10-31-2022

Achieving circular economy through new blue economy initiatives: a road map for ports

Ayo Olusola Pacheco

WORLD MARITIME UNIVERSITY
Malmö, Sweden

ACHIEVING CIRCULAR ECONOMY THROUGH NEW BLUE ECONOMY INITIATIVES: A ROAD MAP FOR PORTS

By

AYO OLUSOLA PACHECO
THE FEDERAL REPUBLIC OF NIGERIA

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE
in
MARITIME AFFAIRS

MARITIME ENERGY MANAGEMENT

2022

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): .....

(Date): 20 September 2022

Supervised by: **Dr. Fabio Ballini (Ph.D.), IEEE, IAME**

Supervisor's Affiliation: **Assistant Professor,**
Maritime Energy Management,
World Maritime University

ACKNOWLEDGEMENTS

Firstly, I give thanks to the Almighty God for the strength and divine favour I have received to do this programme and to accomplish the task of this dissertation. To God alone be the praise.

I am grateful to my supervisor, Prof. Fabio Ballini, for his patience and kind guidance in helping me accomplish this task. His supervision and wealth of knowledge was invaluable during the research and writing of this work.

My heartfelt gratitude and love also goes out to my loving wife Mrs. Onyebuchi Pacheco and my lovely children Seunayo, Nikolai and Samson Pacheco. I am most grateful for their love and patience during my prolonged absence from home in order to complete this course. Their support drives me as I rise in my career. I also appreciate my mother, Mrs. Wuraola Pacheco, and my siblings Sqn Ldr Olumide Pacheco and Funmilola Oluwafemi. They are my strong pillars of support.

Furthermore, I thank my Commander Rear Admiral MB Hassan and the Chief of the Naval Staff, Nigerian Navy, Vice Admiral AZ Gambo, for finding me worthy to be proposed and nominated for this prestigious honour. May I also express my heartfelt gratitude to my sponsor, The Norwegian Agency for Development Cooperation for granting me this scholarship opportunity of a lifetime to pursue my graduate studies at the World Maritime University. Words cannot express how grateful I am to you.

Finally, to my head of specialisation, Prof. Aykut Olcer, all the staff and members of faculty at the World Maritime University, I say a sincere thank you for a wonderful time in Malmo Sweden. The pleasure of this experience will remain with me for the rest of my life.

ABSTRACT

Title of Dissertation: **Achieving Circular Economy Through New Blue Economy Initiatives: A Road Map for Ports.**

Degree: **Master of Science**

The concept of sustainability is at the centre of all global development efforts across industries and government sectors. This is relevant to the maritime sector as the attention of the world is shifted to the industrialisation of the oceans. As nations and various other stakeholders increasingly seek to extract value from the maritime domain, there is greater need to ensure that they do so sustainably. The Circular Economy approach is one of the ways in which this can be accomplished, by making sure that the value of products and processes are maintained for as long as economically possible.

The study takes a look at ways to enhance Circular Economy in the maritime domain, while focusing on ports, employing what has been described as New Blue Economy initiatives. The study was conducted in an extensive literature review format due to paucity of time and the novelty of the concept of the New Blue Economy to existing literature. Fortunately, as the EU's Blue Economy leads in the world, some relevant existing concepts were found to be useful for the study. The study explored the potential of digital and ICT resources to harness marine resources. Strategies were designed to form a roadmap by which ports could be used as hubs to influence effective circularity in the maritime domain.

The research found a strong interconnection between the Blue Economy and the Circular Economy, and the need to emplace a circular regime in the maritime domain, especially

in ports, in order to further enhance sustainability. This was to be achieved by emplacing strategies and policies that would promote and regulate the New Blue Economy.

The value of the knowledge tools, strategies and policies afforded by the New Blue Economy, ensures that the resources of our oceans are accurately valued and maximally harnessed in a sustainable manner. Another more important implication is that these knowledge resources and strategies, guided by the right policies, would enable us plan for the future of our oceans in order to better determine what would be left for succeeding generations.

KEYWORDS: Blue Economy, Circular Economy, Digital Transformation, Innovation, New Blue Economy, Policy, Renewable Energy, Sustainability.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AUV	-	Autonomous Underwater Vehicle
ASV	-	Autonomous Surface Vehicle
CEAP	-	Circular Economy Action Plan
CMP	-	Copenhagen-Malmo Port
DTO	-	Digital Twin Ocean
EDA	-	European Defence Agency
ESPO	-	European Sea Ports Organization
EU	-	Europian Union
FDF	-	Federal Department of Fisheries
GDP	-	Gross Donestic Product
ICT	-	Information and Communications Technology
IF CEED	-	Incubator Forum for Circular Economy in European Defence
IMO	-	International Maritime Organization
JIT	-	Just-in-Time
MSP	-	Marine Spatial Planning
NBE	-	New Blue Economy
NSC	-	Nigeria Shippers Council

NIMASA - Nigerian Maritime Administration and Safety Agency

NIOMR - Nigerian Institute for Oceanography and Marine Research Nigerian

NN - Nigerian Navy

NPA - Nigerian Ports Authority

SWOT - Strengths, Weaknesses, Opportunities and Threats

UNECA - United Nations Economic Commission for Africa

UNSDG - United Nations Sustainable Development Goal

CHAPTER 1

1 – Introduction

1.1 – Background

A major preoccupation of nations in the current era of dwindling national economic fortunes is the exploitation of their natural resource endowments (Barbier, 2010; Büscher, 2012). One of such endowments is the geographical construct which places some states in the neighbourhood of the seas and oceans, as littoral states. Thus, confronted with the overexploitation of finite land-based resources and increasing populations, littoral states are compelled to turn their searchlight to various other means of production and value generation (Ramirez-Llodra et al., 2011). However, as production increases, so does the waste that is inevitably generated from the production processes. Over time, this take-make-waste model or linear economy model of production contributed largely to the pollution of the ecosystem (Brydges, 2021). These anthropogenic pollutants threaten the sustainability of our world and continually degrade the quality of what would be passed on to future generations. This has necessitated a transition to an economic model where greater consideration is being put into the durability of products and the prospects of their reusability. This is a departure from the current model of production, using, and discarding, known as the linear economy.

The term "linear economy" refers to the conventional paradigm in which raw resources are converted into products and discarded as waste without any thought to their long-term effects (Jørgensen & Pedersen, 2018). Poisoning of wild and marine life which may unintentionally ingest them is one of these effects (Landrigan et al., 2020; Schwarzenbach, Egli, Hofstetter, Von Gunten, & Wehrli, 2010). Since these negative impacts may be carried up the food chain, mankind, at the top of the food chain, also bears the brunt of these repercussions. For instance, following this linear economy model, fish in the oceans may consume microplastics, which may then end up in the human diet (*Figure 1*) (Garrido Gamarro, Ryder, Elvevoll, & Olsen, 2020).

Figure 1 Linear Economy Model

Source: (Stahel & MacArthur, 2019)

In the linear economy model, as shown in Figure 1, resources are extracted and finished products are distributed and consumed. Little or no consideration is given to the waste from this process which is discarded mostly as non-recyclable waste. This is the dominant economic model in use today. However, the idea of circular economy is now on the ascendancy.

On the other hand, the term "circular economy" refers to a production and consumption model that incorporates sharing, leasing, reusing, repairing, refurbishing, and recycling existing raw materials and products for as long as is practicable (Ritchie & Freed, 2021). It is an expression of mankind's efforts to roll back the harmful effects of our activities on the planet. The focus of the circular economy is to enable resource efficiency by maintaining the added value of materials while eliminating waste as best as possible.

Figure 2. The Circular Economy Model

Source: (Stahel & MacArthur, 2019)

Growth and the use of finite resources are separated in a circular economy. Products and materials are used productively for as long as feasible (*Figure 2*), and when their useful life is over, they are successfully cycled or "looped" back into the system (Lacy et al., 2020).

To tame the harmful effects of waste, the European Commission of the EU proposed the Circular Economy Action Plan (CEAP) in March 2020 (European Commission, 2020). The Plan focuses on intensive sectors such as energy, ICT, and manufacturing among others. By February 2021, the parliament adopted the CEAP, demanding additional measures to be emplaced so that by 2050, a carbon-neutral, ecologically sustainable, toxic-free, and completely circular economy would be achieved. The Plan emphasizes sustainability, which entails that resources are utilized in such a manner that nature's capital is not depleted. It seeks to guarantee that future generations benefit from the resources of today.

In the maritime domain, the quest for sustainability of ocean resources is captured in the concept of the Blue Economy. This quest for sustainability led to the establishment of the flagship initiative on resource efficiency launched in 2011 and operationalised through the roadmap for a resource efficient Europe. This led to a range of policy measures collectively known as the Circular Economy Package which was later replaced by policy measures such as the "Closing the Loop – An Action Plan for Circular Economy" which emphasized the need to rethink production and consumption models (McDowall et al, 2017).

The European Commission defines the blue economy as comprising all activities that are linked to the water, the sea and the oceans (Addamo et al., 2022). It depends on traditional forms of utilisation like fishing and aquaculture in addition to a wider spectrum of activities that may provide key sources of sustainable economic growth for member states and their coastal communities. The 'blue' in the concept derives from the characteristic blue colour of the ocean. The ocean covers over 70 per cent of the earth's surface and serves as a transit medium for over 90 per cent of internationally traded goods. It is also a veritable means of livelihood for over 3 billion people (United Nations, 2020). It is estimated that the demand for food, jobs, energy, and raw materials to sustain a likely global population of 9 - 10 billion people by 2050 would be high (OECD, 2020). The ocean has a corresponding potential to meet these requirements. This potential defines the relevance of the circular economy as a drive to strive for the achievement of a blue economy in order to further enhance sustainability. Fully harnessing the potential of the ocean would require substantial expansion of many maritime-based economic activities which could lead to over-industrialization of the ocean and the destruction of marine biodiversity. The effects of

these maritime-based economic activities can be readily measured and their processes influenced from ashore through Ports. This could be achieved by the application of knowledge-based resources for data and information which could be used to address blue economy challenges. They could also be applied to develop solutions for better resource efficiency, hence achieving a virile circular economy. These knowledge-based resources used in addressing blue economy challenges, in addition to their enablers, are collectively conceptualized as the New Blue Economy. They aid in fully harnessing the potential of the blue economy providing real-time ocean knowledge. They therefore hold enormous potentials to drive the achievement of a circular economy in ports.

Ports are critical infrastructure of the State which serve as hubs for the conduct of maritime activity especially as related to facilitating trade by sea. Because they are usually sited within relatively safe confines and are protected against the harsh weather elements experienced at sea, they serve as ideal doorways through which most maritime activities connect to shore. They are therefore ideal for the emplacement of technologies with which to detect, monitor, and influence the processes of blue economy activities. Accordingly, the United Nations (UN), through the UN Sustainable Development Goals (UNSDGs), adopted in 2015, the UNSDG 14 by incorporating sustainability, protection, and restoration of maritime systems. The Blue Economy is conceptualised mostly in consonance with SDG 14 (Kørnøv et al., 2020). The New Blue Economy, on the other hand, would derive its force from SDG 9, Industry, Innovation, and Infrastructure, which supports the various sectors of the Blue Economy and maximizes their economic output.
In light of this, the European Commission adopted a policy tagged "A Green Recovery for the Blue Economy - Transforming the EU's Blue Economy for a Sustainable Future". This strategy for a sustainable blue economy makes for sustainability in the oceans and ashore. In this regard, various European nations have keyed into EU's ambition of achieving a circular economy and enhancing the maritime sector by the utilisation of ports.

1.2 – Statement of the Problem

In the current Anthropocene era, human actions have superseded natural factors as the primary determinant of the state of our planet. These harmful practices include excessive resource extraction with little regard for environmental consequences (White, 2013) (Ellen MacArthur Foundation, 2013). Most societies currently operate in a linear economy (take-make-waste) world which presupposes that resources are infinite. However, because the reality is that resources are

finite and depleting, there is an urgent need to shift from the linear economy to a circular economy in order to become more resource efficient. The problem is that if we continue with the linear model, the resources would be depleted and it would adversely affect the planetary boundaries for sustainability (Li et al., 2021). There is therefore the need to emplace and implement strategies that would ensure not just sustainability but also rejuvenation of the environment despite mankind's activities. This study thus focuses on ports being used as hubs to influence such rejuvenation in the maritime domain.

Europe, as one of the world's leading technological hubs, has enormous new blue economy potentials considering the presence of large renowned ports and great strides in technological advancement. There are over 1,200 commercial seaports in 23 of the EU's 28 Member State. Ideally, the European nations ought to have the capacity to harness the potentials of these various ports in the region for new blue economy activities. This is considered an imperative as most nations strive to transform from linear to circular economies in order to encourage sustainable economic growth and development. In this regard, governments of various European nations have emplaced measures to develop their ports and increase the chances of achieving a circular economy. Some of the efforts include the enactment of legal provisions such as the EU Port Service Regulation in 2019 and the investment in port infrastructure among others. The EU Port Service Regulation sets up a framework for how port services are to be provided under market competition forces, as well as common rules for financial transparency and charges for port infrastructure. Such regulation is likely to foster a greater disposition to technological innovations which could engender the NBE. Despite these efforts, the European maritime sector is estimated to have contributed about 1.09 per cent to the EU's GDP and generated employment for about 2.2 million people (*European Union*, 2009). This indicates that the European ports are still grossly under-utilised, and it points to the need for initiatives and strategies that could further harness the potentials of these ports. Working within the BE sphere, NBE strategies, initiatives and tools could help to ensure resource efficiency, process effectiveness, and save costs to realise these goals. Consequently, the study seeks to examine workable measures for achieving a circular economy through new blue economy initiatives by harnessing the potentials of ports in Europe.

1.3 – Objectives of the Study

The main objective of this study is to appraise potentials for enhancing circular economy through the implementation of new blue economy initiatives in ports and to articulate measures towards its effective establishment for sustainable development in the maritime sector in Europe. However, the specific objectives are to:

a. Establish the conceptual relationship between the new blue economy and the maritime sector.

b. Discuss the barriers to achieving the circular economy through new blue economy initiatives.

c. Highlight the barriers and drivers of the circular economy in the port sector.

d. Identify the strategies to mitigate the challenges militating against the utilisation of new blue economy initiatives as a drive in achieving the circular economy.

1.4 – Research Questions

It is against this backdrop this study seeks to provide answers to the following questions:

a. What is the conceptual relationship between the new blue economy and the maritime sector?

b. What are the barriers to achieving the circular economy through new blue economy initiatives?

c. What are the barriers and drivers of the circular economy in the port sector?

d. What are the strategies to mitigate the challenges militating against the utilisation of new blue economy initiatives as a drive in achieving the circular economy?

1.5 – Significance of the Study

The outcome of this study indicates its value and usefulness in four key areas of policy improvement, performance improvement, further research and body of knowledge. These are discussed subsequently.

a. **Policy Improvement**. The study would be useful to the European Union in formulating policies for ports towards enhancing circularity. In the proposed EU Oceans Digital Twin, for example, the study could shed some light on strategies to better exploit such a great level of control on the maritime domain, hence, the Blue Economy. New

policies would have to be made and reviewed regularly. These policies would guide the potential discoveries made and how they affect society at large. It would also be useful for developing countries seeking to emplace circular economy measures in their ports. For example, the findings and recommendations of the study would further be useful in providing the necessary guide to the Federal Government of Nigeria and her policy makers in the nascent drive to establish a viable blue economy which would require policies that are in line with global best practices. The infusion of New Blue Economy Initiatives would engender a smoother transition to a circular economy and sustainable development in Nigeria.

b. **Performance Improvement**. In Europe, the study would be relevant to the CMP and ESPO particularly in innovative ways to monitor and influence the BE in order to achieve CE especially in ports. In Nigeria, NPA, NIMASA, FDF, Nigerian Institute for Oceanography and Marine Research (NIOMR), Nigerian Shippers Council (NSC), Nigerian Navy (NN), the oil sector and other relevant maritime stakeholders who could also apply the findings and recommendations to improve their operations for sustainable development in Nigeria.

c. **Further Research**. The study would be useful as an information tool for the public on the relevance of the NBE as a drive in achieving CE and sustainable development. It would also stimulate further research on how developing countries in general and Nigeria in particular, could diversity their economies through the exploitation of knowledge tools and ICT-oriented policies to engender CE and sustainable development.

d. **Body of Knowledge**. The study could contribute to the existing body of knowledge in the areas of CE, BE and NBE. The knowledge would be useful for port planners, managers and stakeholders. The proposed NBE initiatives, being in their infancy as related to their CE applications in ports, would be particularly useful for further research.

1.6 – Scope of the Study

The scope of this study is defined by time, space and content boundaries. These are further explained hereunder:

a. **Time**. The study will focus on the time from 2012 to 2022. This spans from the period when the United Nations Conference on Sustainable Development was held in Rio De Janeiro, where the Blue Economy Concept was born. It also covers the period of the establishment of UNSDGs. These SDGs (*Figure 3*) advocate responsible consumption and production, sustainable use of the oceans (life below water) and effective partnerships (partnerships for the goals) respectively, by the UN.

- SDG1 – end poverty
- SDG2 – end hunger
- SDG3 – ensure healthy lives and well-being
- SDG5 -- achieve gender equality
- SDG8 -- promote sustained, inclusive and sustainable economic growth
- SDG9 -- build resilient infrastructure
- SDG10 -- reduce inequality within, and among countries
- SDG11 -- make cities and human settlements safe, resilient and sustainable
- SDG13 -- combat climate change

Figure 3. SDGs Relevant to CE

Source: Bryan et al., (2015)

b. **Space**. The space boundary of the study covered the Maritime zones of Europe in which the representative ports are sited. This covers the maritime zones of the Port of Amsterdam, Antwerp, Valencia, Rotterdam and Copenhagen-Malmo respectively. This space is chosen due to the relative technological advancements in the region and the favourable disposition of the ports' stakeholders to adopt Circular Economy, Blue Economy and New Blue Economy Initiatives.

c. **Content**. The content span of the study encompasses shipping, fisheries, marine tourism, marine biotechnology, deep sea mining and offshore oil and gas activities as swell as UNSDG 12, 14 and 17.

1.7 – Research Methods

The research was descriptive, using logical reasoning and integrated data comprising qualitative data. Official documents and publications were were consulted. The study employed secondary data obtained from literarure, journals and data from relevant organizations.

1.7.1 – Sources of Data

Data for the research was obtained from secondary sources including literature and journals.

1.7.2 – Method of Data Presentation

The study was conducted as a qualitative Desk-Based research which relied heavily on secondary data.

1.7.3 – Research Type

This study adopted an inductive approach which began with a research question and then collected empirical data which was used to generate a theory. This was largely due to a dearth of research particularly with the concept of the new blue economy. The study, being a qualitative study, explored the degree of acceptance and implementation of circular economy in ports, and their implications to the blue economy and other relevant stakeholders.

1.7.4 – Research Strategy

The research adopted a multiple case study approach, as it touched on the phenomenon of circularity in selected case study ports namely the Ports of Rotterdam, Valencia, Amsterdam, Antwerp, and Copenhagen-Malmo Port. It employed the embedded case study method as opposed to the holistic case study method. The study employed the SWOT analysis technique to evaluate the internal and external workings of the organizations under consideration.

1.7.5 – Time Horizon

This study employed the cross-sectional approach due to the nature of the research which afforded limited time for data collection. This was the most feasible approach considering the limited amount of time available for the dissertation, which made longitudinal research impractical.

1.8 – Assumptions and Limitations

Circular Economy is still a budding concept, and its implementation is largely a manifestation of the uniqueness of the entities implementing it. It connects people, places, and ideas in such a way that the strategies developed for one system may not be completely adaptable by another system. For example, strategies developed for European ports may have to be tweaked in order to suit African ports contexts. Due to limited data on actual discrete CE regimes in ports, this research relies heavily on qualitative method and secondary sources. The researcher was limited by time, therefore, could not effectively employ questionnaires for obtaining quantitative data.

1.9 – Research Outline

This study consists of six chapters. This chapter provided a background of the circular economy, the blue economy and the new blue economy especially delivered from a European perspective. The chapter also details the statement of the problem, the research objectives, and the research questions after which the significance and scope, including the limitations and assumptions of the study, are enumerated. Chapter 2 conducts a conceptual discourse into the concepts of BE, NBE and CE and takes a look at their relationships in light of existing literature. Chapter 3 takes a closer look at the relevance of NBE to CE while Chapter 4 sheds more light on CE in EU ports. Chapter 5 considers scenarios of applying NBE to CE while attempting to suggest a roadmap for the achievement of CE. Finally, Chapter 6 presents the discussion and highlights the findings of the study, before making recommendations. The research outline approach is shown in *Figure 4*.

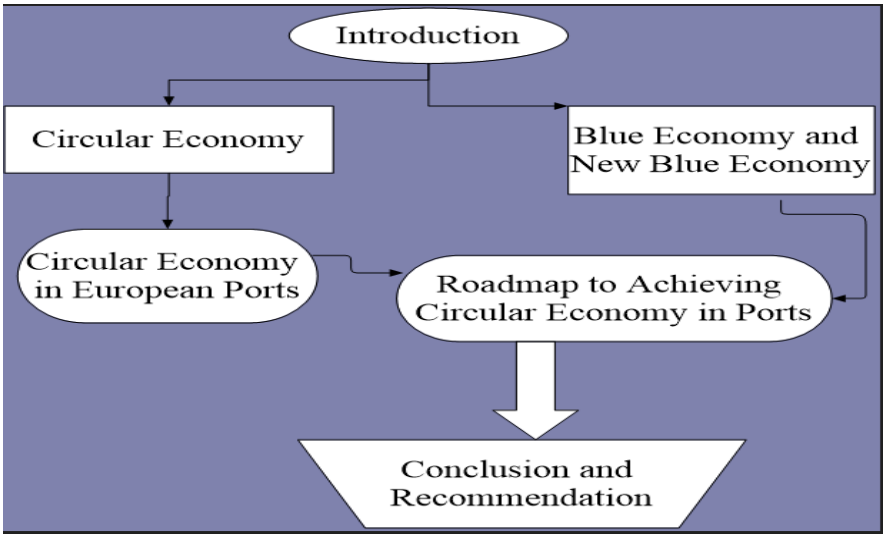

Figure 4. Research Outline Flowchart

Source: (Author, 2022).

CHAPTER 2

2 – Conceptual Discourse

2.1 – Introduction

The chapter begins with an introduction to the important variables and an establishment of the relationship between those variables before proceeding to a review of some relevant studies. The variables in this study are the traditional Blue Economy (BE), the New Blue Economy (NBE) and Circular Economy (CE). In this chapter, these concepts are clarified, after which relevant literature are reviewed to shed light on their relationship and how they apply to ports. The NBE is a relatively new concept which is still evolving in development literature. However, there is considerable consensus on its essential elements which constitute the fundamental indices for ascertaining its existence or otherwise within any nation. They include ICT and emerging technologies. The overarching theme of the BE, NBE and CE is that at their core, they all seek to achieve sustainability. This chapter, therefore, seeks to establish a working relationship between these concepts. Because the NBE facilitates the BE, it is necessary to first take a look at BE. NBE facilitates BE such that it further enhances sustainability by better harnessing and utilising the resources of the maritime domain.

2.1.1 – Blue Economy

According to Smith-Godfrey (2016), the idea of the "Blue Economy" was originally introduced during the Rio de Janeiro 2012 United Nations Conference on Sustainable Development. Decoupling environmental damage from economic development was the essential premise, and it spread fast around the globe. The necessity to integrate sustainability and conservation into the management of the maritime domain gave rise to this concept. The concept of sustainability focuses on consumption and replenishment patterns that, at their core, result in lower emissions of greenhouse gases (GHG). Since the oceans are a major source of food for both humans and animals, they are regarded as the primary element of this sustainability component. Blue Economy is the variety of commercial applications of ocean and coastal resources, including energy, fisheries, aquaculture, mining, tourism, and transportation, according to Bertazzo (2018). It also includes economic benefits which are not widely commercialized, such as carbon sequestration, coastal preservation, cultural values, and biodiversity. The definition also shows a traditional means of exploring blue economy (Bertazzo, 2018). This is because, Bertazzo's definition lacks

the exploitation of blue economy with the use of ICT and emerging technologies but focuses only on its uses and benefits to the economy. The definition also does not encompass sustainability, economic deliverables, human well-being, ocean-based and ocean-related activities. Thus, Bertazzo's definition does not support the purpose of the study and will not be adopted further.

2.1.2 – New Blue Economy

The Economist Intelligence Unit (EIU) sees NBE as a field which emerges when economic activity is in balance with the long-term capacity of ocean ecosystems to support the activity and remain resilient and healthy." This position identifies with the economic component of NBE and succinctly captures ocean resilience as the true test for NBE functionality. However, it does not accommodate citizens' well-being, the place of ocean-related activities as well as technology and innovations. Thus, it does not meet the requirements of this study.

Townsend defines NBE as "a convergence of economic, climatological and technological forces that will bring the oceans back to the forefront as a new frontier for human activity." Townsend's position identifies with the economic element of blue economy and the central role that technology and human activities would play in bringing about the economic deliverables. However, it does not identify the critical element of ocean sustainability and the place of ocean-based activities as well as human well-being. Hence, Townsend's definition is not comprehensive for this study and is therefore not adopted. In light of these definitions, and for the purposes of this study, NBE is defined as "a form of sea or ocean economy, which, in addition to a refined traditional maritime practices and objectives, employs technology to achieve ocean sustainability, increased ocean-based and ocean-related activities, enhanced economic growth, and improved human well-being." This definition covers the key attributes of NBE and thus, adopted for the study.

2.1.3 – Circular Economy

The concept, circular economy has meant different things to different people in different era. Its very essence lies in its ability to improve human well-being, health security and a nation's status in the global arena through the utilisation of renewable sources. In this era of sustainable development, circular economy would entail developing a nation towards attaining sustainable economic growth. Notwithstanding, different scholars conceive circular economy differently.

According to Youmatter (2020), the Ellen McArthur Foundation views circular economy as an economic system that seeks to redefine growth by emphasizing societal benefits. It involves progressively separating economic activity from consumption of scarce resources and regulating the system's waste. This position acknowledges economy's transition from the consumption of finite resources (non-renewable) to recycling of waste. However, this view, though elaborate, does not consider human wellbeing and health security which also plays a key role in achieving sustainable development. Therefore, Ellen McArthur Foundation's is not suitable for the study and not adopted.

The World Economic Forum describes circular economy as an industrial system that is intended and designed to be restorative or regenerative (Youmatter, 2020). To enhance health security, it replaces the concept of end-of-life with restoration, moves toward the use of renewable sources, and eliminates the use of hazardous substances. These efforts impede reuse and return to the biosphere while aiming to eliminate waste via better design of materials and systems for greater human well-being. The position is compatible with the cardinal objectives of circular economy which encompasses renewability, sustainability, health security and human wellbeing. Therefore, the World Economic Forum's definition is comprehensive and apt. This view is considered most appropriate for the study and therefore adopted.

2.2 – Relationship Between New Blue Economy and Circular Economy

The key attributes of blue economy include refined tradition maritime practices, employing technology, improvements in economic growth and human well-being, as well as increased ocean sustainability and ocean-based and ocean-related activities. In contrast, the primary characteristics of circular economy are restorative or regenerative, a move toward the utilization of renewable sources, and the elimination of hazardous substances, eliminate wastes, improved health security, the better design of products as well as the enhancement of human health. This implies that the utilisation of a refined tradition maritime practices through employment of technology would engender increased ocean-based and ocean-related activities, increased economic growth, and improved human well-being. This would in the long run promote restoration and regeneration of its resources, eliminate the use of toxic chemicals, eliminate wastes and improved health security as well as create an environment for superior design of products and business models. Conversely, the absence of refined tradition maritime practices with the aid of technology would limit ocean

sustainability, ocean-based and ocean-related activities, as well as economic growth and human well-being. This would further undermine restoration and regeneration of its resources, increase the use of toxic chemicals, and undermine health security with an unfavourable environment for superior design of products and business models. This shows that a functional NBE would enhance circular economy and a dysfunctional or absence of NBE would inhibit circular economy. Therefore, there is a direct relationship between NBE and circular economy as indicated in Figure 5.

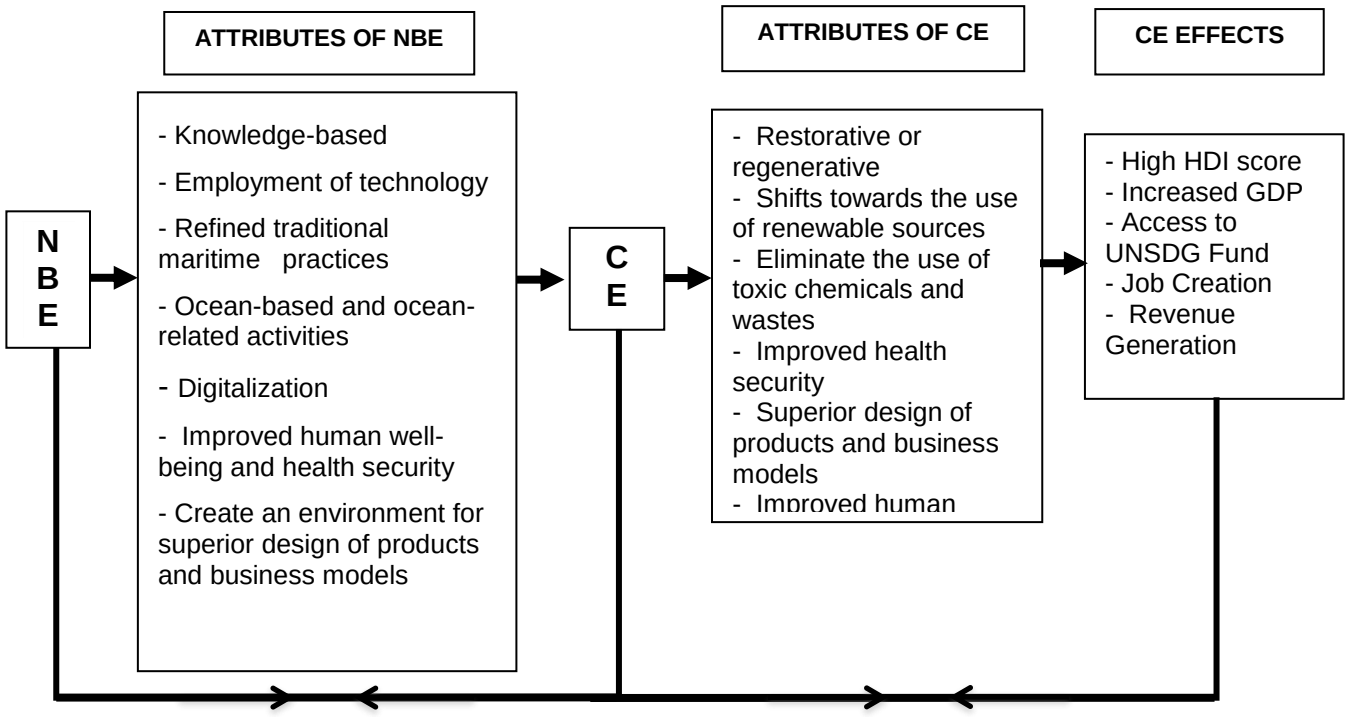

Figure 5. Relationship between New Blue Economy and Circular Economy

Source: Researcher's Design, 2022.

2.3 – Review of Existing Literature

Two classes of blue economy were identified from the literature reviewed. These are the traditional blue economy, which encompasses concepts such as ocean economy, maritime economy and coastal economy. The other is the NBE, which is the fusion of traditional and technology innovations for ocean sustainability. However, there are several literatures related to NBE and

circular economy. Some of these literatures which include the works of Hotaling and Spinrad (2021), Khajuria, Atienza and Chavanict et al, (2022), Carpenter, Johnson and Skinner (2021). Others are Chang, Wang and Zhao (2010) as well as Humayun and Zafar (2015) are germane and thus reviewed in this study.

Hotaling L., and Spinrad R., (2021) in their work titled, "Preparing a Workforce for the New Blue Economy: People, Products and Policies" employed qualitative data to support their argument. The authors adopt descriptive methodology to examine the new blue economy and how the industry will develop and train the next generation. The research considers the use of big data, key skillsets, training undergraduates and graduates as key requirements and drive to the exploitation of NBE. The authors emphasised on the need for African countries to utilise the economic opportunities and potentials of the African coastal countries in attaining regional development. The authors concluded by providing a wide range of case studies on a variety of topics, including oil spills, data security, commercial fishing, weather forecasting, and sustainability. All of these were shown to emphasize the need for meeting the educational standards of the labor force and the possibilities for economic growth. Their work aptly established that the adoption of NBE initiative in the Africa would engender economic growth and development considering the huge economic potentials of the African coastal countries. However, the study's focus was on NBE in Africa without a link to the European region and circular economy.

Khajuria, Atienza and Chavanict et al, (2022), in their work titled, "Accelerating Circular Economy Solutions to Achieve the 2030 Agenda for Sustainable Development Goals", utilise the qualitative research approach. The researchers use an explanatory approach to discuss sustainable circular economy ideas and activities. New approaches, cutting-edge technologies, managerial techniques, and real-world examples were only some of the focal points of this investigation. The purpose of this analysis and compilation is to shed light on the ways in which circular economy might help achieve SDGs. The studies concluded that shifting from a linear to a circular economy would preserve product and resource value while reducing waste. In order to better use natural resources and advance toward or accomplish sustainability, the government should establish laws and programs with the participation of public-private partnership on reduce, reuse, and recycle (3R) efforts (Khajuria et al., 2022). Khajuria et al. (2022) did not consider NBE initiative as a drive

to achieving circular economy. This gap is essential to this study and the researcher intends to examine it.

Carpenter et al. (2021) studied solutions for a sustainable marine domain, including maritime transportation, Maritime Spatial Planning (MSP), maritime education, and maritime training. Small-scale, sustainable fisheries and greening the blue economy are also discussed. The researchers use an explanatory methodology to create a paradigm for effective ocean governance that will continue beyond 2030. It emphasized challenges pertinent to excellent ocean governance in various countries, regional and international for sustainable development, stressing continuing efforts to establish and promote the governance structure that would accommodate industrial needs. (Carpenter et al., 2021). The study would benefit the UN Agenda for Sustainable Development 2030, the EU and other regional and national levels, and scholars across many disciplines, particularly those involved in cross-sectoral research and development in marine transport and the broader maritime environment. The authors, however, were silent on the area of port as part of the activities in the maritime sector which is necessary for this study.

Chang et al. (2010) in their exploratory work titled "The Current Development of the Ocean Governance Mechanism in China", dedicated a small fraction of the study to China's blue economic zone. The work employed a mixture of quantitative and qualitative data to support the research. It further adopted descriptive methodology to aptly establish that NBE contrasts traditional maritime economy in that the former incorporates ocean-related industries while the latter does not. Their work also addressed the sustainable development criteria of NBE. However, the study's focus was on ocean governance without a link to circular economy.

Asaf Humayun and Naghmana Zafar (2015) conducted an exploratory and qualitative work titled "Pakistan's 'Blue Economy': Potential and Prospects", which sees the blue economy as the movement of states towards the seas and oceans for economic development and national power. Geographical factors, resources, a long maritime tradition, community, and maritime mindsets engendered by dependency on the sea were recognized by the authors as essential components of sea power necessary in the blue economy. The authors also identified shipping, ports, maritime infrastructure, seafaring, ship building and breaking, recycling, fishing, seafood industry, offshore resources and coastal tourism as essential Pakistani blue economy enablers with potential for huge

economic outputs. However, the work was more about sea power than NBE as it only focused on national development using blue economy as leverage for sea power without recourse to ocean sustainability and attainment of circular economy.

2.4 – Gap in Literature

The various literature reviewed addressed various approaches and aspects to NBE and circular economy. The literature reveals that NBE differs from the traditional blue economy just as linear economy differs from circular economy in one form or the other. However, the various authors whose literature was reviewed have made valuable contributions to NBE and circular economy. However, none of the literature reviewed expressly considered the adoption of NBE initiative through the utilisation of port activities as a tool for transiting from linear to a circular economy in Europe. It is on this premise that this study seeks to fill the gaps in the previous studies by assessing the activities of European ports with a view to suggesting strategies for infusing NBE initiatives towards achieving circular economy. In carrying out this assessment, it is necessary to provide the theoretical framework upon which the study is situated.

CHAPTER 3

3 – Blue Economy and the New Blue Economy

3.1 – Introduction

This chapter is presented especially in the EU context, as the research focused on blue economy in the EU. It takes a look at the concept of the blue economy before discussing the vital aspect of marine spatial planning which, ideally, is vital to consider for policy reasons before any kind of man-made imprint is done on the blue economy. The importance of the blue economy in Europe is then investigated, expounding on the established and emerging sectors. Having understood the blue economy in Europe, the new blue economy is then explored, highlighting some of the areas in which the blue economy is enhanced by the new blue economy.

3.2 – Marine Spatial Planning

The concept of Marine spatial planning (MSP) has been described as "a practical way to create and establish a more rational organization of the use of marine space and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems, and to achieve social and economic objectives in an open and planned way." (Ehler & Douvere, 2009). This definition emphasizes the importance of focusing on the planning and management of human activities in the maritime space and how they affect marine ecosystems or its components. By adopting MSP, nations and maritime stakeholders could specify the intended impact on particular marine areas by objective or by uses. For example, areas may be specified as preservation areas or set aside to be used for sand and gravel mining, offshore aquaculture or wind farms. MSP essentially decides where and when human activity occurs in the marine environment.

Effective MSP regimes are characterized by distinct qualities the first of which is that they are ecosystem-based. They exemplify systemic thinking which seeks to balance ecological, economic, and social goals and objectives toward sustainable development. Furthermore, effective MSP should be integrated across sectors and agencies, and among levels of government, taking critical stakeholders into account. It should also be place-based or area-based and it should be adaptive, able to utilize the experience of lessons learnt, to evolve and improve its future direction. This future direction should ideally, be strategic and proactive focusing on long-term actions and their

impact to relevant stakeholders, whom should be actively involved in the process. Hence, MSP should be a participatory process.

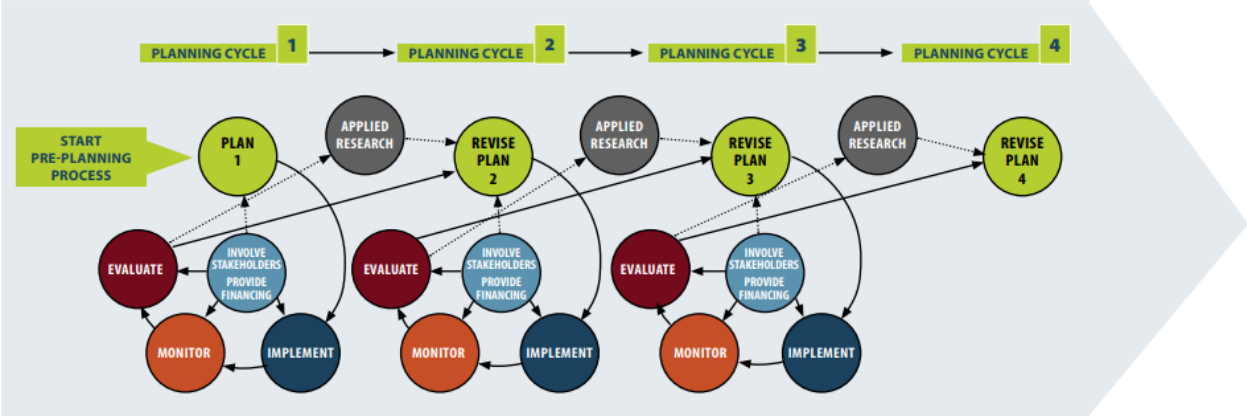

Figure 6. The MSP Cycle.

Source: (Ehler & Douvere, 2009).

MSP is typically conducted in accordance with a continuing cycle which is intended to be an iterative circular process that evolves and adapts over time, rather than a linear process in a step-to-step sequence (Figure 6. The MSP Cycle.). Although MSP should accommodate single-sector planning, effective MSP should be comprehensive enough to provide an integrated framework which assesses existing and future conditions and evolves as new data and information is fed into the planning process. Ehler & Douvere (2009) recommended 10 steps for accomplishing effective MSP. These steps were not considered in this study as the research only sought to emphasize the importance of MSP to the emplacement of a virile blue economy. A future-oriented MSP serves as a foundation for achieving the blue economy by mapping out human activities that impact on it such as waste disposal, maritime transportation, oil and gas prospecting, and offshore renewable energy among others. According to Ehler & Douvere (2009), this helps to avoid conflicts among human uses (user-user conflicts) and between human uses and the marine environment (user-environment conflicts). In July 2014, the European Union established a general framework for MSP with the expectation to "contribute to the effective management of marine activities and the sustainable use of marine and coastal resources, by creating a framework for consistent, transparent, sustainable and evidence-based decision-making" (EU, 2014). This effort was projected to enhance efficiency in the blue economy by lowering management costs guaranteeing

sustainability of the maritime space and attracting more investment amongst other benefits to the EU (Potts, 2015).

Some goods and services of the marine ecosystem, hence the blue economy, were identified by Ehler & Douvere (2009) as shown in Table *1*.

Table 1 Marine Ecosystems Goods and Services.

Source: (Ehler & Douvere, 2009)

Renewable Goods	Renewable Services	Non-renewable Goods
Marine animals for food	Protected Areas	Oil and Gas
Marine animals for recreaction	Storm and flood protection	Sand and Gravel
Water	Erosion control	Marine Minerals
Energy (Wave, Wind, Thermal and Tidal)	Nutrient Cycling	
Medicines	Waste Processing	
Other raw materials (E.g Ornaments)	Marine Transport Routes	
	Education and Research	
	Carbon Sequestration	
	Tourism, Leisure and Recreation	

The benefits of Marine Spatial Planning to the blue economy are demonstrated in how effectively the goods and services of the marine ecosystem are harnessed for maximum utility of the maritime space and to ensure sustainability. Kaczynski (2011) compared the emergence of the blue economy to how the "outer space industry" has evolved over the past decades. The careful planning and use of this vast common heritage is therefore a responsibility that must be taken on by member states and relevant stakeholders in order to create better opportunities for the blue economy.

3.3 – The Blue Economy in Europe

According to European Commission (2022), blue economy encompasses "all sectoral and cross-sectoral economic activities based on or related to the oceans, seas and coasts". The report further divided blue economy activities into 2 broad categories which are marine-based activities and marine-related activities. Marine-based activities include extraction of marine living resources form the ocean, in activities such as aquaculture and fisheries; and extraction of marine minerals in activities such as oil and gas development, and marine renewable energy, for example, wind farms. Other marine-based activities include maritime transport, coastal tourism, and desalination. Marine-related activities are those associated with products and services from the ocean or from marine-based activities, such as seafood processing and distribution, and biotechnology. They also include industrial activities like port activities, shipbuilding and repair, technology and equipment and digital services among others.

The blue economy is vital in realizing the goals of the European Green Deal which, according to Siddi (2020), is "a roadmap of key policies for the EU's climate agenda". This indicates the importance of a systemic approach for harnessing the potentials of the blue economy, bearing in mind that the wellbeing of one component of the environment, affects the wellbeing of others (in this case, the vitality of the blue economy is critical to achieving the climate agenda). According to European Commission (2021), a sustainable blue economy provides a variety of ways to accomplish the goals of the European Green Deal. It emphasizes the need for many present activities to lower their carbon footprints while new carbon-neutral activities take the lead. It argues that through creating offshore renewable energy and greening ports and marine transportation, the blue economy can help the EU achieve carbon neutrality. Additionally, the document highlights the significance of ports to the European blue economy and the necessity for their functions to evolve as the industrial landscape transforms. Beyond transshipment and logistics, it was determined that the future of ports depends on strengthening their position as energy hubs for integrated electricity and other renewable and low-carbon fuels systems. In collecting, transshipping, and disposing of waste from shipping and other port businesses, as well as for decommissioning ships, the circular economy is an additional important competitive advantage to exploit. It expressed confidence that these additional responsibilities would enhance working and living conditions for operators and nearby populations.

3.4 – Relevance of the Circular Economy to the Blue Economy

From the perspective of the EU, the circular economy presents several opportunities for the blue economy. In building a framework to facilitate sustainable investment in several EU sectors, including the blue economy, the European Parliament (2020) highlighted the transition to a circular economy amongst other environmental objectives. Other priorities included climate change mitigation, adaptation to climate change, sustainable use and conservation of water and marine resources, pollution prevention and control, and protection and restoration of biodiversity and ecosystems. To buttress this, European Commission (2020) cited circularity as a prerequisite for climate neutrality and drew a nexus between circularity and reduction of greenhouse gas emissions. European Commission (2022) also affirmed that the objective of circular economy is to link business cycles so as to preserve the value of goods and services for as long as possible, while maximizing resource efficiency and decreasing waste and emissions. The relevance of circular economy to the blue economy is therefore shown by the need to determine how to handle the availability, extraction, usage, and distribution of raw materials throughout the value chain of the different blue economy sectors.

The initiatives outlined by European Parliament (2008) continue to represent the EU's stance on the prospecting for, acquisition, and use of raw materials. At the heart of these initiatives is the need for sustainability, which could be facilitated in terms of raw materials, through circularity. By reducing the impact associated with the supply of materials along the EU value chain, this enables greater results to be accomplished with less resources.

3.5 – Established and Emerging Sectors of the Blue Economy

The most significant contributions to the EU Blue Economy come from the established sectors. According to European Commission (2022), these include Marine living resources, marine non-living resources, and marine renewable energy. Others are Maritime transportation, Coastal tourism, Shipbuilding, and repair, and Ports operations. Each of these sectors is broken down further into subsectors and contributes economically to the blue economy as a whole. The term "emerging sectors" refers to those economic sectors and activities linked to the marine environment that are not mature or for which there is insufficient data in the public domain. An example of a sector that is not regarded as not mature, is ocean energy other than oil, gas or offshore wind. On the other hand, Maritime defense, safety, and security are examples of sectors

for which data is not readily accessible in the public domain. Because of the lack of data that is currently available for the emerging sectors of the blue economy, in-depth analyses of the economic impacts of these sectors are not entirely possible.

Many aspects of these emerging sectors cannot be ignored because, however insufficient the data available on them are, their impact on the maritime space, hence on the blue economy, is significant. Therefore, their activities are noteworthy, and the EU expects that over time, their impacts would be quantifiable especially in economic terms (European Commission, 2022). Maritime defense, security and surveillance is an aspect that stands out as an emerging sector although its impact on the blue economy has been present before the concept of the blue economy was mooted. Technological innovations in the Navy for example, which have both military and civilian applications, make it necessary to map their activities and their wider economic impact as the Navies grow and gain greater relevance in the blue economy. Due to increasing availability of data and more streamlined policies between EU member states, the economic impact of the Defence sector should be more observable, better coordinated and reported in the near future. The European Defence Agency (EDA) contributes to the blue economy by conducting activities in the maritime sector which promote the EU's Green Agenda. An example is the Incubator Forum for Circular Economy in European Defence (IF CEED) which has been on since October 2021, and which seeks to apply the EU Green Deal's circular economy approach to European Defence. The EDA also supports Defence Ministries of member states to address energy, environmental and climate change related challenges.

As evidenced in the aforementioned sectors, the blue economy is quickly becoming more technologically dependent. In order to fully harness its potentials and to keep it maximally sustainable, there must be a greater reliance on, and use of, relevant knowledge resources. These knowledge resources would be able to provide feedback and inform improved future actions to help stakeholders truly future-proof their efforts. The European Commission's establishment of Knowledge and Competence Centres is an example of such efforts. It affords the opportunity to review and analyse available knowledge in order to process science-based evidence, inform policymakers, and provide tools and services for all EU policy areas (Science Hub, 2021). Hotaling & Spinrad (2021) described the tools used to capture data for the formulation of this knowledge, their application, and their overall impact on the blue economy, as the "New Blue

Economy". According to their research, the NBE is achieved when economic value can be derived from the commercialization of value-added maritime data, information, and expertise. They argue that these economic benefits are made possible by the significant enhancement of observational capacities and the creation of prediction models. They anticipate that an increase in the volume, variety, and quality of data, as well as improved techniques of forecasting and nowcasting, will make it possible to develop products and services that will improve traditional aspects of the blue economy (Hotaling & Spinrad, 2021).

3.6 – The New Blue Economy

The blue economy (the economic exploitation of the oceans) has evolved over time. Material extraction of food, energy, minerals, and compounds, as well as other kinds of bioprospecting, have largely been conducted as independent industries. This has defined the blue economy as being based on physical resources such as food and energy, as well as critical services such as shipping. Data has played a supporting role in the development of the conventional blue economy, since it has been required but not crucial to the growth of these industries.

As the maritime domain evolves, data, particularly data describing the state and trends of the ocean's ecosystem, will become the economic driver of the new blue economy. It is expected that the volume, quality, and diversity of data, as well as the complexity and accuracy of predictive capabilities and models, will define this paradigm. (Hotaling & Spinrad, 2021). This study argues that the impact of data as a driver of the NBE should also be harnessed to accelerate the CE in order to further enhance sustainability in the maritime domain. These impacts are consistent with the trends of the Fourth Industrial Revolution (4IR) which is estimated to change the interaction of state actors and stakeholders with the maritime domain.

3.7 – The Fourth Industrial Revolution in the Circular Economy

The concept of the Fourth Industrial Revolution (4IR) encapsulates a class of technologies also collectively termed as Industry 4.0. According to Lacy et al. (2020), previous industrial revolutions (mechanization, mass production, and automation) allowed firms to "leapfrog" in terms of industrial productivity. However, with the Fourth Industrial Revolution, it is not simply a handful of technological innovations, but rather an array of technologies and their combinations that will drive significant transformation throughout global value chains (Lacy et al., 2020). It is anticipated that these technologies will allow the intelligent utilization of resources and generate new

possibilities for the CE. In addition to cellular and tissue engineering, they involve artificial intelligence and nanotechnology. In comparison to earlier industrial revolutions, these technologies are being created and scaled at an accelerated rate, which is their defining attribute. Thus, they are sufficiently positioned to facilitate a good transition towards the CE. Some of these technologies are discussed subsequently:

3.7.1 – Digitalization and Digital Twin

According to Sun (2021), digitalization refers to the acceptance or expansion of the use of digital or computer technology by an organization, an industry, or a nation as one of the future's most significant developments. Given the significance of the BE, the EU has made it a priority to foster digitization and autonomy as crucial areas for marine research. To accomplish CE, the potential offered by different types of digitalization to the maritime domain must be at the core of all future plans for the industry (Lambert et al., 2019). In addition to logistic technology and automation, the EU recognized digitalization as one of the important drivers in the growth of port operations in 2022. According to the report, digitalization enhances the port activity trends aggressively pushed by EU policy. They include the shift to more sustainable port operations by lowering port externalities, as well as a stronger emphasis on technical innovation by increasing the use of artificial intelligence, networking, automation, and robots. The support of shifting patterns as a consequence of the structurally expanding worldwide demand and consumption patterns and the subsequent global integration and consolidation in the logistics sector is an additional significant development. These developments would position ports and port operations to continue to play a significant role as supply chain hubs linking international routes and marine and terrestrial forms of transportation (EU, 2022).

The construction of the Digital Twin Ocean (DTO) as part of "Mission Restore Our Ocean and Waters" is one of the most important applications of digitalization to the BE in Europe. The mission is an element of the EU Missions operating under the aegis of the Horizon Europe Initiative from 2021 to 2027. The DTO is a computing environment that enables the evaluation of various situational scenarios and provides knowledge-based information for making informed decisions. The Digital Twin Ocean will open the door to information and the translation of that knowledge into action. EU identifies it as a "digital co-creation space" that brings together diverse communities and specialties. It is estimated that its applications are limitless. The DTO is

anticipated to be operational by 2024. Under an NBE framework, such an endeavor would mark a new frontier for CE. This would improve the use of the ocean's resources and the monitoring of its ecosystem so as to minimize waste and increase value (EU, 2022).

CHAPTER 4

4 – Circular Economy in European Ports

4.1 – Introduction

Ports are nodes of transport, energy, industry, and the blue economy (cite). This chapter begins by pointing out the importance of ports, providing an overview of the European Seaports Organisation and highlighting its mission and role among other considerations. The study then appraises the efforts of selected European ports as regards circular economy. These are the ports of Rotterdam, Amsterdam, Valencia, and Copenhagen-Malmo. Their circular approach to sustainability is then analysed through their barriers and drivers and by a SWOT analysis.

4.2 – Overview of The European Seaports Organisation

The European Seaports Organisation (ESPO) was founded in 1993 as an offshoot of the Port Working Group, a working group comprised of port authority representatives from Europe's main ports. Since its creation, the organization has launched several noteworthy projects, such as the publication of the first Environmental Code of Practice in 1994 and the development of EcoPorts a few years later. ESPO's primary responsibility is to ensure that seaports have a strong voice within the EU. Therefore, it represents the shared interests and promotes the shared perspectives and values of its members before the European institutions and their policymakers. ESPO supports its members in getting deeper insight of significant policy efforts, while also supporting policymakers in grasping the function and significance of port authorities. This is largely facilitated by its broad industry expertise and reliance on dependable information and data. The organization has established a unique knowledge network of European port authorities, giving it the ability to engage with all European port and maritime stakeholders (ESPO, 2022).

ESPO is crucial for the implementation of a sustainable circular economy regime and the accomplishment of stable growth in European ports. In the next decades, European ports are projected to face a number of possibilities and challenges that cannot be managed by a single port or economic player. Due to the quick rate of technological and political change in the world, a European Ports Circular Economy Roadmap would need collaboration from European ports in order to work. Consequently, ports would need to collaborate with one another, as well as other stakeholders within the port ecosystem and external stakeholders. The merger of the ports of

Rotterdam and Amsterdam, according to Chandra and van Hillegersberg (2017), was a clear example of interorganizational collaboration in the port business. The supply chain operations were more effective as a consequence of this collaboration, which also enhanced platform connectivity between ports and the adoption of data governance rules, policies, and plans. To guarantee that Europe's ports fully take advantage of the prospects of the circular economy, particularly via the emerging new blue economy, such synergy between ports might be scaled up through the intervention and direction of the ESPO. The ESPO is also crucial to serve as an umbrella organisation for the coordination of the implementation of EU's overarching maritime policies such as the European Grean Deal and particular strategies such as the Marine Strategy Framework Directive and its several BE initiatives. The Horizon 2020 (now Horizon Europe) is another pertinent example which the ESPO can interpret for execution in EU's ports between now and 2027, in order to usher them into the new paradigm of CE especially engendered by NBE.

4.3 – Circular Economy Efforts in European Ports

This section highlights the assessment of the case study ports (Rotterdam, Amsterdam, Valencia, CMP, and Antwerp) using SWOT Analysis. These case studies were chosen because they represent a diversity of geographical, policy and strategic characteristics so they provide insight into the pervasiveness of CE across the spectrum of European ports. They were also selected due to the priority they place on circularity, which is a common characteristic to all of them. The characteristics of these case studies have also shed light on the impacts of CE and how the information gleaned could facilitate a possible roadmap for EU ports in general:

4.3.1 – Port of Rotterdam

Outside of East Asia, the Port of Rotterdam is the biggest seaport and one of the most significant ports in Europe. Rotterdam has established and circular design projects, according Gravagnuolo et al. (2019). Rotterdam has established a "2030 Roadmap" that incorporates the participation of all port stakeholders. It includes short-, medium-, and long-term objectives to advance circular enterprises, particularly in the food, clean-tech, and maritime industries, which are the primary economic clusters (Gravagnuolo et al, 2019). The road map includes a communication system for circular economy issues such as policy, real-world case studies, and citizen benefits. To encourage academic participation, a connection with educational centers was established (Karimpour, 2017).

4.3.2 – Port of Amsterdam

In order to realize its goal of becoming a CE hotspot in Europe, the Port of Amsterdam has been working to develop strategies for attracting enterprises and entrepreneurs. One example is the collaboration established to collect plastics in Amsterdam canals and transform these various streams of plastic into new products. To boost innovation in this sphere, the Port of Amsterdam established the incubators Prodock and Prodock 2.0, where start-ups and scale-ups may collaborate with other circular and biobased ventures (ESPO, 2022). The port is also a hub for the Innovation Circles of Amsterdam, a programme which ran from 2016 to 2018 to provide insights into the most innovative projects which could promote circularity (Karimpour, 2017).

The port of Amsterdam launched the expansion of sustainable fuels within the port on July 6, 2021, demonstrating its commitment to circular production. The goal was to reduce carbon emissions by 55% by 2030. A new biofuel facility, Advanced Methanol Amsterdam (AMA), was to be built to generate around 87.5 kilotons of renewable methanol per year, helping to reduce carbon emissions (ESPO, 2022).

4.3.3 – Port of Valencia

Fundacion Valenciaport coordinates a project called LOOP-Ports a CE transition for ports through an innovative Circular Economy Network. This comprises of 3 main areas of intervention which were identified to encourage CE initiatives in European ports. The first intervention is the Circular assets and equipment by which ports, through maintenance and smarter use, can optimize the capacity and lifetime of existing port infrastructure and equipment. The second intervention is the Circular Flows within Ports by which the transition to CE is facilitated by efficiently harnessing waste from port activities. For example, cement is made from dredged sand, fish by-products are used for cosmetics and animal nutrition markets and biodegradable nets are developed to ensure sustainable production of seafood. Ports and Circular Markets is the third intervention, where ports help other industries become more circular by fostering the growth of new activities that link the port's supply and demand for resources and materials.

4.3.4 – Copenhagen-Malmo Port

Copenhagen Malmo Port serves both Denmark and Sweden. The port sections are positioned on either side of the Oresund, a strait that separates the two countries. CMP chose Stena Recycling as

its exclusive recycling partner in 2016. Stena processed waste from around 200 ships totaling 4,000 tonnes in its first year of operations. The waste was transferred to Stena's recycling plant in Halmstad, where it was converted into other products utilized by high-energy-consuming industries. This initiative reflected CMP's commitment to pursuing sustainability and the desire to achieve CE. Similarly, the 'Shared Energy' initiative was developed as a partnership between the Copenhagen Malmö Port, the energy firm E.ON, and the City of Copenhagen's Environmental Department, with the goal of utilizing residual heat flows in the port region. The City of Malmö and Vinnova's Challenge-Driven Innovation initiative, a national research and development fund, supported the project.

4.3.5 – Port of Antwerp

Antwerp's port is called the Port of Antwerp-Bruges. It is situated in Flanders (Belgium), mostly in the province of Antwerp but also in East Flanders. It is a harbor in the midst of Europe that can accommodate capesize ships. After Rotterdam, it is Europe's second-largest seaport. Antwerp is located at the upper end of the Scheldt tidal estuary. Ships of more than 100,000 Gross Tons may navigate the estuary up to 80 kilometers inland. The port initiated efforts on May 6, 2021, to collect waste heat from a waste incineration plant and connect it to district heating. The project was the largest hot water network in Flanders, resulting in an annual CO2 reduction of 20,000 tons. Although waste heat was previously being utilized for industrial operations and energy production, the installation of this initiative contributed to bolster CE principles by channeling surplus heat to residences in the area for domestic purposes (ESPO 2022).

On 11 October 2022, the Port of Antwerp unveiled its plan to establish an 88-hectare NextGen District which is intended to be a circular economy hotspot. According to ESPO (2022), the area was purposely chosen because of its closeness to Europe's biggest chemical cluster, and it would house industries interested in exploring circular carbon solutions and sustainable energy technology.

Error! Reference source not found. below is a summary of some of the CE efforts carried out by the selected EU ports. These activities indicate the desire of EU ports to make their operations more circular and environmentally friendy. This quest for greener ports is in line with the EU green deal and, in time, would be facilitated by NBE.

Table 2. CE Efforts in Selected European Ports.

Name of Port	CE Efforts in Place	Comments
Port of Rotterdam	Vision 2030 Roadmap.	The Vision 2030 calls for tight coordination among businesses, governments, and research organizations to provide a high-quality work force and living environment, as well as outstanding accessibility. It aspires to be Europe's worldwide hub for containers, fuel and energy flows, energy carriers, and fuels. This concept is to use Rotterdam and its surroundings as an integrated network in order to lead in terms of sustainable and efficient chains. It also seeks to emplace the smart use of information as the new standard.
	Xycle will begin building its first plastic recycling factory.	Xycle, a Dutch chemical recycling firm, is preparing to begin building of a factory in the port of Rotterdam that will yearly turn 20,000 tons of non-mechanically recyclable plastic into high-quality sustainable raw material. The Rotterdam Port Authority has leased a property to Xycle on Rijndwarsweg in Europoort for this purpose.
	Advanced biofuels will be produced from waste by Gidara Energy AMR.	The Advanced Methanol Rotterdam (AMR) facility, to be built by GIDARA Energy in the Port of Rotterdam, was announced as part of CE efforts to make Port of Rotterdam carbon neutral by 2050 . In order to produce advanced methanol, waste will be processed at a plant in Rotterdam's port (Elias, 2022).

Port of Amsterdam	Revaluing Municipal Waste.	The Port of Amsterdam provides circular businesses with a platform to network with cutting-edge water cycle technologies and programs that recover energy from waste.
	Biorefineries of the future.	Biorefineries are projected to provide sustainable energy for succeeding generations.
	Innovative Circles.	An innovative ecosystem where collaborations may facilitate cutting-edge products to facilitate CE.
Port of Valencia	Circular Assets and Equipment.	Maintenance and smarter use of equipment and infrastructure to optimize their capacity and lifetime.
	Circular Flows.	Harnessing waste from port activities.
	Ports and Circular Markets	By creating new activities that link supply and demand for resources and materials through ports, industries are able to move toward a more circular economy..
Copenhagen-Malmo Port	Stena Waste Recycling.	Converting ships' waste into productive high-end energy products.
	'Shared-Energy' Initiative.	Facilitating industrial symbiosis to cut down on greenhouse gas emissions from enhanced resource efficiency
	Fossil-Free Vehicle Fleet and Machine Park.	CMP has announced its goal to provide users in Malmö and Copenhagen with a fossil-free vehicle fleet and machine park. To do this, diesel-powered automobiles and staff buses at the terminals would be replaced by electric vehicles. The goal is to employ renewable sources of power.

As CE is continually encouraged amongst Port Authorities, States, and the EU region in general, ports are expected to align their policies and sustainability goals to achieve the overarching aims of the region. Table 5.1 captures the summary of CE efforts put in place by selected European ports to enhance their progress towards circularity. These include policies in some instances as well as specific projects in others. For example, the 2030 Roadmap for the Port of Rotterdam and the 2040 Energy Strategy for the Port of Amsterdam are long range aims guided by relevant policies. The conversion of marine waste to clothes is an ongoing project for the Port of Valencia, as well as the Waste-to-Energy Biogas powerplant, is for CMP. The CE initiatives of the selected ports also meet with the standards of expectations espoused by ESPO as expressed in the environmental priorities (See Figure 5.1). They include Good Air Quality, Climate Change mitigation, energy efficiency and relationship with local communities amongst others. CE enables the achievement of these priorities which are in line with the EU Green Deal and can be facilitated by the NBE. These priorities tend to change yearly (See Figure 5.2), and this highlights the necessity for CE in ports to evolve in order to meet contemporary ecological, social, and business needs. In 2020 for example, the Shared Energy Initiative of CMP would have helped to promote ESPO's cleaner air quality priority while also meeting the climate change mitigation targets.

Figure 7. ESPO Environmental Priorities.

Source: (ESPO, 2021)

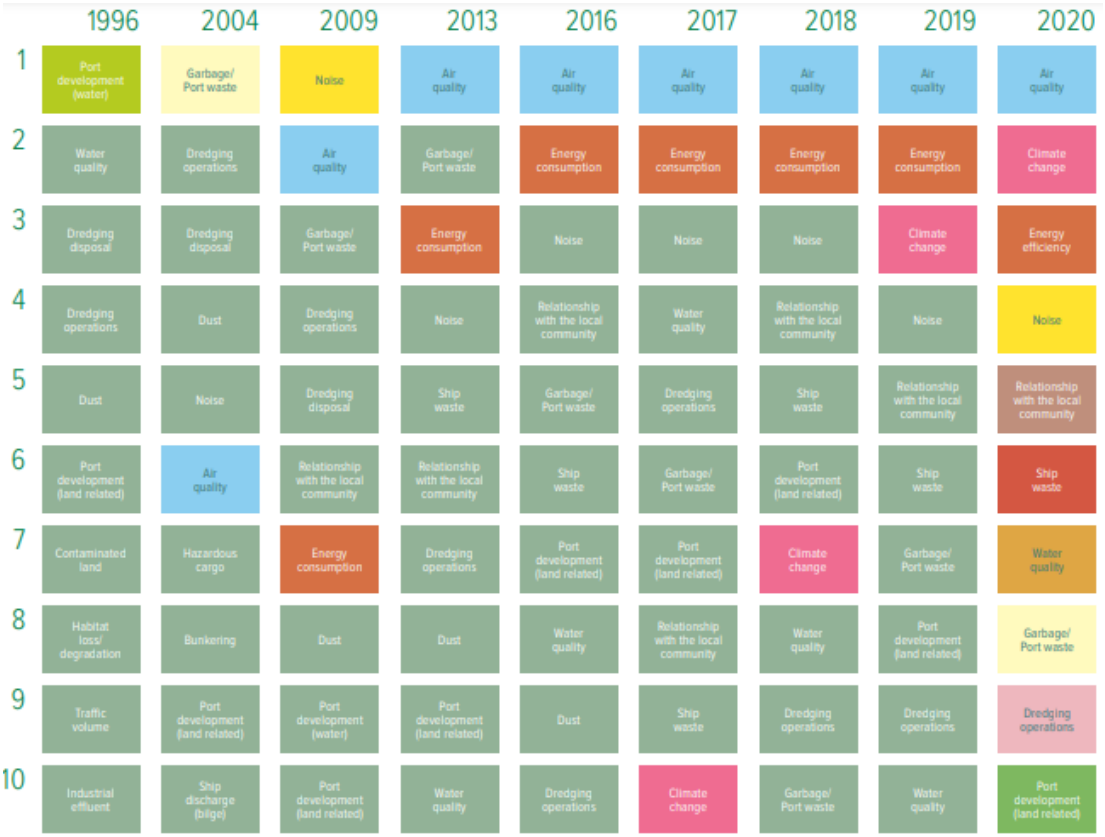

Figure 8. ESPO Environmental Priorities.

Source: (ESPO, 2021)

4.4 – Barriers to Circular Economy in European Ports

Ports and shipping are essential to the circular economy. They are the first point of contact for the positive and negative externalities that ultimately influence society since they host the confluence of industries which may mutually benefit one another. One industry's waste or output may serve as the raw material or input for another. This concentration of activity from the port's components and the communities near them makes ports an excellent starting place for the circular economy transition (Kuipers & Jong, 2015). However, there are barriers which need to be overcome in order to facilitate the circular economy and drivers which enhance the performance, and which may hasten the transition of ports to the circular economy. These barriers and drivers largely determine the Strengths, Weaknesses, Opportunities and Threats presented to the circular economy in the context of the port. The ports' SWOTs are assessed in light of the barriers and drivers.

In their ground-breaking work, Kirchherr et al (2018) highlighted four categories of barriers to circular economy namely Cultural, Regulatory, Market and Technological barriers. Similarly, a study by Araujo Galvão et al (2018) pointed out seven barriers namely Technological, Policy and Regulatory, Financial and Economic, Managerial, Performance Indicators, Customer, and Social barriers. It also pointed out that the means to achieve these ends may be expensive in the short term but over the medium and long terms, and through industrial symbiosis, CE would become the natural way to conduct business. While the aforementioned views captured a general perspective, Kayikci et al (2021) and Cui et al (2021) focused more on the barriers from the technological aspect of CE development. Kayikci et al (2021), while presenting the concept of Smart and Sustainable Circular Economy (SSCE), identified four barriers in what was termed the "SSCE Eco Cluster" namely Technological, Producer, Consumer and Policy barriers. In the same vein, Cui et al (2021) assessed the barriers to the adoption of Internet of Things (IoT) for the CE. The study generated 22 main barriers the top 5 of which were Sensor Technology, Fog Networking, Systems Interface, Cyber-Physical Systems Standardization and Integration, and Development of Smart Devices. Finally, (de Jesus & Mendonça, 2018), while recognizing that CE is a dynamic concept, pointed out what were termed "Hard" and "Soft" barriers and drivers to CE. The study related hard drivers and barriers to technical and economic factors (Techno-economic trajectories) while it related soft barriers and drivers to institutional and social factors (regulatory and cultural issues). Amongst many other extant studies on drivers and barriers of CE, this study adopts some of these highlighted barriers to weigh as elements of SWOT analysis for CE in the selected case study ports.

The SWOT could then be used to examine how the barriers can be overcome and how the drivers could be enhanced to boost CE in ports. This study finds that multiple barriers to CE exist depending on the context of the environment being considered. As the present linear system is continually challenged by the emergence of CE, conflict is inevitable between the interests of stakeholders. Therefore, what some stakeholders see as an opportunity may be perceived by others as a threat. In light of this multiplicity, the study highlights selected barriers based on generic themes in order to provide context for the research. These are categorized as Technological Barriers, Policy and Regulatory Barriers, and Social Barriers.

4.5 – SWOT Analysis of Circular Economy in European Ports

The selected case study ports will serve as the basis for developing the CE SWOT analysis for European Ports, having provided us with a direction for the CE trend in Europe. The SWOT analysis provides an overview scientific analysis of the ports' internal resources and external environment, which interact to determine the best use of set organizational goals. The SWOT analysis enables an organization to assess its own competitive advantages, disadvantages, opportunities, and threats. The Strengths and Weakness columns address the organization's internal conditions, whereas the Opportunities and Threats columns address the organization's external conditions. Based on the SWOT of the Case Study ports presented above, Table 3 depicts an assessed SWOT for EU Ports.

Table 3. SWOT Analysis for Circular Economy in Ports

Strengths of CE	**Weakness of CE**	**Opportunities**	**Threats**
Extensive tecnological experience of ports and States in the region hence availability of knowledge needed for CE.	Inefficient exchange of information between the various sectors of the port communities.	Appeals to the interest of a wide range of the society that hope to see sustainability objectives (such as reduced waste) achieved.	Cost
Pioneer in promoting sustainability in all sectors of the economy.	Information gaps on coordination strategies between stakeholders, technologies, and processes.	Government policies and regulations to support CE growth.	Politics
Consensus among critical stakeholders at port, state and regional	Expensive to deploy	Technological innovation support	

levels for the promotion of CE approach.			
Adequate EU legislation to encourage CE efforts in ports.	Inadequate public awareness	Environmental regeneration	

4.6 – Conclusion

As European ports intensify efforts to comply with the aspirations of the EU Green Deal by becoming more circular, they each emplace measures to become greener and waste less resources while becoming more competitive. Measures to enhance CE in European ports cut across a spectrum of activities which have been categorised into Technological, Policy, and Social factors.

This study assesses that this lean approach to conducting port activities might be expensive to accomplish initially but over time, and with effective collaboration and industrial symbiosis, CE would not only be inexpensive, but it would also become the natural way of doing things. The study estimates that this would become a great opportunity for the emplacement of NBE initiatives to further increase circularity through technological innovation.

CHAPTER 5

5 – Roadmap for Achieving Circular Economy in Ports

5.1 – Introduction

This chapter draws on the ideas and lessons of previous chapters to establish a recommended path for enhancing circular economy through new blue economy initiatives and tools. It demonstrates the application of the NBE to achieve CE by highlighting NBE characteristics and enablers in ports. It then looks at the Strengths, Weaknesses, Opportunities, and Threats of the new blue economy and expounds on the influence of new blue economy on circular economy. Some ideas for improvement and measures to transform weaknesses into opportunities are then suggested before the study proposes a roadmap for ports and concludes the discourse.

5.2 – Applying the New Blue Economy to Circular Economy

According to Spalding (2016), the approach to NBE is a comprehensive one that considers both public and private sector operations from, in, and to the ocean as well as direct and indirect market and nonmarket products and services. According to the study, in order to truly understand how effective sustainability initiatives are, we must be able to distinguish between value and externalities when attempting to optimize the system. The foundation of the idea is the application of data, information, and knowledge about the oceans to specific goods and services for many of the long-standing blue economy's sectors (such as oil and gas, shipping, etc.) as well as other applications (Spinrad, 2021). To accomplish this, data on the distribution and state of natural capital provided by extractive and non-extractive marine and coastal systems must be gathered. This would make it possible for us to keep track of changes over time and have an impact on policymaking, which is crucial for maintaining ecosystem and marine services for the benefit of people and sustainability. When this logic is applied to CE, it becomes clear how important data is for maintaining and improving the system. Therefore, NBE would further accelerate CE in order to achieve optimum value (Spalding, 2016).

An example of the use of acquired data for CE in the context of ports is the optimization of the impact of the supply chain, for a more sustainable port environment. Notteboom et al. (2020) identified the negative environmental impact of logistical and industrial port functions (i.e, transport, terminal, warehousing and assembly activities, including goods and energy production).

The connectivity between port cities and hinterlands facilitates the transmission of these environmental impacts caused by port-based maritime operations. Because ports are industrial nodes in a vast global transport network that connects global supply chains, these environmental effects appear unrelated to other maritime space ecological functions, increasing over time. Nonetheless, the NBE, in support of the 'Green Port' concept, could provide a more accurate representation of supply chain activities' effect on other BE sectors. A topology on global supply chain management action fields pertinent to ports and their actors was presented (Figure 6.1). This encompasses actions attributed to Green Shipping, Green Inland Logistics, and CE, among others. A holistic approach that incorporates these actions would optimize the supply chain and result in more climate-friendly circular processes than the current linear processes. This could be translated into a policy that guides port management and operations stakeholders toward more responsible CE-related goals and behaviours.

Figure 9. Port-Related Supply Chain Fields of Action**.**

Source: (Notteboom et al., 2020)

The influence of ocean observation on the activities of marine industries also has implications for supply chains and ports. According to Marcelli et al. (2021), most global marine observation equipment is challenging to deploy, expensive to operate, and requires specialized technical knowledge. This is despite the fact that a harmonised observation program for the world's coastal

waters has not yet been developed. Coastal ocean observing and modeling systems should enhance the accuracy of information forecasts to manage safe and sustainable maritime activities (Franz et al., 2021). Operational oceanography assists both industry and the public make ocean use decisions (El Serafy, 2020). This is evident in the EU's goal to make the Digital Twin Ocean operational by 2024. EuroGOOS and Mercator Ocean International signed a Memorandum of Understanding on 8 September 2022 for a "Sustainable Observation System" that includes the establishment of the Digital Twin Ocean (Mercatorocean, 2022). This innovative step by the EU answers the question posed by stakeholders regarding the connection between ocean observation and the exploitation of ocean resources made possible by NBE (Hotaling & Spinrad, 2021).

Figure 5.2 depicts the circular relationship for achieving a more industrialized and expanding ocean observing environment, which benefits all stakeholders and society. It is a process facilitated by NBE, that demonstrates the enhanced value proposition offered by the ocean observing system and aims to industrialize maritime sectors' collaborative space sustainably (Steps 1 – 3). This will be accomplished by providing a more robust database of the maritime domain in order to deliver superior information products and fuel the BE (Steps 4 through 6) in a sustainable loop that ensures CE and more effective resource management (Hotaling & Spinrad, 2021).

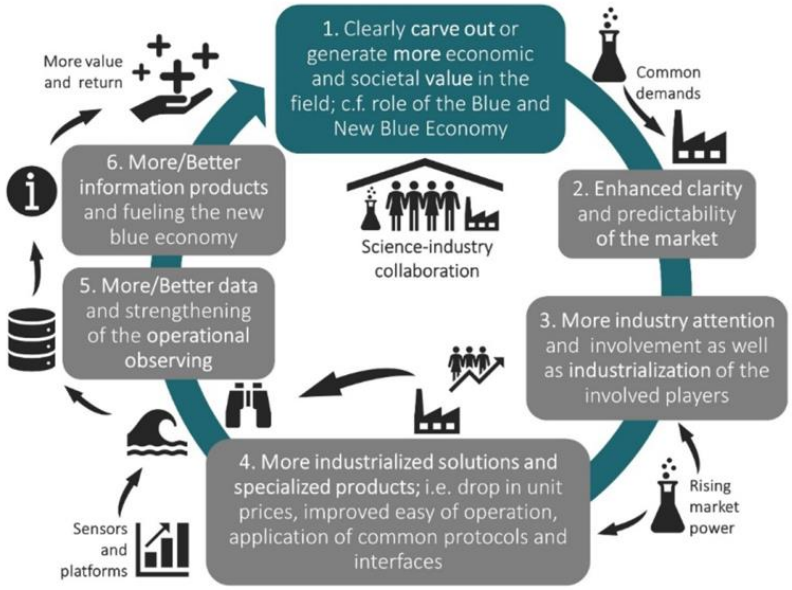

Figure 10**.** Circularity in the Application of NBE to CE.

Source: Hotaling & Spinrad (2021).

5.2.1 – Characteristics of the New Blue Economy

The NBE is an effort to define economic sectors and activities associated with the ocean in a common, global concept to produce comprehensive and progressive economic health. The potential effects on ecosystem services are considered in addition to the advantages to industry. It reveals whether the sector is beneficial to the ocean or detrimental and whether this results in costs that may be quantified using various valuation methods (Spalding, 2016). For these valuation mthods to be effective, Hotaling and Spinrad (2021) opined that they must be characterized by two broad characteristics the first of which is data and the second, models, and predictive capability or capacity.

When considering data for NBE, the volume of the data must be taken into account, as more data corresponds to greater predictive power. More significant technological progress has led to the development of new platforms and sensors across all industries. This has also increased the aspirations of the BE. An example is the European Union's ambition to establish and make operational a digital twin of the maritime space by 2024. Such advancements necessitate vast quantities of data to monitor changes and adjust to the overall objectives and policies. In order to properly direct CE efforts, the availability of diverse, high-quality data enhances the predictive capabilities of relevant authorities and stakeholders. Such predictive capabilities are desirable for effective CE, particularly in ports, to ensure that CE policies and projects contribute positively to the overall EU CE agenda.

Because the application of data to predictive models is the essence of data acquisition, predictive models, as well as their adaptability to dynamic natural conditions or evolving user needs, are at the heart of CE efforts. This is where innovation, entrepreneurship, and policies come into play within a specific economic sector. As a result, stakeholders must adapt the complexity of these models while ensuring their diversity and accuracy, in CE decision-making. For example, a predictive model of inbound vessel traffic could aid in the design of better Just-in-Time (JIT) rosters for ships arriving at the port. As a result, a port-specific model could reduce emissions and underwater noise from ships in the port area, contributing to CE by reducing resource waste by awaiting ships.

5.2.2 – Enablers of the New Blue Economy

The NBE is enabled by technology, policy, programs, and resources, according to Hotaling & Spinrad (2021). Significant technological advancements enable the transition to this new approach in ocean measurement, modelling, and forecasting. The NBE relies on platforms, sensors, and models for its advancement. Satellites, buoys, ships, and autonomous platforms such as autonomous underwater and surface vessels (AUVs and ASVs) are essential for feeding the NBE's large data requirements. Multiple data variables that could provide information about changes in the marine ecosystem are also made possible by sensors. These are then utilized to create models that accurately reflect the natural systems they represent. For CE applications, the feedstock of overfished marine ecosystems could be monitored in real time to make decisions regarding restorative and regenerative policies. These policies could create programs or tap into existing programs and resources to achieve their goal.

5.2.3 – SWOT Analysis for New Blue Economy in the Circular Economy

The CE is an economic system aimed at eliminating waste, reducing pressure on the environment, stimulating innovation and creation of new good-paying jobs. Thus, it provides ample opportunities for the employment of NBE to enhance sustainability and generate revenue in the BE by reallocating high-value resources through reuse, recycling and redeployment. The following SWOT Analysis assesses the influence of NBE on CE in the maritime domain in general.

Table 4. SWOT for New Blue Economy in EU Ports.

Strength of New Blue Economy	**Weakness of New Blue Economy**	**Opportunities**	**Threats**
Provides reliable information for the emplacement of CE.	Not equally distributed due to technological advantage of some stakeholders.	Effective harnessing of the maritime space.	Opposition from Luddites.
Engenders transparency in maritime industry.	Expensive to venture into.	Supports better collaboration.	Likelihood to foster exclusion.

Supports innovation.	Likelihood of complexity.	Long-term prosperity.	Lack of subjectivity in results.

5.3 – Roadmap for Achieving Circular Economy through New Blue Economy Initiatives

The NBE encourages more in-depth research and analysis of the ocean to help us make better, more long-lasting economic growth and environmental preservation decisions. Experts are informing the public, and in response, relevant stakeholders, particularly States, are taking decisive action. Consequently, this study attempts to propose a road map, based on the information presented and in light of the research aim, questions and objectives. The proposed roadmap touches on Strategies and priorities and strategies at the Regional, National and Port levels. It also emphasises framework, engagement with stakeholders, and capacity building:

- **Strategies and Priorities at Regional, National and Port Levels:**

A regional strategy outlining policies and proposals for the New Blue Economy, especially for the circular economy, is needed in EU ports and port cities. This strategy must also permeate down to the national and port authority levels. To achieve their goals in the Circular Economy, EU ports will need to investinvest in areas outside their regular practices, which should be clearly stated in advance.

- **Development of Regulatory Frameworks:**

A clear regulatory framework that modernizes the region's ports and facilitates the sustainability and competitiveness of EU ports is needed to unlock the identified strengths and move forward into the new blue economy. To achieve circular economy, sustainability metrics like carbon footprint, resource consumption, and others would need to be established as starting points for such a framework. The framework should also account for geographical and social differences and correct any regional inequities. By taking these measures, we can ensure that growth-promoting, context-based innovation is fostered.

- **Engagement with Port, State, National, and Regional Stakeholders:**

Attaining a new blue economy on an EU-scale would necessitate increased horizontal and vertical collaboration between stakeholders from various sectors and jurisdictions. This collaboration would require a shift from node-based to supply chain-wide planning (Dooms, 2019). Port planning would also require new development models to incorporate the adaptability and flexibility of port infrastructure for the circular economy. In addition, port planning would require promoting business continuity principles that prioritize the more robust integration of technological developments.

- **Capacity Building:**

To accelerate the pace of the transition to a new blue economy in the EU, relevant national entities need to enable ports to meet sustainability standards. This would only be possible through available technical support, building knowledge and awareness, providing financial and non-financial incentives, and facilitating access to finance. Most importantly, accelerating the transition to a new blue economy requires all stakeholders (especially internal stakeholders) to have the right skills, knowledge, and resources to provide materials, equipment, and technical and financial services needed to facilitate and support the new blue economy platform within the ports. This is because there will be a massive shift from the current knowledge base that supports a circular economy which may not be adequate for a new blue economy environment. Some aspects that can be focused on include supporting local/national training to fill this gap.

CHAPTER 6

Discussion and Conclusion

6.1 Introduction

This chapter concludes the study by providing an overall summary of the key findings of the study and how they address the research aim. It discusses the findings in relation to the overall aim after which it highlights how the study contributes to the field. Limitations of the study are also highlighted and finally, recommendations are made.

The study aimed to examine workable measures for achieving a circular economy through new blue economy initiatives by harnessing the potentials of ports in Europe. To achieve this aim, the study appraised the potential of ports to enhance circular economy through the implementation of new blue economy. It further articulated measures for the effective establishment of these initiatives for sustainable development in the maritime sector in Europe. The research sought to:

a. Establish the conceptual relationship between the new blue economy and the maritime sector.
b. Discuss the barriers to achieving the circular economy through new blue economy initiatives.
c. Highlight the barriers and drivers of the circular economy in the port sector.
d. Identify the strategies to mitigate the challenges militating against the utilisation of new blue economy initiatives as a drive in achieving the circular economy.

The research was therefore geared towards answering the following questions:

a. What is the conceptual relationship between the new blue economy and the maritime sector?
b. What are the barriers to achieving the circular economy through new blue economy initiatives?
c. What are the barriers and drivers of the circular economy in the port sector?

d. What are the strategies to mitigate the challenges militating against the utilisation of new blue economy initiatives as a drive in achieving the circular economy?

The study was conducted as desk-based research, with secondary sources providing the majority of the data and references. The study adopted the interpretivism philosophy, which heavily relied on context to determine the meaning of the concept of the New Blue Economy. Thus, the presented findings allowed the researcher to generalize theories, as they were anticipated to influence the functioning of the new blue economy in order to achieve a more effective circular economy.

The research employed the case study research strategy to collect data on numerous entities, such as ports and organizations. These included regional organizations such as the European Union (EU) and business organizations such as certain maritime and blue economy stakeholders. The study also sought to examine the phenomena of circular economy and the new blue economy in their respective contexts and how they operated for ports. As the study examined the phenomenon of circularity in multiple ports, it utilized a multiple case study methodology. Ports of Rotterdam, Valencia, Amsterdam, Antwerp, and Copenhagen-Malmo were chosen as case study ports. It used the embedded case study method as opposed to the holistic case study method, focusing on key aspects and processes of the multiple representative ports under consideration. Due to the exploratory nature of the study, it was necessary to assess the internal and external operations of the organizations under consideration, as well as their interactions. Consequently, the SWOT analysis method was utilized.

6.2 – Findings

The research found a conceptual and practical relationship between the new blue economy and the maritime sector. It established that new blue economy tools could be utilized to enhance circular economy in the maritime domain. The study further highlighted some barriers to achieving circular economy through NBE initiatives which included legislation on NBE, and lack of coordinated data to achieve better regional and state predictive capabilities in the maritime domain. Lack of awareness of the NBE was also highlighted. The research also shed light on the barriers as well as drivers in the of CE in the port sector. The barriers include lack of common CE protocols for ports in the EU and the high cost of deploying CE initiatives in ports. The drivers include technology and effective stakeholder collaboration and coordination by governing bodies such as ESPO.

Finally, the research proposed strategies for mitigating the challenges militating against the use of the new blue economy to achieve circular economy in the EU port sector. The strategies include the streamlining of policies from the regional level to the states and ports levels to facilitate NBE acceptance and utilization in the EU. Another strategy involves activities to foster stakeholder engagement to collaborate towards emplacement of NBE for EU ports and maritime sectors generally. To accomplish these, there must be adequate financing. Therefore, it was proposed that the EU prioritize financing for NBE efforts to enhance circularity in its ports.

The study concludes that the new blue economy is a viable tool for accountability, transparency, and optimized ocean control. When applied to the circular economy, it ensures that waste can be better tracked and utilized to ensure better resource management and environmental restoration. Even though the research aim and objectives were achieved, the findings did not meet the researcher's expectations, as the new blue economy was not mainstream in the maritime domain, as was anticipated. However, this presents an opportunity for additional research and contributions to this emerging maritime field of endeavor.

6.3 – Contributions of the Study

The common theme and overall goal that the blue economy and circular economy seek to achieve, is sustainability. As maritime industries extract value from the ocean, it is not enough for them to be asked to do so sustainably, especially when there is no immediate incentive to do so. These industries alongside state actors must be provided with the tools to operate sustainably. These tools range from policy interventions to research and development, and actual services by which they can develop sustainability standards and comply with those standards. This study drew attention to the novel concept of the new blue economy which hitherto had not been viewed as a category of resources relevant to the maritime domain. The study portrays it as essentially a field of knowledge resources derived from the application of various forms of technology and sought to identify its potentials especially in enhancing circular economy in ports. Being a new concept, the study presents it as a field for further research.

6.4 – Limitations of the Study

The study encountered some limitations the first of which was sampling issues. Being that the new blue economy is only still being proposed, its existence as a field of study is still limited to

literature. The research therefore raises a further question as to how the new blue economy would be coordinated when it is eventually recognized as a sector of the maritime industry. It is hoped that with the launch of the EU Digital Twin Ocean in 2024, the relevant fields that support the production and use of the acquired data would then be practically categorized as a new maritime industry in its own right with fields and applications such as Artificial Intelligence, Internet of Things, Blockchain etc. Secondly, the researcher had to hypothesize on the convergence of these technologies as they are yet to be deployed as an independent category of maritime discipline. Further research is therefore required to explore the potentials of these tools as a maritime discipline to employ knowledge resources for more sustainable use of the oceans.

6.5 – Recommendations

From the results and conclusion drawn from this study, the following recommendations are put forward;

Policy recommendations:

a. The European Commission, and thus EU member states, should ensure that the new blue economy approach is implemented in all aspects of port governance and government responsibility. This is critical for directing the development of specific actions required in the coming years. To maintain a sense of urgency, regional and national governments must provide strong leadership.

b. All ports should be required by the EU to create an explicit first-order objective to support the transition to the new blue economy by a defined future date.

c. Port authorities should establish a multisectoral and multi-disciplinary operational group to support the development of the strategy, and drive delivery across the port. This multisectoral and multi-disciplinary group should among other things be tasked with enhancing knowledge and promoting research; funding, stakeholder engagement, and policy implementation.

References

Addamo, A. M., Calvo Santos, A., Guillén, J., Neehus, S., Peralta Baptista, A., Quatrini, S., Telsnig, T., & Petrucco, G. (2022). The EU blue economy report 2022. https://op.europa.eu/publication/manifestation_identifier/PUB_KLAR22002ENN

Anand, R. (2022). *10 Beaches In Belgium That You Must Visit On Your Trip*. Retrieved from https://traveltriangle.com/blog/beaches-in-belgium/

Antonio. (2022). *Genoa: Itally*. Retrieved from https://www.britannica.com/place/Genoa-Italy

Araujo Galvão, G. D., de Nadae, J., Clemente, D. H., Chinen, G., & de Carvalho, M. M. (2018). Circular economy: Overview of barriers. *Procedia CIRP*, *73*, 79-85. https://10.1016/j.procir.2018.04.011

Asaf Humayun, & Naghmana Zafar. (2014). Pakistan's 'Blue Economy': Potential and Prospects. *Policy Perspectives: The Journal of the Institute of Policy Studies*, *11*(1). https://doi.org/10.13169/polipers.11.1.0057

Barbier, E. B. (2010). *Scarcity and frontiers: how economies have developed through natural resource exploitation*: Cambridge University Press.

Bertazzo, S. (2018, March 7). *What on Earth is the 'Blue Economy'?* Retrieved from https://www.conservation.org/blog/what-on-earth-is-the-blue-economy

Bryan, T. et al., *Blue Economy: Sharing Success Stories to Inspire Change*, UN Environment, GRID-Arendal. Retrieved from https://policycommons.net/artifacts/2390374/blue-economy/3411691/ on 15 Sep 2022. CID: 20.500.12592/w7dzcc.

Brydges, T. (2021). Closing the loop on take, make, waste: Investigating circular economy practices in the Swedish fashion industry. *Journal of Cleaner Production*, *293*, 126245.

Büscher, B. (2012). The Political Economy of Africa's Natural Resources and the 'Great Financial Crisis'. *Tijdschrift voor economische en sociale geografie*, *103*(2), 136-149.

Carpenter, A. (2021). *Sustainability in the Maritime Domain: Towards Ocean Governance and Beyond (Strategies for Sustainability)* . Springer .

Chandra, D. R., & van Hillegersberg, J. (2017). Governance lifecycles of inter-organizational collaboration: A case study of the Port of Rotterdam. *Procedia Computer Science*, *121*, 656–663. https://doi.org/10.1016/j.procs.2017.11.086

Chang, Y. C., Wang, N., & Zhao, Y. (2013). The Current Development of the Ocean Governance Mechanism in China. *Coastal Management*, *41*(2), 120–133. https://doi.org/10.1080/08920753.2013.768515

Cui, Y., Liu, W., Rani, P., & Alrasheedi, M. (2021). Internet of things (IoT) adoption barriers for the circular economy using pythagorean fuzzy SWARA-CoCoSo decision-making approach in the manufacturing sector. *Technological Forecasting & Social Change*, *171*, 120951. https://10.1016/j.techfore.2021.120951

Deutz, P. (2020). *Circular Economy* . Retrieved from https://www.sciencedirect.com/topics/social-sciences/circular-economy

Ehler, C., & Douvere, F. (2009). *Marine Spatial Planning: A Step-by-Step Approach Toward Ecosystem-Based Management*. UNESCO.

Elias, T. (2022, June 30). *10 projects that will make Port of Rotterdam carbon neutral by 2050*. SAFETY4SEA. Retrieved September 19, 2022, from https://safety4sea.com/10-projects-that-will-make-port-of-rotterdam-carbon-neutral-by-2050/

Ellen MacArthur Foundation. (2013). Towards the circular economy: Opportunities for the consumer goods sector. *Ellen MacArthur Foundation*, , 1-112.

El Serafy, G. (2020, March 23). Aim, activities and early outcomes of the Coastal Working Group of the European Global Ocean Observing System (EuroGOOS). *Geoscience Online*. https://doi.org/10.5194/egusphere-egu2020-22401

ESPO, E. (2021). *ESPO Green Guide 2021, a Manual for European Ports Towards a Green Future*. www.espo.be. Retrieved September 19, 2022, from https://www.espo.be/publications/espo-green-guide-2021-a-manual-for-european-ports-

ESPO, E. (2022). *ESPO - Our organisation*. European Seaports Organization. https://www.espo.be/organisation

European Commission (2001), *Communication of the Commission to the European Parliament and the Council. Reinforcing quality services in sea ports: a key for European Transport* (COM (2001) 35) 2001/0047 (COD).

European Commission. (2020, March). *Circular Economy Action Plan*. European Union. https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF

European Commission. (2021). *EU Sustainable Blue Economy Communication*. European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0240&from=EN

European Commission (2022). *The EU Blue Economy Report 2022*. Publications Office of the European Union, Luxembourg.

EU, Directive 2014/89/EU of the European Parliament and the Council of 23 July 2014 establishing framework for maritime spatial planning, Official Journal of the European Union. Brussels, L 257/135, 28.8.2014

European Parliament. (2008). *EU Raw Materials Initiative*. European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52008DC0699&from=EN

European Parliament. (2020). *EU Taxonomy Regulation*. European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0852&from=EN

Franz, G., Garcia, C. A. E., Pereira, J., de Freitas Assad, L. P., Rollnic, M., Garbossa, L. H. P., da Cunha, L. C., Lentini, C. A. D., Nobre, P., Turra, A., Trotte-Duhá, J. R., Cirano, M., Estefen, S. F., Lima, J. A. M., Paiva, A. M., Noernberg, M. A., Tanajura, C. A. S.,

Moutinho, J. L., Campuzano, F., . . . Polejack, A. (2021, August 10). Coastal Ocean Observing and Modeling Systems in Brazil: Initiatives and Future Perspectives. *Frontiers in Marine Science, 8*. https://doi.org/10.3389/fmars.2021.681619

Garrido Gamarro, E., Ryder, J., Elvevoll, E. O., & Olsen, R. L. (2020). Microplastics in fish and shellfish–a threat to seafood safety? *Journal of Aquatic Food Product Technology*, *29*(4), 417-425.

Gravagnuolo, A., Angrisano, M., & Fusco Girard, L. (2019). Circular economy strategies in eight historic port cities: Criteria and indicators towards a circular city assessment framework. *Sustainability*, *11*(13), 3512. https://10.3390/su11133512

Hotaling, L., & Spinrad, R. W. (2021). *Preparing a Workforce for the New Blue Economy: People, Products and Policies* (1st ed.). Elsevier.

International Trade Administration . (2021, April 28). *Italy's Port Infrastructure*. Retrieved from https://www.trade.gov/market-intelligence/italys-port-infrastructure

Jørgensen, S., & Pedersen, L. J. T. (2018). The circular rather than the linear economy. In *RESTART sustainable business model innovation* (pp. 103-120): Springer.

Kaczynski, W. (2011). The Future of Blue Economy: Lessons for European Union. *Foundations of Management*, *3*(1), 21–32. https://doi.org/10.2478/v10238-012-0033-8

Karimpour, R., (2017). Circular economy modelling to accelerate the transition of ports (2017).

Kayikci, Y., Kazancoglu, Y., Lafci, C., & Gozacan, N. (2021). Exploring barriers to smart and sustainable circular economy: The case of an automotive eco-cluster. *Journal of Cleaner Production, 314*, 127920. https://10.1016/j.jclepro.2021.127920

Khajuria, A., Atienza, V. A., Chavanich, S., Henning, W., Islam, I., Kral, U., Liu, M., Liu, X., Murthy, I. K., Oyedotun, T. D. T., Verma, P., Xu, G., Zeng, X., & Li, J. (2022). Accelerating circular economy solutions to achieve the 2030 agenda for sustainable development goals. *Circular Economy*, *1*(1), 100001. https://doi.org/10.1016/j.cec.2022.100001

Kørnøv, L., Lyhne, I., & Davila, J. G. (2020). Linking the UN SDGs and environmental assessment:

Towards a conceptual framework. *Environmental Impact Assessment Review*, *85*. https://doi.org/10.1016/j.eiar.2020.106463

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the circular economy: Evidence from the european union (EU). *Ecological Economics, 150*, 264-272. https://10.1016/j.ecolecon.2018.04.028

Kuipers, B., & Jong, O. D. (2015). De Amsterdamse haven draait (groen) door.Dutch Pamphlets Online. doi:10.1163/2214-8264_dutchpamphlets-kb0-kb09842

Lacy, P., Long, J., & Spindler, W. (2020). The Circular Economy Handbook: Realizing the Circular Advantage. In *No Title* (1st ed. 2020). Palgrave Macmillan.

Lambert, N., Turner, J., & Hamflett, A. (2019, September 24). *Technology and the Blue Economy: From Autonomous Shipping to Big Data* (1st ed.). Kogan Page.

Landrigan, P. J., Stegeman, J. J., Fleming, L. E., Allemand, D., Anderson, D. M., Backer, L. C., . . . Czerucka, D. (2020). Human health and ocean pollution. *Annals of global health*, *86*(1).

Li, M., Wiedmann, T., Fang, K., & Hadjikakou, M. (2021). The role of planetary boundaries in assessing absolute environmental sustainability across scales. In *Environment International* (Vol. 152). Elsevier Ltd. https://doi.org/10.1016/j.envint.2021.106475

MARCELLI, M., PIERMATTEI, V., GERIN, R., BRUNETTI, F., PIETROSEMOLI, E., ADDO, S., BOUDAYA, L., COLEMAN, R., NUBI, O. A., JOJANNES, R., SARKER, S., SOHOU, Z., ZENNARO, M., WHILTSHIRE, K., & CRISE, A. (2021, March 16). Toward the widespread application of low-cost technologies in coastal ocean observing (Internet of Things for the Ocean). *Mediterranean Marine Science*. https://doi.org/10.12681/mms.25060

MERCATOROCEAN. (2022, September 8). *Memorandum of Understanding EuroGOOS & Mercator Ocean International - 8 sept. 2022* [Video]. YouTube. Retrieved September 18, 2022, from https://www.youtube.com/watch?v=05AEe2jHCtU

Notteboom, T., van der Lugt, L., van Saase, N., Sel, S., & Neyens, K. (2020, February 24). The Role of Seaports in Green Supply Chain Management: Initiatives, Attitudes, and Perspectives in Rotterdam, Antwerp, North Sea Port, and Zeebrugge. *Sustainability*, *12*(4), 1688. https://doi.org/10.3390/su12041688

Placek, M. (2021, December 13). *Average Number of Employees of Copenhagen Malmö Port AB (CMP) from 2016 to 2020*. Retrieved from https://www.statista.com/statistics/1063372/number-of-employees-of-copenhagen-malmoe-port/

Port of Amsterdam . (2022). *Strategy 2021-2025: Taking the Lead Sustainable Accelerated Growth in the Amsterdam Port* . Retrieved from https://www.portofamsterdam.com/sites/default/files/2021-03/Strategy%202021-2025_Port%20of%20Amsterdam%20%28EN%29.pdf

Port of Antwerp Bruges. (2022). *World Port* . Retrieved from https://www.portofantwerpbruges.com/en/our-port/world-port

Ports of Genoa . (2019, September 23). Retrieved from https://www.portsofgenoa.com/en/news-media-en/news-en/2430-costa-group-job-europe.html

Potts T., Marine Spatial Planning and various uses and interests relating to the marine environment, in D. Hassan, T. Kuokkanen, N. Soininen (eds.), Transboundary Marine Spatial Planning and International Law, Routledge Taylor and Francis Group, London and New York, 2015, pp. 42-59

Raad voor Verkeer en Waterstaat (2010), Gateway Holland: fundamentele keuze voor een welvarend Nederland, April 2010

Ramirez-Llodra, E., Tyler, P. A., Baker, M. C., Bergstad, O. A., Clark, M. R., Escobar, E., . . . Smith, C. R. (2011). Man and the last great wilderness: human impact on the deep sea. *PLoS one, 6*(8), e22588.

Schuler, M. (2022, April 29). *Belgian Ports of Antwerp and Zeebruge Officially Combine*. Retrieved from https://gcaptain.com/belgian-ports-antwerp-zeebruge-combine/

Schwarzenbach, R. P., Egli, T., Hofstetter, T. B., Von Gunten, U., & Wehrli, B. (2010). Global water pollution and human health. *Annual review of environment and resources, 35*(1), 109-136.

Science Hub, E. (2021). *Knowledge & competence centres*. EU Science Hub. Retrieved September 19, 2022, from https://joint-research-centre.ec.europa.eu/knowledge-competence-centres_en

Siddi, M. (2020). The European Green Deal: Asseasing its current state and future implementation

Smith-Godfrey, S. (2016). Defining the Blue Economy. *Maritime Affairs: Journal of the National Maritime Foundation of India, 12*(1), 58–64. https://doi.org/10.1080/09733159.2016.1175131

Spalding, M. J. (2016, February 28). The New Blue Economy: The Future of Sustainability. *Journal of Ocean and Coastal Economics*, *2*(2). https://doi.org/10.15351/2373-8456.1052

Statista. (2021, December 13). *Net revenue of Copenhagen Malmö Port AB (CMP) from 2014 to 2020(in million SEK)*. Retrieved from https://www.statista.com/statistics/1063365/revenue-of-copenhagen-malmoe-port/

Sun, X. (2021). *Digitalization in the port industry from the perspectives of bibliometric analysis*. https://commons.wmu.se/all_dissertations

Webster, K., & MacArthur, E. (2016). The Circular Economy: A Wealth of Flows: 2nd Edition. In *No Title* (2nd ed.). Ellen MacArthur Foundation Publishing.

White, R. (2013). Resource extraction leaves something behind: Environmental justice and mining. *International Journal for Crime, Justice and Social Democracy, 2*(1), 50-64.

Youmatter. (2020, February 21). Retrieved from https://youmatter.world/en/definition/definitions-circular-economy-meaning-definition-benefits-barriers/

Zauner, A. (2008). Strategic port planning: A case study of the Rotterdam seaport cluster applying the SWOT framework. *der markt, 47*(3), 130-141.