University of South-Eastern Norway

Green Labelling a Sea Voyage using Real Time Data

Candidate name: Vilde Johnsen Angelsen

University of South-Eastern Norway
Faculty of Technology, Natural Sciences and Maritime Sciences

MASTER THESIS

May 2022

Abstract

A case study research design of a sea voyage between Port A and Port B was chosen for this study. The goal was to identify challenges and bottlenecks of sea-going activities inside and between ports. The purpose is to contribute to the body of knowledge regarding green labels in the maritime industry, as well as contributing to identifying parameters for a green framework. Three interviews were conducted: with the port authority of Port B, a VTS System Supplier, and a Norwegian environmental organization. In addition, secondary data sources were studied from Port A. An extensive literature review was carried out, analysed thematically to identify consistency of related research. The findings from the industry and the literature were eventually compared with the aim of identifying similarities and potential knowledge gaps between industry and research.

The findings suggest that challenging areas within maritime shipping can be related to regulatory, collaborative, standardization, and motivational factors. In terms of regulations, barriers, stopping sustainable progression, were identified in charter parties, encouraging shipowners and operators to sail full speed to port, rather than at economical speed, despite long anchorage times in ports. The maritime industry consists of complex stakeholder environments, where stakeholders represent different interests and financial models. Collaboration would increase communication, data sharing, and potentially increase efficiency. In ports, the visiting vessels, terminals, and VTSOs collect different data, which, if shared, could allow the stakeholders to make more efficient decisions. Standardization of parameters to measure environmental performance, methodologies, measuring- and analytical tools is vital to ensure that the market conditions are equal. Data sharing and different data formats are outlined as a current barrier for adopting green frameworks. The maritime industry is known for its conservativity, suggesting that implementing innovations can be difficult. The motivational factors outlined in this study relates to reluctance of sharing and collaborating, “watch-and-wait” attitude, and business-as-usual approaches.

While many of the industry findings correlated with the literature findings, there were some differences, especially related to motivational factors for adopting green labels. Additionally, findings suggests that when conducting studies in the maritime industry, one should have a holistic view, where different stakeholder opinions are considered, to ensure the complexity of the industry is embraced.

Acknowledgements

First of all, I would like to thank my university, the University of South-Eastern Norway, for providing me with my education. Through five years I have met many people, students, and lecturers, who have inspired to move forward. A special thanks to my colleagues this semester!

I would like to thank my supervisor, Per Haavardtun, for agreeing to support and guide me through my master thesis with your professional expertise, knowledge, and excellent discussions.

I am grateful for all the companies who agreed to participate in this study. I would not have learned as much as I have, without your participation in interviews, meetings, and otherwise supportive efforts.

Finally, I would like to thank my family and friends who were forced to endure my ups and downs during the work on my thesis. I am especially thankful for everyone who were able to read and provide vital feedback on my thesis. I would not have been able to complete this without you!

I hope the reading is enjoyable, and that you find this topic as interesting and important as I have.

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1. Introduction

Maritime Transportation is a big contributor to global emissions. If we are to meet UN's sustainability goals by 2050, changes need to be made within this sector. While Ravn (2021) identified parameters for measuring green performance, for shore-based operations in port, this study will direct its attention on sea-going activities, and thus contribute to the development of a common framework for measuring green performance within maritime shipping. This study follows a case study research design, where a sea voyage from Port A and Port B is the object of study. Both ports reside in the UK, and as such the findings should be considered from a Short Sea perspective. It aims to identify parameters for measuring CO_2 emissions and thus identify challenges and bottlenecks potentially increasing CO_2 emissions. The case study targets emissions during the sea voyage between ports, the interaction between ship - port and related sea-going port activities. Green labels, also known as eco-labels, effectively referring to green frameworks are studied to investigate whether they have any influential effect on the stakeholders involved in maritime shipping.

The focus of the study is divided in three fields:

1. Green labels

Green labels serve the purpose of reporting and informing consumers of the product's green performance. This requires a waterproof framework containing parameters, measuring methods, monitoring methods, administrators and so on. The labels aim to decrease the knowledge gap between consumers and the industry, and further influence the consumer to make green purchases and thus the producer to transform their activities to more environmentally friendly practices. The contributions of this study will be a deep dive into green labels and their usefulness in maritime shipping, which will be investigated through in-depth interviews with a Norwegian Environmental Organization with maritime expertise.

2. Interaction shore/ship

An assumption for this study is that better planning and better communication can increase efficiency and thus decrease emissions. By investigating two pre-selected ports, the goal is to identify bottlenecks and challenges related to the communication and data-sharing between shore and ship. In order to achieve this, several industry players will be included: interview with the port authority of Port B, investigation of Port A through seconday data

sources, and finally in-depth interviews with a Vessel Traffic Services (VTS) System Supplier to identify technical challenges, limitations and possibilities, especially concerning big data.

3. Real time data

The increasing access to real time data, especially through Automatic Identification System (AIS), have uncovered new possibilities related to navigational purposes, safety, and monitoring. However, concerning environmental monitoring, there are still limitations related to access of data, which further forces organizations and researchers to base calculations upon assumptions, thus decreasing the accuracy. This study aims to identify the challenges related to collecting and processing real time data and provide comments on whether this new access is increasing accuracy relative to historical data, which has been popularly used in the past.

The findings will be cross-checked to find any potential similarities in reported challenges and/or bottlenecks which will form the basis for the discussions in the final parts of the study. Covid-restrictions, as well as challenges related to data collection are present, and potentially affect the quality of the contributions. However, this study's main contribution will be a proposition of a set of parameters which has the potential of measuring green performance, and thus aims to increase the body of knowledge regarding environmentally friendly maritime shipping and the potential use of green labels in such an industry.

1.1 Impact

According to UN's sustainability goals, the world needs to cut emissions to stabilize temperature rise well below 2 degrees (UN, 2022). This requires maritime shipping, which counts for approximately 2.2 % of global CO_2 emissions (IMO, 2019a), to pull its weights. This study seeks to address the challenges and need for a switch to greener practices, with the ultimate goal of reducing total emissions.

To tackle this challenge, an increase in the body of knowledge regarding bottlenecks and challenges, directly affecting maritime activities, is required, as well as awareness of common methods and approaches. The latter is a huge challenge in the maritime industry due to its international character and raises questions regarding who has legislative authority, and further authority to monitor this. It further suggests that any frameworks will be of a voluntary nature given the structure of the industry today.

This study will thus investigate the possibility of developing a common framework meant as an aiding tool for maritime industry players to transform their activities to tackle the

climate crisis and simultaneously meet UN's sustainability goals, which potentially will be an important source for regulatory pressures in the future.

1.2 Goal

The goal of this study is first and foremost to increase the body of knowledge and create more awareness regarding challenges and bottlenecks hindering environmental solutions within the maritime transportation sector. Furthermore, the findings will contribute to the development of a common framework for measuring and controlling emissions, by identifying potential parameters.

1.3 Structure and Strategy

This paper is divided into three parts: the literature review, the data collection with in-depth interviews with ports, a VTS System Supplier, and an environmental organization, and a presentation of the findings and corresponding discussion. The findings will be cross analysed to help identify potential similarities and differences between industry findings and literature findings. The results and conclusion will be presented at the very end after a thorough discussion of the findings.

Sustainability can only be achieved through collaboration, which is the motivation for including participants from different areas of this industry. The goal is to use a case study approach to ensure a holistic view of the value chain of a sea voyage. An assumption for this study is that many factors affecting emissions must be viewed from a holistic perspective, as all participants potentially affect or are affected by this. The ports will be studied either through in-depth interviews regarding potential operational bottlenecks and challenges, or by studying secondary data sources. A VTS System Supplier was also chosen as a participant as they offer valuable information regarding technical solutions, limitations, challenges, and possibilities. This can increase the body of knowledge when studying interaction between ship/shore communication, and data sharing during a voyage, which again affects voyage planning. Finally, a Norwegian environmental organization was included, to get more insight in relevant studies being carried out regarding environmental solutions in the maritime industry, and to include a neutral third-party without any direct commercial interests.

1.4 Change management

This study was initially planned as a case study following a sea voyage from port A to Port B. The researcher would join the sea voyage to make observations of the operational aspect, which were to form the basis for the interview with the ship operator/owner. Furthermore, observations were planned carried out in relevant VTS' as well, to observe port

of calls from the ports' perspective. This was to form the basis for the interview afterwards. The VTS System Supplier would participate in two interviews, one pre-observation, focusing on the technical perspective of VTS systems, and one after the observations, which would be based upon findings from the former observations and interviews.

Due to covid-19 restrictions, observations became impossible, as well as participation on a sea voyage. This forced the researcher to change the strategy for the study which resulted in a greater focus on the literature review, and the interview guides would now be formed based upon findings from the literature as well as "best practices."

2. Literature review

This chapter outlays the theoretical foundation and the framework for this study and contains three subchapters. The first explains the goal for the review, the second displays the method used for finding and selecting literature. In the third subchapter, the reviewed literature is presented.

2.1 Goal

The overall goal of this literature review is to 1) investigate the assumptions stated in the introduction, 2) explore the research problem in more depth and detail, and 3) explore previous studies relevant for the research problem. The literature review consists of three parts all designed to help answer the relevant research question.

RQ1: Do green labels encourage the industry to switch to more green practices?

An assumption for this study is that green labels encourage industry to switch to greener practices. The literature review will focus on previous studies to define green labels, investigate the effect on the industry as well as consumers, and finally to discover success factors of implementing such labels.

RQ2: Will improved data management tools (capable of handling big data) increase efficiency(emissions)?

The assumption is that there is unexploited potential in the communication aspect between ship/shore and amongst stakeholders in general. This requires deeper knowledge of communication tools, such as VTS systems, technology that enables data-sharing, and finally an outline of the benefits as well as challenges related to the communication aspect.

RQ3: Are Real-time data more accurate than historical data?

Real-time data is data measured in real time. However, there are various grades of real-time measuring, so defining how accurate the data must be to be classified as real-time data is a field of interest for this review. Furthermore, historical data is typically used to calculate emissions related to sea voyages today, so more knowledge of why this is a preferred data source relevant to real-time data and how accurate measures, like emissions, should be, is the topic for this section of the literature review.

2.2 Method

The search for literature was divided into four separate searches. The purpose of the first one was to identify relevant search terms, the second one focused one efficiency during sea voyages, the third focused on technology on-shore and during sea-going activities, whilst the final one focused on green labels.

Identifying relevant search terms

The purpose of the first search was to get an overview of research trends, within the field of sustainable freight transport. The search was conducted in the database Scopus. The keywords used were "sustainable freight transport." Furthermore, the limitations of the search were English and Scandinavian language. This resulted in 65 hits, which were shortened down by reading and evaluating the abstract of each article. 23 articles from the search were of interest and were registered in Endnote for further review, which Table 1 provides an overview of.

Table 1: Number of Papers and Journals included in the literature review

Articles included	23
Conference proceedings/conference papers	2
Journals included	16

These papers were then skimmed through, while main topics were noted down, as well as useful keywords for later purposes. In this process 3 articles were deemed relevant and kept with intention of being read more carefully.

This process also generated several keywords relevant for further literature search. It resulted in 37 keywords displayed in the Table 2. Furthermore, these keywords were placed in different categories, representing the field of interest.

Table 2: Keywords for literature review

Approach	Technology	Sustainability	Shipping	Transportation	Technical	Green label
Jit- just in time Real-time switching Real-time planning	ICT – information and communication technology PI – physical internet Transport system identification IoT applications Big Data analysis	Green logistics Smart logistics solutions Sustainable logistics Energy sustainability Carbon active ERT – environmentally responsible transport EMS – environmentally management systems	SSS – short sea shipping Vessel efficiency Inland waterway transport – IWT Green port Green marine O-D – origin – destination Last mile transport/distribution	Freight flow Energy balance Road/vehicle efficiency Reverse logistics Logistics 4.0 Energy logistics utilization In- and outbound logistics External cost Hinterland transport Inland navigation Cargo transport	White paper Grey paper Grey theory	Eco-label

Using the snowball effect while reading the 25 initial papers, the reference list of each paper was reviewed, and articles were selected based on title. Later this list was reviewed, and the abstract was read to measure their relevance. This resulted in 47 articles of interest.

In the second search, the terms “energy efficiency,” “energy balance,” and “vessel efficiency” were used, combined with “ports.” Three search engines were used: Scopus, Science Direct and IEEE. Overall, this resulted in 21 hits. Based on title and abstract, this list was shortened down to 6 papers, both including articles and conference papers, all peer reviewed. A similar search was conducted focusing on the sea voyages. All metadata was

considered, and the search resulted in 5 hits, whereas 2 articles were included in the reading list based on abstract and title.

The third search focused on technology, communication technology and big data in ports and/or at vessels. The search terms used were “ICT,” “information technology,” “VTS” and “port.” Title, abstract and keywords were included, and resulted in 83 hits in Scopus. Using the title as exclusion criteria, 16 articles were marked for further review, and 10 were further included in the reading list. Science Direct provided 12 hits, whereas 2 of the papers were already included.

The final literature search concerned green labelling, where Scopus and Science Direct was chosen as search engines. “Green labels” and synonyms were used as search terms, together with “cargo transport,” “logistics” and other synonyms. Scopus came back with 11 hits, Science Direct with 12 hits. Based upon the title, 13 articles were marked for further review, and based upon abstract, 7 articles in total were included in the reading list. A final search was performed on green labels, where only “green labels” and synonyms were used as search terms, to make sure the initial search did not exclude relevant articles. This resulted in a total of 83 hits from Scopus, and 22 hits from Science Direct. Based on title, 17 were considered for further review, and after reading the abstract, 8 articles were further included in the reading list (2 of the articles were already included from previous searches).

Table 3 summarizes the process of finding and selecting literature.

Table 3: Selection process of literature review

Search terms	Hits	Selection criteria #1: Title	Selection Criteria #2: Abstract	Selection Criteria #3: Paper
Sustainable freight transport	65		23	23
Snowball	47			
Energy efficiency, vessel efficiency, ports	21		6	6
Efficiency, sea voyages, vessel	5		2	2
ICT, IT, VTS, port	95	16	12	12
Green labelling	128	30	13	13

The total reading list included 56 (not included Snowball) papers, whereas 25 articles were deemed as relevant and included in this review. The articles were from 20 different journals, consisting of research articles and conference proceedings, ranging from the years 2007 – 2021, with the majority being from after 2014.

2.3 Reviewed literature

In this final subchapter of the literature review, the literature selected is presented. This subchapter is divided into three main sections, namely Green Labels, Environmental Frameworks and Maritime Activities. In each section, the literature is presented, and the main topics are defined, which forms the theoretical framework for this paper.

Green Labels

Green labels, also known as eco-labels, are typically product or service labels with the purpose of reporting environmental performance. Labels such as these have been introduced across industries and sectors, with various levels of success. The literature review below, aims to 1) define what such labels are, 2) define the requirements for success, and finally, 3) how such labels are affecting consumers.

Definition

Eco labels, also known as green labels, can be defined as a policy information-tool, reporting the environmental performance of a product (Galati et al., 2021; Meis-Harris et al., 2021; Polinori et al., 2018). It serves the purpose of providing consumers with information regarding environmental performance, in an easy, accessible way (Sønderskov & Daugbjerg, 2010), thus reducing the knowledge gap between consumers and producers (Baumeister & Onkila, 2017). The Global Directory of Eco-Labels reported 455 registered eco-labels, divided on 199 countries and 25 industry sectors (Global Directory of Eco-Labels). Eco-labels are receiving much attention in sectors such as fisheries (Galati et al., 2021; Thrane et al., 2009), construction (Wu et al., 2014) and agriculture (D'Souza & Yiridoe, 2019).

Eco-labels can be divided into two types, namely Type I and Type II (D'Souza & Yiridoe, 2019). Type I labels are developed and monitored by the private company adopting the same label (D'Souza & Yiridoe, 2019) and gives companies the possibility of claiming product attributes that their consumers care about (Baksi & Bose, 2007). Type II labels are developed by an independent third party, who will often be responsible for monitoring users of the same label (D'Souza & Yiridoe, 2019), in return for financial compensation from the company adopting the label (Baksi & Bose, 2007). Eco-labelled products are often sold with a price premium compared to similar products without eco-labels (Prieto-Sandoval et al., 2016) and could help companies gain competitive advantages (Meis-Harris et al., 2021).

Design

Baumeister and Onkila (2017) identified five criteria for eco-label development, in their study on developing an eco-label for the airline industry. These five criteria were:

1. Credibility

In terms of credibility, Baumeister and Onkila (2017) emphasize the need of global recognition of labels, third-party verification, enforcement by policymakers and a commonly agreed methodology. Trust is recognized as a vital success factor for eco-labels (D'Souza & Yiridoe, 2019; Sønderskov & Daugbjerg, 2010), and third-party certification have been seen to increase the level of trust from consumers (Baksi & Bose, 2007; Meis-Harris et al., 2021). The need for a recognized and common methodology is identified in several studies (D'Souza & Yiridoe, 2019; Meis-Harris et al., 2021; Polinori et al., 2018).

2. Comparability

Information included in eco-labels should be easily comparable at decision-making moments, to give consumers the possibility of comparing and thus purchasing more sustainable products (Meis-Harris et al., 2021).

3. Clarity

Eco-labels requires a clear definition, strategic development, and a single label for the sector (Baumeister & Onkila, 2017). The contents of the eco-label should be clearly defined, such as methodology, parameters, and environmental performance (Baksi & Bose, 2007). Too many labels can create confusion among consumers and decrease trust (D'Souza & Yiridoe, 2019).

4. Transparency

Communicating eco-labels to consumers is challenging, both in terms of type of information that should be included (Baksi & Bose, 2007), and the amount of information, as too much information can result in information overload (D'Souza & Yiridoe, 2019). Due to lack of interest in reading labels amongst consumers, the label might lose its effect (Galati et al., 2021).

5. Participation

Baumeister and Onkila (2017) recognized the need to include stakeholders in the development of eco-labels, this is further supported by Prieto-Sandoval et al. (2016).

Consumer's perspective

The main purpose of eco-labels is to inform consumers about the environmental performance of a product or service (Polinori et al., 2018). This require the information is presented in an easy way, clearly differentiating the product/service from others, and thus making the environmental performance comparable amongst products/services (Baumeister & Onkila, 2017; Sønderskov & Daugbjerg, 2010).

Polinori et al. (2018) found that consumers are responsive to pro-environmental signals and are attentive to policy makers. This aligns with the findings of Meis-Harris et al. (2021), which suggests that marketing campaigns combined with regulatory and policy approaches increases consumer's awareness and thus the success of eco-labels. Furthermore, Sønderskov and Daugbjerg (2010) found that state involvement attracts more confidence in eco-labels, which was previously discussed as a vital factor for success, when implementing

eco-labels. Consumers also needs to be aware and informed of the existence of such labels (Baumeister & Onkila, 2017; Galati et al., 2021).

Consumer's motivation for purchasing products with less negative environmental impact, was found to be personal values and preferences (Galati et al., 2021) and the design and governance of the label (Baumeister & Onkila, 2017). However, Meis-Harris et al. (2021) found that the influence of eco-labels on consumer's purchasing decisions were limited to already green consumers. Galati et al. (2021) study on consumer's attention to fish eco-labels were most prevalent to older, more educated consumers, however, they also found that information positively influenced consumer's perception of the label. When studying the potential for an eco-label for the airline industry, Baumeister and Onkila (2017) found that consumers with weak or no interest were not responsive to eco-labels, consumers with intermediate interest responded to negative labels, while consumers with high interest responded to both negative and positive labels.

Environmental Frameworks

Environmental frameworks are frameworks, either developed by individual businesses or third parties. The EU Taxonomy, developed by the European Union is briefly presented below, together with the Environmental Ship Index, developed by the organization International Association of Ports and Harbours (IAPH).

EU Taxonomy

The EU taxonomy is a classification system, listing environmentally sustainable economic activities, with the purpose of increasing EU sustainable investments (European Commission, 2021a). The regulation has established six environmental objects, namely climate change mitigation, climate change adaption, the sustainable use and protection of water and marine resources, the transition to a circular economy, pollution prevention and control, and finally, the protection and restoration of biodiversity and ecosystems (European Commission, 2021a). In addition, the Commission developed a list of environmentally sustainable activities by defining technical screening criteria (European Commission, 2021a). The EU taxonomy is a transparency tool, and the aligned activities allows for comparison between investment portfolios and companies (European Commission, 2021b).

Environmental Ship Index (ESI)

The ESI Framework commenced on 1st of January 2011 (Environmental Ship Index, 2011a). It is a database administrated by the IAPH, and it is one of the projects under World Ports Sustainability Program (WPSP) (Environmental Ship Index, 2011a). Today the database is registered with 6 933 vessels with a valid score and 60 incentive providers (IP). The latter consists of port authorities, costal authorities etc., that offers incentives, often financial, to seagoing vessels exceeding a specific ESI score (Environmental Ship Index, 2011a). It is an open register available to the public, displaying the ESI score of registered vessels based on emissions, fuel types, scrubber installations etc., and it is voluntary to register both for vessels and for IP.

Parameters

The scheme's parameters are air emissions, more specifically related to emissions of:

- Nitrogen oxide
- Sulphur oxide
- Particulates
- Carbon dioxide

Data collection/registration

The data is based on self-declared data from shipowners and operators, and does not require verification or certification (Environmental Ship Index, 2011c). There are, however, performed audits at some pre-selected IP providers, which was an agreed approach, between ship organizations (Environmental Ship Index, 2011c). Furthermore, the registered data will be checked by the administrators of the index, and ship owners and operators can be asked to provide further documentation of their registered data, especially when reporting abnormal numbers (Environmental Ship Index, 2011c). According to the administrators of the index, all the incidents where further documentation were required, all vessels were able to verify the reported data. The registered data is then used for calculating emissions related to the parameters, based on formulas that can be found on the webpage on the index (Environmental Ship Index, 2011b). This lays the foundation for the ESI score which each registered vessel will be assigned.

Maritime activities

Maritime activities refer to sea-going activities in ports and during a sea voyage. Firstly, potential data sources for environmental data will be discussed, namely the Automatic Identification System (AIS), and the Vessel Traffic Service (VTS). Secondly, studies covering relevant sea-going activities inside and outside of ports are presented.

Data sources for environmental data

In this first section, potential sources for environmental data, inside and outside port areas, are discussed. AIS is properly defined, application areas are listed, and studies relevant for AIS data is presented. Furthermore, the function of a VTS is defined, and relevant studies presented. Note that a VTS does not necessarily collect primary data, however, they collect secondary data from different systems in ports.

Automatic Identification System (AIS)

Kwang-Il et al. (2014) defines an AIS as "an autonomous and continuous broadcast system." The aim of the system is to increase safety navigation and avoid collisions in coastal areas, by tracking and identifying vessels (Kwang-Il et al., 2014).
According to Chi et al. (2015), the AIS is the most appropriate technology for monitoring CO_2-emissions in real time. The AIS system typically reports data on the ship's identity, type, position, course, speed, draught and timestamp of the messages (Chi et al., 2015), with the purpose of enhancing safety and navigational security at sea (IMO, 2019b).

It is required for all ships engaging in international voyages of 300 gross tonnage (GT) and above, ships not engaging in international voyages of 500 GT and upwards, and all passenger ships to be fitted with AIS (IMO, 2019b), excluded vessels serving a military function. Furthermore, the regulation, found in SOLAS V/19, requires all vessels to maintain AIS in operation at all times, and the AIS shall provide and receive information, monitor and track ships, and exchange information with shore-based facilities, such as port authorities (IMO, 2019b).

The information collected includes:

- Ship's identity (MMSI) and type
- Position and course
- Speed
- Navigational status

- Other safety related information

Collection of AIS data also has potential for research-related purposes, such as monitoring and measuring efficiency of vessels (Chi et al., 2015; Feng et al., 2020). However, as stated by Chi et al. (2015), collection and utilization of AIS data impose some limitations, as shore-based AIS systems only receive messages within 50 nautical miles. However, satellite AIS system, could theoretically cover greater parts of ocean areas (Chi et al., 2015), although, marine satellites have a limited and expensive bandwidth (Wang et al., 2021). Furthermore, the utilization of AIS data pose challenges related to processing of big, raw data sets (Feng et al., 2020; Yang et al., 2019), compromises of a ship's privacy, and long transfer time due to the large size of the datasets (Kwang-Il et al., 2014).

Vessel Traffic Service

The first harbour surveillance system was implemented in Liverpool in 1948 and later a radar surveillance system was implemented at Long Beach, California, which formed the basis for the first formal VTS system (IMO, 2019c). VTS is a communication system, with the purpose of navigating vessels efficiently and safely in port areas (IMO, 2019c) by offering the three services: information service, traffic organisation, and navigation assistance (Park et al., 2020). While VTS operators (VTSOs) are responsible for monitoring and managing vessel traffic, the master of the vessel still holds the ultimate responsibility for safe navigation, and as such the VTS only offers guidance. VTS communication platforms include VHF radio, phone, fax, email and AIS, however, VHF radio is the most common communication form (Park et al., 2020). Technologies used in VTS (Heilig & Voß, 2016) include:

- Vessel movement reporting systems (VMRS)
- Radar systems
- Radio communication systems
- Traffic signals
- Video surveillance systems

Praetorius et al. (2015) found that VTS contributed to safe and efficient traffic movements in two ways: shaping preconditions and by creating foresight for vessels through communication. Furthermore, they discovered that different VTS' and VTSOs are organized in different ways, depending on constraints in the VTS area, and thus serve different functions. Park et al. (2020) analysed communication in port areas using queuing theory,

where they identified a need for reducing channel congestion and simplifying the content shared and the procedures during port operations. Furthermore, they discovered that analysing congestion in ports using queuing theory offered different results than those reported by the users.

Indicators: Port and vessel

Port operations concern all ship movements and activities from crossing the VTS line entering the port, until crossing the VTS line exiting the port. Port activities include ship movements, e.g., to and from berth and ship traffic, cargo handling, e.g., discharging/loading, mooring etc., as well as maintenance services of vessels. Several studies have addressed efficiency in ports using different indicators, such as economic efficiency (Núñez-Sánchez & Coto-Millán, 2012), time efficiency (Feng et al., 2020) environmental efficiency (Abioye et al., 2019; Dulebenets, 2018; Song, 2014), energy efficiency (Chi et al., 2015), efficiency related to VTS (Praetorius et al., 2015), and speed optimization (Andersson & Ivehammar, 2017; Jia et al., 2017).

With the use of Nationwide Automatic Identification System (NAIS) data, Farhadi et al. (2016) quantified the resilience of ports following major disruptive events. They used time, cost, capacity, and environmental impact as parameters for the ports studied, and vessel dwell time and net vessel transit counts in and out of ports as measurements of system resiliency, demonstrating another use of AIS data (Farhadi et al., 2016).

Song (2014) calculated the ship emissions inventory in Shanghai Yangshan Port, based upon the vessel's energy demand and an emissions factor. The port was divided into 7 segments, to assign emissions more accurately to its operation. The findings suggest that the emission hotspots were at sea and during hotelling at berth, that ship size correlated with amount of emissions, and that increases in ship traffic, increases emissions (Song, 2014). Chi et al. (2015) proposed a framework for calculating emissions in real time using AIS data. Looking at time efficiency, Feng et al. (2020) tracked vessels movements in two ports using AIS data. They used indicators related to time spent in different areas of the port, however, they argue that time spent cannot be the only efficiency indicator, due to different layout at ports, e.g.: some ports have longer distances to travel between areas (Feng et al., 2020). Their findings point out time spent in anchoring areas, mainly due to availability of berth upon arrival, or due to ship schedules and customs checks upon departure, however, their findings suggested that VTS line-to-berth took more time on average, than berth-to-VTS line (Feng et al., 2020).

New approaches for increasing efficiency of sea voyages and port operations are being studied. One approach is related to speed optimization and speed adjustment with the purpose of arriving just-in-time (JiT). Andersson and Ivehammar (2017) studied the potential cost savings of implementing green approach, also referred to as continuous descent approach. It entails communicating berth availability to incoming vessels with enough time to make speed adjustments to arrive just-in-time and reduce waiting times in port. They suggested that the factors for potential fuel savings depended on how long before the original estimated time of arrival (ETA), the vessel received information regarding berth availability, and how much a vessel can reduce its speed (Andersson & Ivehammar, 2017).

Jia et al. (2017) calculated a potential 19% cost savings in fuel if all excess time in port were utilised for sailing, investigating the implications of implementing Virtual Arrival. Virtual Arrival is an operational process involving an agreement included as a charter party clause to reduce vessel speed to arrive a port at required time of arrival (Jia et al., 2017).

3. Research Method

In this chapter the research method is explained and justified. In the general introduction part below, research method as a scientific approach is discussed, why it should be applied and how. The next sections explain and justifies choices made with regards to research design, the development of research questions, the selection of the population for this study, with an explanation of each population and how they fit into this study. In the final sections, data collection process is explained, the data analysis method, and finally the research quality and ethical considerations.

What

Frankfurt-Nachmias et al. (2015, p. 12) defines a scientific methodology as "a system of rules and procedures that provides the foundation for conducting research and evaluating claims to knowledge." As such, it dictates the rules and represent a framework for scientific research. Johannessen et al. (2016, p. 25) argues the most important characteristics of research methods as systematics, thoroughness, and transparency. This aligns with the prior definition, as it recognizes that research methods represent a systematic framework of how one should conduct scientific research and translate this into a common language that contributes to the body of knowledge.

Why

As scientific methodology offers a framework of rules and procedures, which give researcher a methodology to find, it also allows researchers to speak "the same language," thus reducing misinterpretations, biases, and provides the opportunity of replication of studies to verify its results (Frankfurt-Nachmias et al., 2015, p. 13). Reporting methodology used in a study, allows other researchers to examine studies and follow the train of logic which led to the results and conclusion, thus allowing for criticism, as well as replication.

How

When applying method to a study, the first step is to identify what one is trying to research and in what context. For instance, if one is looking for relationships between variables, or causal determination, one could apply quantitative methods. In this research, the goal is to (1) identify parameters for measuring green performance, (2) identify bottlenecks and challenges related to port operations and/or during deep sea, (3) recognize the technology utilization in operations, and (4) investigate the effect of using real-time data to green label sea voyages and the effect of such labels upon the industry. To identify discrepancies during a sea voyage, one could use quantitative methods, collecting statistics, showing the actual consumption. In order to identify the reasons behind these discrepancies, one could use qualitative methods.

3.1 Research Design

The research design of a study forms a framework for how the study will be conducted. For this study, a case study design was chosen, which is discussed more in depth below.

Case study

A case study allows a researcher to obtain in-depth answers while focusing on a "case" and retaining a holistic view of the real world (Yin, 2014, p. 4). Case studies as a research design is of interest when a researcher aims to answer research questions that explain a present circumstance, or if a researcher requires in-depth descriptions to answer the research questions (Yin, 2014, p. 4). As the case study allows the researcher to focus on a case of a contemporary design, it gives a snapshot of the phenomenon being studied (Yin, 2014, p. 4).

Identifying an appropriate design is based on type of research questions, assumptions, and what the researcher is trying to research. Research questions formulated as "how" or "why" question, could indicate that a case study is the appropriate research design, as it

allows the researcher to go in-depth and explore different variables affecting the "why" or "how" of a problem statement (Yin, 2014, p. 10).

So far, the formulation of the research questions has been identified as an important driver for choosing an appropriate research design. However, in some cases, several research designs can be an appropriate choice, depending on the nature of the questions asked. For example, research question 3: "Are Real Time data better for measuring emissions than historical data?", could be answered through the utilization of different strategies. For instance, one could gather statistical data on the prevalence of usage of either, which could give an indicator of a preferred data source, transforming the nature of the question to "how many". Furthermore, one could collect data from both sources and compare the results, performing a comparative analysis. Finally, one could perform observations and interviews to explore why either data source is being utilized, and further try to identify why it is so, which is the strategy chosen for this study. The second research question is: "Will improved data management tools (capable of handling big data) increase efficiency (emissions)?" Which could be answered using experiments and testing the capabilities of the data management tools. Furthermore, it could be answered by reviewing literature and studies conducted on the field. However, to be able to capture the user's perspective, as well as the producer, of such systems, methods allowing the researcher to discover in depth-knowledge and answers is required.

Thus, a case-study design was chosen for this study. This allowed the author to exclusively focusing on a practical case, in this instance – the sea voyage, exploring in-depth data while considering the perspective of the relevant stakeholders. A case-study design is characterized by its focus on a specific case (Hiranandani, 2014). It is especially suitable for studies researching contemporary events, in an environment where relevant behaviours cannot be manipulated (Yin, 2014, p. 12). Furthermore, it allows the researcher to collect in-depth data which can be interpreted towards understanding a concept or a situation, and add theoretical reflections on said concept (Hiranandani, 2014). Yin (2014, p. 19) defines four different applications of case studies:

1. Explain presumed causal links in real-world interventions too complex for survey or experimental methods

2. Describe an intervention and the real-world context in which it occurs

3. Illustrate certain topics within an evaluation

4. Enlighten those situations in which the intervention being evaluated has no clear, single set of outcomes.

These applications underline the strengths of case studies, such as the possibility of observing a phenomenon in the real-world without manipulating behaviour factors. Furthermore, it emphasizes the scope of case studies, being to understand how and why, instead of prevalence or correlation. Yin (2014, pp. 19-22) also identified concerns related to case studies:

- Is it rigorous enough?

Case study research are still lacking rigorous procedures, as well as standards on how to conduct a good case study research, compared to other methods where a lack of rigor is less likely to happen.

- Easily confused with teaching cases

Case studies used in teaching context can be deliberately altered to emphasize a particular point more effectively. This can create confusion, and potentially more biases compared to other methods.

- Generalizing

There is a concern that results from a single case study does not offer possibilities of generalizing. However, it is important to remember the goal of a case study is, namely, to explore research questions in depth and discover underlying reasons.

- Level of effort

Case studies have the potential of taking a lot of time to conduct and might result in a large number of documents. As identified by Yin (2014, p. 21) this was a challenge that occurred more frequently in the past, and does not necessarily offer any concern today.

- Comparativeness

Yin (2014, p. 22) states the concern regarding the possibility of comparing single case studies relevant to comparing experiments. However, case studies should be considered for its

other advantages, such as exploring the reasons why and how, instead of confirming or rejecting theories, or proving causal relationships.

Defining the case

Yin (2014) identifies five components especially important for case study research:

1. The questions
2. The propositions
3. The unit(s) of analysis
4. The logic linking data to propositions
5. Criteria for interpreting the findings

As briefly discussed before, the nature of the research questions for this study is "how" and "why" questions, which makes a case study research design appropriate. However, the "case" needs to be further defined, boundaries need to be set, propositions need to be formulated, and the unit(s) of analysis needs to be defined. Returning to research question 3: "Are Real Time data better for measuring emissions than historical data?", both the concept of real time data and historical data are identified as points of interest. The background for this question relates to the efficiency of a vessel and how to measure this, thus one of the propositions for this question is that real time data will improve measuring accuracy, and thus presents a better tool for measurement. The second research question; "Will improved data management tools (capable of handling big data) increase efficiency(emissions)?", recognizes a relationship between the capability of data management tools and efficiency. The proposition for this question relates to data sharing (data management tool) and communication (efficiency) between vessel and shore, and the proposition is thus that improved data management tools will improve communication, and thus efficiency during a voyage. Our first research question, "Do green labels encourage the industry to switch to more green practices?", identifies the relationship between green labels and companies' effort to transform to greener practices, and thus leads to the proposition that green labels encourage this change.

To investigate these questions further a case study was chosen, and the case is a sea voyage of a cargo vessel starting from Port A, hereby referred to as PA, and ending at Port B,

further referred to as PB. This case was chosen, as it will allow investigating the topics in real-life, while exploring it in-depth by interviewing relevant parties. The unit of analysis for this study is divided into three. The first one being the ports included in this sea voyage. This will allow for observing the communication and data sharing, as well as investigating points of interest that affect efficiency of said voyage. In addition, a VTS System Supplier, further referred to as Supplier, is included, with the purpose of investigating the data management tools and its capabilities and limitations. To answer the final research question regarding green labels, a Norwegian environmental organization, hereby referred to as EO, is chosen as the unit of analysis, as it will allow the researcher to investigate the phenomena of green labels from a neutral point of view, without commercial interest.

A case study design was identified as the most appropriate research design for this study, for the following reasons:

1. Reflects a real-world situation where factors cannot be manipulated
2. Allows for in-depth data collection in order to understand a research topic
3. Complements an exploratory design.

With an exploratory design, the data collection methods consist of interviews with relevant parties, where the purpose is to get insight in a real-world context and explore the factors relevant for the study. For instance, when researching bottlenecks and challenges which have the potential of decreasing efficiency, increasing emissions etc., the interviews will allow for exploring the factor further considering the perspectives of the stakeholders. By choosing a case of a sea voyage, it gives a holistic view of the life cycle of the cargo during sea transportation, and by considering the angles of relevant participants this have the potential of revealing challenges and bottlenecks within said case.

3.2 Research Questions

Case study research designs are appropriate when the research questions are formulated as “how” and “why” questions. Furthermore, as the research design allows the researcher to obtain in-depth answers, they should be formulated to explain a present circumstance that require in-depth descriptions.

RQ1: Do green labels encourage the industry to switch to more green practices?

Green labels serve the purpose of reporting environmental performance, giving the consumers or customers the option to choose environmentally friendly products and services. However, whether it does affect consumers' and customers' purchasing decisions, and thus the industry willingness to adopt such frameworks, is the main focus in this question.

RQ2: Will improved data management tools (capable of handling big data) increase efficiency(emissions)?

While there are different data management tools available for the maritime industry, such as data measuring and collection tools, data platforms, communication technology, etc., there are still questions to be answered whether these tools are efficiently used, and if they do cover necessary functions, especially related to efficiency and environmental performance. By reviewing literature and interviewing industry players, this paper aims to discover the gaps between research and industry and map out the challenges and bottlenecks directly relating to data management tools.

RQ3: Are Real Time data better for measuring emissions than historical data?

Real time data is widely used in maritime shipping today. In terms of emissions, AIS data have been used in studies, as well as in the industry. However, how accurate should those data be? Additionally, what are the alternatives of collecting real time data, or using historical data? This study aims to identify the different application areas of real time data, and the related challenges.

3.3 Population and Sample

The population for this study was chosen based upon the research questions. The population contains industry players from various parts of the value chain related to a ship voyage. The population is divided into four, namely:

1. Ports

Two ports were selected through the author's own personal network. Both Ports are UK based, and of medium size, trading in several segments. The ports have different sustainability profiles and have had different levels of focus on this field. Ports were selected for this case study to cover their perspective, related to sea-going activities in port areas.

2. VTS System Supplier

A VTS System Supplier were included in the population to make it possible to investigate the data management tools from the producer's side. The data collection was done through interviews, and there were no criteria for the selected, except that it did produce VTS systems.

3. Environmental Organization

In order to investigate the effect of green labels on the industry, a Norwegian environmental organization with experience within the maritime shipping industry were chosen. The criteria were that the organization had experience within maritime shipping and were concerned with environmental performance of maritime shipping activities.

3.4 Data collection

Data collection was done mainly through interviews. PB, EO, and Supplier participated in one 1-hour interview, while secondary data sources were used for analysing PA.

Interviews

The interviews were conducted as focused or semi-structured interviews, on the digital platform Microsoft Teams. According to Frankfurt-Nachmias et al. (2015, p. 196), these interviews are characterized by four traits:

1. Respondents are known to have participated in the event being questioned
2. Situation is analysed prior to the interview
3. An interview guide specifying topics are provided
4. Focused on subject's experiences

The respondents would be given an interview guide before the interview, with enough time to prepare. The interview guides were given 1-4 weeks in advance. The main purpose of the interviews was to investigate the respondents own real-world experiences, and thus much preparation was not needed, and was voluntarily for the respondents. The interviews were performed on Microsoft Teams, where it was recorded and transcribed for further analysis.

Secondary data

PA was analysed using secondary data sources, such as their webpage and published documentations.

3.5 Data Analysis Methods

Below the method for analysing the literature, and the data collected from interviews are explained.

Theoretical data

The theoretical findings were based on previous research. The process of finding and selecting literature for the theoretical framework is thoroughly explained in the Literature Review chapter, so this section will focus on how it was analysed and processed.

As data was collected, primarily through interviews, literature correlating with the findings were collected. The literature was then thematically analysed, with the intention of identifying similarities and differences stated in previous research. The process consisted of three steps:

Firstly, the article was thoroughly read, and a summary was written. Based on the summary, challenges, barriers, advantages, and other findings of interests were divided into a main set of categories. The results of this process can be found in Appendix A, table 12. After this had been done with all collected literature, the findings were further compared to investigate whether research was reporting the same findings. The initial categories were divided into a set of subcategories and the findings appearing in more than one research were grouped together. These results can be found in Appendix A, Table 13 for green labels, and Appendix B for Maritime Activities. All findings were then summarized, displayed in table 4-5 and 7 in the Findings chapter.

Interviews

The interviews were performed on Microsoft Teams, recorded, and later transcribed. All interviews lasted approximately 1 hour, and after transcribing the recordings, a summary was written. The findings from the interviews were then divided into categories. After all the findings were properly coded and divided into respective categories, the findings from each interview were compared to find potential similarities and differences. The interviews represent different stakeholders from the industry, with different interests, challenges and focus areas, thus many similarities were not necessarily expected to be found.

After all the interviews had been properly analysed and coded, the findings were compared with the findings from the literature, and potential similarities and differences identified were divided into similar subcategories corresponding with the subcategories used during the literature analysis. The results from the analysis of the interviews can be found in Table 6 for Maritime Activities, and Table 8 for Real Time Data, both displayed in the Findings chapter. Table 9-11 at the end of the Discussion chapter summarizes the findings from the comparative analysis of the findings from the literature and the interviews.

3.6 Research Quality

Yin (2014) emphasize four logical tests to judge the quality of a research design, namely:

1. Construct validity
2. Internal validity
3. External validity
4. Reliability

These tests all occur in different phases of the study, thus making it a part of the design work related to chosen research design and is a continuously work throughout the study.

Construct validity

This test refers to operationalization of measures, concepts and constructs in the case study research (Yin, 2014, p. 46). The researcher must define how the concepts/constructs in the study will be defined – by which parameters – and how they will be observed or measured. In other words, validity is concerned with the question "Am I measuring what I intend to measure?" (Frankfurt-Nachmias et al., 2015). For instance, when measuring sustainability, one can chose parameters concerned with the social, economic, or ecological bottom line, however, a company can have environmentally friendly solutions, without being sustainable. Thus, one must investigate the parameters used to define sustainability, and ask whether these parameters capture the concepts, or if other, unidentified parameters might be the cause for whether a company is sustainable or not. Validity is thus a tool for measuring the relevance between the concepts/construct being studied and the operationalization of variables (Johannessen et al., 2016).

Construct validity specifically refers to the link between the measuring instrument and the general theoretical framework (Frankfurt-Nachmias et al., 2015). Yin (2014) draws on three tactics to increase construct validity: 1) multiple sources of evidence, especially relevant during data collection, 2) establish chain of evidence, and finally 3) have key informants review draft case study report.

As this was an exploratory study, theoretical findings were frequently added, as industry findings emerged. The intention was to investigate whether the industry and research reported the same findings, thus seeking evidence from several sources. The interviews were transcribed, as are the citations used in this paper, to reduce misinterpretations, while documenting the line of logic that follows the discussion of the findings and finally the conclusion. Different topics emerged during the interviews with different stakeholders, and while there were not any expectations of finding similarities, many of the informants were given the possibility of confirming or debunk each other's statements.

Internal validity

Internal validity is concerned with the relationship between variables (Yin, 2014, p. 47). For instance, in this study one proposition is that better communication leads to increased efficiency and reduction of fuel consumption and related emissions. This assumes a relationship between the variables communication and efficiency (in terms of emissions), however, several factors affect efficiency during a sea voyage, forcing the researcher to deal with threats to internal validity, such as rivalry explanations and possibilities, and the strength of the evidence for this causal relationship (Johannessen et al., 2016, p. 311; Yin, 2014, p. 47). Internal validity in case study research can be difficult to assess properly, however, there are some tactics that can be used, namely 1) pattern matching, 2) explanation building, 3) address rival explanations, and 4) use logic models (Johannessen et al., 2016, pp. 308-310; Yin, 2014, pp. 45, 47).

Pattern matching was used as a data analysis technique to compare the findings from the literature with the findings from the industry, with the purpose of finding similar patterns. Yin (2014) states that if empirical and predicted patterns appear similar, it can strengthen the study's internal validity. The findings were analysed thematically and sorted thereafter, with the purpose of finding the level of prevalence of reported topics from different sources, and to further compare the theoretical findings with the empirical findings, to investigate whether they confirmed or debunked one another. While some of the findings confirmed one another

thus suggesting the relationship between variables were present, some of the variables could be explained by an additional rivalry explanation.

External Validity

External validity is concerned with the possibility and grade of generalizability of findings from a study (Johannessen et al., 2016, pp. 389-390; Yin, 2014, pp. 45, 48). In case study research, the external validity is closely related to the research questions stated, and thus the research design process. The development of the theoretical framework, supporting your research questions, will thus be an important part of external validity in a case study design (Yin, 2014, p. 48).

The theoretical framework of this study was conducted in stages. The first stage aimed to find proper search terms, ensuring that the literature searches would capture the relevant literature for this study. The second served the purpose of defining relevant terminology, technology applications, and other phenomena relevant for this study. The final stage was conducted as a precursive search, where relevant literature was identified as the industry findings emerged. The process is thoroughly defined in the Literature Review chapter. However, level of generalizability could be increased by conducting a similar study, including more stakeholders, either from different segments or more stakeholders from the same segment, to ensure that the results reflect the industry, and not just the individual environment surrounding the selected stakeholders included in this study.

Reliability

Reliability refers to how reliable your findings and conclusions are (Frankfurt-Nachmias et al., 2015, p. 135; Johannessen et al., 2016, p. 36; Yin, 2014, pp. 48-49). One way to test reliability is to replicate the study, to check whether one arrive at the same findings and conclusions. These can both be done by the original researcher or a different one. This requires the researcher to properly document the procedures, making it possible to replicate correctly. The better documented, the higher chance the findings and conclusions will match if replicated, thus strengthening the reliability. Yin (2014, pp. 48-49) poses two tactics: 1) case study protocol and 2) case study database.

The theoretical framework was developed from the findings during the literature searches. This process is documented in the literature review section, stating search terms, findings, and what was included in the study, making these searches possible to replicate.

3.7 Ethical Considerations

For safe storage and the protection of personal data, the study has been notified to The Norwegian Data Protection Regulations (NSD) the 18th of January 2022 and has been approved.

All participants, along with companies will be anonymized in this paper. Furthermore, personal data will not be used in this paper, but will be stored for identification purposes during data analysis. All recordings will be deleted upon finalizing this paper.

All data including personal information will be stored on a secure server, provided by the University of South-Eastern Norway. Only the author and her supervisor have access.

4. Findings

In this chapter the findings are presented. The chapter is divided into three subchapters**:** Green Labels, Maritime Activities, and Real Time Data. Each subchapter follows the same structure, where the literature analysis and literature findings are presented first, followed by the findings from the industry. The findings from the industry are based on interviews with PB, EO, a Supplier and secondary data sources from PA.

4.1 Green Labels

This subchapter presents the findings related to green labels. First, the findings from the literature are presented, and then the findings from the industry, based on the interview with EO.

Findings from literature

The literature findings were analysed thematically in three steps. The first aimed to identify bottlenecks and challenges in general, the second was a cross-analysis to investigate the prevalence of each finding resulting from the first step. The results from the first and second step can be found in Appendix A, Table 12-13. The third step was to categorize the findings, which is displayed in Table 4.

Table 4: Literature findings: Challenges and Advantages of green labels

	Challenge	Advantages
Business	- Financial burden - Type I or Type II - Standardization - Green washing	- Gain competitive advantage - Price premium - Industry standard
Consumer	- Design of label - Governance of label - Information - Awareness	- Behavioural change - Potentially force industry to switch to green practices

Industry: Challenges

The challenges seen from the business perspective can be divided into four main categories, namely:

1. Financial Burdens

Implementing green labels can put a financial constraint on firms through 1) paying a third-party certifier to monitor and control implementation of a Type II label, and 2) the requirements related to changes in production or internal processes in order to meet the specific requirements related to the specific label.

2. Type I and Type II labels

Type I labels are defined as self-labels, where companies develop a label of their own, while also being responsible for monitoring, controlling, and reporting whether they meet requirements. This creates challenges, as it potentially increases the risk of poor monitoring, as well as poor design of the framework of the label. In addition, some studies report that with more and more Type I labels emerging, it can cause confusion with consumers, and reduce the general trust in green labels. Type II labels offers challenges related to financial constraints and reduced financial freedom for firms, as it might require changes related to production or internal processes in the firm. In addition, it also requires third-party certifiers to develop a robust monitoring system, which can be costly and time-consuming.

3. Standardization

Many previous studies have reported the need for a common framework, to reduce confusion, increase transparency, and thus reduce the risk of green washing. The latter will be further explained below. However, as different industries and segments require different approaches and have different needs, creating one common framework can prove challenging. Global trade adds yet another layer of complexity as national, legal frameworks comes into play as well.

4. Green washing

Green labels being used as green washing represent an increasing problem. While gaining a competitive advantage from implementing green labels serves as a motivational factor for switching to greener practices within a firm, it also motivates less serious players to implement the same labels but without proper monitoring. There are also possibilities to take shortcuts, and not changing to greener practices, in order to gain the competitive advantage. This can potentially decrease consumers trust in such labels, and thus reduce its effect on consumers.

Industry: Advantages

However, there are also advantages that can be gained from implementing green labels. These have been divided into three groups:

1. Competitive advantage

For environmentally aware consumers, green labels offer an incentive to choose more environmentally friendly products. Companies that are able to meet certain environmental requirements in the production of their products, can gain a competitive advantage as opposed to their competitors. This can potentially increase their market share, improve reputation, and create a loyal customer base.

2. Price premium

Green labels ensure a certain quality related to the production of a product, e.g.: through sustainable materials, renewable energy consumption, improved working conditions, to mention some. This could give the companies a possibility of offering their products for a higher price than their competitors, potentially increasing their overall financial profit.

3. Industry Standards

With an increasing interest in environmental impacts of business operations, the businesses are experiencing an increased pressure from its consumers, as well as regulatory institutions. As some companies pioneer in changing their business to adopt new, greener practices, this has the potential of increasing the expected standard for the industry. This is further enhanced if companies are able to gain visible competitive advantages, increasing their market share and thus decreasing the market share of a company without the environmental focus. Potentially it could pressure all big players in an industry to follow the newly adopted standards and thus switch to greener practices.

Consumer: Challenges

The challenges identified in previous studies have been divided into four groups, namely:

1. Design

The design of a label plays a vital role in whether a consumer will be positively affected by it or not. The label needs a consistent, easily understandable, and visible design. As outlined in previous studies; failing to properly address the challenges related to the design, could potentially have the opposite effect, reduce trust in green labels, or be perceived as a tool for green washing by consumers.

2. Governance

While Type I labels have the advantage that a firm could develop a framework that emphasizes the areas they could excel in, seen from a sustainability perspective, it could also affect consumer negatively, as consumers might not have the trust needed to believe the reported results on a Type I label. Type II labels requires third-party certification, which potentially increase the trust of consumers in such labels. It also ensures that governance of the label, in terms of requirements and monitoring, are frequently controlled.

3. Information

There are two main types of challenges related to information, emphasized here. The first relates to type of information included on the label, such as methodology of the framework used, governance of label, and areas the label is connected to, e.g., material sourcing. Lack of information on a label could potentially reduce interest of consumers and/or, it could be perceived as green washing, thus creating a hurtful effect on green labels in general. The second challenge relates, again, to the design and prioritization of this

information, to reduce information overload, and thus potentially losing effect due to lack of interest in reading labels from consumers. Referring to external sources of information could be a solution, however, transparency should in general be of great importance when designing such labels.

4. Awareness

When implementing a quality label of any sorts, the consumer must be aware of its existence, in order for it to have any effect. As previous studies have outlined there have been great variations in interest levels in searching for product labels. By increasing awareness, potentially through marketing campaigns, it could make more consumers aware of the existence, and increase the consumers interest in such labels. Creating awareness for big environmental challenges in general could be beneficial for such labels.

Consumer: Advantages

The advantages of green labels, seen from a consumer's perspective is divided into Behavioural changes and pressurizing the industry.

Green labels have the potential of creating more awareness regarding environmental performance of a product. As consumers are becoming more and more aware of environmental challenges and negative impacts caused by industry, green labels encourage consumers to make more aware choices when choosing products. By providing consumers with environmental performance-related information, it also give consumers the opportunity of making more aware choices.

As consumers change their demands and requirements related to products, companies are forced to do the same in order to stay relevant in their respective markets. Behavioural changes of consumers might pressure the industry into changing behaviour as well, through adopting greener practices. Moreover, the potential competitive advantages companies are gaining from being pioneers in sustainability, also incentivize and/or pressure more companies to switch their practices.

Findings from industry

Below the findings from the interview with the Environmental Organization is presented.

Application Areas

While this study is mainly focused on exhaust, reducing fuel consumption and thus emissions, there are many application areas in which frameworks could be directed, to overall

increase environmental performance. For instance, biofouling represents a major challenge, both due to increased energy consumption, but also related to invasive species, which threaten local marine life. Sewage-, ballast-, and waste management are all areas where one could improve performance, even though the topics have received various amount of attention, both from a legislative perspective, as well as research. Hull design is also receiving attention, and finally voyage planning, with suggestions such as Virtual Arrival, Green Approach and e-Navigation. Better voyage planning could potentially reduce waiting times in ports, anchoring, allow for speed reductions which would reduce fuel consumption and thus emissions, and is an area worth studying further.

Common Frameworks

Once again, the need for common approaches and common frameworks is recognized. Implementing different frameworks, incentive schemes, and approaches is challenging due to several reasons:

1. Interpretation

Due to the international nature of the maritime industry, players in different nations and different flag states can potentially interpret green implementation, either legislative, mandatory, or voluntarily, differently, thus producing different results. In addition, players display different effort levels to meet requirements of the respective implementation. This creates different "rules" for actors in the maritime industry, and could potentially lead to discrepancies, and unfair market conditions.

2. Financial stress

As with many industries, the maritime industry consists of a variety of companies, with different financial positions and margins. This gives the big players more financial freedom, both in terms of investing in green technologies, and in terms of costly implementations of organizational and/or operational changes. This could, along with differences in interpretation, create discrepancies and unfair market conditions.

3. Competitiveness

The risk of implementing strict frameworks with little flexibility, could potentially affect the levels of competitiveness in the market. While you have some actors who are environmentally aware and possess the financial backbone to invest in technology and competence to improve environmental performance, you will also find actors that do not

possess the financial backbone, nor have the interest or environmental awareness. If, for instance, a port implements too strict requirements, customers might move to a different port, effectively decreasing the initial port's ability to compete. Instead of improving environmental performance, the problem is just relocated to another region.

Implementation

When implementing green frameworks and introducing approaches to increase green performance, several elements must be considered. Above the need for common approaches and framework is presented, below you will find elements to consider and why, when implementing green frameworks.

- Stakeholder environments

Different stakeholders, e.g.: vessel owners and operators, ports, terminals, technology providers etc., will represent different needs and interest, underlining the complexity of the maritime industry. Additionally, they will have different resources to offer, which should be utilized when developing new frameworks. There is a need to investigate different needs and understand the stakeholder environment, to effectively develop measures that have a direct effect on the environmental issue one is trying to solve. Similarly, by understanding this environment, more effective incentive schemes could be implemented.

- Motivation

Similarly, with different interests amongst stakeholders, there will be different ways to motivate and incentivize the players. For instance, seen from the vessel's perspective, reducing operating and fuel costs represent a great motivation for reducing fuel consumption. Ports might have an interest in decreasing local emissions in port areas, but they will have no interest in the rest of the sea voyage. However, there might be an interest for increased voyage planning, both for ports and terminals. Understanding what underlying forces and motivation can prove to be vital, to implement accurate and focused measures to improve environmental performance.

- Data

The maritime industry is a conservative industry. Data sharing is still challenging, potentially due to lack of interest/unwillingness to share, the data being of sensitive nature, lack of proper technology tools to make data sharing simpler and so on.

4.2 Maritime activities

In this subchapter the findings concerning maritime activities are presented. Maritime activities include sea-going activities in port areas, and activities related to vessel voyages between ports. Firstly, the findings from the literature in presented, followed by the findings from the interview with PB, and secondary data sources from PA.

Findings from the literature

The literature related to sea-going activities in port, where analysed thematically, where six main categories where identified, and further six subcategories were identified. The results can be found in Appendix B, Table 14. Table 5 provides a summary of the challenges and barriers identified in the literature, Challenges in this context refers to areas worth studying and focusing more on, while barriers are related to areas that are actively hindering more sustainable and efficient operations today. Note that the challenges below are sorted according to the topics that emerged from the literature analysis, seen in Appendix B, Table 14, where the findings are also referenced.

Table 5: Literature findings: Challenges and Barriers of maritime activities

	Challenge	Barrier
Port	- Complex Frameworks - Standardization - Inaccurate/missing data - Communication	- Unwillingness to share data - Collaboration
Vessel	- Standardization - Complex frameworks	- Charter clauses - Collaboration

- Regulatory/Standardization

The first regulatory finding is related to standardization of reporting procedures upon arrival to port. The literature reported that these procedures can vary from port to port and be time-consuming forcing vessel delay. This challenge reduces the efficiency of vessels, and could be decreased by implementing a standardized procedure, which would also potentially reduce confusion, waiting times, and increase efficiency.

Standardization of maritime activities and frameworks have been a topic of study for much research, including studies offering a potential framework for calculating efficiency, e.g., fuel consumption and emissions. As there are different formulas and frameworks available, producing different results, potentially adding confusion in the industry, and thus

creating a barrier for using such frameworks. Additionally, using different frameworks and reporting different results could create differences with regards to the supposedly beneficial effect of, for instance, measures used to increase environmental performance. Similarly, the complexity of several frameworks proposed by the literature, for measuring efficiency in terms of fuel consumption or emissions are of such a complex nature, it increases the barrier for implementing them by vessel owners, operators, and other stakeholders.

The last finding is related to charter clauses actively stipulating ship owners and operators to arrive at berth as "soon as possible." This forces owners and operators to sail at full speed to port, regardless of potential waiting/anchoring times due to the availability of the designated berth.

- Communication

Challenges related to communication generally involve VTS activities, and/or the interaction with the vessel, or collaboration and data sharing with other organizations in ports. Firstly, there are various ways to organize a VTS, in terms of services offered to vessels, staffing, how regulated it is, and the amount of authority the VTSOs have in navigation in its designated area. Generally, the master of a ship will be the responsible party, and thus has the last word, which limits the authority a VTSO have. In terms of regulations in a VTS area, this will vary depending on several factors, such as the geography of the designated area, the traffic density, and complexity of operations. Previous studies underline that the more regulated a port area and thus the VTS is, the less flexible it is and vice versa.

To effectively manage traffic in a busy port area, a VTS also require information from other organizations at port. For instance, terminals might get earlier notifications on arrival time of a vessel than VTSOs, which could, if shared, offer a more accurate picture of upcoming traffic and allow for earlier planning of arrivals and departure of vessels.

- Operational Bottlenecks

The most frequently reported bottleneck in port operations, appears to be related to waiting and anchorage time, awaiting availability of a berth. This underlines the need to further study alternative approaches to increase just-in-time arrivals. Some studies have addressed concepts such as Virtual Arrival and Green Approach to tackle this problem, however, many of the challenges mentioned above are potential barriers of implementing systems such as this.

- Collaboration

Several studies have underlined the need for increasing collaboration and willingness to share data between stakeholders in port, in order to increase efficiency. This will be further discussed in Discussion section.

Findings from industry

The findings from the industry are based upon data collection from two medium-sized ports in the UK, respectively PA and PB. While data collected from PA is based upon digital, written communication, and secondary sources, data collected from PB is based on one 1-hour long interview.

Port A

The data from PA is based upon digital, written communication along with secondary data sources.

- Secondary sources

The port is registered as an incentive provider for encouraging greener practices through the ESI framework. The port has implemented a Green Tariff in exchange for a reduction in port fees, to encourage this. Furthermore, PA has implemented an emissions inventory, with the purpose of monitoring and reporting emissions.

Emissions Inventory

An emission inventory seeks to account for pollution releases to the environment from a set of sources. The inventory provides a baseline for measuring the effect of policies and measures implemented to reduce emissions, as well as the impact of emissions on air quality. The inventory collects data from sources, such as: AIS for individual ship identification, position, speed, and direction at a given point. This data is further matched with data from Lloyd's List Intelligence (LLI) through the ship identification number, and data related to ship type, dimensions, engine type, year of build etc. In addition, a survey was sent to ship operators, supplying with data related to fuel consumption, also including ships not fitted with AIS transponders. All collected parameters are used to calculate more accurate emissions and assign those emissions to their respective areas.

Green Tariff

Green Tariff was implemented in 2017 for ships calling in the commercial port. The purpose is to offer greater incentives for the greenest vessels performing better with regards to air emissions relative to the requirements set by the International Maritime Organization (IMO).

The scheme recognises seagoing vessel's ESI score and offers discounts based on this score, namely 10% discount off vessel conservancy charge with a score greater than 30 points, and an additional 10% discount for scores greater than 50 points.

Port B

Table 6 is a summary of the main findings from the interview with PB. The findings were thematically sorted, with a main category and a subcategory. There were four main categories identified, each explained below.

Table 6: Industry findings: Port B

Main category	Subcategory	Content
Collaboration	Visibility	Increased collaboration and data sharing would give better visibility in port
Behavioural	Attitude	"Watch and wait"
	Legacy	Distrust new, not well-known, and tested systems "The way it's always been"
	Vessel	Often excluded as component - AIS gives enough information – no need to contact - Sending data expensive
Legal	Liability	Vessel has liability in the event of accidents – limits VTS control, demotivates new approaches
	C/p	Clauses discourage JiT arrivals
	Financial models	How players make money discourages JiT arrivals
Standardization	Monitoring - Measurement	What to monitor, measurement tools, accuracy of data Methods, frameworks Lack of data: Assumptions are difficult to accurately measure, creates inaccurate data
	Reporting	How to report data and where - Common data platform Formats: Ensure same meaning of data fields - Lighten data processing - Increase accuracy
	Data - Sharing - AIS	Members take different things into account when reporting data Fuel type Auxiliary engines Actual consumptions Generators Load (have draught)
	Implementation - Quality assurance	Open and transparent test procedures, quality management etc. Ensure verification of data – increase trust Must notify users when updates are posted – verify information from relevant users to create same truth
	VTS	Different levels of authority Different organizational structures

1. Collaboration

The Collaboration category mainly revolved around visibility, as that appeared to be the main motivation for increased collaboration amongst the members of the port community. Members include, but are not limited to, the Port Authority, VTS and VTSOs, terminals, agents, and incoming vessels. Note that there are many members of a port community, however, the above mentioned were the main focus of the interview, due to the purpose of this study.

Collaboration amongst members of the port community refers to the sharing of information and data amongst each other, to create increased, and more accurate visibility, and thus giving the members the "same version of the truth," related to port operations, traffic, berth operations etc. This could potentially lead to more efficient navigation, operations and saved operating costs.

Terminals might have a better estimate of the ETA of an incoming vessel. If this information is shared with relevant members, such as the port authority and VTS, this could give them more time to manage and plan vessel traffic.

Typically, a time window for berth operations is given out to incoming vessels, which can be between 2-3 days. If vessels arrive during this time window and the berth is unavailable, the terminals will be financially liable to the vessel. Vice versa, if a vessel does not arrive within it's time window, they are financially liable to the terminals. This suggest that there is a financial motivation to improve the accuracy of ETAs, in addition to saved operating costs.

2. Behavioural

The main findings in the category Behavioural, refers to factors staggering the implementation and adoption of green practices, such as JiT approaches and increased collaboration in a port community. These factors are related to a "Watch-and-wait" attitude, and legacy referring to a "Business-as-usual" approach.

The first one refers to members' reluctance of adopting new systems and approaches, which are not thoroughly tested and accepted in the industry. The latter is closely related, and refers to a reluctance of change in general, due to legacy in the industry, and "the way it has always been" attitude.

Vessels are often excluded as a component in a port community. As the AIS provides many members with much information, vessels can be excluded from communication beyond legal requirements, as members regard the AIS data as sufficient, and do not see the need for contacting the vessel further. This creates challenges, as it would be beneficial to give vessels the same visibility as other members. It would allow vessels to better plan their time in port, plan maintenance and other necessary operations efficiently if they have an idea of what to expect in terms of waiting times until a berth is available.

3. Legal

The category legal, refers to critical factors actively discouraging more efficient maritime operations. For instance, charter party contracts have clauses encouraging vessels to sail full speed to port, go into anchoring until the designated berth is available, instead of adjusting speed to fit the berth availability and thus reduce fuel consumption and related costs. Some financial models in the maritime industry also have the potential effect of encouraging less efficient and green practices. Finally, the findings suggest liability and responsibility models of port community members, charter party contracts and other maritime operations could be improved to encourage and incentivize green practices.

4. Standardization

The need for standardization is a reoccurring finding. Due to the different fields this subject touches upon, this have been divided into five subcategories, namely Monitoring, Reporting, Data, Implementation, and VTS.

- Monitoring

Monitoring refers to standardization of what to monitor, e.g.: emissions, mix of gases emitted, fuel consumption, technology implemented, for instance scrubbers, etc.

Furthermore, it refers to the methodology of collecting this data. As seen in the literature findings, many studies have attempted to calculate fuel consumption and thus emissions. These calculations can easily get complex, as there are many factors that should be included in such a formula. The AIS offers much relevant and useful data related to ship type, speed, size, draught and so on. However, load factor and cargo mass are examples of missing data, which forces researchers to make assumptions in their framework, decreasing the accuracy of the reported results. In addition to the assumption mentioned previously, the type of operations a vessel is involved could affect fuel and energy consumptions drastically. This

requires standardization of what calculative framework should be used to ensure everyone is reporting comparable results. Many methodologies and frameworks have already been presented, which the interviewee suggested covered the needed accuracy, however, standardizing which to use, is still needed.

- Reporting

After collecting all relevant data, there should be a standardized way of reporting those. Confusions and unnecessary complexity, making reporting systems less feasible and possibly not adopted by the industry, confirms the need for standardization. This could also help verify imported data, making sure they are trustworthy and easily comparable.

Closely related are the challenge related to data formats. Many members collect this type of data in port, which is stored and presented in different formats, which can cause confusion and reduce trustworthiness of the data collected. This would also help reduce complex processing of data to transform them into comparable data fields.

- Data

Different members of a port community collect data for different purposes. For instance, the VTS collect AIS data for navigational- and safety purposes. Terminals might collect data to verify position, ship type etc., of a vessel. Furthermore, different data sources are used, to verify the data. To ensure everyone involved have the same data available, this will help create the same version of the truth related to traffic operations, and other activities in the port, thus increasing visibility.

By sharing data, inaccuracies might also be reduced. For instance, AIS as a data source does not always contain correct information, thus creating a need to verify the AIS data through collecting data from other sources.

- Implementation

As mentioned before, there is a behaviour element to consider when implementing new technologies that encourages members to share data, a challenge seen across the industry. For instance, to reduce insecurity related to new technology, one could have a transparent and open testing procedure, to show members both the need to, and reduce reluctance to adopting it. In terms of data reported there must be a standardized system for verifying the content as well, to ensure trust levels among members, as well as increasing accuracy.

Furthermore, the system must be designed in such a way that users can actively be alerted about updates and verify new content on the platform, ensuring all information is correct.

- VTS

Ports across the world will have different organizational structures, financial models, operational patterns, traffic density, and organization of the VTS or Local Port Service. VTS' have different organization in terms of manning levels, VHF channels, legal authority etc., in addition to differences in national legal frameworks, which further generates different levels of complexity.

4.3 Real Time Data

The final subchapter comprises of findings related to Real Time Data. The literature findings are presented first, followed by the findings from the interview with the VTS System Supplier.

Findings from the literature

The AIS have proved to offer great insight in maritime operations. It offers a real-time picture of vessels positions, other navigational information, as well as characteristics of the vessel. Table 7 provides an overview of different application areas of AIS data, both for researchers, planners, and operational purposes.

Table 7: Literature findings of Real Time Data

Data source	Uses	Reference
AIS	Geographical uses	(Feng et al., 2020)
	Environmental monitoring	(Feng et al., 2020; Yang et al., 2019)
	Collision warning and avoidance	(Feng et al., 2020)
	Logistics	(Feng et al., 2020)
	Satellite-AIS: more application areas, can be extended outside of coastal area	(Feng et al., 2020)
	Navigation safety (main purpose)	(Yang et al., 2019)
	Ship behaviour analysis	(Yang et al., 2019)
NAIS	Quantitative vessel patterns	(Farhadi et al., 2016)
	Baselining	(Farhadi et al., 2016; Jia et al., 2017)
	Time stamps in defined area	

However, AIS can send data with 2 second intervals depending on speed, which produces large datasets, making it challenging to process, both for VTSOs, other organizations in port, and researchers. Furthermore, AIS data rely on self-reporting, which

increases the risk of human error when typing in information. The information from AIS, should thus be verified from different sources, in order to create an accurate picture. This has, however, proved challenging due to unwillingness of data sharing between organizations. Previous studies have also reported findings related to lack of data from AIS, forcing them to make assumptions when developing calculative frameworks and potentially decreasing accuracy of results based on the respective framework.

Findings from the industry

The interview was analysed thematically, sorting findings into a main category, and later extending the coding scheme to include a subcategory. The summary of the main findings and the seven main categories, as well as the twenty subcategories, can be found in Table 8.

Table 8: Industry Findings of Real Time Data

Main category	Subcategory	Content
Data	AIS	Inaccurate data
	Technical	Showing right data to user
		Different formats
	Sharing	Unwillingness to share between stakeholders
		Competitive data withheld
		Investment level too high
	Application areas	Environmental monitoring Maritime Infrastructure planning (where to build, based on future traffic predictions) Land distribution – where to fish, where to build offshore etc National security (smuggling, behavioural activity)
Standardization	Data	Display
	Port	Sharing Port calls
	Globalization	Standardize across borders
VTS	Data	Trust of incoming data
	Ship – shore Operational Technical	Sharing What and why to show How to share
Operational	Challenge	Earlier notification of ETA
JiT	Challenge – VTS	Data format
	Challenge – Vessel	Utilization, management, decision support
	Barriers	Share data National security Benefits Investment level Different interests
	Management	Who should manage such a system?
Collaboration	Barriers	More communication/dialogue Need to identify the benefits Connectivity shareholders
	Initiatives	SafeSeaNet Single Window Common data infrastructure initiative
	Culture/Legacy	"Safety is just a cost" Need to see physical benefits
Environment	Data	Speed monitoring

1. AIS

The most frequent finding with regards to AIS was the reported inaccuracy of data. This requires the users to verify the information via another data source, such as nautical charts, vessel database which some ports operate with, or similar databases. The main reasons of inaccuracies in AIS data derive from human error in mistyping information.

2. Technical

There are technical challenges related to data sharing, both in terms of the technical solution related to how to share the data, but also prioritizing what data to show and how to present it. Different stakeholders will have different usages of data. For instance, a VTSO will have an interest in maintaining navigational safety in the port area, while vessel operators will be more interested in the surrounding area of the respective vessel, thus requiring less data. In addition, there will typically be different systems on shore-side and onboard vessels, this creates technical difficulties related to all the different formats and interfaces needed for a data transfer.

3. Sharing

As reported previously, an unwillingness to share data amongst stakeholders is a challenge, that potentially reduces efficiency in ports. There could be many reasons as to why this unwillingness emerges, some are related to the competitive position of the port and/or the vessel, lack of interest, difficulty of seeing the benefit, and finally, reasons related to investment requirements of implementing new technology that would make data sharing easier.

4. Application Areas

As discussed previously, there are many sources for data collection for activities in port areas. Some of the application areas of this data are environmental monitoring, infrastructure planning, distribution, national security, and criminal investigation’s aid.

5. Standardization

In terms of data there is a need to standardize what data should be displayed to different stakeholders, as well as what data that should be shared amongst them. Furthermore, requirements related to information sharing during port calls can vary from port to port. The process and specific requirements should be standardized to increase efficiency levels. Lastly,

the international character of the maritime industry makes it challenging to implement standardizations as well.

6. Collaboration

Even though there are indicators of how close collaboration amongst stakeholders in ports, potentially increases efficiency, there are still barriers slowing down this process. The interviewee expressed a need for more straightforward studies, effectively visualising the benefit one could achieve from sharing more data, increasing communication, and overall collaborating more. As stated in the interview, “It might be many stakeholders that get small benefits, but it is no one really having the overall responsibility (Supplier).” Furthermore, the findings suggest that there are barriers related to attitude towards new practices.

5. Discussion

In this chapter, the findings will be further discussed. The chapter partly follow the same structure as the Findings chapter, with the subchapters Green Labels, Maritime Activities, and Real Time Data. The literature findings will be discussed, and compared with the findings from the industry, investigating whether there are knowledge gaps between the two. The discussions concerning each topic, contains findings from different interviews and secondary sources, which will be clearly stated in the text.

5.1 Green Labels

Table 4 is derived from the Findings chapter and forms the basis for the discussion. This subchapter will thus follow the proposed structure of the table 4, and each topic well discussed in light of the industry findings.

Table 4: Literature findings: Challenges and Advantages of green labels

	Challenge	Advantages
Business	- Financial burden - Type I or Type II - Standardization - Green washing	- Gain competitive advantage - Price premium - Industry standard
Consumer	- Design of label - Governance of label - Information - Awareness	- Behavioural change - Potentially force industry to switch to green practices

Business

Below the findings from the literature will be discussed and compared to the findings from the industry. It is divided between Challenges and Advantages, which is again divided based on the respective topics, derived from Table 4.

Challenges

The literature review showed four main points, namely "Financial Burden," "Type," "Standardization," and "Green washing."

- Financial Burden

The literature review revealed a challenge related to the additional financial burden that implementing green frameworks will exert on businesses. EO recognized the variety in the maritime industry, in terms of financial margins. While there are big players with great margins, and the financial resources to invest in both technology and competence, there are also smaller companies without the same possibilities. Furthermore, by implementing mandatory frameworks, requiring companies to invest in technology, infrastructure, competence etc., without taking the diversity into account, different market conditions could emerge, making it difficult to compete fairly. However, EO also recognized the need for pressurizing the industry to switch to greener practices, along with PB, who identified the need for standardization, which will be further discussed below, as well as the Supplier, who proposed more studies showing direct benefits, to make it easier for companies to justify high investment levels caused by implementation of green measures.

- Type

Type I labels offer the advantage of designing a framework specific for the environmental issue one wish to address, based upon the resources available. This is a flexible

system, which allows companies to improve and label their green performances, while potentially gaining a competitive advantage by increasing market shares with environmentally aware consumers. However, Type I levels also increase the risk of companies using these independently developed frameworks as a means of green washing, to gain that competitive advantage, or to sell products with a price premium, without any real improvement on environmental performance. Type II labels require a neutral third-party to authenticate and monitor the framework. For instance, the ESI framework encourages vessels to improve their environmental performance, as they will receive financial advantages from ports and coastal authorities depending on how high their ESI score is. The incentive providers are encouraged to sign up to this program, as they would be able to label green performance related to sea-going activities, which could be received positively by local community, stakeholders etc. The framework is administrated by a third-party, increasing the trust and reducing the possibilities of using this framework as a means of green washing. However, it requires auditing and monitoring by the administrator, in addition to the fee the incentive providers pay. Many of the participants of this study emphasized the need for standardization, suggesting that Type II levels would be a better approach, as it might increase trust levels, the risk of green washing is reduced, consumers experience less confusion as the amount of Type I levels increase, and finally, everyone have the same requirements.

- Standardization

All participants confirmed the need for standardization as lined out in the literature findings. However, participants had slightly different angles, suggesting the need for a holistic view when developing standardizations for the industry. The EO emphasized concerns related to interpretation of frameworks, as both nations and flag states could interpret new requirements differently and thus implement different procedures to meet these. This could potentially reduce the effect of the requirement or create a situation where the requirement has no effect at all towards the issue it is trying to resolve. In addition, with different implementation processes, the risk of green washing increases, for instance by transferring the problem to a different region, as EO explained:

> Let's say this was implemented through the IMO, and then again down through the flag states: you do see that the different flags have very different approaches and in the same way that you have different seriousness about the owners and the operators, you

also have the same with the flags. So even though the IMO makes a convention or makes a mandatory framework, you can still have flags that gives exceptions like this and they don't really follow this playing field.

PB emphasized the need for standardization to ensure shared data was trustworthy. If members of a port community share data to create a common picture of activities happening in port, the data needs to be verified to ensure that no data is inaccurate, potentially creating dangerous situations, or delaying operations, which would also require members/user to verify data uploaded in the system. Furthermore, different members take different elements into account, when collecting and reporting data, depending on their field of operation or interest. For instance, while a VTSO will mainly be interested in the traffic picture for safety reasons and navigation, a terminal or an agent will have different interests in gaining more visibility of incoming vessel's ETA or other operational information. Both parties, the terminal and the VTS, might receive different estimates for time of arrival, so sharing this type of information would potentially increase visibility and efficiency. However, PB emphasized that there were no current incentives for members to share such data, so a common framework would pressure or/and incentivize members to do so.

…a bigger problem over the whole industry is that there could be that reluctance to share data (PB).

There could be more than one reason for this reluctance, thereof behavioural reasons, such as legacy, "business-as-usual" attitudes, competitive levels of the industry; data considered sensitive, for competitive purposes or national security interests and so on, which will be further discussed below. Additionally, reluctance to data sharing can be due to insufficient data management tools, and insecurities and confusion with regards to data format, what type of data to collect, monitoring tools etc. By developing frameworks containing such information, and guidelines with regards to type of data management system for data sharing, some of these challenges could be further addressed, and would thus make advantages of collaboration and data sharing more visible for the industry.

- Green washing

Green labels could potentially lead to green washing in three ways, 1) companies take shortcuts, in order to supposedly meet requirements of green framework which could lead to

better green credentials of a business, and 2) different interpretation leading to less serious measures to decrease environmental impact, or 3) Type I levels where the producer of the label is the same as the administrating part, thus increasing the risk of poor auditing and monitoring. In the first scenario, the business could potentially gain a competitive advantage if end-consumers are environmentally concerned. In addition, it could give the company some benefits for incentive providers of the industry, even though the company is not improving its environmental impact. In the second scenario, different authorities, such as national authorities and flag states could potentially interpret frameworks differently, thus leading to different levels of effort put in place, to reduce environmental impact. This could, for instance be an attempt by the authorities to attract businesses not interested in investing in environmental solutions, if the authority is able to either find a shortcut or avoid the framework all together, as stated by the EO above. Type I labels have several weaknesses related to development, monitoring, and administration of the label. When the same company both produce and administer a framework, the risk of poor monitoring might increase. In addition, end-consumers could be confused with too many green frameworks and labels available, thus reducing overall trust in such frameworks, while the environmental impact has yet to be reduced. However, Type I labels requires no fee to the administrator of the framework and thus reduced the financial burden on the company implementing it. Additionally, it could potentially improve the environmental performance of a company, which could positively affect other suppliers in that segment to follow suit, effectively increasing the industry standard.

Advantages

The literature review identified three main points related to advantages of green labels, namely "Competitive Advantage," "Price Premium," and "Industry Standard." These points will be discussed in light of the findings from the industry, to determine their actual relevance.

- Competitive advantage

Companies could potentially gain competitive advantages through green labelling their activities and/or products, both in terms of attracting new partners, consumers etc., that have environmental concerns, and by optimizing efficiency of operations that could reduce environmental impact. For instance, more and more consumers are increasingly environmentally aware, with an interest for consuming products and services that have been produced in environmentally friendly manners. Shipowners and operators that are interested in improving their green credentials, might be motivated to call on ports with the same

interests if given the choice, which again could be a motivation for ports to switch to greener practices. Likewise, cargo owners might choose transportation modes with similar interests if it has the potential of producing competitive advantages.

Optimization of operations and services could have positive environmental effects as well. For instance, better voyage planning could decrease waiting times in port, provide more efficient utilization of lay days, provide the possibility of speed adjustments of vessels, to mention some. While these measures would have the potential of decreasing operational costs, they could also reduce emissions and thus the environmental impact. However, these measures require tight collaboration, data sharing and many additional measures to successfully be implemented, making it difficult to incentivise the different stakeholders.

- Price premium/discount

While companies selling products that report the environmental performance, might have the possibility of offering the same product with a price premium, the nature of the maritime industry and the complexity thereof, makes it difficult to discuss a price premium as such. However, some ports have implemented green frameworks, offering shipowners and operators discounts and other advantages if green performance is reported and meet specific requirements. For instance, the ESI framework, implemented in several ports and coastal authorities, allow its incentive providers to offer such discounts, encouraging environmental awareness among shipowners and operators.

- Industry standard

Companies in an industry possess power to pressurize one another into switching practices. In addition, trade partners could have certain requirements to each other, for instance, related to environmentally friendly practices, either related to a specific collaboration, or as a standard basis for doing business. Pioneers within sustainability in the maritime industry, could potentially encourage other industry players to switch to greener practices, as the benefits of a certain implementation or a business model appears realized. For instance, the ESI framework is adopted by certain incentive providers, offering visiting vessels financial advantages based on specific green credentials. As more companies adopt such frameworks, and the advantages are identified, both related to internal processes and external customers, this could become part of an industry standard. PB stated that: “Most companies, most ports, most authorities, they are all sort of looking and watching,”

confirming a hesitant, however interested, attitude related to changes in the industry. However, PB also stated that:

> I don't think that we'll necessarily wait until we're pushed, so until legislation comes in to makes us do something. But I think there certainly needs to be some traction and some momentum of more of a move in that direction.

Suggesting that the industry is interested and potentially ready to implement changes and switch to greener practices. EO further confirms a rather conservative attitude by stating that "I think industry in general, but maybe especially the shipping industries that is so conservative is going to be very reluctant and very sceptical to everything that is new." However, EO further stated

> And in a way, you have to push them. Make them go forwards because they don't want to do it, or very few of the players want to do this by themselves. While at the same time, you have to help them do the baby steps. But at the same time, you cannot be too patient, because this is a transition that needs to happen… …So, you need to find the balance between going too slow and too fast.

Which suggest some similar opinions regarding the current attitude of the industry, nevertheless none of the informants confirms nor denies whether the "momentum," "move," or "help" should emerge from legislation, voluntary frameworks, or other industry players, making it difficult to assess how the general attitude in the industry is affecting one another.

Consumer

Below the findings from the literature is discussed and compared to the findings from the industry. It is divided between Challenges and Advantages, which is again divided based on the respective topics.

Whilst many maritime companies do not have any direct contact with an end consumer, consumer refers to the relevant customers in this paper, e.g.: ports are consumers of technology providers, incoming vessels are consumers of ports and terminals, while ports, terminals, vessels etc. are all consumers of technology providers.

Challenges

Below the main points of the findings related to challenges of the consumer side, will be discussed.

- Design of labels and information

The literature findings suggested that consumers need consistent, easily understandable designs, in order to be positively affected into purchasing greener products. Similarly, players in the maritime industry require trustworthy frameworks where the reported data can be trusted. Likewise, in order to motivate companies to adopt such frameworks, they need to be feasible and possible to implement. This makes it challenging to meet requirements related to necessary complexity while still designing it in an easily understandable way that encourages adoption. Finally, green labels should cover an area or issue with relevance to the challenges faced by different players. For instance, a terminal, a VTS, a shipowner or operator all face different challenges, and all have different interests. Green labels should be designed in such a way that it captures and aims to resolve the actual issue, while it encourages and motivates players to adopt it. For instance, by solving challenges related to inefficiencies, both offers an environmentally positive effect, increased efficiency and/or reduced costs can be achieved. Similarly, frameworks could be designed with regards to whom the labels will positively influence into making more environmentally friendly choices, e.g.: green product labels are designed with the intent of influencing the consumers purchasing decision into making a greener choice. Likewise, trade partners in the maritime industry could have bigger incentives to adopt labels, if they positively influenced one another.

PB stated, “It's challenging to find out which is the true picture or improve the accuracy,” when discussing challenges related to sharing and trusting data on common platforms in a port community. The EO also confirmed challenges related to trusting collected and reported data in green frameworks. In addition, due to the international nature of the maritime industry, where shipowner and operators need to comply with international and national regulations and requirements, layers of complexity requires that green frameworks do not add an additional burden on these companies:

> I believe the methodology of defining a common set of standardized methods, regulations and where you actually have independent third parties that are not commercially depending on the cleaning companies or calling companies, they can

> actually verify this. Because you need to have some trust… I don't think it's reasonable to expect that they should have the competence or the capacity to follow up on this in every aspect.

This is closely related to the need for standardization of frameworks, third-party certifiers, which could potentially increase the trust in the frameworks. However, both for the purpose of encouraging companies to adopt green frameworks and ensuring trustworthiness of the framework, the design must be taken into account. For instance, the ESI framework, implemented in PA**,** as previously discussed, relies on ship owners and operators to report data to their database, which the administrators use as the basis for further calculation of emissions. All formulas are explicitly uploaded on their webpage, giving both vessels, and the incentive providers the possibility of verifying this data after their own requirements and standards. This level of transparency increases the trust in such a framework. However, the reported data relies on self-reporting from vessel owners and operators, potentially increasing the risk of errors and even untrue data. That being said, the administrators of the framework, do perform monitoring and random audits of its registered users, effectively increasing the quality.

- Governance of labels

Governance can both refer to the administration of the green framework, the one responsible for quality assurance, monitoring, audits etc., to verify that participants are following requirements, or the one responsible for following up the requirements. For instance, if one were to implement a system for better voyage planning related to JiT arrivals, who should have the overall responsibility of conveying information to the relevant parties and collecting data? Both pose a challenge and require more research. As the Supplier stated: "…it is sort of difficult to see who gets the benefits of the perfect working system. It might be many stakeholders that get small benefits, but it is no one really having the overall responsibility." Suggesting that there is unwillingness to take responsibility for such a system. However, PB stated, when asked about the distribution of responsibility, that:

> I think we would just provide them with information, provide them with some visibility of our model, our sort of digital twin of what we expect to happen, so that ships [know] the timings of the various movements and where it's going to move. If

> we could share that and it was just given with the information: This is what the Port Authority expects will happen when your ship arrives, and then allow them to make their own decisions on the basis of that information.

Which further raises the question of what one should do with the information received, which will be further addressed in section regarding “Real Time Data.” In terms of environmental monitoring there are various levels of competence within this field amongst different players, such as ports and shipowner and operators. The EO stated that:

> I believe that at some ports, maybe especially the bigger ports, it could be an option because they have the manpower or the competence to do this. Whereas if you look at the smaller ports, they don't have this and it's not feasible for them to hire resources just to focus on this.

Outlining the various resources available for different players, and the general variety in the industry. Furthermore, by transferring responsibility of monitoring and auditing, along with the general administration of a framework to third-parties, would reduce the burden on companies, as stated by EO**:** “I don't think it's reasonable to expect that they should have the competence or the capacity to follow up on this in every aspect.” Allowing them to rather focus on specific measures for reducing environmental impact instead of acquiring competence for monitoring purposes.

Third-party certification would also reduce the risk of green frameworks being used as a tool for green washing. EO briefly commented on the topic of green washing**:**

> **…** my short comment on green washing, is that I really do believe that, you need standardized methods and methodologies and perhaps also independent third-party verification bodies.

This could further be connected with issues related to different interpretation causing different levels of effort, as previously discussed, and eventually altering the market condition unfairly, if not implemented.

- Awareness

Awareness of green labels and frameworks is important for two reasons, 1) to reach out to trade partners or customers, positively affecting them with green credentials, and 2) for interested players to adopt potential frameworks. In addition, more awareness related to environmental impacts and concerns in general is vital for creating interest and motivation of adoption of such frameworks. Previous studies have shown that the consumers most interested in green product, are consumers with already existing environmental concerns, or consumer already making green purchases. How do we then reach the consumers, customers etc. that does not have this interest for environmental concerns, or greener purchases, collaborations etc.?

Advantages

The advantages, seen from the consumers perspective consists of behavioural changes, and pressure.

The literature findings showed that green labels could potentially encourage behavioural change amongst consumers, by influencing the purchasing decision. Customers within the maritime industry, could have the same potential influence with their suppliers. For instance, PB compared how supply chain management have evolved during the last years, with customers evaluating suppliers based upon green credentials. PB stated:

> It may just be as simple… increasingly supply chains are looking at. Years ago there was a quality thing where you had your own quality assurance system, and then you extended that out to all the suppliers you wanted to have a quality assurance system. The same thing is happening now with environmental credentials. You set your own environmental use and you have an environmental strategy and continuous improvement. You branch that out to all the contractors and all the companies that you work with, you benchmark them, and you judge them with green credentials. I know we do with procurement, when we're buying, when we're tendering and either commissioning new work or buying new equipment. It's well up there in the procurement scoring process. Environmental credentials are increasingly a large part

of that. That continues to move and ultimately [will] gain some momentum, probably before legislation pushes it that way. But you know, you don't know.

Which could suggest behavioural changes could be extended to environmental practices. However, as PB stated, there is still much uncertainty within this field, different levels of interest, and a conservative attitude.

PA has implemented the ESI framework, offering financial benefits to vessels with a certain environmental score, thus encouraging ship owners and operators to invest in greener technologies. However, the financial model of many trades might pose challenges and reduce the potential influence such frameworks have, as operational, technical and commercial responsibility could be distributed differently depending on charter party contract. In addition, PA has developed and implemented an Emission Inventory, with the purpose of accounting for emission pollution. The inventory provides a baseline in which the port can use to monitor development of emissions, emission hotspots, need for development and planning etc. The data sources used for the inventory, also suggest a form of collaboration between different actors in the port community. Frameworks like this, could potentially make benefits of monitoring emissions more visible, thus encouraging other companies to adopt something similar.

5.4 Maritime activities

As shown in Table 5, the literature findings were divided into challenges and barriers, one related to ports specifically, and one related to visiting vessels. Below, each finding will be further discussed in light of findings from the interviews.

Table 5: Literature findings: Challenges and Barriers of maritime activities

	Challenge	Barrier
Port	- Complex Frameworks - Standardization - Inaccurate/missing data	- Unwillingness to share data - Collaboration
Vessel	- Standardization - Complex frameworks	- Charter clauses - Collaboration

Challenges refer to the challenges identified while working with improving green performance, while barriers refer to issues actively discouraging or even blocking companies from improving their green performance.

Challenges

Many challenges ports face is similar to those faced by sea-going vessels, terminals, and other relevant stakeholders, emphasizing the need for having a holistic perspective when analysing these issues. This section is divided into three main topics, namely "Complex Frameworks," "Standardization," and "Data." These are briefly discussed in the "Green Label" section, however, in this section it will be discussed considering the findings from the literature related to maritime activities and aims to cover the perspectives of shipowners and operators, as well as ports, rather than green frameworks in general.

Complex frameworks

As discussed previously, complex frameworks and methodologies makes it challenging and less motivating for companies to adopt. The literature findings support the issue with complex frameworks, which the informants also recognized.

PB stated that enough methodologies and standard measuring tools existed, however, there is yet to be an agreed set of standards for what to measure. For instance, in terms of emissions, should the different mixes of gases in the fuel be considered, along with fuel type? Furthermore, agreeing upon how to use such data, should be considered, as it could be used to benchmark environmental performance, identify troubling or congested areas in terms of vessel traffic, for fuel development, to mention some potential usages. Due to the reluctance and challenges related to data sharing amongst companies, many assumptions must be taken when calculating, for instance with emissions, producing results with various accuracy levels, as well as various factors taken into account, making it difficult to compare results.

The complexity of frameworks could arise when measures require a certain degree of accuracy, or when the framework needs to be adjusted to local conditions, such as national legal frameworks, financial models etc. EO raised the issue of flag states, nations, and international organizations implementing different frameworks. For instance, the recent frameworks proposed by the EU, "Fit for 55," and with the purpose of reducing greenhouse gas emissions, and the "EU Taxonomy" used to classify investments related to their green performance. Even though frameworks such as these promote environmental awareness, and potentially improve environmental performance, they also do add another layer of complexity for global industries such as the maritime, as companies would have to adapt to different frameworks and regulations across the globe.

In addition, environmental issues require investments in competence, that smaller companies might not be able to justify financially. EO recognises that frameworks should

balance the needed complexity, competence and investment levels required, acknowledging the huge variations of companies in the industry. Which further suggest that there is trade-off to be considered between pressurizing the industry and incentivizing it, to be able to motivate, while still making notable improvements. However, the global nature of the industry in general, adds extra complexity when implementing frameworks as well.

Standardization

The literature recognizes the challenges related to different practices around the globe. For instance, there can be found many different procedures and requirements related to port calls, such as different requirements for reporting upon arrival and departure, forcing the ship owners and operators to comply by several legal frameworks, and adding additional work upon them.

The industry findings suggest that there is a need for standardization of procedures to make operations and activities more efficient, potentially increase environmental performance, and reduce operational costs, as stated by Supplier**:**

> Different ports have different procedures. I think one of the challenges, probably, is standardizing these port of calls in best possible way. What are the requirements for port of call, and it is different from every place around the world, but of course a lot of similarities.

However, as discussed above, these standardizations need to be implemented through a trustworthy and global organization, such as the IMO, thus reaching every company in the industry and reducing the risk of companies needing to comply by different frameworks in different regions. However, as we have also seen, the maritime industry is generally very conservative, reluctant to try new developments and implementations, while there is a high level of diversification, both in terms of areas different companies operate in, different interests and needs, as well as different benefits, which should be more thoroughly examined in the future. EO stated that

> It's really hard to find this one solution that fits all. That would be ideal, but maybe you could have like a general framework, but motivate them to go on this framework with [prior] different incentives anyway.

For instance, the ESI framework is mainly focused on emissions, however, there are more areas being considered integrated in the framework, such as air quality monitoring. Frameworks such as this could be used as a basis, while ship owners, operators, ports, and other relevant stakeholders could participate in different programs, adaptable to their specific situation and competence. However, requirements to transparency, trustworthiness, and avoidance of too much complexity must still be considered. Furthermore, companies that are not signing up for such frameworks should be investigated to find potential administrative, financial, or other reasons as to why it is not reaching all the companies.

Finally, as previously discussed, many maritime companies have different organizational structures, approaches, operations and so on, increasing the complexity of the industry. Firstly, differences could make it challenging for some companies to adopt a standardized framework. Currently, one should consider developing a framework that is either flexible and could be adapted to fit different needs or implementing specific frameworks relating to specific fields of interests or regions. Nonetheless, standardizing mandatory services in ports, or at sea, should be further investigated. The literature findings suggested that there could be big variations in how a VTS is organized. In addition, there are also different legislations regulating what type of service a port or coast should offer, VTS, Local Port Service, port VTS, costal VTS etc., possibly being a reason for the different organizational structures. PB stated that

> The levels of traffic management, the VTS management of traffic: Some of them will only be an information service, so they won't regulate times of entry or anything like that at all… …So we control them quite strongly. But you're right it does vary enormously.

The level of authority a VTSO possess will also vary from region to region, nation to nation, especially depending on the traffic density. The literature findings suggested that there was a trade-off between regulating a VTS strictly and flexibility. This could potentially add to the layers of complexity and require further studies to determine to what extent it affects the industry as a whole. Nevertheless, it does require frameworks to be possible to adopt, both for strictly regulated areas, as well as more flexible areas, without compromising any services.

Data

Many of the challenges hindering development of green performance in the maritime industry can be related to data. The literature findings point out data sharing, due to the reluctance from companies, as well as collection and reporting of data, as many data sources could give inaccurate data due to missing data fields, or human error when reporting. While authorities, such as ports and coastal authorities usually extract data from several sources, such as internal ship databases or third parties such as Lloyd's List Intelligence, to increase accuracy, not all companies have access to these databases. In addition, some members of a port community, might have access to updated information, for instance regarding more accurate ETAs, which is not necessarily shared with authorities. This creates different versions of the traffic picture, increasing the risk of making poor decisions.

In terms of sharing data, there are several challenges related to this, such as what to share. For instance, related to emission monitoring, many companies use AIS as a core data source today, and then emissions are calculated based upon data such as speed, ship type, draught etc. Even so, assumptions must be made when there are missing data fields, making the calculations more inaccurate, as well as more time-consuming, especially when vessels could be equipped with sensors monitoring exact fuel consumption at any given point, as PB outlined: "They already know ships have equipment on, that is monitoring and is metering how much fuel is being used all the time." If one were to standardize the type of information to be shared, thus pressurizing the vessel owner and operators to share such data, this would give more accurate monitoring of environmental performance.

> So, it's then just a case of standardizing how that's recorded. Put some sensors on recorded, retain it in a standardized format, distribute it in a standardized format, and that that would be the theory of doing that. [That] is quite simple because the ships already know if you asked an engineer on the ship, [he] gonna tell me how much fuel we're using at this moment. He would give you an instantaneous rate of consumption of fuel. They could do that very easily. It's capturing that, standardizing it, and then somehow sharing or distributing it, that's the difficult aspect of doing it that way, but that that would seem to be the ultimate goal. (PB)

Which brings us to the next topic of interests; how to share it. Different members of a port community use different systems for reporting and capturing data, which makes it more complex to share data amongst the members. This could be due to different formats, limitations related to bandwidth, when including vessels in the equation, or interest levels. Different members will have different interests with data sets, which will also vary depending on situation or operation. In order to share data effectively, the different levels of usages and interests must then be taken into account, to reduce information overflow. Developing a shared data platforms for the physical transferring of data is thus necessary, as outlined by Supplier**:**

> Each user has a different system, and different formats, so that is also why [in] IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities), for example, we have this maritime common data infrastructure initiative, which of course, have the intention of making it as standardized as possible so sharing data will be easier.

Furthermore, the challenges related to different data formats must be addressed if systems are to be linked. PB are working on linking systems with one of their trade partners, in order to increase visibility, by reporting more accurate ETAs from shore-shore. They have the advantage of using similar port community systems, removing the challenges related to conversion of data into the same formats.

> Because we're using the same port community system as port of [Trade partner], it’s stored in the same way in the database. Similar data fields have the same meaning, so that it probably doesn't need a complicated exchange format, because the same kind of information should be stored in the same way and should mean the same thing. It gets complicated when you actually store a different value or store in a different format, or you combine some things together. That's when it gets complicated. You have to sift and separate the data, standardize it, and put it into a standard format for exchange, so we probably don't need to do that because we're working on the same system.

Which suggest that there is an interest for this type of data sharing, however, the more complicated the exchange becomes, or the more investments are required, the less chance of adopting collaborations such as these. Supplier further outline that the achieved benefit is currently not a justifiable reason for such high investments in data sharing platforms,

> …but it is a bit difficult to defend high investment in technology development and setting up these kinds of data sharing platforms which get highly complicated because of lot of different formats.

Finally, sharing of data will have some limitations depending on the nature of data. For instance, competitive sensitive data as discussed previously, as well as data being of national interest, which restricts data sharing in some regions.

Barriers

Barriers refer to areas of interest that actively hinder progressions in the maritime industry with regards to green performance. There are two main topics, namely, collaboration, and regulatory, which will be discussed in more depth below.

Collaboration

The literature findings suggested that lack of collaboration was a frequent challenge in the maritime industry, especially as this increase reluctance of data sharing amongst companies. Furthermore, both PB and EO directly addressed the challenge of lack of collaboration between companies, while Supplier recognized it through the reluctance of data sharing. A potential cause of this challenge derives from the lack of benefits it would offer, for the companies involved. As mentioned previously, Supplier stated that it was difficult to recognize who would get the overall benefit for increasing collaboration. While one could easily identify small benefits for all involved, it does not necessarily justify high investments at its current state. Supplier also requested more studies investigating the benefits from such collaboration and presenting it a clear, straightforward way.

What is then the benefits of developing a collaborative model, for instance in ports? If we look at PB**,** which explained the current state of a port collaboration, related to emission monitoring:

> There's the Port Authority itself, the company that I work for, [company name] and the operations that we have, and the berths that we operate, that we have quite a bit of

control over. Then within the port there are other births of the terminals operated by different companies, in which we don't have any control over. So that then becomes a case of collaboration and making sure we have a shared model and a shared strategy for how to do this, which we don't really have at the moment.

Which brings us to the first benefit, seen from a port perspective: environmental monitoring. As stated above, the port authority has models for monitoring emissions within their own operations, however, operations run by other companies currently have a lack of monitoring environmental performance. As discussed previously, monitoring environmental performance, for instance with regards to emissions, could give an overview of operational bottlenecks, by highlighting the emissions hotspots. By baselining emissions, one could implement specific measures to reduce emissions in that area, which would be beneficial for the local area, in addition to potentially making operations more efficient, thus reducing fuel consumption and reducing operational costs for vessels, terminals and other related services. PA baselined their emissions in port using their Emission Inventory, which in term made it possible to assign emissions to specific areas, using AIS data. The data for the inventory was collected through AIS, third party databases, such as Lloyd List Intelligence, as well as a survey given out to vessel owners and operators, giving a more accurate calculation of emissions. PA used these results to baseline emissions in the different port areas, which will be reviewed, and thus potentially uncover inefficiencies, where resources should be allocated, e.g., through infrastructure planning. Overall, obtaining more accurate results, could potentially give more accurate suggestions of problem areas, opening up possibilities of implementing more specific changes to improve the issue, e.g., reduce emissions, increase efficiency etc.

Furthermore, collaboration could help reduce complexity in the industry. For instance, collaboration amongst ports, adoption of similar frameworks, reduces confusion due to different requirements of, for instance, port calls. EO underlined the need for more collaboration, to reduce and avoid complexity.

You have different type of stakeholder environments, but still it's going to be a complex stakeholder environment between industry actors of different types, authorities, [and] ports coming together. It’s really no other way for a global industry

> to… It needs collaboration to actually agree on a common set of standards or procedures anyway. Because otherwise the complexity is… You cannot have different regulations in every country. (EO)

In addition, agreeing on similar frameworks, such as a set of standards related environmental performance, might simplify the process, and free previously resources used to comply with different frameworks, in different regions, and thus encourage more companies by making it possible to focus on such performance.

Another benefit relates to improved voyage planning. The literature outlined hoteling at berths as an operational bottleneck. This resides from vessels arriving at port while the berth is not available, causing much waiting, time that potentially could be utilized for other required operations, from a vessel perspective. Just-in-time arrival is becoming a topic of interests, both for researcher and the industry. JiT-arrivals could potentially increase efficiency, reduce waiting time, or more efficiently utilize that waiting time, in addition to increasing the visibility of port community members. However, it does require collaboration and data sharing amongst one another.

PB outlined the different potential benefits of implementing systems that encourage JiT. For instance, terminals often have a more accurate ETA, as they receive updates from vessels. These types of updates are not explicitly available for the VTS. Even though PB stated that: “The anchorage area is at sea. It's outside the port. It doesn't get so congested that it causes a problem. I don't think it matters too much for us.”

PB still recognized benefits deriving from more visibility regarding vessel traffic. More accurate ETAs would effectively give VTSOs more room for planning and create some contingency for the operators. However, terminals would potentially benefit from more flexible ETAs, due to the financial risk associated with vessels awaiting berth availability, when within their time window.

> I think that would suit them [vessel owners or operators] better, actually. Because, at the moment, the thing that the shipowners want is for the ship to arrive nice and early at the start of the lay day windows, be ready and then the terminal not to be ready. That's the shipowner’s ideal world. The ship is waiting at anchor, and it's being paid.

> Whereas for the terminal, what they really want is for the ship to have a flexible arrival time that fits with their flexibility in their moving picture of their schedule of ships that are going to take a particular berth (PB).

This statement raises another challenge related to the financial model of sea-going activities in port, which will be further discussed in the next section. In terms of benefits for the vessels, PB stated that there is a tendency to exclude the ship in data sharing schemes amongst port community members, however, vessel owners and operators would equally earn benefits from being included in the data flow.

> I think there is a tendency to exclude the ship and not treat them as a component of the system, but actually I think it would be much better to give the ship the same visibility. So if you actually fed back and gave the ship some visibility of what was happening in the port or what they were likely to expect in the port, and the ship could see that we're expecting it to go to anchor for two days… …and I think that would be very helpful to the ship and also, if they had some maintenance they wanted to do. They had some operations or something like that. They could perhaps fit that within a flexible charter party to accommodate those, and that time efficiently or save some fuel or whatever else they could do (PB).

Similarly, the terminals would benefit from more accurate ETAs, and thus more visibility. For instance, more accurate and trustworthy ETAs would give terminals the possibility of increasing scheduling and planning of equipment, manning levels, and other operational aspects related to discharge- or loading operations. PB exemplified the possible benefits, if they were to implement systems increasing JiT arrivals:

> … if they get an update in [Trade partner] that the change is the departure time of a ship, that's then going to come to the [Port B]. That can be really useful information, because if that can adjust the add on the passage time, adjust the ETA of when it comes to [Port B], then terminals on the [Port B] could possibly make some decisions on manning levels, when they have shifts working, [and] when they have equipment

> available. Even rotating the berth and things like that, you know repetitions on the berth that could improve efficiency by having a better picture. That's the possibly in the next area of work that we do

However, JiT arrivals and similar concepts, such as E-navigation services, are yet to be widely adopted. EO stated that voyage planning in general have been an overlooked topic for research and development, despite its potential fuel and cost savings. Supplier recognized the same challenge, however, related it to high investment levels of creating systems for data sharing, and requested more straightforward analysis of actual savings, and/or increased efficiency.

Regulatory

In terms of regulatory barriers to implementing, for instance JiT arrivals, or encourage data sharing amongst players, there are three main points identified.

1. Charter Party clauses

The literature findings suggested that there were challenges related to charter party clauses stipulating arrival as soon as possible. Surprisingly, few studies embraced this fact, which could suggest weaknesses in the literature review, or a research gap. However, all participants outlined these clauses as a challenge, which actively hindered slow steaming, and JiT arrivals. PB stated that:

> The just in time works well in some trades, but as we discussed before, there's still a lot of commodities, a lot of particular sorts of bulk products where a ship is chartered for a voyage, [and] there's no incentive at all for delivering that just in time. In fact, it's the opposite, the way the chartering market works, discourages you from saving fuel. The whole focus is to arrive at the load port at a particular time.

Furthermore, communication with PA confirmed the same finding. Approaches just as Virtual Arrival and Green Approach aims to address this particular problem. Virtual Approach is a charter contract clause one can add to increase flexibility with regards to ETAs. A Calculated Time of Arrival is introduced, relative to the ETA, however, there are challenges related to the calculations being complex, and in combination with a lack of trust between the contracting parties, it has been challenging to implement. Green Approach,

already practiced in the aviation industry, refers to speed adjustments during sea voyage, to adjust arrival to availability of berth, in order to avoid anchoring outside, very much related to the goals of e-navigation services, and JiT arrivals.

PB stated that this approach can be found, especially in the cruise- and ferry industry, where vessels will depart from ports earlier, in order to run at an economic speed and thus save fuel costs. PB stated, related to container scheduled services:

> … and with container ships we used to adjust the speed every day almost. We wouldn't calculate what our ETA was at next port. We would know what the ETA should be. We would know when we're expected, and we would adjust the speed to arrive on time.

Which suggest that practices related to improved voyage planning to reduce fuel costs, JiT arrivals have been implemented, however, due to regulatory barriers, different segments of shipping should be analysed individually.

5.3 Real Time Data

AIS data allows one to collect data about vessel movements, as well as characteristics of the particular ship, in real time. This has opened possibilities for ports – to track movements and traffic in port areas, monitoring emissions, which again could contribute to make better decisions related to investments, infrastructure planning etc. Furthermore, it allows researcher to track vessel movements in real time and offers a vast database for several research-related purposes. Finally, it allows monitoring of abnormal behaviour of vessels, especially now that satellite AIS is being introduced, allowing for tracking of vessels globally without the restrictions normal AIS pose.

However, AIS data is not perfect. There are missing data fields for measuring and calculating fuel consumption and emissions accurately. EO suggested the positive effects of having access to AIS data, and proposed that this data served as a good starting point for green monitoring, frameworks etc. EO further suggested, upon discussing the topic of how strict and complex frameworks should be, and how accurate data should be in order to improve green performance and be adopted by the industry:

> I mean somewhere in between is the way to go, because in a perfect world, where you would have data sources and it would be semi or ultimated and you could actually

verify the information, that would be ideal but, I don't think we're going to be there for a very long time, maybe not ever.

Suggesting that current frameworks do fulfil the need in terms of data accuracy, while still acknowledging that there are more potential for further development. However, EO stated that: “I believe you shouldn't kind of let the perfect stand in the way of progress in a way…,” which both refers to the time constraints we are facing with environmental issues and the need to push companies to improve their performance. Simultaneously, imperfect frameworks or data sources should still be actively considered if there is an environmental benefit. Which conflicts on the theory findings related to green labels, which urged accuracy and third-party certification of labels. Furthermore, PB suggested similarly:

I think it's probably good enough, certainly, as a starting point to make some assumptions. You use the AIS if you know the draught of the ship. You know what it might be loaded at but you're going to make some assumptions on what type of fuel that ship is burning, what the consumption, maybe what auxiliary is, what generators are running as well and, it could be quite tricky to measure that…

Suggesting AIS was a good starting point, however pointing out that much of the data fields missing from AIS data, could be derived directly from ship owners and operators, proposing standardization of what data to share amongst maritime companies. This could reduce the current issues related to AIS data.

Finally, AIS data allows for tracking vessel movements, thus assigning fuel consumption and emissions to specific areas and regions, which allows for tracking of environmental performance of vessels, more directed implementation to improve green performance, as well as increase efficiency.

5.4 Bridging the gap

In this subchapter, the theoretical and industry findings are compared with the intention of investigating whether they confirm or reject one another. The subchapter follows a same structure as the Discussion and Findings chapter in general, starting with Green Labels, then Maritime Activities, before finalizing this subchapter with Real Time Data.

Green Labels

Table 9 provides an overview of the topics discussed and the findings from the theory and the industry.

Table 9: Cross-analysis of green labels

Green Labels	Theoretical	Industry
Financial burden	Suggested increased financial burdens on companies would be a barrier	Recognizes diverse industry, with big and small companies, not all have the financial backbone to invest
Standardization	Need for common approaches to: - Reduce confusion - Increase transparency - Reduce risk of green washing	Support theoretical finding to: - Reduce confusion - Increase trust (transparency) - Reduce risk of green washing Additionally: - Relieve burden on companies (lack of competence, infrastructure, tools etc.) - Increase data sharing - Avoid green washing
Governance	Differs between Type I (self-labelled), and Type II (third party administrator)	Support need for third party administration, however, Type I could increase progression now
Design	Findings stresses requirements for successful labels: - Visible - Consistent - Easily understandable	Findings related to standardization and the need to standardize design of labels. In addition, labels need to be: - Transparent to increase trust - Standardized to avoid complexity - Easily understandable (avoid too complex, hard-to-adopt frameworks)
Awareness	Awareness of available frameworks as well as for the environmental concerns.	Findings could suggest that the industry does not have awareness of environmental concerns and/or available frameworks. However, difficult to exclude rival explanations as a potential explanation.
Advantages	Reported three sources of motivation: 1. Competitive advantage 2. Price premium 3. Industry Standard	Findings suggest that the reported sources are not enough on their own. Might have to be combined with legislation. Prevalence of adopted framework not great

The challenges related to green labels were namely classified as Financial Burdens, Standardization, Governance, Advantages, Design and Awareness. Financial burdens consisted of the additional financial strain implementing new frameworks would impose on the industry. This was confirmed by the literature findings, as well as from the EO. However, while the industry findings suggested balancing the need for complexity in frameworks versus the required resources needed to comply, the literature findings had no suggestions to support this. Standardization was confirmed as a challenge from both industry and theoretical findings, however, while the industry maintained a holistic perspective when addressing these issues, thus emphasizing the need for collaboration, the literature suggestions were more limited to certain aspects, such as AIS data, methodologies etc. Governance was addressed by both literature and industry, and both recognized the advantages from Type I labels, as it would make progression faster. However, in order to create trust and encourage data sharing, Type II labels were deemed more efficient. Challenges related to design, such as designing frameworks in such a way that encourages collaboration and trust by being transparent and clear about potential benefits, were to a certain extent confirmed by both industry and theoretical findings. However, while the literature findings were based on studies on green labels in general, often related to consumer products, there might be industry specific requirements when investigating this matter in the maritime industry. The final points concerned awareness and motivation. There is a possibility that companies lack awareness of environmental concerns as well as available frameworks and methodologies, however, this needs further investigation. In terms of motivation, the literature suggested gaining competitive advantages, offering price premiums, and raising industry standards as main motivation, something the industry findings did not confirm. However, improving green credentials were suggested by PB. In addition, the industry findings suggested that there needed more investigation to uncover willingness and motivation factor for improving sustainability in the maritime industry.

Maritime Activities

Table 10 below provides an overview of findings, and whether industry and theoretical findings confirm or reject one another.

Table 10: Cross analysis of maritime activities

Maritime Activities	Theoretical	Industry
Complex frameworks	Recognized, addressed in Green Labels segment of this subchapter	Recognized, addressed in Green Labels segment of this subchapter
Standardization	Literature does not offer straightforward suggestions of what or how to standardize	Need to standardize: - What to measure - Why - Operations (e.g., Port of calls)
Data	Data sharing recognized as a barrier in the industry as a whole	Standardization of: - Type of data to share - Platform for sharing - Formats of data
Collaboration	Literature suggested lack of collaboration, however, to reduce lack of data sharing	All participants recognized the lack of collaboration, in ports, amongst stakeholders, between ports and vessels etc. This reduces data sharing, information flow, and potentially efficiency of maritime activities.
Regulatory	Surprisingly few mentions, however, could be due to weaknesses in the literature review	Charter party clauses discourage JiT arrivals. Financial models discourage more efficient voyage planning

In terms of maritime activities, the theoretical findings suggested lack of data could be reduced by increasing collaboration and thus sharing data, or making more data public, especially related to cargo mass. In addition, the literature findings suggest that there are several layers of complexity regarding current methodologies and available framework, thus making it less attractive for the industry to adopt. However, the industry findings suggested that the current methodologies and frameworks served its purpose, however, there was a need to standardize the methods, requirements, along with reporting issues, in order to make data understandable for different stakeholders. Regarding collaboration, the literature findings lacked any concrete mentions or suggestions towards creating a shared model, however, this could be due to gaps in the literature review. Likewise, the literature findings had surprisingly few mentions of the regulatory challenges related to charter parties and the financial models

of the industry. The industry findings emphasized and confirmed this from different stakeholders as a major issue.

Real Time Data

Table 11 provides an overview of the findings related to Real Time Data from both the theoretical and industry findings.

Table 11: Cross Analysis of Real Time Data

Maritime Activities	Theoretical	Industry
AIS data	Contains inaccuracies, however, have given access to broad source for data – allows for more accurate calculations	Findings support inaccuracies, VTS use additional data source to verify data, however, offers broad range of application areas, allows allocating of energy consumption to specific areas, results deriving from AIS data could offer better decision support
Application Areas	See extensive list in Findings chapter, however, application areas suggest more accurate results, better decision support	Supported by industry findings. However, one must take inaccuracies into account.

Concerning real time data, AIS has been the most frequent source, both for studies, as well as for the industry. The broad variety of application areas for AIS data, has formed the basis for many studies, for instance measuring environmental performance, vessel efficiency in ports, economic efficiency etc. For the industry, AIS data have been applied in port areas to determine vessel and emission patterns, as a decision support tool for, for instance infrastructure building planning, to mention one. The introduction of satellite AIS removes the prior limitations related to range of tracking vessels, thus increasing the application areas. Findings from industry and theoretical findings thus correlate and both suggest that AIS data is an improvement, despite its inaccuracies. However, for further development research, one could investigate the possibilities of either including more data in the AIS database, such as fuel consumption, or cargo mass, or make external databases more available, such as Lloyd List Intelligence.

Final Notes

An additional finding, not discussed extensively in this section, is the acknowledgement of the complexity of the maritime industry. There are complexity deriving from regulatory entities, both local, national, and international. There are complex stakeholder environments with different needs and interests, and finally there is very little collaboration. Many of the challenges and barriers discussed in this paper, suggest that a shared model of collaboration could potentially increase efficiency, safety, and thus environmental performance.

5.5 Research questions

1. Do Green labels encourage the industry to switch to greener practices?

Green labels, frameworks and initiatives are increasingly being adopted amongst maritime companies, though at a slow pace. Examples are the ESI framework adopted by both ports, costal authorities, and vessels around the globe, including PA**,** and the Emission Inventory developed and utilized by PA**.** This could potentially create competitive advantages for the company, especially if customers, consumers, stakeholders are environmentally aware. This could potentially pressurize competitors in adopting similar approaches, however, competitive advantages could be difficult to assess and thus it might not have the effect one could hope on other companies.

In addition, adopting green frameworks or similar might require additional investments, in either infrastructure, competence, equipment, registration fees etc., and financial margins can vary greatly across the maritime industry, thus making it a barrier for implementation. Furthermore, due to the global nature of the maritime industry, different authorities, flag states etc., could interpret frameworks differently, potentially creating different and unfair market conditions. This could reduce the effect of implementations, and worst case decrease trust in green frameworks and initiatives. Finally, this requires the authoritative part of the framework to be carefully considered, for instance, IMO which would be the natural authoritative figure within the maritime industry. By implementing many frameworks from different organization without authority, and possibly without any impact outside a specific region, increases complexity and confusion in the global market.

However, industry must also be pressurized due to conservative attitudes, “watch and wait,” approaches, and “business as usual” scenarios. Sources of pressure, such as customers and consumers could potentially influence the adoption of green frameworks amongst

maritime companies, for instance cargo owners to vessels, vessels to ports, terminals to vessels and ports, suppliers, depending on type of products they offer and to what group of stakeholders, e.g., vessels, ports, terminals etc.

Additionally, when designing such frameworks, a goal should be to avoid green washing as a result of poorly designed and administrated frameworks. While Type I labels allows for more flexibility, as companies can develop frameworks specific to their own financial margins and competence, while still reporting green performance, they could more easily be used as tools for green washing, compared to Type II labels. Type II labels would potentially be more complex and might require registration fees imposing more financial burdens on a company, in addition to investments that would need to be made to comply with requirements of specific framework. However, having a third party certifier might increase trust and ensure green performance is improved, which needs to be the main goal of such frameworks regardless of financial margins, authorities, flag states, segment etc.

Green frameworks and labels could potentially encourage companies to improve green credentials, either through independent measures and initiatives, or by adopting third party frameworks. However, design of framework, authoritative body, transparency, and implications of said framework must be considered to avoid the above-mentioned challenges. Furthermore, studies outlining clear benefits of such frameworks, potentially including cargo owners, should be conducted.

2. Will improved data management tools increase efficiency?

Data sharing represent a huge challenge in the maritime industry. This is due to conservative attitudes, as well as lack of proper data management tools. Improved data management tools, such as a common data platform for sharing could improve this, giving companies a better and more truthful picture of operations, laying a foundation of better decisions, reducing operational costs, and overall increasing efficiency.

Collaboration, in general, is a weak point within maritime communities, such as port environments where there are complex stakeholder environments. Benefits are difficult to measure, as we have seen, many stakeholders would gain some obvious benefits from more collaboration, however, it is still debatable whether these benefits justify investments in complex data management tools and other complementary technology.

However, by standardizing elements related to data sharing, it would make it easier for companies to participate, and might reduce some of the financial stress, as well as confusions and lack of trust in the industry. Firstly, one should develop requirements of what the data management should be able to do, such as what to share, requirements of the data shared, such as accuracy, formats – making sure data fields have the same meaning to reduce confusions, make data more trustworthy, and more specifically stating the usages and thus benefits of the data.

For instance, vessels could utilize waiting time in ports more efficiently if they had visibility of the situation in ports before arrival. Terminals would be able to plan operational aspects, such as manning levels, equipment etc., if they had a more accurate ETA, and lastly VTSOs would gain more visibility which potentially could improve planning. However, straightforward business cases which synthesize these benefits might encourage more companies to participate in a closer collaboration, at least until standardization comes into place.

3. Are Real Time Data more accurate than Historical Data?

Real time data which can be derived from AIS have given many stakeholders more accurate data to work with, in addition to more data in general to work with. AIS allows stakeholders to track position, and allocate, for instance emissions, to specific areas or routes, and could give indicators of efficiency levels in general.

However, AIS data is not accurate, and either require additional information from other data sources, such as vessel databases, ship registries etc., or one would have to make assumptions covering the missing data fields. This does not give fully correct calculations, for instance, when calculating fuel consumption, however, it does offer much more insight than have previously been available.

Additionally, AIS data have many application areas beside environmental monitoring, such as monitoring of abnormal behaviour and illegal activity, infrastructure planning, vessel behavioural analysis and trade patterns, and finally navigational safety, which is the main purpose today. The introduction of satellite AIS, which removes many of the limitations normal AIS possess, in terms of geographical limitations, open for even more application areas.

However, including more data fields in the AIS database might reduce inaccuracies in today's data. Alternatively, making more external databases more available for the public. However, the latter would pose more burdens on the maritime companies, potentially creating a barrier for collecting and utilizing AIS data more efficiently.

On a concluding note, real time data offers more accurate data for stakeholders, despite the inaccuracies, in addition to its various application areas outside of the navigational purposes. This might produce more accurate studies, give stronger foundations for improved decision making, for instance related to infrastructure planning and environmental issues, and overall driving the industry forward, thus suggesting that real time data is better, in terms of application and accuracy, than historical data. However, it is potential for improvements related to real time monitoring and data as well, and when working with AIS data one should be aware of the limitations.

6. Conclusion

This case study followed a sea voyage from Port A to Port B. The intention was to identify parameters for measuring environmental performance. The data collected consisted of interviews with relevant stakeholders, namely ports, a VTS System Supplier, an environmental organization, in addition to a thorough literature review. The findings revealed issues either classified as a challenge, thus possible to improve, or barriers, which were actively stopping progression.

The effect of green labels, as asked in RQ1, are difficult to measure. However, the low adoption rate of green frameworks, suggest that the effect on industry is low. Furthermore, findings related to motivational factors, though not directly addressed in this study, differs from industry and empirical findings, suggestion a gap in the body of knowledge.

Real time data, referencing RQ2, have opened up more possibilities for accurately measuring performance, thus offering a more accurate tool for decision support. However, AIS data, which is widely used, have inaccuracies, and requires that one verifies the data from external sources. In terms of environmental performance, it does allow for more accurate measuring and is thus an enrichment on this field.

Better data management tools, as asked in RQ3, could potentially improve efficiency, especially in terms of simplified data sharing techniques. However, the findings suggest that

the technology is available, or could be developed, however, again back to motivational factors, the industry show unwillingness to embrace changes and adopt new systems.

The findings of this study suggest that one should have a holistic perspective, when researching matters that affect stakeholders across the industry. The comparison between literature findings and industry findings suggested that while the industry recognized the complexity, this lacked in many studies, thus creating gaps between empirical literature and industry practices. The analysis also identified much overlap, for instance related to the need for standardization to reduce the complexity of industry. Surprisingly, collaboration was not heavily addressed by the literature, except when referred to by the lack of data sharing, while the industry confirmed this as a ubiquitous challenge. Another surprising finding were the few mentions of regulatory barriers discouraging speed adjustments during sea voyages; however, this might be due to gaps in the literature review.

As a concluding remark, this study aims to contribute to the body of knowledge regarding sustainability in the maritime industry and is thus contributes by highlighting areas of interest for further research.

6.1 Recommendations for further research

Many topics emerged during the work on this study, however, the one's deemed most important are outlined below.

1. Regulatory forces create barriers for sustainable maritime operations. For instance, there are no incentives for ship operators on charter to reduce sailing speed, despite long lay times in ports waiting for cargo. Further research could identify how regulatory frameworks and forces are affecting the sustainable development.
2. Holistic perspective. The complexity of the industry, for instance in terms of legislation where local, national, and international legal frameworks have been implemented, or in complex stakeholder environments, such as in ports, require that studies should have a holistic perspective, in order to address and understand issues
3. Motivational factors. Many of the stakeholders involved recognized the lack of benefits from introducing collaborative models or develop systems for data sharing. The VTS System Supplier specifically called out for more straightforward business cases showing potential benefits. Closely related is the lack of motivation for implementing green approaches and improving sustainability, which should be further

studied, for instance by identifying why some companies are already adopting green frameworks, while the majority is not.

6.2 Limitations

1. Data collection in ports appeared challenging, thus explaining the use of secondary data sources.
2. The study intended to used observation as a data collection method, however covid-19 restrictions excluded observational studies.
3. Literature review and theoretical framework should contain more studies, as some challenges lined out in previous literature may have been overlooked. Due to time constraints this was not possible in current study.
4. The two ports considered in this study both reside in the UK, which is advantageous as they comply by similar legal frameworks, however, it might reduce the variety of issues addressed. Similarly, both ports were of medium size, and including bigger ports might have given different findings as well.

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8. Appendices

Appendix A: The Literature analysis of Green Labels

Table 12: Green labels: Results of first phase literature analysis

Main category	Sub category	Content	Reference
Descriptive	Purpose	Provide customers with information	(Baumeister & Onkila, 2017; Galati et al., 2021; Meis-Harris et al., 2021; Polinori et al., 2018)
		Provide easily accessible information	(Sønderskov & Daugbjerg, 2010)
		Close knowledge gap	(Baumeister & Onkila, 2017)
		Reduce negative environmental impact	(Galati et al., 2021; Meis-Harris et al., 2021)
Descriptive	Definition	Information policy instrument	(Galati et al., 2021; Meis-Harris et al., 2021)
		Soft policy instrument	(Polinori et al., 2018)
		Information-based intervention tool	(Meis-Harris et al., 2021)
		Breadth/depth increasing (435 today)	(Prieto-Sandoval et al., 2016)(cross ref)
Descriptive	Alternative approaches	Eco-innovation process	(Prieto-Sandoval et al., 2016)
		3 determinants – supply/demnd/government influence	(Prieto-Sandoval et al., 2016)
		Credence goods: Goods consumers care about, willing to pay premium, attributes observable after consumption	(Baksi & Bose, 2007)
		Consumer Motivation: health, altruistic values	(Baksi & Bose, 2007)
		E.g.: farm animal welfare, GMO food, Coffee, Seafood	(Baksi & Bose, 2007) (Polinori et al., 2018)
		Consumer willing to pay more for environmentally friendly goods, voluntarily contribution to public	(Baksi & Bose, 2007) (cross ref)
Descriptive	Type	Type I: voluntarily	(D'Souza & Yiridoe, 2019)
		Self-labelling: firms claim attributes consumer care about	(Baksi & Bose, 2007)
		Type II: third party certified	(D'Souza & Yiridoe, 2019)
		Firms obtain permission in return for payment	(Baksi & Bose, 2007)
Descriptive	Characteristics	Specific for environment	(Galati et al., 2021; Meis-Harris et al., 2021)
		Price premium for eco-label	(D'Souza & Yiridoe, 2019)

		Based upon standardization of principles	(Sønderskov & Daugbjerg, 2010)
		Licensed by third-party state	(Sønderskov & Daugbjerg, 2010)
		Only affects demand, not supply	(Polinori et al., 2018)
		Design dependent on industry, eg.: Airline: energy-label	(Baumeister & Onkila, 2017)
		Related to operational directives	(Polinori et al., 2018)
Descriptive	Purpose	Define, compile, test, summarize environmental performance of each product	(Baumeister & Onkila, 2017)
		Steering wheel to stimulate	(Polinori et al., 2018)
Descriptive	Implementation	Present to consumer in easy way	(Baumeister & Onkila, 2017)
		Usually voluntarily	(Polinori et al., 2018)
Descriptive	Certifiers	Governmental/quasi-governmental	(Baksi & Bose, 2007)
Requirements	Business	Respect strict guidelines	(Polinori et al., 2018)
		Single label for market, globally recognized, third-party certification, parameters (language, terminology), strategically developed, cannot be voluntarily, involve shareholders in design process	(Baumeister & Onkila, 2017)
Requirements	Consumer	Clearer, easily comparable information – support decision making process	(Baumeister & Onkila, 2017; Meis-Harris et al., 2021)
		Trust – can create distrust	(D'Souza & Yiridoe, 2019; Sønderskov & Daugbjerg, 2010)
		Information: transparent, discriminatory, based on sound science, substantiated, not mislead	(D'Souza & Yiridoe, 2019; Polinori et al., 2018)
		Must contain meaning of label, characteristics, requirements, guarantees	(Baumeister & Onkila, 2017)
		Credibility, comparability, clarity, transparency, participation	(Baumeister & Onkila, 2017)
Outcomes	Business	Emergence of new green (innovative) products	(Prieto-Sandoval et al., 2016)
		Protection of environment	(Meis-Harris et al., 2021; Prieto-Sandoval et al., 2016)
		Achieve sustainable goals	(Prieto-Sandoval et al., 2016)
		Price premium	(Prieto-Sandoval et al., 2016)
		New cleaner methods for production	(Prieto-Sandoval et al., 2016)
		Greener practice	(D'Souza & Yiridoe, 2019)

		Green supply sources	(D'Souza & Yiridoe, 2019; Prieto-Sandoval et al., 2016)
		Long term visions, flexibility, anticipation of market conditions, sustainable value of good	(Prieto-Sandoval et al., 2016)
		Sustained presence – increased financial value	(Prieto-Sandoval et al., 2016)
Outcomes	Consumer	Behavioural changes	(Baumeister & Onkila, 2017; Galati et al., 2021; Meis-Harris et al., 2021; Polinori et al., 2018)
		Consumers making more aware choices – related to individual preferences	(Polinori et al., 2018)
Outcomes		Consumers change might force change in producer	(Baumeister & Onkila, 2017; Galati et al., 2021; Meis-Harris et al., 2021; Prieto-Sandoval et al., 2016)
		Standardization could force change in sector	(Meis-Harris et al., 2021)
Challenges	Label: Type I	Misleading, impose cost on firm, possible to misuse, firms making false claims	(Baksi & Bose, 2007)
		Impose cost on firm	(Baksi & Bose, 2007; Polinori et al., 2018)
	Label: Type II	Will require monitoring	(Baksi & Bose, 2007)
Challenge	Business	Firms evading rules	(Baksi & Bose, 2007)
		Impact of eco-label diggifult to appraise	(Polinori et al., 2018)
		Eco-labels only complementary – not sufficient alone	(Meis-Harris et al., 2021; Polinori et al., 2018)
		How to identify green prod.	(Prieto-Sandoval et al., 2016)
		Assess environmental performance	(Meis-Harris et al., 2021)
		No market penetration	(Meis-Harris et al., 2021; Polinori et al., 2018)
		Misused, manipulated for competitive advantage	(Meis-Harris et al., 2021)
		Too many labels	(Baumeister & Onkila, 2017; D'Souza & Yiridoe, 2019)
		Labels minimize info	(D'Souza & Yiridoe, 2019)
		Limits freedom of action (financially)	
Challenge – consumer		Eco-label to understood	(Galati et al., 2021)
		Lack of interest in reading label	(Galati et al., 2021)
		Incomplete information	

			(Baksi & Bose, 2007; Baumeister & Onkila, 2017)
		Info override other product info	(Baumeister & Onkila, 2017)(cross ref)
		Reluctant to pay price premium	(Meis-Harris et al., 2021)
		Communicate to consumer	(Baumeister & Onkila, 2017)
		Viewed as Green washing	(Baumeister & Onkila, 2017)
		Limited to already green consumers	(Meis-Harris et al., 2021)
Motivation	Consumers	Governmental/quasi-governmental labelling agencies more credible – increase trust – cred influence purchasing decision	(Baksi & Bose, 2007; Meis-Harris et al., 2021)
		Social media influencing public behaviour	(Polinori et al., 2018)
		No/weak interest: no response to label Intermediate response: avoid negative labels Strong interest: Response to both positive and negative labels	(Baumeister & Onkila, 2017)
		Older, more educated more attentative to eco-labels	(Galati et al., 2021)
		Information positively influences consumer perception	(Galati et al., 2021; Polinori et al., 2018; Prieto-Sandoval et al., 2016)
		Fill knowledge gap, heighten consumer awareness	(Polinori et al., 2018) (cross ref: Morris 1997)
Motivation	Business	Product differentiation	(Baksi & Bose, 2007; Baumeister & Onkila, 2017; D'Souza & Yiridoe, 2019; Meis-Harris et al., 2021; Polinori et al., 2018; Prieto-Sandoval et al., 2016)
		Price premium	(Baksi & Bose, 2007; D'Souza & Yiridoe, 2019)
		Improve Reputation/image	(Polinori et al., 2018) (cross ref: Morris 1997)(Meis-Harris et al., 2021)
		Increased product value	(Meis-Harris et al., 2021)
			(Meis-Harris et al., 2021)

		Pressure (customers, shareholders, neighbourhood, community groups, policy) New market opportunity Control of supply chain Collaboration Environmental Gain competitive advantage	(Meis-Harris et al., 2021) (Meis-Harris et al., 2021) (Meis-Harris et al., 2021) (D'Souza & Yiridoe, 2019; Meis-Harris et al., 2021)
Determinants		Consumers must be informed, be aware Consumer personal values People expect higher quality State involvement attracts more confidence	(Baumeister & Onkila, 2017; Galati et al., 2021; Meis-Harris et al., 2021; Polinori et al., 2018) (Prieto-Sandoval et al., 2016)(cross ref)(Galati et al., 2021) (Prieto-Sandoval et al., 2016) (Sønderskov & Daugbjerg, 2010)
Conclusions		Self-label best label method Increase competition Available at key decision-making moments Common approach – mandatory, neutral governor Campaign increase awareness - Holistic marketing strategies - Regulatory or policy approaches	(Baksi & Bose, 2007) (Baumeister & Onkila, 2017) (Baumeister & Onkila, 2017; Polinori et al., 2018) (Baumeister & Onkila, 2017) (Meis-Harris et al., 2021)

Table 13: Green Labels: Results of second phase literature analysis

Challenge	Definition	Reference
Too many labels	Self-labels might be easier to achieve, and requires no third party-certifications. The labels requirements are linked to attributes consumers care about. By offering too many eco-labels it can offer confusion and lack of credibility to consumers.	(Baksi & Bose, 2007)
Green washing	Eco-labels can be misused and manipulated with the goal to gain competitive advantage. This reduces overall trust in eco-labels	(Meis-Harris et al., 2021; Polinori et al., 2018)
Financial burden on firms	Obtaining type II labels often requires a payment to a third-party, as well as improvements in elements of the firms, for instnce production. This limits the firm's freedom of action financially	(D'Souza & Yiridoe, 2019)
Monitoring	Type II labels requires frequent monitoring of firm's who have obtained these labels, to make sure the firm is following the guidelines properly. This requires both financial and time resources for the third-party involved	(Baksi & Bose, 2007)

Appendix B: The Literature analysis of Maritime Activities

Table 14: Maritime activities: Cross analysis of literature findings

Code	Subcode	Challenge	Reference
Regulatory	Reporting/procedures	Need for simpler and standardized procedures related to reporting upon arrival/departure from port	(Morrall et al., 2016; Park et al., 2020)
	Calculation framework	Complexity of design	(Chi et al., 2015)
	Charter	Charter clauses stipulates arrival as soon as possible	(Andersson & Ivehammar, 2017)
Communciation	VTS	VTSO have limited authority	(Praetorius et al., 2015)
		Relies on other organization for information	(Praetorius et al., 2015)
		More regulation – less adaptable to unforeseen events	(Praetorius et al., 2015)
		Late notifications from arriving vessels	(Praetorius et al., 2015)
		Communication ship-shore	(Andersson & Ivehammar, 2017)
Data Source	AIS	Big Data (volume, variety, velocity, veracity)	(Chi et al., 2015; Feng et al., 2020; Kwang-Il et al.,

			2014; Yang et al., 2019)
		Inaccurate data	(Feng et al., 2020; Yang et al., 2019)
	Port	Lack of/unwillingsness to share data	(Chi et al., 2015; Hiranandani, 2014)
Operational Bottlenecks	Port	Hotelling at berth Awailability of berths – increased time in anchorage	(Song, 2014) (Feng et al., 2020)
	Port – Vessel – Port	JiT arrival – Green Approach, Virtual Arrival	(Andersson & Ivehammar, 2017)
Collaboration		Closer collaboration of stakeholders in port, including data sharing	(Andersson & Ivehammar, 2017; Feng et al., 2020)