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Sustainability Transitions in Baltic Sea Shipping: Exploring the Responses of Firms to Regulatory Changes

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Abstract: This study investigates how the introduction of more stringent environmental regulation regarding sulphur and nitrogen emission control areas induced shipping companies to react to a new situation and opened up a window of opportunity for build-up of niches for alternative vessel energy sources. By drawing on a multi-level perspective from the socio-technical transition literature, the study provides empirical evidence for how realignments in the environmental regulatory regime alter incumbent actors' positions and produce varying environmental innovation responses to reduce air-borne pollution from shipping. The study illustrates that the stringency of a regional command-and-control regulation in combination with evolving pressures in the external landscape environment and shipping companies' task environments are essential components shaping the adoption of environmental innovations. Although incremental innovations seem to dominate in a fossil fuel-based maritime transportation socio-technical system, our results demonstrate the role of regulations and the behaviour of frontrunners in the context of regime fragmentation and sustainability transition processes.

Keywords: sustainability transitions; environmental innovations; multi-level perspective; Baltic Sea shipping; incumbent companies; sulphur and nitrogen emission regulation

1. Introduction

Various industries face growing societal pressures to address sustainability challenges. The mobility sector, including maritime transportation, has been identified as one such domain in need of transformative change [1–4]. Shipping accounts for the transport of more than 80% of the total global trade volume, and the demand for sea-borne transportation is projected to increase in the coming decades [5]. At the same time, maritime transportation is a contributor to global environmental pollution and negative health impacts [6–8]. Given the estimated growth in shipping operations worldwide and since the majority of the world's vessels are still running on highly polluting heavy fuel oil [9], it is urgent that environmentally benign shipping practices are facilitated.

The maritime environmental governance architecture has been characterized as polycentric and fragmented [10–12]. This means that the control of pollution from shipping encompasses a number of different actors with multiple centres of decision making. The International Maritime Organization (IMO) is the main international organization responsible for orchestrating measures pertaining to safety, security, and pollution prevention in international shipping. However, given that the IMO member states possess different levels of ambition for environmental standards in shipping and that ecological and oceanographical conditions vary from one sea basin to the next, some sea areas received

a higher level of protection [10]. The Baltic Sea area is one example of a regional approach to regulating emissions from shipping. Due to its environmental sensitivity the Baltic Sea has been designated as a “special area” in regard to air-borne pollution, oil, sewage, and garbage discharges where more rigorous environmental regulation (in the form of emission control areas or ECAs) is applied [13].

This study focuses on the Sulphur Emission Control Area (SECA) and Nitrogen Emission Control Area (NECA) in the Baltic Sea area. The main objective in this study is to explore shipowners’ responses to stricter sulphur and nitrogen emission level requirements in the Baltic Sea area and their motives behind investing in technologies aiming to reduce the emissions. The implementation of the SECA caused widespread debate among different maritime actors in the Baltic Sea region, and a search for different options to meet existing and forthcoming regulations [14,15]. The key question is whether SECA and NECA triggered a more profound change in shipping, where alternative energy (niche technologies) would start to develop to replace existing fossil-fuel based energy regime. The focus of this study is on shipping companies who were among the first ones to experiment with exhaust gas cleaning technological solutions such as scrubbers and alternative energy sources such as methanol and liquefied natural gas (LNG).

The introduction of SECA and NECA are two examples of a regional and more stringent command-and-control approach to regulate vessel emissions, irrespective of the flag that the vessel is flying. Sulphur (SO_x) and nitrogen (NO_x) emissions contribute to increased levels of acidification of land and seas, eutrophication, and negatively affect human health by increasing the likelihood of respiratory and cardiopulmonary diseases [16–18]. Since January 2015, shipping companies operating in the Baltic Sea SECA have to ensure that the SO_x content in the marine fuel used does not exceed 0.1%, unless a ship is fitted with exhaust gas cleaning technologies. Meanwhile, the introduction of NECA in the Baltic Sea means that all new vessels as well as those that undergo major modifications on or after 2021 will have to meet the NO_x Tier III emission reduction level. The NO_x Tier III regulation aims to reduce NO_x emission levels by approximately 80% compared with marine engines designed to meet less stringent NO_x Tier I requirements [16]. The underlying difference between SO_x limits in SECA and NO_x Tier III regulation in NECA is that the former applies to all vessels, whereas the latter concerns only newly built vessels.

Acknowledging that environmental engagement among shipping companies is largely driven by a compliance-oriented behaviour [19], it is unclear why some established shipping companies decide to invest in new maritime niche technologies that go beyond regulatory standards. Several recent studies analyse the economic impacts of emission regulation to shipowners, see e.g., refs. [20–23] and the anticipated impacts of the global sulphur cap, see e.g., refs. [24,25]. In contrast to these studies, the focus of this paper is on adoption of technological environmental innovations from a system perspective. How and why do maritime actors adopt emission reduction technologies? Do their technological choices reduce dependence on fossil-fuels and thereby contribute to energy transitions in shipping? What is the role of regulations and governance in this process? Previous studies have shown that the anticipation of forthcoming regulations facilitates the development and adoption of environmental innovations in shipping [14,15,26–28]. Besides anticipation of regulations; social, customer, and market pressures; corporate image; a first-mover advantage; emerging niche opportunities; and networking activities influence the adoption of innovations [29,30]. However, shipping companies’ responses to both SECA and NECA regarding the adoption of environmental innovations and underlying implications for energy transitions in shipping were not qualitatively explored so far.

The multi-level perspective (MLP) of socio-technical transition theory is used as a theoretical framework guiding and structuring the empirical observations of this study. The MLP framework has been developed by sustainability transitions researchers [31,32] with a goal to understand system changes that encompass “long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption” [33] (p. 956). In this study, the focus is on incumbent regime actors (established

companies in a mature shipping sector) who were among the first ones to experiment with new technologies. Following Berggren, et al. [34] and Fischer and Newig [35], the study adopts a dynamic approach suggesting that regime-level actors can adopt diverse responses to emerging niche innovations.

Given recent calls to clarify incumbent actors' responses to transition processes [36,37], it becomes relevant to study and understand how and why actors engage in sectorial transformations, what types of innovations they adopt and how existing governance arrangements enable or hinder mature firms to engage with niche technologies. The contributions of this study intend to bear relevance to the overall discussion pertaining to sustainability transitions theory linked to regime fragmentation and destabilization [37,38]. Regime fragmentation herein is understood as divergent firms' responses to external pressures [37]. By employing the system perspective, the study reveals key drivers behind individual shipowners' decisions to invest in maritime niche technologies and illustrates that change processes in the existing socio-technical regime do not necessarily follow incremental directions. The study illuminates the role of mature companies in translating regulatory requirements in advanced and new-to-the-existing-regime innovation trajectories that co-exist in tandem with the socio-technical regime environment.

The study is organized into five sections. Section 2 is dedicated to the introduction of a theoretical framework that draws on the MLP. In Section 3, we describe the methodology. In Section 4, we discuss the main findings of this study in light of the proposed analytical framework. Finally, in Section 5, we draw conclusions and policy implications.

2. Conceptual Framework: Socio-Technical Transitions and Environmental Innovations

The study builds on a multi-level perspective (MLP) of socio-technical transition theory. The MLP is a process theory highlighting that transitions towards greener modes of production and consumption involve complex interactions between structure and agency at three different levels: landscapes (the exogenous environment), socio-technical regimes (dominant set of rules and practices), and niches (locus of radical innovations) [31,38–40]. The MLP approach assumes that there is an intertwined relationship between technological development and social, economic, and institutional contexts that determines the scope and direction of change [31,33,41]. Both technological and non-technological innovations are regarded as important elements for socio-technical transitions to materialize [33]. In this study, the MLP framework is employed for exploring how developments in the socio-technical regime (e.g., introduction of new environmental regulations) interplay with external landscape pressures such as increased environmental awareness and economic fluctuations and how these dynamic processes stimulate incumbent shipping actors to adopt environmental niche technologies (see Figure 1).

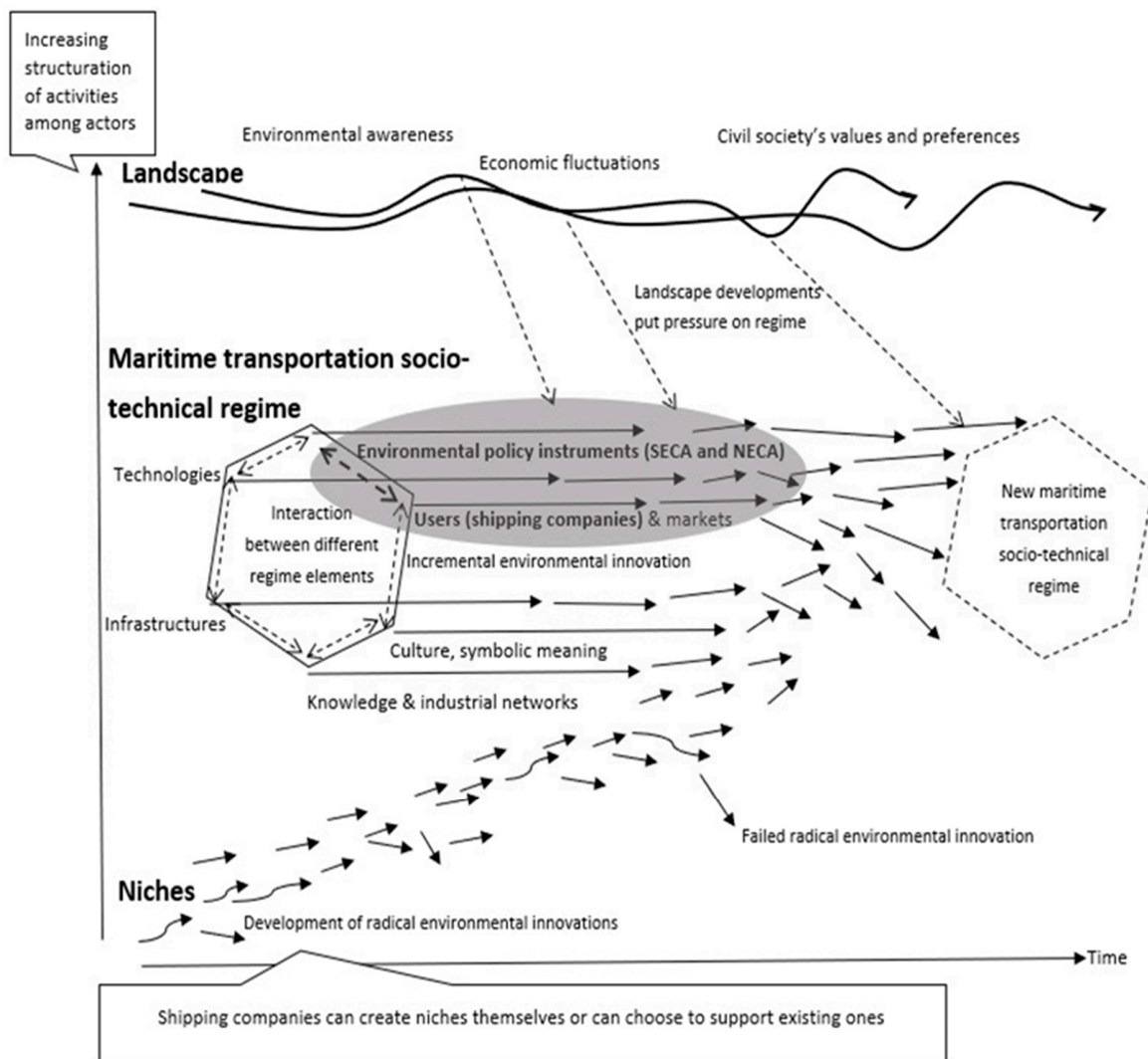


Figure 1. Multi-level perspective of sustainability transitions. Source: authors' own modification based on Geels [31], Geels and Schot [38], Geels [40].

The socio-technical landscape is an exogenous structure that influences niche and regime dynamics [1]. Environmental change, social movements, political and economic developments are examples illustrating socio-technical landscape components [31,42]. Landscape pressures might weaken and influence reconfiguration within the socio-technical regime, and this in turn can provide opportunities for niche development. To exert an influence, landscape pressures must be perceived and translated by regime and niche actors [38]. In this study, increased societal concerns over negative environmental impacts of shipping, economic fluctuations, and civil society's preferences operate in the external landscape environment.

The socio-technical regime represents a semi-coherent set of rules that are carried and reproduced by actors in a given socio-technical system [31]. Established technologies, markets and user practices, infrastructure, cultural and symbolic meaning, policies and knowledge are different regime elements that constitute a socio-technical system [40]. Transition from one system to another requires regime changes that do not occur easily because different regime elements (actors, institutions, and technological artefacts) are closely aligned. Although a close regime alignment provides lock-in and stability that supports incremental change trajectories, the regime environment can also be a source of tensions among regime actors [1]. Actors play an active role in interpreting, implementing, and transforming the regime's rules in various ways [40]. These actors can be firms, policy makers, engineers, end-users, and special interest groups such as industry associations [4,41]. In this

study, maritime transportation relying on fossil fuel-based propulsion technologies represents a socio-technical system. Shipping companies, regulatory institutions, infrastructures and technologies are different elements of this system.

The final analytical category—niches—are the loci of radical innovations [31]. The niche is a different type of structure that provides nurturing conditions and protective space for radical innovations, see e.g., ref. [43]. Such a protective environment is important because “radical innovations must compete with well-developed technologies that have gone through a series of incremental improvements, have gained precise user understanding and are integrated in the economic system and social life” [32] (p. 381). Protection can be warranted via demonstration and experimentation projects that are supported by public subsidies and/or entrepreneurial actors who are willing to invest in radical technologies [42,44]. Radical innovations can be developed as a result of emergent landscape pressures, technical problems at the firm level, actors’ ambitions to gain competitive advantage, regulatory pressures, and changing user preferences [40]. According to Markard and Truffer [41], niches that have the potential to provide solutions to some of the regime’s problems might be more successfully adopted by regime actors. To mitigate negative environmental externalities, some shipping companies can engage with maritime niche technologies (either by initiating demonstration/experimentation projects or choosing to adopt existing solutions developed in niches). At the same time, some companies might adopt incremental innovations entrenching a fossil fuel-based shipping regime.

Although the MLP approach acknowledges that the activities of actors are important for maintaining or changing a socio-technical system [40], it has been criticized for giving insufficient attention to the conceptualization of the roles of actors and agency [45]. In particular, incumbent actors are assumed to be supporters of the dominant technological and institutional routines, whereas newcomers (niche-level actors) are regarded as proponents of radical configurations [35,46].

Arguably, prescription of different degrees of agency to regime and niche-level actors is inspired by the theory of structuration introduced by Giddens [47]. For Geels and Schot [38], structuration is an important element guiding (but not determining) actor behaviour at regime and niche levels. Structuration is strongest at the landscape level and weakest at the niche level because actors cannot change landscapes by their own will and since institutional elements are less articulated within niches [38,40]. Meanwhile, structuration dynamics in the socio-technical regime have been described as “semi-coherent” because it largely depends on the stability of actor configurations in the existing regime [48,49]. Regulative, normative, and cognitive institutional rule elements influence actor behaviour and the extent of innovative activities at the regime and niche levels. Regulative elements represent rule-setting, monitoring, and sanctioning procedures; normative elements relate to mutually held expectations and obligations; cognitive pillar represents belief systems and understandings that provide recipes for action [50]. All three institutional pillars underline the different logic behind actors’ actions and provide different bases for legitimacy and compliance. At the same time, Geels [40] acknowledges the account of Giddens [47] regarding agency, which suggests that actors are actively involved in re-interpretation and reproduction of rules. Actors are guided by different preferences, private rule systems, strategies, and resource capabilities that provide variation in local practices but also opportunities to exercise agency and shape the existing “rules of the game” [40].

Actors’ preferences and strategies can also be shaped by their task environment defined as those aspects of organizational environment that are “relevant to goal setting and goal attainment” [51] (p. 133). For example, markets, suppliers, customers, and competitors are important elements constituting a firm’s task environment [51,52]. Bergek, et al. [53] highlight the role of the task environment in guiding the behavior of firms in the established sectors and emphasize interlinkages between the task environment and socio-technical systems. Actors in a given socio-technical system, be it companies or public actors, undertake strategic moves to improve their position or control of resources [40]. Following Bergek, Bjorgum, Hansen, Hanson and Steen [53], in this study, it is assumed that a market segment and firms’ operational characteristics as well as customer demand and supplier relationships are important elements influencing firms’ behaviour during transitions.

Thus, by acting upon institutional and task environments, incumbent firms can employ different types of behaviours during transitions. Incumbent companies can choose either first to enter niches or follow the pioneers and further transitions [54]. In contrast, others can remain inert or delay transition processes [55]. Hence, incumbent actors can operate both on regime and niche levels and undertake activities that may influence sustainability transitions in positive and negative directions, see e.g., refs. [34,36,56].

An explicit focus on environmental innovations requires a reflection upon their conceptual boundaries. The term environmental innovation is understood as “... a production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resource use (including energy use) compared to relevant alternatives” [57] (p. 398). Following this interpretation, environmental innovation does not have to be new to the market. It is enough that it is new to a specific company. The question of how to identify and measure environmental innovations is not in the least ambiguous. The innovation literature refers to two different approaches, namely, the objective approach that draws on technical criteria such as different indicators or patents and the subjective approach that relies on the logic behind actors’ activities [58]. In this study, the subjective approach is employed because we also aim to map ideas that did not lead to formal patents and those environmental innovations that were considered but have not been adopted by a respective shipping company.

3. Methods and Data

Given the explorative character of this study, the case study design was a suitable research strategy to reveal individual shipping companies’ motivation to invest in maritime niche technologies and to obtain an in-depth understanding of how and under what conditions policy interventions might stimulate or hamper sustainability transitions in the shipping sector. A target of the empirical inquiry was shipping companies who were among the first ones to undertake experimentation and adopt maritime niche technologies. Informed by the characteristics of innovation adopters suggested by Rogers [59], we define early adopters of environmental innovations as those companies who are actively engaged in implementing, monitoring and reporting their environmental work. A thorough review of publicly available information such as firms’ sustainability reports, online portals, and maritime press releases was undertaken to identify relevant companies.

In addition to company engagement with maritime niche technologies, the location of shipping operations and the shipping segment were important criteria that guided the selection of the companies. Five incumbent shipping companies providing short-sea-shipping services in passenger (Ro-Pax), wheeled (Ro-Ro), and container feeder transportation business segments in the Baltic Sea were selected. We have chosen to focus on these shipping segments informed by earlier research findings suggesting that a direct link with end customers increases environmental activities in these particular shipping segments see e.g., ref. [60]. A typical feature with many liner shipping companies operating on regular routes and fixed schedules in the Baltic Sea is that they transport both passengers and cargo on the same vessel (Ro-Pax). Liner shipping companies that transport high-value commodities (e.g., technical equipment, machinery, or consumer goods) as unitized cargo and especially passenger shipping companies are closer to their end-users, in contrast to tanker or dry bulk shipping segments where service provider–customer relationships can be more complex. Moreover, in contrast to ocean-going vessels, the short-sea-shipping segment is assumed to be the most suitable for testing alternative fuels with significant energy and fuel storage costs [61].

Semi-structured interviews, personal communication, and company documents form the backbone for the empirical analysis in this study. Shipping companies’ annual and sustainability reports were used to obtain background information on firms’ environmental engagement and to prepare for the interviews. Semi-structured interviews were conducted with 18 representatives from shipping and ship management companies, shipowner associations, national authorities, and regional

organizations from the Baltic Sea region (see Appendix A, Table A1). All interviews were conducted between May 2017 and February 2018 and lasted from 30 min to 1 h and 20 min. To clarify the context of the studied phenomenon, additional informal conversations were conducted with maritime experts and researchers during maritime seminar and workshop events. Interview guides were prepared for each individual interview (see Appendix B, Table A2). Four shipowner associations and representatives that are actively engaged in shipping regulation were incorporated in the study to obtain a wider perspective on greening behaviour among shipping companies and specifics on sulphur and nitrogen regulations in emission control areas.

The interviews were transcribed verbatim, coded and analysed following a thematic content analysis research method. In this method, the key focus is given to exploring relationships between topics and sub-topics central to the research question [62]. Empirical material was coded following a multi-stage process during which all interview material was categorized into main topics and sub-topics (see Appendix C, Table A3). The establishment of main thematic categories was guided by the research question, whereas sub-themes were identified based on the data while reading text passages that were assigned to each main category scheme during the first coding process. When key themes and sub-themes had been identified and placed into separate tables, relationships between themes and sub-themes were explored and interpreted considering the MLP approach. Following Kuckartz [62], those parts of the empirical material that did not correspond to predetermined topics were left uncoded.

The results are based on a single region and therefore are limited in terms of generalizability. However, findings of this case study focusing on shipping companies' responses to stricter environmental regulations on a regional level bear relevance considering the forthcoming global SO_x emission regulation in 2020. The shipping companies operating beyond SECA areas are likely to face similar questions and dilemmas as to what are the best means to transition into less sulphur-intensive modes of operation [63]. Moreover, the results of this study provide theoretical insights into incumbent actor behaviour during transitions in other mature and multi-segmented sectors that are exposed to stringent regulatory requirements, market and technological uncertainties.

4. Findings and Discussion

In this section, we discuss key findings of this study in light of the MLP framework. First, we show what types of environmental innovations were adopted among the Baltic Sea shipping companies with a goal to reduce local air-borne pollution. Second, we explore the underlying companies' motivations to invest in maritime niche technologies and the conditions under which the evolving environmental regulation regime reinforced or inhibited the adoption of identified environmental innovations by shipping companies.

4.1. SECA—A Wake-Up Call for the Baltic Sea Shipping Actors

The introduction of tighter sulphur limits in marine fuel challenged the existing fossil fuel-based shipping regime in the Baltic Sea region and created opportunities to adopt both end-of-pipe technologies, such as SO_x scrubbers and alternative fuels, i.e., LNG and methanol. Out of all the ships sailing the Baltic Sea in 2015, Antturi, et al. [64] estimated that 4719 ships had switched to low-sulphur fuel (MGO), and 136 ships had installed a scrubber. A few vessels were equipped with the LNG or methanol as fuel [63]. The majority of shipping companies decided to use low-sulphur fuel as a temporary solution so that they would have time to consider other technologies. Many shipping companies anticipated that, besides sulphur, other emissions would be regulated too.

The increased environmental awareness of the negative environmental impacts from shipping on the landscape level put pressure on regulatory authorities to stimulate environmental improvements in maritime transportation. All interviewed shipping companies named the increased public awareness and demands for cleaner transportation as an important driver for change. The SECA, as a command-and-control regulation, which set the limit on sulphur content in marine fuel to 0.1%

(unless the vessel is fitted with a scrubber), addressed increased societal demands but simultaneously generated internal tensions among regime actors. For example, the negotiation process between regulatory authorities at the IMO level and shipping lobby groups involved contestations and different proposals regarding acceptable sulphur reduction limits globally as well as in the emission control areas, see e.g., ref. [65].

Interviewed shipowners' associations and shipping companies were of the opinion that regional environmental regulation creates an uneven playing field among shipping companies. All interviewed companies but one were against the introduction of stricter sulphur emission limits in the Baltic Sea SECA. For the interviewed shipowners, the final decision to introduce a 0.1% sulphur limit in marine fuel in the Baltic Sea SECA came rather unexpectedly, and it challenged established (business) practices. However, the feared negative economic consequences—such as modal shift to road, clients lost, and even relocation of cargo-owner industries—that were heatedly debated by the shipping sector before the regulation did not materialize. Companies operating on regular liner traffic in the Baltic Sea did not make any major route changes or schedule adjustments either, but many of them transferred the additional cost caused by SECA to their clients in the form of a bunker fee [66]. Raza, Woxenius and Finnsgård [66] show that contrary to prior expectations, slow steaming did not increase either among Ro-Ro and Ro-Pax shipping companies operating in the SECA. Their results show that in the Ro-Ro segment slow steaming is done on a small scale primarily to save fuel costs. In contrast to deep-sea transports, getting savings by practising slow steaming is much harder in short-sea-shipping as the sea-legs are shorter and customers' lead-time requirements are very tight. For the Ro-Pax segment, slow steaming is not possible due to customer/passenger demands.

Although interviewed shipowners first resisted tighter sulphur limits, the SECA regulation instigated shipping companies reconsidering their environmental practices and fuelled discussions on the forthcoming regulations and adaptation to them. Several interviewees stressed that the shipping industry has increased engagement in addressing environmental matters over the last decade and has become more proactive in discussing forthcoming regulations. A representative from a shipowner association noticed:

The SECA regulation, although we were negative to it, it did work as an incubator for innovation. It started to make people and companies think . . . We have SO_x regulations on the radar now, what is going to be the next one? It is going to be NO_x (R03 Interview)

Arguably, SECA's regulatory requirement was an important regime-level catalyst that created incentives for companies to revise their strategies and opened up a window of opportunity for different moves among incumbent shipping companies. Three interviewed shipping companies chose to invest in more radical or transitional environmental innovations, specifically LNG and methanol-driven vessels. We refer to LNG and methanol as 'transitional innovations' since, although they help to reduce emissions, both are still largely relying on the existing shipping technological regime. Although LNG fulfils the sulphur requirements and can help to reduce NO_x emission levels and address CO₂ emission levels to a certain extent, it is still a fossil fuel, and its impact on mitigating climate change is debatable, see e.g., ref. [67]. Methanol can be produced either from fossil or renewable sources (e.g., biomass, industrial, or food waste). Adoption of methanol and LNG as maritime fuels required overcoming several technological, regulatory, normative, and cognitive barriers. There was no previous experience with their use in shipping, so in the eyes of maritime actors, both fuels represented radically new, "alternative" technology with a significant risk. Maritime actors and environmental authorities were concerned about the safety of LNG use (as it is a gas that is stored under a high pressure) and whether an LNG or methanol fuelled vessel will be sufficiently reliable. The possibility of reducing some emissions (but not all greenhouse gases) with LNG and methanol made shipowners rethink their long-term energy options and thus paved the way for alternative energy sources in shipping. Thus, from an environmental and societal point of view, adoption of these forms of environmental innovations represents a stronger case of sustainability transitions than incremental end-of-pipe solutions such as scrubber technologies.

The company that pioneered the building of LNG-driven vessels in the Ro-Ro shipping segment perceives the sulphur regulatory requirement in a positive light [68]. According to the company's representative, stricter regulations are important for the environment and especially for maintaining the company's competitive advantage:

We very much welcome new legislation within an environmental sector because it makes easier for us to take steps towards our vision. (. . .) It is often difficult and expensive to be a frontrunner (. . .) because then you have all the child diseases of new technology and you have to take a bigger cost than those who follow afterwards (. . .) it is good for our brand, of course. There is a specific value of it in itself, and, of course, it will help law makers (. . .) we can show them that things are possible and the sooner everyone else follows the better. (. . .) This SECA regarding sulphur emissions has helped us to introduce technology – LNG-powered ships that we would not have done otherwise, I think, because it would have been too expensive. (R10 Interview)

Arguably, shipping companies' interpretations and perceptions of the SECA command-and-control mechanism in general, and the chosen strategies for compliance in particular, were to a large extent guided by a company's task environment, visions, and environmental objectives. Earlier studies highlight that visions and expectations provide, among other things, "a stable frame for target-setting and monitoring progress: visions stabilize technical and other innovative activity by serving as a common reference point for actors collaborating on its realization" [45] (p. 1506). With the abovementioned company, the vision of emission-free shipping in combination with adequate financial, know-how, and network resources enabled it to exercise agency and push for the unorthodox investment in LNG-driven car carriers (Interview R07). Moreover, increased demand for year-round trading in the Baltic Sea area combined with the strict sulphur regulation were important elements that facilitated company investment in LNG propulsion [69]. Regulatory certainty was also important for ensuring that infrastructure supporting operations of LNG-driven vessels was in place. This illustrates how the choice of incumbent actors to adopt unconventional energy sources in shipping can bring changes in the path-dependent socio-technical regime environment.

In addition to the abovementioned company operating in a wheeled cargo business segment, two other incumbent companies in the Ro-Pax shipping segment chose to invest in LNG and methanol-driven vessels. One of the interviewed shipping company responded to the 0.1% sulphur emission regulation with a switch to low sulphur content fuel oil. Other technological alternatives, such as scrubbers, were considered but were found not suitable for applications on existing vessels because of economic, technical, infrastructural, and regulatory uncertainties. According to interviewees, life-cycle costs, technical durability, and uncertainties regarding scrubber wastewater reception facilities in port areas were the main concerns to the company (Interview R04). However, when planning for a newly built vessel in 2014, the company chose to invest in LNG propulsion that was previously pioneered by their competitor in the Ro-Pax shipping segment [70]. The choice to invest in the LNG-driven vessel was motivated by the opportunity to comply with existing and future emission regulations (including greenhouse gases) and ambitions to maintain competitiveness in the market segment [71]. Public funding from the European Union was allocated to partially support the company's investment in a LNG-driven vessel that commenced its operations in 2017.

Another Ro-Pax shipping company chose to convert its vessel to a dual methanol-diesel operation mainly in response to regulatory requirements but also because of economic considerations and ambitions to lead technological development in shipping (Interview R02, Interview R05). Although methanol was a successful environmental innovation from a technical point of view, changing economic pressures on the landscape level (decreased fuel prices) hindered the shipowner from converting more vessels to methanol:

Our plan at that time was to convert many ships to methanol because it had a good economy. A little bit more expensive than heavy fuel oil, but we took away all the sulphur; we also had very good NO_x

values (. . .) Then the oil price . . . it went from 100 dollars per barrel to 28 or something like that. So, the whole world changed. I mean this is what we live with . . . the fuel price. (Interview R05)

One year prior, the regulatory requirement was coming into effect, and the fuel prices were relatively high. Shipowners expected that the price of the low-sulphur fuels would rise due to the increasing demand, but the price of methanol and LNG would remain more stable. Hence, by choosing methanol, the company saved costs, increased its environmental reputation, and gained recognition among the maritime community and its customers for pioneering methanol-based propulsion in the ferry shipping segment. For the remaining fleet, other solutions, such as scrubbers or low sulphur fuel oil, were implemented. Although methanol remained a small-scale experimentation project in the Baltic Sea Ro-Pax shipping segment, the upscaling of this maritime niche propulsion technology has been implemented in the ocean-going tanker shipping segment, see e.g., ref. [72].

However, for some of the interviewed shipping companies, LNG and methanol are only interim solutions. They are investigating more radical propulsion technologies, such as electricity, wind, solar, and wave energy and want to drive technological development:

We want to be part of shaping those technologies (. . .) We have a lot of knowledge in shipping and engines and so on (. . .) Especially, in a company like ours which is one of the biggest container lines in the world. We have an obligation to drive the industry in the right direction. (R15 Interview)

Normative rule elements, including moral responsibility in environmental leadership in shipping and an ambitious vision, play an important role in motivating companies to move beyond contemporary environmental requirements. In addition, increasing demands from customers for cleaner transportation is an important element constituting companies' task environment that is especially relevant for the interviewed shipping company in the container business segment. For the interviewed shipping company, meeting customers' environmental demands is one way to differentiate from competitors in the field (Interview R15). However, even environmental frontrunners face challenges translating visionary frameworks into practice. For example, a representative from the Ro-Ro shipping segment highlights that knowledge and technology is already available for utilizing wind energy. However, uncertainties with upcoming regulatory requirements and the market situation hinder the adoption of wind energy technologies and thus investments in niche development (Interview R10).

In summary, shipping companies' responses to tightened sulphur emission levels in the Baltic Sea SECA and their motivation to (not) engage with particular maritime niche technologies cannot be interpreted in isolation. The MLP perspective enabled us to assess the number of important elements that are considered by incumbent regime actors, such as altering pressures on the landscape level (changing fuel prices) and specifics of companies' task environments, including their environmental strategy, moves of competitors, and customers' demands. Financial, know-how, and network resources in combination with normative ambitions to lead sustainable development in shipping were at the centre of the decision-making process when choosing end-of-pipe solutions, such as scrubber or transitional LNG or methanol solutions. The introduction of stricter sulphur limits was also found to be a game changer for the shipping regime in a regional context. The divergent company responses to environmental regulation illustrate the first signs of the shipping regime's fragmentation. Moreover, we found that landscape pressures played a somewhat dual role in shipping regime fragmentation and destabilization. On the one hand, increasing environmental concerns triggered a restructuring process in the shipping regulatory regime, which resulted in tighter sulphur regulations. On the other hand, fluctuations in oil prices in the external landscape environment provided strong incentives for companies to reconfigure their compliance choices. Thus, our study shows that when different landscape pressures work in opposite directions, they pave the way to incremental innovation trajectories. However, when landscape pressures are closely aligned, they are more likely to challenge existing socio-technical regimes and create pathways towards adoption practices of more radical solutions.

4.2. NECA and Wait-and-See Strategies of Baltic Sea Shipowners

The NECA Tier III nitrogen emission reduction targets can be viewed as complementary regulatory attempts to reduce local atmospheric pollutants from shipping on a regional scale. As the SECA case illustrates, although sulphur regulation shook shipping companies' expectations, it also showed the regulators' ability to undertake such schemes and alerted shipowners that similar restrictions concerning other pollutants can be implemented in the future. We discuss to what extent, and under what conditions, the introduction of the Baltic Sea as a NECA (in effect from 2021) is likely to facilitate or hinder shipowners to plan for or adopt environmental innovations to curb NO_x emissions.

The nitrogen reduction criteria are designed based on the ship construction date following a different-level (tiered) approach as specified in Regulation 13 of the IMO MARPOL Convention Annex VI and NO_x technical code [73]. While Tier I and Tier II nitrogen emission levels apply to all vessels constructed on or after 2000 and 2011, Tier III standards are applicable only to newly built ships operating in NECA areas. In contrast to sulphur emission limits that concern all vessels operating in the Baltic Sea, the NECA Tier III regulation is applicable to new vessels constructed during or after 2021 that operate in the Baltic Sea and the North Sea or to existing vessels that undertake major diesel engine conversions. In addition to the Baltic Sea, ships constructed in or after 2016 that operate in the North American and the United States Caribbean Sea have to meet Tier III nitrogen emission requirements.

The final decision to introduce the Baltic Sea as a NECA was adopted in 2017 [74]. Interviewees from a regional organization and shipowners' associations highlighted that the focus during discussions linked to introducing the Baltic Sea as a NECA has always been on newly built vessels (Interview R16, Interview R08). Fuel switching, combustion-related, or post-treatment of exhaust gas techniques are suitable ways to reduce NO_x emissions [75]. Selective catalyst reduction (SCR), exhaust gas recirculation (EGR), and switching to LNG or methanol are mentioned as the most promising technical solutions in the literature. We argue that each of these alternatives provides different opportunities in terms of facilitating sustainability transitions in shipping. For example, SCR and EGR are incremental end-of-pipe environmental innovations that are specifically tailored to reduce NO_x emission levels while simultaneously enforcing fossil fuel-based operations. In contrast, the switch to alternative fuels, such as LNG or methanol, is a transitional solution that is more likely to challenge the maritime transportation regime because the use of these fuels requires new bunkering or fuel supply infrastructure (to ensure fuel availability) and investments into either vessel engines or completely new vessels that may also require different types of operating and maintenance skills compared to conventional vessels. Often, the actors must also convince authorities that new fuels are safe to use. Thus, when changing a vessel's main energy source, shipping companies must exercise agency because the introduction of alternative methods involves overcoming institutional, technological, and market uncertainties.

The interviewed shipowners were somewhat less active in considering alternative energy sources to power their vessels in response to NECA requirements. NECA has not aroused any heated debates among shipowners, as was the case with SECA. This could be partially explained by the fact that the NECA regulation concerns newly built vessels and that some of the interviewed shipping companies took into consideration nitrogen emissions when changing the main vessel energy sources in response to SECA (e.g., vessels driven by LNG and methanol). The remaining interviewed shipowners, who have not invested in alternative energy sources or selective catalyst reduction systems for their existing vessels, adopted wait-and-see strategies. Several interviewees highlighted that it is up to engine manufacturers and other technology providers to ensure that their products comply with the Tier III nitrogen emission requirements for new vessels.

Regulatory ambitions to reduce nitrogen emissions from shipping were not seen as controversial by the interviewed Baltic Sea shipowners, although they argued that a regional approach to regulating air-borne emissions from shipping should be avoided because it creates an uneven playing field. In addition, one interviewee noted that it is unclear whether NECA will have a positive impact on encouraging investments into new vessels and if it will have an immediate effect on reduction of NO_x

emissions. According to one interviewee, some shipowners might be willing to bring and operate older vessels in the Baltic Sea area that are exempt from present NO_x Tier III requirements. Other interviewees highlighted the following:

(. . .) I do not think we will do much more than necessary following the NO_x rules, as I see it. Maybe we should actually aim our efforts towards things that give bigger environmental effects like CO₂ so try to reduce that much more than we do today. (R10 Interview)

NECA is of course for new builds only and since we do not regularly trade to the US, because there has been NECA for some time, none of our ships are born with Tier III requirements (. . .). That does not mean we are not concerned about the NO_x emissions. A number of our ships are fitted with selective catalyst converters. (R11 Interview)

We supported the NECA decision simply because it is not as difficult to comply with as was the sulphur regulation. It is only for new builds. That is not such a big requirement. (R08 Interview)

Thus, shipowners were not as actively engaged in trying to implement (as the regulation is not in force yet) or employ actions going beyond the NO_x Tier III requirements. The relatively high costs of NO_x Tier III abatement technologies and increasing landscape pressures to reduce other pollutants such as CO₂ have driven shipowners to prioritise reduction of other pollutants. The timing of landscape pressure formation, as MLP theory suggests, is one of the key factors influencing sustainability transition pathways. In light of NECA developments, it seems that increasing environmental pressures to focus on the climate impact of shipping operations in combination with changes in the economic landscape (fuel prices), during the time before NECA takes effect, create a major source of uncertainty that reduces the active engagement of shipowners. This indicates that the design of command-and-control mechanisms is essential in stimulating innovative responses. Whereas SECA spurred the adoption of transitional environmental innovations in the realm of the existing fossil fuel-based maritime transportation socio-technical regime, present NECA developments are not, at least in the short term, likely to challenge the existing fossil fuel-based shipping regime and enable more radical transformation pathways in the shipping sector.

In addition to these examples in which shipowners have chosen to invest in transitional environmental innovations in the wake of SECA regulatory requirements (e.g., LNG or methanol solutions), one interviewed shipping company was part of an experimental pilot project aiming to retrofit one of their vessel's auxiliary engines with the SCR system in 2014 (Interview R11). This example shows that anticipation of forthcoming regulations in combination with ambitions to lead technological development and gain an environmental reputation can provide a strong impetus to experiment with environmental technologies before regulation is enforced. Other interviewed shipowners have chosen to adopt SCR technologies in response to market-based policy measures, notably, environmentally differentiated port and fairway fees. This observation is in line with earlier research suggesting that shipowners' motivation to invest in NO_x reducing technology is often driven by environmental discounts in port fees [26,76]. Considering that the NECA command-and-control regulatory requirement is applicable only to newly constructed vessels, financial incentives can be a good source of motivation enabling shipping actors to improve the environmental performance of existing vessels. A representative from a shipowner association highlights the following:

Commercially, soft regulations are also a no-go to breach (. . .) In order to become competitive and in order to win contracts and charters, you need to go far beyond. (R03 Interview)

However, given that the SCR is an end-of-pipe technology directed at filtering and cleaning, a widespread adoption of this solution would imply a failure to challenge the continuous use of a fossil fuel-based energy sources in shipping that is needed to address CO₂ emissions.

Another observation in relation to shipowners' responses to NECA developments relates to compatibilities between technological solutions and regulatory frameworks. In the existing fossil

fuel-based maritime transportation regime, shipowners experience regulatory uncertainty with regard to what measures will be used to reduce CO₂ emission levels from shipping and question the compatibility between different regulations. As one representative from a passenger shipping company noted:

I think you have to take things like NECA together with other things that are happening in the maritime world (. . .) you look at NO_x, and you look at CO₂, and again they are on each side of the scale. You can optimize on your NO_x and that will cost you CO₂ and the other way around. (R11 Interview)

The timing of the emerging landscape pressures to reduce CO₂ emission levels seems to be important not only in relation to niche developments, e.g., wind propulsion [77], but also because it influences the internal dynamics of the shipping regime. In terms of its impacts, NECA Tier III is considered a relatively weak regulation [16] because it is applicable only to newly constructed vessels in particular world regions. The most environmentally driven shipping companies feel a moral obligation to explain the technological or economic barriers to adopting solutions that go beyond NECA requirements. For example, one interviewed shipping company from the container shipping segment noted that they were not willing to increase CO₂ emission levels and thus the amount of fuel being consumed at the expense of reducing NO_x, which is compulsory only for newly built vessels:

If you reduce NO_x emissions, which is possible today, you will increase your CO₂ emissions and increase the amount of fuel you are burning (. . .) You can definitely reduce NO_x, but it comes with a significant added cost plus increased CO₂ emissions. (R15 Interview)

In contrast to SECA, incumbent shipping companies were not actively engaged in supporting maritime niche solutions in the case of NECA. The relatively weak stringency of this command-and-control mechanism (concerns only newly built vessels) in combination with other factors such as economic fluctuations in the landscape environment together with growing environmental concerns over CO₂ reduction measures instigates shipping regime actors to consider adoption of incremental environmental innovations such as selective catalyst reduction systems. Thus far, NECA represents a weaker case in terms of forwarding sustainability transitions in the Baltic Sea shipping in comparison to SECA.

5. Conclusions and Policy Implications

Drawing on the MLP, the study has shown that regulatory stimulus can be an important element providing impetus for action among incumbent actors in the established and mature shipping sector, but it is not the only factor contributing to the uptake of particular technological solutions. A combination of evolving pressures on both landscape and regime environments as well as actors' responses are important for understanding regime fragmentation processes in a fossil fuel-based shipping socio-technical system. The case of Baltic Sea shipping illustrates how incumbent actors can enact several roles simultaneously during transitions as adopters of both incremental and radical environmental innovations.

With SECA, increased environmental concerns over local air-borne pollution from shipping were translated into a stringent environmental sulphur regulation on a regime level. At a time when oil prices were relatively high, this landscape pressure operated in a synergetic relationship with sulphur regulations, enabling some of the shipping companies to consider more radical compliance solutions, such as the use of methanol. The stringency of the command-and-control regulation and anticipation of new environmental requirements were important regime-level components that motivated shipping companies to adopt alternative energy sources for some of their vessels. However, a radical drop in oil prices provided strong incentives to consider other solutions such as end-of-pipe exhaust gas cleaning systems that support fossil fuel-based shipping operations. Similarly, the NECA case illustrates that relatively weak command-and-control regulation and uncertainty regarding the alignment

between existing and upcoming environmental requirements (such as GHG emissions), in combination with economic signals from the landscape level, instigates shipping companies' reluctance to adopt transitional or more radical environmental innovations. Although it is difficult to compare SECA with NECA because the latter has not yet been enforced, NECA development has played a negligible role in facilitating the adoption of more radical environmental innovations among interviewed Baltic Sea shipowners. The shipping companies are planning for incremental improvements in pursuing the nitrogen requirement or have already adopted end-of-pipe technological solutions such as SCR technologies as a result of economic incentives introduced by national or port authorities.

We see two general theoretical implications emanating from this study. First, both SECA and NECA cases show that timing and pressures from the landscape level (economic fluctuations, increasing societal demands for cleaner transportation) are important elements that can bring regime fragmentation and destabilization, depending on how regime actors choose to respond to them. Regime actors interpret and translate landscape pressures differently at any point in time and space and may also adopt divergent strategies to react to them. Landscape pressures can work in unison, creating a "window of opportunity" for the adoption of environmentally benign practices in general and radical innovations in particular. Second, configurations in the existing regime environment (stringency and alignment between existing and forthcoming regulations, infrastructural and technological opportunities) as well as companies' task environments (market opportunities, customer demands and the moves of competitors) are important elements of the socio-technical regime environment that incumbent companies take into account when choosing to invest in niche technologies.

The fact that regime actors translated SECA and forthcoming NECA applications into multiple innovation practices illustrates earlier observations by Karltorp and Sanden [37] and Steen and Weaver [36], which underline differences in incumbents' responses towards external pressures when explaining regime destabilization and fragmentation. Regime actors' positions are shaped not only by regulatory but also cognitive and normative rule elements that provide different bases to exercise agency. In contrast to earlier propositions suggesting that "large incumbent firms will probably not be initial leaders of sustainability transitions" [1] (p. 25) and most likely employ resistance strategies [56], our results show how incumbent shipping actors play an active role in creating protected niches in which transitional environmental innovations, such as a methanol-driven vessel, are developed. Exploring agency dynamics more thoroughly within the existing shipping regime, especially those concerning how agency is activated and shaped by external and company-specific factors, could be an avenue for future research in the context of maritime transportation. Such studies might create a more nuanced understanding of the stimuli and barriers for sustainability transitions in shipping.

Based on the findings of this study, we highlight a need for a holistic approach in the design of command-and-control regulations in shipping. Although "a need to innovate" is imprinted in the environmental policy and regulatory agenda aiming to decrease negative environmental impacts from shipping, and companies themselves stress it, the main challenges are linked to implementing this in practice. Regulations can play a role in motivating shipping companies to advance their sustainability practices. However, the results of this study show that regulatory commitment that is signalled by the authorities (whether regulation concerns existing or newly built vessels) can make important differences in companies' choices. It should also be recognized that although regulatory command-and-control mechanisms can contribute to solving a particular environmental problem with newly introduced environmental technology, a partial solution, focused on one emission source only, might increase emission levels of another [67,78]. We argue that an emphasis on synergetic relationships between different regulatory frameworks is needed to provide stronger incentives for the shipping industry to search for more radical compliance solutions. As SECA, NECA, and ongoing CO₂ discussions show, regulations have thus far been designed in a fragmented manner focusing on one pollutant at a time. Finally, there is a need to understand the role of other policy instruments (e.g., market-based measures and private standards) and policy mixes in polycentric maritime environmental governance. Considering that shipping companies are free to choose compliance pathways, parallel

governance mechanisms rewarding proactive shipping companies for moving beyond compliance are necessary to stimulate sustainability transitions in shipping.

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Appendix A

Table A1. A list of interviews.

Code	Category	Interviewees	Selection	Status	Date	Duration	Recording	Transcript	Confidentiality
R1	Clean shipping official	Coordinator	Direct	conducted in person	19 May 2017	1 h 20 min	Audio recording	transcribed, transcript posted	Granted
R2	Shipping company	Head of sustainability unit	Snow ball	conducted in person	5 September 2017	51 min	Audio recording	transcribed, transcript posted	Granted
R3	Shipowners' association	Senior policy advisor	Direct	conducted in person	14 September 2017	1 h 7 min	Audio recording	transcribed, transcript posted	Granted
R4	Shipping company	Environmental specialist & CEO ship management (2 interviewees)	Snow ball	conducted in person	13 October 2017	1 h 6 min	Audio recording	transcribed, transcript posted	Granted
R5	Shipping company's technical department	Marine standards advisor	Snow ball	conducted in person	25 October 2017	1 h 19 min	Audio recording	transcribed, transcript posted	Granted
R6	Shipping company	Deputy managing director	Snow ball	conducted in person	23 October 2017	57 min	Audio recording	transcribed	Granted
R7	Ship management company/shipowner	Head of sustainability and operational excellence	Snow ball	conducted in person	31 October 2017	58 min	Audio recording	transcribed, transcript posted	Granted
R8	Shipowners' association	Director of security, health, environment and innovation division	Direct	phone interview	3 November 2017	36 min	Audio recording	transcribed, transcript posted	Granted
R9	Shipping company's corporate level	Sustainability coordinator	Snow ball	phone interview	6 November 2017	57 min	Audio recording	transcribed, transcript posted	Granted
R10	Ship management company/shipowner	Project manager for strategic projects	Snow ball	conducted in person	30 November 2017	1 h 1 min	Audio recording	transcribed, transcript posted	Granted
R11	Shipping company	Director for environment and sustainability	Direct	Skype interview	7 December 2017	55 min	Audio recording	transcribed, transcript posted	Granted
R12	National authorities	Environmental advisor & legal advisor (2 interviewees)	Snow ball	Skype interview	11 December 2017	59 min	Audio recording	transcribed, transcript posted	Granted
R13	Shipowners' association	Head of association	Direct	conducted in person	29 December 2017	1 h 18 min	Audio recording	transcribed, transcript posted	Granted
R14	Shipowners' association	Board member	Snow ball	phone interview	11 January 2018	1 h 10 min	Audio recording	transcribed, transcript posted	Granted
R15	Shipping company	Senior sustainability advisor	Snow ball	phone interview	18 January 2018	26 min	Audio recording	transcribed, transcript posted	Granted
R16	Regional authority	Professional secretary	Direct	Skype interview	19 February 2018	1 h 31 min	Audio recording	transcribed, transcript posted	Granted

Appendix B

Table A2. Interview guides.

Interviews with Shipping Companies	
1.	Could you tell me more about environmental initiatives that your company is working on? Why did you choose to focus on these and not the other initiatives?
2.	Could you tell me more about technological/organizational innovations with the goal to decrease SO _x and NO _x air-borne emissions that your company adopted?
3.	Where there any environmental innovations that your company considered but chose not to develop/adopt, in particular in relation to SO _x and NO _x ? What were the reasons that hampered such innovative activities?
4.	What are they key factors encouraging your company to develop and implement these environmental initiatives/innovations? Where does the impetus to change come from?
4.1	In your view, what role do formal environmental regulations play in facilitating transition into clean shipping?
5.	Is your company going beyond regulations in terms of maritime emissions/clean shipping practices (doing, voluntarily, more than what is required by law)? If yes, what is the driving force behind this?
6.	What was your company's position/reaction towards the SECA regulation before adoption?
6.1	What about the enforcement?
6.2	Did this regulation trigger any actions in terms of new technology adoption or new organizational activities at the company level?
7.	How did your company meet discussions with regards to introducing the new NECA? What are the key concerns/challenges?
7.1	What about the enforcement?
7.2	Did the launch of this regulation trigger any actions in terms of new technology adoption or new organizational activities at the company level?
8.	What is your view on overall drivers of change towards cleaner or less emission-intensive shipping?
9.	What could be done to forward sustainability and adoption of environmental innovations in shipping?
10.	Are your company's positions on the matters we just discussed well aligned with your personal views? Maybe you have slightly different personal views on some of the matters we just discussed. If so, could you provide some examples?

Table A2. Cont.

Interviews with Shipowners' Associations

1. Could you tell me more about your association's work linked to reducing negative environmental impacts from shipping? How is your work structured?
 2. What are key environmental initiatives that shipowners are focusing on at the moment? Do they change over time? If so, what is the driving force behind the changes?
 3. In the context of your work, do shipowners discuss their failed efforts to adopt/implement innovations or do they share only success stories? Could you give examples?
 4. What are the key factors encouraging shipowners to develop and implement these environmental initiatives/innovations? Where does the impetus to change come from?
 - 4.1 In your view, what role do formal environmental regulations play in facilitating the transition into clean shipping?
 5. Would you say that members of your association are going beyond the regulations in terms of maritime emissions/clean shipping practices (doing, voluntarily, more than what is required by law)? What is the driving force behind this?
 6. Can you describe your association's position/reaction towards the introduction of the sulphur regulation in SECA and challenges/opportunities linked to its enforcement.
 7. How has your association perceived the recent IMO decision to introduce Baltic Sea as a NECA?
 8. What is your association's view on the overall drivers of change that encourage shipping companies to become "more green"?
 9. What could be done to forward sustainability in shipping?
 10. Are your association's position on the matters we just discussed well aligned with your personal views? Maybe you have slightly different personal view on some of the matters we just discussed. If so, could you provide some examples?
-

Appendix C

Table A3. The interview data coding scheme.

Analytical Level	Main Categories	Sub-Categories	Examples from the Data
Landscape and regime level	Drivers for environmental improvements and innovations	Regulatory	"Obviously, this sulphur emission cap in ECA areas has driven technology like alternative fuels, like LNG or low sulphur diesel. That is not a big technology shift but still." (R10)
		Economic	"The price. I mean our plan at that time was to convert many ships to methanol because that had a good economy." (R05)
		Customer pressure	"We have to listen to the partners we have in our business, and that is our customers. We get a lot of feedback on what our customers want us to do." (R11)
		Societal pressure	"We see pressure from society to become greener." (R03) "Public opinion that is the initiative and trigger." (R04)
		Company-specific factors	"But there are always some agenda: to get a competitive advantage against the others or to use it for getting more orders." (R13)
Regime level	Sulphur emission control area	Attitude towards regulation	"SECA regulation, although we were negative to it, did work as an incubator for innovation." (R03)
		Company responses	"We have been calculating different options, looking at different technologies (. . .) Our conclusion was that installation of scrubbers was not economically feasible." (R15)
	Nitrogen emission control area	Attitude towards regulation	"There we have not been too proactive . . . rather we think the legislation is good and, of course, we will follow it. Perhaps within some margin." (R10)
		Company responses	"Our ambition on NO _x is to be in compliance. We have done a lot of innovation across the whole fleet to reduce our fuel consumption." (R11)
Regime and niche level	Adopted and/or failed environmental innovations	Incremental innovations	"When it comes to energy efficiency, quite often it is more incremental steps. Because you do small improvements gradually which could be technical or it could be functionality and time-driven which sort of improves energy efficiency performance every year." (R02)
		Radical innovations	"Using LNG as a fuel onboard. This was for us totally new technology. And also, we built up logistics for the LNG supply around it." (R04)

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