide information on: (1) Evacuation routes (2) Safe locations for staff to gather for head counts (3) Floor plans and maps showing service conduits (such as gas and water lines)		

	(4) The potential environmental consequences and actions to be taken in the event of explosion, fire, floods, oil/chemical spill, and shipping accident (5) The communication, control and containment procedures (6) The location and type of equipment (7) The communication procedures with government departments, NGOs, local community, media and other interested parties. Exercises and drills may be conducted to practice all or critical portions (such as evacuation) of the plan. A thorough and immediate review after each exercise, drill, or after an actual emergency will point out areas that require improvement. The plan should be revised when shortcomings have been known, and should be reviewed at least annually. Changes in plant infrastructure, processes, materials used, and key personnel are a convenient time for updating the plan. Apart from the major benefit of providing guidance during an emergency, developing the plan has other advantages. The port may discover unrecognized hazardous conditions that would aggravate an emergency situation and then, the port can work to eliminate them. The planning process may bring to light deficiencies, such as the lack of resources (equipment, trained personnel, supplies), or items that can be rectified before an emergency occurs. In addition an emergency plan promotes safety awareness and shows the organization's commitment to the safety of workers [2]. In addition to the generic Emergency Response Plan, port authorities also may implement other emergency plans particularly designed to specific situations, such as the Cargo Handling Plan, Oil Spill Response Plan, or the Water Leakage Response Plan. It is also recommended to carry out an Environmental Risk Assessment whenever it is considered necessary. The port authority should have a representative responsible for managing safety issues and it is highly recommended that the responsibilities of this representative are documented and that the port employees are familiarised with safety regulations.
Recommended indicators	Number of times that the Emergency Response Plan has been activated Total number and volume of (significant) oil and chemical spills Annual number of environmental accidents Annual number of environmental incidents
Example	The Dublin Port Company provides the Emergency Management Plan in order to guide all port users on how to respond appropriately to a range of possible emergencies [3]. Below, a screenshot of the contents is provided. The full plan is available at the following link: http://www.dublinport.ie/fileadmin/user_upload/documents/DPC_EMP_Website_Document_Version_2.0_2013.pdf

<table>
<tr><td colspan="2">

Dublin Port Company Emergency Management Plan

Contents

</td></tr>
<tr><td>References</td><td>[1] Business dictionary. Online. Available at: http://www.businessdictionary.com/definition/emergency-action-plan.html#ixzz44NM7GJrC
[2] Canadian Centre for Occupational Health and Safety. Online. Available at: https://www.ccohs.ca/oshanswers/hsprograms/planning.html
[3] Emergency Management Plan. 2013. Dublin Port Company. Version nº Public 2.0. [Online]. Available at: http://www.dublinport.ie/fileadmin/user_upload/documents/DPC_EMP_Website_Document_Version_2.0_2013.pdf Accessed: 08 April 2016.</td></tr>
</table>

<table>
<tr><td>Recommendation</td><td>To conduct an EMS audit</td><td>Recommendation code</td><td>R.23.12</td></tr>
<tr><td>Definition</td><td colspan="3">Environmental auditing has been defined as a management tool comprising an evaluation of the performance of the organisation, management system and processes designed to protect the environment. This evaluation should be systematic, documented, periodic and objective [1].</td></tr>
<tr><td>Contents</td><td colspan="3">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. A non-conformance is defined as any discrepancy between the environmental requirements of the standard and current port performance.</td></tr>
</table>

	Audits assist ports to identify areas of non-conformance, correct them and prevent them from re-occurring. Correction is the act of developing or improving the non-conformance. Prevention is the act of ensuring that non-conformances will not occur again. The prevention involves to understand the cause of the non-conformance and ensure that cause is avoided in the future. There are two main types of audits that can be carried out by companies, either internally or externally. Internal audits imply that they are developed by the same company that is being evaluated. In this case, it may be audited by the responsible of the EMS or it may be audited by personnel of another site of the same company. It is recommended that the auditor is adequately independent of the activities and areas being audited to ensure an unbiased assessment. External audits are developed by a third party, with the possibility to be certified, if the third party is accredited by the national accreditation organisation. In the case of EMS, the standards that can be certified are ISO 14001 and EMAS. Although both certifications require an external EMS audit, EMAS also requires an initial environmental review (an initial analysis of the port environmental performance) and the publication of an annual environmental declaration (a public description of the activities and targets for future improvement and the environmental performance of the organisation when the analysis is completed). In order to conduct the audit, there must be a lead auditor and an audit team. An audit plan has to be established, implemented and maintained. It describes the responsibilities and requirements for planning and conducting audits, reporting results and retaining associated records, as well as the determination of audit criteria, scope, frequency and methods [2]. At the end of the audit, a written report must be prepared to ensure the provision of findings, non-conformances and recommendations. This information must be made known to top management.
Recommended indicators	• Number of EMS audits completed versus planned • Number of EMS audit findings per period • Number of nonconformities
Example	An example of an internal EMS Audit report is provided below [3].

Sample template

Internal EMS Audit Report

Company Name:	United Distillers	**Document Version:**	AP98001V1
Department/Site:	Dailuaine Distillery	**Issue/Revision Date:**	23/01/98
Updated by:	Wirral Green	**Replaces Version:**	None
Approved by:	Grant Fromage	**Page**	1 **of** 2

Activity being audited: Environmental policy

Additional Auditors: Will B. Frank, Jim Nasium	**Audit Schedule Ref:** AS98001V1 **Audit Plan Ref:** AP98001V1

Findings of the audit

1. The environmental policy has not been made known to all employees and represents a nonconformance with the requirements of ISO 14001. Nonconformance form NCR001 has been raised.
2. The site environmental policy is currently not readily available to the public but could be if asked for. This is an observation that does not completely conform to the specific requirements of ISO 14001.
3. The environmental policy does not include a commitment to the development of, and adherence to, corporate standards in the absence of legislation. This is purely an observation related to best practice.
4. The environmental policy does not embody a life cycle approach to the environmental impacts of the organization's activities, products and processes. This is purely an observation related to best practice.
5. Environmental issues and the views of interested parties, employees and the local community are only partially taken into account in strategic decisions affecting the environment. This is a minor nonconformance with the stated policy.
6. The use of water is not being reduced at present. This is a minor nonconformance with the stated policy conditions (specifying the measurement and reduction of water and energy).
7. The site has not ensured that objectives, targets and action plans are determined for reducing and controlling all significant environmental impacts caused by the operations although the most significant are being controlled at present.
8. Current objectives and targets have a legislation-based focus and do not specifically aim to improve continually the environmental performance of the site. This is an observation that does not completely conform to the stated policy.
9. While very open, the current attitudes toward environmental issues could not be described as proactive. This is an observation that does not completely conform to the stated policy.

References	[1] Council of the European Communities. 1993. Council Regulation (EEC) Nº 1836/93 of 29th June 1993 allowing voluntary participation by companies in the industrial sector in a Community Eco-management and audit scheme. Official Journal Nº L168, 10/07/93. [2] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [3] Roberts, H. and Robinson, G. 1998. ISO 14001 EMS Implementation Handbook. Butterworth Heinemann. United Kingdom.

<table>
<tr><td>Recommendation</td><td>To define an inventory of relevant environmental legislation and regulations</td><td>Recommendation code</td><td>R.23.13</td></tr>
<tr><td>Definition</td><td colspan="3">An inventory of environmental legislation is a compilation of all the legislation and regulations relevant to the port's environmental liabilities and responsibilities.</td></tr>
<tr><td>Contents</td><td colspan="3">Port authorities should identify and have access to legal and other requirements to which they subscribe, that are applicable to the environmental aspects of its activities [1].
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 (which is the law developed by public administration) is a major driving force for change affecting behaviour in all sectors. Additionally, there are other requirements to which the port may have to subscribe, such as corporate policies, or port association's standards.
It is widely recognised that 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.
Therefore, since there is not any standardised 'pack' of legislation, it is recommended that each port identifies their applicable legislation according to the resulting environmental aspects and in collaboration with the public environmental institutions of the area.
In addition, the port should establish procedures to maintain and regularly update the inventory of environmental legislation. In case of non-compliance with internal and external standards, the port should establish methods to deal with these non-compliances.</td></tr>
<tr><td>Recommended indicators</td><td colspan="3">• Number of fines received for non-compliance with environmental legislation
• Number of times that the daily limit value of a certain environmental parameter has been exceeded</td></tr>
<tr><td>Example</td><td colspan="3">An example of an inventory of legislation is provided below. It is obtained from the Environmental Report 2014 of the port authority of Valencia [2].</td></tr>
</table>

YEAR	DESCRIPTION
2015	Royal Decree 180/2015, of 13th March, regulating the transfer of waste within Spanish territory.
2014	Valencian Regional Ministry of Infrastructure, Territory, and the Environment Order 26/2014, of 30th October, approving the document to develop the measures drawn up in the Valencian Region's Integrated Waste Plan Prevention Programme.
2014	Valencian Regional Government Law 6/14, of 25th July, on the Environmental Protection, Quality, and Control of Activities in the Valencian Region.
2014	Spanish Law 11/2014, of 3rd July, amending Law 26/2007, of 23rd October, on Environmental Responsibility (Official State Gazette No. 162, of 4th July 2014).
2012	Spanish Royal Decree 1695/2012 of 21st December, approving the National Response System to Marine Pollution.
2011	Spanish Law 22/2011, of 28th April, on contaminated soil and waste.
2011	Spanish Royal Decree 102/2011, of 28th January, on improving air quality.
2011	Spanish Royal Decree 60/2011, of 21st January, on environmental quality standards in the field of water policy.

2010	Spanish Law 6/2010, of 24th March, amending the recast text of the Spanish Law on the environmental impact of projects, passed by Spanish Legislative Royal Decree 1/2008, of 11th January.
2008	Spanish Royal Decree 2090/2008, a regulation partially developing Spanish Law 26/2007 on environmental responsibility.
2007	Spanish Royal Decree 1367/2007, of 19th October, developing Spanish Law 37/2003, of 17th November, on noise, in terms of noise zoning, quality objectives, and noise emissions.
2007	Spanish Law 26/2007, of 23rd October, on environmental responsibility.
References	[1] ISO (International Organization for Standardization). 2004. ISO 14001: Environmental management systems. Requirements with guidance for use. ISO: Geneva. [2] Environmental Report 2014. Valenciaport. Autoridad Portuaria de Valencia.

Recommendation	To carry out an Environmental Impact Assessment (EIA)	**Recommendation code**	R.24.1
Definition	An Environmental Impact Assessment (EIA) is a detailed study that determines the type and level of effects that a proposed project would have on its natural environment. Its objectives include [1]: • To help decide if the effects are acceptable or have to be reduced for proceeding with the proposed project • To design / implement appropriate monitoring, mitigation, and management measures • To propose acceptable alternatives • To prepare an environmental impact report (EIR).		
Contents	Port development activities, such as dredging or construction works, may create a wide range of impacts on the environment. To minimize these adverse effects, the techniques of Environmental Impact Assessment (EIA) become indispensable. EIA procedures are designed to identify environmental problems and determine the magnitude of impact on the environment [2]. An EIA usually has a preliminary and a detailed phase. The first phase is called an Initial Environmental Examination (lEE) and the second is Environmental Impact Studies (EIS) or simply detailed EIA. The lEE is a study on the potential impacts that a proposed project might have on the environment. It is used in the early (pre-feasibility) phase of project planning and suggests whether in-depth studies are needed. An EIA is a more detailed study of the potential significant effects, both beneficial and adverse, that a proposed project will have on the environment [2]. The typical procedure for carrying out an EIA is as follows [2]: • Check legislation and regulations on environmental requirements • Review the lEE submitted and determine whether an EIA is required • Review the EIA report to check its completeness, accuracy, compliance with requirements, appropriateness and adequacy of proposed environmental protection methods • Notify the public and request their comments • Prepare countermeasures to mitigate adverse effects • Adopt or reject the proposed project • Monitor environmental changes during construction and subsequent operations. Although the EIA process can be complex and sometimes expensive, the early identification of adverse environmental impacts can provide the opportunity to take early corrective actions [2].		
Example	As an example, the Environmental Impact Assessment for the construction of a port and a conveyor corridor at Rocky Point and Brazilletto mountain, Clarendon, Jamaica [3] is provided below. It shows the cover and the table of contents of this report.		

ENVIRONMENTAL IMPACT ASSESSMENT

FOR THE CONSTRUCTION OF
A PORT AND CONVEYOR CORRIDOR

[Prepared for Rinker Jamaica Limited/CEMEX]

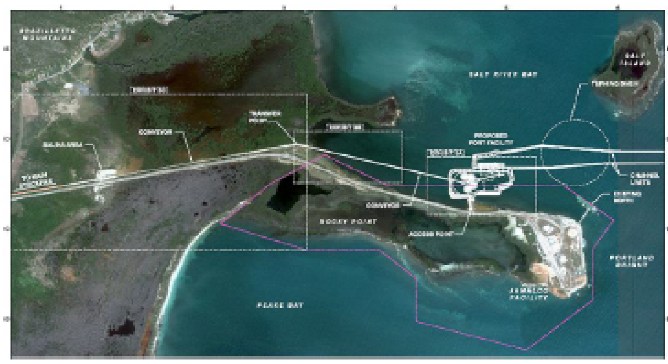


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Table of Contents

References	[1] Business dictionary. 2016. [Online]. Available at: http://www.businessdictionary.com/definition/environmental-impact-assessment-EIA.html [2] United Nations (UN). 1992. Assessment of the Environmental Impact of Port Development. Economic and Social Commission for Asia and the Pacific, UN. [3] http://www.nepa.gov.jm/eias/clarendon/rocky_point/stock-pile/revised_rinker_port_eia.pdf