Marine Policy 106 (2019) 103519

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Sustainability initiatives in Canadian ports

Tahazzud Hossain[a,b], Michelle Adams[b], Tony R. Walker[b,*]

[a] Service NL, Corner Brook, Newfoundland and Labrador, Canada
[b] School for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia, Canada

ARTICLE INFO

Keywords:
Port sustainability
Sustainability initiatives
Environmental performance
Green marine (GM)

ABSTRACT

Canadian ports contribute to the Canadian economy and social development. Society increasingly expects Canadian ports to balance economic growth with social and environmental impacts. In response, some Canadian ports have implemented strategic initiatives to integrate sustainability into their operations. Through participation in the Green Marine (GM) program, these ports can measure and improve their environmental performance. This study evaluated sustainability and environmental performance at 18 Canadian major ports. Twenty-five pre-defined indicators were used to identify operational trends linked to port sustainability. Annual performance reports (eight years) published by GM were analyzed to assess trends in environmental performance. All Canadian major ports participated in the GM program, but only seven proactively integrated 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. All Canadian ports need to integrate sustainability and participate in GM to improve environmental performance and remain competitive in the global maritime supply chain.

1. Introduction

Canadian ports contribute to establishing Canada's commercial marine shipping, interlinking economy, culture, environment, exports and security of the country. The marine shipping industry plays a pivotal role in shaping the Canadian resource-based economy. This industry depends heavily on port facilities and major Canadian ports are considered economic engines and gateways to trade. About 20% (by dollar value) of Canadian exports and imports are transported by marine shipping [1]. Canada's major ports handle ~340 million tons of goods annually worth ~$400 billion (CAD), representing 25% of all Canadian trade. Canada's major ports refer to the 18 ports which are designated as Canada Port Authorities (CPAs) under the *Canada Marine Act* (CMA) [2].

Although ports contribute significantly to the economy, they also pose adverse effects on the environment [3–5]. Environmental effects can be caused by port activities, berthing ships, and emissions from intermodal transport serving the port hinterland [6,7]. 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 [5]. A study found that among 800 North American, European and Asian ports, port authorities cited air quality, water quality, waste disposal, noise, and habitat conservation as the top five environmental issues [3]. Other researchers reported similar environmental effects including discharges to water/sediment, emissions to soil, and resource consumption [8]. Numerous studies have sought to identify key environmental issues, such as air quality [7,9,10]. Water pollution has regularly been identified as another major issue [11,12], as contaminants from ballast water, cargo residue, fuel oil residue, waste disposal and petroleum spills are routinely discharged [6,7,13]. Noise has also been widely reported [4,14–16], 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) remains a challenge [6,17].

The Association of Canadian Port Authorities (ACPA) was founded in 1958 to advocate and advance the Canadian port industry [2]. The ACPA represents all ports in Canada, various government agencies and marine sector companies. The ACPA also assists CPAs to improve environmental performance in port operations. The ACPA signed a Memorandum of Understanding with Green Marine Management Corporation (known as Green Marine) in 2014 to assist CPAs in advancing environmental sustainability [18]. Green Marine (GM) is a North American based voluntary environmental certification program for the

* Corresponding author.
E-mail address: trwalker@dal.ca (T.R. Walker).

https://doi.org/10.1016/j.marpol.2019.103519
Received 4 October 2018; Received in revised form 1 May 2019; Accepted 2 May 2019
Available online 10 May 2019
0308-597X/

marine industry. Since its inauguration in 2007 GM has been serving ports, terminals, ship-owners, shipyards and seaway corporations to help reduce their environmental footprint [19–21]. Under the Green Marine Environmental Program (GMEP), GM participants have to demonstrate annual improvements in environmental performance measured based on several key performance indicators (KPIs) (e.g., reductions in greenhouse gas [GHG] and air pollution emissions) in measurable ways to maintain their certification [19]. Reports are independently verified every two years to ensure rigor and integrity of the GMEP [20,21]. Transparency is achieved, as individual results are made publicly available annually [20]. GM benefits the marine industry across North America by encouraging sustainable development initiatives which is supported by a diverse network of environmental groups and government agencies [21].

The number of KPIs to measure performance varies slightly annually and is determined by GM. For example, GMEP used 11 KPIs in 2016 [20] and 12 KPIs in 2017 [19] to measure GM participants' environmental performance. GM participants receive performance certification by benchmarking their environmental performance by completing annual self-evaluations. Based on self-evaluation reports, 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*' [20]. Eighteen Canadian major ports are members of GM. Some Canadian ports such as Port of Halifax (POH), Port of Montreal (POM), and Port of Vancouver (POV) showed high performance in GMEP, and have been working proactively to improve port sustainability through a variety of sustainability initiatives, while some other ports such as Port of Saint John (POSJ), Port of Nanaimo (PON), and Port of Alberni (POA) showed low environmental performance [19,21]. However, research gaps exist to assess sustainability efforts implemented by Canadian ports and to assess progress made by reporting their environmental performance to GM under the GMEP. This study assessed the state of Canadian ports sustainability initiatives and GMEP's environmental performance scores.

1.1. Legislation and regulations governing Canadian ports

Most Canadian ports have environmental policies and procedures to address environmental effects of port operations. Canadian ports must comply with applicable provincial and federal environmental legislation and regulations. Navigation and shipping fell under federal jurisdiction during formulation of the *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 comprise 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.

Three federal agencies (Transport Canada [TC], Environment and Climate Change Canada [ECCC] and Fisheries and Oceans Canada [DFO]) have their own mandate for protection of the marine environment in Canada. TC is responsible for Canada's transportation system including safety, security and environmental performance of Canadian ports. TC uses regulations such as the *Canada Marine Act, Canada Shipping Act, Transport of Dangerous Goods Act* and *Navigation Protection Act* to regulate port operations. TC 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 responds to marine oil and fuel spill incidents. ECCC has a broader mandate through formulating legislation (e.g., *Canadian Environmental Protection Act* [CEPA], *Canada Water Act*) to protect and improve quality of the natural environment focusing on air, water, and soil quality [22]. CEPA is the main federal environmental legislation regulating toxic substances to prevent pollution. DFO is responsible for managing oceans, small craft harbours and freshwater resources in Canada [23]. DFO is responsible for management of fisheries, habitat, and aquaculture and conducting related research. Though federal legislation applies to port operations, ports are required to follow relevant provincial environmental legislation and regulations within their local jurisdiction. Some Canadian ports are improving environmental performance by exceeding regulatory compliance and 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 ports [24,25]. Table 1 shows federal regulatory agencies and legislation associated with Canadian port operations.

Table 1
Federal regulatory agencies and legislation for Canadian ports.

Regulatory Agency	Legislation
ECCC	*Canadian Environmental Protection Act (CEPA), 1999* *Canada Water Act*, 1985 *Species at Risk Act* (SARA), 2002 *Canada Wildlife Act*, 1985 *Migratory Birds Convention Act*, 1994
TC	*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

2. Methodology

Canadian port sustainability initiatives were assessed at 18 major CPAs. Criteria for port selection included: designated as National Ports System and CPAs under CMA. Data were collected from: inventories of sustainability initiatives adopted by Canadian ports reported on publically available port websites; environmental performance results (from 2009 to 2016) reported by GM for Canadian ports; and reviews of national legislation governing Canadian ports. The twenty-five sustainability indicators (see supplementary material of indicators used, S1) used in this comparative analysis were developed based on an extensive review of the initiatives, strategies and operational norms of the some of the world's most sustainable ports [3,7,8,17,19,21,27–29]. Exisiting sustainability indicator frameworks and guidance documents were also assessed, examining re-occuring themese that would be applicable for port operations. These included materials such as: the Global Reporting Initiative (GRI) [30]; Equator Principles [31]; Global Compact [32]; and Canada's Agenda for implementing the UN Sustainable Development Goals (SDGs) [33]. Finally, port corporate websites – particularly those claiming to be green or sustainable - were reviewed in detail for common claims, initiatives and strategies linked to sustainability. The resulting twenty-five indicator reflected the synthesis of this analysis, incorporating those factors which were considered to be a true reflection of the operationalization of sustainability for the port sector. For example, development of an environmental policy (EP), usually consisting of a written statement supported by senior management (e.g., President or CEO), if made publicly available to communicate to stakeholders was considered an indicator; the absence of which denotes a lack of corporate commitment to environmental performance and therefore an indicator of the ports lack of support for overall sustainability.

A desktop review (rather than interviews with senior management) of sustainability initiatives by reviewing literature and Canadian port corporate websites was conducted intentially to avoid respondent fatigue. Respondent fatigue occurs when survey participants are subject

to requests to complete surveys are a regular basis. Data from the review of port websites, corporate reports, and published literature for each indicator was collected as 'Yes' or 'No'. 'Yes' or 'No' data were entered into SPSS (Statistical Package for Social Sciences). A value of '1' was entered for 'Yes' (if an initiative was adopted) and '0' was entered for 'No' (if no initiative was adopted). Data were used for descriptive analysis of all port indicators.

To compare sustainability initiatives adopted by ports, a sustainability scale was developed by summing 25 items or indicators. The sustainability scale was recoded into three categories (0–2 initiatives = low sustainability; 3–14 initiatives = moderate sustainability; 15–24 initiatives = high sustainability). This recoding was developed based on one standard deviation (SD) above high sustainability mean (15–24 initiatives), one SD below low sustainability mean (0–2 initiatives with rounding value), and in between one SD above and below is moderate sustainability (3–14 initiatives). Reliability of selected indicators to measure sustainability was tested using Cronbach's alpha which is widely used to assess consistency of selected variables to measure scale reliability. Alpha values range from 0 to 1. Values between 0.6 and 0.7 were deemed the lower limit of acceptability [26]. Cronbach's alpha was tested for 25 indicators using SPSS to determine internal consistency of indicators to measure the sustainability scale. SPSS and Microsoft Excel were used to perform descriptive statistical analysis. GIS software "ArcGIS 10.2" was used to present results spatially.

Environmental performance scores were collected from publicly available annual (2009–2016) GMEP performance reports on the GM website (https://www.green-marine.org/program/). GMEP performance reports include GM participants' annual performance scores for each indicator. Performance of ports and seaways were 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 [20]. Waste management was first included as an indicator for ports and seaways 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. 'Dry bulk handling and storage' was not applicable for all ports and was excluded from this study. Performance data for five KPIs listed for the GMEP were extracted from published performance reports (2009–2016) for Canadian ports. Although GM began reporting performance results from 2008, the 2008 report was unavailable, so was excluded. Performance scores (1–5) for 17 Canadian major ports were extracted from published performance reports (Port of Belledune was not a GM participant at the time of data collection). Microsoft Excel was used to analyze temporal Canadian ports' environmental performance. Location of ports and relative size by cargo volume handled in 2015 (Fig. 1).

3. Results and discussion

3.1. Initiatives adopted by Canadian ports

Results indicate 44% of Canadian ports have reportedly established EP (Fig. 2). A clear EP statement signifies intentions and direction of an organization to achieving environmental performance and sustainability [27–29]. Navickas and Kontautiene [34] stated that an effective EP assists business to operate efficiently, improves operational productivity and resource efficiency, and helps reduce costs. Establishing an EP is considered the first step to establishing an Environmental Management System (EMS). In some cases, such as ISO 14001 certification, developing a written and "senior management signed" EP statement is a requirement for obtaining EMS certification [35].

An EMS is a tool to manage environmental impacts following a systematic, comprehensive and documented approach to improving environmental performance of an organization [36]. Ports with ISO 14001 certification use it to continuously improve environmental performance of port operations. Although only POH and POM publically reported having ISO 14001 certification (Fig. 3), all Canadian major ports have obtained GM certification and have submitted performance reports to GM, except Port of Belledune, which participated on May 1, 2017 in accordance with GM's 2016 Performance Report [20]. Nine of those 18 ports reported membership (GM certification) on corporate websites; eight did not report any association with GM, as noted by Hendricks [37]. Hendricks [37] concluded that this disparity of communicating GM membership might be a topic for further research. During previous research involving GMEP, Walker [21] concluded that measurement of environmental performance of GM participants under the GMEP framework affirmed GM's effectiveness in enhancing sustainability in marine transportation. However, this is in contrasts to the perceived high environmental performance of some Canadian ports measured using 25 sustainability indicators in this study.

For example, Port Environmental Review System (PERS) certification is non-region specific and is the only port-sector specific standard for environmental management developed by ports with the initiative of the European Sea Ports Organization (ESPO) and accessible online by any ports on the ecoports website (https://www.ecoports.com/pers) [38]. Globally, 46 ports currently have PERS certification [39], yet no Canadian ports have done so and the reasons would be PERS is mainly focused among the European ports and Canadian ports have been following GMEP. Any port around the world can obtain PERS certification by following the EcoPorts procedure. Currently, outside the EU, seven Taiwanese and four Mexican ports have obtained PERS certification [39]. Canadian ports may benefit from PERS certification for global reputation and exchanging the knowledge of best practices in port sustainability by engaging more directly with ESPO.

Half of Canadian ports reported support for local 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 local communities to improve their corporate social responsibility and social license to operate [25,36,40] as well as to thrive and deliver environmental and economic benefits to the local community [37]. 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.

One-third of ports (33%) have an *environment* related menu bar on their corporate websites to communicate environmental performance information (Fig. 2). Although publically disclosing this information is voluntary, online sustainability communication has been widely adopted across the port sector [41]. Corporate websites are widely accepted by ports to rapidly and cost-effectively disclose environmental performance of operations to stakeholders [42]. Although the extent of sustainability information disclosure and accessibility to content (e.g., social and environmental disclosures) differs between ports, Santos et al. [43] found annual environmental reports a reliable means for communicating corporate environmental information to stakeholders. Some ports have used voluntary Global Reporting Initiative (GRI) guidelines to frame their environmental reporting which provide standards for environmental performance disclosure which increases credibility, comparability, and transparency in sustainability reporting [44]. Santos et al. [41] found that larger ports were more likely to communicate sustainability information online. Results show 17% of Canadian ports (e.g., POV, POM, Port of Toronto [POT]) published annual sustainability reports on their corporate websites (Figs. 2 and 4). However, only two of the reports followed GRI guidelines for preparing sustainability reports (Fig. 2).

Environmental effects monitoring was practiced by only 28% ports (e.g., POV, POM, and POT), but all are located in densely populated cities, which may explain why monitoring was conducted. Five ports (28%) reported monitoring of ambient air quality, water quality, noise levels and wildlife habitat. However, only 22% published these reports

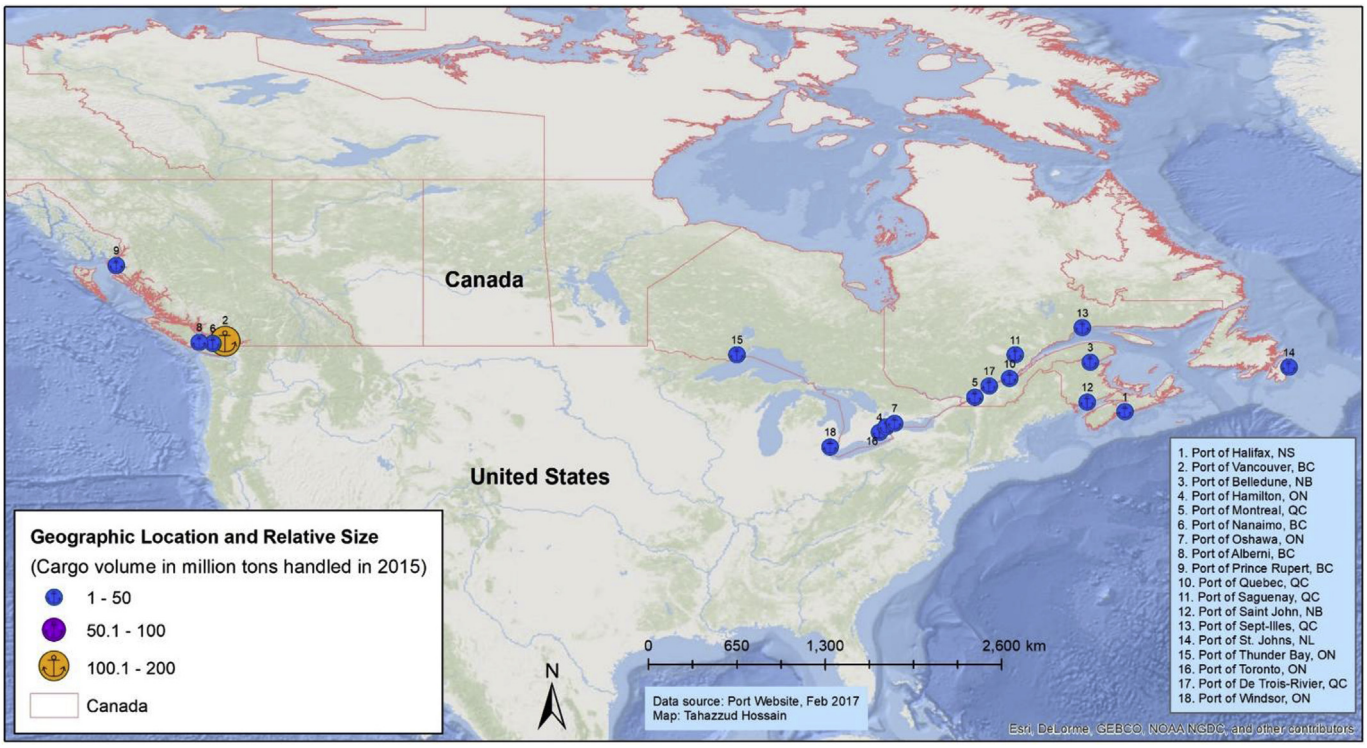

Fig. 1. Location and relative size of Canadian ports.

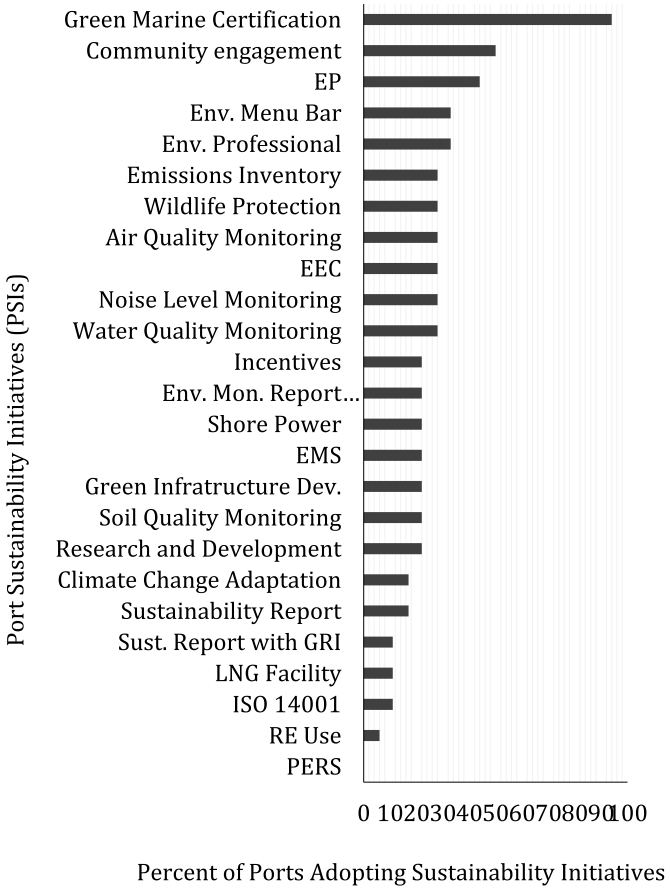

Fig. 2. Variation of sustainability initiatives among Canadian ports.

on their website. Similarly, 28% (e.g., POV, POM, Port of Hamilton [POHM], Port of Prince Rupert [POP], POT) reported emission inventories for their operations (Fig. 2).

Port-related energy management strategies typically do not include renewable energy (RE) generation. However, two ports (e.g., POV and POT) sourced renewable electricity as part of their energy mix. Energy efficiency and conservation (EEC) measures were more widely adopted, with 28% of ports (e.g., POV, POHM, POM, POP, POT) adopting EEC measures (Fig. 2). Acciaro et al. and Lam & Notteboom [7,45] noted benefits of enhanced energy strategies. Acciaro et al. [45] 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 [9]. Some ports among the CPAs such as POH, POV, POM and POP have already started providing shore power and LNG fueling facilities to the ships calling at the port (Fig. 5). Among all ports, only 22% and 11% have shore power and alternative fuel facilities, respectively (Fig. 2). Some of those ports (e.g., POV and POP) provide specific incentives to ship owners to facilitate these services, through reducing port fees and/or providing certificates of environmental performance (Fig. 5). 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 and coastal erosion). However, 22% (POV, POM, POT, and POHM) had integrated (or were starting to integrate) building green or sustainable port infrastructures such as energy efficient buildings. As port infrastructure and port-based economies will be disproportionately affected by climate change effects, the nature and extent of these effects will depend on adaptive capacities of ports and local communities where ports operate [46,47].

Due to geographic proximity, Canadian ports compete with US ports [48] and, therefore, seek ways to remain competitive through research and development (R&D). Four ports (22%), POV, POM, POP, and POT have adopted specific R&D strategies to continually improve environmental performance (Fig. 2).

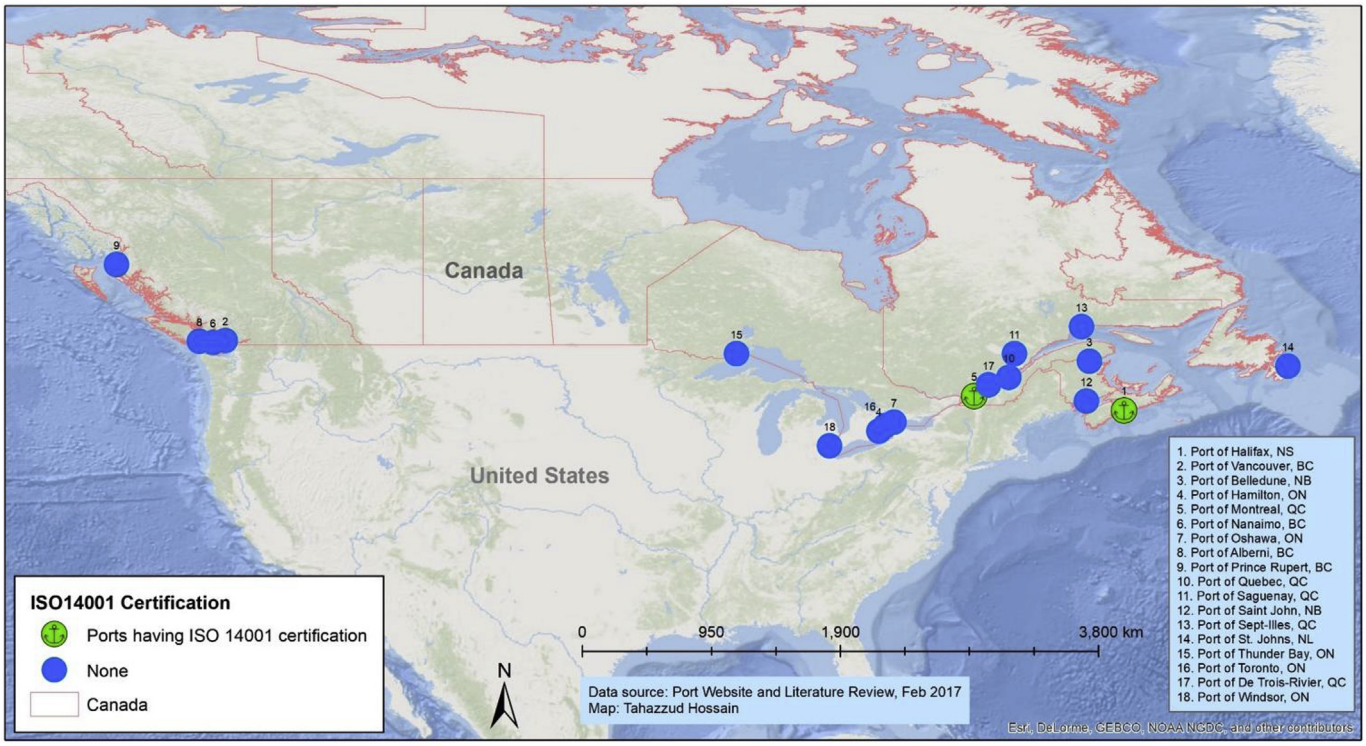

Fig. 3. Spatial variation of ISO 14001 certification across Canadian ports.

3.2. 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 ± SD 7.91) (Table 2). Cronbach's Alpha was 0.97 (Cronbach's alpha ≥0.9 means excellent) which suggest indicators were 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 POHM and POT. Six ports among CPAs adopted only one initiative (Table 2).

Four ports scored high, five medium, and nine low in sustainability (Fig. 6). Sustainability scales were compared with port size in annual cargo handling capacity to see any relationship exists between port size

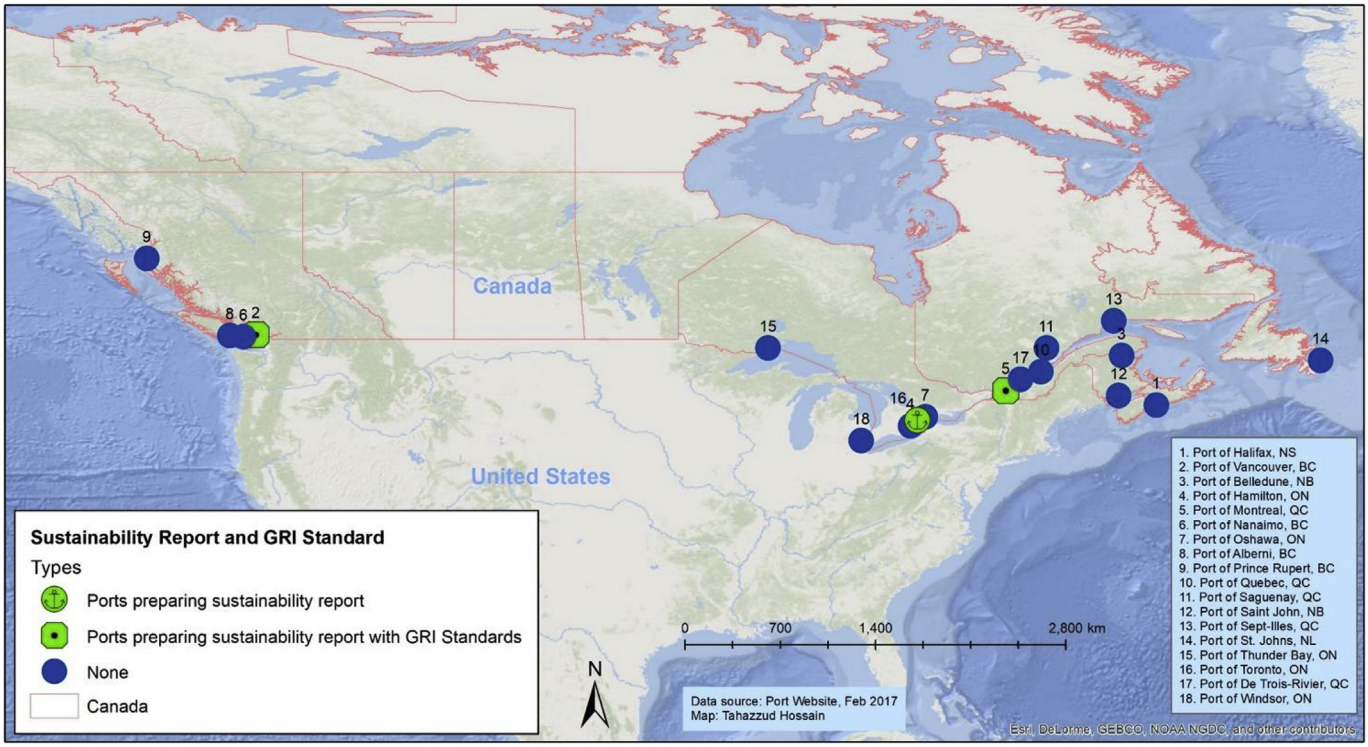

Fig. 4. Spatial variation of sustainability reporting across Canadian ports.

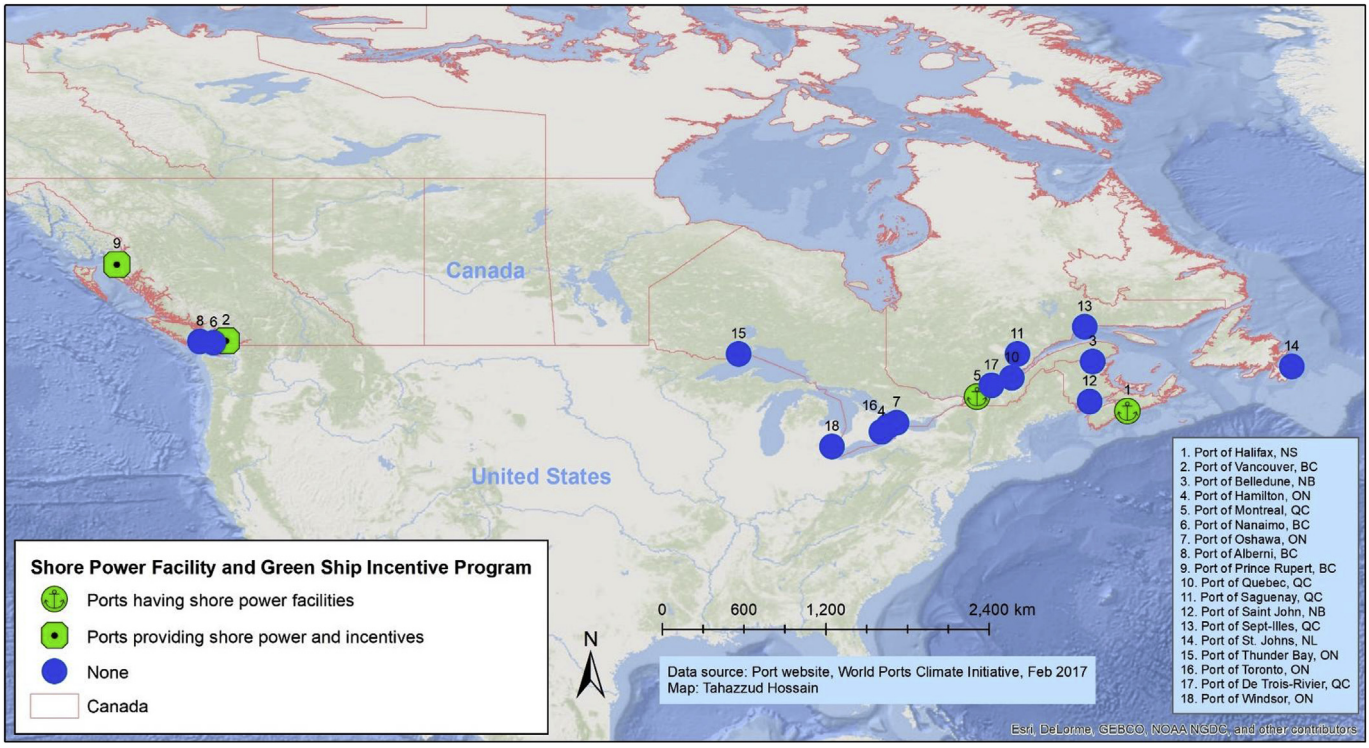

Fig. 5. Spatial variation of shore power facility and incentive programs across Canadian ports.

Table 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

and sustainability performance. Results indicate that both large ports (e.g., POV) and small ports (e.g., POHM and POT) achieved high sustainability scores. Some researchers believe that large ports tend to emphasize more on environmental management components [49] and online sustainability communication [41]. We argue that large ports can have low environmental performance or low sustainability not aiming to be sustainable ports and/or not taking strategic initiatives.

3.3. 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 3). POH ranked highest (mean 4.7), followed by POM and POV (4.5), and POQ and POP (3.5). Sustainability initiatives adopted by ports identified seven ports with medium to high sustainability which correlates with performance results of the top seven ports (with average KPI scores ≥ 3) reported under the GMEP (Table 3 and Fig. 7). Remaining ports achieved average KPI scores of 1 to < 3. Walker [21] 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.

This study analyzed temporal performance trends of Canadian ports for five KPIs (GHGs and air pollutants, spill prevention, community impacts, environmental leadership, and waste management) to assess sustainability efforts of each port. POA became a GM participant in 2015 and reported their environmental performance for the first time in 2016 under GMEP. Hence, performance scores of POA are excluded for trend analysis. However, POA's 2016 performance scores are: GHG–1, spill prevention–2, community impacts–1, environmental leadership–1, and waste management–1 [19].

A correlation analysis was performed to assess temporal trends of the four performance indicators for which temporal data were available. Reporting for waste management began in 2016, so was not included (Table 3). GHG emissions and environmental leadership were assessed over their eight year reporting period (2009–2016) and spill prevention and community impacts were assessed for their five year reporting period (2012–2016). Correlation of all ports combined for GHGs and air pollutants, spill prevention, community impacts and environmental leadership over the reporting periods were $R^2 = 0.57$, 0.57, 0.59 and 0.66, respectively. The best temporal correlation for improvements at individual ports for GHGs and air pollutants, spill prevention, community impacts and environmental leadership over the reporting periods were $R^2 = 0.98$ (POQ), 0.94 (POQ), 0.97 (POSJ) and 0.93 (POP), respectively. Temporal trends for all ports for GHGs and air pollutants, spill prevention, community impacts and environmental leadership are shown in supplementary material (S2, S3, S4 and S5, respectively).

3.3.1. GHGs and air pollutants

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 (see supplementary material, S2). Initiatives that POV adopted to reduce emissions of GHGs and air pollutants include regular emissions inventory, collaboration with

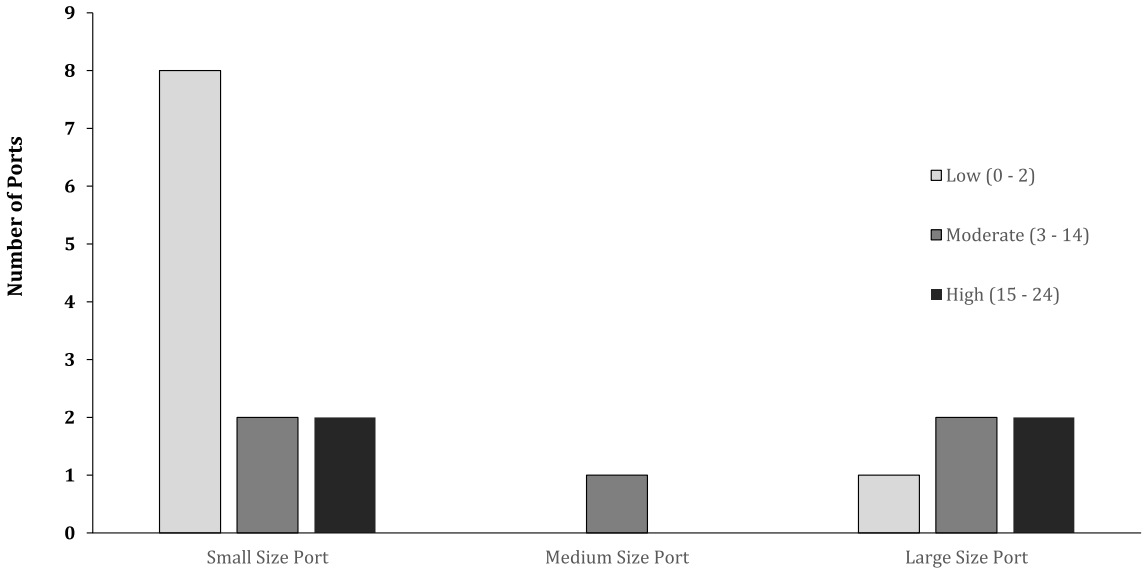

Fig. 6. Variation of sustainability scales in Canadian ports.

neighbouring ports (e.g., Northwest Ports Clean Air Strategy), EcoAction Program (e.g., financial incentives to clean vessels), shore power, and LNG bunkering facilities [50]. POH achieved level 4 in the first year of participation, and reached level 5 in 2012 and maintained until 2015, but dropped to level 3 in 2016. POM and POQ are continuously improving and reached level 5 in 2015 which was maintained in 2016. POM adopted several initiatives to reduce GHGs and air emissions which include regular air quality monitoring, shore power, and use of energy efficient vehicles and locomotives [51]. Among remaining ports, some improved (e.g., POP, POT, POTB), and others remained unchanged below level 5 (e.g., PON, POHM, POSI). POP has adopted several initiatives such as financial incentives for ships that use cleaner fuels and shore power facility to reduce carbon emission [52]. POT reduced GHG emissions by approximately 13% using Bullfrog Power's clean energy [53].

3.3.2. Spill prevention

For spill prevention, POH achieved the highest performance level of 5 in the first year of participation which was maintained until 2016 (see supplementary material, S3). POH is the first Canadian port to achieve an ISO 14001 certification in 2005 [54]. Farguson [54] reported that POH achieved level 5 by installing an oil-water separator in vulnerable port locations and by following standard operational practices to prevent water pollution. POM, POQ, POSI, and POTR continuously improved to achieve level 5 in 2016. Among remaining ports, some improved, and others remained static, but all failed to reach to level 5. As part of the prevention of oil spills and leaks, Canadian ports comply with legislation such as *Canada Shipping Act*, Oil Pollution Prevention Regulations, *Fisheries Act*, and Pollutant Discharge Reporting Regulations [21]. To protect water from marine pollution (e.g., oil spill, illegal dumping of oil) different Canadian agencies (e.g., ECCC, TC, DFO, and Canadian Coast Guard) are working in collaboration by taking various initiatives. One of the remarkable initiatives is TC's National Aerial Surveillance Program (NASP) whose purpose is to detect oil spills in Canadian water and the responsible agencies take legal action against the polluter [55].

3.3.3. Community impacts

POM and POV showed high performance by achieving level 5 in the first year of participation which was maintained until 2016 (see supplementary material, S4). POV emphasized local community engagement to port development. POV reported maintaining regular meetings and consultations with 16 port communities, having a Port Community Liaison Committee, and investing in community development [56]. POM has 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 [51]. POH performance fluctuated from level 4 to 5 in 2015 and dropped to level 4 again in 2016. POQ improved from level 3 to 5 which was maintained until 2016. POP earned level 3 in 2012, reaching level 5 in 2015 which was maintained until 2016. POP improved community impacts by regular environmental quality monitoring (e.g., ambient air, noise, surface water, habitat protection) and building relationship with the local community through various community initiatives (e.g., dialogue, community information forum, community investment) [57]. Among remaining ports, some improved (e.g., POSG, POW, POP, POSJ NL), and others remained static, but all failed to reach level 5 (e.g., POTB, POT, POSI, POSJ NB, POHM).

3.3.4. Environmental leadership

POH and POV showed high performance in environmental leadership achieving level 5 during the first year of participation and maintained until 2016 (see supplementary material, S5). Both POH and POV have an EP, and POH is one of the two Canadian ports with ISO 14001 certification. Besides, POH and POV have adopted various other initiatives (e.g., shore power, green incentive, clean technology) that might have helped these ports to earn the highest performance level in environmental leadership. POM started at level 4 in 2009, reached level 5 in 2010 and maintained until 2016. POP and POQ continuously improved in environmental leadership by starting at level 2 and reaching 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 [57]. POQ adopted a sustainable development strategy in 2013, and continuously improved in environmental performance [58]. POSI started with level 3 in 2009, reached level 5 in 2011, which was maintained until 2015 but dropped to level 4 in 2016. Among remaining ports, some improved in environmental leadership, and some remained at the same level, but all failed to reach level 5.

3.3.5. Waste management

Results show that POH achieved level 4, the highest among all ports. POH was the first Canadian port to have an EMS and achieved an ISO

Table 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: [19].

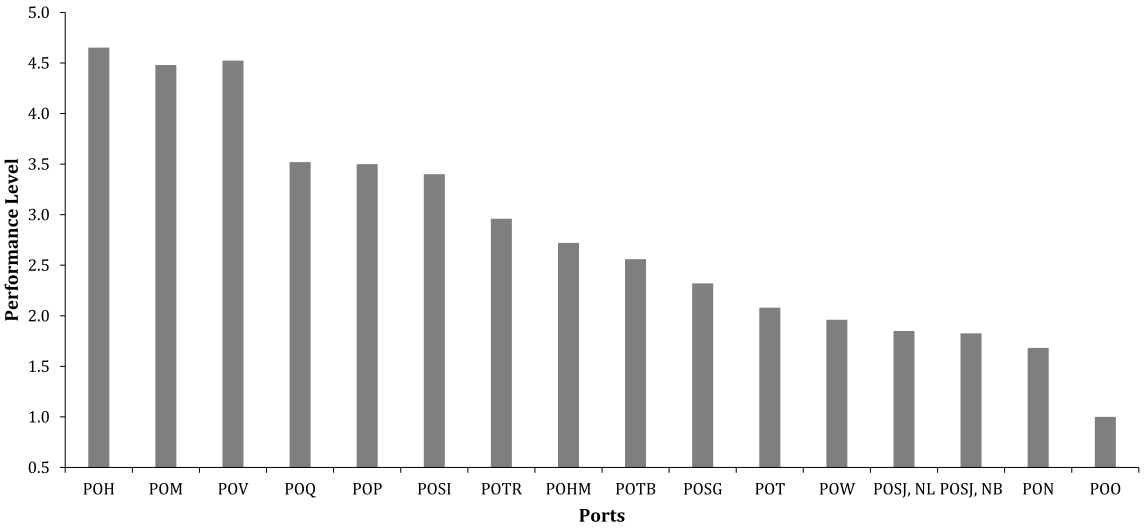

Fig. 7. Variation of KPI score of Canadian ports (2009–2016).

14001 certification in 2005 [54] (see supplementary material, S6). POH scored high-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 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. Remaining ports achieved level 1 to 2. Waste management was added as a new indicator in 2016 which might explain why many ports scored below 4.

3.4. Comparison of GMEP with other port performance trends

ESPO has been supporting environmental management and sustainability initiatives since 1993. Like GM, ESPO completes periodical environmental surveys to assess environmental performance of ports, the main environmental concerns and related trends [8,49]. In 2018, ESPO and EcoPorts identified ten key environmental priorities with many overlapping with GM port specific performance indicators [59] (Fig. 8). Air quality and climate change continue to be top priorities for European and Canadian ports. However, European ports have begun to address the issue of marine debris, which is something that Canadian ports and GM should prioritize due to the pervasiveness of debris in Canada and globally [60–62]. Several environmental monitoring tools such as Self-diagnosis Methodology (SDM) and PERS have also been developed by the ESPO to provide ports with cost-effective methods to assess environmental performance [27] and like GM can be accessed online [34]. Numerous studies have linked voluntary and proactive adoption of sustainability initiatives of ESPO and EcoPorts with increased rigor of monitoring and measurement of environmental performance data [7,8,49]. Similar increases in rigor of monitoring and measurement of environmental performance data is expected with the GMEP as it continues to mature and develop [21], but ongoing research to measure these temporal trends will be required.

4. Conclusions

Canadian ports as economic engines and gateways to trade

Fig. 8. Overlap of Green Marine environmental indicators with the top 10 environmental priorities of European ports for 2018 [55].

contribute to economic and societal development. With increasing social and economic demands along with environmental challenges, port authorities are adopting measures to improve environmental performance and achieve sustainability in port operations [63]. Port authorities have an obligation to comply with environmental regulatory agencies and socially to port communities to protect and ensure security of the natural environment where they operate. Most Canadian ports recognized that GM certification can effectively demonstrate environmental stewardship. POH, POM, POV, POQ, and POP were found to be the most proactive at 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 to GM through GMEP. These ports adopted some measures which 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. Some ports lag behind in taking initiatives to achieve sustainability. Canadian ports need to advance in environmental performance concurrently meeting the societal and economic demands. Relevant federal and provincial Governments and Organizations like ACPA and GM should assist Canadian ports to move forward in achieving sustainability.

Declarations of interest

None.

Acknowledgments

This study was supported by the Social Sciences and Humanities Research Council (SSHRC) of Canada funded project “Green Shipping: Governance and Innovation for a Sustainable Maritime Supply Chain” and the Nova Scotia Research and Innovation Graduate Scholarship (NSGS).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpol.2019.103519.

References

[1] CCA, The Value of Commercial Marine Shipping to Canada, Ottawa (ON), (2017) Retrieved from http://clearseas.org/wp-content/uploads/2017/05/ValueMarineShipping_fullreport_EN.pdf accessed: 17.09.17.
[2] ACPA, Industry Information- CPA Facts, (2017) Retrieved from http://www.acpa-ports.net/industry/industry.html accessed: 24.01.17.
[3] C. Comtois, B. Slack, Restructuring the Maritime Transportation Industry : Global Overview of Sustainable Development Practices, Québec, 2007 Retrieved from http://www.bv.transports.gouv.qc.ca/mono/0938424.pdf accessed: 26.03.17.
[4] M. Mustonen, Noise as an Environmental Challenge for Ports, Stockholm, (2013) Retrieved from http://projects.centralbaltic.eu/images/files/result_pdf/PENTA_result4_noise.pdf accessed: 17.09.17.
[5] T.R. Walker, O. Adebambo, M.C. Del Aguila Feijoo, E. Elhaimer, T. Hossain, S.J. Edwards, C.E. Morrison, J. Romo, N. Sharma, S. Taylor, S. Zomorodi, Environmental effects of marine transportation, World Seas: an Environmental Evaluation, Academic Press, 2019, pp. 505–530.
[6] OECD, Environmental Impacts of International Shipping : the Role of Ports, OECD Publishing, 2011.
[7] J.S.L. Lam, T. Notteboom, The greening of ports: a comparison of port management tools used by leading ports in Asia and Europe, A Transnatl. Transdiscipl. 34 (2014) 169–189.
[8] M. Puig, C. Wooldridge, J. Casal, R.M. Darbra, Tool for the identification and assessment of environmental aspects in ports (TEAP), Ocean Coast Manag. 113 (2015) 8–17.
[9] H. Winnes, L. Styhre, E. Fridell, Reducing GHG emissions from ships in port areas, Res. Transp. Bus. Manag. 17 (2015) 73–82.
[10] EcoPorts, ESPO/EcoPorts Port Environmental Review 2016, Brussels, (2016) Retrieved from https://www.ecoports.com/laravel-filemanager/files/common/publications/ESPO_EcoPorts_Port_Environmnetal_Review_2016_v1.pdf accessed: 06.08.17.
[11] K. Kröger, J.P.A. Gardner, A.A. Rowden, R.G. Wear, Long-term effects of a toxic algal bloom on subtidal soft-sediment macroinvertebrate communities in Wellington Harbour, New Zealand, Estuar. Coast Shelf Sci. 67 (2006) 589–604.
[12] M. Grifoll, G. Jordà, M. Espino, J. Romo, M. García-Sotillo, A management system for accidental water pollution risk in a harbour: the Barcelona case study, J. Mar. Syst. 88 (2011) 60–73.
[13] A.K.Y. Ng, S. Song, The environmental impacts of pollutants generated by routine shipping operations on ports, Ocean Coast Manag. 53 (2010) 301–311.
[14] I.H. Khoo, T.-H. Nguyen, Study of the Noise Pollution at Container Terminals and the Surroundings, Long Beach, California, 2011 Retrieved from https://www.metrans.org/sites/default/files/research-project/09-09_Khoo_METRANS_final_report_0_0.pdf accessed: 18.08.17.
[15] C. Schenone, I. Pittaluga, S. Repetto, D. Borelli, Noise pollution management in ports: a brief review and the EU MESP project experience, 21st Int. Congr. Sound Vib., Beijing, China, 2014 Retrieved from https://www.researchgate.net/profile/Corrado_Schenone/publication/265216678_NOISE_POLLUTION_MANAGEMENT_IN_PORTS_A_BRIEF_REVIEW_AND_THE_EU_MESP_PROJECT_EXPERIENCE/links/5405b9fb0cf2c48563b185f9?origin=publication_detail (accessed: 18.08.17.
[16] J.R. Witte, Noise in ports, 2016 GREEN4SEA Conf. Award, 2016 Retrieved from https://www.green4sea.com/noise-in-ports-2/ accessed: 18.08.17.
[17] C. Trozzi, R. Vaccaro, Environmental impact of port activities, Second Int. Conf. PORTS 2000, Barcelona, Spain, 2000.
[18] ACPA, Memorandum of Understanding (MOU) between ACPA and Green Marine, ACPA, 2014 Retrieved from http://www.acpa-ports.net/advocacy/pdfs/GM_ACPA_MOU_web.pdf accessed: 17.02.17.
[19] Green Marine, About Green Marine, (2017) Retrieved from https://www.green-marine.org/about-us/ accessed: 17.02.17.
[20] Green Marine, Performance Report, (2016) Retrieved from https://www.green-marine.org/wp-content/uploads/2017/05/2016_Performance_Report.pdf accessed: 03.01.18.
[21] T.R. Walker, Green marine: an environmental program to establish sustainability in marine transportation, Mar. Pollut. Bull. 105 (2016) 199–207.
[22] Transport Canada, Canadian Port Authorities- Policy and Legislative Framework, (2012) Retrieved from https://www.tc.gc.ca/eng/policy/acf-acfi-menu-2963.htm accessed: 22.03.18.
[23] T.R. Walker, M. Bernier, B. Blotnicky, P.G. Golden, E. Hoffman, J. Janes, A. Kader, R. Kovacs-Da Costa, S. Pettipas, S. Vermeulen, Harbour divestiture in Canada: implications of changing governance, Mar. Pol. 62 (2015) 1–8.
[24] P. Rao, D. Holt, Do green supply chains lead to competitiveness and economic performance? Int. J. Oper. Prod. Manag. 25 (2005) 898–916.
[25] M. Adams, Quinonez, A.A. Pallis, T.H. Wakeman, Environmental issues in port competitiveness, Halifax (2009) Retrieved from https://www.researchgate.net/publication/228410996_Environmental_Issues_in_Port_Competitiveness accessed: 30.01.17.
[26] Y.H.V. Lun, K.H. Lai, C.W.Y. Wong, T.C.E. Cheng, Green shipping practices and firm performance, Marit. Pol. Manag. 41 (2014) 134–148.
[27] R.M. Darbra, A. Ronza, T.A. Stojanovic, C. Wooldridge, J. Casal, A procedure for identifying significant environmental aspects in sea ports, Mar. Pollut. Bull. 50 (2005) 866–874.
[28] R.M. Darbra, N. Pittam, K.A. Royston, J.P. Darbra, H. Journee, Survey on environmental monitoring requirements of European ports, J. Environ. Manag. 90 (2009) 1396–1403.
[29] S. Roh, V.V. Thai, Y.D. Wong, Towards sustainable ASEAN port development: challenges and opportunities for Vietnamese ports, Asian J. Shipp. Logist. 32 (2016) 107–118.
[30] GRI, GRI4 Guidelines Part 1 Reporting Principles and Standard Disclosures, (2015) Retrieved from https://www.globalreporting.org/resourcelibrary/GRIG4-Part1-Reporting-Principles-and-Standard-Disclosures.pdf accessed: 15.03.19.
[31] Equator Principles, The Equator Principles: June 2013, (2013) Retrieved from https://equator-principles.com/wp-content/uploads/2017/03/equator_principles_III.pdf accessed: 15.03.19.
[32] UN Global Compact, UN Global Compact Management Model Framework for Implementation, (2010) Retrieved from https://www.unglobalcompact.org/docs/news_events/9.1_news_archives/2010_06_17/UN_Global_Compact_Management_Model.pdf accessed: 14.03.19.
[33] Government of Canada, Canada's Implementation of the 2030 Agenda for Sustainable Development, (2018) Retrieved from https://sustainabledevelopment.un.org/content/documents/20312Canada_ENGLISH_18122_Canadas_Voluntary_National_ReviewENv7.pdf accessed: 14.03.19.
[34] V. Navickas, R. Kontautiene, Strategical perspective of corporate environmental policy, Organizacija 44 (2011) 179–184.
[35] N. Asgari, A. Hassani, D. Jones, H.H. Nguye, Sustainability ranking of the UK major ports: Methodology and case study, Transp. Res. Part E Logist. Transp. Rev. 78 (2015) 19–39.
[36] X.Q. Le, V.-H. Vu, L. Hens, B. Van Heur, Stakeholder perceptions and involvement in the implementation of EMS in ports in Vietnam and Cambodia, J. Clean. Prod. 64 (2014) 173–193.
[37] K.R. Hendricks, How People Green the Port: Sustainability in Canadian Ports, Simon Fraser University, 2017.
[38] Ecoports, Port environmental review system (PERS), (2017) Retrieved from https://www.ecoports.com/pers accessed: 06.08.17.
[39] Eco SLC, Sustainable Logistics Chain, (2018) Retrieved from http://www.ecoslc.eu/network accessed: 19.02.18.
[40] M. Ashrafi, M. Adams, T.R. Walker, G. Magnan, How corporate social responsibility can be integrated into corporate sustainability: a theoretical review of their relationships, Int. J. Sustain. Dev. World Ecol. 25 (8) (2018) 671–681.

[41] S. Santos, L.L. Rodrigues, M. Castelo Branco, Online sustainability communication practices of European seaports, J. Clean. Prod. 112 (2016) 2935–2942.
[42] L.S.O. Wanderley, R. Lucian, F. Farache, F. José Milton De Sousa, CSR information disclosure on the web: a context-based approach analysing the influence of country of origin and industry sector, J. Bus. Ethics 82 (2008) 369–378.
[43] M. Dobler, K. Lajili, D. Zéghal, Corporate environmental sustainability disclosures and environmental risk, J. Account. Organ. Chang. 11 (2015) 301–332.
[44] A. Alazzani, W.N. Wan-Hussin, Global Reporting Initiative's environmental reporting: a study of oil and gas companies, Ecol. Indic. 32 (2013) 19–24.
[45] M. Acciaro, H. Ghiara, M.I. Cusano, Energy management in seaports: a new role for port authorities, Energy Policy 71 (2014) 4–12.
[46] A. Becker, S. Inoue, M. Fischer, B. Schwegler, Climate change impacts on international seaports: knowledge, perceptions, and planning efforts among port administrators, Clim. Change 110 (2012) 5–29.
[47] A. Becker, Building Seaport Resilience for Climate Change Adaptation: Stakeholder Perceptions of the Problems, Impacts, and Strategies, Stanford University, 2013 Retrieved from https://stacks.stanford.edu/file/druid:ft948cq5546/BECKER_DISSERTATION_FINAL_FORMATTED_3-augmented.pdf accessed: 19.12.17.
[48] M.C. Ircha, Canadian ports: trends and opportunities Canada and the global economy, Can. Polit. Sci. Rev. Can. Ports Trends Oppor. 2 (2008) 4–25.
[49] M. Puig, C. Wooldridge, A. Michail, R.M. Darbra, Current status and trends of the environmental performance in European ports, Environ. Sci. Policy 48 (2015) 57–66.
[50] POV, 2015 Port Emissions Inventory Report, (2016) Retrieved from https://www.portvancouver.com/wp-content/uploads/2017/12/2015PortEmissionsInventory.pdf accessed: 01.03.18.
[51] POM, The Port of Montreal: a Sustainable Force, (2015) Retrieved from https://www.port-montreal.com/files/PDF/Communaute/2016-05-10_RDD2015-interactif-EN.pdf accessed: 01.03.18.
[52] POP, Carbon Emissions, (2017) Retrieved from http://www.rupertport.com/port-authority/sustainability/carbon-emissions accessed: 05.03.18.
[53] POT, Sustainability Report 2017, (2018) Retrieved from https://www.portstoronto.com/Media/PortsToronto/PortsToronto/PortsToronto_Sustainability_Report_2017_webFINAL.pdf accessed: 05.04.18.
[54] L. Farguson, Halifax Port Authority Receives Top Marks for Commitment to Environmental Sustainability, (2013) Retrieved from http://secure.portdays.com/english/news-and-events/index.html accessed: 02.01.18.
[55] Transport Canada, Protecting Canadian Waters from Oil Spills - Infographic, (2016) Retrieved from http://www.tc.gc.ca/eng/marinesafety/oil-spills-infographic-4379.html accessed: 08.03.18.
[56] POV, 2016 Sustainability Report, Vancouver, BC, (2017) Retrieved from https://www.portvancouver.com/about-us/sustainability/ accessed: 02.01.18.
[57] POP, Environmental Stewardship, (2017) Retrieved from http://www.rupertport.com/port-authority/sustainability accessed: 26.03.18.
[58] POQ, Sustainable Development, (2017) Retrieved from http://www.portquebec.ca/en/commununity/sustainable-development/sustainable-development-strategies accessed: 26.01.18.
[59] EcoPorts, Environmental Report 2018 - Top 10 Environmental Priorities, (2018) Retrieved from https://www.espo.be/news/espo-publishes-environmental-report-2018-top-10-en accessed: 15.03.19.
[60] T.R. Walker, J. Grant, M.C. Archambault, Accumulation of marine debris on an intertidal beach in an urban park (Halifax Harbour, Nova Scotia), Water Qual. Res. J. Can. 41 (2006) 256–262.
[61] S. Pettipas, M. Bernier, T.R. Walker, A Canadian policy framework to mitigate plastic marine pollution, Mar. Pol. 68 (2016) 117–122.
[62] T.R. Walker, Drowning in debris: solutions for a global pervasive marine pollution problem, Mar. Pollut. Bull. 126 (2018) 338-338.
[63] M. Ashrafi, M. Acciaro, T.R. Walker, G. Magnan, M. Adams, Corporate sustainability in Canadian and US maritime ports, J. Clean. Prod. 220 (2019) 386–397.