ASSESSMENT OF SUSTAINABILITY INITIATIVES IN PORT OPERATIONS: AN OVERVIEW OF GLOBAL AND CANADIAN PORTS

by

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Dedicated to

my parents

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Port sustainability has become an essential part of many port authorities in recent decades. Many ports have pledged to improve sustainability and have adopted various initiatives to achieve this, but academic studies are lacking. To explore these port sustainability initiatives (PSIs), a desktop study using port websites was conducted. Analysis of 36 global ports' initiatives provided a global overview of PSIs, and analysis of 18 Canadian major ports' initiatives provided Canadian perspectives of PSIs. A port sustainability scale based on 25 pre-defined indicators was used to compare statistical differences in PSIs. Results indicate that European ports have made significant progress in adopting PSIs as compared to North American and Asia-Pacific ports. Global ports have adopted various approaches to be sustainable. Results of Canadian ports indicate that most participated in the Green Marine program, but less than half (seven of 18 ports) were proactively integrating sustainability into their operations.

LIST OF ABBREVIATIONS USED

AAPA	American Association of Port Authorities
ACPA	Association of Canadian Port Authorities
AP	Asia Pacific
CAD	Canadian Dollar
CEPA	Canadian Environmental Protection Act
CEAA	Canadian Environmental Assessment Act
CLIA	Cruise Lines International Association
CMA	Canada Marine Act
CPAs	Canadian Port Authorities
CSR	Corporate Social Responsibility
EEC	Energy Efficiency and Conservation
EP	Environmental Policy
EPI	Environmental Performance Indicator
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
ESI	Environmental Shipping Index
ESPO	European Sea Ports Organization
EU	European/European Union/Europe
GHG	Greenhouse Gas
GM	Green Marine
GMEP	Green Marine Environmental Program
GRI	Global Reporting Initiative
GT	Gross Tonnages
ICS	International Chamber of Shipping
IMO	International Maritime Organization
ISO	International Organization for Standardization
KPI	Key Performance Indicators
LNG	Liquified Natural Gas
LPG	Liquefied Petroleum Gas
NA	North American/North America
OECD	Organization for Economic Co-operation and Development

OPS	Onshore Power Supply
PERS	Port Environmental Review System
POA	Port of Antwerp
POB	Port of Bremen
POG	Port Gothenburg
POH	Port of Halifax
POK	Port of Kaohsiung
POLA	Port of Los Angeles
POLB	Port of Long Beach
POA	Port of Antwerp
POHM	Port of Hamilton
PON	Port of Nanaimo
POM	Port of Montreal
POP	Port of Prince Rupert
POQ	Port of Quebec
POR	Port of Rotterdam
POSG	Port of Saguenay
POSI	Port of Sept-Iles
POSJ, NL	Port of St. Johns, Newfoundland and Labrador
POSJ, NB	Port of Saint John, New Brunswick
POT	Port of Toronto
POTB	Port of Thunder Bay
POTR	Port of Trois-Rivières
POV	Port of Vancouver
POO	Port of Oshawa
POW	Port of Windsor
RE	Renewable Energy
SD	Standard Deviation
SDM	Self-Diagnosis Method
SPSS	Statistical Package for Social Sciences
TEU	Twenty-foot Equivalent
US	United States
UNCTAD	United Nations Conference on Trade and Development

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CHAPTER 1: INTRODUCTION

1.1 Context and Problem Statement

Ports deliver prosperity by facilitating maritime transport and delivering economic and social development to the host community. For centuries, ports have been serving as an economic engine, enabling the transport of essential goods and services to human society around the world (Pinder and Slack, 2004; Burns, 2015). Ports are gateways for international trade and play a vital role in the world economy by accommodating shipping, which is now considered as the low-cost, most efficient and comparatively environmentally friendly mode of transport. Today, the shipping industry carries about 90% of global trade by volume (Panayides and Song, 2012; ICS, 2017).

Whilst serving world trade and supporting economic and social well-being across the globe, port operations can also pose negative effects on the environment (Gupta et al., 2005; Darbra et al., 2005; Dinwoodie et al., 2012). Emissions to air, releases to water, soil and marine sediment, noise, waste generation, loss/degradation of terrestrial habitats, and changes to marine ecosystems are a few of the key environmental challenges with port operations (Darbra et al., 2005; Puig et al., 2015). In a 2004 survey involving 800 North American, European, and Asian ports, port authorities noted air quality, water quality, noise, waste disposal, and habitat conservation as the top five port-related environmental issues (Comtois and Slack, 2007).

The port industry has experienced extensive growth and technical development over the past decades. The container port industry, in particular, is expected to experience continued growth and development due to urbanization, industrialization, and population growth. This will not only affect efficient traffic handling but also will increase the intensity of environmental effects on the marine ecosystem and on the lives of coastal communities (Yim Yap et al., 2013; Walker et al., 2018). Puig et al. (2017) illustrated that port authorities and the port industry itself are experiencing increasing pressure to establish their environmental performance and credentials in terms of risk-reduction, compliance, and sustainability.

Environmental awareness is expanding throughout the society; as such, effective environmental management in port operations will be essential if port authorities are to ensure support from port stakeholders (Acciaro, 2015; Puig et al., 2017). Environmental management within port operations has been a rapidly growing trend, with many ports around the world adopting different types of approaches and initiatives to enhance environmental performance. At the same time, researchers have suggested that 'greener' ports could experience a competitive advantage linked to ports' economic performance and customer retention (Adams et al., 2009; Lam and Van Voorde, 2012).

Many ports around the world have implemented green port strategies for sustainable growth and development (Lam and Van Voorde, 2012; Dinwoodie et al., 2012; Hiranandani, 2014; Lam and Notteboom, 2014). European ports are progressing towards improved environmental protection and integrated sustainable development through their involvement with regional initiatives (e.g., EcoPorts initiative by the European Sea Ports Organization) as well as individual greening efforts (Darbra et al., 2005; Puig et al., 2015; Puig et al., 2017). Some North American and Asian ports are progressing towards greening port operations (Lam and Van Voorde, 2012; Lirn et al., 2012; Jim et al., 2013; Lam and Notteboom, 2014), but many have still been found to be lagging in this regard. Green port approaches and environmental initiatives are poorly analyzed, with limited scope for examining and identifying best practices. In response, this research explores the various greening and sustainability initiatives of the major ports from North America (NA), Europe (EU), and Asia-pacific (AP) which have claimed or pledged to be a green or sustainable port.

To explore the state of sustainability initiatives of global ports, 36 ports (12 from each region) have been selected and their initiatives evaluated against an analytical framework integrating 25 criteria. Following on, the sustainability initiatives of 18 Canadian major ports have also been analyzed to gain insight to the efforts to be sustainable and status of Canadian ports. In the later case, the environmental performance scores of key Canadian ports, as measured under the Green Marine Environmental Program (GMEP) of Green Marine (GM) have also been analyzed to assess the progress over time. GM is an environmental certification program for the marine industry in North America, and GM measures its participants' environmental performance under the GMEP following particular frameworks (Walker, 2016; Green Marine, 2017).

1.2 Research Objectives

This research has two objectives. The first is to assess the current state of global ports' sustainability efforts by analyzing ports' initiatives. The second is to assess the current state of sustainability efforts within Canadian ports' through a comprehensive analysis of the initiatives adopted by 18 Canadian ports.

1.3 Research Questions

Relating to the research objectives, the following questions guided the research activities:

i. How have ports strategically applied the concept of the 'sustainable port' to port development?
ii. What initiatives ports have adopted to achieve port sustainability?
iii. What sustainability initiatives have most Canadian major ports adopted?
iv. Has the GM program influenced the progress towards improved environmental performance?

1.4 Research Framework

Figure 1.1 shows the research framework where the first column indicates research questions; the second column indicates the research objects that will be studied; the third column indicates research strategies applied to find the answers to the four research questions, and the fourth column indicates the output of the research related to the research objectives.

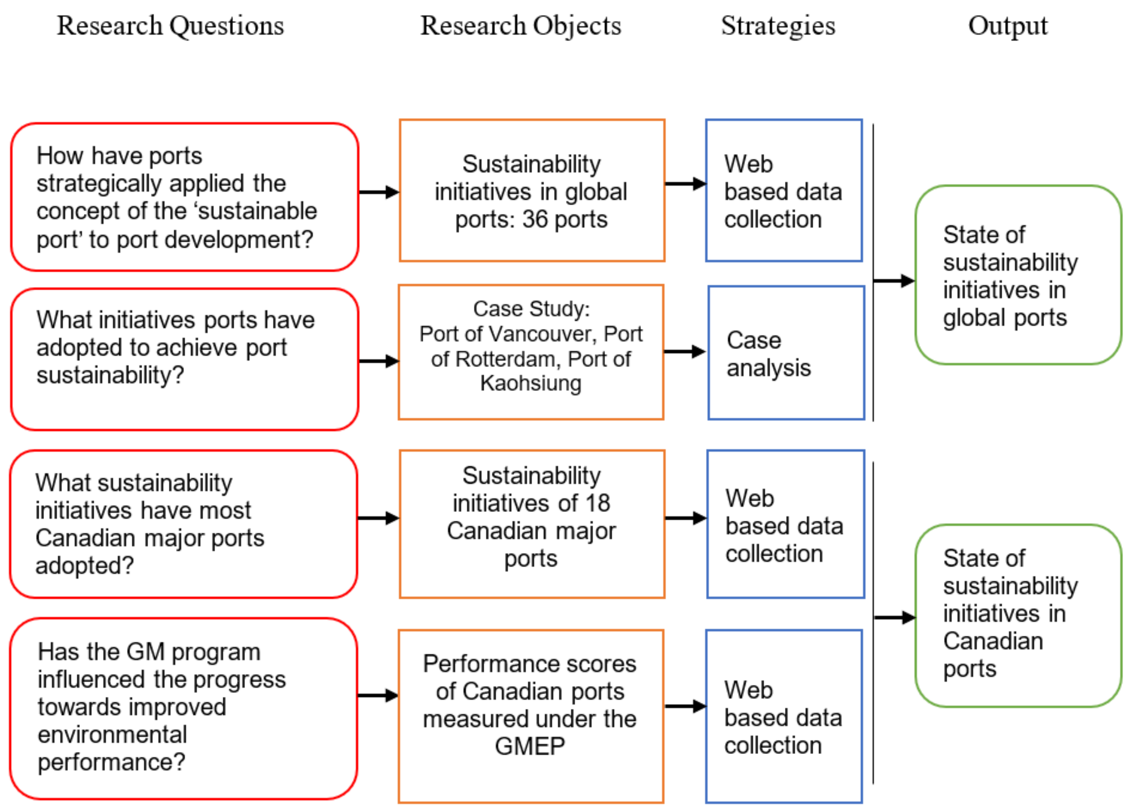

Figure 1.1: A framework of this research.

1.5 Scope

In this research, the different types of environmental management within the different countries in NA, EU, and AP have been listed and discussed. Greener and sustainable ports are essential to develop a sustainable shipping industry and to ensure a safe, secure, efficient and reliable maritime transportation system. The research output highlights different approaches and initiatives of sustainable ports in Canada and globally; it will help address research gaps within the context of environmental management practices of ports. The initiatives and approaches of sustainable ports that have been discussed in this work might help port environmental managers, policymakers, port-related associations, and other port stakeholders to work for building a sustainable port industry.

1.6 Thesis Outline

This thesis is structured in six chapters. Chapter one has provided context, a problem statement dealing with the research context, research objectives, research questions, research framework, and rationale of the research. Chapter two includes an illustration of different terms, concepts, and issues relating to the port sector, associated environmental issues, port environmental management practices, and defining port sustainability. Chapter three has illustrated research methods used in this research. Chapters four and five have provided research findings of the first and second research objectives. These two chapters have been developed as independent manuscripts that will be submitted to relevant academic journals. Chapter six provides conclusions.

CHAPTER 2: LITERATURE REVIEW

2.1 Shipping

Maritime shipping is considered to be low-cost and the most efficient and environmentally friendly mode of transport. Shipping connects businesses, markets, people, and countries, creating opportunities to buy and sell merchandise. Export and import of goods necessary for the modern society would not be possible without maritime shipping, carrying approximately 90% of global trade by volume (Panayides and Song, 2012; ICS, 2017). The shipping industry contributes billions of dollars to the world economy, creates millions of jobs (World Shipping Council, 2017a), and is continuing to expand with the increasing demand for transporting consumer products via sea (UNCTAD, 2016).

Technological advancement has continued to improve the efficiency of the industry; according to United Nations Conference on Trade and Development (UNCTAD) records, for the first time, the global seaborne trade exceeded 10 billion tons by volume in 2015. This is a four-fold increase since 1970 when the global seaborne trade was around 2.6 billion by volume (Figure 2.1) (UNCTAD, 2016). Currently, developing economies contribute larger shares (e.g., 60% of the loaded goods and 62% of the unloaded goods) of the total volume (UNCTAD, 2016). In terms of regional influence, Asia is the dominant hub; contributing 41% share of the loaded goods and 60% share of the unloaded goods (Figure 2.2).

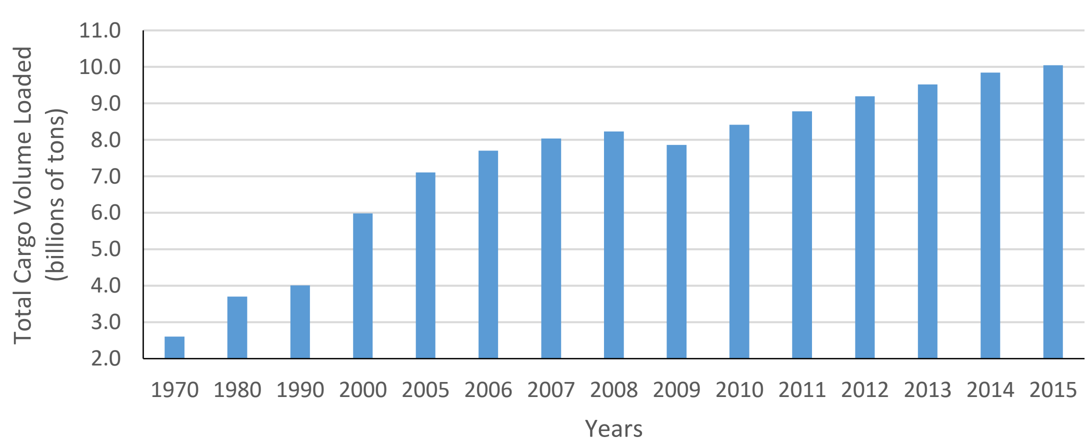

Figure 2.1: Development of world seaborne trade in selected years (UNCTAD, 2016).

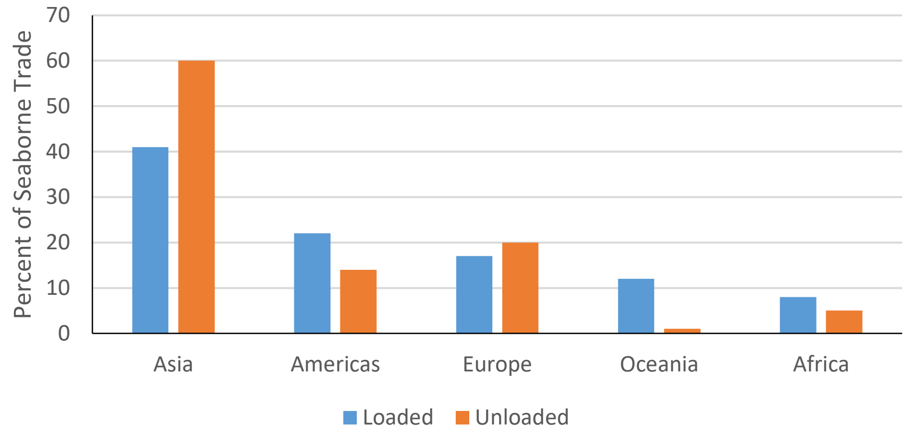

Figure 2.2: Share of global seaborne trade in percent by region in 2015 (UNCTAD, 2016).

2.2 Maritime Transport

Maritime transport is thought as the backbone of globalization, playing a vital role enabling regional and international trade. As an important economic sector, maritime transportation creates jobs, income, and revenue for host countries, while facilitating industrial development by efficiently importing and exporting global goods. Hall and Jacobs (2010) illustrate that maritime transport serves as the 'blood circulation' of the world economy, linking marine corridors to complex shipping networks within countries around the world. It acts as an intermediate mode which links other modes of transport like rail, road, and air (Nam and Song, 2011) enabling the movement of passengers and/or goods from one port to another.

Cruising and container shipping industries both contribute considerably to the world economy. Cruising, as part of a global hospitality and tourism industry, is growing rapidly. The industry has averaged an annual 7% growth rate since 1980 (Coggins, 2014), with a 62% demand increase in the years between 2005 to 2015 (CLIA, 2017). Cruise Lines International Association (CLIA) reported that 24.7 million passengers enjoyed cruising in 2016 (CLIA, 2017). Coggins (2014) reported that four factors have fueled the expansion and growth of the cruise industry including: innovative and well-facilitated cruise ships, the establishment of port and industry marketing organizations like CLIA, marketing cruising as a vacation option, and suitable port and berthing availability. Likewise, the container shipping industry has experienced a significant increase in demand since the

1990s (Figure 2.1). Ng (2012) illustrated that globalization, worldwide trade facility, the emergence of new markets, global division of labor, regional specialty in production, and multimodal supply-chain development has re-shaped container shipping. Container-carrying capacity has grown by approximately 1200% since 1968 (Allianz, 2017) and the rapid increase in ship size has become a contentious issue as ports are pressured to accommodate the increases in ship length, width, height, and depth (Merk et al., 2015).

The largest ships are container ships in the world. The overall length of the current largest container ship (CSCL Globe) is 400 m with a capacity of 187,541 gross tonnages (GT), the largest oil tanker (TI class) is 380 m long with a capacity of 234,006 GT, the largest bulk carrier (Valemax) is 362 m long with a capacity of 200,000 GT, and the largest cruise ship (Oasis class) is 360 m long with a capacity of 225,282 GT (Merk et al., 2015). Figure 2.3 presents container ship capacity in twenty-foot equivalent (TEU[1]), since 1968. It is clear that the size of the container ship has accelerated over the last decade; it is expected that ships with a capacity over 20,000 TEU will be added to the liner shipping industry by 2018. The intensity of ocean-going vessel traffic is also increasing considerably (Figure 2.4). Figure 2.4 shows a map containing ocean-going traffic at a particular time in March 2017 where green, blue and red symbolic vessels represent cargo ships, passenger ships and tankers respectively provided by Marine Traffic. Marine Traffic is an internet based service provider which delivers maritime information of a ship such as ship type, size, spatial location, movement and other information (Marine Traffic, 2017).

[1] TEU is a unit used to measure container ship's capacity.

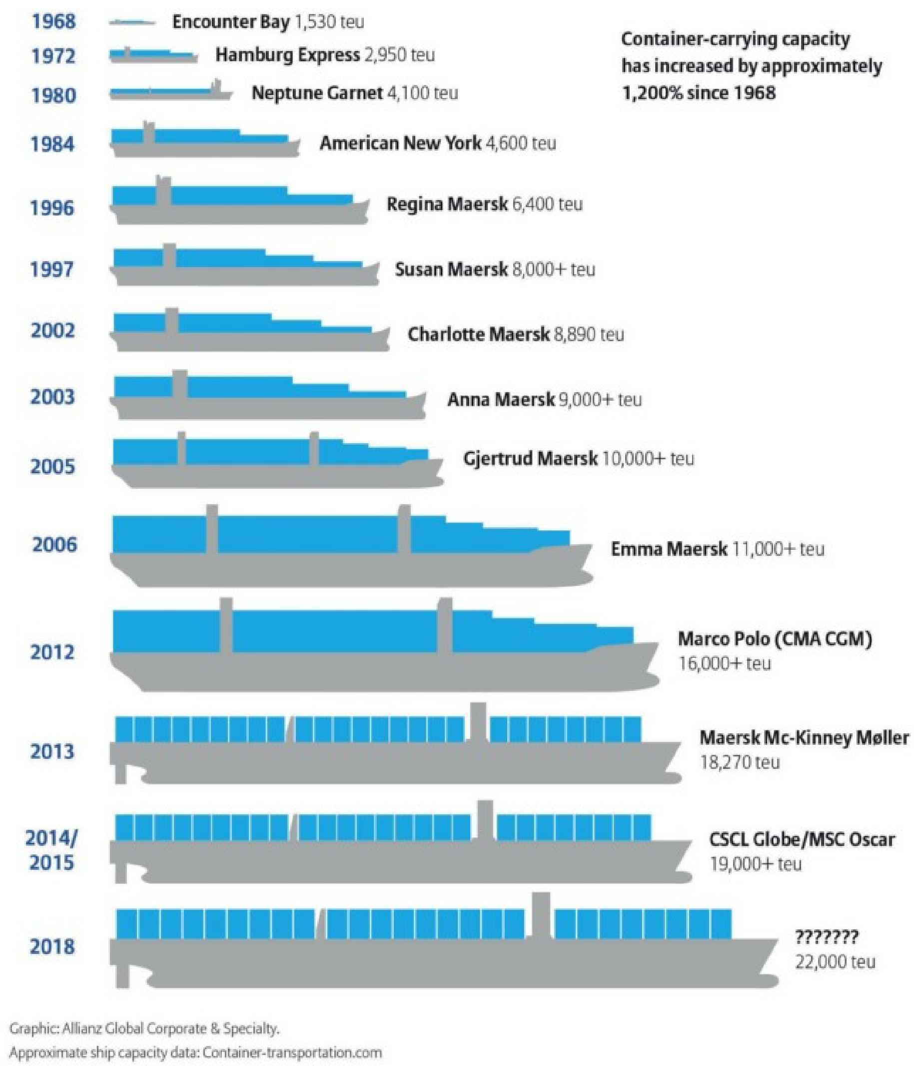

Figure 2.3: Growth of container ship's carrying capacity in TEU since 1968 (Allianz, 2017).

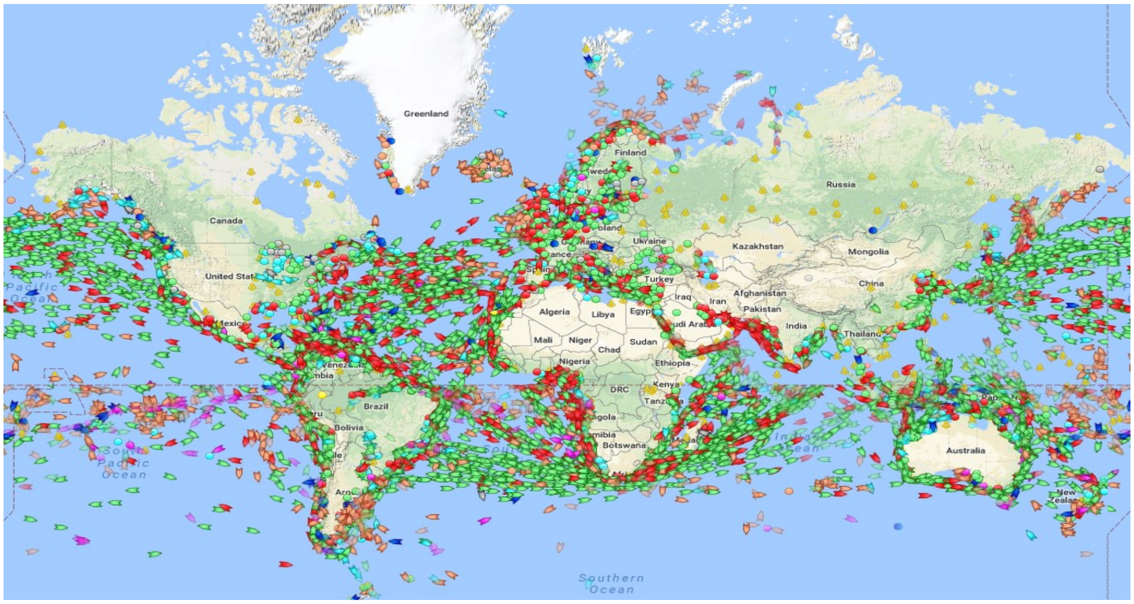

Figure 2.4: Growing and concentrated maritime traffic volumes (MarineTraffic, 2017).

2.3 Port Operations

2.3.1 Overview

For centuries, ports have served as gateways for international trade and played a crucial role in the world economy by accommodating liner shipping and cruising around the world. Ports deliver prosperity to the host regions by being dynamic, vibrant centers of trade and commerce (Nagle, 2013). In modern logistics systems, ports are not only the location for loading and unloading cargoes but also offer value-adding services like storage, warehousing, packing and accessing inland transport (Pettit and Beresford, 2009; Nam and Song, 2011). A country's trade competitiveness is affected by the performance of their ports and terminals; port performance depends on access channels, cargo handling facility, the quality of backhaul area, land-side access and customs efficiency, labor relations and opportunities for the terminal operators (UNCTAD, 2015). Given that a port's competitiveness affects the local and national trade and economy of a country, port authorities put considerable efforts into improving their competitive advantage over neighbouring ports. Port competitiveness has become an increasingly important topic of academic research (Tongzon and Heng, 2005; Yap and Lam, 2006; Yeo et al., 2008; Jim et al., 2010; Yuen et al., 2012).

Yuen et al. (2012) noted that broader research findings suggested that containerization (Cullinane and Song, 2006) and port privatization (Cullinane and Song, 2002; Brooks, 2004) increased port's competitiveness. Other researchers have proposed eight specific determinants of competitiveness (Tongzon and Heng, 2005):

- Operational efficiency;
- Cargo handling charges;
- Reliability;
- Port relationships with carriers and shippers;
- Navigation channel's depth;
- Adaptability to market change;
- Landside accessibility; and
- Product differentiation.

Ports must also make efforts to overcome contemporary port-related social, economic and environmental challenges (UNCTAD, 2015). Such issues include the ever-increasing vessel size and the cost of adapting port infrastructure, changing the marketplace, volatile energy prices, constraints on carbon emissions; changes in shipping routes, and increased societal pressures linked to local environmental impacts such as noise, air pollution and inland traffic (UNCTAD, 2015).

Ports are located geographically in strategic locations to enable connection with the broader global supply chain. Each port differs in terms of cargo handling capacity (throughput), available infrastructure, ship size that can be handled, etc., although it is a ports' *cargo handling capacity* that is used to classify port size. Common to any port is infrastructure that provides maritime access and connection to land-based transportation networks. Figure 2.5 is a diagram of the different categories of required infrastructure. An International Transport Forum's study, Mooney (2016) projects that container traffic will be doubled by 2030 and tripled by 2050, necessitating a considerable increase in handling capacity globally. In light of this projected increase, ports will face increasing opposition and challenges as they try to expand to accommodate this growth.

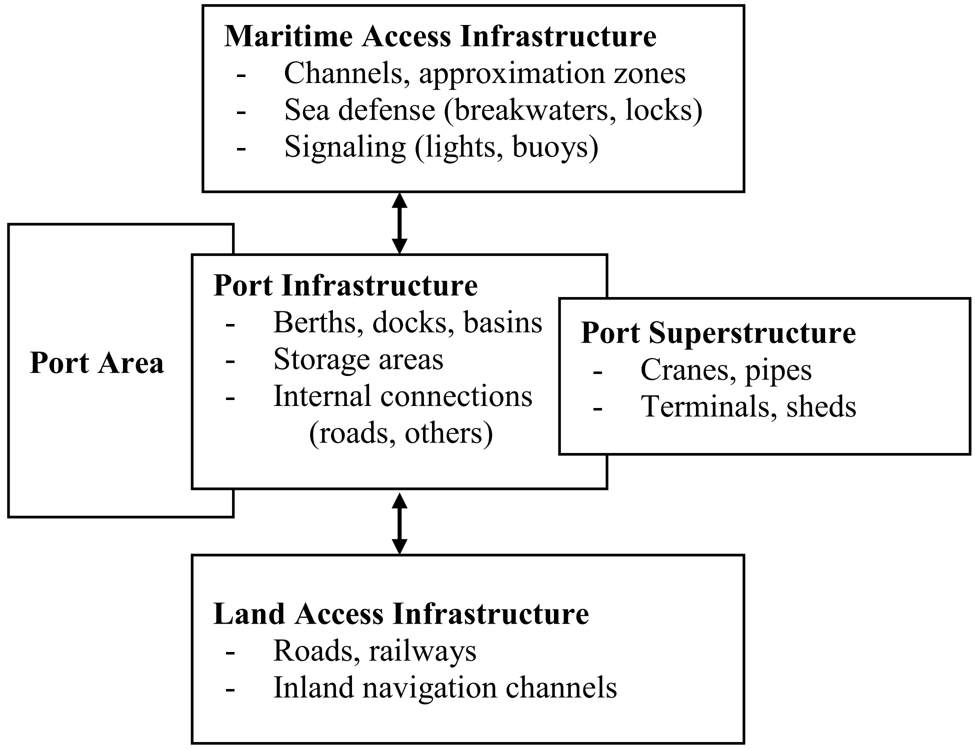

Figure 2.5: Scheme of seaports' structure (Trujillo and Nombela, 1999).

Under the umbrella of "port operations" port activities include (Jakomin, 2003; OECD, 2011; Ford, 2015):

- Transshipment, loading, and unloading cargo to and from the vessels;
- Transferring, embarking, and disembarking passengers and crew;
- Storage and warehousing products on land and stevedoring to and from vessels;
- Facilitating access to inland transport and intermodal connections; and
- Providing complementary other relevant services to shipping carriers.

Port authorities will adapt in different ways; one option has been to improve relationships with port-related national, regional and international organizations that may offer guidance, support, and best practices related to sustainable port expansion. The International Association of Ports and Harbors (IAPH), for example, headquartered in Tokyo has been a leading authority on ports and port-related businesses since 1955. IAPH has 200 member ports, which collectively handle over 80% of world container traffic (IAPH, 2017).

The European Sea Ports Organization (ESPO) headquartered in Brussel, Belgium has been supporting the economic development of European ports since 1993. As part of their environmental management and sustainability initiatives, ESPO started publishing their "Environmental Code of Practice" in 1994; this was their first official policy document. This code was updated in 2003 and then replaced in 2012 by the ESPO Green Guide (ESPO, 2012). The ESPO also completes periodical environmental surveys with a view to studying and analyzing the environmental performance of ports, the main environmental concerns, and related trends (Puig et al., 2015). Several environmental monitoring tools such as Self-diagnosis Methodology (SDM) and Port Environmental Review System (PERS) have also been developed by the ESPO with the aim of providing ports with a cost-efficient methodology for identifying environmental risk, establishing priorities for action and compliance for port operations and providing a port sector-specific environmental management standard (Ecoports, 2017a).

Finally, the American Association of Port Authorities (AAPA) out of Virginia, USA was established in 1912 is an Alliance of 130 public port authorities in the USA, Latin America, Canada and the Caribbean (AAPA, 2017). AAPA advocates for US ports, empowers member ports' professionals, connects and unifies seaport leaders and professionals (AAPA, 2017).

2.3.2 Environmental Issues

Ports can influence adverse environmental effects locally and at a more regional level (Gupta et al., 2005; Dinwoodie et al., 2012) as a result of emissions and impacts associated with port activities and operations, shipping traffic, and intermodal transport serving the port hinterland (OECD, 2011; Lam and Notteboom, 2014). Specific environmental concerns are of times and location specific and will result from particular activities in particular locales. Figure 2.6 presents the major environmental concerns and the most likely impact locale.

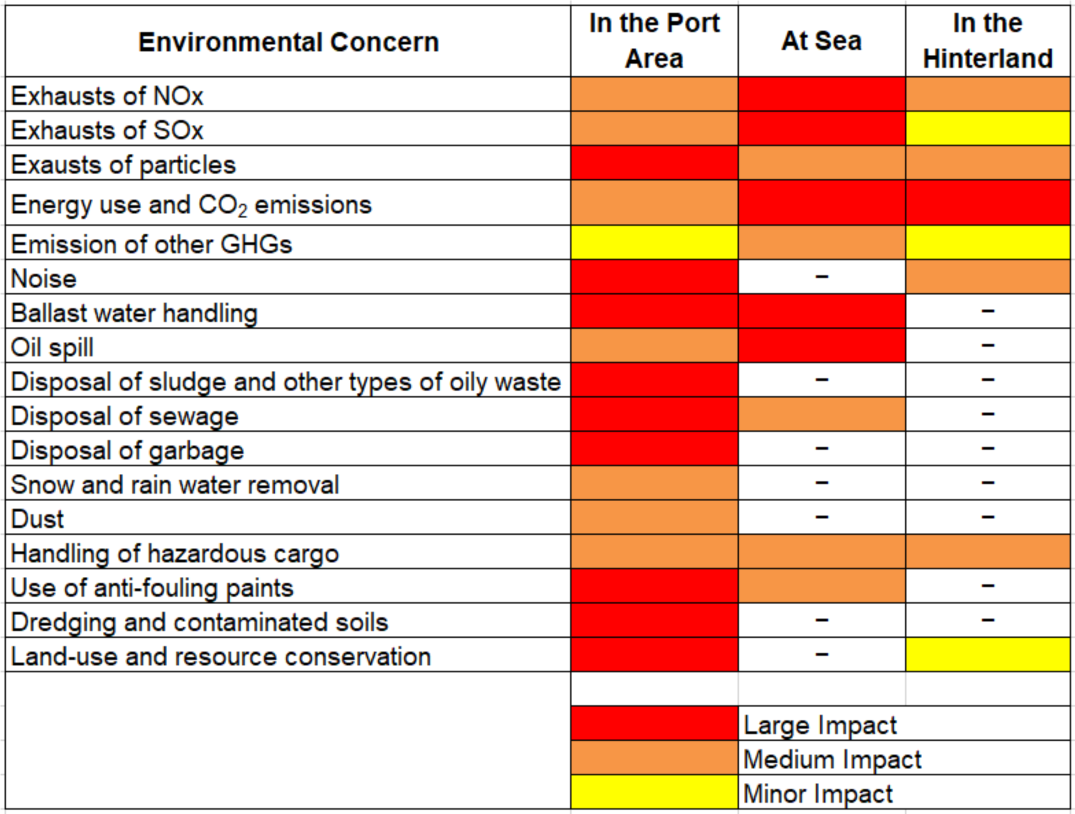

Figure 2.6: Major environmental concerns of shipping and places of occurrence (OECD, 2011).

Numerous studies have been accomplished over the years that have characterized the most contentious environmental issues associated with port operations (Comtois and Slack, 2007; Puig et al., 2015). In a recent study conducted by ESPO and EcoPorts among 91 ports from 20 European Union (EU) maritime member countries in 2016, European port authorities identified ten key environmental priorities for 2016 and are highlighted in Figure 2.7. A selected number will be discussed in greater detail below.

Figure 2.7: Top ten environmental priorities of European ports for 2016 (EcoPorts, 2016a).

Air quality in the port area is one of the major port-related environmental issues (Lam and Notteboom, 2014; Winnes et al., 2015; EcoPorts, 2016), particularly in European ports where it was identified as the number one priority in both 2013 and 2016 (EcoPorts, 2016a). The global shipping industry accounts for approximately 2.4% of anthropogenic greenhouse gas (GHG) emissions and is projected to increase with the rapid expansion of the industry (IMO, 2015). GHG emissions from ships calling at the port are projected to increase by 40% to 2030 if one considers a "business as usual" scenario (Winnes et al., 2015).

Both land and water pollution has been a source of conflict between ports and the surrounding community(s) (Kröger et al., 2006; Grifoll et al., 2011). Ballast water releases, waste discharges, and oil spills all contribute to degraded harbour water quality (Ng and Song, 2010; OECD, 2011; Lam and Notteboom, 2014). While waste management is improving in many jurisdictions [both ships and ports have to comply with national and international regulations such as IMO 73/78 Annexes I-V], there are of times still problems with waste handling at port waste reception facilities (if they have one in the first place) (Trozzi and Vaccaro, 2000; OECD, 2011).

Noise complaints made by adjacent communities about sound linked to port operations have been widely reported within the literature (Khoo and Nguyen, 2011; Mustonen, 2013; Schenone et al., 2014; Witte, 2016). For example, the ESPO prioritized noise in the top three environmental concerns within European ports for 2016 (EcoPorts, 2016a). Noise is generated not only from port activities and operations but also from ancillary activities such as ferry operation, port tenant industrial activities and other services (Schenone et al., 2014; Witte, 2016). Witte (2016) mentioned that Port of Rotterdam (one of the largest ports in Europe) received 1,400 noise complaints in 2015. Low-frequency underwater noise generated by commercial shipping can also affect marine life (Jasny, 2005).

Port development and expansion of times necessary to accommodate large ship and improve hinterland connections are also contentious issues. Land reclamation can conflict with development goals of neighbouring entities, and expanded operations can simply exacerbate already existing problems (Del Saz-Salazar et al., 2012; Morris and Gibson, 2007; Yim Yap et al., 2013). However, substantial growth in the port industry is expected to continue, creating pressure on ports for expanded efficient traffic handling, and intensifying existing adverse environmental effects on marine ecosystems and on coastal communities (Yim Yap et al., 2013).

Regardless of the specific issue, effective environmental management in port operations is essential if long-term sustainability of port operations is the goal. Port environmental performance has become an integral part of the corporate responsibility of port authority as a result of competitive pressure from regulatory agencies, local communities, NGOs, port users and other stakeholders (Acciaro, 2015).

2.3.3 Role of Ports

As regional economic engines with a key role in the vitality of the surrounding communities, ports have a specific responsibility towards the surrounding biophysical environment and host communities to create opportunities for stakeholders to engage in greener, more sustainable activities. Both Dinwoodie et al. (2012) and Kim and Chiang (2014) offered that the port's role is to respond to customers, regulators, and competitors effectively through innovative solutions. Ports need to ensure not only a safe working environment through protecting workers' health and personal development but must also ensure accountability, ethical governance, and social responsibility (UNCTAD, 2015). Ports have a substantial role in the creation of sustainable supply chains (Denktas-Sakar and Karatas-Cetin, 2012). Hence; corporate responsibility has been taken by many ports as an integral part of value creation in response to competitive pressures (Acciaro, 2013; Acciaro, 2015).

Port authorities can apply a wide-ranging mix of policy instruments to manage the environmental effects of shipping causing in the port areas (OECD, 2011). Energy management in port areas is a potential measure to reduce emission to air. Ports can play a significant role in energy management as ports have a high energy demand and have power generation facilities in port areas. Ports require energy for its' direct activities (e.g., terminal operations, buoys, lighting, and administrative buildings), for powering ships calling at the port, and for port-related activities (e.g., railway operations, refineries, steel and metal works, etc.). Ports can be proactive on efficient use of energy and on promoting energy management (e.g., Port of Hamburg in Germany), and in addition, ports can contribute to the promotion of renewable energy use and boost energy efficiency through energy management plan (e.g., Port Energy Management Plan of Port of Genoa in Italy) (Acciaro et al., 2014). Onshore power supply (OPS), alternative fuels supply such as liquefied natural gas (LNG) and liquefied petroleum gas (LPG), and development of biofuels are some other ports' facilities that contribute to both energy management and emission reduction in port areas (Acciaro et al., 2014).

2.4 Environmental Management in Ports

Effective environmental management has become increasingly important for many port authorities and is now seen more like a standard part of the operational strategy as opposed to something beyond the day to day requirements (Morris and Gibson, 2007; Puig et al., 2014). Ports undertake environmental management initiatives not only for maintaining social license to operate and grow (Van Den Bosch et al., 2011) but also for international competitiveness (Lam and Notteboom, 2014; Hollen et al., 2015) and to attract employees and investors (Lam and Notteboom, 2014). Merk (2011) illustrated that port-cities need to make sure that ports are creating value for the city and ports are mitigating negative effects on the environment. However, the primary purpose of port environmental management is still to mitigate adverse effects (Puig et al., 2015; Puig et al., 2017). While some ports adopt environmental management initiatives for regulatory compliance, others go beyond compliance with a focus on improving their performance in environmental management and achieving port sustainability. Ports such as Vancouver (POV), Long Beach (POLB), Los Angeles (POLA), Rotterdam (POR), and Antwerp (POA) exceed regulatory compliance with an aim to improve the performance in environmental management and achieve sustainability in port operations than their competitors. Europe, in particular, has noticeably developed environmental management during the last fifteen years through mutual collaboration among ports, research institutions, and specialist organizations (ESPO, 2012).

An effective port environmental management system requires that the environmental components of concern are identified early on, such that one can determine what can be managed from an environmental perspective (Puig et al., 2015). Tools exist for identifying significant environmental components and for identifying related environmental performance indicators (Puig et al., 2015), two of which are freely available for port authorities through Eports website (Eports, 2017). Puig et al. (2014) concluded that adopting Environmental Performance Indicators (EPIs) provides benefits to ports, allowing for monitoring of the port's progress, illustrating trends over time, and measuring the effectiveness of environmental management activities. Puig et al. (2014) proposed nine management and three operational indicators (Table 2.1).

Table 2.1: Performance indicators for port sustainability.

Environmental Management Indicators	**Operational indicators**
• Environmental management system • Environmental monitoring program • Inventory of significant environmental aspects • Environmental policy • ESPO code of practice • Inventory of environmental legislation • Objectives and targets • Environmental training • Environmental report	• Carbon footprint • Waste management • Water consumption

The Self Diagnosis Method (SDM) is another tool that can be used to assess environmental management performance (Darbra et al., 2004) and can be accessed online (Ecoports, 2017c). As previously noted, PERS was developed by ports through an ESPO initiative and is accessible online as well (Ecoports, 2017b). Currently, 32 EU ports have PERS certification until now (Ecoports, 2017b), but ports also seek various ISO certifications such ISO 50001 (Energy Management), ISO14001:2015 (Environmental Management System), or the Eco-Management and Audit Scheme (EMAS) certification (Darbra et al., 2005; Peris-Mora et al., 2005; Puig et al., 2014; Ecoports, 2017).

2.5 Sustainable or Green Port

Sustainability within maritime shipping is linked to the notion of ensuring safe, secure, efficient and reliable transport of goods while minimizing the effects on the environment and maximizing resource efficiency (IMO, 2013). Port sustainability denotes port strategies and activities that meet the ports' and their stakeholders' current and future needs while protecting and sustaining human and natural resources (AAPA, 2007).

On the other hand, green ports are those ports engaged in the proactive development, execution, and monitoring practices targeted at reducing environmental effects at local, regional and global levels beyond compliance (Acciaro, 2015). Pavlic et al. (2014) defined a green port as a product of long-term strategy for developing port infrastructure sustainably, with a focus on minimizing GHG emissions. Acciaro (2015) suggested that green ports work to balance economic demand with environmental responsibility through research and innovation. The intention is to achieve a positive outcome to both economic performance and customer retention (Lam and Van Voorde, 2012).

Lu et al. (2016) specifically differentiated between sustainability and green. They suggested sustainability considers social, economic and environmental issues, whereas green solely focuses on environmental issues (Lu et al., 2016). Lam and Van Voorde (2012) proposed a combined framework that included elements such as stakeholder involvement, green market development, and cost-effective environmental policy with the green port strategy.

2.6 Opportunities for Green and Sustainable Ports

Many ports around the world have pledged to be a sustainable port and have adopted green port strategies (Lam and Van Voorde, 2012; Hiranandani, 2014). Pavlic et al. (2014) referring to Lam and Van Voorde (2012) found that adopting green initiatives allows ports to establish their commitments and responsibilities to the environment and the society. Adams et al. (2009) found that ports which invest in improving environmental performance had three potential reasons: to get or improve their social license to operate; because it was linked to their corporate conscience; and to improve their competitive advantage (cost reductions, efficiencies, etc.). Lam and Van Voorde (2012) found evidence to suggest that green ports lead other ports in terms of economic performance, social responsibility, and environmental protection. Most have observed that the adoption of environmental management programs and green business strategies do bring better environmental performance (Rao and Holt, 2005; Gimenez et al., 2012) and firm competitiveness (Adams et al., 2009; Yang et al., 2013).

Ports' value-added services related to environmental management can bring direct and indirect benefits to port cities. Value-added services (e.g., industrial development, waterfront development, and port facilities) and activities of ports have direct impacts creating jobs and income and have indirect impacts generated by the port services and supply of goods which in return bring economic productivity, growth, and attractiveness for the ports (Merk, 2011). Researchers reported that the ports which provide a variety of value-added services to its clients would get a competitive advantage in the future (Perez-Labajos and Blanco, 2004; Merk, 2011). In a study conducted by Cerceau et al. (2014), ports were seen as platforms of circulation and conversion of material and energy flows and could be interesting laboratories for implementing a concept known as industrial ecology. Industrial ecology refers to the optimization of resource consumption (e.g., raw material, water, energy) and proper management of by-products (e.g., waste) by densifying interactions among different stakeholders which are located in a common geographic area (Cerceau et al., 2014). For reasons noted throughout this section, ports are considered as self-sufficient exemplary areas that are likely to facilitate local eco-parks development; as nodes in the global port network, ports can facilitate exchanging by-products and share utility among ports (Cerceau et al., 2014).

2.7 Perceived Challenges

There are numerous challenges to be addressed when undertaking to become a green or sustainable port. The environmental, economic, and societal challenges that ports are encountering include increasing marine traffic volumes, ever-increasing ship size, cost of port capacity enhancement, volatile energy prices, the transition to alternative fuels, and stricter Sulphur limits (UNCTAD, 2015). Ports are to be prepared for larger vessels investing money for deepening the channels to be competitive with other ports (Nagle, 2013) for which port authorities might not be interested in investing money for greening port operations. Many port authorities are nowadays facing the challenge to contribute to both greater international competitiveness and better environmental performances.

In a study conducted by ESPO (2010) among 122 ports from EU member states, 71% of the ports experienced some challenges in adopting environmental management measures. The main challenges encountered by ports in implementing environmental management are finding out competent stakeholders/authorities involved, cost of the environmental management measures, and lack of knowledge in implementing good environmental management practices (ESPO, 2010). In the same study, 67% of the ports responded that they experienced restrictions on developments because of environmental planning controls

(ESPO, 2010). Hiranandani (2014) noted that the cost of implementing environmental management measures and lack of data (e.g., emission inventory, impact assessment of pollutants) was the constraining forces for sustainable development in many ports. Some researchers think that regulations and community pressure sometimes hinder port developments as ports are to comply regulations and meet societal expectations (Lam and Notteboom, 2014).

In addition, port operations are now increasingly hindered because of climate change-induced impacts. Evidence suggests that ports are vulnerable due to climate change-induced impacts like sea level rise, storm surge, coastal flooding, and cyclones/hurricanes (Becker et al., 2012; Nursey-Bray et al., 2013). Port infrastructures are damaged, delaying operations during extreme natural events like cyclones/hurricanes, storms, and storm surges which cause substantial economic loss of the ports. For example, Hurricane Katrina caused US$1.7 billion of damage to southern Lousiana ports and over two hundred onshore releases of petroleum products or hazardous chemicals (Santella et al., 2010). Hurricane Ike caused US$2.4 billion of damage to Texas ports and waterways (FEMA, 2008). Becker et al. (2012) analyzed that an average of 130 ports were hit or brushed up by a tropical cyclone each year in recent decades. Port authorities need to identify and assess risks of climate change-induced effects on port infrastructures and operations, and they need to collaborate with the scientific community, policymakers, government, and other relevant stakeholders to formulate and implement proactive adaptation measures in order to make ports resilient to extreme climatic events (Becker et al., 2012; Nursey-Bray et al., 2013; Becker et al., 2015).

CHAPTER 3: METHODS

3.1 Introduction

The purpose of the study was to assess the sustainability initiatives of ports both from global and Canadian perspectives. To achieve the research objectives, the strategy of the research was to use data that could be accessed from publicly available sources. Walker (2016) and Adams et al. (2009) applied a similar strategy when completing research on a) Green Marine's environmental program, and b) the extent of additional port competitiveness that could be relating to environmental issues. De Martino et al. (2017) studied value creation in the port using content analysis.

The following sections illustrate the rationale behind the selection of the sample ports, the location of the ports, and the methods of data collection and analysis.

3.2 Selection of the Sample Ports

According to the World Port Source, as cited in Becker et al. (2012), there are 1056 seaports ranging in size in the world. In this study, 36 ports were selected as representative of the global ports. These 36 ports consist of 12 NA, 12 EU, and 12 AP ports. These ports are major ports in their respective state. To assess Canadian ports' sustainability initiatives and environmental performance 18 Canadian major ports known as the Canadian Port Authorities (CPAs) were selected.

The rationale for port selection included:

- Claims to be green or sustainable or pledges to be green or sustainable. Based on this criterion, the availability of data and information from port websites and secondary sources were also considered.
- Geographic coverages, such that 12 ports were selected to be representative of each of the three regions where seaborne trade is high including NA, EU, and AP. Most of the largest ports are located in these three regions (see Figure 3.1). Moreover, based on our analysis and experience we found that ports from Africa or South America typically lack sufficient publicly available data related to environmental management measures. Hence, these two regions were not selected in this study.

- For detailed case analysis, one large port, each with a history of environmental management, was selected from within each region for comparative purposes.
- Seventeen of the 36 sample ports are within the top 100 ports according to the American Association of Port Authorities (AAPA) as ranked by cargo volume handled in 2015 (World Shipping Council, 2017b). Twenty-seven of the selected ports are listed within the top 250 according to the same ranking. According to Santos et al. (2016), larger ports are more likely to publish and/or disclose their sustainability performance data, hence the focus on larger ports.
- Eighteen major ports (see Figure 3.2) were selected which represent the National Ports System in Canada listed under the Canada Marine Act (1998) (Transport Canada, 2012).

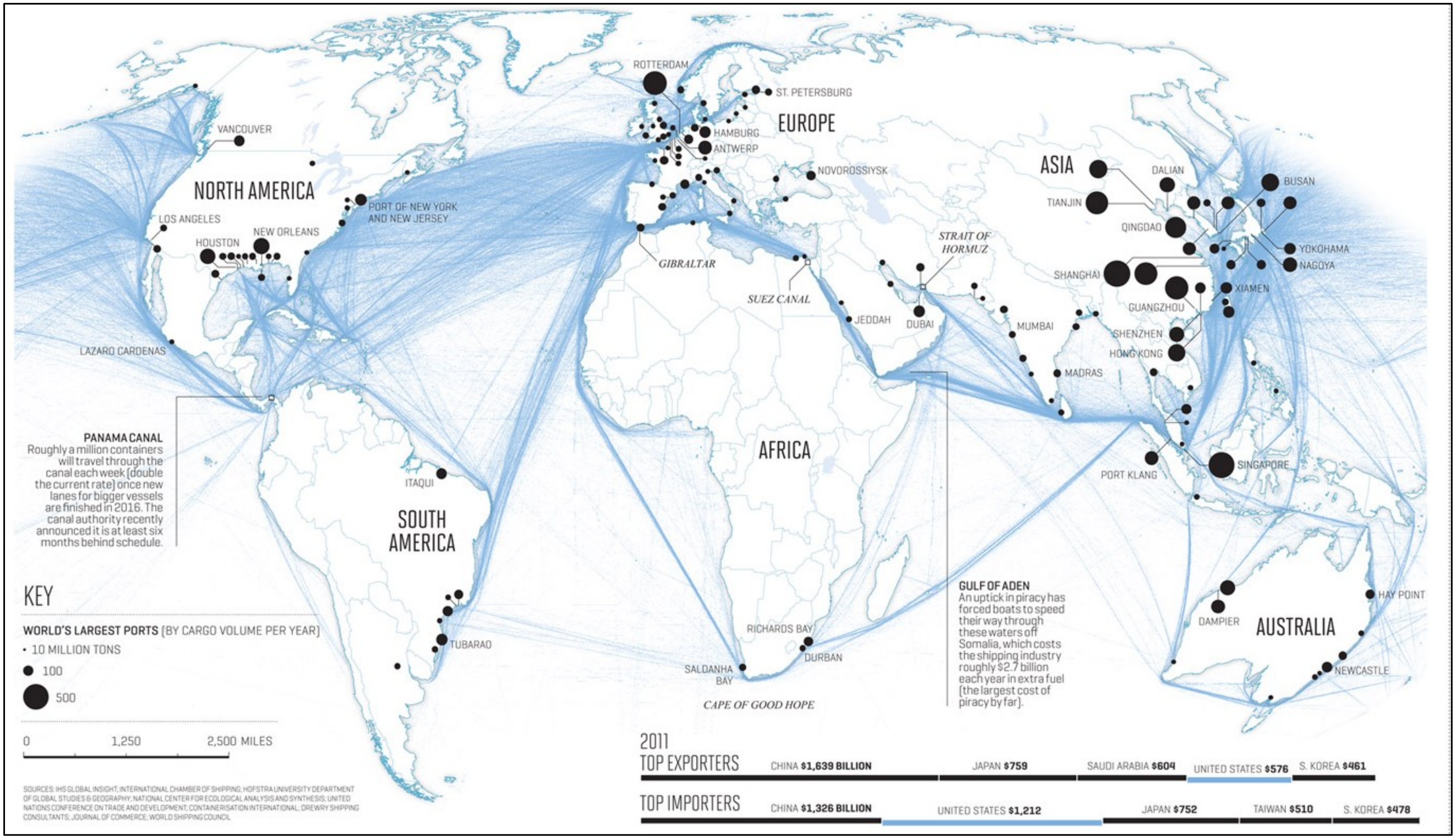

Figure 3.1:World's largest ports by cargo volume handled in 2011 (FORTUNE, 2012 May 21).

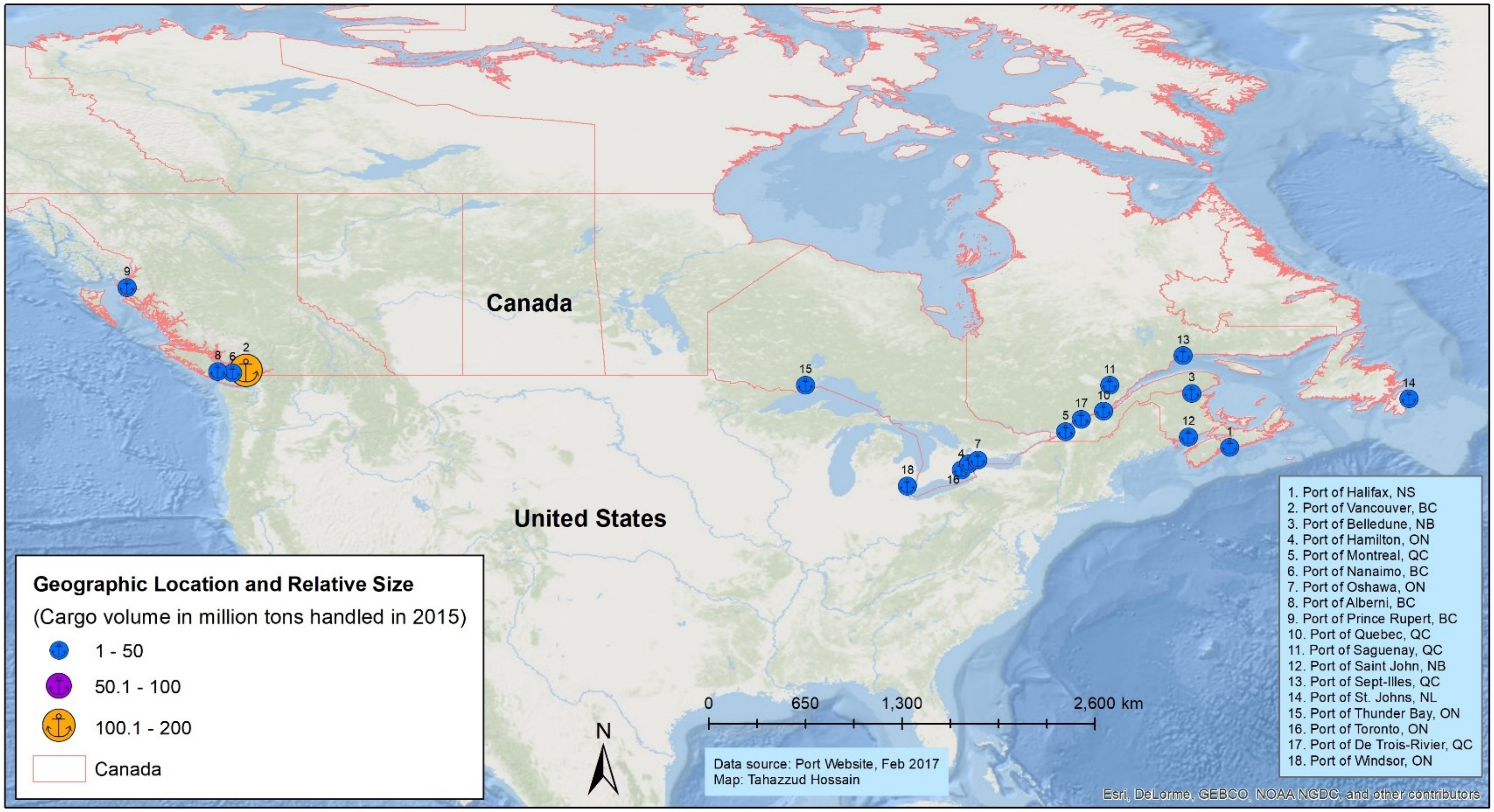

Figure 3.2: Geographic location and relative size of Canadian ports.

3.3 Data Collection and Analysis

This study followed a desk research strategy – sometimes referred to as a content analysis - as applied by Walker (2016) and De Martino et al. (2017) in their studies. A web-based data collection method was chosen. A total of 25 indicators were selected to assess the sustainability initiatives adopted by ports; data were accessed from online sources such as internal sustainability reports, third-party assessments, and scholarly literature. Three steps were followed to select the 25 indicators. Firstly, relevant literature was reviewed to determine port-related social, economic and environmental issues. Secondly, the researcher categorized the ports' initiatives linked to achieving port sustainability by evaluating the corporate websites of the ports. Finally, 25 indicators were selected based on this literature review to measure and compare port sustainability. Each indicator represents an initiative of the port to be green or sustainable. Information about initiatives was collected from corporate websites of each port. For example, one typical initiative is to formally adopt an environmental policy (EP). A structured evaluation matrix was created including each indicator, whereby each was assigned a 'Yes' or 'No' value based on data obtained from reviewing port websites and published reports. The answer to each was entered into Statistical Package for Social Sciences (SPSS). Value '1' was entered if the answer was 'Yes' meaning the port had adopted that particular initiative and value '0' was entered if the answer was 'No' meaning the port had not adopted that particular initiative. The dataset was used to do the descriptive analysis for each indicator for all ports.

To compare the extent of global and Canadian ports' sustainability initiatives a sustainability scale (low sustainability, moderate sustainability, high sustainability) was developed by the researchers considering one standard deviation (SD) above the high sustainability mean and one SD below the low sustainability mean and in between moderate sustainability. Reliability of selected indicators to measure sustainability was tested using Cronbach's alpha. Cronbach's alpha is widely used to assess the consistency of selected variables to measure a scale (Lun, 2014). Alpha values range from 0 to 1. Alpha value between 0.6 - 0.7 is deemed the lower limit of acceptability (Lun, 2014). Cronbach's alpha was tested for 25 indicators using SPSS to determine the internal consistency of the indicators to measure sustainability scale.

To compare Canadian ports' environmental performances, annual performance scores measured by GM under the GMEP were extracted from GMEP performance reports (2009 - 2016). These reports are publicly available on the GM website. The descriptive statistical analysis was done using SPSS and Microsoft Excel. Geographic Information System (GIS) software ArcGIS 10.2 was used to present results spatially.

3.4 Limitations

The limitation of the study is that most of the data were collected from ports' corporate websites. It might be possible that some ports might not have published their environmental performance information on their corporate websites. This might be factual to some extent, but large ports are intended to maintain higher levels of sustainability communication through disclosing information to the public (Santos et al., 2016). Moreover, the sample ports in this study are among the top ports in the world, and all of the ports are major ports in their representative countries. The data were collected in January - April 2017 which is thought as a limitation because it might happen that a particular port has now published their green or sustainability disclosure which was not available during the period of data collection.

CHAPTER 4: STATE OF SUSTAINABILITY INITIATIVES IN GLOBAL PORTS

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4.1 Statement of Student Contribution

Tahazzud Hossain produced the original manuscript. Data collection, analysis, and report writing were performed by Tahazzud Hossain. Michelle Adams and Tony R. Walker guided this research and reviewed the manuscript to finalize for journal publication.

4.2 Abstract

Seaports contribute to the development of maritime supply chains and socio-economic development to host communities, but can pose adverse effects on the surrounding environment. Adopting sustainability initiatives within port operations has been a rapidly growing trend, and many ports claim or pledge to be green or sustainable. Sustainable port initiatives and approaches are poorly described in academic research. This research explores what port authorities define as "green" or "sustainable," and what current trends exist to achieving port sustainability. Thirty-six ports were selected from North America (NA), Europe (EU) and Asia Pacific (AP) as study sample. Twenty-five pre-defined indicators were used with the intent of identifying operational trends linked to the sustainability claimed by ports. Each operation was assessed using publicly available data; using a mixed methods approach, descriptive statistical analysis for the sustainability initiatives was performed to assess port sustainability efforts. Results indicate that EU ports have made greater progress in various aspects of adopting sustainability initiatives as compared to the NA and AP ports. The approaches global ports adopted to be sustainable include a greater emphasis on internal environmental policy development; integration of environmental management systems and third-party certification; identification, mitigation and monitoring environmental impacts; innovation and investment for environmental solutions, incentives and awarding for environmental performance, stakeholder

engagement; policies and regulations; collaboration; adaptation to environmental changes, increased staffing levels of environment-related positions; and voluntary sustainability reporting.

Keywords: Shipping, Port, Port Sustainability, Sustainability Initiatives, Sustainability Scale, Environmental Management, Sustainability Approaches.

4.3 Introduction

Maritime shipping is considered a low-cost, efficient and environmentally friendly mode of transport, connecting businesses, markets, people, and countries to create opportunities to buy and sell merchandise (UNCTAD, 2016; ICS, 2017). The import/export of goods necessary for modern society would not be possible without shipping, as the international shipping industry carries about 90% of global trade (Panayides and Song, 2012; ICS, 2017). United Nations Conference on Trade and Development (UNCTAD) reported that global seaborne trade exceeded 10 billion tons by volume in 2015, up almost 400% since 1970 (2.6 billion tons) (UNCTAD, 2016).

Seaports (ports) are the gateways of international trade and play a crucial role in the global economy, accommodating global shipping and cruising for centuries. Ports are fundamental for the maritime transport sector, delivering prosperity as dynamic, vibrant centers of trade and commerce (Nagle, 2013). In modern logistics systems, ports are not only involved in loading and unloading cargoes but also in creating value-adding services like storage, warehousing, packing and arranging inland transport (Pettit and Beresford, 2009; Nam and Song, 2011).

4.3.1 Associated Environmental Issues

Port activities and operations contribute significantly to maritime transport development, economic growth of a country, and to direct and indirect employment, but also impose adverse effects on the environment (Gupta et al., 2005; Dinwoodie et al., 2012). Environmental effects can be caused by port activities and operations, shipping traffic, and by emissions from intermodal transports serving the port hinterland (OECD, 2011; Lam and Notteboom, 2014). A study conducted in 2004 with 800 North American, European, and Asian ports, port authorities listed water quality, waste disposal, air quality, habitat conservation and noise as the top five environmental issues (Comtois and Slack, 2007). More recently, in 2016 European Sea Ports Organization (ESPO) and EcoPorts found that officials from 91 ports within the EU identified the 10 environmental priorities as follows: air quality; water quality; noise; garbage/port waste; ship waste; dust; energy consumption; relationship with local community; dredging operations; and port development (EcoPorts, 2016a).

Puig et al. (2015) also included air emissions, discharges to water/sediment, emissions to soil, resource consumption, and biodiversity conservation as additional environmental considerations. In particular, air quality is also widely reported as a major port-related environmental issue (Lam and Notteboom, 2014; Winnes et al., 2015; EcoPorts, 2016) and has been identified as the number one environmental priority by European ports in 2013 and 2016 (EcoPorts, 2016a). Water pollution can be a significant environmental issue (Kröger et al., 2006; Grifoll et al., 2011), where ballast water releases, cargo residue, fuel oil residue, waste discharges and oil spills all contribute (Ng and Song, 2010; OECD, 2011; Lam and Notteboom, 2014). Management of garbage is another challenge although in many jurisdictions both ships and ports have to comply with national (depending on the area of port operation) and international regulations (e.g., IMO 73/78 Annexes I-V) for waste disposal and management (Trozzi and Vaccaro, 2000; OECD, 2011).

Many researchers have noted that noise complaints widely reported by those that live and work in close proximity to port operations (Khoo and Nguyen, 2011; Mustonen, 2013; Schenone et al., 2014; Witte, 2016). ESPO prioritized noise as the third most impactful environmental aspect for European ports for 2016 (EcoPorts, 2016a). Low-frequency underwater noise generated by commercial shipping can affect marine life by disturbing the marine species (e.g., whales) who use sound for hunting, detecting predators, finding mates and communication (Jasny, 2005).

Finally, apart from the typical port-related environmental effects, port development and expansion - to accommodate large size ship and improve hinterland connections – are a major challenge. Land reclamation and exacerbation of existing environmental issues are all linked to port development and expansion projects (Del Saz-Salazar et al., 2012). Opposition to such expansion projects are increasing (Morris and Gibson, 2007; Yim Yap et al., 2013), but the substantial growth in the port industry that has been observed in recent decades is expected to continue. This not only creates pressure on ports for efficient traffic handling but intensifies the adverse environmental effects on marine ecosystems and on coastal communities (Yim Yap et al., 2013). Effective environmental management in port operations is therefore essential if port authorities are to deliver their port operations sustainably in the face of increasing environmental awareness in society.

4.3.2 Environmental Management in Ports

Effective environmental management has become increasingly important for many port authorities as environmental awareness is growing throughout society (Morris and Gibson, 2007; Puig et al., 2014). Ports undertake environmental management initiatives not only for maintaining social license to operate and grow (Van Den Bosch et al., 2011) but also for international competitiveness (Lam and Notteboom; Hollen et al., 2015) and to attract employees and investors (Lam and Notteboom, 2014). However, the primary purpose of port environmental management is still to mitigate adverse effects (Gupta et al., 2005; Dinwoodie et al., 2012; Walker, 2016). While some ports adopt environmental management initiatives for regulatory compliance, others go beyond compliance with a focus on improving their sustainability. Ports such as the Port of Vancouver (POV), Port of Long Beach (POLB), Port of Los Angeles (POLA), Port of Rotterdam (POR), and the Port of Antwerp (POA) exceed regulatory compliance with an aim to become more sustainable than their competitors. Europe, in particular, has noticeably developed environmental management during the last 15 years through mutual collaboration among ports, research institutions, and specialist organizations (ESPO, 2012).

An effective port environmental management system (EMS) requires identification of environmental components of concern, based on port activities and operations, to then determine what can be managed from an environmental perspective (Puig et al., 2015). Tools exist for identifying significant environmental components and for identifying related environmental performance indicators (Puig et al., 2015), two of which are freely available for port authorities through Eports website (Eports, 2017). Puig et al. (2014) concluded that adopting Environmental Performance Indicators (EPI) provides benefits to ports, allowing for monitoring of the port's progress, illustrating trends over time, and measuring the effectiveness of environmental management activities. Puig et al. (2014) proposed nine management and three operational indicators (Table 4.1).

Table 4.1: Performance indicators for port sustainability.

Environmental Management Indicators	**Operational indicators**
• Environmental management system • Environmental monitoring program • Inventory of significant environmental aspects • Environmental policy • ESPO code of practice • Inventory of environmental legislation • Objectives and targets • Environmental training • Environmental report	• Carbon footprint • Waste management • Water consumption

The Self Diagnosis Method (SDM) is another tool that can be used to assess environmental management performance (Darbra et al., 2004) and can be accessed online at Ecoports website (Ecoports, 2017c). The Port Environmental Review System (PERS) was developed by ports through an ESPO initiative and is accessible online as well at Ecoports website (Ecoports, 2017b). Ecoports is a European port sector based environmental initiative under the ESPO whose principles are to cooperate and share knowledge among ports. Ecoports provide information and technical support to its 92 member ports regarding the two tools 'SDM' and 'PERS'. Currently, 32 EU ports have PERS certification (Ecoports, 2017a). Apart from PERS certification ports also seek various ISO certifications such ISO 50001 (Energy Management), ISO14001:2015 (Environmental Management System), or the Eco-Management and Audit Scheme (EMAS) certification (Darbra et al., 2005; Peris-Mora et al., 2005; Puig et al., 2014; Ecoports, 2017).

4.3.2 Defining Sustainable Port

Port sustainability denotes strategies and activities that meet the current and future needs of port stakeholders while protecting and sustaining human and natural resources (AAPA, 2007). Environmental management in ports is growing rapidly with increasing demand for sustainable maritime transportation. Sustainability in maritime transportation systems is required to ensure safe, secure, efficient and reliable transport of goods while minimizing negative effects on the environment and maximizing resource efficiency globally (IMO, 2013).

Green ports are those ports engaged in the proactive development, execution, and monitoring practices targeted at reducing environmental effects at local, regional and global levels beyond compliance (Acciaro, 2015). Pavlic et al. (2014) defined a *green port* as a product of long-term strategy for developing port infrastructure sustainably, with a focus on minimizing GHG emissions. Acciaro (2015) suggested that green ports work to balance economic demand with environmental responsibility through research and innovation. The intention is to achieve a positive outcome to both economic performance and customer retention (Lam and Van Voorde, 2012). However, Lu et al. (2016) differentiated between sustainability and green. Sustainability is understood to consider social, economic and environmental issues, whereas green is solely focused on environmental issues (Lu et al., 2016). Lam and Van Voorde (2012) proposed a combined framework that included stakeholder involvement, green market development, cost-effective environmental policy, and sustainable operations and development, as major elements of their green port strategy.

This study assesses sustainability initiatives adopted in global ports, using the publicly available data for 36 global ports. The descriptive statistical analysis is used to evaluate the variation in sustainability initiatives of NA, EU, and AP. Strategies for improving port sustainability are discussed with the intent of generating new knowledge and addressing an apparent gap in port sustainability research.

4.4 Research Methodology

To assess initiatives and approaches adopted by ports to achieve port sustainability, 36 global ports were selected: 12 ports in North America (NA), 12 in Europe (EU), and 12 in Asia-Pacific (AP). Appendix A represents the list of these ports. Port location and relative size by cargo volume handled (in 2015) are shown in Figure 4.1. POV, POR, and Port of Kaohsiung (POK) were selected for more detailed case analysis.

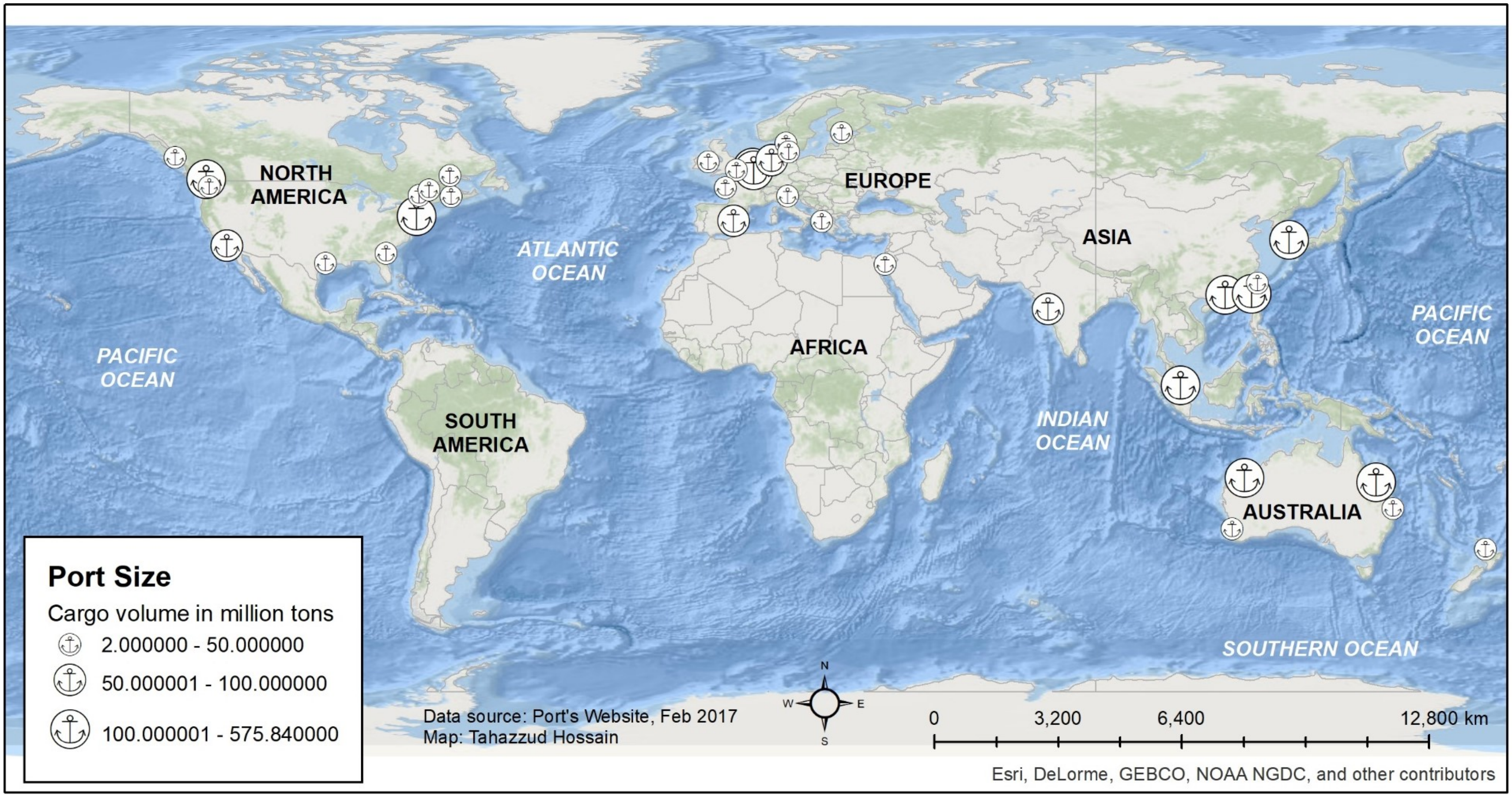

Figure 4.1: Geographic location and relative size of ports by cargo volume.

The rationale for port selection included:

- Claims to be green or sustainable or pledges to be green or sustainable. Based on this criterion, the availability of data and information from port websites and secondary sources were also considered.
- Geographic coverages, such that twelve ports were selected to be representative of each of the three regions where seaborne trade is high including AP, EU, and NA. Most of the largest ports are located in these three regions (see Figure 4.1). Moreover, it has been reported that ports from Africa or South America typically lack sufficient publicly available data related to environmental management measures.
- For detailed case analysis, one large port, each with a history of environmental management, was selected from within each region for comparative purposes.
- Seventeen of the 36 sample ports are within the top 100 ports according to the American Association of Port Authorities (AAPA) as ranked by cargo volume handled in 2015 (World Shipping Council, 2017b). Twenty-seven of the selected ports are listed within the top 250 according to the same ranking. According to Santos et al. (2016), larger ports are more likely to publish and/or disclose their sustainability performance data, hence the focus on larger ports.

A total of 25 indicators were selected to assess the sustainability initiatives adopted by ports; data were accessed from online sources such as internal sustainability reports, third-party assessments, and scholarly literature. For example, one typical initiative is to formally adopt an environmental policy (EP). This is usually a written statement supported by the top management (e.g., CEO) and is publicly available on the corporate website normally to communicate to the stakeholders. Therefore, one of the indicators selected was the presence/absence of a formally declared environmental policy (Appendix B presents the full set of indicators).

A structured evaluation matrix was created including each indicator, whereby each was assigned a ‘Yes’ or ‘No’ value based on data obtained from reviewing port websites, published reports and documents. The answer to each was entered into SPSS (Statistical Package for Social Sciences). Value ‘1’ was entered if the answer was ‘Yes’ meaning the port had adopted that particular initiative and value '0' was entered if the answer was 'No' meaning the port had not adopted that particular initiative. The dataset was used to do the descriptive analysis for each indicator for all 36 ports.

To compare the extent of sustainability initiatives adopted by the ports among the three regions, a sustainability scale (1-10 initiatives = low; 11-21 initiatives = moderate; 22-23 initiatives = high) was developed by summing all 25 indicators. This sustainability scale was developed based on one standard deviation (SD) above the high sustainability mean (22-23 initiatives), and one SD below the low sustainability mean (1-10 initiatives), in between moderate sustainability. Reliability of selected indicators to measure sustainability was tested using Cronbach's alpha. Cronbach's alpha is widely used to assess the consistency of selected variables to measure a scale (Lun, 2014). Alpha values range from 0 to 1. An alpha value between 0.6 - 0.7 is deemed the lower limit of acceptability (Lun, 2014). Cronbach's alpha was tested for 25 indicators using Statistical Package for Social Sciences (SPSS) to determine the internal consistency of indicators to measure sustainability scale. SPSS and Microsoft Excel were used to do the descriptive statistical analysis. ArcGIS 10.2 (GIS software) was used to present results spatially.

Finally, the various initiatives were categorized and discussed as approaches, with a specific focus on highlighting how each approach is best used to support improved sustainability within the port sector. The level of importance of each approach is then comparatively discussed.

4.5 Results and Discussion

4.5.1 State of Sustainability Initiatives in Global Ports

Environmental Policy (EP) and Environmental Management System (EMS)

Result indicates that 92% ports (33 of 36) have established EPs (Table 4.2), a written statement (usually signed) by the senior executive of the port that includes the commitment to manage the environmental impacts of port activities and to comply laws and regulations. Most ports make their EP publicly available on their websites, and when comparing across the three regions, all EU and AP ports were found to have EPs, while NA ports still have some work to do on this front, with only 75% (nine of twelve ports) reporting having an EP (Figure 4.2).

Establishing an EP is normally considered as the first step in developing a robust EMS (Le et al., 2014). As previously noted, an EMS is a tool to manage environmental impacts following a systematic, comprehensive and documented approach to achieve the environmental performance of the organization (Le et al., 2014). In this study, more than half (53%) of the ports have established an EMS (Table 4.2). EU ports appear to be the most likely to have an EMS (75%); of those evaluated in AP and NA, more than half have yet to report implementing such programs (Figure 4.2). Of the various types of EMS protocols, it is reported that Green Marine is widely adopted by NA ports (Walker, 2016); however, PERS and ISO 14001 certifications are more widely adopted by EU ports (Darbra et al., 2009). Within AP ports ISO certification is the only EMS system – nothing directly related to port-specific operations has been found to be commonplace.

Table 4.2: Cross-tabulation of EP, EMS and EMS certifications among global ports.

		Does the port have an EMS?		
		Yes	No	Total
Does the port have an EP?	Yes	19	14	33
	No	0	3	3
Total		19	17	36
		Is the port EMS ISO14001 certified?		Total
		Yes	No	
Does the port have an EMS?	Yes	19	0	19
	No	0	17	17
Total		19	17	36

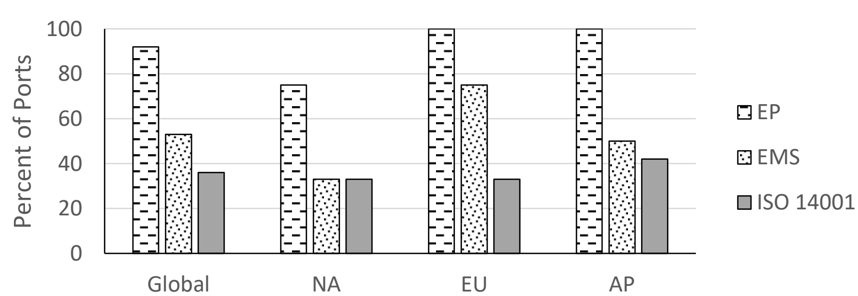

Figure 4.2: Percent of ports having EP, EMS or ISO 14001 certifications.

Emission Inventory

Of the 36 ports, 23 (64%) reported conduct emissions inventories. More than 80% of EU ports complete emissions inventories compared to NA (67%) and AP (42%) ports (Figure 4.3). Under the influence of ESPO, member ports regularly monitor and report emissions (Puig et al., 2015); this may explain the considerably larger percentage of EU ports doing emissions inventory. The emissions inventory is a common measure of environmental performance in many EU ports (Puig et al., 2017), and today many ports conduct annual emissions inventory to determine the source, composition, and level of air pollutants. The intent is to track the progress of air quality improvement initiatives, mitigate GHG emissions, and reduce health risks to neighbouring communities. Port emissions inventory is an activity-based accounting of emissions from different significant (mobile) sources within the port influencing area, as well as the sources of emission include administrative buildings and lighting, cargo handling equipment, trucking, rail, and the visiting ships while berthed (McEwen, 2012). This latter category is a significant emitter; for example, Winnes et al. (2015) found that half of the port-related emissions occur at the berth. POV reported that 59% of port-related GHG emissions in 2015 were from ocean-going vessels calling at its port which were the highest compared to other sources such as rail (17%), on-road (17%), non-road (6%) and administrative (1%) (POV, 2016).

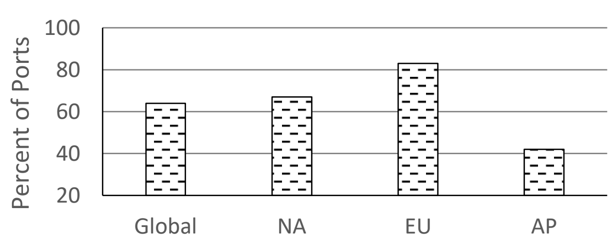

Figure 4.3: Percent of ports doing emissions inventory.

Wildlife Habitat Protection

More than 70% of the evaluated ports have implemented wildlife habitat protection measures, although measures adopted by NA and EU ports are slightly more advanced than the global average with AP port trailing (Figure 4.4). Wildlife habitat protection is intended to counteract the negative impacts of port operations, and expansion linked to habitat loss and is considered by some authorities to be among the top environmental issues (Darbra et al., 2004; Comtois and Slack, 2007). Under such strategies, ports take various measures to control aggressive invasive species, reduce wildlife mortality, and create or restore habitat for the threatened species in the port influencing areas (Vincent, 2014). POV reported that they are protecting wildlife and wildlife habitats through the Enhancing Cetacean Habitat and Observation (ECHO) program and other habitat enhancement measures (POV, 2017). Under the ECHO program, POV started measuring underwater noise in 2015 to assess the impacts of shipping on whales in port areas (POV, 2017).

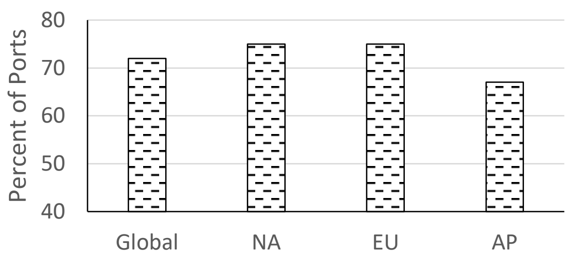

Figure 4.4: Wildlife habitat protection measures adopted by ports.

Shore Power Facility and Green Incentive Program

Shore power (also known as cold ironing or alternative maritime power or shore side electricity) has been implemented by many ports to reduce the environmental impacts (e.g., air emissions, noise) of ships while berthing at the port. Shore power facility allows ships to plug into the port provided electricity network instead of using auxiliary engines while in the port. A number of studies found that shore power facility delivers both environmental and economic benefits to the ports and ships (Hall, 2010; Winkel et al., 2015; Sciberras et al., 2016). Collectively, half the ports evaluated provided shore power facilities (Table 4.3). Regionally, approximately 65% of NA ports provide shore power facility, while only half of EU ports and 33% AP ports have shore power facilities (Figure 4.5).

To encourage ships to use shore power many ports provide incentives (e.g., EcoAction Program of POV; Green Award Program of POR; Green Ship Incentive Program of POLB). POR gives 10% discount on port dues to the vessels that have high Environmental

Shipping Index (ESI) scores (Port of Rotterdam, 2017a). Seagoing vessels which have low NOx emissions by using LNG as fuel can get doubled discount on port dues at POR. In this study, 12 ports were found to provide incentives to ships to connect into port electricity networks (Table 4.3) - 40% NA and EU ports and 30% AP (Figure 4.5). Overall, the study showed that compared to AP ports, NA and EU ports are more likely to maintain shore power facility and offer a green incentive program. Regulations and voluntary environmental performance measurement programs such as the Green Marine Environmental Program (GMEP) from Green Marine (GM) and EcoPorts from ESPO may cause NA and EU ports to have a higher percentage of shore power facilities and incentive programs. For example, the EU has made it mandatory for its member states to install shore power facilities in ports by 2025 through the Directive 2014/94/EU (WPCI, 2017). GM has included shore power as a criterion under the *Environmental Leadership* to measure environmental performance of the ports for 2016 GMEP (Green Marine, 2016).

Table 4.3: Cross tabulation between shore power facility and incentive program.

		Does the port provide any incentive or award to the green ships?		
		Yes	No	Total
Does the port have shore power facility?	Yes	12	6	18
	No	2	16	18
Total		14	22	36

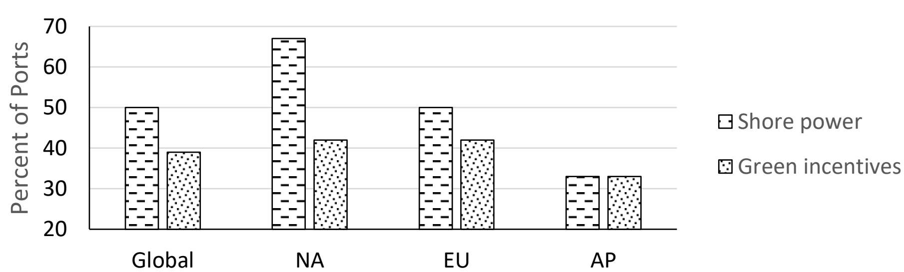

Figure 4.5: Shore power facilities and green incentives.

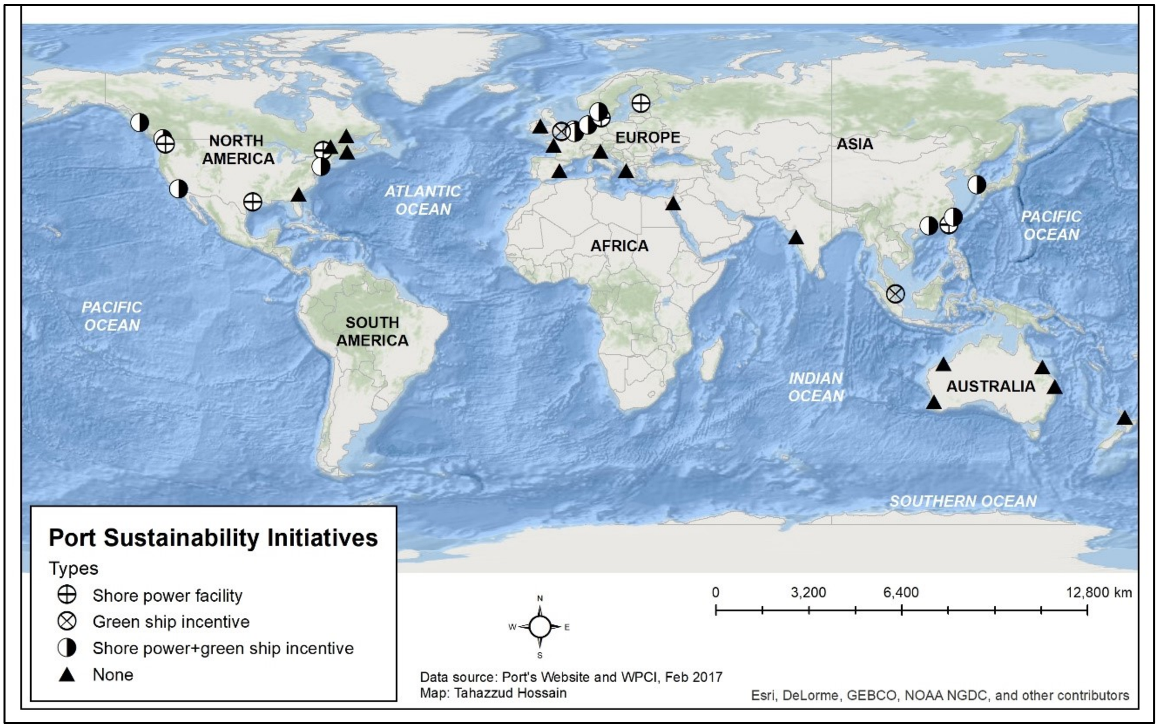

Figure 4.6: Ports with shore power facilities and/or incentive program.

Renewable Energy (RE) Use and Energy Efficiency and Conservation (EEC)

Energy management is considered one of the most important environmental strategies, particularly as it is directly linked to GHG emission mitigation. Acciaro et al. (2014) argued that improved energy efficiency and integrating renewable energy into port electrical systems can offer significant economic gains (reduced energy costs), generate alternative revenue sources, and help improve competitiveness (Acciaro et al., 2014; Lam and Notteboom, 2014). For example, POV imports electricity produced from wind and hydro, while the Port of Bremen in Germany has implemented an energy management system (EnMS) under ISO50001 to dramatically improve energy efficiency.

Of the evaluated ports, 30 have adopted some element of EEC (Table 4.4); 20 have integrated renewable sources into their energy mix (Table 4.4). Most EU ports adopted EEC initiatives; likewise over 80% AP ports and 75% NA ports have adopted EEC initiatives (Figure 4.7). However, it is the AP ports which have adopted more RE initiatives as compared to EU and NA ports (67%, 58%, and 42% respectively) (Figure 4.7). It has been found that the majority of AP ports such as POK, Port of Keelung, Port of Singapore, Port of Hong Kong and Port of Brisbane have emphasized lowering energy consumption and producing electricity from solar panels.

Table 4.4: Cross tabulation between EEC and RE use.

		Does the port generate/use RE?		Total
		Yes	Not found	
Has the port taken any EEC measure?	Yes	20	10	30
	Not found	0	6	6
Total		20	16	36

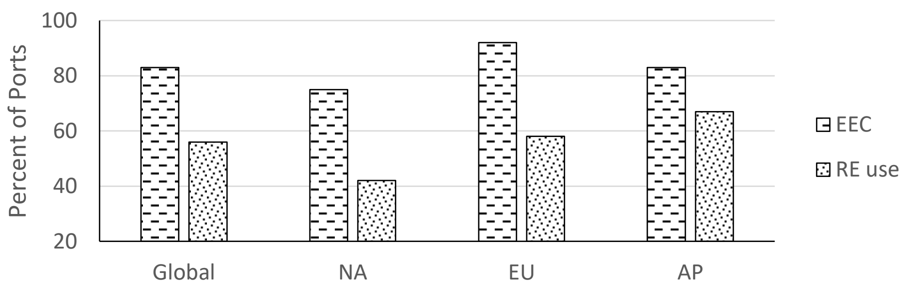

Figure 4.7: EEC and RE initiatives adopted by ports.

Alternative Fuels Facility

Making provision to supply *alternative fuels* to port clients has recently gained attention due to the increasingly stringent environmental regulations to reduce emissions in port areas. LNG is an alternative fuel that can be used by ships to reduce emissions and to meet environmental regulations. Within those ports evaluated, more than half the ports support alternative fuels although EU ports were found to be more developed in this capacity than NA and AP ports (Figure 4.8).

In spite of the current limitation of LNG bunkering infrastructure within ports, LNG has foreseeable economic viability and good environmental performance (Wang and Notteboom, 2015). Winnes et al. (2015) illustrated that the transition from marine fuel oils to alternative fuels like LNG and biofuels could significantly reduce emissions from berthed ships. Some researchers have reported that LNG, as an alternative marine fuel, presents an opportunity for ships to meet MARPOL Annex VI regulations to reduce SOx, NOx, and particulate matter (PM) (Xu et al., 2015; Walker et al., 2018). Some ports also used it as an opportunity to provide alternative fuels facilities to ships calling at their ports. The POR, for example, claims to have a competitive advantage resulting from being an early provider of LNG and biofuel to seagoing vessels and other commercial users across Europe (POR, 2017).

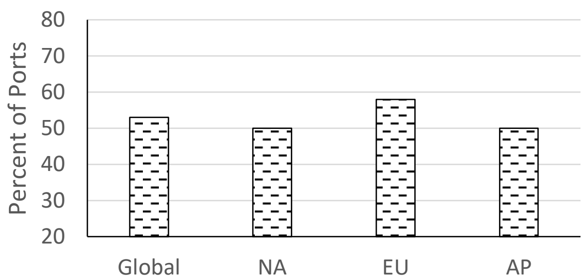

Figure 4.8: Ports with alternative fuel facilities.

Environmental Certification

Certification of environmental management systems (EMSs) within port operations is a growing trend aimed to demonstrate environmental compliance and commitment to continuous improvement of port environmental performance (Royston, 2008; Puig et al., 2014). Among the EMSs, PERS is the only port-sector specific standard for environmental management, although ISO 14001 has also been widely recognized and implemented by ports as compared to other standards. Eco-Management and Audit Scheme (EMAS) is a European regulation that helps organizations to implement an EMS. Like other EMS systems, EMAS can have a positive impact on an organization's environmental performance (Iraldo et al., 2009).

This study revealed that 19 of the 36 ports have ISO 14001 certification; nine have PERS certification, six have both certifications and 14 lack any certification (Table 4.5). Port of Valencia and Port of Igoumenitsa have both ISO 14001 and EMAS certifications. Regionally, EU ports appear to be more proactive but also more diversified in their approach having recognized and implemented all three types to some degree, whereas ISO 14001 is the only standard adopted by NA ports (Figure 4.9). EU ports are advanced in gaining environmental certification because of the EcoPorts initiative, the practice of cooperation and knowledge sharing, and individual ports' willingness to improve environmental performance (EcoPorts, 2017). Among 93 EcoPorts members from 23 EU member states, 49 ports have ISO 14001 and 32 ports have PERS certification (EcoPorts, 2017). In AP ports, ISO 14001 and PERS have both been implemented, but currently, EMAS has no presence in the region (Figure 4.9).

Table 4.5: Cross tabulation among environmental certifications adopted by ports.

ISO 14001 and PERS		Does the port have Port Environmental Review System (PERS) certification?		Total
		Yes	No	
Is the port EMS ISO 14001 certified?	Yes	6	13	19
	No	3	14	17
Total		9	27	36
ISO 14001 and EMAS certification		Does the port have EMAS certification?		
		Yes	No	
Is the port EMS ISO 14001 certified?	Yes	2	17	19
	No	0	17	17
Total		2	34	36

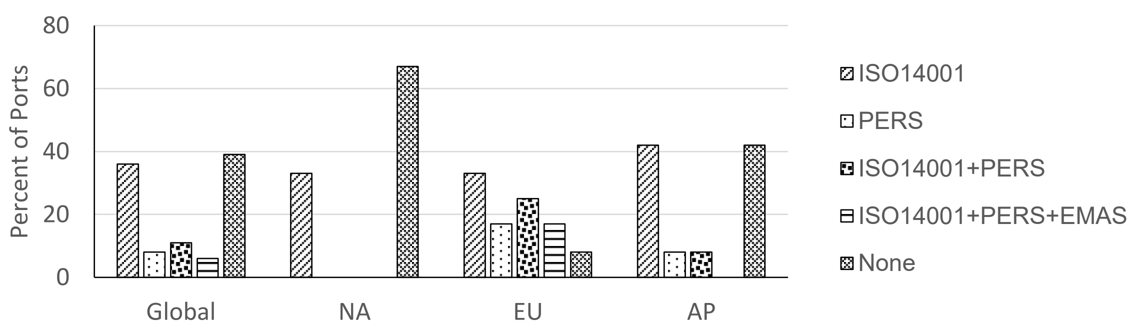

Figure 4.9: Variation of environmental certifications across global ports.

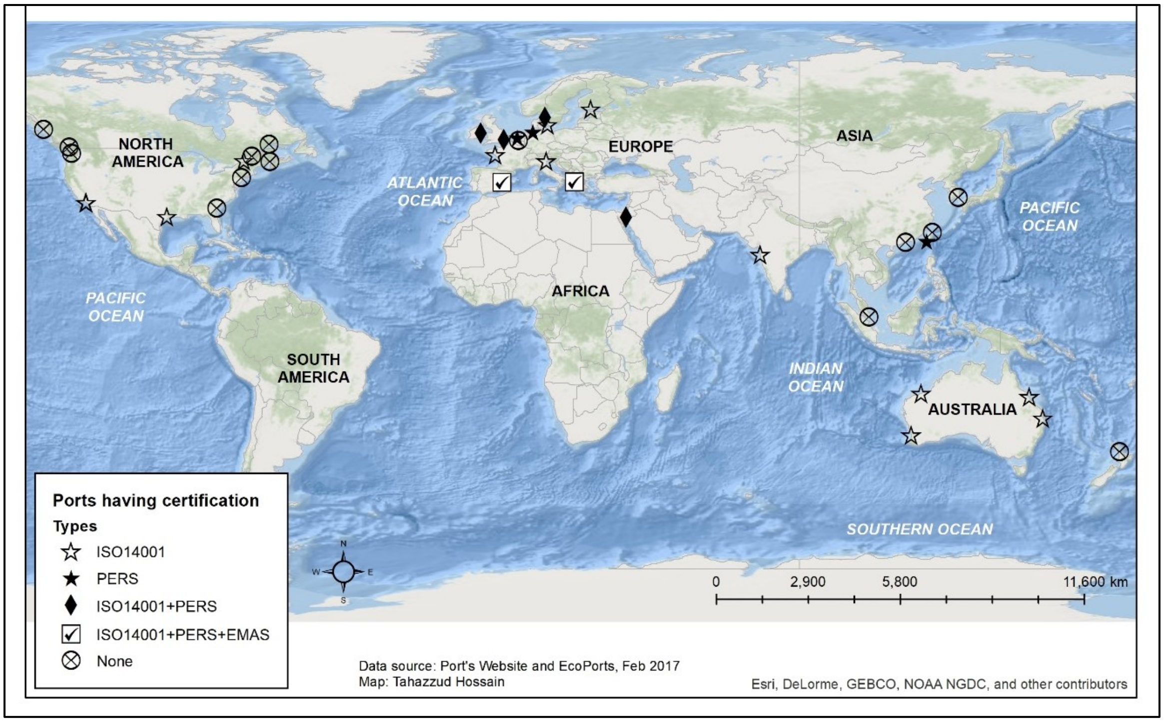

Figure 4.10: Spatial variation of environmental certifications across global ports.

Sustainability Reporting

Ports prepare annual sustainability reports, and/or standalone environmental reports; most appear to be and are published on their corporate websites (Santos et al., 2016). Corporate sustainability reporting is voluntary in most jurisdictions and indicates an organization's willingness to be good corporate citizens (Piecyk and Björklund, 2015). Dobler et al. (2015) found annual environmental reports a reliable means for communicating corporate environmental information to stakeholders. Some ports have used Global Reporting Initiative (GRI) guidelines to frame their environmental reporting. The voluntary GRI sustainability reporting guidelines provide standards for environmental performance disclosure which increases credibility, comparability, and transparency in sustainability reporting (Alazzani and Wan-Hussin, 2013). Results indicate that collectively 19 ports (53%) prepared annual sustainability reports; eight followed the GRI standards (Table 4.6). Regionally, 67% of EU ports prepared annual sustainability reports as compared to 50% of NA ports and 42% of AP ports. Environmental reporting has become a common practice among the EU ports especially among EcoPorts members. As members of EcoPorts, EU ports monitor and report their environmental best practices and performance to EcoPorts in order to prepare the annual ESPO/EcoPorts Port Environmental Review report (EcoPorts, 2016b). The 2016 ESPO/EcoPorts Port Environmental Review reported that 66% of ports have made their environmental report available to the public (EcoPorts, 2016b). Figure 4.12 shows a spatial variation of global ports which prepare annual sustainability report and follow GRI standards.

Table 4.6: Cross tabulation between sustainability reporting and sustainability reports following GRI standards.

		Did the annual sustainability report follow GRI standards?		
		Yes	No	Total
Does the port prepare annual sustainability report?	Yes	8	11	19
	No	0	17	17
Total		8	28	36

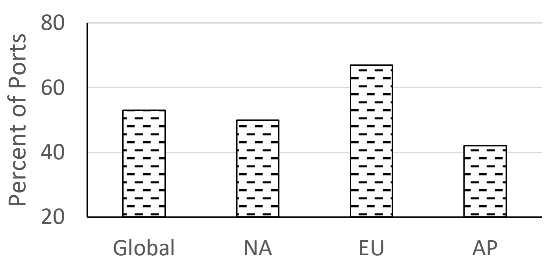

Figure 4.11: Percentage of ports preparing annual sustainability report.

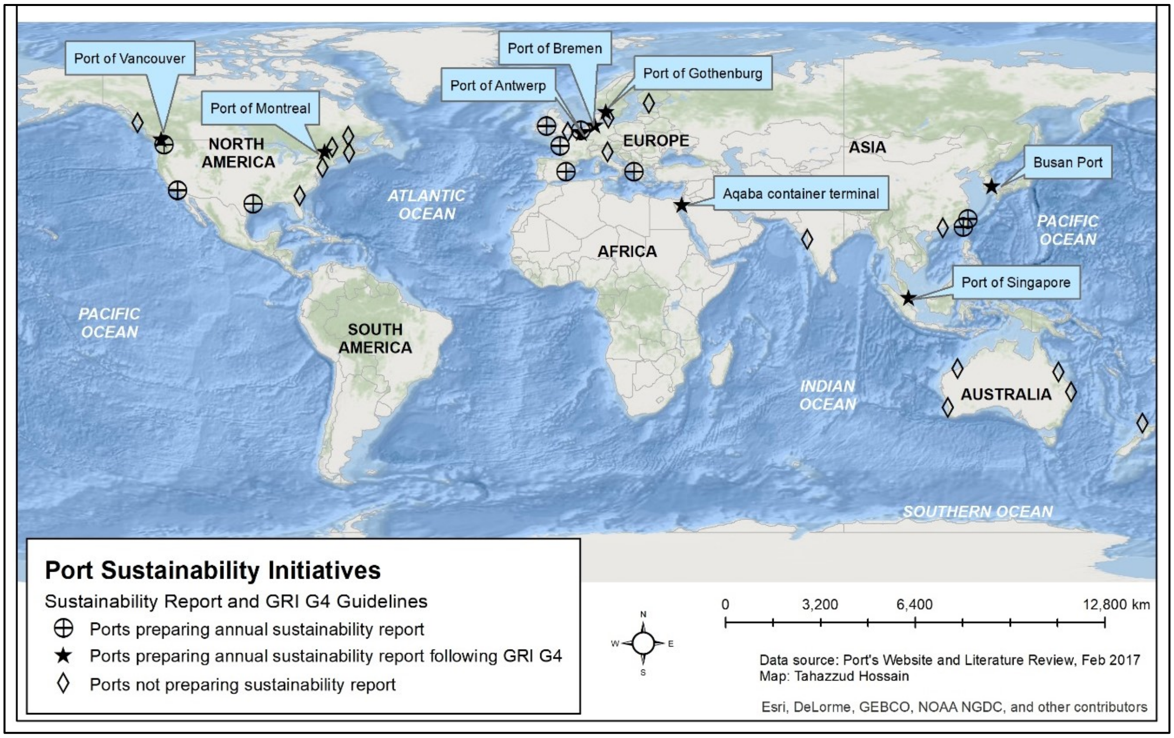

Figure 4.12: Spatial variation of those ports which prepare annual sustainability reports.

Public Disclosure of Sustainability Initiatives

The intention of including this indicator was to highlight the presence of a standalone menu bar on the port website that discloses environmental information or sustainability initiatives; the implication being transparency of disclosure. Online sustainability communication has gained popularity in the port sector (Santos et al., 2016). In this study, 27 ports (75%) have a standalone environment menu bar on corporate websites (Figure 4.13), although ease of navigation varied considerably. EU ports are more advance in the practices of online sustainability communication compared to NA and AP (Figure 4.13); AP ports in particular need to improve on this front. EU ports have emphasized maintaining transparency by disclosing information to the public through systematic environmental reporting and online disclosure of their reports. This is possibly because of EU directives and ESPO's requirements. EU ports monitor and report their environmental best practices and performance to EcoPorts to prepare the annual ESPO/EcoPorts Port Environmental Review report (EcoPorts, 2016b). According to the 2016 ESPO/EcoPorts Port Environmental Review report, 66% of ports have made their environmental report available to the public (EcoPorts, 2016b).

The corporate website is a widely accepted medium through which ports disclose environmental performance, publicizing information effectively to its stakeholders (Wanderley et al., 2008). The content and extent of sustainability information disclosed, and accessibility to the particular content differs from port to port. However, Santos et al. (2016) found that larger ports are more likely to communicate sustainability information online.

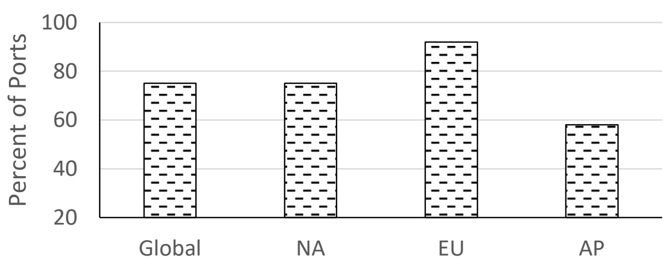

Figure 4.13: Specific menu bar for environmental content on the port website.

Climate Change Adaptation Strategies

Due to the geographic location and nature of the business, ports are at considerable risk of climate change-induced effects (e.g., storm surge, cyclone/hurricane, coastal flood, sea level rise) (Becker et al., 2012; Nursey-Bray et al., 2013; Becker, 2013). Port infrastructures and port-based economies are expected to be disproportionately affected by the climate change impacts; the nature and intensity of the effects depend on the adaptive capacities of the ports (Becker et al., 2012; Becker, 2013). Realizing the potential effects of climate change, many ports and organizations serving ports (e.g., IMO, AAPA, ESPO) have adopted strategies to not only mitigate climate change but to also seek to adapt to its effects. Adaptation measures include relocation of marinas and wharves, renovation of vulnerable infrastructures, and consideration of climate-sensitive designs for new buildings and infrastructures. Pielke (2007) argued that proactive adaptation is far more cost-effective than reactive response. Other researchers emphasize adaptation strategies to improve resilience to extreme events (Hallegatte, 2009; Nursey-Bray et al., 2013; Becker, 2013).

This study identified the ports which have addressed climate change effects on port operations and have adopted adaptation strategies. One-quarter of evaluated ports have initiatives focused on climate change adaptation. Among the three regions, EU ports were found to be more proactive, whereas less than 20% of AP ports appeared to consider adaptation as a key port strategy (Figure 4.14). There might have two drivers of EU ports to be proactive to consider climate change adaptation strategies. The first driver can be individual EU ports' willingness to protect their port infrastructures from the extreme events of climate change due to their locations (e.g., POR, POA). The second driver can be ESPO's initiative to include *climate change* as one of the top 10 environmental priorities for 2017 (ESPO, 2017).

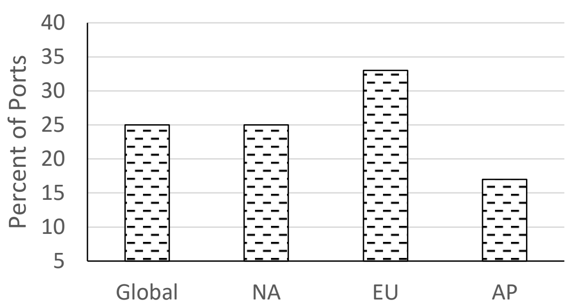

Figure 4.14: Percentage of ports with climate change adaptation strategies.

Community Engagement

During this study, ports' efforts to engage local stakeholders was inventoried. The majority (90%) of ports did put some effort into local stakeholder engagement; regional variations were limited with 92% of NA ports, 92% of EU ports and 83% of AP ports having local stakeholder engagement initiatives (Figure 4.15). Engaging local stakeholders (i.e., members of the host community) in port operations, planning and development is an important aspect of port sustainability initiatives. Port operations have both positive (creating jobs and economic growth) and negative (polluting the environment) consequences on host communities. Therefore, efforts to maintain a strong relationship with the neighbouring community are important to ensure maintenance of existing social license (Adams et al., 2009) and a thriving operation that can deliver environmental and economic benefits to the local community (Hendricks, 2017).

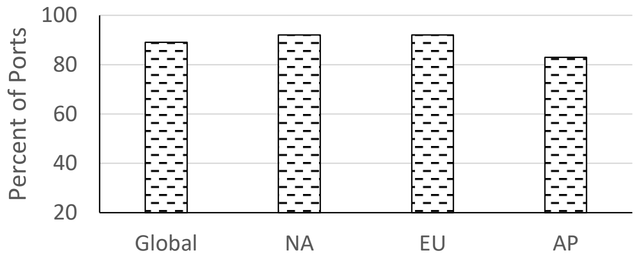

Figure 4.15: Percentage of ports proactively engaging local community.

Figure 4.16 represents all the sustainability initiatives and the percent of global ports adopted the initiatives.

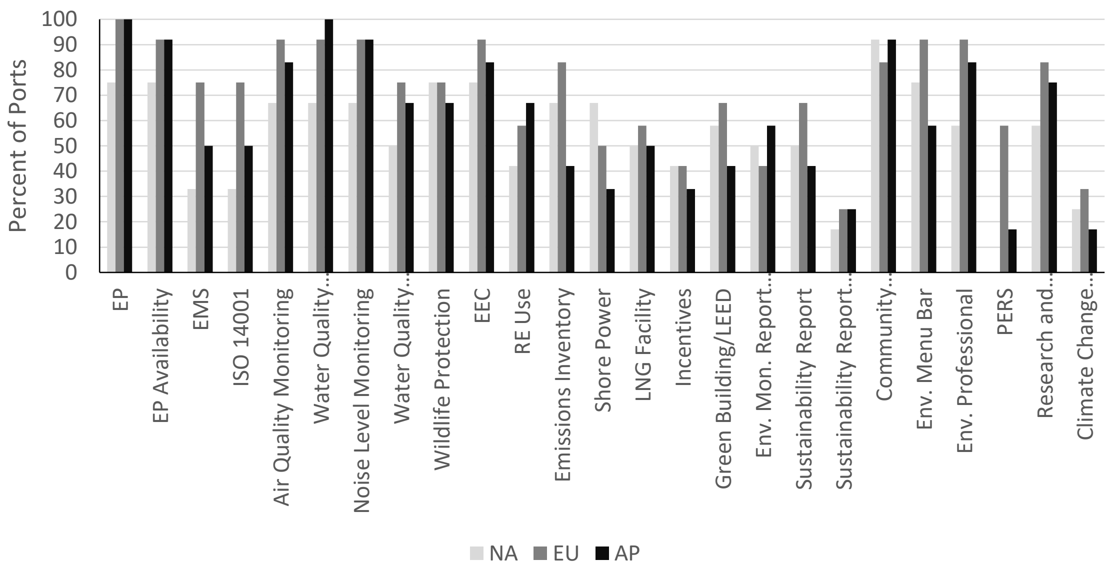

Figure 4.16: A summary of variation of the initiatives adopted by NA, EU and AP ports.

Scale of Port Sustainability in NA, EU, and AP

Result indicates that minimum and maximum number of sustainability initiatives (indicators) adopted by ports are 1 and 23 respectively where mean and standard deviation were found 15.58 and 6.03 accordingly. The value of Cronbach's Alpha for the 25 indicators was found 0.899 (Cronbach's alpha $\geq$ 0.9 means excellent) which means that the indicators are strongly internally consistent to measure port sustainability. The result shows that maximum 23 initiatives out of 25 were adopted by Port of Los Angeles (POLA) (NA port) and Port of Gothenburg (POG) (EU port) (Table 4.7). Results indicate that maximum 22 initiatives out of 25 were adopted by Port of Montreal (POM), Port of Long Beach (POLB), POR, POA, and Port of Bremen (POB) where three ports are in EU and two ports are in NA. Results also indicate that maximum 17 initiatives were adopted by seven ports where one of them is North American, two of them are European, and four of them are Asia-Pacific ports.

Table 4.7: Results of the sustainability initiatives adopted by ports.

Sum of Initiatives (Indicators)	Number of Ports Adopted the Initiatives	Number of Ports (Regionally)		
		NA	EU	AP
1	1	1		
2	1	1		
3	1	1		
5	1	1		
8	1			1
10	1			1
11	2			2
12	2	1	1	
13	1		1	
14	1		1	
15	1		1	
16	1			1
17	7	1	2	4
18	2	1		1
19	4	1	2	1
20	1	1		
21	1			1
22	5	2	3	
23	2	1	1	
Total	N= 36	N= 36		

Figure 4.17 shows that three NA ports (which are POM, POLB and POLA) and four EU ports (which are POR, POA, POB, and POG) are at high sustainability scale, but no AP ports fall under the high sustainability scale (Figure 4.17). Five NA, eight EU, and 10 AP ports fall under the moderate sustainability scale. Results show that no EU ports operate at a low sustainability scale (Figure 4.17). Overall, EU ports are ahead in sustainability scale compared to NA and AP ports. Researchers have linked this proactive behaviour to increased rigorous monitoring and measurement of environmental performance influenced by the initiatives and efforts of ESPO and EcoPorts network in the 20 years since 1997 when ESPO initiated the process at a number of proactive EU ports (Puig et al., 2014; Lam and Notteboom, 2014; Puig et al., 2015; Puig et al., 2017).

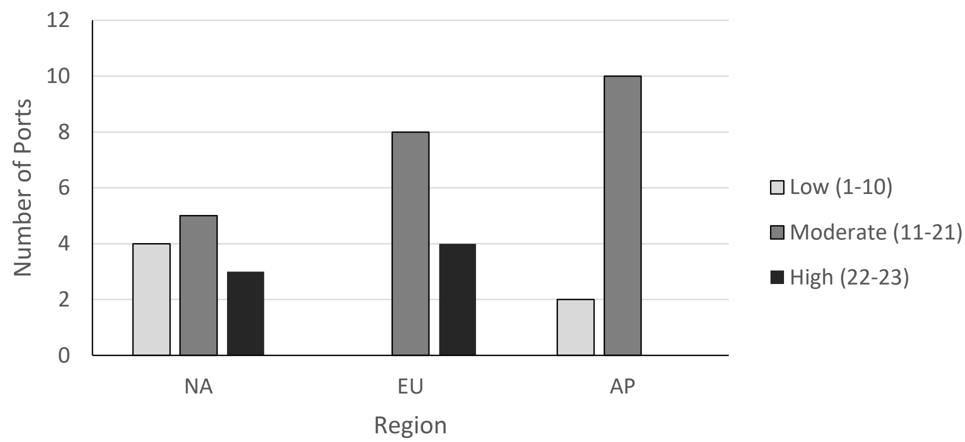

Figure 4.17: Variation of sustainability scale in three regions.

4.5.2 Case Analysis: Ports of Vancouver, Rotterdam, and Kaohsiung

Port of Vancouver (POV)

POV is the largest port in Canada and the third largest port in North America by annual tons of cargo. POV is located on the southwest coast of British Columbia and handled about 150 million tons of cargo involving 170 countries in 2016 (POV, 2017). POV has expressed an objective to be the most sustainable port in the world (POV, 2017) and has adopted a number of the strategic initiatives outlined in this research. One of the laudable initiatives was a two-year consultation process with over 100 different stakeholders representing various groups. The intent was to gain input on how to develop the port's sustainability strategy and growth scenario later designated *Port 2050* (POV, 2017). POV developed metrics for air emissions, water quality, noise levels, habitat and wildlife impacts and report the results publicly every year.

For example, POV monitors the real-time ambient noise levels at eleven stations located around the port. In addition, POV measures underwater noise in cooperation with the Enhancing Cetacean Habitat and Observation (ECHO) program to assess impacts on at-risk whales. Based on these results, POV has taken mitigation measures to reduce underwater noise levels. In addition, to engage clients with their sustainability initiative, POV established the EcoAction program, which offers incentives to ships that have implemented measures (e.g., shore power, LNG, energy efficiency, underwater noise) to reduce emission and environmental effects (POV, 2017).

POV published its first sustainability report in 2011 and claimed to be first in North America to do so (POV, 2017). The reports are structured according to the Global Reporting Initiative G4 guidelines, which, as previously mentioned, is an internationally accepted reporting framework. POV is also a member of the GMEP, an environmental certification program designed to evaluate and support improved environmental performance within the North American marine transportation industry (Walker, 2016). In 2016 GMEP awarded POV a five (out of five) for the Port's environmental performance, denoting excellence and leadership. Of specific note was POV's mitigation efforts on greenhouse gas emissions and air pollutants, community engagement, and environmental leadership (Green Marine, 2017).

Port of Rotterdam (POR)

The POR, located in the Netherlands, is the largest seaport in Europe handling 508 million tons in 2016 (POR, 2017). Similar to POV, POR endeavors to be world's most sustainable port.

POR has been working with Rotterdam city officials to make the region's industrial and energy the largest, most modern and most sustainable energy complex in Europe. Among its many strategic initiatives, energy transition is a key focus as POR intends to reach to net zero emissions by 2050 (POR, 2017). POR encourages emission reductions by offering ships LNG, incentivizes the use of shore power facility, and includes renewable energy in its electricity mix (POR, 2017). It is also the world's largest bio-industry clusters. POR is also pioneering the use of the Environmental Shipping Index (ESI) to provide other incentives (e.g., ESI performance certification) to clean vessels for emission reduction (Lam and Notteboom, 2014). Along with the city of Rotterdam, POR has invested heavily in an *innovation hub* initiative, providing support for those developing technology and strategy innovations that may benefit the port and the city (POR, 2017b).

POR is one of the EU ports that has PERS certification although it has not sought other environmental certifications like ISO 14001 and EMAS. POR addresses its environmental management and sustainability initiatives through Corporate Social Responsibility (CSR) program and follows online sustainability communication method through publishing information and annual reports on its corporate website. POR is at the forefront of the global ports which has adopted strategic initiatives for the mitigation and adaptation to climate change (Lam and Notteboom, 2014).

Port of Kaohsiung (POK)

The POK located on the southwest coast of Taiwan is one of the top 50 world's largest ports, handling about 121 million tons in 2015 (World Shipping Council, 2017b). POK is the first port in Asia to received EcoPort Certification from the ESPO in 2014 (POK, 2017) and has a well-developed (and documented) environmental policy signed by the President. POK's ten specific environmental objectives and the related monitoring data are publicly available on the corporate website; such transparency is intended to strengthen the relationship with the local communities (POK, 2017).

Monitoring data are also used to manage resource consumption such as electricity, fuel, water and other consumables, and to guide environmentally related initiatives such as wildlife habitat restoration. POK has also adopted renewable energy generation (solar) initiatives, improved management of dredged material, and invested in green building infrastructure (POK, 2017). All environmental performance data are presented with POK's annual environmental report, which is posted on their corporate website, and the data are available to the public. It should be noted that even before receiving the EcoPorts certification 2014, researchers have commented on the level of environmental management and performance of POK (Lirn et al., 2012; Chang and Wang, 2012; Lu et al., 2016; Papaefthimiou et al., 2017).

4.5.3 Approaches to Developing Port Sustainability

Thus far, this paper has illustrated the various initiatives adopted by 36 key global ports; such initiatives have had varying degrees of influence on individual port sustainably. In this section, we categorized these initiatives into different approaches that can be used to support sustainable development at the port level and highlight the strengths, weaknesses, and the ideal opportunities for application.

Development of EP and EMS: It is best practice to formally develop and follow a meaningful Environmental Management Plan (EMP) regardless of the specific certification. Establishing an EP is the first step for developing and implementing EMS, but the key to the successful integration of such policies and frameworks is a commitment from upper management to do more than pay lip service to such policies. An EMS is still the best tool for managing environmental impacts as such programs follow a systematic, comprehensive and documented approach to achieving the environmental goals of the organization (Le et al., 2014).

Ensuring "adaptive" management of environmental impacts: Potential impacts must be first identified in order to be managed, such that metrics to be monitored can be developed. Monitoring data must be regularly reviewed as it provides the foundation for any mitigative measure. To determine the utility of mitigative measures, monitoring must be an ongoing process. Finally, the original identification of "potential impacts" should be revisited to ensure port authorities are not overlooking key environmental problems (Puig et al., 2015).

Environmental certification and/or membership: Environmental certifications such as ISO 14001/50001, PERS or EMAS, and membership programs such as Green Marine (North American) and EcoPorts (European) are voluntary. The penchant for participation noted in this study seems to reveal that ports view such involvement as a means for broadcasting their environmental performance and commitment to continuous improvement of environmental management as such programs are not specifically required for a port to maintain a robust, internal EMS initiative.

Reporting and disclosure of environmental performance: Corporate environmental reporting has become an important mode for disclosing port environmental performance to key port stakeholders. Annual sustainability reports or standalone environmental reports, are voluntary and are increasingly found on corporate websites (Santos et al., 2016). Piecyk and Björklund (2015) linked robust (and transparent) environmental reporting with an organization's consciousness, maturity, and willingness to be good corporate citizens, while Dobler et al. (2015) found annual reports to [increasingly] be a reliable source of corporate environmental information for stakeholders. Using corporate websites to disclose environmental information broadcasts such information faster and less expensively than other alternatives such as mailouts of printed materials and hard-copy reports.

Stakeholder engagement: Port stakeholders can include local (host) communities, tenants, shippers, shipping companies, port terminal operators, logistics service providers, government, and the general public. Stakeholder engagement is becoming common practice as individual port authorities and the broader sector as a whole face increasing pressure to improve communication – particularly related to issues of risk-reduction/mitigation, compliance and sustainability (Lam et al., 2013; Puig et al., 2017). Open and ongoing communications enable port authorities to respond to stakeholder concerns and/or pressures from regulators, customers, and competitors (Dinwoodie et al., 2012). Such engagement is also key for building and maintaining the port's 'social license to operate' (Adams et al., 2009; Acciaro et al., 2014; Kim and Chiang, 2014).

Innovation and investment: Strategic investment in innovation is increasingly common as ports seek to "green" their infrastructure and internal operations. Programs such as the Genoa's Port Environmental Energy, Singapore's Green Technology Program, Long Beach's Clean Truck Program, and technology infrastructures such as shore power facilities, renewable energy developments, and alternative fuel facilities are all examples of port investment in sustainability-related innovations. Data from this study revealed a considerable number of ports had specific initiatives linked to this approach. Alternative fuels/LNG facilities, green buildings, renewable energy development, energy efficiency, and low emission transportation technologies are some of the specific examples noted.

Incentive programs: Ports use this approach to encourage ship owners, port users, and tenants to adopt innovative measures that the port itself cannot control. Data show that this approach has typically incentified improved emissions performance of ships while at berth. Lam and Notteboom (2014) noted that this can be an effective approach to reducing pollution, while also engaging port users to consider their own environmental performance - delivering both economic and environmental benefits (Lam and Van Voorde, 2012;

Winnes et al., 2015). POV, for example, offers incentives (as discounted port fees) through their EcoAction Program - to the vessels that connect to shore power and reduce underwater noise or to carriers that bring cleaner ships into the port.

Policy and regulation: While there are numerous international conventions with a focus on sustainability and/or environmental protection, it is ultimately left to the ports to implement policies and regulations to mitigate environmental pollution within the local jurisdiction. Ports can impose penalties on port users, vessels, and tenants for pollutant release or other forms of environmental mismanagement (Acciaro et al., 2014). Lam and Notteboom (2014) agreed that imposing penalties and/or providing incentives can be effective motivation. However, Winnes et al. (2015) suggested more strict policies and regulations on an international level rather than on a local port level are also important.

Climate change policies: Port infrastructure and operations are considered particularly vulnerable to climate change impacts such as increased sea level rise and storm severity (Nursey-Bray et al., 2013; Becker et al., 2015). In response, climate change considerations have been integrated into the sustainability initiatives of many ports. GHG emission mitigation and improving infrastructure resiliency are hallmarks of many *green ports* (Lam and Notteboom, 2014; Acciaro et al., 2014; Acciaro, 2015).

Collaboration: Inter-agency collaboration is another important approach to port sustainability; knowledge exchange and support between ports and their clients, port cities, regional industrial complexes and research institutions will be key to ensuring the application of best practices and integration of innovation. Acciaro (2013) found that both internal collaboration (e.g., communication and participation, employee training, and green ship) and external collaboration have been positively associated with improved sustainability performance. Roh et al. (2016) reported similar findings. For example, seven American ports collaboratively developed the Sustainable Design and Construction Guidelines with the intention of providing guidance during the design and construction of industrial maritime development; however, there are many other examples of collaboration to achieve port sustainability around the world (I2S2, 2013; POV, 2017b).

4.6 Conclusion

With increasing socio-economic and environmental pressures, port authorities are taking various measures to achieve sustainability in port operations. This study has evaluated the initiative of 36 global ports, 12 ports in each of three regions – North America, Europe, and the Asia Pacific. Results indicate that most ports have emphasized the identification, mitigation, and monitoring of impacts, as well as improved energy management, and stakeholder engagement – particularly linked to EP development. Many ports were found to progress on research and development, stakeholder participation, wildlife protection, environmental performance disclosure, and providing support for the better environmental performance of port operations. However, many ports are still lagging behind in taking initiatives to achieve sustainability. Results indicate that EU ports have made greater progress in various aspects of adopting sustainability initiatives as compared to the NA and AP ports. European Union directives, collaboration among port stakeholders, and individual port's willingness under the framework and guidance of ESPO might have an influence on the performance of environmental management achieved by EU ports. GMEP launched by Green Marine in NA has been assisting maritime industries in greening port operations. Similar to EcoPorts and Green Marine, organizational guidance and framework might benefit AP ports to improve the environmental performance of port operations where the majority of large ports exist.

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CHAPTER 5: CURRENT STATE OF SUSTAINABILITY INITIATIVES IN CANADIAN PORTS

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5.1 Statement of Student Contribution

Tahazzud Hossain produced the original manuscript. Data collection, analysis, and report writing were performed by Tahazzud Hossain. Michelle Adams and Tony Walker guided this research and reviewed this Chapter and manuscript to finalize for journal publication.

5.2 Abstract

Canadian ports as economic engines contribute to the growth of the Canadian economy and social development. Like most industrial sectors, society increasingly expects Canadian ports to balance financial returns with socio-economic demands and environmental challenges. In response, some Canadian ports have taken strategic initiatives to better integrate sustainability into their operations. Through participation in the North American based Green Marine program, these ports have found an opportunity to measure and progress in the environmental performance. This research sought to evaluate 18 Canadian major ports' efforts to be sustainable and environmental performance. Twenty-five pre-defined indicators were used to identify operational trends linked to port sustainability. Annual performance reports (eight years) published by Green Marine were analyzed to assess progress and trends in environmental performance. Results indicate that most Canadian ports participated in the Green Marine program, but only a portion (seven of 18 ports) were proactively integrating sustainability into their operations. Sustainability initiatives included environmental policy development, environmental monitoring, proactive energy management, stakeholder engagement, incentivizing sustainability for port users, enhanced environmental reporting, and on-going research and development. The balance lag behind and need to advance in environmental performance if Canadian

ports are to compete with neighboring US ports as environmental performance plays an increasing role in selection considerations.

Keywords: Port Sustainability; Sustainability Initiatives; Sustainability Scale; Environmental Performance: Green Marine.

5.3 Introduction

Like other ports around the world, Canadian ports contribute to establishing Canada's commercial marine shipping, interlinking the economy, culture, environment, and security of the country (CCA, 2017). Canada has a resource-based economy and is highly export-dependent. The marine shipping industry plays a pivotal role in shaping the Canadian economy and contributes $3 billion CAD to the gross domestic product (GDP) of the country (CCA, 2017). The Canadian commercial marine shipping industry depends heavily on port facilities. Major Canadian ports as hubs of the marine transport industry are considered economic engines and gateways to trade. About 20% (by dollar value) of Canadian exports and imports are transported by marine shipping (CCA, 2017). Canadian ports handle approximately $400 billion CAD worth of goods annually, which is a quarter of all Canadian trade (ACPA, 2017).

Although ports contribute significantly to the economy, they also pose adverse effects on the environment (Gupta et al., 2005; Comtois and Slack, 2007; Dinwoodie et al., 2012; Mustonen, 2013; Walker et al., 2018). Environmental effects can be caused by internal port activities, berthing ships, and by emissions from intermodal transports serving the port hinterland (OECD, 2011; Lam and Notteboom, 2014). Environmental effects include localized ambient air pollution, water pollution, noise and light pollution, traffic congestion, introduction of invasive species, effects on marine ecosystems and impacts of marine accidents and spills (CCA, 2017; Walker et al., 2018). Comtois and Slack (2007) found that among 800 North American, European and Asian ports, port authorities mentioned air quality, water quality, waste disposal, noise, and habitat conservation as the top five environmental issues. Puig et al. (2015) had similar findings, which also included discharges to water/sediment, emissions to soil, and resource consumption. Numerous studies have been undertaken to identify key environmental issues; air quality was noted as a key environmental issue in studies by Lam and Notteboom (2014), Winnes et al. (2015) and EcoPorts (2016). Water pollution has regularly been identified as another major issue related to port operations (Kröger et al., 2006; Grifoll et al., 2011) as contaminants from ballast water, cargo residue, fuel oil residue, waste disposal and petroleum spills are routinely discharged (Ng and Song, 2010; OECD, 2011; Lam and Notteboom, 2014).

Noise issues have been reported as an ongoing concern (Khoo and Nguyen, 2011; Mustonen, 2013; Schenone et al., 2014; Witte, 2016), while management of port and ship wastes to ensure operations comply with national (depending on area of port operations) and international regulations (e.g., IMO 73/78 Annexes I-V) is a continuing challenge (Trozzi and Vaccaro, 2000; OECD, 2011).

The Association of Canadian Port Authorities (ACPA) was founded in 1958 to advocate and advance the Canadian port industry (ACPA, 2017). The ACPA represents all ports in Canada, various government agencies and marine sector companies. The ACPA also assists Canadian Port Authorities (CPAs) to improve environmental performance in port operations. The ACPA signed a Memorandum of Understanding (MOU) with Green Marine Management Corporation (known as Green Marine) in 2014 to assist CPAs in advancing environmental sustainability (ACPA, 2014). Green Marine (GM) is a North American based voluntary environmental certification program for the marine industry. Since its inauguration in 2007 GM has been serving ports, terminals, ship-owners, shipyards and seaway corporations in reducing environmental footprint (Green Marine, 2017; Walker, 2016). GM participants demonstrate annual improvements in environmental performance measured based on several key performance indicators (KPIs) under the Green Marine Environmental Program (GMEP) (Green Marine, 2017). The number of KPIs to measure performance varies slightly each year and is determined by GM. For example, GMEP used 11 KPIs in 2016 (Green Marine, 2016) and 12 KPIs in 2017 (Green Marine, 2017) to measure GM participants' environmental performance. GM participants receive performance certificate by benchmarking their environmental performance by completing a detailed annual evaluation. Based on the self-evaluation report, GMEP determines participant's ranking for each KPI on a 1 to 5 scale. Level 1 represents ‘*monitoring of regulations*’ (baseline), and Level 5 represents ‘*excellence and leadership*’ (Green Marine, 2016). Eighteen Canadian major ports are members of GM as of time of writing. Some of the Canadian ports showed high performance in GMEP, and they have been working proactively to improved port sustainability through a variety of sustainability initiatives, while some other ports showed low environmental performance (Walker, 2016). Research gaps exist to assess efforts that Canadian ports implement to be sustainable. There is also research gaps to measure progress that Canadian ports made by reporting their environmental performance to GM under the GMEP. This study has assessed the current state of Canadian ports’ efforts to be sustainable by analyzing their initiatives and GMEP’s environmental performance scores.

5.3.1 Legislations and Regulations Governing Canadian Ports

Most Canadian ports have their own environmental policies and procedures to address environmental effects of port operations. Canadian ports must comply with any applicable environmental legislation and regulations at both the provincial and federal government levels. Navigation and shipping were taken under federal jurisdiction during formulating British North America Act (now the Constitution Act, 1867). Since 1998, all Canadian major ports listed under the Canada Marine Act (CMA) have had the legal designation of CPAs. CPAs consists of 18 port authorities known as the National Ports System; the CMA provides an overall governance structure to manage CPAs with important local governance and control of the province.

Mainly three federal agencies (Transport Canada, Environment Canada and Fisheries and Oceans Canada) have their own mandate for the protection of the marine environment in Canada. Transport Canada is responsible for Canada’s transportation system including the safety, security and the environmental performance of the Canadian ports. Transport Canada has the relevant regulations such as Canada Marine Act, Canada Shipping Act, Transport of Dangerous Goods Act and Navigable Waters Protection Act to regulate port operations. Transport Canada is the chief agency responsible for the national Oil Spill Preparedness and Response Regime which is an active partnership program between industry and government that provides an explicit structure for responding to an incident of marine oil and fuel spills. Environment Canada has made broader mandate through formulating legislation (e.g., CEPA, Canada Water Act) to protect and improve the quality of the natural environment with the focus on air, water, and soil quality (Transport Canada, 2012). The goal of the Canadian Environmental Protection Act (CEPA) is to prevent pollution. CEPA is the main federal environmental legislation which focuses on regulating toxic substances. The Department of Fisheries and Oceans Canada (DFO) is responsible for managing oceans and freshwater resources in Canadian jurisdiction. DFO is additionally responsible for the management of fisheries, habitat, and aquaculture and conducting related research. Though federal legislation applies to port operations, ports are required to follow the relevant environmental rules and regulations of the province in which jurisdiction they are located. Some Canadian ports are improving in environmental performance going beyond regulatory compliances by adopting strategic initiatives. This practice of improving environmental performance and achieving sustainability in port operations might bring socio-economic benefits, improved corporate image, and competitive advantages to the ports (Rao and Holt, 2005; Adams et al., 2009). Table 5.1 shows the federal regulatory agencies and legislation associated with Canadian port operations.

Table 5.1: Federal regulatory agencies and legislation for Canadian ports.

Regulatory Agency	Legislation
Environment Canada	Canadian Environmental Protection Act (CEPA), 1999
	Canada Water Act, 1985
Transport Canada	Canada Marine Act, 1998
	Canada Shipping Act, 2001
	Transportation of Dangerous Goods Act, 1992
	Navigation Protection Act, 1985
DFO	Fisheries Act, 1985
	Oceans Act, 1996
	Canada National Marine Conservation Areas Act, 2002
	Coastal Fisheries Protection Act, 1985
Canadian Environmental Assessment Agency	Canadian Environmental Assessment Act (CEAA), 2012
Species at Risk Public Registry	Species at Risk Act (SARA), 2002
	Canada Wildlife Act, 1985
Parks Canada	Migratory Birds Convention Act, 1994

5.4 Methodology

To assess Canadian ports' sustainability initiatives, 18 Canadian major ports (known as CPAs) were selected as sample ports. Criteria for selecting these particular ports included: designated as National Ports System and CPAs under the CMA, Canadian large ports, and data availability. Data were collected from three sources including: a) inventories of sustainability initiatives adopted by Canadian ports reported on port websites; b) environmental performance results reported by GM for Canadian ports from 2009 to 2016 under the GMEP; and c) a review of national legislation governing Canadian ports. Twenty-five sustainability initiatives were identified by reviewing Canadian port corporate websites that pledged to be green or sustainable. These initiatives were considered indicators to assess ports' efforts to be sustainable. For example, one initiative was the development of an environmental policy (EP) which usually consists of a written statement supported by senior management (e.g., President or CEO). Ports make EP publicly available on their corporate website to communicate to stakeholders. In this study, a port EP was considered as one indicator (Appendix B). A structured survey question was developed for each indicator; questions were answered ('Yes' or 'No') using data generated by reviewing port websites, corporate reports, and related literature. Survey responses were entered into SPSS (Statistical Package for Social Sciences). Value '1' was entered if the answer was 'Yes' meaning the port had adopted that particular initiative and value '0' was entered if the answer was 'No' meaning the port had not adopted that particular initiative as of yet. The dataset was used to complete a descriptive analysis of all indicators for ports.

To compare the extent of sustainability initiatives adopted by ports, a sustainability scale (adoption of 0-2 initiatives= low sustainability; adoption of 3-14 initiatives= moderate sustainability; adoption of 15-24 initiatives= high sustainability) was developed by summing all 25 indicators. This sustainability scale was developed based on one standard deviation (SD) above the high sustainability mean (15-24 initiatives), and one SD below the low sustainability mean (0-2 initiatives), in between moderate sustainability (3-14 initiatives (Table 5.2). Reliability of selected indicators to measure sustainability was tested using Cronbach's alpha. Cronbach's alpha is widely used to assess the consistency of selected variables to measure a scale (Lun, 2014). Alpha values range from 0 to 1. Alpha value between 0.6 - 0.7 is deemed the lower limit of acceptability (Lun, 2014). Cronbach's alpha was tested for 25 indicators using SPSS to determine the internal consistency of indicators to measure sustainability scale. SPSS and Microsoft Excel were used to do the descriptive statistical analysis. GIS software "ArcGIS 10.2" was used to present results spatially.

Environmental performance scores were collected from publicly available annual GMEP performance reports on the GM website. The GMEP performance reports include GM participants' annual performance scores for each indicator. The performance of ports and seaways are evaluated based on six KPIs such as environmental leadership, greenhouse gases (GHG) and air pollutants, dry bulk handling and storage, spill prevention, waste management, and community impacts (Green Marine, 2016). Waste management was added as an indicator for ports and seaway for the first time in 2016. In this study, five KPIs (environmental leadership, GHG and air pollutants, spill prevention, waste management and community impacts) were chosen as these KPIs are used by GM to measure ports' performance. The indicator 'dry bulk handling and storage' are not applicable for all ports and therefore, this indicator was not taken to analyze ports' performance in this study. Performance data for five KPIs listed for the GMEP were extracted from the published performance reports (2009 - 2016) for Canadian ports. GM started reporting performance results from 2008, but the 2008 report was unavailable, so was not included for analysis in this study. Performance scores (level 1 to level 5) for 17 Canadian major ports were extracted from the published performance reports as Port of Belledune was not GM participant as of time of data collection. The scores were entered into Microsoft Excel to analyze the progress of Canadian ports' environmental performance over time. Location of ports and their relative size by cargo volume handled in 2015 are shown in Figure 5.1.

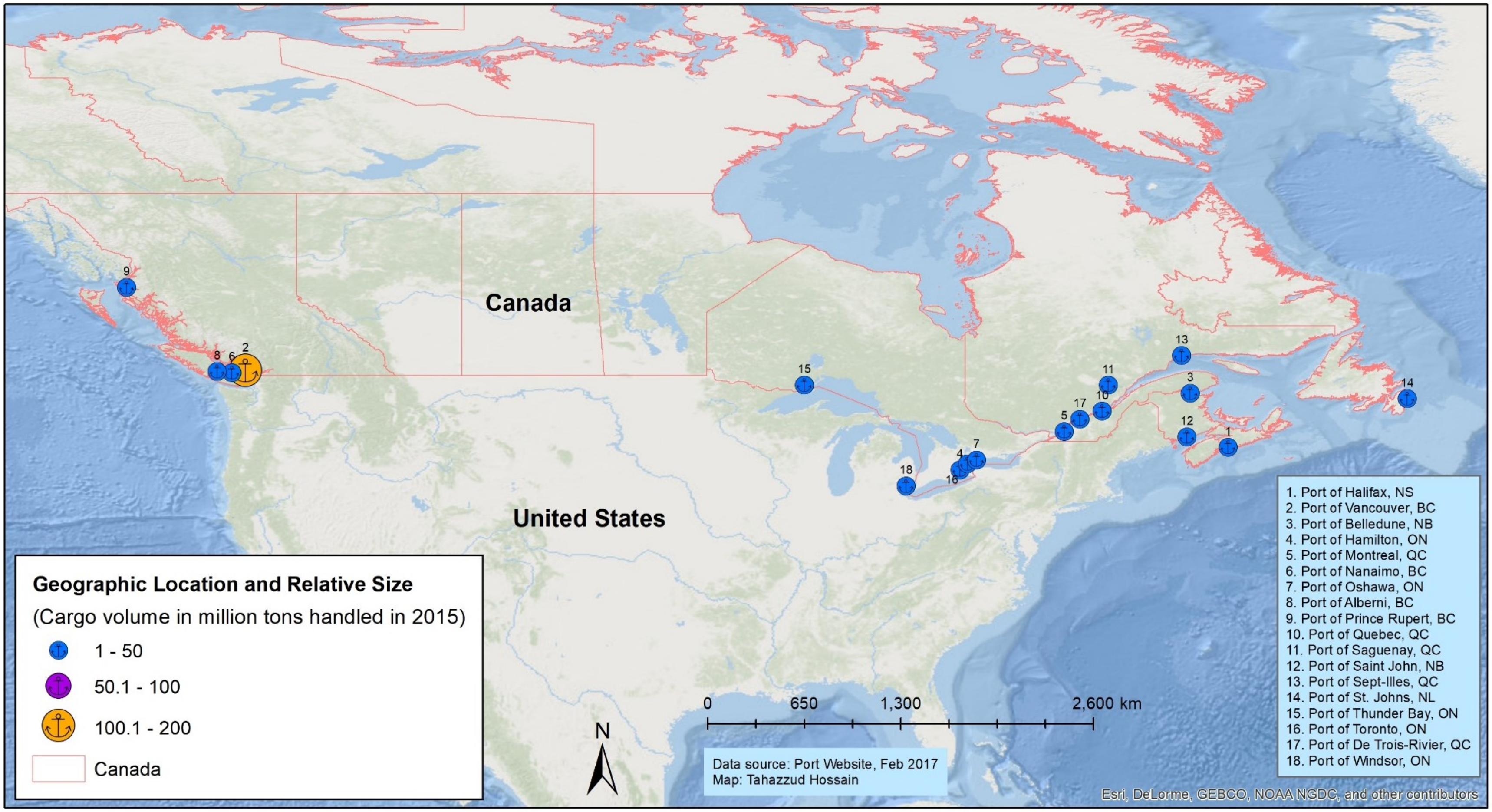


Figure 5.1: Geographic location and relative size of Canadian ports.

5.5 Results and Discussion

5.5.1 Initiatives Adopted by Canadian Ports

Results indicate that less than half of Canadian ports (44%) have reportedly established EP (Figure 5.2). A clear EP statement signifies an organization's intentions and direction to achieving environmental performance and sustainability (Darbra et al., 2005; Darbra et al., 2009; Roh et al., 2016). Navickas and Kontautiene (2011) stated that an effective EP assists business to operate efficiently, improves operational productivity and resource efficiency, and helps reduce costs. As noted, establishing an EP is considered the first step to establishing an Environmental Management System (EMS). In some cases, such as ISO14001 certification, developing a written and "senior management signed" EP statement is a requirement for obtaining EMS certification (Asgari et al., 2015).

An EMS is a tool to manage environmental impacts following a systematic, comprehensive and documented approach to improving the environmental performance of the organization (Le et al., 2014). Ports with ISO14001 certification use it to continuously improve the environmental performance of the port operations. Although only two ports have publically reported having ISO 14001 certification, all Canadian major ports have obtained GM certification and have submitted a performance report to GM except Port of Belledune which participated on May 1, 2017 (Green Marine, 2016). Nine of those 18 Canadian ports reported membership (GM certification) on corporate websites; the balance did not report any association with GM, as also noted by Hendricks (2017). Hendricks (2017) concluded that this disparity of communicating GM membership might be a topic for further research. During previous research involving GMEP Walker (2016) concluded that the measurement of environmental performance of GM participants under the GMEP framework affirmed GM's effectiveness in enhancing sustainability in marine transportation.

Port Environmental Review System (PERS) certification is the only port-sector specific standard for environmental management developed by ports with the initiative of European Sea Ports Organization (ESPO) and accessible online by any ports at ecoports website (Ecoports, 2017b). Globally 46 ports have obtained PERS certification until now (Eco SLC, 2018), but no Canadian ports done so as of time of writing. PERS is not region specific. Any port around the world can obtain PERS certification by following the EcoPorts procedure. Outside of the EU, seven Taiwanese and four Mexican ports have obtained PERS certification as of time of writing (Eco SLC, 2018). It is suggested that Canadian ports might benefit from engaging more directly with ESPO and PERS certification.

Half of the Canadian ports reported support for neighboring communities and adopting various community-based initiatives (e.g., consultation, complaint resolution, reduction of noise and dust and by maintaining good relationships). Many ports attempt to maintain strong relationships with neighboring communities in order to achieve an improved social license to operate (Adams et al., 2009), as well as to thrive and deliver environmental and economic benefits to the local community (Hendricks, 2017). Another factor that might have influenced improved stakeholder engagement within Canadian ports is the addition of community impacts as one of the KPIs of GMEP.

When communicating port environmental performance to the public, results represent that one-third of the ports (33%) have an environment related menu bar on their corporate websites to communicate environmental performance information (Figure 5.2). Although disclosing such information to the public is voluntary, sustainability communication on the web has gained popularity in the port sector (Santos et al., 2016). The corporate website is widely accepted strategy used by ports to disclose the environmental performance of operations; it allows ports to publicize information faster and less expensively to its stakeholders (Wanderley et al., 2008). The content and extent of sustainability information disclosure and accessibility to the content (e.g., social and environmental disclosures) differ from port to port. Dobler et al. (2015) found annual environmental reports a reliable means for communicating corporate environmental information to stakeholders. Some ports have used Global Reporting Initiative (GRI) guidelines to frame their environmental reporting. The voluntary GRI sustainability reporting guidelines provide standards for environmental performance disclosure which increases credibility, comparability, and transparency in sustainability reporting (Alazzani and Wan-Hussin, 2013). A study found that larger ports are likely to communicate sustainability information online (Santos et al., 2016). Results show that 17% of Canadian ports published an annual sustainability report on their corporate website (Figure 5.2). However, only two of the reports actually followed the GRI guidelines for preparing sustainability reports (Figure 5.6).

Environmental effects monitoring was found to be a practice among some of the Canadian ports such as Port of Vancouver, Montreal, and Toronto, representing 28%. These ports are in densely populated cities which might be a reason to emphasize on environmental effects monitoring. Ports were found to be monitoring ambient air quality, water quality, noise level and wildlife habitat in port areas (Figure 5.2); however, only 22% published the related reports on their website. Similarly, 28% ports reported conducting emission inventories for their operations (Figure 5.2).

Port-related energy management strategies typically did not include renewable energy (RE) generation. However, a few ports such as Port of Vancouver (POV) and Port of Toronto (POT) sourced renewable electricity as part of their energy mix. Energy efficiency and conservation (EEC) measure were more typical, with 28% of ports adopting EEC measures (Figure 5.2). Both Acciaro et al. (2014) and Lam and Notteboom (2014) noted the benefits of enhanced energy strategies: Acclaro et al. (2014) specifically argued that energy management in ports can offer significant efficiency gains, generate alternative revenue sources, and help improve port competitiveness.

Shore power and alternative fuel such as Liquefied Natural Gas (LNG) facilities have recently gained popularity among global ports because of stringent international regulations to reduce air emissions from ships. Some ports among the CPAs such as Port of Halifax (POH), POV, Port of Montreal (POM) and Port of Prince Rupert (POP) have already started providing shore power and LNG fueling facilities to the ships calling at the port. Among all the ports, 22% and 11% have shore power and alternative fuel facilities, respectively (Figure 5.2). As previously noted, some of those ports such as POV and POP provide specific incentives to the ship owners to make sure of such services, through reducing port fees and/or providing certificates of environmental performance (Figure 5.2). As a further climate change related strategy, three ports (POH, POM and POV) were found to be actively taking measures to mitigate climate change effects (e.g., storm surge, hurricane, sea-level rise, coastal erosion). However, 22% ports had integrated (or were starting to integrate) building green or sustainable port infrastructures. As port infrastructures and port-based economies will be disproportionately affected by the climate change effects, the nature and proportion of the effects will depend on the adaptive capacities of the ports and the communities in which the ports operate (Becker et al., 2012; Becker, 2013).

Due to geographic proximity, Canadian ports compete with US ports (Ircha, 2008) and, therefore, are seeking ways to remain competitive through research and development (R&D). Four ports (22%) found to be adopting specific R&D strategies to continually improve in environmental performance (Figure 5.2); the POV was particularly notable in their efforts.

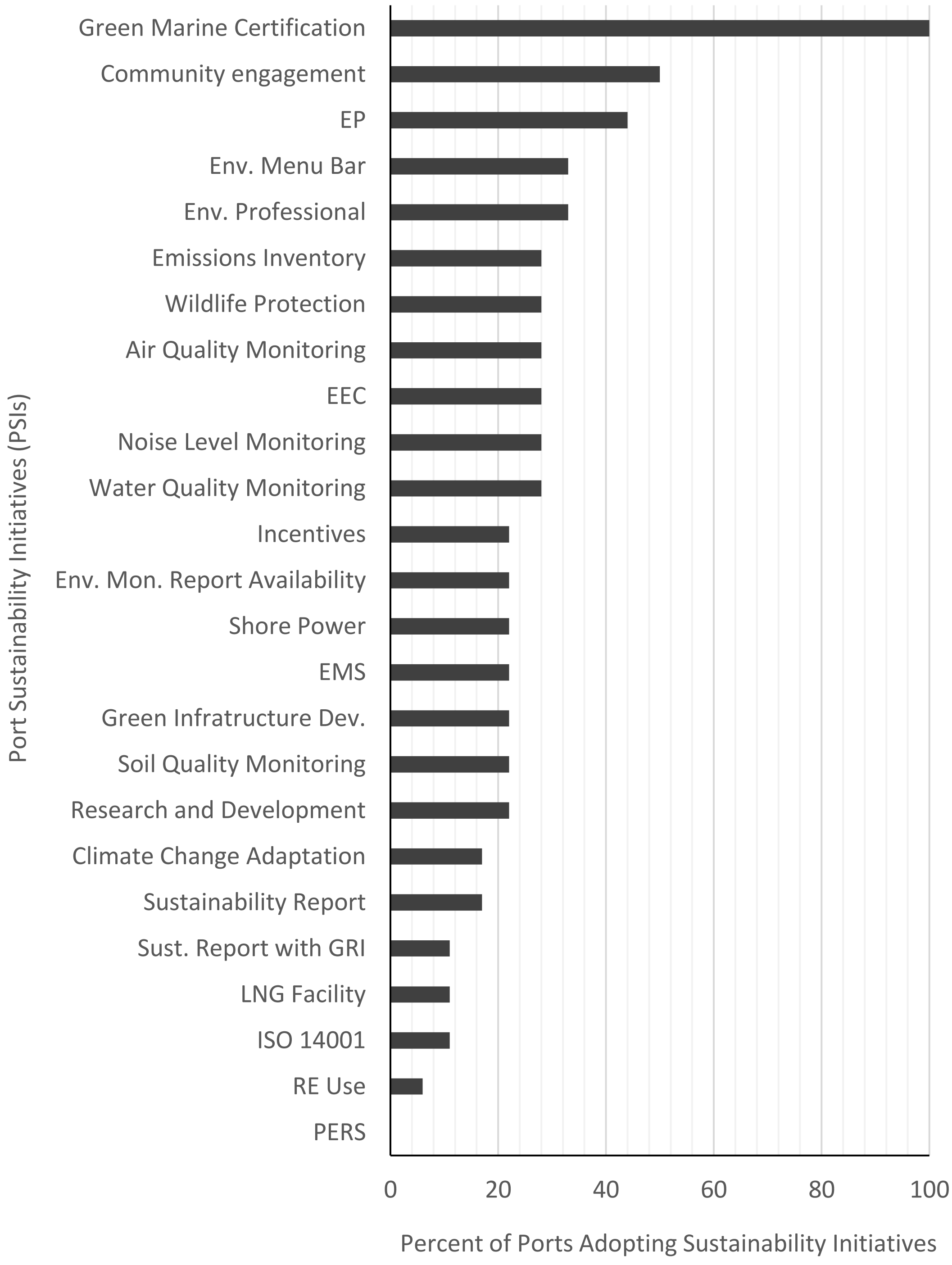


Figure 5.2: Variation of sustainability initiatives among Canadian ports.

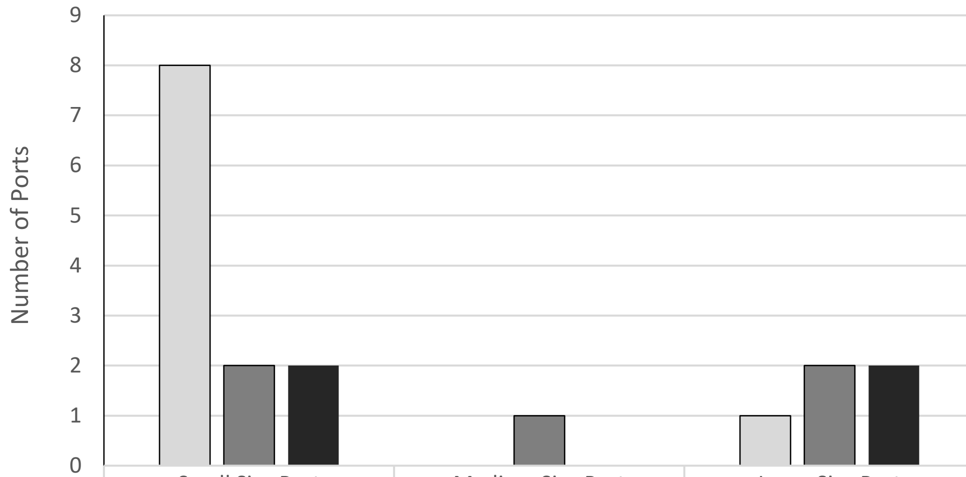
Sustainability Scale

Results indicate minimum and maximum number of sustainability initiatives (indicators) adopted by ports were 1 and 23, respectively, with highly variable mean values (6.83±7.906) (Table 5.2). The Cronbach's Alpha was 0.967 (Cronbach's alpha ≥ 0.9 means excellent) which means that the indicators are strongly internally consistent to measure port sustainability. Results show that maximum 23 initiatives out of 25 were adopted by POM, maximum 22 initiatives were adopted by POV and maximum 17 initiatives were adopted by Port of Hamilton (POHM) and POT. Six ports among CPAs adopted only one initiative (Table 5.2).

Table 5.2: Descriptive statistics of sustainability initiatives.

Sum of Sustainability Initiatives (Indicators)	Number of Canadian Ports Adopted the Initiatives
1	6
2	3
3	2
4	1
8	1
14	1
17	2
22	1
23	1
Total	18

Result shows that four ports scored high in sustainability (Figure 5.3). Five scored medium, and nine scored low in sustainability (Figure 5.3). The sustainability scale was cross-tabulated with the port size to see association for ports. Result indicates that not only large ports achieved high sustainability scores (e.g., POV), but also small ports achieved high sustainability scores (e.g., POHM and POT). In contrast, results show that large ports can have low environmental performance or low sustainability not aiming to be sustainable ports and/or not taking strategic initiatives.



	Small Size Port	Medium Size Port	Large Size Port
Low (0 - 2)	8	0	1
Moderate (3 - 14)	2	1	2
High (15 - 24)	2	0	2

Figure 5.3: Variation of sustainability scales in Canadian ports.

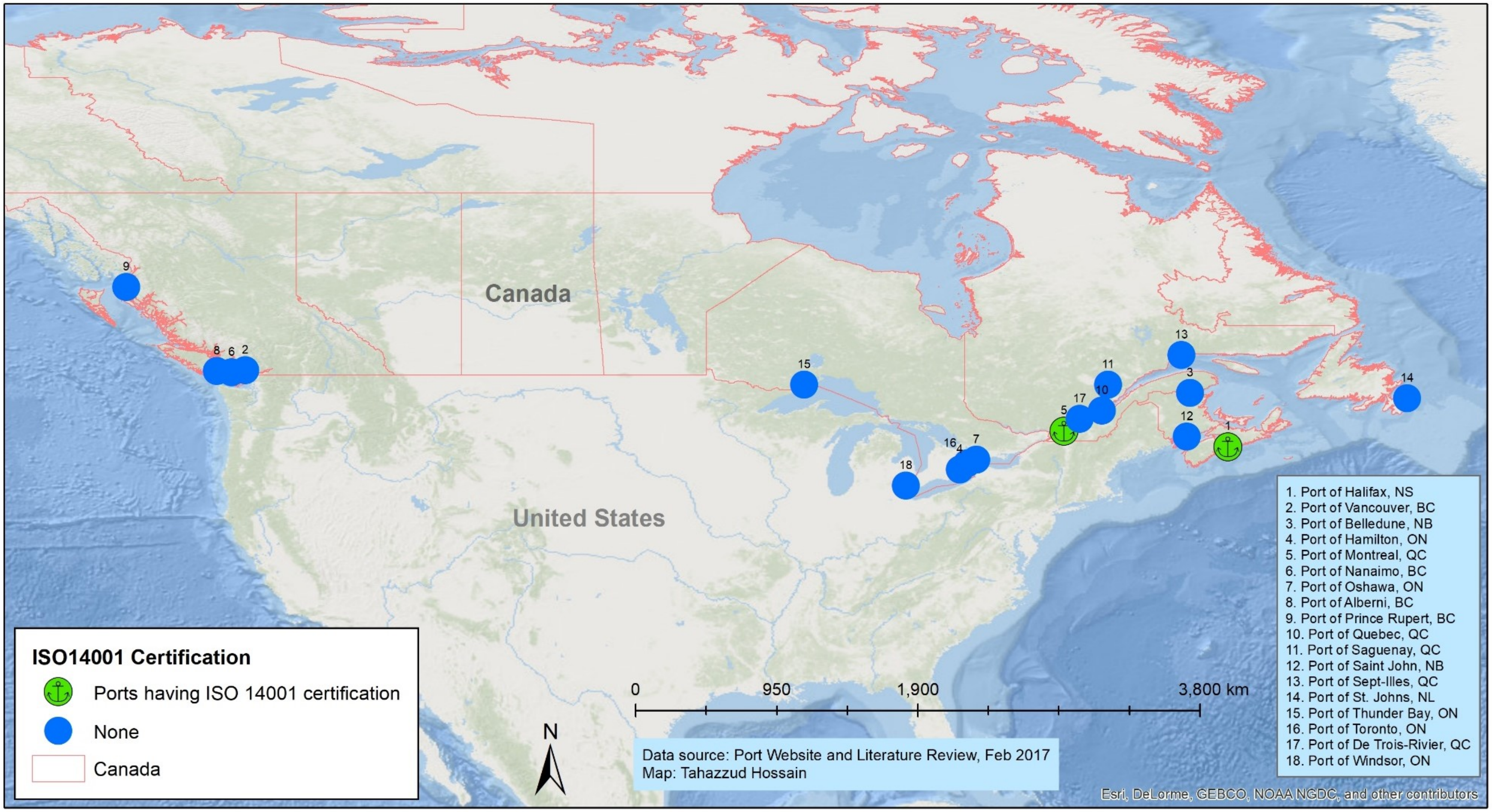


Figure 5.4: Spatial variation of ISO 14001 certification across Canadian ports.

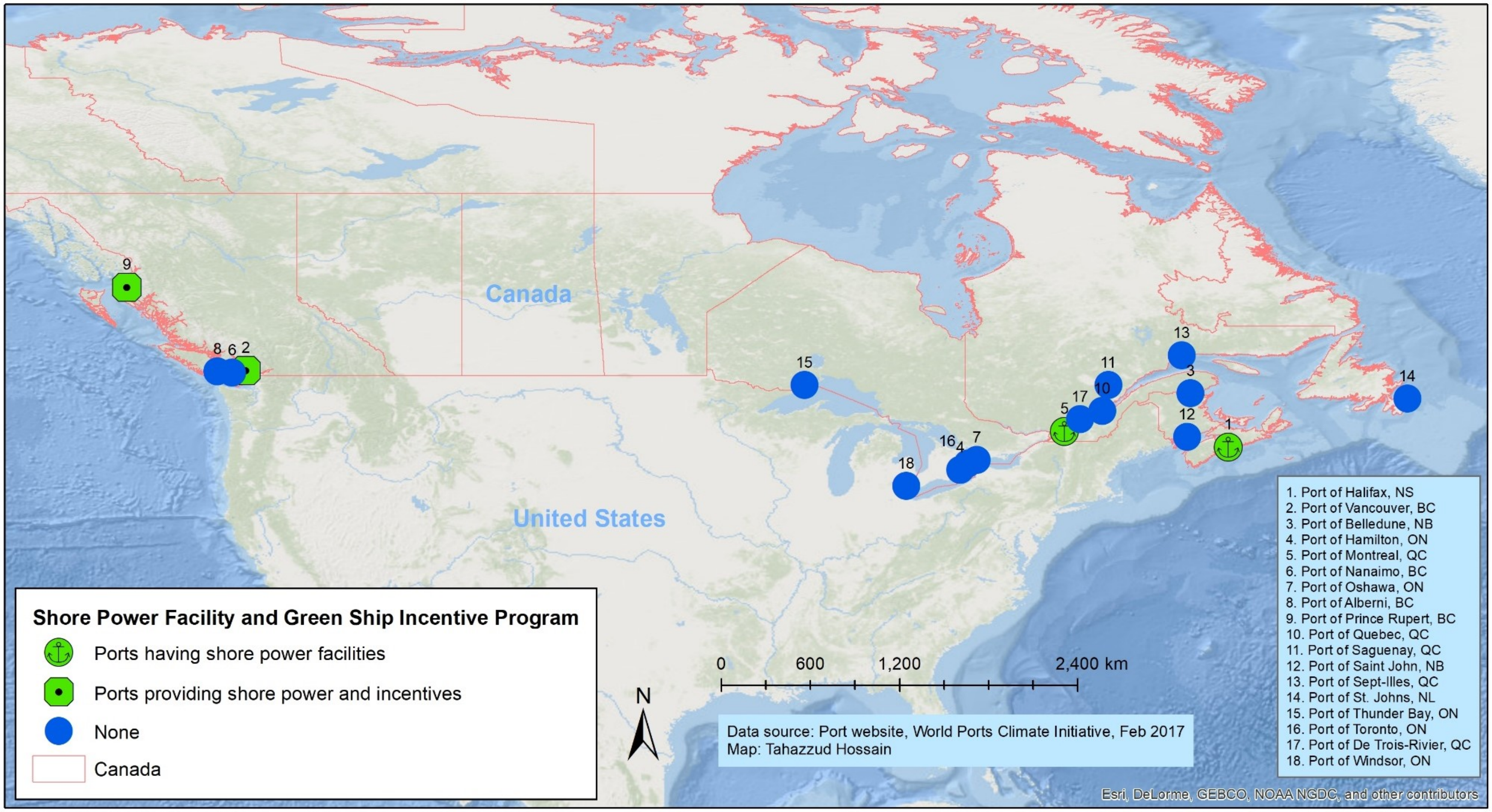


Figure 5.5: Spatial variation of shore power facility and incentive program across Canadian ports.

78

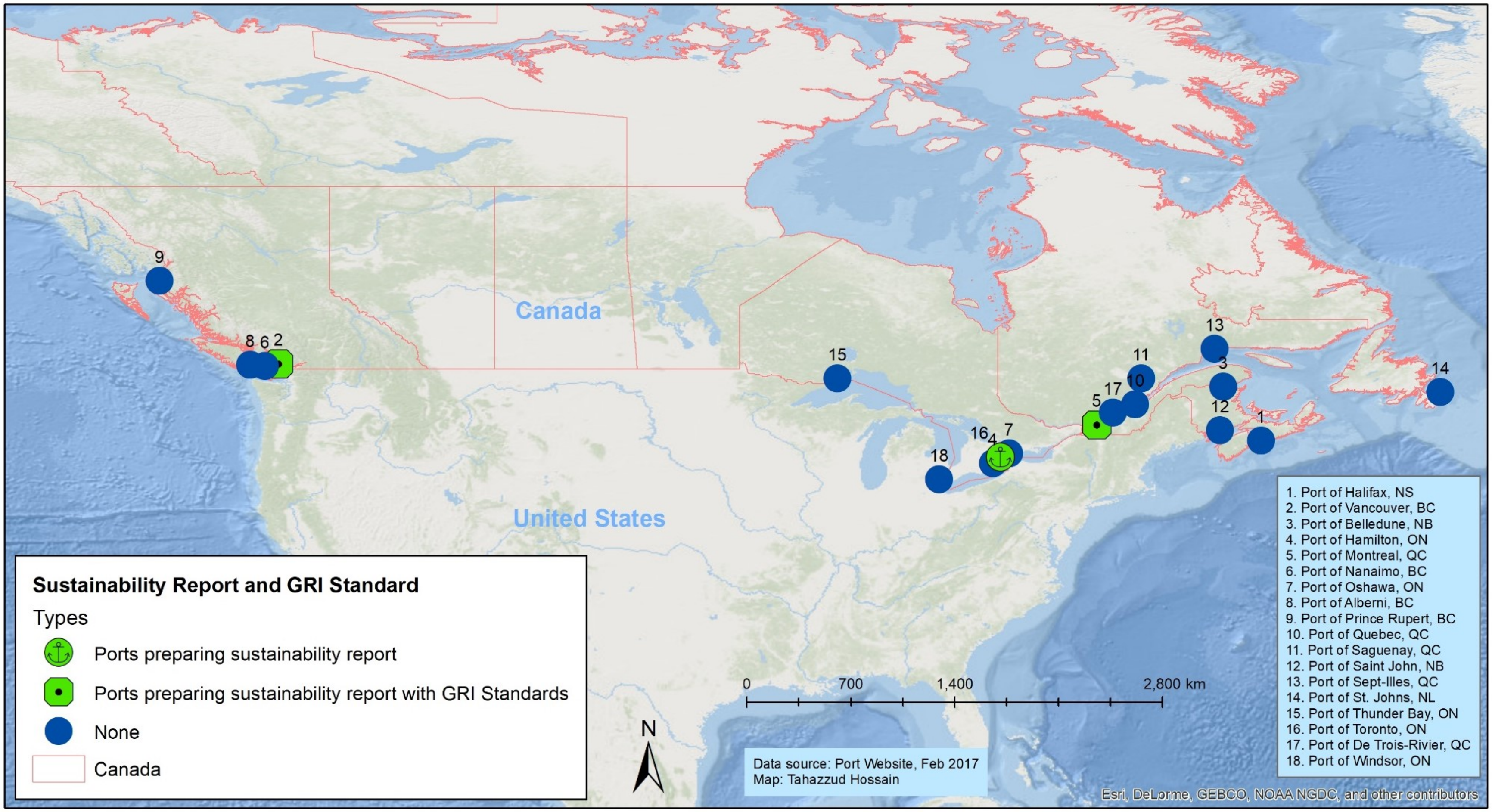


Figure 5.6: Spatial variation of sustainability reporting across Canadian ports.

5.5.2 Review of Performance Results Published under GMEP

Performance results from 2009 to 2016 for 17 Canadian ports show that seven (POH, POM, POV, POQ, POP, POSI and POTR) achieved average KPI scores ≥3 (Table 5.3). POH ranked highest (mean 4.7), POM and POV ranked second (4.5), and POQ and POP ranked third (3.5). Analysis of sustainability initiatives adopted by ports illustrated in section 5.5.1 (see Figure 5.3) identified seven ports which achieved sustainability at a scale medium to high which correlates with performance results of top seven ports (achieved average KPI score ≥3) reported by GM under the GMEP (shown in Table 5.3 and Figure 5.7). Remaining ports achieved average KPI scores of 1 to <3. Walker (2016) suggested that some ports were early adopters of GMEP which might explain their low KPI scores. However, other ports such as POH, POM, and POV reported good KPI scores during their first year of participation. Presumably, they had already made some progress in environmental performance before participating in GM.

Figures 5.8 to 5.12 present temporal trends of the performance of Canadian ports for five KPIs (GHGs and Air Pollutants, Spill Prevention, Community Impacts, Environmental Leadership, and Waste Management). Port of Alberni (POA) became a GM participant in 2015 and reported their environmental performance first time in 2016 under GMEP. Hence, performance scores of POA are not included for trend analysis in the Figures 5.8-5.12. However, POA's performance scores are: GHG – 1, spill prevention – 2, community impacts – 1, environmental leadership – 1, and waste management – 1 (Green Marine, 2017).

Table 5.3: Performance results of Canadian ports measured by GM (2009-2016).

Ports	**Performance Indicators (PI)**																											**Avg. Score**	**Rank Based on Average Score**
	GHG								**Spill Prevention**					**Community Impacts**					**Environmental Leadership**								**Waste Mgt.**		
	2009	2010	2011	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2009	2010	2011	2012	2013	2014	2015	2016	2016		
POH			4	5	5	5	5	3	5	5	5	5	5	4	4	4	5	4			5	5	5	5	5	5	4	**4.7**	**1**
POM	4	4	4	4	4	4	5	5	2	4	4	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	3	**4.5**	**2**
POV				5	5	5	5	5	3	3	3	4	4	5	5	5	5	5				5	5	5	5	5	3	**4.5**	**2**
POQ	1	2	2	3	3	4	5	5	2	3	3	5	5	3	3	4	5	5	2	2	2	3	3	3	5	5	3	**3.5**	**3**
POP		2	3	3	3	3	3	4	3	3	3	3	4	3	3	3	5	5		2	2	4	4	5	5	5	3	**3.5**	**3**
POSI	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	4	2	**3.4**	**4**
POTR	2	2	2	3	2	2	2	2		2	5	5	5	3	3	4	4	4	3	3	3	3	3	3	3	3	2	**3.1**	**5**
POSG	2	2	2	3	3	3	3	3	2	2	2	3	5					4	2	2	3	3	3	3	3	2	2	**2.8**	**6**
POSJ, NL						2	3	3			3	3	3			2	3	4						3	3	3	2	**2.8**	**6**
POHM	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	2	2	2	2	2	3	3	3	2	**2.7**	**7**
POTB	1	1	1	4	4	4	4	4	2	2	2	2	2	2	2	2	2	2	3	2	2	3	3	3	3	3	1	**2.6**	**8**
POW	2	2	2	2	2	2	2	2					2	2	2	2	2	4	2	2	2	3	3	3	3	3	2	**2.3**	**9**
POT	1	1	1	1	2	3	4	4	1	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	4	1	**2.1**	**10**
POO	1						2	2				2	3				2	3	1						1	2	2	**2.0**	**11**
POSJ, NB			1	1	1	2	2	2	2	2	2	2	2	1	2	2	2	2			2	2	2	2	2	2	2	**1.8**	**12**
PON				2	2	2	2	2	1	2	2	2	2	1	1	2	2	2				1	1	1	2	3	2	**1.8**	**12**
POA								1					2					1								1	1	**1.2**	**13**

Port of Halifax (POH), Port of Montreal (POM), Port of Vancouver (POV), Port of Quebec (POQ), Port of Prince Rupert (POP), Port of Sept-Iles (POSI), Port of Troise-Riveres (POTR), Port of Hamilton (POHM), Port of Thunder Bay (POTB), Port of Saguenay (POSG), Port of Toronto (POT), Port of Windsor (POW), Port of St. Johns (POSJ, NL), Port of Saint John (POSJ, NB), Port of Nanaimo (PON), Port of Oshawa (POO), Port of Alberni (POA).

Source: Green Marine (2017).

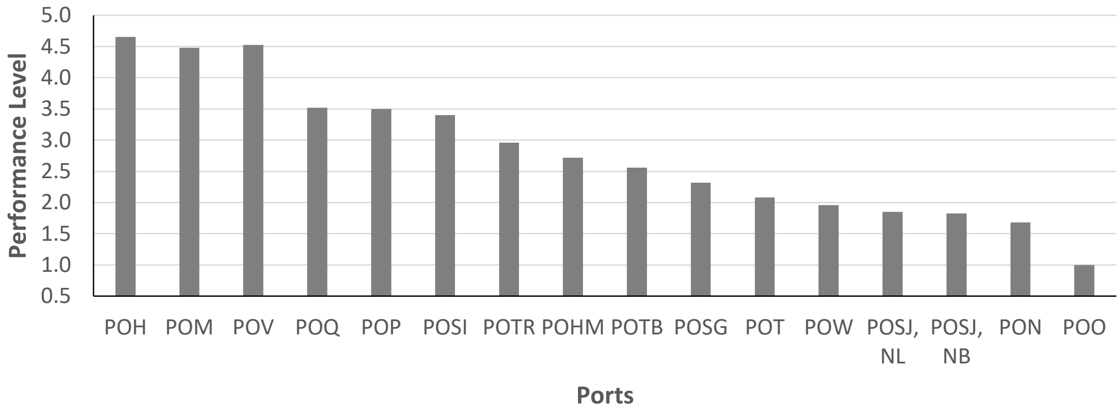


Figure 5.7: Variation of KPI score of Canadian ports (2009-2016).

GHGs and Air Pollutants (Figure 5.8): POV achieved the highest performance in reducing GHGs and air pollution emissions, starting with level 5 in the first year of participation which was maintained until 2016. POH achieved level 4 in the first year of participation, and reached level 5 in 2012 which was maintained until 2015, but dropped to level 3 in 2016. POM and POQ are continuously improving and reached to level 5 in 2015 and remained unchanged in 2016. Among rest of the ports, some of them are improving, and some of them remained unchanged at below level 5.

Spill Prevention (Figure 5.9): In spill prevention, POH was found at the top of performance level. POH achieved level 5 in the year of participation and kept this level unchanged until 2016. POH is the first Canadian port to achieve an ISO 14001 certification in 2005 (Farguson, 2013). Farguson (2013) reported that POH has achieved performance level 5 by installing an oil-water separator in the most vulnerable port areas and by following standard operational practices to prevent water pollution. POM, POQ, POS, and POTR were found continuously improving and achieved level 5 in 2016. Among rest of the ports, some of them are improving, and some of them remained at the same level, but they did not reach to level 5.

Community Impacts (Figure 5.10): In community impacts, POM and POV showed top performance by achieving level 5 in the year of participation and keeping this level unchanged until 2016. POV has highly emphasized local community engagement to port development. POV has reported maintaining regular meetings and consultations with 16 port communities, having a Port Community Liaison Committee, and investing in community development (POV, 2017). POM has highly emphasized the improvement of the population's quality of life, support for local community development efforts, and maintaining liaisons with the local communities through the Good Neighbour Committee (POM, 2015). The performance level of POH fluctuated starting with level 4, reaching to level 5 in 2015 and then dropping to level 4 again in 2016. POQ improved from level 3 to level 5 and remained unchanged until 2016. Among rest of the ports, some of them are improving, and some of them remained at the same level, but they did not reach to level 5.

Environmental Leadership (Figure 5.11): POH and POV showed top performance in environmental leadership achieving level 5 in the year of participation and keeping this level unchanged until 2016. POM started at level 4 in 2009, reached to level 5 in 2010 and continued this performance at level 5 until 2016. POP and POQ were found continuously improving in environmental leadership. POP and POQ participated started at level 2 and reached to level 5 in 2014 and 2015 respectively. POP and POQ kept their performance level 5 unchanged until 2016. POP has reported continuous improvement of their environmental initiatives such as carbon emissions reduction, environmental quality monitoring (air, dustfall, water, noise), shoreline habitat protection, and detecting invasive species to improve environmental sustainability performance (POP, 2017). POQ adopted a sustainable development strategy in 2013, and they are continuously improving in environmental performance by taking various initiatives (POQ, 2017). POSI started with level 3 in 2009, reached to level 5 in 2011, kept this level unchanged until 2015 and then dropped to level 4 in 2016. Among rest of the ports, some of them are improving in environmental leadership, and some of them remained at the same level, but none of them reached to level 5.

Waste Management (Figure 5.12): Waste management was added as an indicator in 2016. The result shows that POH achieved level 4 which is the highest among all the ports. POH was the first Canadian port to have an EMS and achieved an ISO 14001 certification in 2005 (Farguson, 2013). POH scored top performance scores for other criteria over time which might have strengthened their adaptive capacity to meet GM's new performance evaluation criteria for waste management. Moreover, POH is located in the Halifax

Regional Municipality (HRM) of Nova Scotia which has a reputation for good municipal waste management that may have indirectly influenced POH to score well in waste management. POM, POP, POQ, and POV achieved level 3. Rest of the ports achieved level 1 to 2. Waste management being a new indicator might be the reason for not achieving level 5 and having many ports at a level below 4.

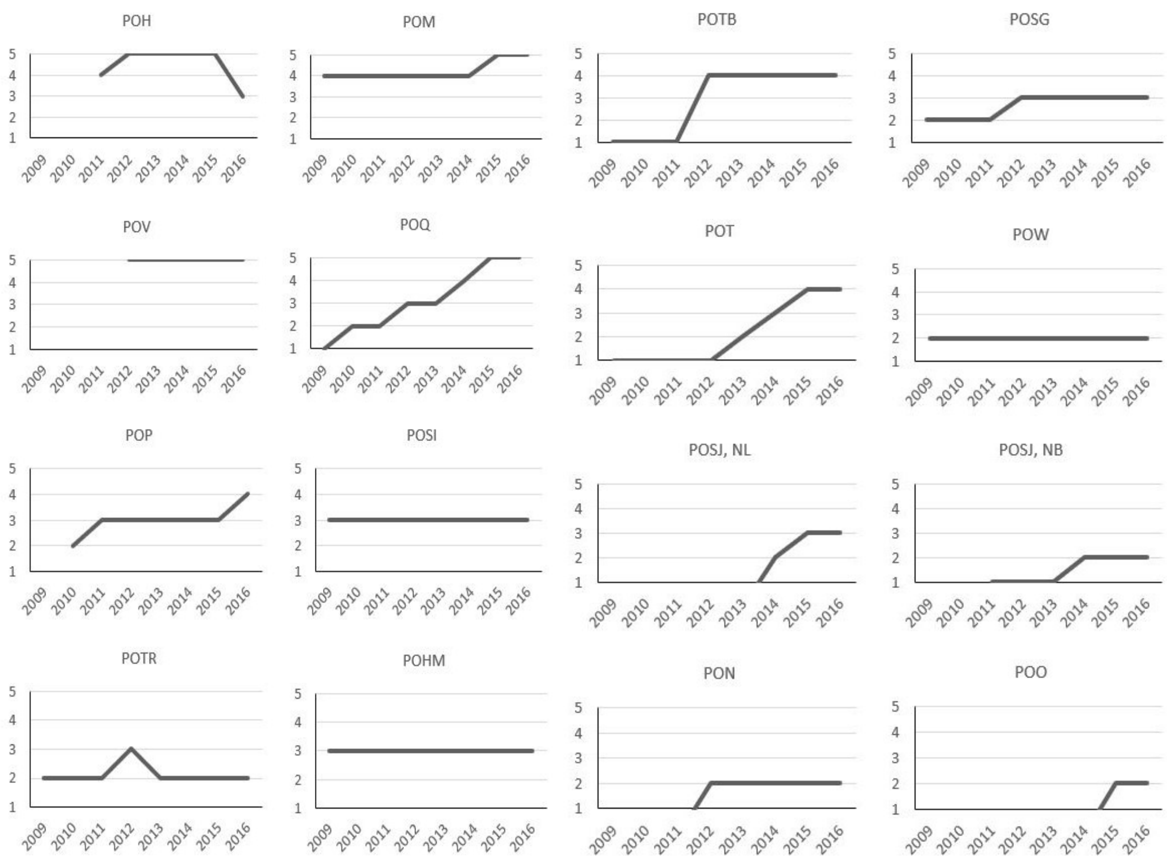


Figure 5.8: Temporal GHG KPI trends for Canadian ports from 2009 to 2016.

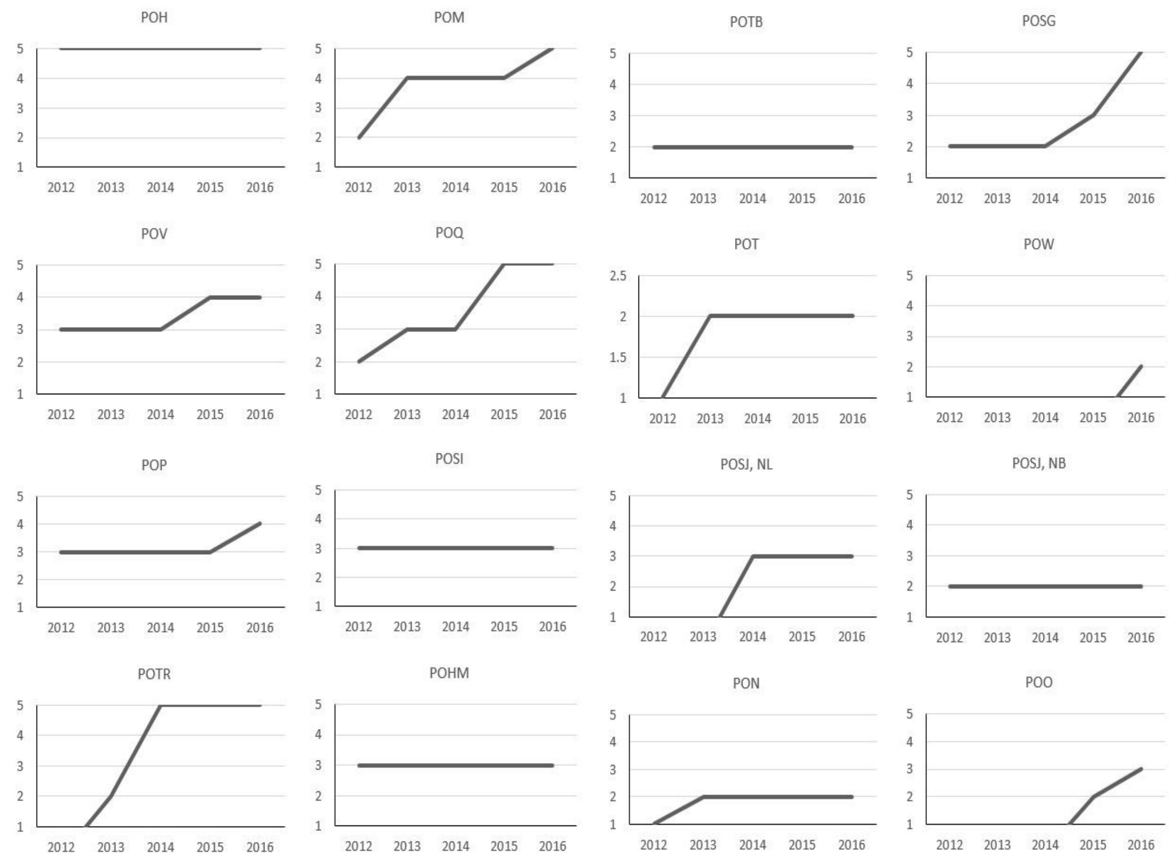


Figure 5.9: Temporal Spill Prevention KPI trends for Canadian ports from 2012 to 2016.

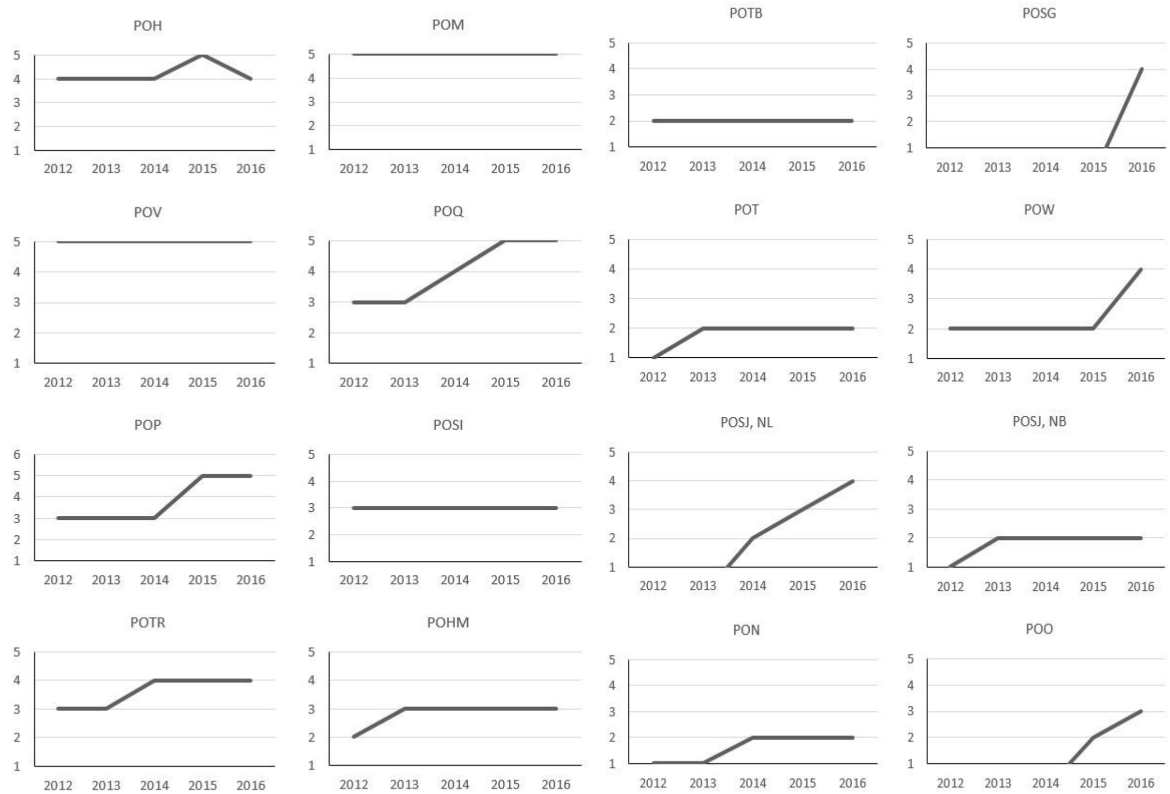


Figure 5.10: Temporal Community Impacts KPI trends for Canadian ports from 2012 to 2016.

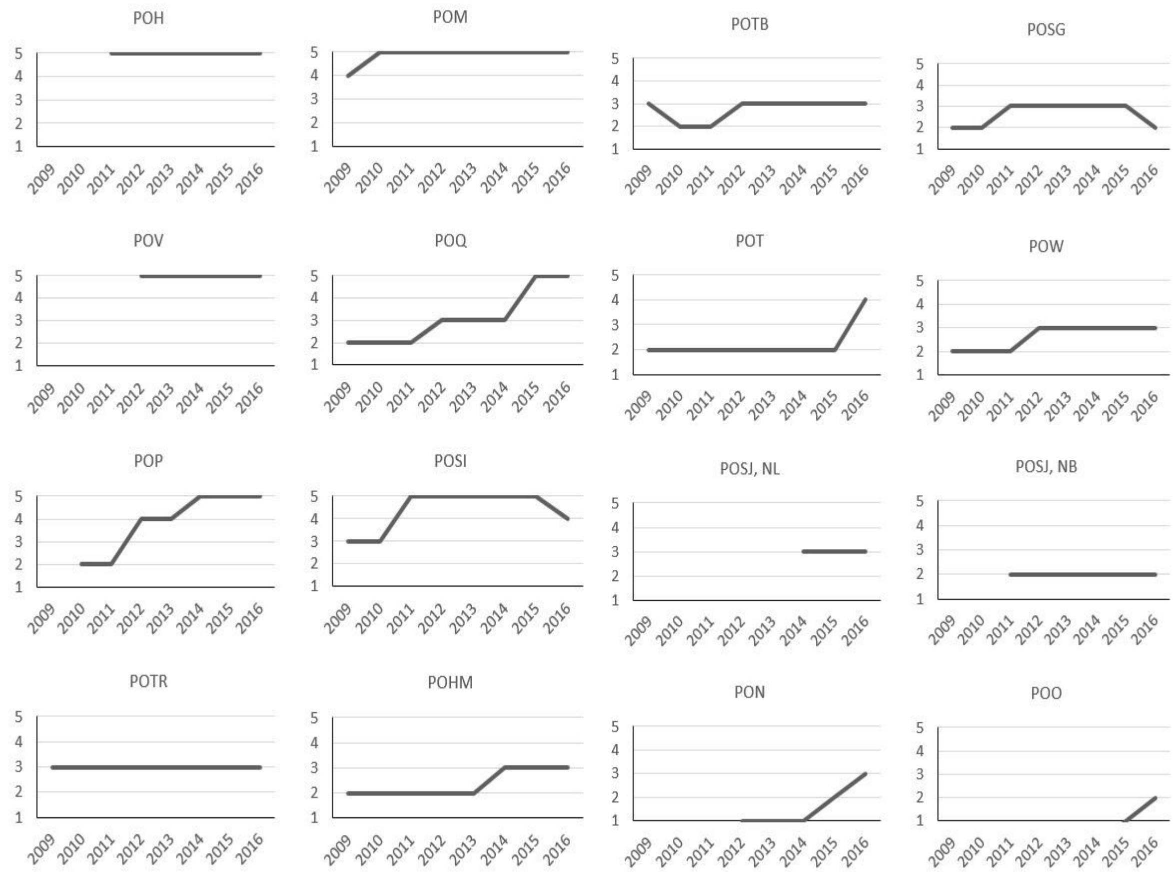


Figure 5.11: Temporal Environmental Leadership KPI trends for Canadian ports from 2009 to 2016.

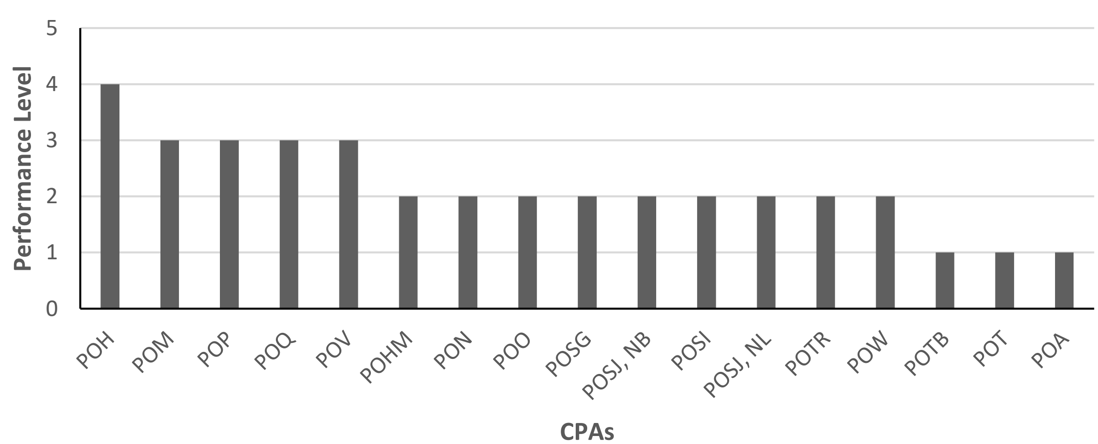


Figure 5.12: Performance in waste management of Canadian ports in 2016.

5.6 Conclusion

With increasing social and economic demands along with environmental challenges, port authorities are taking various measures to improve environmental performance and achieve sustainability in port operations. Canadian ports as economic engines are contributing to the economic and societal development. They have also an obligation legally to the environmental regulatory agencies and socially to port communities to protect and ensure the security of the natural environment where they operate. This study evaluated the sustainability initiatives and environmental performance of Canadian ports. Results indicate that most ports recognized that GM certification can effectively demonstrate environmental stewardship. POH, POM, POV, POQ, and POP were found proactive in taking strategic initiatives to improve environmental performance compared to their Canadian peers. These ports reported good performance in GHG emissions reduction, waste management, spill prevention, community engagement, and environmental leadership taking various measures. These measures include mitigations and monitoring of environmental impacts (e.g., air, water, noise, sediment), wildlife protection, energy management, stakeholder participation, environmental reporting, and research and development. Results show that some ports are lagging behind in taking initiatives to achieve sustainability. Canadian ports need to advance in environmental performance to compete with neighboring US ports. Relevant federal and provincial Governments and Organizations like ACPA and Green Marine should come forward to assist ports to achieve sustainability.

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CHAPTER 6: CONCLUSION

This thesis has explored the current state of global and Canadian ports' initiatives and approaches to achieving sustainability in port operations. To achieve the first objective, this study evaluated initiatives of 36 global ports, 12 ports in each of three regions – NA, EU, and the AP. This study found that most ports have implemented identification, mitigation, and monitoring of impacts, as well as improved energy management, and stakeholder engagement – particularly linked to EP development. Many ports have made progress on environmental monitoring (air, water, noise), wildlife protection, environmental performance disclosure on the port website, research and development, stakeholder participation, and providing support for the better environmental performance of port operations. However, many ports are lagging behind in taking initiatives to achieve sustainability. This study found that EU ports have made greater progress in adopting sustainability initiatives, compared to NA and AP ports. European Union directives, collaboration among port stakeholders, and individual ports' willingness under the framework and guidance of ESPO might have influenced the performance of environmental management achieved by EU ports.

NA ports have made greater progress in adopting sustainability initiatives compared to AP ports. Participation in the GM and reporting environmental management measures annually to GM under the GMEP is one of the key initiatives common in many NA ports (Walker, 2016). GMEP launched by GM in NA in 2007 has been assisting maritime industries in greening port operations. Walker (2016) concluded that North Amerian marine industry has been benefiting from GM's programs by adopting sustainability initiatives. Therefore, we suggest that similar to ESPO and GM, organizational guidance and frameworks might benefit AP ports to improve the environmental performance of port operations where the majority of large ports exist.

To achieve the second objective of assessing the state of Canadian ports' efforts to be sustainable ports, this study has evaluated the initiatives of 18 Canadian major ports which represent the National Ports System in Canada. This study has also evaluated the environmental performance scores measured under the GMEP of 16 participant Canadian major ports. We found that most ports have emphasized GM certification to demonstrate environmental stewardship. POH, POM, POV, POQ, and POP were found proactive in taking strategic initiatives to improve environmental performance compared to their Canadian peers. These ports reported good performance in GHG emissions reduction, waste management, spill prevention, community engagement, and environmental leadership taking various measures. These measures include mitigations and monitoring of environmental impacts (e.g., air, water, noise, sediment), wildlife protection, energy management, stakeholder participation, environmental reporting, and research and development. All Canadian ports need to advance in environmental performance to compete with neighboring US ports.

This study has a number of limitations. Firstly, due to resource and time constraints, this study has applied a desk research strategy and collected data that are publicly available. A port is a large industry and a public entity of a country, and they have to deal with a variety of stakeholders. Therefore, ports are supposed to maintain a higher authenticity and transparency in disclosing port information publicly. Secondly, this study has taken limited sample ports from each of three regions. The selected ports are comparatively large, claiming or pledging to be green or sustainable ports, and are maintaining a good corporate image in their countries. Thirdly, a language barrier hampered the data collection within selected Asian ports. Therefore, the author suggests that further research can be done on this topic by increasing the number of sample ports, and by surveying and consulting port stakeholders, and by taking some ports as case studies.

In conclusion; this study has evaluated the current state of ports' efforts to integrate sustainability into their operations. It applied desktop research strategies based on publicly available information to perform an analysis of the initiatives and approaches adopted by ports. Results reveal current practices to achieving port sustainability from Canadian and global perspectives. Ports which would like to be green or sustainable in their port operations might benefit from this research by reviewing initiatives herein and visiting the ports' websites that have adopted successful initiatives. The port industry has been growing with increasing societal and economic demands, and they need to balance these with environmental challenges. Therefore, all ports and their stakeholders need to move forward to achieve a sustainable port industry by sharing relevant information, cooperating, and coordinating.

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APPENDICES

Appendix A: List of the 36 global ports.

Sl. No.	Ports	Regions	Country
1	Port of Vancouver	NA	Canada
2	Port of Montreal		Canada
3	Port of Prince Rupert		Canada
4	Port Quebec		Canada
5	Port Saint John		Canada
6	Port of Sept-Iles		Canada
7	Port of Long Beach		United States
8	Port of Los Angeles		United States
9	Port of New York and New Jersey		United States
10	Georgia Port		United States
11	Port of Seattle		United States
12	Port of Houston Authority		United States
13	Port of Rotterdam	EU	Netherlands
14	Port of Antwerp		Belgium
15	Port of Bremen		Germany
16	Port of London		United Kingdom
17	Nantes Saint Nazaire Port		France
18	Port of Venice		Italy
19	Port of Valencia		Spain
20	Port of Copenhagen		Denmark
21	Port of Helsinki		Finland
22	Port of Igoumenitsa		Greece
23	Dublin Port		Ireland
24	Port of Gothenburg		Sweden
25	Port of Singapore Authority	AP	Singapore
26	Jawaharlal Nehru Port		India
27	Busan Port		South Korea
28	Port of Hong Kong		China
29	Port of Kaohsiung		Taiwan
30	Port of Keelung		Taiwan
31	Aqaba Container Terminal		Jordan
32	Fremantle Port		Australia
33	Port Hedland		Australia
34	Port of Hay Point		Australia
35	Port of Brisbane		Australia
36	Port of Auckland		New Zealand

Appendix B: List of sustainability initiatives (indicators) adopted by ports.

Sl.	Indicators
1	Environmental Policy (EP)
2	Publicly availability of EP
3	Environmental Management System (EMS)
4	EMS Certification (ISO 14001)
5	Air Quality Monitoring
6	Water Quality Monitoring
7	Noise Level Monitoring
8	Sediment Quality Monitoring
9	Wildlife Protection
10	Energy Efficiency and Conservation (EEC)
11	Renewable Energy (RE) Use
12	Emissions Inventory
13	Shore Power
14	LNG Facility
15	Green Incentives
16	Green Infrastructure Development/LEED building
17	Availability of Environmental Monitoring Report
18	Sustainability Reporting
19	Sustainability Reporting with GRI Guidelines
20	Community engagement
21	Environment Menu Bar on port website
22	Environmental Professional
23	Research and Development (R&D)
24	Climate Change Adaptation
25	Port Environmental Review System (PERS) for global ports/ Green Marine Membership (for Canadian ports)