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Ana X. Halabi-Echeverry

*Universidad de La Sabana*, ana.halabi@unisabana.edu.co

Philippe Clermont

*Ecole Nationale d'Ingénieurs de Tarbes (Enit), Laboratoire Génie de Production (LGP)*, philippe.clermont@enit.fr

Nelson Obregon-Neira

*Universidad Javeriana*, nobregon@javeriana.edu.co

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# A systemic-driven perspective towards port's informational decisions through consideration of port sustainability

Ana X. Halabi-Echeverry<sup>1</sup>, Philippe Clermont<sup>2</sup>, Nelson Obregon-Neira<sup>3</sup>

<sup>1</sup>Escuela Internacional de Ciencias Económicas y Administrativas, Universidad de La Sabana,  
Km 7 Autopista Norte de Bogotá, D.C., Chía (Cundinamarca), Colombia  
[ana.halabi@unisabana.edu.co](mailto:ana.halabi@unisabana.edu.co)

<sup>2</sup>Ecole Nationale d'Ingénieurs de Tarbes (Enit), Laboratoire Génie de Production (LGP) Carrera 7 no.  
42-27 Piso 7, Toulouse, France,  
[philippe.clermont@enit.fr](mailto:philippe.clermont@enit.fr)

<sup>3</sup>Instituto Geofísico, Universidad Javeriana, Carrera 7 no. 42-27 Piso 7, Bogotá, Colombia,  
[nobregon@javeriana.edu.co](mailto:nobregon@javeriana.edu.co)

**Abstract:** This paper presents some of the challenges in the development of Decision Support Systems for ports. Specifically, it refers to port informational integration in a context of sustainable factors, practices and functions of the port. It discusses the systemic perspective of port informational integration containing the boundaries of the complex system named Port Decision System Approach (PDSA) and presents the recognition of a decision-making situation as the step one in a methodology that offers a high-level support enhanced through the application of techniques from Computational Intelligence. The PDSA provides the necessary theoretical elements to recognise and deal with the inherent complexity of port informational integration that could be extended or modified as new knowledge emerges.

**Keywords:** Port Decision System Approach (PDSA), Port Informational Integration, Sustainable Development in Ports, Intelligent Decision Support Systems.

## 1 RATIONALE OF THIS WORK

This paper presents the systemic perspective for port informational integration that builds into the conceptual definition of the Port Decision System Approach (PDSA) which incorporates flows of information, data structures and intelligent support. The rationale of this work is made up by several constructs (also hypotheses) some of which have been tested with empirical evidence elsewhere.

### 1.1 Introduction

As suggested by Woo et al. (2011), the development of concepts, theory and analytical frameworks has been very slow and there is an important gap for research on port systems, an aspect that links to the objectives in this paper. Theorists such as Holton and Lowe (2007) specify theoretical frameworks such as the systems approach as useful in developing theory and proposition (i.e., statements subject to empirical testing). The systemic perspective for port informational integration explores the appropriateness of a systems approach to port's information-related decisions. The port informational integration concept is presented in this paper as a higher perspective of port cooperation in which development of capabilities on sharing information, planning and execution allow two or more ports to advance. The systemic-driven perspective follows a systems approach towards port's informational decisions, mainly shaped through consideration of port sustainability issues where knowledge from coastal (eco) system and different types of port proximities (spatial and institutional) are essential conditions in becoming port partners for informational integration.

*What are future challenges in the development of Decision Support Systems for ports?*

From a systemic-driven perspective, Port Community Systems (PCS) are becoming crucial for port management, governance and operation. These systems encompass an ambitious scope of information ranging from exports to global footprints, and from port users to international communities. According to The International Port Community Systems Association (IPCSA), a Port Community System (PCS) is “a neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders in order to improve the competitive position of the sea and air ports’ communities (2014)”. van Baalen & van Oosterhout (2009), define the new role of a port (in terms of its IT architecture) which can become the coordinator or information broker just like the main node in a global information network. This new role provides to the PCS the following benefits:

- Connectivity (between separate systems),
- Translation services (metadata and ontologies), and
- Reuse of data (originally obtained through a number of services/sources).

According to van Baalen & van Oosterhout (2009), in this role are ports such as the Ports of Rotterdam and Amsterdam, the Ports of New York and New Jersey, and the Ports of Los Angeles and Long Beach. They face many challenges in managing complex information flows that have led to their development of global information networks such as imports and exports cargo, tracking of goods and customs clearance.

## **1.2 Port Sustainability**

Sustainability is seen as a balance between economic progress, environmental and social responsibility. Sustainability is also importantly recognised as a long-term business strategy and corporate social responsibility (Klettner et al., 2014). Corporate Social Responsibility (CSR) in the context of ports is recognised by the European Seaports Organization (ESPO 2010) as the responsibility that has a broad scope and can in some cases stretch far beyond the port jurisdiction focusing in the surrounding societal environment and human factors. In the same line, Hiranandani states that “for ports, sustainability implies business strategies and activities that meet the current and future needs of the enterprise and its stakeholders, whilst protecting human and natural resources (2014, p. 130)”. Interesting questions are proposed in Hiranandani (2014, p.127):

1. What are the [factors], drivers and constraining forces in achieving sustainable development in ports?
2. What specific sustainable practices do ports utilise to manage environmental [and ecological] aspects such as air pollution, water quality, ballast water, dredging and disposal of dredge materials, waste disposal, hazardous substances and land/resource use?
3. What policy [and regulatory] frameworks do ports adopt to attain sustainable development?

Next section details Environmental Management Practices and Systems in Ports as links between the physical environment and management processes carried by ports with a technological perspective. An explanation of Biogeographic regions is also presented as essential places to understand different environmental management scenarios.

## **1.3 Factors and Key Drivers for Sustainable Development in Ports**

Although it is clear a port experiences different environmental questions while in operation, a general awareness exists on three important drivers for its sustainability (APPA, 1998; Kruse, 2005; Ng & Song, 2010; Acciaro et al., 2014; Lam & Notteboom, 2014; Hiranandani, 2014): a) Air emissions, b) Water quality, and c) Impacts of growth.

Air emissions becomes an environmental and ecological issue because vessels arriving at ports use their engines to provide heating, cooling and electricity for loading and unloading activities generating in this way emissions (International Council on Clean Transportation –ICCT-, 2007). Other transport and industrial activities within the port area may generate emissions of carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), Sulphur oxides (Sox) and particulate matter (PM) (Bailey et al., 2004). Water quality becomes an environmental and ecological issue because there are plenty sources of water pollution at ports, some include: runoff water from storm drains, ship sewage and ballast waters that result in the introduction of non-native or invasive species, port or ship discharges containing detergents, chemicals, etc., and dredging activities consisting on periodic removal of sediments from seabeds to

maintain port access channels, the latest affects water quality because increases suspended sediments and releases contaminants (ESPO, 2013). Impacts of growth become an environmental and ecological issue because generally, surrounding communities are increasingly interested in the impacts of port expansion. Congestion, safety, and environmental impacts are derived from port growth.

#### **1.4 The Sustainable Port Function**

It is through responsible governance that ports can foresee possibilities for sustainability. According to Acciaro et al. (2014), there is a need to stimulate and facilitate ports in adopting green practices. Pursuing green objectives, the main functions of port authorities (PAs) are likely to influence such practices. Cullinane & Song (2002) point out a starting point of port essential functions: a) the regulatory function, b) the landowner function, and c) the operator function. The regulatory function specifically refers to controlling, surveillance and policing functions of PAs that ensure the safety and security port area. The landlord function refers to the management of areas and activities entrusted to PAs including the implementation of policies. The operator function accounts for the operating factors of the port and their respective profits. Acciaro et al. (2014) distinguish also the community function of PAs that strengthens the management with stakeholders and the community in general, solving conflicts of interest between the parts.

#### **1.5 Environmental Management Practices and Systems in Ports**

The substantial amounts of information that must be gathered, preserved, and used to analyse environmental and ecological factors, drivers and constraining forces, and to account on analyses for decision-making has served as the origin of environmental management practices (EMPs) and environmental management systems (EMSs) in ports.

EMPs are referred by APPA (1998) after conducting a detailed on-site survey with 30 US ports which still is an obliged source of reference and has a proven track record. The most effective and commonly used EMPs at ports are:

1. EMP N° 04: Bulk Storage and Handling Liquid: this practice prevents releases from bulk liquid storage and handling facilities. The main potential pollutants are: oil and grease, fuels, organic chemicals, inorganic chemicals.
2. EMP N° 05: Chemical Storage and Handling (Non Bulk): this practice prevents releases of pollutants from the handling and storage of chemicals in 55-gallon drums or smaller quantities. The main potential pollutants are: organic chemicals, inorganic chemicals, metals, oils and grease.
3. EMP N° 09: Protection of Marine Mammals and Sensitive Aquatic Habitats: this practice protects marine mammals and other sensitive marine life from ship strikes, ship docking procedures, and other port activities.
4. EMP N° 014: Ship Air Emissions: this practice reduces the discharge of pollutants to the air from operation of ships. The main potential pollutants are: nitrogen oxides, sulphur dioxides, particulates, hazardous air pollutants.
5. EMP N° 016: Dredging and Dredge Material Disposal: this practice reduces the impacts from dredging and dredge materials disposal. The main potential pollutants are: hydrocarbons, heavy metals and pesticides.

It is thus expected for ports working with EMSs to build relationships with business partners to find sustainable solutions to the complex challenges that need to be met such as climate change (air pollution), water quality (social needs) and land use (impacts of growth) (EPA, 2007; Puente-Rodríguez et al. 2015a, 2015b). According to EPA, one way to incorporate sustainability into an EMS is to widen its scope to include more facilities and activities, i.e., all entities impacted by the port's exercise of jurisdiction. For example, "taking a step-wise approach to defining the port boundary for the purposes of sustainability...[by:] a) considering areas within the port's direct control, b) extending to tenants, and c) extending to the region in which the port is located (2007, p.7)".

#### **1.6 Biogeographic regions**

Because an environmental management system links the physical environment and management processes to offer a computerised version of nature, the explanation of Biogeographic regions becomes essential to understand the space into which assess different port management scenarios. Biogeographic regions are natural frameworks for marine zoning which increasingly are the interests, for instance, of regional fisheries organisations. A marine ecoregion, also known as a marine ecosystem, is the smallest-scale unit in a biogeographic region. It may include (in ecological terms): nutrient inputs, sediments, freshwater influx and coastal complexities (Spalding et al., 2007).

## **1.7 Port environmental regulation**

To guide efforts for EMS development and adoption, ports mostly use policy and regulatory frameworks and technology developments. A mandatory or voluntary approach to environmental regulation largely depends on international requirements to enable an organisation to develop and implement green policies and objectives. The International Organisation for Standardisation (ISO), The Environmental Protection Agency (EPA) and The Association of American Port Authorities (AAPA) are some of the advocates on port environmental performance improvement and recognition of the achievements gained. Royson (2008) presents various standards, codes and schemes developed to certify a port's environmental performance. This review also adds voluntary alliances and protocols to accomplish environmental objectives. Very common are the use of the International Organisation for Standardisation - ISO 14001:2004 Standard and the Port Environmental Review System (PERS) International Standard. Furthermore, safety and security frameworks can also be extensions of an EMS such as The International Convention for the Safety of Life at Sea (SOLAS) but in this case the management system approach is to Security Management Systems (SMSs) or to both EMS/SMS approaches. Cross-cutting EMSs programs such as the Global Environmental Program (GEP) that encompasses projects such the Land-Ocean Interactions in the Coastal Zones (LOICZ), identify and report environmental management data and processes describing land-ocean interactions in coastal zones. Yet, few technological prototypes combine environmental and management challenges; one identified in the literature is The Environmental Information Management System (EIMS) conducted in 2006 by Cambridge Systematics and Venner Consulting Inc. (NCHRP, 2007).

## **2 METHODOLOGY**

This subsection discusses the systemic perspective of port integration containing the boundaries of the complex system named Port Decision System Approach (PDSA). The obtained methodology offers a high-level support enhanced through the application of techniques from Computational Intelligence. This methodology is a bottom-up one that manages the systemic complexity of port integration. Steps in the methodology are motivated by the recent developments found in Mora et al. (2011) about their free-access methodology for new developers of intelligent decision-making support systems (i-DMSS). The paper mainly refers to step 1 or the recognition of a decision-making situation.

### **2.1 The Systemic-driven Perspective towards Port's Informational Decisions**

The idea of looking at ports from a systemic perspective has been mentioned in the literature since decades ago but the way this perspective opens possibilities for port competition, cooperation and integration has been noted recently by few scholars among are Ducruet (2009, 2008) and Notteboom (2010). Cetin & Cerit (2010, p. 200) states that "it can be referred that port organisations are complex adaptive systems". The general definition of a system is a group of interacting, interrelated, or interdependent elements, forming a complex unit which seeks to assist observation, understanding and analysis of the reality involved. "The slightest decision taken on one side of the world might have an unexpected impact somewhere else in the world (Cassaigne & Lorimier 2006, p. 401)". "Uncertainty and complexity are becoming common facts leading to the greater recognition of systemic and holistic approaches to problem solving (ibid, p. 401)".

The systemic perspective of port integration requires consideration and weighting of complex aspects, which effects can be seen now and in the future. To bring into the systemic aspects of port integration, previous work in Halabi et al. (2011) explored the interdisciplinary framework called The Social Process Diagram (SPD) created by the Consortium for International Earth Science Information

Network (CIESIN, 1992). The SPD has been proposed to bring the benefits of Earth monitoring systems to policy makers and applied users worldwide. The Consortium's success hinges on accounting from an interdisciplinary of global change research and understanding of rapid evolution of technology (CIESIN, 1992). Likewise to the SPD, the systemic perspective of port informational integration is novelty proposed here from an interdisciplinary approach (PDSA) that places emphasis on driving factors influencing the current approaches to port integration such as physical connectedness (port networks), but also to new referent factors importantly influencing ports such as Globalisation and Expansion Capacity (Comtois, 2008). Christopher remarks that ports are open systems in which "transactional exchanges or the continuing inflow and outflow of information of resources, sustain the endeavour" (2014, p.51). In other words, ports are open systems in which exchanges of information and resources constantly occur. The importance of taking the port informational integration with a systemic perspective is that "subsystems can also be regarded as processes or transformations in the ports (Cetin & Cerit 2010, p. 202)", then the consequent acknowledgment is that processes work on functions of the port such as ship and cargo operations, logistics services and safety and security, and those as interconnected subsystems.

An especial emphasis is placed on showing the complexity of the system that arises when hypothesing information sharing among ports. From this point, this research incorporates factors responding to hypotheses on which flows of information may occur for port integration. Also, factors of one subsystem influence the evolution of factors presented in other systems. These factors are represented by arrows (linkages) and both: factors and connected subsystems constitute the processes driving port informational integration. Outputs from one subsystem act as inputs of another, thus they should not be evaluated in isolation. For example, Lee et al. (2008) identify geographical coverage concepts resulting from the pressure of land patterns at the city-port area such as the inland centrality (i.e., land dispersion between the shore and the inland area). The proposed hypothesis is that the identified factor, i.e., "centrality", can be conceptually linked to the subsystem of Production and Technology (FPT). In other words, the factor "centrality" can be an output of FPT because this system is generally dependent on the use of resources such as the use of land. Then the factor "centrality" can be tied up to the FPT system. Because systems are not isolated in the PDSA, the following question is to which system, the factor "centrality" serves as an input. Because, the subsystem of Global Scale Environmental Processes (GEP) determines the way land is exploited and thus settlement patterns must be considered, the resulting construct for the factor "centrality" can be tied up to GEP creating an influential element that feeds the discussion on flows of information for port integration.

## **2.2 Decision-making Elements for Ports Concerned with the Ability to Integrate information**

This section presents the effective knowledge in decision-making and the necessary assistance in understanding diverse and complex situations for port informational integration. Decision-making elements are concerned in this paper with the ability to integrate information with a port partner recognising ports as ecosystems and involving normative, systemic and procedural dimensions. The regulatory function of the port has led PAs to face high pressures to become accredited and internationally recognised. Moreover, a number of environmental measures, produced by agencies and local administrative authorities, are difficult with respect to decision making and as a result with defining strategies to understand the consequences of cooperation between ports using clear benchmarks and standards.

The schema in Figure 1 captures the general structure of this decision making situation. The main problem is to discover the benchmarks/factor (w's mined variables) associated to a port in an environmental and ecological context and run a classification on a class variable (decision variable) based on: 1) who the port leader, 2) the follower and 3) the average user of EMS standards might be (Y's Outputs). This classification also will help PAs to become more aware of the scope and impacts of their activities, defining new port boundaries for the purpose of sustainability. The classification outcomes are indicated as if-then rules (Z's scenario variables) in the schema (for an extended version of this classification consult Halabi et al. (2012; 2015). The interaction of the decision elements, the boundaries of the construct and the interrelationships between the data levels complete the analysis. Each decision-making element is provided with a dictionary: code, name, value (ordinal, binominal, continuous), source (repository, website, etc.), comments and if-then rules. Tables 1 to 3 exemplify each element.



**Table 3.** Extract of the Dictionary of Elements Scenario Variables

		O3cont	>75	ppb (parts per billion)	Inadequacies	=NO	Number of	Hypothetical classification: A=20/F=7/L=1 Algorithm classification: A=21/F=6/L=3	Rule
05	IF	The area in which the port operates <b>do not meet</b> the 8-hour standards set with a threshold below 75 ppb (in 2008) toward better air and a stronger ozone standard	AND		none historical encountered problems in discharging waste to reception facilities at the port		THEN	the port could be classified among those that <b>should meet</b> additional measures and requirements appropriate for <b>reducing air emissions</b> in EMS programmes <b>or is seeking (by their own)</b> important improvements for the sake of this issue	<b>Improving Water Quality Monitoring</b>

### 3 CONCLUSIONS AND RECOMMENDATIONS

In the conceptual PDSA, data flows and interactions determine the law of interactions so commonly referred in Theory Development which is a common criterion to further specify: a) alternative subsystems, b) business intelligence processes, c) decision elements, and d) situation/contexts for port informational integration. Although, the PDSA conceptual model is not definitive or exhaustive, provides the necessary theoretical elements to recognise and deal with the inherent complexity of port informational integration that could be extended or modified as new knowledge emerges or new problems or solutions arise.

The bottom-up methodological approach suggested adds significant complexity to the data collection and analysis. The process starts by creatively thinking of different ways of linking the PDSA, so exploration of multiple repositories and data aggregation for analysis is accomplished using data mining techniques and empirical analyses. That may indicate in the future challenges for including linkages grounded in the learnt process, for instance, in the PDSA linkages regarding port safety and security processes. Although, the PDSA conceptual model is not definitive or exhaustive, provides the necessary theoretical elements to recognise and deal with the inherent complexity of port informational integration that could be extended or modified as new knowledge emerges or new problems or solutions arise.

### REFERENCES

- Acciaro, M., Vanelslander, T., Sys, C., Ferrari, C., Roumboutsos, A., Giuliano, G., Kapros, S., 2014. Environmental sustainability in seaports: a framework for successful innovation. *Maritime Policy & Management*, 41(5), 480-500.
- American Association of Port Authorities AAPA. 1998. *Environmental Management Handbook*.
- Bailey, D., Plenys, T., Solomin, G.M., Campbell, T.R., Feuer, G.R., Masters, J., Tonkonogy, B., 2004. *Harbouring pollution: the dirty truth about US ports*. National Resources Defence Council, NY.
- Cassaigne, N., Lorimier, L., 2006. A Challenging Future for i-DMSS Intelligent Decision-making Support Systems, pp. 401-422.
- Cetin, C. K., Cerit, A. G., 2010. Organizational effectiveness at seaports: a systems approach. *Maritime Policy & Management*, 37(3), 195-219.
- Christopher, K., 2014. *Port Security Management*, Second Edition: CRC Press.
- Comtois, C., 2008. *Greening the Asia Pacific Gateway: Sustainability as a Competitive Asset*.
- Consortium for International Earth Science Information Network (CIESIN). n.d. Executive Summary. [www.ess.co.at/GAIA/SPD/spd\\_image.html](http://www.ess.co.at/GAIA/SPD/spd_image.html) (last accessed 01.10.14.).
- Cullinane, K., Song, D.-W., 2002. Port privatization policy and practice. *Transport Reviews*, 22(1), 55-75.
- Ducruet, C., 2008. World typology of city-port relationships. <http://www.cybergeoeu/index17332>. (last accessed 03.03.16.).

- Ducruet, C., 2009. Port Regions and Globalization. In *Ports in Proximity: Competition and Coordination Among Adjacent Seaports*. (Eds.) Langen, P. W. d., Ducruet, C. s., & Notteboom, T. pp. 41-53.
- Environmental Protection Agency EPA., 2007. An Environmental Management System Primer for Ports: Advancing Port Sustainability. [http://archive.epa.gov/osem/sectors/web/pdf/ems\\_primer.pdf](http://archive.epa.gov/osem/sectors/web/pdf/ems_primer.pdf). (last accessed 03.03.16.).
- European Sea Ports Organization ESPO., 2013. Annex 1: Good practice examples in line with the 5 Es. [http://www.ecoport.com/templates/frontend/blue/images/pdf/Annex%201\\_Good%20Practices\\_Version%202\\_July%202013.pdf](http://www.ecoport.com/templates/frontend/blue/images/pdf/Annex%201_Good%20Practices_Version%202_July%202013.pdf). (last accessed 01.10.14.).
- Halabi Echeverry, A., Richards, D., Bilgin, A., 2011. Proposing a port decision system approach for dynamic integration of South American sea ports. In *International Conference on Advances in ICT for Emerging Regions (ICTer)*. Colombo, Sri Lanka, pp. 58-64.
- Halabi Echeverry, A., Richards, D., Bilgin, A., 2012. Identifying Characteristics of Seaports for Environmental Benchmarks Based on Meta-learning. In D. Richards & B. Kang (Eds.), *Knowledge Management and Acquisition for Intelligent Systems: Lecture Notes in Artificial Intelligence 7457*, Springer Berlin Heidelberg, pp. 350–363.
- Halabi Echeverry, A., Montoya-Torres, J., Richards, D., Neira, N., 2015. Computational Intelligence to Support Cooperative Seaport Decision-Making in Environmental and Ecological Sustainability. In F. Corman, S. Voß, & R. Negenborn (Eds.), *Computational Logistics: Lecture Notes in Computer Science*, Vol. 9335, pp. 510-525.
- Hiranandani, V., 2014. Sustainable development in seaports: a multi-case study. *WMU Journal of Maritime Affairs*, 13(1), 127-172.
- Holton, E. F., and J. S. Lowe. 2007. Toward a General Research Process for Using Dubin's Theory Building Model. *Human Resource Development Review*, Vol. 6, p. 297-320.
- International Council on Clean Transportation ICCT., 2007. Air Pollution and Greenhouse Gas Emissions from Ocean-going Ships: Impacts, Mitigation Options and Opportunities for Managing Growth. *Maritime Studies*, Vol. 7, p. 153.
- Klettner, A., Clarke, T., Boersma, M., 2014. The Governance of Corporate Sustainability: Empirical Insights into the Development, Leadership and Implementation of Responsible Business Strategy. *Journal of Business Ethics*, 122(1), 145-165.
- Kruse, C. J., 2005. Environmental Management Systems at Ports - A new initiative. *Proceedings of the 14th Biennial Coastal Zone Conference*. pp. 1-6.
- Lam, J. S. L., Notteboom, T., 2014. The Greening of Ports: A Comparison of Port Management Tools Used by Leading Ports in Asia and Europe. *Transport Reviews*, 34(2).
- Mora, M., Fen, W., Gelman, O., Kljajic, M., 2011. IDSSE-M: a software system engineering methodology for developing intelligent decision-making support systems. *International Journal of Decision Support System Technology*, 3(4), pp. 55-84.
- National Cooperative Highway Research Program NCHRP., 2007. Proto-type software for an environmental information management and decision support system. [http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rrd\\_317.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_317.pdf). (last accessed 01.10.14.).
- Ng, A. K. Y. and S. Song., 2010. The environmental impacts of pollutants generated by routine shipping operations on ports. *Ocean & Coastal Management* Vol. 53, pp. 301-311.
- Notteboom, T. E., 2010. Concentration and the formation of multi-port gateway regions in the European container port system: an update. *Journal of Transport Geography*, 18(4), 567-583.
- Puente-Rodríguez, D., Giebels, D., de Jonge, V.N., 2015a. Strengthening coastal zone management in the Wadden Sea by applying 'knowledge-practice interfaces'. *Ocean & Coastal-Management*, 108(0), 27-38.
- Puente-Rodríguez, D., van Slobbe, E., Al, I. A. C., & Lindenbergh, D. E., 2015b. Knowledge co-production in practice: Enabling environmental management systems for ports through participatory research in the Dutch Wadden Sea. *Environmental Science & Policy*. Vol. 55, pp. 456-466.
- Royson, K., 2008. Environmental certification for ports: assessing the options. <http://www.greenport.com/news101/Projects-and-Initiatives/environmental-certification-for-ports-assessing-the-options#sthash.2jWMZuBQ.dpuf>. (last accessed 03.03.16.).
- Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferda., 2007. Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. *BioScience*, 57(7), 573-583.
- The International Port Community Systems Association IPCSA., 2014. Port Community Systems. <http://www.epcsa.eu/pcs>. (last accessed 03.03.16.).
- van Baalen, P.J. van Oosterhout, M., 2009. IOS Adoption and Implementation in Global Port Communities. In R.A. Zuidwijk, P.J. van Baalen & J.A.E.E. van Nunen (Eds.), *Port Inter-Organizational Information Systems: Capabilities to Service Global Supply Chains*, pp. 57-72.