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Port Waste Management in the Baltic Sea Area: A Four Port Study on the Legal Requirements, Processes and Collaboration

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Academic Editor: Mary J. Thornbush
Received: 27 March 2017; Accepted: 26 April 2017; Published: 28 April 2017

Abstract: The cruise ship industry has become a well-implemented industry in the Baltic Sea area, and each year, the number of cruise ship passengers rises steadily. Efficient waste management in cruising ports around the Baltic Sea is a crucial element in minimizing environmental impacts. This research involves the four selected ports of Copenhagen, Helsinki, Stockholm and Tallinn. The study applies statistics and interview data to the analysis of waste management systems for cruise ship-generated waste. The interview data involves 12 executives and professionals responsible for environmental issues and decision making in their respective ports. The interviews highlighted the need for standardized environmental legislation and related procedures, which would result in coherent measurement systems. These systems would enable transparent environmental monitoring, thus maintaining the ports' competitiveness. A common environmental legislation would support the emerging waste management system for the whole Baltic Sea area. The study suggests that ports should focus on handling specific types of wastes and collaborate as a spatial network. Specialization to allow the discharge of certain fractions of waste is essential. The paper concludes by addressing demands for future research, particularly vessel- and customer behavior-focused studies.

Keywords: ports; waste management; Baltic Sea; cruise ships; sea environment; recycling

1. Introduction

Maritime transportation trends have changed rapidly during the last decade, facing numerous green port challenges [1,2]. The number of passengers rises steadily, by more than 250% from 2000 to 2016 [3]. The cruise ship market has grown worldwide and has consequently "introduced a unique set of environmental pressures that need to be addressed and investigated, particularly those pertaining to waste management" as Butt ([4], p. 592) observes. Three trends are identifiable in the Baltic maritime transportation: (1) an increased intensification of shipping; (2) a change in the structure of transported goods (steady increase of liquid bulk); and (3) ports aiming to improve their operations using numerous developments and programs.

A crucial part of minimizing environmental impacts in the Baltic Sea area is an efficient and well-functioning waste management system in the cruising ports [5–7]. This research analyzes cruise ship-generated waste in four Baltic Sea cruising ports. The study ports are the Port of Helsinki, Ports of Stockholm, Port of Tallinn and Copenhagen Malmö Port. There is a shortage of research dealing with cruise ship-generated waste streams and especially concerning port waste management in the Baltic Sea area (for large oil tankers, see [8]). This study aims to bridge this gap using a special geographic setting and port management (also [9]). The research questions are:

- How is cruise ship-generated waste handled in the Baltic Sea area, and what quantities are involved?
- Are individual ports already specialized in specific types of waste handling management, and how does this reflect on the "no special fee" system?
- Could collaboration between the specified four ports be improved to better handle waste from cruise ships, and can certain fractions be discharged in ports specialized in specific types of waste?

Logistics and the cruise ship industry go hand-in-hand with environmental impacts (e.g., [10–13]). Environmental impacts are managed by minimizing unnecessary transportations, maximizing shipment loads and by cutting down transportation speeds, simultaneously minimizing the usage of fuel and the production of air emissions. Although occurring seldom, the environment can be significantly affected by accidents. Accidents may result in oil spills from the ship itself or from its cargo. Other relevant issues include the use of energy and natural resources; the areas used for the ports; erosion; and other health and environmental hazards produced by the off- and on-loading of goods [14]. Waste streams are considered unevenly distributed, although laws and regulations state otherwise. The Baltic Sea is a relatively small area with special environmental characteristics and business potential for ports (see [15–17]). The cruising ports are also close to each other. This indicates that vessels do not need to hold on to produced waste for extended times.

The cruise ship industry is steadily growing, with more than 22 million people cruising annually worldwide and 55 new ships to be launched between 2015 and 2020 worldwide (see [18,19]). Th impact of these waste streams will vary due to laws and regulations, port reception facilities and waste management plans onboard individual cruise ships (also [20]). Extensive research on waste streams has mainly been accomplished in the USA, the U.K. and parts of Europe and South Korea (see [21–27]).

2. Maritime Transport, Ports and Waste Management

2.1. Cruise Ship Waste Streams and the "No Special Fee" (NSF)-System

The International Maritime Organization (IMO) is a specialized agency of the United Nations and the global regulator of shipping. The Baltic Sea region is a designated special area in the International Convention for the Prevention of Pollution from Ships (MARPOL). The convention was first adopted in 1973 by the IMO and later updated by amendments. The MARPOL protocol is one of the major international agreements relevant to cruise ship pollution (also [28,29]). Regulation by six technical Annexes prevents and minimizes pollution from ships, both accidental pollution and that from routine operations [30]. The most important regulation to this study is Annex V on pollution by garbage from ships (Appendix A). According to this Annex, plastics and all other garbage, including paper products, rags, glass, metal, bottles, crockery, dunnage, lining and packing materials, are prohibited from being discharged into the sea. The only exceptions to discharging overboard relate to safety or the release of garbage due to damage. The vessels need to have a garbage record-keeping book on-board to record all discharge operations, including accidental loss or escape of any garbage, and completed incineration at port and at sea. The Port Authority of each port is also obliged to ensure the provision of port reception facilities, without causing undue delay to vessels ([31], pp. 241–246).

Currently, numerous leading cruise lines have implemented practices and procedures to reduce environmental impacts [32]. According to MARPOL 73/78 and the EU Directive 2000/59/EC [33], ports are obligated to maintain adequate port reception facilities to cope with the volume of waste generated by vessels calling to the ports (also [34]). National policies govern the countries' waste handling. The European Maritime Safety Agency (EMSA) report [35] maintains that a majority of European ports facilitate the collection of sewage. Few ships request the use of the service, however, as ships can still legally discharge sewage into the sea. To protect the Baltic Sea environment, the Helsinki Commission (HELCOM) introduced the NSF-system in 1998.

HELCOM's ([36], p. 2) definition of the NSF is "a charging system where the cost of reception, handling and disposal of ship generated wastes, originating from the normal operation of the ship,

as well as of marine litter caught in fishing nets, is included in the harbor fee or otherwise charged to the ship irrespective of whether wastes are delivered or not". Thus, ships calling at ports with the NSF-system implemented will pay the same port fee whether the ship leaves waste or not. Passenger ships or other ships calling at the port regularly during the year can have an authorized certification not to leave their waste in the port. Thus, these ships are obligated to handle their own waste management. The NSF-system encourages ships to deliver waste ashore, thereby avoiding undesirable waste streams between ports and preventing discharges into the sea. New recommendations have since been established, and the definition and explanation of the system used here refer to the HELCOM recommendation 28E/10 [36], superseding recommendations 19/8, 26/1 and 28/1. The four ports of this study have implemented the system.

The NSF system requires every ship to pay for the reception, handling and disposal of oil residues, sewage and garbage at any calling port. The fee involved covers waste collection, handling and processing, including infrastructure, and is usually counted on the basis of a ship's gross tonnage. Moreover, the waste management fee does not cause financial profit for the port. The fee only covers investments in reception facilities, the operation of reception facilities, repair and maintenance costs of such facilities and the costs of handling, treatment and final disposal of received wastes. Hence, the system should not be economically competitive amongst the ports. As ships are required to leave any waste generated from their last port of call at the following port, waste streams ought to be evenly distributed. Consequently, waste management is a complex problem because of the environmental, economic and social aspects that must be considered [37].

Per EU waste legislation and policy, the prevention of waste production is closely linked to manufacturing methods and also influences a consumer's demands. The EU Directive 2008/98/EC ([38], p. 4) states "The first objective of any waste policy should be to minimize the negative effects of the generation and management of waste on human health and the environment. Waste policy should also aim at reducing the use of resources, and favor the practical application of the waste hierarchy." The directive particularly states that waste management should be carried out without risking water, air, soil, plants or animals; without causing nuisance through noise or odors; or negatively affecting either the countryside or places of interest. A waste hierarchy (from prevention to disposal in five steps) was first introduced in 1997 by the European Commission (EC). Thus, the minimization and recycling of waste has already been a hot topic for two decades.

2.2. Laws and Regulations on Ship Waste Management

An average cruise ship sailing the Baltic Sea has approximately 2000–3000 passengers and 800 workers. People, both passengers and workers, and different on-board activities produce different types of wastes, including wastewater, oily waste, solid waste, hazardous waste and food waste (also [39]). A minimum of 1 kg of solid waste, two bottles and two cans per passenger and an amount of 50 tons of black water (sewage) are generated by an average cruise ship per day [4,32]. A new type of waste called scrubber waste has also been created, resulting from new legislation [40] on sulfur emissions introduced on 1 January 2015. The new legislation, amending Directive 1999/32/EC, states that the sulfur content of fuel mass cannot be more than 0.10%. For satisfactory waste handling, the fractions need to be sorted on-board a ship (e.g., [41]).

The resolution [42] in Annex V states that each port must ensure adequate facilities at ports and terminals for the reception of garbage, without causing delays to ships. Discussions on adequate facilities have been heated among ports and shipping companies, as sizes and measurements are minimally defined. This resolution divides garbage categories into nine fractions; plastic, food wastes, domestic wastes, cooking oil, incineration ashes, operational wastes, cargo residues, animal carcasses and fishing gear. Domestic waste is not divided into subgroups. The resolution only advises how to divide domestic wastes, such as paper product, rags, glass, metal, bottles and crockery. Within special areas, food wastes may be discharged when on route and no less than 12 nautical miles from

the nearest land (also [43]). Food should be comminuted or ground, and it should fit through a screen with openings no greater than 25 mm.

Another international directive with implications for the cruise ship and port business is EU Directive 2000/59/EC on port reception facilities (PRF) for ship-generated waste and cargo residues adopted by the EC in 2000. By improving the use and availability of PRFs, the Directive aims to reduce illegal discharges from ships, thereby enhancing the protection of the marine environment. This directive pursues the same aim as the MARPOL 73/78 Convention, focusing on ship operations in European Union (EU) ports. The Directive ([33], p. 82) further announces that "in order to reconcile the interest of the smooth operation of maritime transport with the protection of the environment, exceptions to this requirement should be possible taking into account the sufficiency of the dedicated storage capacity on-board, the possibility to deliver at another port without risk of discharge at sea and specific delivery requirements adopted in accordance with international law". This allows ships to keep wastes of particular standards on-board and grants ports more accurate waste handling and better recycling methods and opportunities. Garbage that can be recycled and reused should not be defined as waste.

3. Case Studies

The Baltic Sea is a very sensitive maritime area as a cruising destination network [44]. It is the second largest brackish water basin after the Black Sea, and covers the Gulf of Finland, the Gulf of Bothnia, the Gulf of Riga, the Baltic proper and the Belt Sea (also [45,46]). Baltic Sea water changes slowly because of shallow water, the lack of tides, low salinity and its location on a tectonic plate. The Danish Strait is the only connection with the open seas. Therefore, harmful substances brought to the Baltic Sea will stay there for a long time. Consequently, the area is highly sensitive to all environmental impacts. Eutrophication of the Baltic Sea is a severe threat, and algal blooming is an annual phenomenon.

All four ports, Copenhagen Malmö, Helsinki, Stockholm and Tallinn, have ISO 9001:2008 Quality Management System and ISO 14001:2004 Environmental Management System certificates (also [47]). Furthermore, all ports follow the MARPOL 73/78 convention, the EU Directive 2000/59/EC and have introduced the NSF-system (see [48]). Each port is expanding its port area, as seen in Table 1. The Port of Helsinki was granted an exceptional permit for its West Harbor in 2014 in accordance with the original plan.

The ports are all important at the EU-level, as can be seen from Table 1. In order to improve Europe's infrastructure network, the EU defined the ports of Stockholm, Helsinki and Copenhagen Malmö as "core ports". These three ports belong to the Scandinavian-Mediterranean corridor. As the name implies, it is a network of roads, maritime roads, ports and nodes from Russia through Finland and Sweden all the way through Europe, ending in Malta. Moreover, the Port of Helsinki is part of the North Sea-Baltic Network together with the Port of Tallinn [49–51]. The ports' environmental policies differ slightly from each other, but their essence is the same.

Table 1. Summary of study port characteristics.

	Cargo Volume 2014 (Millions of Tons)	Passenger Volume 2014 (Millions of Passengers)	Number of Employees 2014	Infrastructure Improvements	Cruise Ship Improvements	EU Level	Environmental Policy
Port of Helsinki	10.8	10.9	160	Expanding West harbor (2017–2018); increasing the drought of the Vuosaari route	Service point for cruise ship crew	Twin-port II, M EUR 30 (2015); core port	Good practices of all parties at the port. All operation promotes recycling and reclamation. Implement investment that spares the environment.
Ports of Stockholm	8	11.7	146	Rebuilding and expanding Kapellskär (2014–2016); Värtahamnen port and city development (until 2016)	Mobile gangway at Nynäshamn and new cruise berth at Frihamnen	Core port	Working actively, long-sightedly and strategically to create reliable and sustainable transportation.
Port of Tallinn	28.3	9.6	275	LNG bunkering terminal by 2017; expanding Muuga harbor	Microtunnel, receives sewage up to 1000 m^3/h	Twin-port II, M EUR 30 (2015)	Operating environmentally friendly and preventing pollution. Assessing all of the environmental impacts when planning.
Copenhagen Malmö Port	14.5	1.6	384	Road traffic and bus services expanded; new quay	On-board check in	Core port	Focus on how the port should work. Environmental aspects included in analysis of the entire supply chain.

4. Data, Methods and Limitations

The methodology is mainly qualitative, although available statistics collected by statistical offices and port authorities in their respective countries are applied. They are mainly waste amount statistics. The statistics provide the port context for each case, and semi-structured interviews deepen the focus on the processes and specifics of each port. The selection of candidates to interview was based on management and control of the environment and waste handlings of international cruise ships in each port. All interviews were conducted in the mother tongues of the interviewee: interviews held in Stockholm and Copenhagen were in Swedish; in Tallinn, they were in English; and in Helsinki, they were in Finnish (see Appendix B for the list of interviewee and their positions).

The interviews were held at each port with one, two or three participants at a time. In total, 12 persons were interviewed on nine occasions. Seven of the interviews were done with a single person; one included two persons, and one three. During the single interviews, it was learned that group interviews (done last) might provide better insights based on the earlier responses. The method is a form of the snowballing technique in interview studies. As the interviews were designed to be in the form of discussions and social interaction, it was possible to have interviews with multiple persons at a time. All interviews took place with permission. Each interview lasted between half an hour and an hour, and all of the interviews were transcribed to enable coding and analysis of the discussions (e.g., [52]).

The interviews were thematically structured (see Appendix C): most of the questions were designed to lead into a discussion with open answers, and the overall interview had five main themes. The themes were set up to cover the waste reception from cruise ships at port, how the port itself is functioning and cooperating with other ports regarding reception and other environmental issues. The five themes were: (1) port reception facilities; (2) cruise ship-generated waste; (3) cooperation with the other ports; (4) national legislation; and (5) sustainable development and the future. The analysis of the interviews was made through the transcribed material.

The quality of the semi-structured thematic professional interviews was verified at an early stage, through framing of the interviews. The frame was designed with additional tacit knowledge obtained from the Port of Helsinki and the University of Helsinki. The statistical data should be reliable, as they involve the official numbers used both in the annual reports (of the ports) and official national statistics. The results of this research can be compared and applied to similar research in other geographic areas.

5. Results

5.1. Distribution of Waste among the Ports

The distribution of waste streams among the four ports is uneven, which supports one of the presuppositions of this study. The first study question is illustrated in Table 2, which shows the percentage of total discharged garbage and the percentage of the total number of passengers between the years 2010 and 2014. The following fractions have been counted to the total amount of garbage: food waste, cardboard, glass, metal, mixed domestic waste, hazardous waste and other wastes (mainly wood and cooking oil). The fractions are not evenly distributed, because if they were, the percentage number of both figures would be more or less the same. It is assumed that the amount of waste on-board cruise ships is directly correlated with the number of passengers. These data show that the Port of Tallinn is the port receiving the highest quantity of garbage. The Port of Helsinki, Ports of Stockholm and Copenhagen Malmö Port receive less garbage compared to the number of passengers. The results are established from the gathered waste streams data from each port. The statistics of this research covers only cruise ships.

Table 2. Passenger and waste accounts obtained from the study ports (N/A = Not Available).

		Passengers	Oily Wastes		Garbage (Ton)							Total Garbage (Ton)	Sewage (m^3)
			Oily Wastes (m^3)	Oily Rags (Ton)	Food Waste	Cardboard	Glass	Metal	Mixed Domestic Waste	Other Wastes	Hazardous Waste		
Helsinki	2010	342,000	2343	1.1	28.9	1.0	1.4	0.3	567.4	3.7	0.5	604.2	50,200
	2011	385,000	2529	0.9	216.8	1.4	0.7	0.7	636.1	0.0	1.6	858.3	51,200
	2012	368,000	2364	0.3	204.0	1.8	3.6	0.3	536.3	0.0	0.1	746.3	55,500
	2013	420,000	2891	3.0	429.0	3.0	13.0	1.0	759.0	3.3	1.5	1212.8	51,561
	2014	420,000	2668	1.7	366.6	87.7	172.1	34.7	716.8	4.1	9.6	1393.2	63,528
Stockholm	2010	415,000	1858	23.3	N/A	3.7	9.2	93.1	739.1	104.9	82.7	1056.0	29,679
	2011	452,000	2162	10.2	N/A	10.8	10.5	39.5	728.5	68.0	51.4	918.8	41,631
	2012	470,000	2064	3.5	N/A	20.1	0.0	36.9	782.9	64.6	15.2	923.3	49,929
	2013	485,581	1837	0.2	N/A	2.5	62.9	0.1	609.0	7.2	35.2	717.1	51,803
	2014	470,000	2412	N/A	N/A	7.4	0.7	5.3	649.7	15.4	34.6	713.1	46,641
Copenhagen	2010	662,000	1790	N/A	N/A	N/A	N/A	N/A	2753.0	N/A	N/A	2753.0	14,631
	2011	815,000	2724	N/A	N/A	N/A	N/A	N/A	1675.0	N/A	18.0	1693.0	8905
	2012	840,000	2779	N/A	N/A	N/A	N/A	N/A	1504.0	N/A	17.0	1521.0	4180
	2013	800,500	1839	N/A	N/A	N/A	N/A	N/A	1545.0	N/A	18.0	1563.0	1690
	2014	739,000	1957	N/A	N/A	N/A	N/A	N/A	1778.0	N/A	21.7	1799.7	5058
Tallinn	2010	390,000	4453	18.3	204.3	385.0	395.4	97.9	689.0	114.3	65.7	1951.7	3976
	2011	437,517	4158	25.8	204.3	331.6	382.2	84.0	730.8	237.6	113.1	2083.6	4076
	2012	440,504	4906	22.2	179.1	306.7	242.2	85.5	681.1	190.8	151.2	1836.6	7195
	2013	519,319	6020	26.7	314.7	455.0	382.2	104.7	998.3	331.8	198.3	2784.9	7172
	2014	479,000	5120	50.7	349.8	349.4	395.4	111.3	696.1	261.1	259.5	2422.6	3216

Wastewater discharge is the most unevenly distributed fraction. Here, again, the amount of wastewater produced on-board a cruise ship is in direct correlation with the number of passengers. Figure 1 shows the number of passengers and the amount of the received wastewater in each port between 2010 and 2014. In the Port of Helsinki and the Ports of Stockholm, the amount of received wastewater is remarkably higher than the number of passengers; in Copenhagen Malmö Port and Port of Tallinn, the opposite is true. The decline in Copenhagen Malmö Port can most likely be explained by the restriction put on the amount of discharged wastewater.

The efficient wastewater facilities at the Ports of Helsinki and Stockholm receive all wastewater without extra charge or other restrictions. Both ports have facilities to connect the pipelines from cruise ships directly to the municipal wastewater systems. As a result, a vessel can discharge wastewater for as long as it is at quay. Copenhagen Malmö Port and the Port of Tallinn have already installed improvements in wastewater facilities.

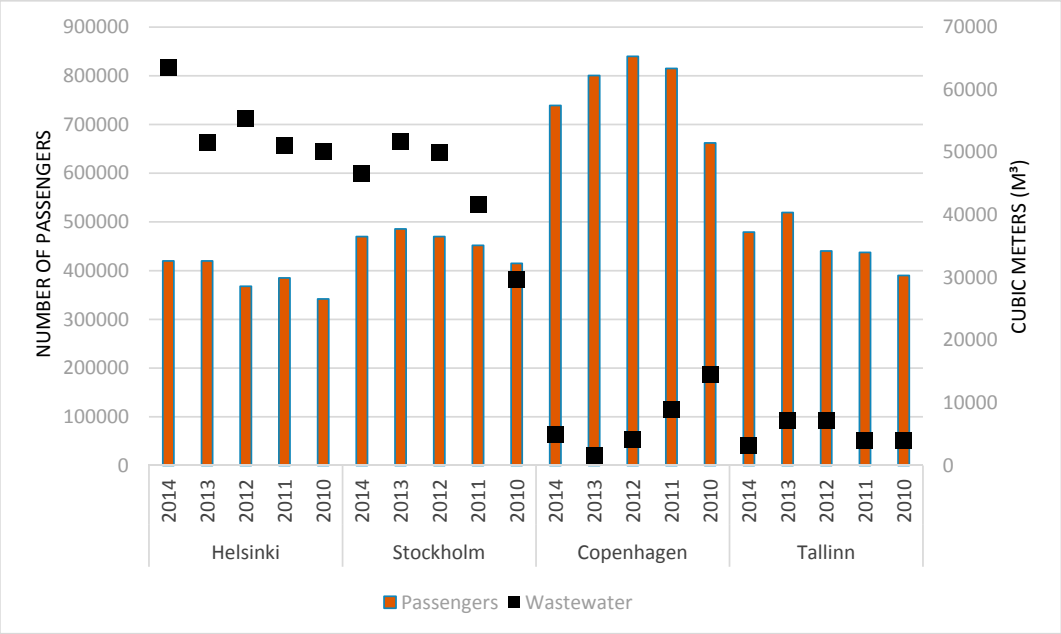

Figure 1. The uneven distribution of discharged wastewater in the ports, 2010–2014.

The Port of Tallinn receives notably more amounts of oily wastes than the other ports (Table 2). As seen in Table 3, the Port of Tallinn and the Ports of Stockholm are the only ports without a restriction on the quantity of oily wastes discharge allowed. The wastewater distribution among the ports is more unevenly distributed than the garbage. The port receiving the largest amounts of wastewater is clearly the Port of Helsinki, followed by the Ports of Stockholm. The other two ports, the Port of Tallinn and Copenhagen Malmö Port, receive remarkably less wastewater. The amount of wastewater at the Ports of Stockholm has risen, except for 2014, when it declined slightly. The Port of Tallinn is specialized in receiving and handling oily wastes and has the necessary facilities for this. It received 42% of all oily wastes between 2010 and 2014. The port's daughter company, Green Marine Ltd., processes oily wastes to produce recycled new products.

5.2. Waste Management in the Ports of the Study

Waste management procedures in the four ports under study differ slightly from each other. The national laws on waste management in each country also vary. Table 3 shows the waste management charges. The ports have implemented the NSF-system, and Table 3 presents the basis for the tariff calculation. It also shows the similarities and differences of the ports and the various possibilities and abilities to handle different waste fractions involved in the second study question.

The ports have their own waste management charge. The charge is calculated per gross tonnage in all four ports. The table shows which fractions belong to this charge and whether there are any restrictions. The table does not show the recyclable fractions separately; instead, they are included in domestic waste. Recyclable wastes received without any extra cost by all of the ports include paper/cardboard, glass and metal. Cruise and other ships calling at any port pay other charges, in addition to this tariff, including vessel charges, mooring and unmooring, water supplies and quay charges. The fees and amounts vary from port to port, as the NSF-system does not define amounts per se. Furthermore, each port as an independent business runs on slightly different grounds (also [53]).

Table 3. The study ports and their tariffs according to the waste types in 2015 (GT = Gross Tonnage).

	Copenhagen	**Tallinn**	**Helsinki**	**Stockholm**
Waste management charges	DKK 3.60/GT (≈€0.50)	€0.032 or €0.029/GT	€12.65/100 net (min €233, max €2915)	SEK 0.53/GT (≈€0.06) (max SEK 10,450 ≈€1142)
Oily wastes	No special fee; "oily tank washing water" costs DKK 590/m^3	No special fee	No special fee (max 20 m^3)	No special fee
Wastewater	Only black (130 L/day); gray water costs DKK 115/m^3 (≈€82)	7 m^3 no special fee; the ship pays for the exceeding amounts	No special fee	No special fee
Domestic waste	No special fee	No special fee	No special fee	No special fee
International food waste	No special fee	No special fee	No special fee (max 7 m^3/6 ton)	No special fee
Hazardous waste	No special fee	No special fee	On the basis of costs that occurred	No special fee
Electronics	No special fee	No special fee	On the basis of costs that occurred	No special fee
Scrubber waste	On the basis of costs that occurred	No special fee (Ellen Kaasik, verbal information, 28 May 2015)	On the basis of costs that occurred	On the basis of costs that occurred, tariffs by asking the port
Reductions	7th (and following) call 25% reduction	If the cruise ship sorts: €0.029/GT	None	SEK 5.51/pax reduction if sorted; LNG ship SEK 0.05/GT 11th visit reduction (and following)
Passenger fee	DKK 3/pax (≈€0.40)	€1.46/pax	€0.965/arriving pax; €0.965/departing pax	SEK 31.53/pax (with reduction 26.02/pax (≈€2.85))
Restrictions	Waste fee includes only black water	The waste fee includes only 7 m^3 wastewater	Loading time 4 h; going over time: €73.50/h	
Remarks	2015 sorting started at the port			1 mill. SEK to vessel owner that rebuilds the vessel to use LNG; Discounts if the carbon dioxide emissions are low

In Copenhagen Malmö Port, all of the new quays can receive wastewater directly into the municipal wastewater system. The old quays do not have this ability; therefore, Copenhagen Malmö Port has decided to limit wastewater quantities received. The port receives some amounts of black water free of charge, whereas gray water always has a fee.

> "They [the cruise ships] may not leave water here, and they don't do. They can discharge cleaned water into the sea, but of course we do receive it if they want. Black water is free of

> charge, however, they must pay for gray water. But if they declare everything as black water they can leave it . . . And some vessels do." (Manager Strategy and Planning, Copenhagen)

Ships are given reductions if they run on liquefied natural gas (LNG) or have small nitric oxide emissions. A ship that is rebuilt to use LNG will receive a reward of one million Swedish crowns. The Port of Stockholm is a forerunner in tempting shipping companies to become more environmentally friendly. The Port of Helsinki will give reductions to cruise ship discharging wastewater at the port from the year 2016 onwards according to an interviewee from the Helsinki Port.

Cruise vessels are obliged to send a form to the port clarifying the types of waste being discharged and in what quantities. This allows the port to order the right kind of containers and trucks to receive the fractions. As the numbers are usually estimates, however, the actual fractions may vary.

> "Of course, we are flexible. If the ship has already arrived at the quay and they have some other fractions and amounts of waste, we will come up with a solution to receive it. They [the ship] always notify the amounts in cubic meters which is only an estimation. These numbers are just indicative; sometimes there might be large differences. Sometimes the amounts might be less but usually it is more." (Harbor Master, Helsinki)

It is in the port's interest to ensure that vessels calling at the ports are running according to the associated laws and regulations. However, the port cannot function as an authority. Additionally, the interviews had a common trend: the waste fee payable by cruise ships needs to break even with the expenditure on waste management at the ports.

5.3. Sorting, Recycling and Reusing of Cruise Ship-Generated Waste

Recycling and reusing of waste is commonplace today. If they are sorted properly, most garbage subgroups can be reused or recycled. For example, oily wastes can be processed into a new oil product. The reception and recycling of cruise ship-generated waste in the ports of the Baltic Sea are well established, although not very long-standing (approximately ten years). Every port stated that they recycle over 50% of all cruise ship-generated waste.

In all study ports, most of the cruise ship-generated waste is recycled. Thus, quantities of hazardous waste also go to treatment plants, where the waste is handled. To get a clear and measurable estimate of the best practice to use, a life cycle assessment (LCA) of waste management throughout the whole chain is required. Zuin et al. [37] present an LCA on-ship-generated waste at the port of Koper and conclude, among other things, that the use of disposal in landfill should be avoided; the use of electricity minimalized; and the production of waste on-board cruise ships reduced. LCA methodology on waste management should be produced separately at all four ports; consequently, research on costs and (environmental) benefits would determine the best practice (also [54]).

Referring to Zuin et al. ([37], p. 3037): "an integrated management of ship-generated waste will be achieved through the provisions of adequate reception facilities that encourage the disposal of waste in ports and terminals, through the adoption of recycling or reuse systems, and by removing any incentives for illegal discharges at sea." This can be interpreted in the Baltic Sea as sharing the burden of waste management between closely-located ports. Adequate reception facilities are not needed at each of the ports.

> "I think a system like this could work; if it is put into action in a good way. If the ports would specialize in some fractions the cooperation would most likely also improve." (Deputy Harbor Master, Stockholm)

Most of the experts interviewed considered this to be a "good system". Problems identified include the capacity of the vessels and the laws and regulations in each area. The regulations force vessels to leave all of their waste at the calling port. According to the Head of Quality and Environmental Management at the Port of Tallinn, a similar proposal made a few years previously was rejected. Scrubber waste is a new fraction of waste resulting from the sulfur directive enforced in January 2015.

The Port of Tallinn is the only port to interpret this fraction as belonging to the NSF-system and has therefore chosen to receive scrubber waste without extra charges. Scrubber waste is an expensive waste fraction, and in the other ports, vessels will be charged per amounts of scrubber waste discharged.

Interview data provide answers to the third research question. The four ports work together and also search for new ideas and solutions together, in particular regarding environmentally-friendly solutions. This outcome complies with Kunnaala-Hyrkki et al. [55] that sharing best practices will allow ports to choose the most cost-effective measure to decrease their environmental impact. It is important to remember that these ports have the same customers, as the Manager Cruise and Ferry and Deputy Harbor Master states in his interview. The Head of Quality and Environmental Management at Tallinn also explained the cooperation:

> "We [the ports] are all together in many different organizations through which we meet many times a year. We can all easily call or send an email to each other and ask whatever we want." (Head of Quality and Environmental Management, Tallinn)

The environmental section of the ports does not yet yield substantial economic benefits, but the experts interviewed considered that it will in the long term. The ports' images are highly dependent on their environmental achievements. Current environmental discussions indicate that environmentally-friendly innovative solutions will be profitable in the long run (also [56]). If an updated waste management system is introduced to the Baltic Sea, it is not only the responsibility of the ports. It was noticed throughout the interviews that communication between the port, owner and the vessel itself is sometimes slow. Communication between the port and ship owner tends to run smoothly, but it takes time before information reaches the vessel.

6. Conclusions and the Future Research

The studied ports have quite similar environmental measurements, but there are also clear differences. A unified legislation for all EU ports would diminish this variation. The ports would all have the same environmental legislation and procedures and, therefore, also the same measurement systems. This would result in better environmental protection and maintain the ports competitiveness on an equal basis. Common environmental legislation is expected to support the proposed waste management system.

The first research question dealt with the quantities of cruise ship-generated waste handled in the Baltic Sea area today. The cruise ships sort their waste, and each of the four ports of the study handle different waste fractions. This study shows that due to the growth of the cruising market, the laws and regulations, port reception facilities and waste management plans onboard individual cruise ships, the impact of waste streams varies. The Port of Tallinn, Ports of Stockholm and, since 2016, the Port of Helsinki, all give special reductions on their waste fee if cruise ships follow their guidelines. This reduction means it will be cheaper to discharge wastewater at the port than into the sea. Copenhagen Malmö Port started receiving sorted fractions only in 2015. These reductions are incentives by the ports to encourage better waste handling by cruise ships.

The second question addressed the specialization of specific types of waste handling management by individual ports. The four ports clearly have different strengths in their waste handling management. The Port of Helsinki and Ports of Stockholm are specialized in receiving wastewaters from ships. Both ports receive unlimited amounts of wastewater straight to the municipal wastewater system at all of the quays. Furthermore, it appears that the cruise ships have been content with meeting the waste-handling company at the dock when discharging waste fractions. Communication between the port, ship owner and vessel was considered time consuming by the interviewees. Therefore, online forums would be good platforms for future discussion, in which all parties can participate. The Port of Tallinn is indisputably specialized in receiving oily wastes. Its daughter company, Green Marine Ltd., is specialized in processing oily wastes and can even create a new oil product from oily wastes.

The third research question involved the collaboration between the four studied ports (also [57]). Regulations state that a ship needs to discharge any waste produced on-board after the last port of call. There are exceptions: a ship may hold onto waste, if it can prove there is enough storage space on-board. These regulations are designed to improve waste distribution between the ports and, most importantly, to reduce dumping waste into the sea. Our research indicates deficiencies in the plan.

Cruise lines have their own varying environmental objectives and targets. Therefore, strategies for finding optimal practices for waste handling suitable to the current economy also vary. Cruise lines cannot be quoted as one entity. Zuin et al. ([37], p. 3037) argues that "a responsible and integrated management of ship-generated waste will be achieved through the provision of adequate reception facilities that encourage the disposal of waste in ports and terminals, through the adoption of recycling or reuse systems, and by removing any incentives for illegal discharges at sea". Collaboration between the ports, encouraging cruise ships to leave certain fractions in the specific port specialized in that fraction, will result in better waste handling management and, through that, a better environment (also [58–60]). Waste should not be defined as waste if it can be reused or recycled. This would be the most sustainable solution for the entire Baltic Sea if cruise ships are able to hold on to waste, not discharging it to the sea, but only at the port having the best reception facilities and high standards of reusing and recycling. The four ports considered this a good suggestion, if the cruise ship itself has the opportunity to hold on to the particular wastes (that is, if it has enough storage space).

Directions for the Future Research

A number of questions concerning waste management in Baltic Sea ports emerged from this study. Research concerning cruise ship-generated waste from a vessel's point-of-view is both desirable and necessary. An extensive study of cruise ships using interviews and surveys is desirable, for example, passenger attitudes and decisions provide a potential platform for future research (also [61]). In addition, the prevention of the production of waste itself needs to be addressed. An LCA of the waste chain, from the port to the end-station, would give an estimate of impacts (e.g., emissions, energy, incineration) deriving from management. The assessment could be done on all fractions in all four ports, as per Zuin et al. [37].

Cruise ships are the vessel type discharging the largest amount of wastewater. The amount of wastewater produced by other vessel types is considerably lower, as they do not have as many passengers and crew members. Whether or not the ships themselves could do something to reduce the amount of waste produced is a vital question. It mainly concerns cruise companies, however, as ports have a limited influence on this. The ports of this study have good environmental policies and management, but an updated system with closer cooperation is needed. The interviewed experts in each harbor agreed that the ports cooperate satisfactorily, but there is room for improvement. As environmental image and environmental expertise among ports are important elements of the ports' business, they need to pursue new innovative solutions for collaborative waste management.

Acknowledgments: This research was supported by the Helsinki Metropolitan Region Urban Research Program and Merenkulun Säätiö (Foundation for Sea Faring). We also thank all of the interviewees, participating ports and companies for their contributions.

Author Contributions: Irina Svaetichin and Tommi Inkinen conceived of and designed the experiments. Irina Svaetichin performed the experiments. Irina Svaetichin analyzed the data. Irina Svaetichin contributed reagents/materials/analysis tools. Irina Svaetichin and Tommi Inkinen wrote the paper.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Description of the MARPOL convention and what year each Annex entered into force [30].

	Year	Regulation	Description
Annex I	1983	Regulations for the Prevention of Pollution by Oil	Covers prevention of pollution by oil from operational measures as well as from accidental discharges. 1992 amendments made it mandatory for new oil tankers to have double hulls and brought in a phase-in schedule for existing tankers to fit double hulls, which was subsequently revised in 2001 and 2003.
Annex II	1983	Regulations for the Control of Pollution by Noxious Substances in Bulk	Details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk. No discharge of residues containing noxious substances is permitted within 12 miles of the nearest land.
Annex III	1992	Prevention of Pollution by Harmful Substances Carried by Sea in Package Form	Contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications.
Annex IV	2003	Prevention of Pollution by Sewage from Ships	Contains requirements to control pollution of the sea by sewage; the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; sewage which is not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land.
Annex V	1988	Prevention of Pollution by Garbage from Ships	Deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastics.
Annex VI	2005	Prevention of Air Pollution from Ships	Sets limits on sulfur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances. A chapter adopted in 2011 covers mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships.

Appendix B

List of Interviewees and Their Positions

Port of Helsinki

Mr. A.P.	Harbor Master
Mr. A.P.	Environmental Consult
Mr. K.M.	Managing Director

Ports of Stockholm

Ms. A.K.	Deputy Harbor Master
Ms. A.W.	Environmental Engineer
Mr. H.A.	Manager Cruise and Ferry and Deputy Harbor Master
Ms. U.P.	Environmental Engineer

Port of Tallinn

Ms. E.K.	Head of Quality and Environmental Management
Mr. J.V.	Specialist of Environmental Management

Copenhagen Malmö Port

Ms. A.B.N.	Administrative Coordinator
Mr. A.M.P.	COO Cruise and Ferries
Mr. G.N.	Manager Strategy & Planning

Appendix C

Interview Questions (Thematic Expert Interviews)

Person(s) interviewed: Status:
Port of: Date & time:
Do all cruise ships leave their waste at the port?
Does any cruise ship have a permit to NOT to leave their waste?
Who/what organization handles the waste?
What substances do you recycle?

Theme I: PRF

(1) Do the ships leave ALL their waste at the port?
(2) How does a ship inform the port about the waste to be left at the port?
(3) Does the port have a "No special fee" system implemented?
A good and equal system for ports in the Baltic Sea? Describe difficulties and advantages.
(4) Have any ships left scrubber waste at the port? If yes, how does the port deal with it?

Has research been done on waste generated from scrubbers?

Theme II: Cruise ship-generated waste

(1) How much of cruise ship-generated waste is recycled?
(2) Is it possible to recycle 100% of cruise ship-generated waste at the port?
(3) How does the port deal with international food waste?

Theme III: Cooperation with the other ports (Helsinki, Tallinn, Stockholm and Copenhagen)

(1) According to you, what works well and what does not in the ports' cooperation? How could the cooperation be improved?
(2) Could a system be introduced to the Baltic Sea area, whereby these four ports would cooperate fully and particular types of wastes would mainly be recycled in one port? What type of waste would be sent to which port and why?

Theme IV: National legislation on waste

(1) Please give a short description of your country's legislations.
(2) Does each country's waste legislation match the waste handling process at each port?
(3) Difficulties and advantages with the national legislations and cruise ship-generated waste.

Theme V: Sustainable development & future

(1) 1Please describe future environmental strategies and developments. Why have they been designed in this way?
(2) What are the ports' motives in improving the recycling of ship-generated waste?

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