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Article

Circular Economy Development in the Shipping Sector in Finland

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Abstract: The world is facing unprecedented sustainability challenges and circular economy (CE) can provide some solutions to promote more sustainable practices among companies. This study aimed at exploring, discovering, analysing and synthetizing the integration and application of the CE principles (10Rs) in the shipping sector in Finland. The research approach was based on qualitative research and similar approach has been applied in multiple previous studies. The findings of this study suggest that companies place most focus on the following 10R principles: (1) replacement of products or making of products redundant (R0); (2) rethinking of products (R1); and (3) reduction of the use of resources in the manufacturing and use of products (R2). The reuse of products (R3); repair of products (R4); refurbishment of products (R5); remanufacturing of products (R6); repurposing of products and their parts (R7); and recycling and recovery of materials (R8 & R9) received significantly less attention and approaches in these fields were often non-existent. There was typically some approaches related to the R8 and R9 principles whereas were few approaches were found related to R4, R5, R6 and R7. For many companies, there were no approaches at all related to R3-R7.The findings suggest that even though companies are not always reporting on and publishing online materials related to CE, many approaches related to the 10Rs are included in and integrated into current reporting and communication instruments and practices. This implies that they are also a part of management and monitoring practices including associated consideration in the context of company operations. In the future, shipping companies could place more emphasis on the aspects of CE that are linked to keeping products and materials in circulation such as repair, reuse, refurbishment, remanufacturing and repurposing. In addition, more focus is needed on recycling and recovery of all products and materials.

Keywords: circular economy; shipping sector; Finland

1. Introduction

1.1. Circular Economy Development

Circular economy (CE) aims at keeping materials, components, and products at their highest value and utility at all times covering both technical and biological cycles [1]. In addition, its regenerative by design and addresses increasing challenges related to resources at all levels [1]. It is noteworthy that ways to achieve the CE goals and the UN SDGs are often linked in many ways [2]. In addition, CE is a very influential concept to promote the achievement of the UN SDGs, and the Agenda 2030 and decentralized and low-tech CE projects can be helpful in this context [3]. A transition to a CE is about a new economic model based on systems-thinking encompassing focus on, for example, prolonged product cycles, cascaded use and virtual solutions [1]. CE can support more sustainable and resilient future including focus on climate change and resource depletion provided that obstacles such as behaviour change, technology transfer and lack of public-private investment can be addressed [4]

Many regional initiatives promote CE such as the EU Green Deal and the Regulation on taxonomy for sustainable activities and the application of sustainability principles by companies, practitioners and policy makers [5]. The overall promotion of CE at the national level requires focus

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on the establishment of private-public ecosystems to facilitate collaboration in an equal manner; up-to-date policies and advanced approaches such as eco-design; and supportive legislation (e.g., to develop waste value chains towards new CE business opportunities) [6]. National level measures to promote CE could encompass e.g., stronger support from the public sector and public institutions [7]. In addition, CE can potentially provide socio-economic benefits (e.g., reduced reliance on imports, resilience, improved public health and jobs creation) at the national level [8].

Any transition towards circular systems within planetary boundaries should include consideration of the social foundations of these systems covering relations between societal and material needs in terms of equity, fairness and justice at the global scale [9]. The origin of CE in Europe was motivated by the goals of sustainable development and sustainability as well as by the eradication of social injustices such as inequality, poverty and environmental degradation [10]. EU level CE discourse is quite holistic whereas policies tend to focus on end-of-pipe solutions without any focus on socio-ecological implications of a circularity transition. Thus, more holistic long-term thinking and multiple actions are necessary to (1) address the systemic challenges of a circular future from a diverse perspective; and (2) promote socio-ecological change considering both human well-being and ecosystem health [11].

CE could help the transition to a sustainable, just and resilient future considering the prevailing socio-ecological challenges. However, there is no clear view on how to define and implement or set targets for CE and various sectors and actors maintain CE discourses aligned with their interests without considering social, ecological and political implications [12]. The current linear economy conflicts with many environmental, social and economic challenges [13]. There is a lot of focus on the concept of CE in the context of efforts to achieve a more sustainable society [14,15]. and tackling of global challenges such as resource scarcity [15]. CE is promoted as a means to advance sustainable development [16].

CE imaginaries are aligned with sustainability whereas CE policy programmes usually minimize or ignore academic criticism [17]. In addition, CE business model innovation has received too little attention [16]. Businesses and policymakers should focus their efforts on remanufacturing, refurbishment and repurposing with particular emphasis on system effects [14]. There is a need for increased involvement of science, technology and innovation actors and other societal actors in CE policymaking processes [17]. The policy measures that can support CE encompass innovation and collaboration support as well as public procurement and fiscal measures that support circular goods and services [18].

1.2. Global and European Outlook

Overall, the world is not on the right path regarding meeting the UN SDGs [19]. There is a need for innovative and responsible (e.g., socially sustainable) ways to meet human needs and to discontinue unsustainable activities [19]. In general, critical actions to achieve sustainable resource use globally encompass the creation of circular, resource-efficient and low-impact solutions and business models [20]. The overall transformation towards sustainable resource use needs to promote sustainable production and consumption and discontinue practices that are most resource-intensive and create most environmental impacts [18]. In addition, CE strategies such as eco-design, reuse, repair, remanufacturing, recycling and refurbishment could help to achieve resource efficiency. These strategies maintain the value of materials and products and reduce the need for virgin material extraction and waste disposal [18]. Globally, CE is in decline and the Earth cannot sustain infinite growth in material consumption. This means that without urgent action there is no chance of achieving the broader environmental and social goals associated with CE such as increased use of secondary materials and reduction of emissions [19].

The potential circular solutions to be promoted encompass e.g., prioritization of circular materials and approaches; extending the lifetime of equipment, machinery and goods; and mainstreaming industrial symbiosis and efficiency. Additionally, there is a need to develop circular and sustainable skills and expertise [19]. The roadmap to a sustainable shipping industry highlights

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alignment with the UN SDGs encompassing focus on multiple areas such as (1) financing to promote sustainable performance and the uptake of associated design, technology and innovation approaches; (2) change to a diverse set of zero carbon energy sources; (3) resource efficiency; (4) zero-emission shipping; and (5) avoidance of negative environmental impacts [21]. Other important focus areas encompass novel standards of building, life cycle analysis of fuels, green corridors, investment in research and development, the development of fuel supply and a global price on carbon [22]. A global transition to zero carbon shipping requires multiple new technologies, cooperation among all stakeholders and a broad range of mutually supporting global regulations [22]. The future vision for international shipping comprises focus on the reduction of the carbon intensity of international shipping and promotion of the uptake of zero or near-zero greenhouse gas emission technologies, fuels and energy sources [23].

The European Green Deal, The Green Deal Industrial Plan, The Ecodesign for Sustainable Products Regulation and especially the new circular economy action plan all promote a transition to a CE including, for example, sustainable and circular products and net-zero technologies **[24–27]**. In general, the EU aims at making sustainable products the norm encompassing focus on designing more sustainable, circular and energy performing products [28]. In addition, the aim is to promote circular business models such as product-as-service models; reuse and repair services; reverse logistics; and on-demand manufacturing. Circular business models are designed to create and capture value as well as to limit and optimize the use of resources [28].

The Blue Economy Sustainability Framework provides a preliminary set of sustainability criteria and indicators for all blue economy sectors [29]. CE principles can be used to promote rethinking, reusing and recycling products and materials; provide new and sustainable business opportunities; and to reduce the overall impact of emission- and pollution-intensive industries. The overall sustainability framework encompasses criteria and indicators for environmental, social and economic sustainability and for sustainable governance. The indicators for sustainable governance include e.g., (1) the integration of the UN SDGs into company strategies and operations; (2) the application of nature-based solutions; (3) information and training about sustainability; (4) stakeholder engagement; (5) life cycle assessment and supply chain policy; (6) climate change adaptation measures; and (7) environmental impact assessments [29].

2. Materials and Methods

2.1. The Chosen Research approach

This study aimed at exploring, discovering, analysing and synthetizing the integration and application of the CE principles (10Rs) in the shipping sector in Finland. The specific result sections are structured based on the 10Rs. The chosen approach is innovative and creative with emphasis on novelty because there are no similar studies on the integration and application of the CE principles in the shipping sector in Finland.

The 10Rs used in this study were replacement of products or making of products redundant (R0); Rethinking of products (R1); Reduction of the use of resources in the manufacturing and use of products (R2); Reuse of products (R3); Repair of products (R4); Refurbishment of products (R5); Remanufacturing of products (R6); Repurposing of products and their parts (R7); Recycling of materials (R8) and Recovery of materials (R9) in accordance with the similar previous study [30]. In this study, the R8 and R9 principles were combined to be one unit of analysis called recycling and recovery of materials (R8 & R9).

The studied companies encompassed those member companies of the Finnish Shipowners' Association [31] that have produced online reports and/or materials related to sustainability, environmental management and overall responsibility. Those reports and associated materials were the materials of this study. The studied companies were Eckerö Group; Finnlines; Viking Line; Tallink Silja; Wasaline; Arctia; Bore; ESL Shipping; Meriaura Group; Alfons Håkans; and Rederi AB Nathalie (Tables 1-5).

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In general, this study applied a qualitative research approach [32] based on the idea that the purpose of the study needs to be the basis for design of the research approach. The following specific approaches were applied in this study: (1) collection and analysis of mostly qualitative information (textual materials); (2) organization and synthesis of information and evaluation and content analysis of that information; (3) pattern and category construction; and (4) summative synthesis and statements. In addition, the chosen qualitative approach applied open discovery and new insights and understandings [32].

Previous research has identified and synthesized the 10R framework for CE [14,33–35]. The 10Rs can be applied to the assessment of progress of CE transitions in product chains [32] and these CE frameworks can be used as a metric to measure CE at many levels [36]. In addition, companies can apply 10Rs to assess their potential to advance CE including creation of new business models. In general, businesses should focus their efforts on the realization of more desirable and shorter loop retention options such as repurposing, refurbishing and remanufacturing considering overall system effects [14].

Similar qualitative research approach and method has been applied in previous studies [37–39] as well as in multiple studies on CE that applied thematic analysis methodology [40] including analysis of documents and discourse [11,12]. For example, one previous qualitative research applied review of sustainability reports in the cruise and container shipping industry supported by review of relevant literature and practices related to sustainable development [41]. In addition, multiple previous studies have applied similar qualitative research approaches to study various aspects of CE [3,4,6–8,15,42–52].

3. Results and Discussion

3.1. The Identified 10R Approaches of Viking Line and Tallink Silja

The findings related to both companies are presented in Table 1. The identified 10R approaches of Viking Line encompassed, for example, investment in climate-smart vessels and update of technology throughout their life cycles (R0); creation of circular material flows and development of a new carbon-neutral sea route (R1); sustainability as a criteria for products in all product categories and reduction of environmental impacts (R2); reuse of materials (R3); use of fibres from textiles as sustainable raw materials and CE through processing of carpets into raw material for new carpets (R6); and sorting of waste and by-products generated by operations and maximization of recycling (R8 & R9). No approaches were identified for R4, R5 and R7. Not many approaches were identified for R3 and R6.

Table 1. Identified 10R approaches of Viking Line and Tallink Silja.

Viking line	Tallink Silja
Replacement of products or making of products redundant (R0): (1) application of new climate-smart technology [53]; (2) testing of alternative technological solutions [53]; (3) no use of environmentally hazardous paint on the bottoms of vessels [53,54]; (4) environmentally friendly cleaning routines [53]; (5) cooperation with local producers and use of locally produced food [53]; (6) use of digital information and reduction of paper consumption [53]; (7) sustainability as a criteria for products in all product categories [53]; (8) investment in climate-smart vessels and update of technology throughout their life cycles [53]; (9) sustainable wines in onboard shops [53]; (10) use of LED lights, solar cells and geothermal	**Replacement of products or making of products redundant (R0):** (1) reduction and phasing out of single use plastics [65,66]; (2) goal to become paperless business, office and service [65,66]; (3) local sourcing of products and buying of local materials and supplies [65,67,68]; (4) sourcing of sustainable products, supplies and materials [53,67,68]; (5) promotion of circular economy [65,67]; (6) use of liquefied natural gas fueled vessels in one route [65]; (7) installation of new and more efficient propellers for one route [65]; (8) development of CE principles within the company [68]; (9) use of only paper or reusable shopping bags [69]; (10) reduction of use of and replacement of plastic straws with biodegradable straws [69];

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heating [53]; (11) dynamic control system for the automatization of lights, heating and ventilation in cabins [55]; (12) use of azipod rudder propeller system to reduce fuel consumption [55]; (13) offering of vegan and plant-based options in restaurants [55]; and (14) offering of an option to add a biofuel surcharge for travel bookings [56]	(11) minimization of the use of single use dishware and unnecessary plastic usage in restaurants and cafeterias [69]; (12) abandoning of single use dishes and plastic Club One cards in stages [69]; (13) cooperation with suppliers to reduce plastic packaging [69]; (14) use of detergents without phosphates [69]; (15) use of energy efficient light bulbs and fluorescent lightning tubes including gradual change towards Led-technology [69]; (16) reduction of printing on board and on land operations [69]; (17) use of sustainable, certified and locally produced food and materials [69]; (18) development of vegetarian and vegan food selection and use of Nordic meat and materials produced in neighboring countries [69]; (19) gradual use of only chicken eggs that originate form open air coops [69]; and (20) provision of drinking water from a separate tank to fill the water bottles [69];
Rethinking of products (R1): (1) continuous improvement of sustainability and environmental work [53]; (2) gradual uptake of sustainable fuels (e.g., biogas and biodiesel) and phasing out of fossil fuels [53]; (3) strategic partnerships related to climate transition (e.g., international and national research and development projects) [53]; (4) participation in knowledge exchanges [53]; (5) commitment to the UN SDGs [53]; (6) integration of sustainability into value chain [53]; (7) sustainability as a basis of decisions with ecological and economic consequences [53]; (8) no use of environmentally hazardous paint on the bottoms of vessels [53,54]; (9) creation of circular material flows [53]; (10) continuous dialogue with cargo customers and collaboration with stakeholders as a part of sustainability work in cargo and logistics [53]; (11) development of a new carbon-neutral sea route [53]; (12) environmentally friendly cleaning routines [53]; (13) cooperation with local producers and use of locally produced food [53]; (14) use of digital information and reduction of paper consumption [53]; (15) sustainability as a criteria for products in all product categories [53]; (16) investment in climate-smart vessels and update of technology throughout their life cycles [53]; (17) sustainable wines in onboard shops [53]; (18) use of LED lights, solar cells and geothermal heating [53]; (19) gradual compliance with and continuous improvement to meet the EU taxonomy Regulation requirements [57]; (20) dynamic control system for the automatization of lights,	**Rethinking of products (R1):** (1) deliverance of sustainable environmental, ethical, labour and economic performance [65]; (2) compliance with legislation, regulations, standards, best practices, guidelines, internal policies and ethical norms including expectation of similar behaviour by all business partners [65,66]; (3) reporting based on the EU Corporate Sustainability Reporting Directive [65,67]; (4) development of the double materiality assessment process (e.g., circular economy, identification of sustainability areas, and wide value chain perspective and mapping) as a basis of new reporting in accordance with the European Sustainability Reporting Standards [65,67]; (5) trained staff for sustainability reporting [65]; (6) vessel level environmental data collection, verification and sharing with relevant authorities [65]; (7) reduction and phasing out of single-use plastics [65,66]; (8) goal to become paperless business, office and service [65,66]; (9) local sourcing of products and buying of local materials and supplies [65,67,68]; (10) sourcing of sustainable products, supplies and materials [65,67,68]; (11) promotion of circular economy [65,67]; (12) continuous increasement of energy efficiency and saving of resources [65]; (13) use of liquefied natural gas fuelled vessels in one route [65]; (14) installation of new and more efficient propellers for one route [65]; (15) partnering with organizations with similar goals and values [65,70]; (16) monthly monitoring and collection of environmental data from ships (under Significant Environmental Aspects) [65]; (17) reporting (climate change mitigation) based on, gradual

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heating and ventilation in cabins [55]; (21) use of azipod rudder propeller system to reduce fuel consumption [55]; (22) investment in sustainable maritime transport and climate-smart innovations [55]; (23) offering of vegan and plant-based options in restaurants [55]; (24) customers tips for a climate-smart trip [55]; (25) support of organizations that help to protect the Baltic Sea (share of plastic bag sales) [55]; (26) development of a carbon-neutral seaway between Turku and Stockholm [58]; (27) use of sulphur-free liquefied natural gas as fuel [59–61]; (28) optimized hull design [60,61]; (29) energy recycling system (conversion of waste heat from the engines into electricity) [60,61]; (30) utilization of waste cold from liquefied natural gas for cold storage and cooling equipment [60]; and (31) offering of an option to add a biofuel surcharge for travel bookings [56]	compliance with, and continuous improvement to meet the EU taxonomy Regulation requirements [65,67]; (18) engagement of stakeholders (investors, suppliers and partners) as part of the double materiality process [67]; (19) working towards the achievement of the UN SDGs [70]; (20) setting of goals that are linked to the UN SDGs including metrics for the assessment of development and impact [71]; (21) corporate sustainability strategy focus areas including looking after resources (linked to UN SDG 12 responsible consumption and 15 life on land), looking after the sea (linked to UN SDG 14 Life under water and 6 Clean water, looking after climate (linked to UN SDG 13 Climate action and 7 Clean energy) and looking after people (linked to e.g., sustainable communities) [71]; (22) introduction of new all-stakeholders-connecting-sustainability-agenda [71]; (23) collaboration with research institutions to advance technological innovations (e.g., to enhance energy, fuel and water savings) and with partners to reduce greenhouse gas emissions [66]; (24) continuous monitoring of the impact of supply chain and logistics [66]; (25) consideration of guidelines, codes and standards from maritime organizations [66]; (26) promotion of environmental awareness through training and education of employees [66]; (27) consideration of the efficient use of materials and energy in the operation of ships and office [66]; (28) application of similar environmental standards by suppliers, contractors and all affiliated companies [65,66]; (29) continuous dialogue with relevant authorities on current environmental issues [66]; (30) development of CE principles within the company [68]; (31) support of community organizations and activities that are aligned with corporate sustainability strategy and associated focus areas [72]; (32) saving of waste heat from engines and its reuse onboard for e.g., general heating [69]; (33) connection of vessels to shore power supply network [65,69]; (34) regular cleaning of hulls by divers and use of non-toxic paints (no chemicals that are harmful to the environment) [69]; (35) use of only paper or reusable shopping bags [69]; (36) reduction of use of and replacement of plastic straws with biodegradable straws [69]; (37) minimization of the use of single use dishware and unnecessary plastic usage in restaurants and cafeterias [69]; (38) abandoning of single use dishes and plastic Club One cards in stages [69]; (39) cooperation with suppliers to reduce plastic packaging [69];

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	(40) use of detergents without phosphates [69]; (41) use of energy efficient light bulbs and fluorescent lightning tubes including gradual change towards Led-technology [69]; (42) reduction of printing on board and on land operations [69]; (43) cooperation with partners with focus on the environment and community (e.g., research and awareness raising) [69]; (44) use of sustainable, certified and locally produced food and materials [69]; (45) development of vegetarian and vegan food selection and use of Nordic meat and materials produced in neighbouring countries [69]; (46) gradual use of only chicken eggs that originate form open air coops [69]; (47) reduction of food waste through cooperation with a partner and passengers (e.g., focus on environmental impacts and creation of information and awareness) [69]; and (48) provision of drinking water from a separate tank to fill the water bottles [69]
Reduction of the use of resources in the manufacturing and use of products (R2): (1) reduction of environmental impacts [53]; (2) minimization of emissions [53]; (3) compliance with EU legislation (e.g., Fit for 55) [53]; (4) reduction of the use of chemicals and water in operations [53]; (5) reduction of waste quantities [53]; (6) creation of circular material flows [53]; (7) reuse of materials [53]; (8) fuel saving using smart technologies [53]; (9) reduction of food waste in restaurants [53]; (10) use of digital information and reduction of paper consumption [53]; (11) sustainability as a criteria for products in all product categories [53]; (12) investment in climate-smart vessels and update of technology throughout their life cycles [53]; (13) sustainable wines in onboard shops [53]; (14) use of LED lights, solar cells and geothermal heating [53]; (15) continuous reduction of carbon footprint and work towards a climate-neutral future [55]; (16) use of shore power at ports [55]; (17) dynamic control system for the automatization of lights, heating and ventilation in cabins [55]; (18) utilization of waste cooling from liquefied natural gas [55]; (19) environmentally-sound management of residual products from operations [58]; (20) energy recycling system (conversion of waste heat from the engines into electricity) [60,61]; and (21) utilization of waste cold from liquefied natural gas for cold storage and cooling equipment [60]	**Reduction of the use of resources in the manufacturing and use of products (R2):** (1) reduction of waste [65,68]; (2) reduction and phasing out of single-use plastics [65,66]; (2) annual reduction of CO_2 emissions and pollution [65]; (3) goal to become paperless business, office and service [65,66]; (4) local sourcing of products and reduction of footprint through buying of local materials and supplies [65,67,68]; (5) sourcing of sustainable products, supplies and materials [65,67,68]; (6) promotion of circular economy [65,67]; (7) offering of an emissions surcharge for travel bookings [65]; (8) group level monitoring and analysis of fuel consumption and greenhouse gas emissions [65]; (9) continuous increasement of energy efficiency and saving of resources [65]; (10) control of the use of chemicals and pollutants [65]; (11) installation of shore power equipment on vessels and connection of vessels to shore power supply network [65,69]; (12) use of liquefied natural gas fuelled vessels in one route [65]; (13) installation of new and more efficient propellers for one route [65]; (14) monthly monitoring and collection of environmental data from ships (under Significant Environmental Aspects) [65]; (15) simultaneous increasement of CE practices and support of communities (e.g., reuse of items from ships, offices and hotels such as furniture, technical equipment, textiles, soft furnishings, bedding, decorations, lamps and food outside the company) [65,70]; (16) working towards the achievement of the UN SDGs [70]; (17) setting of goals that are linked to the UN SDGs including

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	metrics for the assessment of development and impact [71]; (18) corporate sustainability strategy focus areas such as looking after resources (linked to UN SDG 12 responsible consumption and 15 Life on land), looking after climate (linked to UN SDG 13 Climate action and 7 Clean energy) and looking after people (linked to e.g., sustainable communities) [71]; (19) collaboration with research institutions to advance techno-logical innovations (e.g., to enhance energy, fuel and water savings) and with partners to reduce greenhouse gas emissions [66]; (20) continuous monitoring of the impact of supply chain and logistics [66]; (21) consideration of the efficient use of materials and energy in the operation of ships and office [66]; (22) development of CE principles within the company [68]; (23) use of low sulhur fuel, economical navigation and use of modern engines and catalysers [69]; (24) saving of waste heat from engines and its reuse onboard for e.g., general heating [69]; (25) fuel monitoring system to optimize the operation of ships and to lower fuel consumption, emissions and use of energy [69]; (26) lower travel speed to reduce fuel consumption and emissions [69]; (27) regular cleaning of hulls by divers and use of non-toxic paints (no chemicals that are harmful to the environment) [69]; (28) calculation of emissions/footprint for passengers and cargo [69]; (29) use of only paper or reusable shopping bags [69]; (30) reduction of use of and replacement of plastic straws with biodegradable straws [69]; (31) minimization of the use of single use dishware and unnecessary plastic usage in restaurants and cafeterias [69]; (32) abandoning of single use dishes and plastic Club One cards in stages [69]; (33) cooperation with suppliers to reduce plastic packaging [69]; (34) use of detergents without phosphates [69]; (35) use of energy efficient light bulbs and fluorescent lightning tubes including gradual change towards Led-technology [69]; (36) reduction of printing on board and on land operations [69]; (37) use of sustainable, certified and locally produced food and materials [69]; (38) development of vegetarian and vegan food selection and use of Nordic meat and materials produced in neighbouring countries [69]; (39) gradual use of only chicken eggs that originate form open air coops [69]; (40) reduction of food waste through cooperation with a partner and passengers (e.g., focus on environmental impacts and creation of information and awareness) [69];

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	and (41) provision of drinking water from a separate tank to fill the water bottles [69]
Reuse of products (R3): (1) reuse of materials [53,62]; (2) creation of circular material flows [53]; (3) use of fibres from textiles as sustainable raw materials [53,62]; and (4) CE through processing of carpets into raw material for new carpets [53,62]	**Reuse of products (R3):** (1) adoption of the principle of reuse [66]; and (2) sending of as many item to reuse as possible [68]
Repair of products (R4): –	**Repair of products (R4): –**
Refurbishment of products (R5): –	**Refurbishment of products (R5): –**
Remanufacturing of products (R6): (1) use of fibres from textiles as sustainable raw materials [53]; and (2) CE through processing of carpets into raw material for new carpets [53]	**Remanufacturing of products (R6): –**
Repurposing of products and their parts (R7): –	**Repurposing of products and their parts (R7): –**
Recycling and recovery of materials (R8 & R9): (1) no discharge of waste water and treatment of all waste water ashore [53,63]; (2) sorting of waste and by-products generated by operations [53,62]; (3) maximization of recycling [53,62,64]; (4) creation of circular material flows [53]; (5) reuse of materials [53,62]; (6) use of fibres from textiles as sustainable raw materials [53,62]; (7) CE through processing of carpets into raw material for new carpets [53,62]; (8) recycling of glass, scrap metal and paper [53,62,64]; and (9) recycling of biowaste to produce biogas [55,62]	**Recycling and recovery of materials (R8 & R9):** (1) promotion of circular economy [65,67]; (2) strict zero-spill to the sea policy [65,66]; (3) monitoring and sorting of waste based on categories [65]; (4) adoption of the principle of recycling [66]; (5) development of CE principles within the company [68]; (6) recycling of metal, glass, plastic, cardboard, organic and special waste onboard [69]; (7) treatment of all waste waters in waste water treatment plants [69]; (8) investigation of the use of organic waste for composting [69]; and (9) reduction of food waste through cooperation with a partner and passengers (e.g., focus on environmental impacts and creation of information and awareness) [69]

The identified 10R approaches of Viking Line included, for example, local sourcing of products and buying of local materials and supplies as well as sourcing of sustainable products, supplies and materials (R0); promotion of circular economy and continuous increasement of energy efficiency and saving of resources (R1); simultaneous increasement of CE practices and support of communities as well as monthly monitoring and collection of environmental data from ships (R2); adoption of the principle of reuse and sending of as many item to reuse as possible (R3); and monitoring and sorting of waste based on categories and the development of CE principles within the company (R8 & R9). No approaches were identified for R4-R7. Not many approaches were identified for R3.

Circularity transition can support the sustainability of the maritime industry and actions such as industry-wide campaigns to create awareness are necessary [73]. Previous study on Finland that included also many maritime sector (e.g., shipping and port actors) concluded that (1) the principles of CE (10Rs) are considered to be important by most companies; (2) recycling and recovery of materials are perceived as particularly important by companies; (3) companies considered that the refurbishment, reuse and repair of products are very important or important; (4) important management approaches comprise business ecosystems, CE strategy and goals, and development of markets for recycled and recovered products and parts; (5) important CE assessment and measurement approaches include increase in recycled content in products, recovery, reduction in disposable products, prevention of premature obsolescence, recycling, waste minimization and utilization of waste as a raw material; and (6) important CE reporting approaches comprise reporting in the whole supply and value chain, continuous reporting of CE as a part of online communication of companies, the definition of best practices and best available techniques for CE [30].

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The main challenges and opportunities in the field of short sea shipping encompass decarbonization, digitalization and autonomous navigation [74]. It has been noted that synergies are very important for short sea shipping and more focus is needed on the role of policy makers in promoting cooperation and trust among all transport chain members [75]. For example, one study focused on the design of sustainable maritime supply chains and noted that it is important for shipping companies to apply the Use of Green Design Ships, Engines and Machinery technical requirement [76]. In general, the development of environmentally sustainable shipping operations can be advanced through environmental governance mechanisms and focus on the environmental performance of shipping operations [77]. The management of maritime logistics encompasses broader collaboration and partnering among private and public shipping companies, port authorities, stevedores and import and export companies. Sustainability requires the simultaneous balancing of environmental, social and economic dimensions of decisions, policy and general management of organizational functions [78].

The transition of seaports towards a CE can be assessed through, for example, the application of CE indicators, 9Rs and various sustainability perspectives based on the collection of information from open-access documents, annual reports, seaport webpages and Google searches [79]. In addition, it has been noted that ports are facing environmental and societal challenges that affect their operations, and CE provides a way for ports to redevelop sustainably and remain open in the future [80]. There is a need to build inter-organizational networks within the seaports industry to enhance economic, social and ecological dimensions of sustainability as well as to promote overall cleaner production [81]. The development and application of tools could assist port managers to both identify essential environmental aspects and continuously improve the environmental performance of ports including associated creation of broader benefits to the whole port sector [82].

In addition, tools such as sustainability indexes covering institutional, economic, social and environmental dimensions of sustainable development can be applied to the assessment and benchmarking to provide information for port authorities and stakeholders [83]. Many ports include corporate sustainability topics in their online communication practices but much more effort is still needed in this field [84]. In addition, online sustainability communication by European ports varies among ports from different countries and there are not many studies on corporate sustainability of ports even though ports have direct impacts on social and physical environments in which they operate [84]. For example, small ports typically overlook practical sustainability management and current environmental management, and safety systems are not supporting sustainability [85]. In general, more research is needed on drivers and barriers to the sustainability of ports including the role of leaders in making ports more sustainable [86].

3.2. The Identified 10R Approaches of the Eckerö Goup and Finnlines

The findings related to both companies are presented in Table 2. The identified 10R approaches of the Eckerö Group encompassed, for example, the replacement of necessary packaging and disposable materials by ecological alternatives based on renewable or recycled materials (R0); the creation of ecosystems including collaboration with educational institutions, authorities, suppliers, partners and tour operators (R1); the reduction of fuel consumption, energy optimization measures; and transitioning to climate-neutral energy sources in the long term (R2); the minimization of the use of disposable items (R3); repair of old products instead of buying new products (R4); keeping old products in use and collaboration with partner organizations (R5); collaboration with partner organizations to advance waste reduction and enhance recycling efficiency (R6); and sorting of all waste based on defined categories as well as recycling of discarded products and materials (R8 & R9). Very few approaches were identified for R3-R6 and none for R7.

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Table 2. Identified 10R approaches of the Eckerö Group and Finnlines.

Eckerö Group	Finnlines
Replacement of products or making of products redundant (R0): (1) use of energy-efficient LED lamps, induction hobs, automatic water taps and vacuum flushed toilets [87]; and (2) replacement of necessary packaging and disposable materials by ecological alternatives based on renewable or recycled materials [87]	**Replacement of products or making of products redundant (R0):** (1) gradual development of new technologies and alternative fuels [89]; (2) ecological choice of commodities (e.g., materials used in the design of ship interiors, chemicals and food assortments) [90]; (3) investment in clean technologies and emission-free port calls to combat climate change and its impacts [90,91]; (4) investment in fleet renewal [92]; (5) change of propeller blades and installation of bulb rudders (reduction of water resistance and energy savings) [92]; (6) use of new hybrid vessels with technology to save energy and minimize emissions such as high-powered battery banks, an air lubrication system under the keel, solar panels and connection to on-shore power [92]; (7) actions related to the EU "Fit for 55" package [91]; and (8) investment in modern vehicles and equipment [93]
Rethinking of products (R1): (1) sustainable, local and high-quality food including monitoring of food waste covering the whole supply chain [87], (2) multiple measures to reduce food loss encompassing procurement (e.g., optimized amounts, reliable suppliers and efficient storage cycle); preparation (e.g., careful planning of food quantities, monitoring of food consumption, use of high-quality kitchen tools and cooking methods, optimized processing of raw materials, and training g of personnel), serving (e.g., food presentation, size of serving plates and cutlery, and size of pieces and portions), plate waste (e.g., self-service buffet restaurants and raising of customer awareness), and minimization of the loss of café products (e.g., 30% off-products) [87]; (3) creation of ecosystems (e.g., collaboration with educational institutions, authorities, suppliers, partners and tour operators) [87]; (4) preference of domestic and locally produced products and application of seasonal thinking in procurement [87]; (5) buying of fish and seafood from responsible suppliers and sustainable and certified sources [87]; (6) focus on the origin of meat and dairy products (e.g., responsible domestic producers) and preference of organic products in procurement [87]; (7) preference of local partners (e.g., services and events) [87]; (8) provision of sustainable transportation for passengers and employees [88]; (9) incremental implementation of the EU Taxonomy Regulation (one objective is transition to a CE) and the	**Rethinking of products (R1):** (1) environmental responsibility as a part of daily operations and its inclusion in strategic and operational planning jointly with stakeholders [94]; (2) support of the transition towards greener shipping and participation in the development of low-emission maritime transport [89]; (3) gradual development of new technologies and alternative fuels [89]; (4) monitoring, assessment and measurement of progress [89]; (5) taking part in societal activities (e.g., decision-making and research) [89]; (6) commitment to and compliance with the economic, ecological, social and cultural sustainability criteria (set by Visit Finland) [94]; (7) compliance with the UN principles of sustainable development and their introduction into operations [91,95]; (8) reduction of material footprint trough digitalisation and automation [90]; (9) ecological choice of commodities (e.g., materials used in the design of ship interiors, chemicals and food assortments) [90]; (10) investment in clean technologies and emission-free port calls to combat climate change and its impacts [90,91]; (11) focus on the role of professional personnel in the transition to clean energy [90]; (12) life cycle approach to the environmental effects of the whole transport chain [90]; (13) continuous investigation and testing of energy-saving innovations [90]; (14) continuous planning and improvement of processes [90]; (15) verified passenger-specific carbon dioxide emission figures [94]; (16)

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Corporate Sustainability Reporting Directive (CE and resource use are one environmental disclosure factor) [88]; and (10) commitment to the UN Sustainable Development Goals [88]	continuous improvement of environmental programmes including integration into operations, regular measurement of the results of efforts, and associated training of employees [96]; (17) preference of environmentally friendly products [97]; (18) auditing of suppliers and assessment of their sustainability [97]; (19) actions related to the EU "Fit for 55" package [91]; (20) investment in modern technologies and vehicles as a part of port and stevedoring operations [91]; (21) collaboration with flag and port state administration, customers, personnel, owners, port operators, classification society, contractors and inhabitants of harbour and fairway areas in environmental matters [91]; (22) overall development of a sustainable transport system with emphasis on adaptability, flexibility and smart approaches considering continuously changing needs and trends [91]; (23) continuous renewal and development of fleet based on latest technologies and innovations [93]; and (24) continuous dialogue with customers, stakeholders and employees [93]
Reduction of the use of resources in the manufacturing and use of products (R2): (1) reduction of fuel consumption; energy optimization measures; and transitioning to climate-neutral energy sources in the long term [87,88]; (2) limitation of water consumption; increasement of energy efficiency through multiple technical solutions [87], (3) reduction of waste generation [87], (4) replacement of packaging and disposable materials with ecological alternatives made from renewable or recycled materials [87]; (5) minimization of the consumption of disposable packaging materials (e.g., use of reusable cutlery and utensils and of biodegradable napkins) [87]; (6) closed wastewater system and treatment of wastewater ashore [87]; (7) reduction and monitoring of food loss covering the whole supply chain and including the application of main waste categories [87]; (8); application of life cycle thinking and focus on local suppliers and manufacturers in procurement [87[; (9) advancement of clean energy technology [88]; and (10) commitment to the UN Sustainable Development Goals [88]	**Reduction of the use of resources in the manufacturing and use of products (R2):** (1) use of eco/energy-efficient vessels [89,91]; (2) high utilisation rates in routes and vessels (ro-pax concept) [89]; (3) gradual development of alternative fuels [89]; (4) smart use of resources as part of operations [89]; (5) commitment to the UN Sustainable Development Goals and continuous reduction of ecological footprint [91,94]; (6) compliance with the UN principles of sustainable development and their introduction into operations [91,95]; (7) reduction of energy use and environmental effects of cargo and passenger operations [[90,91]; (8) reduction of material footprint trough digitalisation and automation [90]; (9) ecological choice of commodities (e.g., materials used in the design of ship interiors, chemicals and food assortments) [90]; (10) investment in clean technologies and emission-free port calls to combat climate change and its impacts [90]; (11) life cycle approach to the environmental effects of the whole transport chain [90,91]; (12) continuous investigation and testing of energy-saving innovations [90]; (13) continuous planning and improvement of processes [90]; (14) route optimisation [92]; (15) installation of exhaust gas cleaning systems [91,92]; (16) regular cleaning of the underwater hull of all ships to reduce friction and fuel consumption [92]; (17) responsible use of natural

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	resources [96]; and (18) investigation of methods to reduce consumption and waste [97]
Reuse of products (R3): (1) use of reusable cutlery and utensils [87]; and (2) minimization of the use of disposable items [87]	**Reuse of products (R3):** (1) reuse as part of operations [89]; and (2) reuse of waste and processing of waste into material [93]
Repair of products (R4): (1) repair of old products instead of buying new products [87]	**Repair of products (R4):** (1) retrofitting existing vessels [92]
Refurbishment of products (R5): (1) keeping old products in use and collaboration with partner organizations [87]	**Refurbishment of products (R5):**) (1) retrofitting existing vessels [92]; and (2) lengthening of ro-ro vessels (reduction of emissions per cargo unit) [92]
Remanufacturing of products (R6): (1) collaboration with partner organizations to advance waste reduction and enhance recycling efficiency (e.g., textiles) [87]	**Remanufacturing of products (R6):** (1) retrofitting existing vessels [92]; and (2) lengthening of ro-ro vessels (reduction of emissions per cargo unit) [92]
Repurposing of products and their parts (R7): –	**Repurposing of products and their parts (R7): –**
Recycling and recovery of materials (R8 & R9): (1) sorting of all waste based on defined categories [87], (2) raising awareness of the negative environmental impacts of plastic waste (cigarette stumps) ([87]; and (3) recycling of discarded products and materials [87]	**Recycling and recovery of materials (R8 & R9):** (1) recycling as part of operations [89]; (2) maximization of waste recycling [97]; (3) utilization of biowaste in nutrient production [89,97]; (4) recycling of metal, glass, paper and cardboard as raw material for industry [89,97]; (5) ship recycling including inventory of hazardous materials (in accordance with EU and international regulations) [98]; (6) waste recovery and processing of waste into materials [93]; and (7) separation of hazardous waste and its delivery to a designated container in the port [93]

The identified 10R approaches for Finnlines included, for example, investment in fleet renewal, clean technologies and emission-free port calls as well as ecological choice of commodities (R0); life cycle approach to the environmental effects of the whole transport chain and auditing of suppliers and assessment of their sustainability (R1); reduction of material footprint trough digitalisation and automation and route optimisation (R2); reuse as part of operations (R3); retrofitting existing vessels and lengthening of ro-ro vessels (R4-R6); and recycling as part of operations (R8 & R9). Similarly to the Eckerö Group, very few approaches were identified for R3-R6 and none for R7.

Companies in the seafaring sector are willing to promote CE encompassing, for example, (1) investments in the development of sectoral guidelines, employee training and best practices; (2) development of the use of energy; (3) development of new business models [99]. In general, the maritime and shipping industry are paying attention to the UN SDGs and the Agenda 2023 through sustainability strategies. However, the information companies report is mostly qualitative and there is a lack of specific indicators for the evaluation and measurement of sustainability performance at the corporate level [100]. Sustainable maritime supply chains are about integrating maritime organizational units such as ports and shipping companies covering the entire supply chain including coordination of information, materials (e.g., containers and general carbo) and financial flows [78]. In addition, sustainable transport chains could be promoted through the integration of shipping (e.g., Roll on-roll off) into intermodal transport chains including behavioral change campaigns covering all stakeholders and the identification of associated barriers [101].

Most important areas of CE for companies in the seafaring sector include (1) investments in new and modernization of property; (2) used fuels; and (3) development of harbour management and operations. In addition, companies perceive the development of international guidelines and rules and best practices as well as life cycle thinking and recycling and reuse as very important CE

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development areas [99]. Container shipping managers should focus on organizational level green shipping management capabilities (e.g., policies, suppliers and ships) to enhance their environmental and financial performance [102]. Overall, sustainability of maritime shipping and sustainable maritime logistics can be promoted through informed decision-making in maritime supply chains considering environmental sustainability jointly with competing objectives [103].

Port management actions are currently including more focus on sustainability and CE than before [104]. In addition, ports can create CE benefits and support local communities including measures to address social and environmental challenges [105]. Essential development processes can create, for example, indicator systems for the measurement, reporting and monitoring of port sustainability and involve multiple stakeholders such as researchers and port and industry representatives [106]. The promotion of the sustainability of ports including advanced environmental and social integration can also contribute to the sustainability of the region or city where the ports operate [80]. For example, ports can be linked to and take advantage of circular city concepts and tools to promote overall sustainable development in the context of port-city interconnectedness [107].

There is increasing pressure on ports to become more sustainable but there is very limited research on organizational change management for sustainability [108]. Therefore, multiple practices should be used to evaluate the sustainability port development including a holistic approach to sustainable development (covering environmental, social and economic dimensions) and consideration of all stakeholders in sustainable port development [109]. It has been noted that sustainable supply chain management covering internal sustainable development and external sustainable collaboration have positive effects on and linkages with sustainability performance of ports [110]. In addition, the sustainability of ports can be advanced through the development and application of Port sustainability indicators covering environmental, social and economic aspects [106].

3.3. The Identified 10R Approaches of Wasaline and Arctia

The findings related to both companies are presented in Table 3. The identified 10R approaches of Wasaline encompassed, for example, investments in sustainability initiatives and working towards fuel diversity (R0);) investments in sustainability, use of sustainable materials and cooperation with sustainability networks and suppliers (R1); continuous reduction of environmental footprint and focus on resource and energy efficient operations as well as cooperation with local companies and use of local raw materials ((R2); use of sustainable materials such as recyclable tabletops and carpets and garbage management including recycling and use of recyclable packaging as needed (R3); use of sustainable materials such as recyclable tabletops and carpets (R6); and onboard waste management by the crew, waste sorting according to multiple categories, garbage management including reduction at the source, recycling and use of recyclable packaging as needed (R8 & R9). No approaches were identified for R4, R5 and R7. Not many approaches were identified for R3 and R6.

Table 3. Identified 10R approaches of Wasaline and Arctia.

Wasaline	Arctia
Replacement of products or making of products redundant (R0): (1) investments in sustainability (e.g., engine with lower emissions) [111]; (2) pilot project (Green Corridor Fridays) including the use of certified biogas and additional payments by customers [111]; (3) use of intelligent heating, ventilation and lightning on board [111]; (4) intelligent use of water [111]; (5) optimized energy consumption [111]; (6) vessel machinery that runs on a dual fuel and battery solution [111]; (7) use of sustainable materials (e.g.,	**Replacement of products or making of products redundant (R0):** (1) contribution to the maintenance of stocks of critical supplies of the society [116]; (2) life cycle efficient products (e.g., buoys) [116]; (3) materiality analysis [116]; (4) smart fairway infrastructure and digital technology [116]; (5) use of renewable energy sources (as possible) [116]; (6) the promotion of CE including use of rental equipment in customer projects [116]; (7) use of operating models that support CE [116]; (8) environmental investments

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recyclable tabletops and carpets) [111]; (8) use of shore power in ports [111]; (9) cooperation with local companies and use of local raw materials [111]; (10) striving towards zero emissions and continuous optimization of crossings, arrivals, loading and departures to save fuel and reduce emissions [111]; (11) reduction of garbage at the source (e.g., minimization of packaging onboard) and recycling including the use of recyclable packaging as needed [111]; (12) investments in sustainability initiatives (e.g., technical vessel modifications, shore power and efficient terminal operations) in accordance with the EU Fit for 55 package and the EU emission trading system [112]; (13) working towards fuel diversity (e.g., renewable, future and alternative fuels and e-fuel) [113]; (14) local suppliers of food [113]; and (15) climate compensation fee as an option to offset the carbon footprint of journeys (operating with biogas and batteries) [114,115]	(e.g., specific operating modes to ensure more reliable monitoring and optimization of fuel consumption in varying conditions) [116]; (9) use of substitute refrigerants in onboard refrigeration systems (to replace ozone-depleting refrigerants) [116]; (10) consideration of environmental aspects in decision-making and operations [117]; (11) systematical measurement of environmental footprint [117]; (12) setting of environmental targets annually [117]; and (13) continuous improvement including the development of products and services based on customer and stakeholder feedback [117]
Rethinking of products (R1): (1) investments in sustainability (e.g., engine with lower emissions) [111]; (2) cooperation with sustainability networks and suppliers [111]; (3) allocation of more resources to sustainability projects [111]; (4) pilot project (Green Corridor Fridays) including the use of certified biogas and additional payments by customers [111]; (5) use of intelligent heating, ventilation and lightning on board [111]; (6) intelligent use of water [111]; (7) optimized energy consumption [111]; (8) vessel machinery that runs on a dual fuel and battery solution [111]; (9) use of sustainable materials (e.g., recyclable tabletops and carpets) [111]; (10) use of shore power in ports [111]; (11) continuous reduction of environmental footprint [111]; (12) focus on resource and energy efficient operations [111]; (13) continuous training of personnel [111]; (14) cooperation with local companies and use of local raw materials [111]; (15) striving towards zero emissions and continuous optimization of crossings, arrivals, loading and departures to save fuel and reduce emissions [111]; (16) recycling and use of recyclable packaging as needed [111]; (17) working with multiple partners to achieve climate neutrality and green shipping corridors (zero emission routes) [111,113]; (18) investments in sustainability initiatives (e.g., technical vessel modifications, shore power and efficient terminal operations) in accordance with the EU Fit for 55 package and the EU emission trading system [112]; (19) working towards fuel diversity (e.g., renewable, future and alternative	**Rethinking of products (R1):** (1) sustainable maritime services [116]; (2) contribution to the maintenance of stocks of critical supplies of the society [116]; (3) new business opportunities associated with the green transition [116]; (4) life cycle efficient products (e.g., buoys) [116]; (5) research cooperation with universities [116]; (6) sustainability management, monitoring (e.g., performance) and reporting [116]; (7) materiality analysis [116]; (8) smart fairway infrastructure and digital technology [116]; (9) competent staff and appropriate allocation of resources [116]; (10) the promotion of CE including recycling of materials, use of side streams to reduce the consumption of raw materials and use of rental equipment in customer projects [116]; (11) CO_2 roadmap to reduce emissions (e.g., modernisation of fleet) [116]; (12) digitalisation to optimise overall transport emissions in the long-term; [116]; (13) environmental programme (supplier management, waste recycling and reuse, the reduction of energy consumption and lower environmental risks) [116]; (14) use of operating models that support CE [116]; (15) environmental investments (e.g., specific operating modes to ensure more reliable monitoring and optimization of fuel consumption in varying conditions) [116]; (16) use of substitute refrigerants in onboard refrigeration systems (to replace ozone-depleting refrigerants) [116]; (17) consideration of environmental aspects in decision-making and operations [117]; (18) systematical measurement of environmental

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fuels and e-fuel) [113]; (20) local suppliers of food [113]; and (21) climate compensation fee as an option to offset the carbon footprint of journeys (operating with biogas and batteries) [114,115]	footprint [117]; (19) setting of environmental targets annually [117]; (20) continuous improvement including the development of products and services based on customer and stakeholder feedback [117]; and (21) commitment to the UN SDGs [118]
Reduction of the use of resources in the manufacturing and use of products (R2): (1) investments in sustainability (e.g., engine with lower emissions) [111]; (2) pilot project (Green Corridor Fridays) including the use of certified biogas and additional payments by customers [111]; (3) use of intelligent heating, ventilation and lightning on board [111]; (4) intelligent use of water [111]; (5) optimized energy consumption [111]; (6) vessel machinery that runs on a dual fuel and battery solution [111]; (7) use of sustainable materials (e.g., recyclable tabletops and carpets) [111]; (8) use of shore power in ports [111]; (9) continuous reduction of environmental footprint [111]; (10) focus on resource and energy efficient operations [111]; (11) cooperation with local companies and use of local raw materials [111]; (12) striving towards zero emissions and continuous optimization of crossings, arrivals, loading and departures to save fuel and reduce emissions [111]; (13) waste sorting according to multiple categories and garbage management including reduction at the source (e.g., minimization of packaging onboard), recycling and use of recyclable packaging as needed [111]; (14) working with multiple partners to achieve climate neutrality and green shipping corridors (zero emission routes) [111,113]; (15) investments in sustainability initiatives (e.g., technical vessel modifications, shore power and efficient terminal operations) in accordance with the EU Fit for 55 package and the EU emission trading system [112]; (16) working towards fuel diversity (e.g., renewable, future and alternative fuels and e-fuel) [113]; (17) local suppliers of food [113]; and (18) climate compensation fee as an option to offset the carbon footprint of journeys (operating with biogas and batteries) [114,115]	**Reduction of the use of resources in the manufacturing and use of products (R2):** (1) energy efficiency [116]; (2) the promotion of CE including recycling of materials, use of side streams to reduce the consumption of raw materials and use of rental equipment in customer projects [116]; (3) waste management to support CE [116]; (4) CO_2 roadmap to reduce emissions (e.g., modernisation of fleet) [116]; (5) digitalisation to optimise overall transport emissions in the long-term [116]; (6) environmental programme (supplier management, waste recycling and reuse, the reduction of energy consumption and lower environmental risks) [116]; (7) use of operating models that support CE [116]; (8) environmental investments (e.g., specific operating modes to ensure more reliable monitoring and optimization of fuel consumption in varying conditions) [116]; (9) reduction and enhanced sorting and recovery of all waste from ships and sites [116]; (10) monitoring and reporting of waste volumes by site and type [116]; (11) port collection of waste and transport to recycling or reuse facilities [116]; (12) sorting and collection of hazardous waste at all sites [116]; (13) measurement of carbon footprint associated with waste management operations and offsetting of the measured emissions through certified afforestation projects by the waste management contractor [116]; (14) training of employees related to the waste management system [116]; (15) consideration of environmental aspects in decision-making and operations [117]; (16) systematical measurement of environmental footprint [117]; (17) setting of environmental targets annually [117]; (18) continuous improvement including the development of products and services based on customer and stakeholder feedback [117]; and (19) commitment to the UN SDGs [118]
Reuse of products (R3): (1) use of sustainable materials (e.g., recyclable tabletops and carpets) [111]; and (2) waste sorting according to multiple categories and garbage management including recycling and use of recyclable packaging as needed [111]	**Reuse of products (R3):** (1) environmental programme (supplier management, waste recycling and reuse, the reduction of energy consumption and lower environmental risks) [116]; (2) use of operating models that support CE [116]; (3) reduction and enhanced sorting and

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	recovery of all waste from ships and sites [116]; (4) monitoring and reporting of waste volumes by site and type [116]; (5) port collection of waste and transport to recycling or reuse facilities [116]; (6) sorting and collection of hazardous waste at all sites [116]; and (7) training of employees related to the waste management system [116]
Repair of products (R4): –	**Repair of products (R4): –**
Refurbishment of products (R5): –	**Refurbishment of products (R5): –**
Remanufacturing of products (R6): (1) use of sustainable materials (e.g., recyclable tabletops and carpets) [111]	**Remanufacturing of products (R6): –**
Repurposing of products and their parts (R7): –	**Repurposing of products and their parts (R7): –**
Recycling and recovery of materials (R8 & R9): (1) use of sustainable materials (e.g., recyclable tabletops and carpets) [111]; (2) onboard waste management by the crew [111]; and (3) waste sorting according to multiple categories and garbage management including reduction at the source (e.g., minimization of packaging onboard), recycling and use of recyclable packaging as needed [111]	**Recycling and recovery of materials (R8 & R9):** (1) the promotion of CE including recycling of materials and use of side streams to reduce the consumption of raw materials [116]; (2) waste management to support CE [116]; (3) environmental programme (supplier management, waste recycling and reuse, the reduction of energy consumption and lower environmental risks) [116]; (4) use of operating models that support CE [116]; (5) reduction and enhanced sorting and recovery of all waste from ships and sites [116]; (6) monitoring and reporting of waste volumes by site and type [116]; (7) port collection of waste and transport to recycling or reuse facilities [116]; (8) sorting and collection of hazardous waste at all sites [116]; and (9) training of employees related to the waste management system [116]

The identified 10R approaches of Arctia included, for example, life cycle efficient products, materiality analysis and the promotion of CE including use of rental equipment in customer projects (R0); new business opportunities associated with the green transition and sustainability management, monitoring and reporting (R1); use of operating models that support CE, CO_2 roadmap to reduce emissions and digitalisation to optimise overall transport emissions in the long-term (R2); port collection of waste and transport to recycling or reuse facilities and training of employees related to the waste management system (R3); the promotion of CE including recycling of materials and use of side streams to reduce the consumption of raw materials as well as waste management to support CE (R8 & R9). No approaches were identified for R4-R7.

Previous studies have noted that (1) the CE approach is not well-established in the maritime industry and it is significantly behind other transportation industries [73]; (2) the concept of CE is very in very early stages within the maritime industry and the adoption of CE by this industry is essential to ensure growth in a sustainable manner [119]; and (3) important focus areas include e.g., the identification of appropriate strategies and technological solutions as well as the contribution of stakeholders to promote circular end-of-life applications [73]. In general, companies perceive that there is a need for more awareness building and capacity-development to promote more proactive approaches to the advancement of CE with particular emphasis on, for example, life cycle thinking, material and energy efficiency, and whole supply chain approaches. Companies identified challenges related to CE such as the development international guidelines and best practices and enhancement of cooperation and interaction both sectorally and among various actors [99].

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Future research on sustainable maritime transport and supply chain should focus on e.g., the measurement of sustainability in maritime supply chains; the design of sustainable maritime supply chain networks; real-life case studies on maritime supply chains; and policy making for, cultural aspects of and integration of regulations into sustainable maritime supply chains [78]. According to sectoral companies, the most promising CE innovations in the seafaring sector include e.g., energy efficiency and fuels; clever products and services; and intelligent production and processes [99]. In addition, the sustainability, decarbonatization and the achievement of the greenhouse gas reduction targets of the maritime industry/sector can be advanced through the concept of Green Shipping Corridors including focus on all stakeholders (at the infrastructure and operational level and at the governance and supporting level), digitalization along the trading routes, supply chains and total value chains [120].

CE has potential to address sustainability challenges of harbours including management of circular transition and transformation operations and various integration activities within the city-port context. In addition, there is a need for interaction and dialogue processes between various stakeholders [121]. For example, circular city models can be promoted within the city-port context encompassing focus on (1) sustainable approaches to seas and marine resources; (2) well-being and quality of life; and (3) economic development [121]. The development of secondary ports (e.g., for logistics, transport, storage, transshipment and industrial activities) can advance and be major partners in circular supply chains in accordance with the overall CE model [122]. However, this requires that challenges related to circular supply chain management such as information sharing, coordination and availability of suitable partners can be overcome. The stevedores in these secondary ports need to develop service offers that address cargo as a part of circular supply chains [122].

Sustainable practices in the ship-port interface can be advanced through the development of new technologies and digitalization investments with due focus on the overall ecosystem [123]. In addition, port sustainability can be advanced through more systematic supply chain perspectives on cargo movement systems instead of narrow focus on single operational aspects of ports [124]. One previous study on green ports and maritime logistics concluded that the gap between naval architects and researchers from other clusters needs to be bridged, including better understanding of the relationship between ship design/construction and ports/maritime logistics [125]. In addition, actors in the fields of ports and maritime logistics should be more aware of matters in the field naval architecture such as energy efficiency and emissions [125].

In general, it has been noted that the barriers to sustainability in the context of ports include (1) lack of awareness of sustainability, commitment and measurement and incentives; (2) status quo; (3) economic focus that disregards environmental and social issues; (4) economic aspects (e.g., short-term perspective); (4) ignorance of sustainability; (5) lack of or bad timing; (6) focus on only managerial change efforts; (7) investment in equipment; (8) customer decisions; (9) competitors; (10) decisions of suppliers; (11) industry pressures; (12) long-term contracts with customers; (13) political interest; (14) deregulation; (15) cost/price premiums; (16) laws and regulation,; (17) too lengthy processes; (18) forcing tenants to engage with sustainability; (19) and other transport systems [108].

3.4. The Identified 10R Approaches of Bore and ESL Shipping

The findings related to both companies are presented in Table 4. The identified 10R approaches of Bore encompassed, for example, sustainable shipping including rotor sail technology, voyage optimization system, scrubbers, frequency drives, led lighting and combinatory mode technology; long-term thinking for sustainability and continuous improvement and improvement of operations including environmental aspects (R1); and reduction of environmental footprint and fleet emissions as well as improvement of fuel efficiency (R2). No approaches were identified for R3-R9.

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Table 4. Identified 10R approaches of Bore and ESL Shipping.

Bore	ESL Shipping
Replacement of products or making of products redundant (R0): (1) green shipping and technology (e.g., onboard Rotor Sails to reduce fuel consumption) [126]; (2) sustainable shipping including rotor sail technology, voyage optimization system, scrubbers, frequency drives, led lighting and combinatory mode technology [127]; and (3) continuous improvement and improvement of operations (including environmental aspects) [126,128]	**Replacement of products or making of products redundant (R0):** (1) fleet renewal and environmental upgrading of the existing ships [129]; (2) roadmap towards fossil-free shipping [129]; (3) investment in best available ship technology (shift from fossil to non-fossil fuels) [129]; (4); hybrid vessels equipt with battery packs and shore power connection [130]; (5) LNG powered bulk carriers [130]; (6) renewable fuels (e.g., co-processed marine fuel oil and e-fuel hub for the production of hydrogen fuels) [130]; (7) sustainable procurement of products and services (ESL Shipping Sustainability Report); (8) reduction of the environmental footprint [131]; (9) supplier management [131]; (10) increasement of positive impacts and reduction of negative impacts [132]; and (11) investments in sustainable innovation [132]
Rethinking of products (R1): (1) long-term thinking for sustainability [126]; (2) green shipping and technology (e.g., onboard Rotor Sails to reduce fuel consumption) [126]; (3) continuous improvement and improvement of operations (including environmental aspects) [126,128]; (4) reduction of environmental footprint [126]; (5) reduction of fleet emissions and improvement of fuel efficiency [126]; and (6) sustainable shipping including rotor sail technology, voyage optimization system, scrubbers, frequency drives, led lighting and combinatory mode technology [127]	**Rethinking of products (R1):** (1) fleet renewal and environmental upgrading of the existing ships [129]; (2) roadmap towards fossil-free shipping [129]; (3) investment in best available ship technology (shift from fossil to non-fossil fuels) [129]; (4) commitment to the UN SDGs [129]; (5) hybrid vessels equipt with battery packs and shore power connection [130]; (6) LNG powered bulk carriers [130]; (7) renewable fuels (e.g., co-processed marine fuel oil and e-fuel hub for the production of hydrogen fuels) [130]; (8) decreasement of carbon footprint [130]; (9) reduction of emissions and fuel consumption (correct timing of hull cleaning) [130]; (10) ballast water treatment systems [130]; (11) reporting of carbon dioxide emissions [130]; (12) fossil free vessels [131]; (13) the development of digital solutions to promote sustainable shipping (e.g., fleet scheduling optimiser software) [131]; (14) commitment to sustainability [131]; (15) double materiality analysis [131]; (16) target of net-zero operations by 2040 [131]; (17) sustainable procurement of products and services [131]; (18) reduction of the environmental footprint [131]; (19) supplier management [131]; (20) use of environmental performance indicators including fuel consumption, energy efficiency, emissions, purchased energy, energy consumption, air quality and ecological impacts [131]; (21) increasement of positive impacts and reduction of negative impacts [132]; and (22) investments in sustainable innovation [132]

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Reduction of the use of resources in the manufacturing and use of products (R2): (1) green shipping and technology (e.g., onboard Rotor Sails to reduce fuel consumption) [126]; (2) reduction of environmental footprint [126]; (3) reduction of fleet emissions and improvement of fuel efficiency [126]; (4) sustainable shipping including rotor sail technology, voyage optimization system, scrubbers, frequency drives, led lighting and combinatory mode technology [127]; (5) fuel efficiency (Sound Environment); (6) reduction of pollution [127]; (7) minimization of environmental incidents and accidents [128]; and (8) continuous improvement and improvement of operations (including environmental aspects) [126,128]	**Reduction of the use of resources in the manufacturing and use of products (R2):** (1) fleet renewal and environmental upgrading of the existing ships [129]; (2) roadmap towards fossil-free shipping [129]; (3) investment in best available ship technology (shift from fossil to non-fossil fuels) [129]; (4) hybrid vessels equipt with battery packs and shore power connection [130]; (5) LNG powered bulk carriers [130]; (6) renewable fuels (e.g., co-processed marine fuel oil and e-fuel hub for the production of hydrogen fuels) [130]; (7) decreasement of carbon footprint [130]; (8) reduction of emissions and fuel consumption (correct timing of hull cleaning) [130]; (9) ballast water treatment systems [130]; (10) reporting of carbon dioxide emissions [130]; (11) double materiality analysis [131]; (12) target of net-zero operations by 2040 [131]; (13) sustainable procurement of products and services [131]; (14) reduction of the environmental footprint [131]; (15) supplier management [131]; (16) use of environmental performance indicators including fuel consumption, energy efficiency, emissions, purchased energy, energy consumption, air quality and ecological impacts [131]; (17) increasement of positive impacts and reduction of negative impacts [132]; and (18) investments in sustainable innovation [132]
Reuse of products (R3): –	**Reuse of products (R3): –**
Repair of products (R4): –	**Repair of products (R4): –**
Refurbishment of products (R5): –	**Refurbishment of products (R5): –**
Remanufacturing of products (R6): –	**Remanufacturing of products (R6): –**
Repurposing of products and their parts (R7): –	**Repurposing of products and their parts (R7): –**
Recycling and recovery of materials (R8 & R9): –	**Recycling and recovery of materials (R8 & R9):** (1) management of waste water [131]; (2) minimisation of the amount of grey water [131]; (3) waste water discharge to shore [131]; (4) garbage management plans in vessels and reduction of waste generation [131]; (5) sorting of all waste and use of waste statistics [131]; and (6) recycling and waste management [132]

The identified 10R approaches of ESL shipping included, for example, fleet renewal and environmental upgrading of the existing ships (R0); roadmap towards fossil-free shipping and investment in best available ship technology including shifting from fossil to non-fossil fuels (R1); decreasement of carbon footprint (Environmental responsibility); (8) sustainable procurement of products and services, supplier management and use of environmental performance indicators (R2); and sorting of all waste, use of waste statistics, recycling and waste management (R8 & R9). No approaches were identified for R3-R7.

The European port sector promotes sustainable development, and multiple European ports provide environmental management data including priority focus areas such as air quality, energy consumption and noise. In addition, the most monitored aspects are energy consumption, waste and water quality [133]. For example, one previous study focused the Copenhagen-Malmö Port with

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focus on CE aspects such as involvement of cooperation of multi-stakeholders and the utilization of resources through circulation of ship-originated waste to use at the highest utility in the biological cycle [134]. Many shipping companies have started to adopt green shipping practices to improve their operations including (1) company policy and procedure; (2) shipping documentation; (3) shipping design and compliance; (4) shipping materials; (5) shipping equipment; and (6) shipper cooperation [135].

Previous research has suggested that life cycle thinking, and assessment are considered to be very important for the development of industrial and cross-company ecology and symbiosis in the seafaring sector encompassing focus on e.g., full life cycle assessment of products and comprehensive supply chain assessments with other actors [99]. For example, the integration of short sea shipping into intermodal transport can advance sustainability through environmental, energy efficiency and safety benefits and provide connections to peripheral and remote areas without high infrastructure investments [75]. In addition, digitalization can be used to improve the sustainability of seaports and maritime transports including e.g., the development of applications that contribute to the rational use of resources and the reduction of CO_2 emissions and overall environmental pressures through enhanced business logic and model [136].

The drivers that encourage maritime companies to adopt maritime green supply chain management encompass top management support, green initiatives, regulation pressure and security [137]. It has been noted that shipping firms with a proactive green supply chain management strategy perform better financially including focus on aspects such as (1) internal environmental proactivity; (2) innovative internal and external green shipping practices; (3) green marketing; (4) green collaboration with partners, suppliers and customers; and (5) financial performance [138]. In addition, the use of indicators could provide information on the environmental performance of the European port sector including evaluation of the overall sectoral progress and benchmarking against the EU average as well as reporting by various ports to their stakeholders [139]. The role of ports in the green transition of the maritime sector is essential and ship owners' investment decisions (e.g., uptake of green technologies and reduction of emissions) can be positively impacted through environmental differentiation of port fees [140].

In general, ports are facing multiple environmental and social challenges and there is a need for enhanced focus on institutional barriers and supply chain bottlenecks to promote port sustainability [124]. Previous study on a port in Sweden concluded that there were differences in perception of sustainability and similarities between drivers and barriers to sustainability [108]. The drivers encompass (1) government; (2) business case; (3) societal awareness; (4) legislation and regulation; (5) international treaties; (6) reputation; (7) expectations of stakeholders; (8) unions; (9) growth and profit; (10) shared values of employees; (11) leadership; (12) personal engagement; (13) shareholder value; and (14) board of directors [108]. In general, the port industry should pursue enhanced resilience for long-term value creation through innovative management and planning systems including new technologies and digitalization [123]. In addition, there is a need for research on port sustainability and port sustainability performance metrics encompassing supply chain coordination and cooperation aspects [124].

3.5. The Identified 10R Approaches of Meriaura Group, Alfons Håkans and Rederi AB Nathalie

The findings related to all three companies are presented in Table 5. The identified 10R approaches of Meriaura Group encompassed, for example, increased use of renewable energy and development and contribution to a sustainable society based on circular economy and clean energy (R0); investments in circular economy and clean technology including bioenergy solution and ecosystem based on closed circulation as well as calculation of the emissions of shipping operations based on full life cycles of vessels (R1); development and implementation of new sustainable forms of energy, minimization of the environmental footprint of fleet and reduction and assessment of the environmental impact of operations (R2); and biofuel made of recycled raw materials, improvement

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of recycling, further treatment of ship-generated waste and waste management plan (R8 & R9). No approaches were identified for R3-R7.

Table 5. Identified 10R approaches of Meriaura Group, Alfons Håkans and Rederi AB Nathalie.

Meriaura Group	Alfons Håkans (A) & Rederi AB Nathalie (B)
Replacement of products or making of products redundant (R0): (1) renewable energy and energy efficiency related projects offshore and on land [141,142]; (2) increased use of renewable energy [141]; (3) development and implementation of new sustainable forms of energy [141,142]; (4) biofuel made of recycled raw materials (waste-based bio-oil) [141,142]; (5) development of more environmentally friendly ships and transport solutions to achieve 100% carbon and greenhouse gas neutrality (e.g., hybrid propulsion concept that combines battery technology and sustainably produced bio-oil) [141,142]; (6) contribution to a sustainable society based on circular economy and clean energy [141]; (9) reduction of fuel consumption including route optimization, fuel monitoring, training of personnel, real-time visualization and connection of fleet, digitalized route planning and minimization of ballast [141]; (10) investments in circular economy and clean technology including bioenergy solution and ecosystem based on closed circulation (use and recycling of waste, waste energy, nutrients and carbon dioxide) and use of waste-based oils [141,142]; (11) use of renewable and carbon neutral electricity [142]; and (12) double materiality analysis [142]	**Replacement of products or making of products redundant (R0) (A):** (1) sustainable business operations [144]; (2) minimization of environmental impacts associated with all aspects of operations [144]; (3) reduction of emissions [144]; (4) improvement of energy efficiency [144]; (5) investment in modern and eco-friendly technologies [144]; (6) implementation of sustainable practices covering the whole fleet and all logistics processes [144]; (7) sustainable ecosystem covering society, community and the environment [144]; and (8) collaboration and partnerships with organizations, industry experts and local communities as a part of sustainability strategy to collectively address global sustainability challenges, exchange knowledge and share best practices [144] **Replacement of products or making of products redundant (R0) (B):** (1) sustainable culture within the company [145]; (2) continuous improvement of environmental performance [145]; (3) environmental management system and policy [145]; (4) environmental standards (set by policy) for operations [145]; (5) promotion of more sustainable industry with all associated business partners [145]; (6) participation in local actions and initiatives related to the environment [145]; (7) greener transport [145]; (8) preservation of common resources for the future [145]; (9) reduction of emissions covering all vessels [145]; (10) weather routing and speed optimization [145]; (11) continuous search for environmentally friendly substitutes covering a broad range of aspects from conventional chemicals to planned hybrid technology for new building projects [145]; and (12) minimization of energy consumption in all actions related to company operations (e.g., employee transports and switching off illumination) [145]
Rethinking of products (R1): (1) renewable energy and energy efficiency related projects offshore and on land [141,142]; (2) increased use of renewable energy [141,142]; (3) decreased carbon dioxide emissions [141,142]; (4) development and implementation of new sustainable forms of energy [141,142]; (5) biofuel made of recycled raw materials (waste-based bio-	**Rethinking of products (R1) (A):** (1) sustainable business operations [144]; (2) minimization of environmental impacts associated with all aspects of operations [144]; (3) reduction of emissions [144]; (4) improvement of energy efficiency [144]; (5) investment in modern and eco-friendly technologies [144]; (6) route optimization [144]; (7) implementation of sustainable practices

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oil) [141,142]; (6) minimization of the environmental footprint of fleet [141]; (7) discharge of ship sewage into port reception facilities [141]; (8) the promotion of carbon-neutral maritime traffic including calculation and reporting of CO_2 emissions [141,142]; (9) development of more environmentally friendly ships and transport solutions to achieve 100% carbon and greenhouse gas neutrality (e.g., hybrid propulsion concept that combines battery technology and sustainably produced bio-oil) [141,142]; (10) contribution to a sustainable society based on circular economy and clean energy [141]; (11) reduction of fuel consumption including route optimization, fuel monitoring, training of personnel, real-time visualization and connection of fleet, digitalized route planning and minimization of ballast [141]; (12) investments in circular economy and clean technology including bioenergy solution and ecosystem based on closed circulation (use and recycling of waste, waste energy, nutrients and carbon dioxide) and use of waste-based oils [141,142]; (13) reduction and assessment of the environmental impact of operations [142,143]; (14) calculation of the emissions of shipping operations based on full life cycles of vessels [142,143]; (15) skilled personnel [143]; (16) use of renewable and carbon neutral electricity [142]; (17) chemical lists on board; (18)) double materiality analysis [142]; (19) the carbon footprint of sea freight [142]; and (20) commitment to the UN SDGs [142]	covering the whole fleet and all logistics processes [144]; (8) sustainable ecosystem covering society, community and the environment [144]; and (9) collaboration and partnerships with organizations, industry experts and local communities as a part of sustainability strategy to collectively address global sustainability challenges, exchange knowledge and share best practices [144] **Rethinking of products (R1) (B):** (1) sustainable culture within the company [145]; (2) continuous improvement of environmental performance [145]; (3) environmental management system and policy [145]; (4) environmental standards (set by policy) for operations [145]; (5) promotion of more sustainable industry with all associated business partners [145]; (6) participation in local actions and initiatives related to the environment [145]; (7) greener transport [145]; (8) preservation of common resources for the future [145]; (9) reduction of emissions covering all vessels [145]; (10) weather routing and speed optimization [145]; (11) continuous search for environmentally friendly substitutes covering a broad range of aspects from conventional chemicals to planned hybrid technology for new building projects [145]; (12) ballast water management plan covering all vessels [145]; (13) crew training related to environmental aspects and risks [145]; and (14) minimization of energy consumption in all actions related to company operations (e.g., employee transports and switching off illumination) [145]
Reduction of the use of resources in the manufacturing and use of products (R2): (1) renewable energy and energy efficiency related projects offshore and on land [141,142]; (2) increased use of renewable energy [141]; (3) decreased carbon dioxide emissions [141,142]; (4) development and implementation of new sustainable forms of energy [141,142]; (5) biofuel made of recycled raw materials (waste-based bio-oil) [141,142]; (6) minimization of the environmental footprint of fleet [141]; (7) development of more environmentally friendly ships and transport solutions to achieve 100% carbon and greenhouse gas neutrality (e.g., hybrid propulsion concept that combines battery technology and sustainably produced bio-oil) [141,142]; (8) contribution to a sustainable society based on circular economy and clean energy [141]; (9) reduction of fuel consumption including route optimization, fuel monitoring, training of	**Reduction of the use of resources in the manufacturing and use of products (R2) (A):** (1) sustainable business operations [144]; (2) minimization of environmental impacts associated with all aspects of operations [144]; (3) reduction of emissions [144]; (4) improvement of energy efficiency [144]; (5) investment in modern and eco-friendly technologies [144]; (6) route optimization [144]; (7) implementation of sustainable practices covering the whole fleet and all logistics processes [144]; (8) sustainable ecosystem covering society, community and the environment [144]; and (9) collaboration and partnerships with organizations, industry experts and local communities as a part of sustainability strategy to collectively address global sustainability challenges, exchange knowledge and share best practices [144]

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personnel, real-time visualization and connection of fleet, digitalized route planning and minimization of ballast [141]; (10) investments in circular economy and clean technology including bioenergy solution and ecosystem based on closed circulation (use and recycling of waste, waste energy, nutrients and carbon dioxide) and use of waste-based oils [141,142]; (11) reduction and assessment of the environmental impact of operations [142,143]; (12) calculation of the emissions of shipping operations based on full life cycles of vessels [142,143]; (13) use of renewable and carbon neutral electricity [142]; (13) double materiality analysis [142]; (14) the carbon footprint of sea freight [142]; and (15) commitment to the UN SDGs [142]	**Reduction of the use of resources in the manufacturing and use of products (R2) (B):** (1) sustainable culture within the company [145]; (2) continuous improvement of environmental performance [145]; (3) environmental management system and policy [145]; (4) environmental standards (set by policy) for operations [145]; (5) promotion of more sustainable industry with all associated business partners [145]; (6) greener transport [145]; (7) preservation of common resources for the future [145]; (8) reduction of emissions covering all vessels [145]; (9) weather routing and speed optimization [145]; (10) continuous search for environmentally friendly substitutes covering a broad range of aspects from conventional chemicals to planned hybrid technology for new building projects [145]; (11) crew training related to environmental aspects and risks [145]; and (12) minimization of energy consumption in all actions related to company operations (e.g., employee transports and switching off illumination) [145]
Reuse of products (R3): –	**Reuse of products (R3) (A): –** **Reuse of products (R3) (B): –**
Repair of products (R4): –	**Repair of products (R4) (A): –** **Repair of products (R4) (B): –**
Refurbishment of products (R5): –	**Refurbishment of products (R5) (A): –** **Refurbishment of products (R5) (B): –**
Remanufacturing of products (R6): –	**Remanufacturing of products (R6) (A): –** **Remanufacturing of products (R6) (B): –**
Repurposing of products and their parts (R7): –	**Repurposing of products and their parts (R7) (A): –** **Repurposing of products and their parts (R7) (B): –**
Recycling and recovery of materials (R8 & R9): (1) biofuel made of recycled raw materials (waste-based bio-oil) [141]; (2) discharge of ship sewage into port reception facilities [141]; (3) improvement of recycling [143]; (4) further treatment of ship-generated waste [143]; (5) waste management plan [142]; and (6) reduction and sorting of waste [142]	**Recycling and recovery of materials (R8 & R9) (A): –** **Recycling and recovery of materials (R8 & R9) (B):** (1) waste sorting [145]; (2) reduction of mixed waste onboard vessels [145]; and (3) increasement of recycling [145]

The identified 10R approaches of Alfons Håkans included, for example, sustainable business operations, investment in modern and eco-friendly technologies and the implementation of sustainable practices covering the whole fleet and all logistics processes (R0); sustainable ecosystem covering society, community and the environment (R1); and minimization of environmental impacts

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associated with all aspects of operations and investment in modern and eco-friendly technologies (R2). No approaches were identified for R3-R7.

The identified 10R approaches of Rederi AB Nathalie comprised, for example, sustainable culture within the company and continuous improvement of environmental performance (R0); promotion of more sustainable industry with all associated business partners and participation in local actions and initiatives related to the environment (R1); reduction of emissions covering all vessels and continuous search for environmentally friendly substitutes (R2); and waste sorting, the reduction of mixed waste onboard vessels and the increasement of recycling (R8 & R9). No approaches were identified for R3-R9.

Previous research has noted that companies in the seafaring sector considered it to be difficult to find information of public steering goals and opportunities both nationally and at the EU level. Additionally, many companies perceive that their efforts to promote CE are only marginal and passive parts of other actions or responding and reacting to public steering [99]. Development of a sustainable rule framework for transportation in both land and sea could help to reduce environmental pressures caused by transportation operations and to achieve enhanced sustainability in this sector [146]. In addition, global seaborne container trade is a significant sector globally and therefore it is important to study sustainable and resilient container transportation including focus on e.g., environmental performance, climate risks, green ports, low carbon transport and emissions [147].

It has been noted that there is a lack of research on maritime supply chain sustainability and the overall concept of maritime supply chain network focuses on the management of raw material, manufacturing, transportation and distribution aspects of business [148]. For example, the sustainability of ports and environmentally responsible maritime operations can be approached through the use of sustainability indicators covering environmental, economic and social aspects [149]. The implementation of sustainable models of seaport business and cargo movement services can be promoted through coordinated activities and collaboration [124]. Research on sustainable maritime supply chains including associated opportunities and challenges is a relatively new focus area [78]. In addition, naval architects should also be more involved in broader maritime issues [125].

The emerging development factors encompass the sustainable relationship between ports and ships including novel focus areas such as CE in EU port cities [134]. Port managers should develop sustainable management strategies and introduce sustainable management initiatives based on the supply chain management approach covering the development of specific internal competencies, resources and capabilities [110]. Ports are platforms of circulation and transformation of material and energy flows and therefore they can promote the implementation of Industrial Ecology including optimization of resource management and more intense interactions between stakeholders within the port area in a broad sense [150]. Port cities need to advance CE transition and promote sustainability encompassing environmental, economic and social aspects [105]. Future research needs to focus on novel business models for CE initiatives and the roles of each actor in ports [151].

Smart sustainable development of port requires focus on both evaluation culture and evaluation tools encompassing focus on circular perspectives based on systemic and holistic view as well as on circularity and creativity principles [152]. Multiple actors such as the EU, city authorities, and governmental institutions should support ports in the implementation of CE [105]. The development of industrial ecosystems within port areas including industrial complexes and various process industry firms can promote both environmental performance and international competitiveness [153]. Large seaport hubs strive to advance the CE transition and become circular hotspots [151].

Previous research has noted that (1) there is a need for research on how port managers can enhance sustainability performance and on the nature of meaningful relationships with external suppliers, partners and customers; (2) port managers should improve sustainability performance and sustainable supply chain management through the development of supply chain collaboration with external stakeholders (e.g., service suppliers and carriers); and (3) port operators need to enhance internal collaboration to advance sustainability performance based on collaboration with external

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suppliers and customers [110]. Ports need to take a holistic approach to become more sustainable encompassing (1) environmental, economic, social and time dimensions of sustainability; (2) internal and external stakeholders; and (3) organizational change management, voluntary initiatives, and cultural/social, technological, legislative and financial approaches [108].

5. Conclusions

The findings of this study suggest that some of the 10Rs are included in and integrated into the online reporting and associated materials of shipping companies in the form of multiple approaches. These reports and materials are mostly related to sustainability, responsibility and environmental management. Companies place most focus on the following 10R principles: (1) replacement of products or making of products redundant (R0); (2) rethinking of products (R1); and (3) reduction of the use of resources in the manufacturing and use of products (R2).

The reuse of products (R3); repair of products (R4); refurbishment of products (R5); remanufacturing of products (R6); repurposing of products and their parts (R7); and recycling and recovery of materials (R8 & R9) received significantly less attention and approaches in these fields were often non-existent. There was typically some approaches related to the R8 and R9 principles (except for two companies) whereas were few approaches were found related to R4, R5, R6 and R7. For many companies, there were no approaches at all related to R3-R7. Based on these findings, it can be recommended that shipping companies place more emphasis on the aspects of CE that are linked to keeping products and materials in circulation such as repair, reuse, refurbishment, remanufacturing and repurposing. In addition, more focus is needed on recycling and recovery of all products and materials.

The findings suggest that even though companies are not always reporting on and publishing online materials related to CE, many approaches related to the 10Rs are included in and integrated into current reporting and communication instruments and practices. This implies that they are also a part of management and monitoring practices including associated consideration in the context of company operations. Future research should focus on further study on the integration of CE into the management, assessment and reporting practices within the shipping industry.

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