



Performance trends of environmental management in European ports

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ABSTRACT

This paper presents the current status and trends over time in the environmental situation of European ports, based on the results of a wide representation of EcoPorts members (90 ports). All the information presented in this research comes from the Self-Diagnosis Method (SDM), a concise checklist managed by European Sea Ports Organisation (ESPO), against which ports can self-assess their environmental management. The results provide data on a total number of 54 indicators, being the existence of an inventory of environmental legislation the indicator with the highest implementation (96,7%), followed by the existence of an environmental policy (95,7%). Waste is the environmental issue that is being more monitored by ports. Air quality continues as the top environmental priority, followed by energy consumption and noise. It is interesting to highlight the growing awareness of Climate change among ports as well as the increasing implementation of green initiatives in ports.

1. Introduction

The imperatives of compliance with legislation, cost and risk reduction, and sustainability continue to drive the action plans of most port authorities throughout the European sector (Walker et al., 2019; De Deckere et al., 2012). The environmental performance of industry is under increasing scrutiny from an ever-widening group of stakeholders. Individual port authorities and the sector itself face growing pressure to both demonstrate their environmental credentials and to provide evidence of appropriate policies being implemented and maintained (Walker, 2016). An example of this is the Green Marine performance report (Green Marine, 2019).

Port authorities have progressively needed to take into account not only the impact of their activities and operations within the port area (OECD, 2011; Comtois and Slack, 2007), but also now their role and influence with shipping, the city, logistic chain operations and overall hinterland connections (Ng and Song, 2010; Winnes et al., 2015). By the same token, international port organisations along with their national associations seek to make representations to governmental and other legislative bodies on behalf of their members, drawing on confirmation of good practices being applied and effective implementation of the port sector's declared policy of compliance through voluntary self-regulation. All these considerations highlight the significance of independently verified environmental performance indicators being made publicly available to reveal trends and progress from initial

baseline data (Puig et al., 2015a, 2015b).

In addition, nowadays ports have to balance the triple bottom lines of port operation, that is, economic, environmental and social performance (Dushenko et al., 2019). Therefore, identifying the appropriate approach to green port management is an additional challenge (Munim et al., 2020).

This article presents the environmental performance results of European ports for 2018 as represented by those Port Authorities that are members of the European Sea Ports Organisation (ESPO) and the EcoPorts Network (www.ecoport.com).

A set of environmental management performance indicators have been analysed and the results are shown and discussed in this document. The data for this study was obtained from the responses of 90 European ports to the EcoPorts Self Diagnosis Method (SDM).

2. Methodology

This section presents the data source for this study and the characteristics of the sample used; this includes aspects such as the geographical location of the ports, tonnage and use of surrounding land.

2.1. Data source

The data gathered for establishing this 2018 European Environmental Port Benchmark come from the Self Diagnosis Method

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(SDM) questionnaire. This tool was developed within the ECOPORTS project (2002–2005) and it has been used since then to assess the environmental situation of ports, not only in Europe through ESPO (www.espo.be) but also around the world through EcoSLC Foundation (www.ecoslc.eu).

During this period, the SDM has been updated according to new changes in legislation or in international standards of Environmental Management Systems (EMS) such as ISO 14001, EMAS or PERS (Port Environmental Review System, the port sector's own, independently verified, international standard of EMS). SDM has also introduced questions on new topics of interest for ports such as green initiatives (i.e. LNG use, onshore power supply, and influence on 'green' shipping).

The SDM identifies environmental risk and establishes priorities for action and compliance (Darbra et al., 2004). When a port submits an SDM (www.ecoport.com), it may apply for a confidential report which includes: its individual answers against a European Benchmark; a GAP analysis between its situation and the international standard requirements; a SWOT analysis to identify its strengths, weaknesses, opportunities and threats; and finally, an analytical report with advice to improve its environmental performance. All the above is managed in complete confidence and reviewed by independent assessors.

The data for this report were obtained from the latest updated version of SDM (September 2018 with 256 qualitative questions) compiled as the ECOPORTS database for ESPO. SDMs responses from the 1st of September 2016 until 1st of September 2018 were included in this research. A total of 90 ports participated in the survey during this period and their responses form the basis of this report. It is important to mention that since the analysis is based on a pre-determined database compiled by ESPO of its own EcoPorts members, there could be some limitations in terms of the representative profile and statistical significance of component items.

The results for 2018 are presented in Section 3 of this paper. The trends over the time of a selected set of environmental indicators included in the SDM survey are presented in Section 4 of this paper.

2.2. Characteristics of the sample

As mentioned, 90 ports participated in this assessment from 19 different countries, all of them being ESPO members. These include the European Union countries plus Norway. Table 1 below provides the list of countries represented, the number of participating ports of each country and the percentage. Spain and the United Kingdom are the countries that have more ports represented around 12% each one, followed by France and Germany with 10% of ports.

With regards to the analysis of the ports that are part of the sample, it is also interesting to observe their geographic settings and their total tonnage of cargo handled annually. These data provide information on the natural surroundings in which the ports are located and on their size, and hence sets the context in which Environmental Management is practised.

Fig. 1 shows that the embayment, protected coast and marine inlet are the most common geographic settings of the contributing ports. The estuaries and the engineered coastline ports share the same importance. In any case, the sample is quite diverse.

Concerning the tonnage of the contributing ports (Fig. 2), most of the ports are small (< 5 million tons) and medium (5 < 15 million tons) sized. Just around 14% of the ports handle more than 50 million tons per year.

Another significant characteristic of the sample is the use of the surrounding land. As it can be seen in Fig. 3, most of the ports are close to or within an urban area. This is significant because of the range of potential impacts that the ports may have on the citizens living in this urban areas. About 68% of ports are surrounded by industry and practically half of them have adjacent protected areas. This is another environmental challenge in terms of protection and conservation.

On the basis of the above characteristics it may reasonably be stated

Table 1

List of countries and number of participating ports. Source: ESPO (European Sea Ports Organisation), 2018.

Country	Number of ports	Percentage (%)
Spain	11	12.2
United Kingdom	11	12.2
France	9	10.0
Germany	9	10.0
Netherlands	8	8.9
Greece	8	8.9
Denmark	6	6.7
Sweden	5	5.5
Finland	5	5.5
Croatia	3	3.3
Ireland	3	3.3
Norway	3	3.3
Italy	2	2.2
Portugal	2	2.2
Lithuania	1	1.1
Latvia	1	1.1
Estonia	1	1.1
Romania	1	1.1
Poland	1	1.1

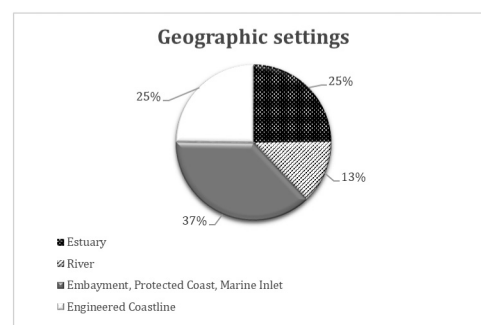


Fig. 1. Geographical characteristics of the sample. Source: ESPO (European Sea Ports Organisation), 2018.

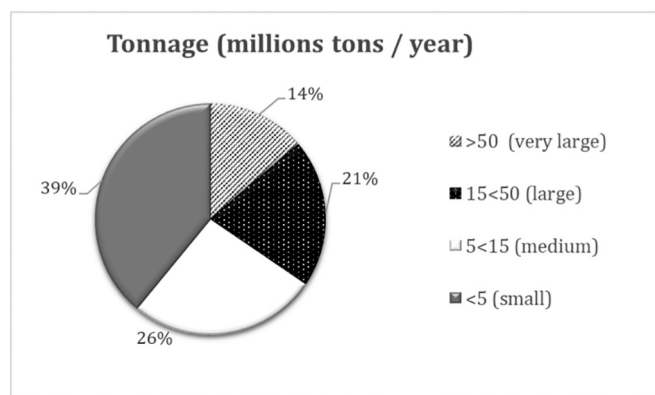


Fig. 2. Tonnage characteristics of the sample. Source: ESPO (European Sea Ports Organisation), 2018.

that the sample is representative of the European port sector and yet herein lies the challenge of summarising the performance of a division when each of its entities may be assessed as being unique in terms of commercial profile, geography, scale of operations, hydrography and often, culture and legislation. Nevertheless, it may be argued that the following indicators provide a valid representation of the performance's trends with regard to environmental management and they also contribute to communicate the key policies promoted by the European Sea Ports Organisation.

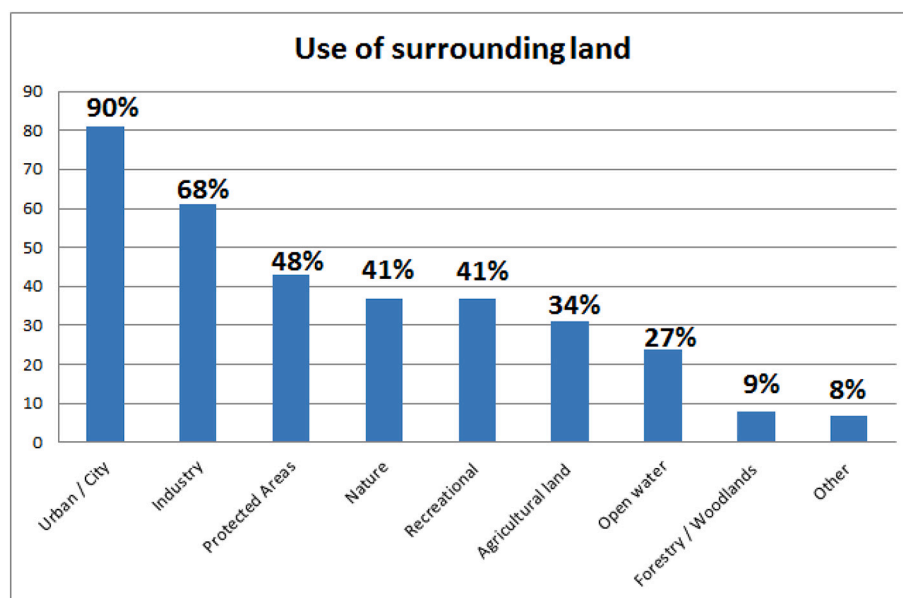


Fig. 3. Number of ports and the use of surrounding land of the sample.

3. Benchmark performance 2018

This section presents the results of this study that are expressed as the percentage of positive responses from the European port environmental managers to a total number of 54 indicators. They are classified into the nine sections that reflect the SDM format, and are represented in the next subsections. These specific 54 indicators were selected for analysis out of the total number of 256 questions included in the SDM, as being representative key indicators of the sector's trends, performance and progress.

3.1. Environmental policy

The first section of the SDM is about the environmental policy of the port. A total number of 93 questions are included in this section, dealing with the policy document itself, the policy scope, the environmental aspects of the ports' activities, the objectives and targets, and finally the resources and budget. Out of this large number of indicators, a set of eight were considered significant to be selected for the purpose of this research. These indicators and the percentage of positive responses are provided in the following Table 2:

The results demonstrate that aspects such as the existence of an inventory of environmental legislation and the existence of an environmental policy are practically fully implemented by all participant ports, with 96.7% and 95.7% respectively. They are followed by the identification of environmental aspects and the definition of

environmental objectives and targets. The formal recognition and implementation of ESPO environmental policy and guidance documentation is still a topic for progress.

3.2. Management organisation & personnel

In this section, 12 questions are included in the SDM questionnaire, dealing mainly with the tasks of the port's representative responsible for managing environmental issues. For the purposes of this research, two questions have been selected to show the performance of ports in terms of management organisation and personnel, as shown in Table 3.

Nearly all of the participant ports have a specific officer for managing environmental issues, which is a positive indicator and demonstrates the level of commitment of the ports towards the environment. In addition, a large percentage of them have such responsibilities clearly defined. This may be interpreted as a strong level of engagement in terms of managing their environmental liabilities and responsibilities.

3.3. Environmental awareness and training

This section covers the topic of port employees' awareness to environmentally-related issues (four questions) and the environmental training provided to the employees (three questions). Out of these seven indicators, four were selected as being of particular significance to this section. They include one question on port personnel awareness and

Table 2

Benchmark performance 2018 on environmental policy.

Environmental policy	% Yes
Does the port have an inventory of relevant environmental legislation and regulations related to its liabilities and responsibilities? ^a	96.7
Does the port have an environmental policy? ^a	95.7
Does the port have an inventory of Significant Environmental Aspects for the port area? ^a	93.3
Have objectives and targets for environmental improvement been defined? ^a	93.3
Is the policy publicly available on the port's website? ^b	84.4
Does the policy include reference to improvement of environmental standards beyond those required under legislation?	75.6
Does the port have a budget specifically for environmental management? ^b	75.6
Does the environmental policy make reference to the implementation of ESPO environmental policy and guidance documentation? ^b	35.6

Notes

^a Indicates that the question is related to a requirement of the International EMS Standards of PERS, ISO 14001 and EMAS.

^b Indicates that the question is related to a requirement of PERS.

Table 3
Benchmark performance 2018 on management organisation and personnel.

Management organisation and personnel	% Yes
Does the port have a representative responsible for managing environmental issues?	94.4
Are the environmental manager's responsibilities documented?	87.8

three questions on port environmental training, as presented in Table 4.

According to the results of the questionnaire, in almost 90% of ports the employees are aware of their responsibility in terms of environment. However, there are still some issues in which participant ports may make progress, such as in the training of employees related to specific activities. There is widespread agreement that dedicated training programs are time and cost-effective methods of implementing environmental policies.

3.4. Communication

The communication section includes a total set of 18 questions dealing with the reporting and on the existing communication tools to communicate internally and externally. Four indicators were selected for this review, including two explicit questions on the environmental report and two questions on internal and external communication. These results are presented in Table 5.

The results confirm that ports have their own procedures to communicate environmental information internally between key environmental personnel (92.2%) and externally with stakeholders (86.7%). In addition, 67.8% of ports confirm that publish an environmental report, ratifying it as an evidence of best practice, although there is still scope for progress. It is interesting to point out that 32.6% of ports use the Global Reporting Initiative (GRI) as reference guidelines of their report.

With regards to the last question, it is appropriate to mention that the Global Reporting Initiative Sustainability Reporting Standards (GRI Standards) are the most widely adopted global standards for sustainability reporting. The GRI Standards are for voluntary use by organisations, reporting on the economic, environmental, and social dimensions of their activities, products and services. GRI promotes sustainability reporting as a way for organisations to contribute to sustainable development, implying a scope more comprehensive than just environmental reports (GRI (Global Reporting Initiative), 2020).

3.5. Operational management

A set of 21 indicators are included in the operational management questions of the SDM, most of them relating to environmental management programs. Three questions were selected as being the most significant for this nature of review and are listed in Table 6.

The results make evident a general positive performance of the sector in relation to these three issues: environmental management programs, non-compliance with standards and environmental management manual. However, there is obvious scope for further progress.

3.6. Emergency planning

Emergency planning section comprises 19 questions related to the

Table 5
Benchmark performance 2018 on communication.

Communication	% Yes
Are there procedures to communicate environmental information internally between the key environmental personnel?	92.2
Are there procedures to exchange port environmental information with stakeholders including external parties?	86.7
Does the port publish a publicly available environmental report?	67.8
Does the report conform to standard practice of the Global Reporting Initiatives (GRI)?	32.6

characteristics of the port emergency and contingency plan. Specifically, the questionnaire asks whether a set of accidents (e.g. fire, explosion, floods, spills) are included in the plan. It is also enquired if the responsibility and role of different stakeholders (e.g. port authority, operators, ship agents) are specified in the plan. For the purpose of this report, six questions out of 19 were selected (provided in Table 7).

Since the existence of an emergency and contingency plan is a legal requirement, it is an indicator with a high implementation among the sector. Regarding the responsibilities of the different stakeholders specified in the plan, the questionnaire confirms that the port authority personnel is the one with a higher response. In addition, 86.7% of the cases, the responsibility for follow-up and reporting is specified in the port emergency and contingency plan.

3.7. Environmental issues and monitoring

The section of environmental issues and monitoring is composed of 26 questions: one concerning the environmental priorities of the port, and the rest on the issues that are covered by the monitoring plan. For this reason, the results provided below on this topic are divided in two parts: firstly, the top ten environmental priorities of ports, providing the results split by port size and location and, secondly, the results on the monitoring section.

3.7.1. Top ten environmental priorities

This section is designed to update the identification of the top ten environmental priorities of the sector. It is recognised as an important exercise that justifies regular updating in order to identify the current issues that ports perceive as being important and noteworthy in terms of their environmental management program. These results are relevant because they identify the high priority environmental issues on which ports are working and sets the framework for guidance and initiatives to be taken by the sector. Table 8 provides the top ten priorities of the sector (first column), together with the priorities of each type of location, according to the categories shown in Fig. 1.

By analysing the outcomes of the different port locations, some conclusions may be taken concerning the geographical characteristics. Overall, it is irrefutable that air quality is the top priority for all ports, whatever is their location. Special attention should also be given to the issue of energy consumption, which is ranked in the second or third position in most of the cases. It is also interesting to emphasize the growing awareness to climate change, especially in estuaries, where it may have a great affectation. Apart from the already mentioned priorities, there are other ones shared by all the categories: noise, relationship with local community, ship waste, and water quality. The

Table 4
Benchmark performance 2018 on environmental awareness and training.

Environmental awareness and training	% Yes
Are all employees aware of their responsibility to conform to the environmental policy and management objectives?	87.8
Are environmental issues included in induction programs for new employees?	67.8
Does the port authority have an environmental training program for its employees?	57.8
Is the environmental training fitted to employees' activities and responsibilities?	55.6

Table 6
Benchmark performance 2018 on operational management.

Operational management	% Yes
Have environmental management programs and action plans been prepared to achieve each objective?	82.2
Are there methods to deal with non-compliance with internal and external standards?	74.4
Is there an environmental management manual for the port?	66.7

Table 7
Benchmark performance 2018 on emergency planning.

Emergency planning	% Yes
Does the port have an emergency and contingency plan?	94.4
Does the plan specify: responsibility and role of port authority personnel?	90.0
Does the plan specify: responsibility for follow-up and reporting	86.7
Does the plan specify: responsibility and role of tenants and operators?	82.2
Does the plan specify: responsibility and role of external agencies?	74.4
Does the plan specify: responsibility and role of ship agents?	67.8

concern of noise, as demonstrated by the results, tends to be also shared by most of the ports, being in the river ports the second priority, after air quality. It is widely agreed that the issue of relationship with the local community involves not only environmental concerns but also other topics, such as governance, social, economic and mobility issues (Deforche et al. (2013), Bergmans et al. (2014)). In any case, since this indicator belongs to a list of environmental issues, when the respondent selects this topic, it is done based on the environmental concerns relating with the topic of 'relationship with the local community'.

It should be pointed out that estuary ports have dredging (operations and disposal) as items of main concern which are not repeated both in any other category. It may be explained by the fact that estuarial ports may have to carry out maintenance dredging more frequently compared to other ports, due to the sedimentation regime controlled by riverine and marine hydrodynamics.

There are two other specific issues of this section that are not shared by any other location. One is the habitat/ecosystem loss, which is a priority of estuarial ports, since these ecosystems may be special. Another is the port development (water related), which is a priority of engineered coastline, since in these type of ports new infrastructure to gain space to the water may be required.

Concerning the top ten priorities by size, the results are provided in Table 9:

In general, by analysing the results by the size of ports, air quality remains as one of the main priorities, although it is not the top one in all the categories. It is interesting to note that small ports have energy consumption as the top priority, which may be related to the costs devoted to the energy supply. In contrast, large and very large ports recognize climate change as a priority, this being perhaps recognition of the global concern over the issue and the impact that ports are deemed to make. Other priorities that are shared among different sized ports, apart from the ones already mentioned, are noise, port development (land related) and water quality.

The importance of the relationship with the local community is highlighted by most of the ports. This shows the concern of ports regarding the interaction with their stakeholders.

Ship waste is an important priority for small and medium size ports, whereas it is not for large and very large. This could be explained by the fact that small and medium ports have less resources and facilities to treat ship waste.

The benchmark performance of the monitoring issues is provided in the following section.

3.7.2. Monitoring issues

The results of the Table 10 make evident that the culture of monitoring environmental parameters is well-established across the sector.

This task consists in characterising the quality of the environment, and it is becoming increasingly important to port authorities since its results confirm compliance, track trends and establish its 'license to operate'. Systematic and targeted monitoring assists with science-based decision making and the provision of evidence of good practice. It is widely acknowledged that monitoring the current state of the environmental vectors (air, water, soil, sediments, ...) is indispensable in order to guarantee the quality of the surrounding, but it is also essential to disseminate these results among the stakeholders and the community. The results of monitoring programs based on appropriate performance indicators provide the port authority with the essence of an Environmental Report (recommended by ESPO). Table 10 shows the extent to which selected indicators are incorporated into monitoring programs.

Almost 89% of respondent ports undertake a monitoring program, a positive indicator demonstrating that this good practice is widely implemented among the sector. The issues that are mostly monitored are waste and energy consumption, which is in line with the top priorities of the sector (Tables 8 and 9). In addition, other priorities, such as air quality or noise, are also widely included in the monitoring programs of the respondent ports. However, the indicator on the identification of Environmental Performance Indicators shows that there is still scope for improvement, since only 68% of the ports have identified indicators.

Within the monitoring section, indicators related to climate change have been included in this paper, presenting the results in Table 11.

According to the responses, most of the participant ports are taking into consideration the climate change for the development of their future infrastructure projects, meaning that this topic is becoming recognised as being highly relevant for EU ports. The other two indicators are also in line with the previous statement, since 59% of ports are taking steps to strengthen the resilience of its existing infrastructure to adapt them to climate change and 41% of ports recognize to have operational challenges due to the effects of climate change.

3.8. Review and audit

This section of the SDM contains a total number of 21 questions. It includes questions concerning the environmental audit process such as the issues that are covered in an audit (e.g. compliance, environmental issues, trends, operators), and the body that conducted it (e.g. local government, own staff, external consultants). A set of five indicators were selected and presented in Table 12.

The results show that 80% of ports conduct an environmental audit, being undertaken in most of the cases by external consultants. This fact shows the interest of port authorities in being audited in terms of environmental performance, since they might be interested in achieving an Environmental Management System (EMS) certificate.

With regards to the number of ports that are EMS certified to an internationally recognised standard, Fig. 4 presents the results of the EMS certificates broken down into categories. A total number of 66 ports out of the 90 are EMS certified, 46 of them under ISO 14001, 6 under EMAS, and 30 ports have achieved the PERS certificate. The total number of certifications is in fact more than 66 because some ports are certified under more than one system.

Fig. 4 shows that more than a half of the certified ports (53%) are ISO 14001 certified. This is followed by more than a quarter of ports (28.8%) that are PERS certified. It continues then with the ports that are certified by both PERS and ISO 14001 (9.1%), and with the three EMS

Table 8
Top ten environmental priorities by location.
Sector 2018

	Embayment, protected coast, marine inlet	River	Estuary	Engineered coastline
1	Air quality	Air quality	Air quality	Air quality
2	Energy Consumption	Noise	Climate change	Energy Consumption
3	Noise	Energy Consumption	Dredging: operations	Noise
4	Ship waste	Climate change	Energy Consumption	Port development (land related)
5	Relationship with local community	Dredging: operations	Noise	Garbage/ Port waste
6	Port development (land related)	Dust	Dredging: disposal	Relationship with local community
7	Water quality	Relationship with local community	Ship waste	Ship waste
8	Garbage/ Port waste	Water quality	Water quality	Water quality
9	Climate change	Ship waste	Relationship with local community	Dredging: operations
10	Dredging: operations	Garbage/ Port waste	Habitat/Ecosystem loss (water)	Port development (water related)

certificates (7.6%). There is a minority of ports that are only EMAS certificated (1.5%). The positive significant trend for the sector is that increasingly more port authorities are openly demonstrating their environmental credentials and transparency of action through independent, third-party review and audit.

3.9. Green services

The last section of the SDM provides the results on the category 'green services', that is, the extent to which port authorities are influencing and rewarding the development of 'green shipping'. This section comprises a total number of 39 questions, related to the initiatives undertaken by port authorities in order to encourage clean ships. These initiatives are the application of environmentally differentiated port dues in order to reward greener vessels visiting the ports, the provision of Onshore Power Supply (OPS) (in high and low voltage), and the provision of Liquefied Natural Gas (LNG) bunkering facilities. Out of the large number of indicators of this section, a set of nine were selected, considered to be the particularly significant, presenting the results in [Table 13](#).

The initiative that has a higher implementation in the sector is offering differentiated port charges to reward greener vessels, with almost 54%. This is a voluntary practise by port authorities that choose to go further than controlling their own environmental impact and reward a positive change of behaviour on the vessels performance side. Environmentally differentiated port charges are encouraged and promoted through the ESPO Green Guide 'Towards excellence in port environmental management and sustainability' ([ESPO \(European Sea Ports Organisation\), 2012](#)).

The results demonstrate that more than half of the participant ports are providing OPS stations to visiting vessels. Although the questionnaire inquires on both, high and low voltage, it may be argued that the most significant result is the high voltage OPS, since in general this is the one required for the commercial seagoing vessels. Low voltage figures mainly relate to inland and domestic vessels as well as auxiliary vessels (e.g. tugs and/or other port authority vessels).

The outcomes regarding LNG show that 30.3% of respondent ports can already provide LNG bunkering regularly or upon request. It is interesting to follow the evolution of this baseline figure in the years to come also in relation to fulfilling the requirements of the EU Directive on Alternative Fuels Infrastructure ([EC \(European Commission\), 2014](#)), under which an appropriate number of refuelling points for LNG should be put in place at ports in TEN-T Core Network by 2025. With reference to the mean of supplying LNG, trucks are the most common one (26%), followed by barge (6%) and through a non-mobile installation (2%). A very encouraging result is the fact that 24% of ports have ongoing projects to build LNG bunkering infrastructure.

4. Trends over time

The performance of 2018 is compared, whenever it is possible, with the performance obtained in the Sustainability Report 2017 ([ESPO \(European Sea Ports Organisation\), 2017](#)), the Sustainability Report 2016 ([Puig et al., 2017](#)), the ESPO Port Performance Dashboard ([Puig et al., 2015a, 2015b; ESPO \(European Sea Ports Organisation\), 2013](#)), the ESPO/Ecoports Port Environmental Review 2009 ([ESPO \(European Sea Ports Organisation\), 2010](#)) and with the ESPO Environmental Survey 2004 ([ESPO \(European Sea Ports Organisation\), 2005](#)).

4.1. Environmental management

These indicators provide representative information about the management efforts that influence the environmental performance of the port. Although they are highly recommended indicators to be implemented within the port environmental management plan, they are voluntary initiatives and, therefore they are not considered as legal

Table 9

Top ten environmental priorities by size.

	Sector 2018	Small	Medium	Large	Very large
1	Air quality	Energy Consumption	Air quality	Air quality	Air quality
2	Energy Consumption	Air quality	Noise	Energy Consumption	Climate change
3	Noise	Ship waste	Energy Consumption	Climate change	Noise
4	Relationship with local community	Noise	Ship waste	Relationship with local community	Energy Consumption
5	Ship waste	Relationship with local community	Port development (land related)	Dredging: operations	Garbage/ Port waste
6	Port development (land related)	Water quality	Dredging: operations	Port development (land related)	Water quality
7	Climate change	Dredging: operations	Relationship with local community	Dust	Odours
8	Water quality	Garbage/ Port waste	Garbage/ Port waste	Dredging: disposal	Ship exhaust emissions
9	Dredging: operations	Port development (land related)	Water quality	Noise	Port development (land related)
10	Garbage/ Port waste	Dust	Port development (water related)	Water quality	Dust

Table 10

Benchmark performance 2018 on monitoring issues.

Monitoring issues	% Yes
Does the port have an environmental monitoring program?	88.9
Does the program address waste?	84.4
Does the program address energy consumption?	80.0
Does the program address water quality?	75.6
Does the program address water consumption?	72.2
Has the port identified Environmental Performance Indicators (EPIs) to monitor trends in environmental performance?	67.8
Does the program address noise?	67.8
Does the program address air quality?	66.7
Does the program address sediment quality?	57.8
Does the program address carbon footprint?	46.7
Does the program address marine ecosystems?	40.0
Does the program address soil quality?	37.8
Does the program address terrestrial habitats?	37.8

obligations.

Table 14, below, shows the percentage of positive responses to each of these indicators in the review of 2018 as well as the results obtained in 2013 (79 participants), 2016 (91 participants), 2017 (91 participants), in order to analyse the variations over time.

As it can be seen in Table 14, the existence of an inventory of relevant environmental legislation (a requirement of all major EMS standards) is the indicator that has a highest percentage of positive response (97%). This means that practically all the participant ports are technically aware of the legislation that applies to them and may be assessed as positive in terms of potential compliance. The second highest percentage is the existence of an Environmental Policy (assessed by auditors as being the driving-force of an effective EMS), showing the degree of commitment of the European ports to improve their environmental performance.

Also, over 90% of ports have an inventory of Significant Environmental Aspects (SEA) and have defined objectives and targets for environmental improvement. These two issues have increased 9% since 2013.

It may be assessed as being significant that the indicator on the existence of an EMS has increased from 54% in 2013 to a 73% in 2018, which is a positive indicator of the willingness of the ports to establish an organized system to manage their environmental issues.

Table 11

Benchmark performance 2018 on climate change.

Climate change	% Yes
Does your port consider climate change adaptation as part of new infrastructure development projects?	78.0
Does your port take steps to strengthen the resilience of its existing infrastructure in order to adapt to climate change?	59.0
Does your port experience operational challenges that could be related to climate change (e.g. more frequent storms, flooding, changes in wind or wave conditions)?	41.0

The trends of performance of most of the indicators have improved relative to 2013, particularly in the cases of documentation of environmental responsibilities of the key personnel (+15%) as well as the existence of an environmental monitoring program (+10%). However, the existence of a training program for port employees has slightly decreased. Another aspect for further improvement is the increase in the percentage of ports making available an environmental report, since transparency is one of the key elements for any credible EMS.

On the basis of the ten indicators present in Table 14, an Environmental Management Index can be obtained. This is calculated on the basis of a specific weighting applied to the significance of these key environmental management components. It is argued that this index is particularly appropriate since it is a measure of competence and capability to deliver the environmental imperatives. The Environmental Management Index is calculated by multiplying the weightings associated to each environmental management indicator (see Table 14 and formula below) to the percentage of positive responses. The final score is calculated by applying the following formula:

$$\begin{aligned} \text{Environmental Management Index} = & A * 1.5 + B * 1.25 + C * 0.75 + D \\ & * 1 + E * 1 + F * 1 + G * 0.75 + H \\ & * 1 + I * 1 + J * 0.75. \end{aligned}$$

The numerical value of each letter is the percentage of positive response divided by 100 (e.g. A is 0.73 in the results of 2018 as showed in Table 14). The resulting index for the performance of the port sector in 2013, 2016, 2017 and in 2018 is provided in Table 15.

As it can be seen in the previous table, the index value has increased year-on-year achieving a steady value of 8.08 out of 10 in the last two years.

4.2. Top 10 Environmental priorities

The third section provides the update of the Top 10 environmental priorities of the European port authorities. This is a significant summary because it shows the priority status ascribed by port professionals to current issues that are assessed as being important and noteworthy in terms of the port's environmental management program. This data is important because it identifies the high priority environmental issues on which ports are working and sets the framework for guidance and initiatives to be taken by ESPO. The 2018 results complement the

Table 12
Benchmark performance 2018 on review and audit.

Review and audit	% Yes
Has an environmental audit been conducted?	80.0
Was the audit conducted by external consultants?	73.3
Was the audit conducted by own staff?	50.0
Was the audit conducted by Environmental Enforcement Agency?	26.7
Was the audit conducted by local government?	7.8

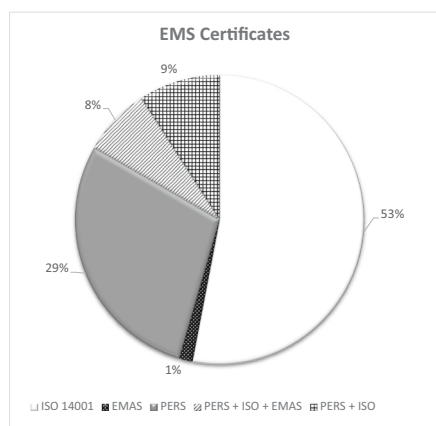


Fig. 4. Distribution of the EMS certificates.

Table 13
Benchmark performance 2018 on services to shipping.

Services to shipping	% Yes
Does the port differentiate dues for 'Greener' vessels?	53.9
Is OPS available at one or more of the berths?	50.6
If yes, low voltage?	41.6
If yes, high voltage?	23.6
Is LNG bunkering available in the port today?	30.3
- If yes, by trucks?	25.8
- If yes, by barge?	5.6
- If yes, through a non-mobile installation?	2.2
- If no, are there currently ongoing LNG bunkering infrastructure projects in the port?	23.6

results of the previous ESPO/EcoPorts surveys that were initiated back in 1996.

All the priorities of the 2017 Top – 10 are again represented in 2018 although there are some changes in the order of priorities. Air quality has remained the number one priority of the European ports since 2013. This could be explained by the different legislation that applies to ports

Table 14
Percentages of positive responses to the environmental management indicators. Source: ESPO (European Sea Ports Organisation), 2018.

Indicators	2013 (%)	2016 (%)	2017 (%)	2018 (%)	% Change 2013–2018
A Existence of an Environmental Management System (EMS)	54	70	70	73	+19
B Existence of an Environmental Policy	90	92	97	96	+6
C Environmental Policy makes reference to ESPO's guideline documents	38	34	35	36	–2
D Existence of an inventory of relevant environmental legislation	90	90	93	97	+7
E Existence of an inventory of Significant Environmental Aspects (SEA)	84	89	93	93	+9
F Definition of objectives and targets for environmental improvement	84	89	93	93	+9
G Existence of an environmental training program for port employees	66	55	68	58	–8
H Existence of an environmental monitoring program	79	82	89	89	+10
I Environmental responsibilities of key personnel are documented	71	85	86	86	+15
J Publication of a publicly available environmental report	62	66	68	68	+6

concerning emissions, such as the implementation of the Sulphur Directive (EC (European Commission), 2012), the new National Emission Ceiling Directive (EC (European Commission), 2016), the introduction of the global 0.5% sulphur cap on marine fuels in 2020 (IMO (International Maritime Organisation), 2019a) or the IMO NOx Tier III requirements for vessels built from 1-1-2021 onwards operating in the North and the Baltic sea (NECAs) (IMO (International Maritime Organisation), 2019b). Energy consumption also remains as the second priority issue of the European ports. Since 2013, this aspect is placed in the top 3 issue for EU ports. One of the reasons for this fact may well be the direct link between energy consumption, and the carbon footprint of the ports and Climate Change. This latter issue appeared in the top ten list for the first time in 2017 in the last position and it has climbed to the 7th position in 2018. As it has been seen in Table 16, climate change effects are already considered seriously by the contributing ports, which are starting to act to reduce its effect and to fulfil the objective of the Paris Agreement.

Noise remains as the third priority concern and its importance has also grown since 2004. This is directly related with the next issue, the relationship with the local community. Port-city issues are becoming of high relevance for European Ports and this is reflected with the increase of importance of the relationship with the local community in the last years. The European Commission has been fostering research on this direction by funding projects on city-port related issues.

Ship waste has also increased its importance in the last year due to the newly adopted Directive on Port Reception Facilities for ship waste. In addition, it is important to point out that waste has been reported as the highest priority monitoring issue by ports since 2013 (Table 10).

In the case of Dredging operations and Water quality, relative importance has decreased in priority whilst Port development (land related) moved slightly up in the priority scale. This issue together with Dredging operations are present in all the top ten rankings since 1996.

4.3. Environmental monitoring

The second category of indicators is focussed on the environmental monitoring programs of European ports. These indicators provide the percentage of ports that monitor selected environmental issues. The percentages of positive responses are given in Table 17, listed in descending order based on the results obtained in 2018. The results obtained in 2013, 2016 and 2017 are also provided in the table below:

In 2018, waste has emerged as the most monitored issue, becoming the top priority monitoring issue since 2013. There has been an increase of 17% of ports monitoring this aspect in the last 5 years. It is followed by energy consumption (that increased +15% since 2013) and water quality with the highest rise in the last years (+20%).

Water consumption and noise are also monitoring issues that have increased their percentages in the last year. Air quality has accumulated an increase of 15% since 2013. Soil quality and terrestrial habitats are the issues with the lowest percentage of ports monitoring them. Concerning Carbon Footprint, although there has been an increase of

Table 15

Progress of the Environmental Management Index over the years.

	2013	2016	2017	2018
Environmental Management Index	7.25	7.72	8.08	8.08

interest related to Climate Change issues (as presented in Table 16), monitoring this issue is rather complicated due to the amount of data necessary to gather, the personnel involved and the resources needed (Azarkamand et al., 2020). This could explain the steady trend of this environmental monitoring indicator.

4.4. Services to shipping

This section is comprised of three indicators based on the extent to which port authorities may influence greener shipping. These are: i) the provision of Onshore Power Supply, ii) the provision of Liquefied Natural Gas (LNG) bunkering facilities and iii) the differentiation of port charges in order to reward greener vessels visiting the ports. Information on these issues started to be collected in 2016 when the EcoPorts SDM was updated to be able to monitor the current status and evolution of these key services that ports may choose to provide to their stakeholders. Hence, the benchmark is presented from 2016 until 2018.

As it can be seen in Table 18, there is positive trend over the years for most of the indicators, highlighting for example the increase in the use of the high voltage OPS from 2016 until 2018 (24%). Offering differentiated port charges for greener vessels is a fairly widespread practice in EU ports with more than half of the participant ports doing so in the last years. The outcome with highest growing trend is the one regarding availability of LNG bunkering at the port. It has increased 8% since 2016 and it seems that investments at ports will contribute to fulfilling the requirements of the EU Directive on Alternative Fuels Infrastructure as regards the provision LNG bunkering facilities in major European ports by 2025.

5. Conclusions

Year-on-year, EU ports are continuing to demonstrate their commitment and progress in terms of environmental protection and their sustainable development. This 2018 review is based on the input of 90 ports that have demonstrated their environmental performance by completing the on-line EcoPorts/ESPO Self-Diagnosis Method, the

completely voluntary and confidential check-list of good practice components. The results show baseline data for 2018 and benchmark performance and trends over several years.

The environmental performance of European ports is constantly improving. The results demonstrate the status given to current environmental issues by port authorities, and their efforts to fulfil the associated regulatory, social and environmental liabilities and responsibilities.

Regarding the existence of environmental management components, ports have shown an increasing interest in having an inventory of relevant legislation and comply with it. The number of ports with certified EMS has increased, which is a positive sign of ports seeking to demonstrate effective implementation of EMS to high standards of quality.

The continued increase in the number of ports with a recognised, certified quality Environmental Management System is a significant and positive trend that underpins ESPO's policy of compliance through voluntary, self-regulation. The sector recognises that compliance is, of course, non-negotiable, but the increase in the numbers of ports with audited confirmation of the key components of a credible EMS (including the Inventories of Legislation and Significant Aspects) may be cited as demonstrable evidence of growing, good practice.

Further evidence of expanding good practice is the number of ports communicating with their stakeholders. Emerging communicating strategies are being applied since recent years (Parola et al., 2013) to improve this communication. This is producing a more integrated approach to Environmental Management where the ports are influencing port-city and port-hinterland initiatives, and more ports are offering options to influence the greening of the shipping industry.

It may be suggested that more individual Port Authorities should be encouraged to produce an Environmental Report. This is a requirement of EMS standards PERS and EMAS, and the same standards require a port to publish a publicly available environmental report (separate or as part of a sustainability report with attention on environmental issues). Reviews also suggest that those Environmental Reports already produced may be enhanced further by the addition of science-based evidence derived from systematic monitoring programs.

The apparent decrease in the number of ports providing an Environmental Training Program for employees is noted for consideration (such programs are a requirement of EMS standards ISO 14001 and EMAS).

In terms of monitoring environmental issues, waste and energy consumption remain in the top priority positions. The monitoring of noise has increased significantly over the last few years, probably related with growing importance of the port-city related issues.

Concerning the Top-10 issues, Air quality remains the highest

Table 16

Top 10 environmental priorities of the port sector over years. Source: ESPO (European Sea Ports Organisation), 2018.

	1996	2004	2009	2013	2016	2017	2018
1	Port Development (water)	Garbage / Port waste	Noise	Air quality	Air quality	Air Quality	Air quality
2	Water quality	Dredging: operations	Air quality	Garbage/ Port waste	Energy Consumption	Energy Consumption	Energy Consumption
3	Dredging disposal	Dredging disposal	Garbage / Port waste	Energy Consumption	Noise	Noise	Noise
4	Dredging: operations	Dust	Dredging: operations	Noise	Relationship with local community	Water quality	Relationship with local community
5	Dust	Noise	Dredging: disposal	Ship waste	Garbage/ Port waste	Dredging: operations	Ship waste
6	Port Development (land)	Air quality	Relationship with local community	Relationship with local community	Ship waste	Garbage/ Port waste	Port development (land related)
7	Contaminated land	Hazardous cargo	Energy consumption	Dredging: operations	Port development (land related)	Port development (land related)	Climate change
8	Habitat loss / degradation	Bunkering	Dust	Dust	Water quality	Relationship with local community	Water quality
9	Traffic volume	Port Development (land)	Port Development (water)	Port development (land)	Dust	Ship waste	Dredging: operations
10	Industrial effluent	Ship discharge (bilge)	Port Development (land)	Water quality	Dredging: operations	Climate change	Garbage/ Port waste

Table 17

Percentage of positive responses to environmental monitoring indicators. Source: ESPO (European Sea Ports Organisation), 2018.

Indicators	2013 (%)	2016 (%)	2017 (%)	2018 (%)	% change 2013–2018
Waste	67	79	88	84	+17
Energy consumption	65	73	80	80	+15
Water quality	56	70	75	76	+20
Water consumption	58	62	71	72	+14
Noise	52	57	64	68	+16
Air quality	52	65	69	67	+15
Sediment quality	56	63	65	58	+2
Carbon footprint	48	47	49	47	-1
Marine ecosystems	35	36	44	40	+5
Soil quality	42	44	48	38	-4
Terrestrial habitats	38	30	37	38	+0

Table 18

Percentage of positive responses to services to shipping indicators.

Indicator	2016 (%)	2017 (%)	2018 (%)
Is On-shore Power Supply (OPS) available at one or more of the berths?	53	48	51
If YES, high voltage?	20	19	24
If YES, low voltage?	47	40	42
Does the port offer differentiated dues for “Greener” vessels?	62	51	54
Is Liquefied Natural Gas (LNG) bunkering available in the port today?	22	22	30

priority since 2013. However, climate change has climbed in the list to the 7th position after entering in the Top-10 list for the first time last year. Climate change is becoming an aspect of high relevance for ports that already are taking into consideration its effects and impacts, and are adapting their infrastructure to reduce them. This makes clear the importance of this issue for European ports, together with the relationship with the local community which now occupies the 4th position.

Since first surveyed in 2016, ports are continuing to increase their influence on the greening of shipping by providing a range of options. Half of the sample ports are offering on-shore power supply to their stakeholders and the same percentage offer the option of differentiated fees for green vessels. There is also a clear rise in the number of ports that have LNG bunkering available. In addition, the prospect of future LNG installations is growing among the European ports.

As a conclusion, it can be stated that European ports are improving their environmental performance over the years through voluntary self-regulation. Initiatives such the EcoPorts program and other ESPO initiatives are motivating ports to continue their path to promote environmental protection and sustainable development.

CRediT authorship contribution statement

Martí Puig: Writing - original draft, Methodology, Investigation. **Sotiris Raptis:** Supervision, Data curation, Resources. **Chris Wooldridge:** Conceptualization, Writing - review & editing, Formal analysis. **Rosa Mari Darbra:** Conceptualization, Writing - review & editing, Supervision, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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