



Coping with plastic pollution in the oceans. To what extent are the elements of  
the port ecosystems for success present for the blue economy?

by

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## Abstract

The 2020s have been characterized by the United Nations as a decade of action where cities, towns, and communities are called upon to become socially and environmentally sustainable. However, the rapid accumulation of plastic pollution in the oceans is a massive problem that existing forms of governance are failing to address effectively. Marine plastic pollution has only gained recognition in recent years as a global challenge with wide-ranging socio-economic and environmental consequences. This dissertation realizes the urgency to find better solutions to limiting the intensifying problem by addressing the research question: ‘To what extent are the elements of the port ecosystems for success present for the blue economy and more specifically to prevent marine plastics pollution?’. The aim of this project is to explore what conditions are needed to facilitate, encourage and stimulate blue entrepreneurship and develop innovation ecosystems in the port-city interface to enable the creation of cleaner ports. In order to conduct this research we examined and compared the port of Rotterdam with three port ecosystems that have explicit blue economy strategies: namely, Barcelona, Oslo, and San Diego. Rotterdam is the only one of them which does not have an explicit strategy on blue economy. For these port ecosystems case studies have been analysed, using a predefined conceptual framework. Moreover, qualitative data that was retrieved from interviews with representatives from each port authority, NGOs, start-ups, and key stakeholders was used for their analysis. The results indicated that Port of San Diego is the ideal example of how to develop and grow the blue economy opportunities and initiatives. Similarly, findings indicated that Oslo has the potential to become a hub center for the blue economy in the coming years by broadening its networks and clients in combination with investments in their infrastructure to expand the port and free up space capacity. Port of Barcelona and Port of Rotterdam do not have the blue economy as a strategy, however, they could learn from Port of San Diego and port of Oslo. As a consequence, these two ports, Barcelona and Rotterdam cannot be considered as leaders of the blue economy establishment as they have other focuses on their strategic plans and their policy objectives on energy transition and decarbonization of the port.

**Key words:** blue economy, blue entrepreneurship, ocean plastic pollution, port ecosystems, SDGs, innovation ecosystems, start-ups, incubators, accelerators, port governance, port authorities, enforcement of policy frameworks, triple helix concept.

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# 1 Introduction

## 1.1 Background and identification of the problem

Covering nearly three-quarters of our planet (71%), oceans generate half of the world's oxygen and regulate our climate (Fava F.M., 2022). The global ocean economy is estimated to be worth USD 3 trillion annually and presents major economic opportunities, with marine and coastal biodiversity providing livelihoods for over three billion people (OECD, 2022). During the past few decades, it has been noted that ocean exploitation has drastically increased. It has been proven that the maritime transportation sector has a positive impact on global trade and economic growth. However, at the same time, maritime transport is a significant contributor to environmental pollution (Avio et al., 2017). According to the United Nations Environment Programme (UNEP), it is one of the biggest global environmental challenges facing the world nowadays and is estimated to cost more than \$2 trillion annually. In particular, maritime transport and fishing activities are the main culprits for the release of vast quantities of pollutants into the oceans (Kolbert et al, 2017). These include oil, heavy metals, plastics, releases of ballast water and other toxic substances that can seriously harm marine life and ecosystems. Plastics being the topic of our interest, since its popularization in the 1950s has increased dramatically due to its benefits to societal health, safety, and energy (Andrady & Neal, 2009). However, because of the plastics' durability and resistance to being decomposed, their widespread use has caused an epidemic of mismanaged waste and their persistence poses a threat in terrestrial, aquatic, and marine environments (Andrady, 2015).

The International Maritime Organization (IMO), the United Nations (UN) and, the European Union (EU) are actively dealing with the most known forms of pollution in the oceans such as CO<sub>2</sub> emissions, plastic pollution, air, and underwater noise pollution. Emphasizing more on the problem of marine plastic litter, these organizations have developed several policies and guidelines for reducing the accumulating rates of plastic and, consequently, enhancing the blue economy.

## 1.2 International policy frameworks to address the plastic pollution

In this section of the chapter, I will review potential international environmental law instruments that could have some relevance to the marine plastic pollution problem. Of course, I will address those instruments in a problem-oriented way implying that I am not going to discuss every amendment or protocol which may have changed the original instrument.

### 1.2.1 United Nations (UN)

Plastic pollution is on the agenda of the United Nations, and resolutions are passed to member nations urging them to take measures to curb the ecological effects of plastic waste. The following discussion will go over the patchwork of treaties, agreements, and action plans that are currently in place to address plastic pollution.

The United Nations Convention on the Law of the Sea (UNCLOS) is commonly referred to as the "constitution for the oceans". More specifically, it is a convention that establishes rules for enterprises, the environment, and the management of marine natural resources while defining the rights and obligations of nations in their use of the world's oceans (Fasoulis, 2021). UNCLOS has provisions related to marine plastic pollution by adopting a series of approaches to preventing, minimizing, and regulating pollution of the marine environment, including the disposal of plastic waste in the oceans (Plastic Soup Foundation, 2020).

Another key initiative is the UN Environment Programme (UNEP) which coordinates the UN efforts to address marine plastic litter and microplastics (United Nations, 2016). They have developed a global plan of action called the "Marine Litter and Microplastics Global Plan of Action" which outlines a number of actions for governments, industry, and civil society to take to eliminate the quantity of plastics entering the ocean and enhance waste management techniques (UNEP, 2021). UNEP collaborates on marine plastic waste issues with the NGO 5 Gyres Institute. Their efforts are concentrated on scientific research, advocacy, and education on the issue. Finally, the UN Sustainable Development Goal 14 (SDG 14) "Life Below Water" program aims to prevent and significantly reduce marine pollution of all types from land-based activities, including marine debris and nutrient pollution, in order to conserve and sustainably use the oceans, seas, and marine resources for sustainable development (Martin, 2023). The UN's strategy for combating marine plastic pollution is helping to raise public awareness of the issue and catalyze appropriate action to address the problem. The UN's initiatives and policy frameworks are still largely ongoing and much more work needs to be done to significantly reduce the amount of plastic entering the ocean worldwide while recent assessments have found that there are currently no coordinated agreements on a global level that comprehensively address marine plastics in an integrated manner.

MARPOL Annex V is also a convention under the United Nations. The designated UN organisation for the safety and security of shipping, IMO has acknowledged the importance of preventing pollution by garbage, particularly plastics from ships since the adoption of

MARPOL Annex V. In order to prevent plastic pollution from ships, IMO together with the Marine Environment Protection Committee (MEPC) have been working on actualising various initiatives and regulations including the development of guidelines for the management of plastic waste on ships. However, studies show that in spite of the existing regulatory framework, discharges into the sea continue to occur (IMO, 2018).

The International Convention for the Prevention of Pollution from Ships (Annex V to MARPOL) is the principal international convention for preventing and reducing marine environmental pollution by ships from operational or accidental causes, including the disposal of plastic waste at sea (Walker, 2019). Nevertheless, MARPOL Annex V is particularly pertinent in the sense that it explicitly regulates plastic disposal in the oceans. The biggest issue of this approach is that it solely addresses and stops ship-related pollution, whereas 80% of the plastic pollution in the oceans originates from land-based sources (Cortat, 2018). Other limitations of MARPOL amongst others are 1) the flags of convenience, which refer to the fact that ship-owners often choose to navigate under a flag with lower regulatory standards or, in this case, one that is not a party to MARPOL and 2) the lack of economic incentives to enforce innovation in the construction of ships, which mostly does not apply to plastics because such lack of investment is relevant to oil leaks and accidents (Farnelli and Tanzi, 2017). The general conclusion is that MARPOL may be considered effective, due to its mandatory technical regime. On the other hand, the abovementioned restraints show that there is still much to improve to significantly reduce the amount of plastic entering the ocean from ships and to improve waste management practices globally (Farnelli and Tanzi, 2017).

### 1.2.2 European Union Initiatives

The European Union (EU) has taken a number of initiatives and developed policy frameworks aimed at mitigating ocean plastics and enforcing the blue economy. The EU is committed to implementing a comprehensive and integrated approach to tackle marine litter and microplastics, including their sources, pathways, and impacts on the marine and coastal environment. A comprehensive strategy to change how plastics are made, used, and recycled in the EU is marked and laid out in the EU Plastics Strategy. This strategy seeks to eliminate single-use plastic consumption, increase the adoption of sustainable alternatives, and make all plastic packaging recyclable (European Commission, 2018). Similarly to this, the Marine Strategy Framework Directive (MSFD) mandates EU member states to take action in order to improve the state of the EU's marine waters' environment by the year 2030, meaning to identify



and address the sources of marine litter, including plastic litter, and keeping an eye on how they affect the marine environment (Galgani et al, 2013).

The European Commission's Action Plan for the Circular Economy is one of the primary pillars of the European Green Deal. This plan intends to close the loop of resource use and promote recycling and the utilization of recycled materials. Some of the measures to achieve the reduction of marine litter among others are the reduction of plastic production as well as the use of single-use plastics. By focusing on sectors where most resources are used and where the potential for circularity is high we can easily promote the use of sustainable alternatives (European Commission, 2020). Lastly, the European Maritime and Fisheries Fund (EMFF) provides funding for projects that promote the sustainable growth of blue economy, including the prevention of marine litter in the ocean (European Commission, 2022). To summarise, the EU has taken significant steps to promote the blue economy and to prevent marine plastic pollution but much more need to be done to address the issue more effectively. To create efficient strategies and minimize the problem, sustained effort and continued innovation are essential.

### 1.3 Initiatives and policies by Port Authorities to address sustainability issues

One of the biggest challenges for ports is figuring out how to co-exist with adjacent societies while preserving the natural ecosystems. Port authorities all around the world are aligning their ambitions towards their contribution to the Sustainable Development Goals and are addressing the sustainability issues through initiatives such as the World Port Sustainability Program declaration (Jansen, 2023). Such programs empower port community actors worldwide to engage and collaborate with business, governmental and societal stakeholders in creating sustainable added values in which their ports are embedded (Jansen, 2023). A coordinated approach to corporate sustainability would aim to increase resilience of the port ecosystem by inducing enterprises to pursue a portfolio of activities, which contribute to multiple SDGs through the creation of co-benefits, while minimising the trade-offs between the SDGs (Van Zanten and Van Tulder, 2021). Hence, ports should develop green strategies and take responsibility to acquire the licence to operate from stakeholders who live and work in the proximity of the port (Acciaro, 2015). Green ports projects established by two significant European consortia of maritime stakeholders called PIONEERS, led by Antwerp Port Authority and the MAGPIE project managed by the Rotterdam Port Authority are obvious examples how ports are collaborating to drastically eliminate the negative effects of climate change (Jansen, 2023). However, the level of how much port authorities demonstrate

leadership in sustainable development is generally motivated by the desire to “do no harm”, even if they also have intentions to “do good” for their ecosystems (Jensen, 2020).

Port policies associated with our topic of interest strive to limit the amount of plastic waste generated by port activities, encourage sustainable practices for the management of marine litter and prevent plastic waste from entering the oceans. However, the enforcement of these policies can be a challenge for port authorities all over the world, and often there are conflicting interests between the need to protect the environment and the desire for economic growth and development. In some cases, there may also be a lack of clear understanding of the severity of the problem and its long-term impacts. Overall, while there are many promising policy frameworks aimed at addressing the ocean plastic pollution, more need to be done to ensure effective enforcement and to overcome conflicting interests and lack of understanding. Whether the policies are effective enough and sufficient will depend on continued monitoring, evaluation, and improvement of the initiatives and policy frameworks from the port authorities’ side.

#### 1.4 Entrepreneurship and Innovation stimulating the sustainable blue economy

Solutions for marine plastic can occur through policy, behavior change and infrastructure improvements, but also through entrepreneurial ventures and technological innovations (Dijkstra et al, 2022). Indeed, even though plastic rates in the oceans are constantly rising, there are some entrepreneurs and start-ups who see the opportunity to tackle plastic waste and contribute to the blue economy by stimulating and developing innovative solutions to prevent marine plastic. They are combining technology, sustainability, and entrepreneurship to create new products, services, and business models that can help eliminate the amount of plastic waste generated (Dijkstra et al, 2021). Those entrepreneurs are contributing to the fight against plastic waste by providing new alternatives that promote the circular economy, and provide livelihood opportunities for communities. Their efforts show that innovation and entrepreneurship can play a vital role in resolving complex environmental problems and creating new economic opportunities (World Economic Forum, 2022).

## 1.5 Problem statement and research question

To summarise the above elaboration, the problem states as follows:

1. Plastic pollution in the oceans is still accumulating
2. No enforcement, lack of policy frameworks and sometimes contradiction of interests
3. No clear understanding of the severity of the matter
4. No clear understanding of defining the effective instruments or policies needed to be advised and actions to be taken
5. There are, however, entrepreneurs who see an opportunity towards the plastic waste prevention and act accordingly

As plastic pollution in the oceans represents a linear trend forecasted to continue, it is essential to understand how to turn the tide on plastic pollution. It is, therefore, necessary and timely for this project to investigate ways of how the issue of plastic pollution waste in the oceans can be addressed more effectively and how port authorities can turn this into an opportunity.

We are, therefore, particularly interested to assess the role and instruments of port and city authorities in their approaches to contribute to eliminating this problem.

For this reason, we use the following leading research question from a governance perspective:

- To what extent are the elements of the port ecosystems for success present for the blue economy and prevention of marine plastic?

The sub-question that derives from the abovementioned question that need also to be analysed and answered is the following:

- How do the policy frameworks and governance mechanisms compare between Port Authorities that have explicit strategies with port of Rotterdam that has no clearly defined blue economy policy framework?

## 2 Literature review

### 2.1 Introduction

In order to answer the aforementioned questions, it is of crucial importance to explore the literature that can assist in the formation of an intact answer. In this chapter, we first reviewed relevant papers and publications used by different authors and researchers to get familiar with the blue economy emerging concept, what it stands for, and the current research in this area. At a later stage, we went through reports and scientific literature to study and deeper understand the importance of the blue economy to work as a facilitator and resolve the environmental issues that currently occur in the oceans among others marine plastic pollution, acidification, aquaculture remediation, and underwater noise pollution. Second, we discussed literatures used in describing and identifying what is the impact and contribution of the blue economy establishment within the ports and how ports can help to facilitate their processes. Third, the connections of the port with maritime transportation sector are strong. For this reason, the shipping sector has a significant impact on the blue economy, however, there is tension between economic growth and environmental protection. Fourth, we examined scientific papers to define the port governance principles and then get a better understanding of the responsibilities that authorities consider for themselves and how they can mobilize actors and cater for the needs of the blue economy ecosystems. Lastly, we analyzed papers to identify what is the role attribution of port authorities in fostering the necessary elements (innovation, digital technologies, mobilization of networks, entrepreneurship, funding, resources, and policy objectives) to develop a blue economy and activate its opportunities so that can eliminate all the environmental problems ports are facing nowadays.

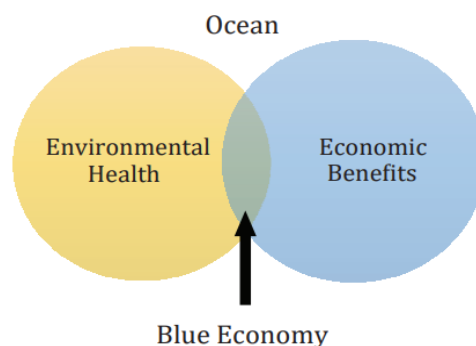
### 2.2 The blue economy (BE) as a new approach

Marine plastic pollution has been a growing problem worldwide, causing negative impacts on the environment, economies, and human health. Port areas, being significant contributors to marine plastic pollution, need to adopt a sustainable blue economy to prevent it. Several studies highlight the need for a sustainable blue economy in port areas. Camilleri (2021), has argued that maritime transport sector accounts for a significant proportion of marine plastic pollution, with port areas being the main sources of such pollution. Liu et al. (2016) propose that sustainable development in port areas should focus on the integration of the port's social, economic, and environmental functions and suggest that ports should adopt a circular economy approach that promotes waste reduction and recycling. The European Union (EU) has also recognized the importance of a sustainable blue economy and has set targets for sustainable

ocean governance, marine biodiversity protection, and decarbonization of shipping (European Commission, 2021). Furthermore, according to United Nations (2017), the blue economy can aid in addressing major global issues including climate change, biodiversity loss, and food security. In the meantime, population growth and global economic expansion are stressing the oceans, leading to resource depletion and environmental degradation (Hugo, 2008). As a result, it is critically necessary to implement sustainable blue economy practices to maintain and protect the oceans while promoting economic growth.

An emerging idea that encourages the sustainable exploitation of ocean resources is known as the "blue economy," and was first described by Gunter Pauli in 2010 (Sakhuja, 2015). Due to its potential to support sustainable economic growth and encourage ocean conservation, the concept of the blue economy has attracted a lot of interest recently (Voyer et al., 2018). According to Vega-Muoz, Salazar-Sepulveda, Espinosa Cristia, and Sanhueza-Vergara (2022), the blue economy requires strong scientific knowledge of the marine environment, in-depth awareness of the activities taking place in the ocean area, and a thorough understanding of the influence on the ecosystem. The conceptual framework provided by Patil defines the blue economy as follows in Figure 1. A sustainable blue economy is created when economic activity is in balance with the long-term ability of ocean ecosystems to support this activity while remaining robust and healthy (Patil et al., 2016).

**Figure 1** The Blue Economy — A Conceptual Framework (Patil et al., 2016)



### 2.2.1 Importance of sustainable development of blue economy and ports' contribution

The blue economy concept has emerged and gained increasing attention in recent years due to its potential to promote sustainable economic growth and protect the marine environment (Brugere et al, 2019). For example, Wang et al. (2021) highlighted that the blue economy can generate jobs and revenue for port regions while also promoting sustainable development. Similarly, according to a report by the World Bank (2018), the blue economy has the potential

to create significant economic growth, job opportunities for coastal communities, and ecosystem health. Port cities are critical in facilitating these opportunities by providing access to markets and serving as key nodes in the supply chain for maritime goods and services. Additionally, ports are at the forefront of engaging with the UN Sustainable Development Goals (SDG) as exemplified by the Association of International Port Cities (AIVP) Agenda 2030. Regarding the European Commission (2020), seaports can also be defined as dynamic nodes for Blue Economy clusters and blue innovation ecosystems by promoting eco-friendly practices, such as the use of renewable energy and sustainable fishing methods. In a study by Zheng et al. (2021), the authors emphasize the importance of developing green ports to support the transition to a sustainable blue economy. Green ports can reduce greenhouse gas emissions and acidification rates, minimize plastic or any other type of waste generation, and promote the use of cleaner technologies, contributing to the overall goal of sustainable development (Zheng et al., 2021).

Numerous authors, scientists, and analysts have conducted research on the blue economy and its role in ports. One area of research is the development of renewable energy in ports. According to a study by Zhu et al. (2020), renewable energy sources, such as wind and solar, can be integrated into port operations to reduce emissions and enhance energy security. The authors argue that the adoption of renewable energy technologies can also create new business opportunities and contribute to the development of the blue economy. Another area of research is the promotion of sustainable fisheries and aquaculture in ports. In a study by Sousa et al. (2021), the authors highlight the importance of sustainable fisheries and aquaculture practices for the development of the blue economy. The authors assert that sustainable fishing practices can improve the resilience of marine ecosystems, leading to increased productivity and economic opportunities for coastal communities. The development of smart ports is also an area of research in the blue economy. In a study by Lee et al. (2020), the authors propose a smart port framework that integrates information and communication technologies to enhance the efficiency and sustainability of port operations. According to the authors, the adoption of smart port technologies can promote the development of the blue economy by improving supply chain management, reducing operational costs, and minimizing environmental impacts.

### 2.3 Shipping sector connection with blue economy and its potential impact

The shipping industry is an essential component of the blue economy, which encompasses all economic activities related to the ocean and its resources. The maritime transport sector is responsible for transporting over 80% of the world's goods, making it a vital contributor to the

global economy (Ababouch, 2015). This can be exemplified by a study on the economic impact of the shipping industry in Singapore, where Cheong and Tang (2020) found that the shipping industry contributed significantly to the city-state's economy, generating over 7% of its GDP and supporting over 170,000 jobs. The authors also noted that the shipping industry was critical to the growth of other industries, such as logistics and marine engineering. However, the industry's impact on the marine environment, particularly in terms of marine plastic waste, has become a growing concern nowadays. For instance, Kershaw et al. (2019) discovered that the shipping industry was responsible for about 10% of the plastic waste entering the Mediterranean Sea annually. Another study by Corbett et al. (2007) found that shipping emissions contribute to global warming, acidification, and changes in ocean circulation patterns, which have serious implications for marine ecosystems. Another area of current research is the impact of COVID-19 on the shipping industry's environmental impact. In a study by Smith et al. (2020), it was investigated that the pandemic had led to a reduction in shipping emissions due to a decrease in global trade. However, the study also highlighted the need for long-term solutions to address the environmental impact of shipping beyond the pandemic. In fact, shipping industry is “out of the picture” or at best operating at the margins of Integrated Coastal & Ocean Management (ICOM) activity, thinking and approaches, internationally, in many countries and in its supporting educational and training institutions (McConnell, 2002). More specifically, the maritime sector is internally fragmented and isolated from the ICOM movement and practice despite their impact on coastal and ocean activity (McConnell, 2002). This isolation is due to a range of cultural factors including the technical specialized orientation of the sector. However, in recent years the process of integration is gradually affecting this sector because of the emergence of issue areas, such as climate change, biodiversity protection, biosecurity, pollution, etc. (McConnell, 2002). McConnell (2002), in his paper stated that the maritime sector is a key factor in effective ICOM, marine ecosystem development, and protection and should take a leadership role. Nevertheless, there needs to be increased capacity to do so but also education and training relevant to sustainable development and integrated management practice need to be widely and methodically available.

## 2.4 Port ecosystem development as a research area

### 2.4.1 Defining port governance principles and stakeholder inclusion as a condition for success

When it comes to ports, governance principles are crucial. According to Pallis (2008), port governance is a system of laws, rules, and procedures for making decisions that encourage environmentally friendly port operations. For laws and regulations to be useful and

enforceable, successful port governance necessitates actionability and port management practices, which call for the participation of all significant stakeholders. This involves putting waste management systems into place, promoting environmentally friendly shipping methods, and lowering plastic, noise, and air pollution (Pallis, 2008). Additionally, governments all around the world are adapting inclusive growth in their agenda. Corporations are embracing the goal of connecting economic growth goals with broader social and environmental benefits in order to reduce "negative externalities" and increase "positive externalities" of their activities (Jensen et al., 2018). According to Woo et al. (2011), port management is becoming more market-oriented and firm-centered, rather than policy-oriented and port-centered as it used to be in the past. Thus, port performance is created at multiple levels of interaction among a wide range of stakeholders. To improve and analyse the port performance, more advanced research approaches are required to capture the interactive and behavioural aspects of port management, such as collaboration, integration, relationships, and trust (Woo et al., 2011). The ability of a port to execute sustainable development goals (SDGs) requires communication and active participation of both internal and external stakeholders. Collaboration between market participants, public policymakers, internal stakeholders, and the community is essential for a successful port ecosystem development (Jansen et al, 2018). According to De Langen (2006) and Haezendonck (2012), coordination mechanisms between stakeholders will need to be established to increase the quality of the port cluster and make cluster governance efficient at accommodating conflicts between actors (stakeholders and governments) within the cluster. Besides providing port services, ports desire to meet social and environmental responsibilities in terms of green policies, market strategy, and port operations and development, in addition to delivering port services (Lam and Van de Voorde, 2012). As a result, new policy instruments for port planning and development focusing on entrepreneurship, innovation, the environment, collaboration, and local community engagement are deemed essential for the port's involvement in promoting sustainable BE development (Sakalayan, Shu-Ling, and Cahoon, 2017).

#### 2.4.2 Role attribution of port authorities in fostering the blue economy

Port authorities play a critical role in fostering innovation towards a more sustainable blue economy (Port of Rotterdam, 2021). Colleti R. et al. (2020) explored the role of ports in supporting a sustainable blue economy in the Mediterranean region. The authors emphasized the need for a circular economy approach and highlighted the importance of strategic planning and stakeholder engagement in promoting sustainable economic growth. One way they can



achieve this is by promoting blue entrepreneurship. Blue entrepreneurship refers to the creation of new businesses and initiatives that promote sustainable economic growth in the ocean economy. Port authorities provide support to blue entrepreneurs and innovators by offering funding, resources, and networking opportunities. Similarly, port authorities can facilitate innovation by providing the necessary infrastructure, access to finance, and regulatory frameworks for blue entrepreneurship. Additionally, port authorities can promote collaboration among stakeholders, such as businesses, government agencies, and NGOs, to promote sustainable economic growth. Indeed, Van Hooydonk et al. (2021) conducted a study on the potential of the blue economy in the Port of Antwerp, Belgium. The study highlighted the importance of collaboration among stakeholders, including researchers, industry players and entrepreneurs, and the need for innovation to promote sustainable economic growth. In their analysis, Wanner et al. (2021) noted that port authorities can act as facilitators and enablers of the blue economy. This can be exemplified by Othman et al. (2021) who found in their study analysis that port authorities create a favorable regulatory environment by providing business development services to start-ups. One of the current policy objectives of municipalities in many port cities across the world to promote innovation in port areas is to facilitate start-ups located in the port-city interface (Witte, 2017). It could be argued that port authorities and city governments could benefit from increased and long-term cooperation with start-ups in innovation ecosystems, particularly in light of challenges like the blue economy enforcement, energy transition, ICT developments (Blockchain, Big data, Internet of Things, and AI (artificial intelligence), and new technologies like 3D printing, robotics, and drones (Witte, 2017). Accordingly, Acciaro & Sys (2020) assert that a greater adoption of these technologies in the maritime transport industry may be crucial to fulfilling the Blue Economy's goals. In terms of regulations, one of the key policy frameworks used by port authorities in enforcing the blue economy is the United Nations Sustainable Development Goals (SDGs). Port authorities use these goals as a framework for implementing policies and initiatives aimed at promoting sustainable practices in the maritime industry. For instance, the Port of Antwerp in Belgium has implemented various initiatives aimed at promoting sustainable practices in line with the SDGs, such as reducing greenhouse gas emissions, promoting circular economy practices, and investing in renewable energy sources (Alamouch, 2021). Port of San Diego has implemented regulations to limit overfishing and protect marine habitats. Specifically, Gommès & Fernandes (2018) mentioned in their paper that port requires commercial fishermen to use specific types of fishing gear that are less damaging to the seafloor, such as traps and hook-and-line gear, and prohibit trawling, which can cause significant damage to the ocean

floor. We can conclude that the port authorities by regulating such activities that impact the marine environment, promoting sustainable practices, and working with local communities, can help to ensure that the blue economy is developed in a sustainable and responsible manner.

### 3 Case Studies : Rotterdam, Oslo, Barcelona and S. Diego port ecosystems

Case studies as we have observed are commonly used in international businesses and social sciences. According to Welch et al. (2013), case studies are regarded as the most popular qualitative research strategy and have indeed the power to generate new theories and insights. Case studies, according to the dominant viewpoints, are only useful for inductive theory building. This restricts their theoretical potential, which includes causal explanations and contextualizing theory (Bendassolli, 2013). However, new perspectives on how case studies can be used are attempting to reconcile the relationship between context and explanation (Angioni & Musso, 2020). In this research, we used exploratory case studies to develop an initial understanding, and raise questions and awareness regarding the topic of marine plastic pollution, especially analysing the projects undertaken for the blue economy enforcement, concerning mitigation measures and pointing out the urge for mandatory policy frameworks and regulations.

#### 3.1 Research method

The research design of this study is based on four case studies of the port ecosystem's development with regard to the blue economy. A case study is an appropriate research method for this research, as it allows for a holistic view of a phenomenon and is particularly useful in more exploratory types of inquiry (Mohd Noor, 2008). In particular, these exploratory case studies center on how port authorities of four chosen ports are mobilizing actors in the port ecosystems (triple helix concept) by contributing to the blue economy and preventing marine litter. This research includes also interviews as a method by gathering qualitative data. The data were drawn from conducting in-depth interviews from all three corners of society; key stakeholders (incumbent companies which are potential adopters of these technologies, i.e. engine manufacturers, shipyards, and big shipping corporations, where a particular interest lay in the innovation and sustainability departments), start-ups (developing or applying radical innovations in preventing the ocean plastic pollution) and port authorities in these particular port regions. The interviews generally provide essential information to understand what aspects of the topic must be considered to obtain reliable results and also play an important role in

outlining possible technical solutions to the issue. More specifically, this type of interview consists in an investigation where the interviewer follows a guide to ask various in-depth questions regarding a specific topic to an interviewee who, on the other side, still possesses a complete freedom in the response. This method allows interviewees to elaborate a response clearly showing their point of view. The main characteristics of this category of interview is its flexibility and the fact that the emphasis must be on how the interviewee frames and understands issues and events (Bryman, 2012). Moreover, we used literature analysis and site observations that potentially constitute and contribute to understanding the level of impact they have on preventing the marine litter. For the literature analysis, academic literature has been used to sketch an overview of the port's ecosystem development. The possibility of studying the topic through the case study and the interviews may provide a deeper understanding of the phenomenon. In this case, we decided to use this method because considering the novelty of the issue demonstrated by a lack of research regarding the topic, it would allow us to reach more complete results. However, some limitations are present. As case studies, we selected Rotterdam, Barcelona, San Diego, and Oslo port ecosystems'. I chose these port regions for two main reasons: a) their extremely intense shipping activity and b) to compare the other three port ecosystems that have shown explicit Blue Economy programs with port of Rotterdam as being one of the largest ports in the world. The literature analysis has been used to provide background information on the port ecosystem development and the framework used based on different aspects (e.g., innovation, entrepreneurship, resources, financial capital and the mobilization of networks) to assess how effective these ports and port authorities are to address the blue economy and particularly, the prevention of marine plastic pollution. The interviews have allowed for deep insights into various stakeholders' views on problems and solutions. A combination of these components enables a rich description of the role of port authorities in addressing the problem, as well as the evolution of the port ecosystems through the various initiatives and actions taken for contributing to the blue economy. The analysis can hereby answer my both RQ regarding to what extent are the elements of the port ecosystems for success present for the blue economy and SQ1 about how do the policy frameworks and governance mechanisms compare between Port Authorities that have explicit strategies with port of Rotterdam that has no clearly defined blue economy policy framework. Since interviewees were selected not at random but due to their position in specific organizations, the sampling took the form of purposive sampling. This research behind the analysis of the case studies aims to obtain pragmatic results and answer to a large extent the questions that this project is focusing on. In Section 3.2, I present and analyze the conceptual framework and the

elements that need to be assessed in the case studies of the port ecosystems. Section 4 consists of the analytical elaboration of the four case studies. Lastly, in Section 5 I proceed with the interview analysis and the main findings and Section 6 ends with conclusions.

## 3.2 Conceptual framework to assess the port ecosystems approach

### 3.2.1 Aspects and characteristics: breeding fertile ground to such ecosystems

Nowadays, port areas are at the frontline of major revolutions and transitions such as renewable energy, digitization, automation of port operations, social transition, urge for sustainability, and circularity. It is argued that in many port cities around the world, there is a renewed interest in ecosystems and an ecosystem services approach toward port and city planning and development (Jansen & Hein, 2023). Port cities that are in the epicentre of attention for the blue economy based on our research are among others: Rotterdam, Oslo, Barcelona, and San Diego. These ports operate as magnets for talent and knowledge (Port of Barcelona, 2020). Many talented people that have the desire to contribute to the blue economy and more specifically to prevent ocean plastic pollution are attracted by the concentrations of economic activities, career opportunities, innovative projects that are currently happening there and by a number of universities and research centers (Port of Barcelona, 2020). Several policy instruments, programs, and projects are implemented in these port cities: smart cities, innovation ecosystems, start-up ecosystems, etc. The question is how to turn talent into technology and entrepreneurship into innovation while sustaining the ecosystem. An ecosystem's approach entails an open exchange of capital resources and is critical for turning knowledge into sustainable innovation and business renewal (Costa, 2020).

The framework for assessing the port ecosystems typically includes the analysis of various aspects and elements such as:

- **Innovation:** The level of technological and process innovation within the port ecosystem, including the use of automation, digitalization, and other advanced technologies (M. Heikkila et al, 2022).
- **(Blue) Entrepreneurship:** The level of entrepreneurial activity within the port ecosystem towards the blue economy concept, including the presence of start-ups, incubators, and other support systems for entrepreneurs.
- **Resources:** The availability and quality of resources such as infrastructure, equipment, and skilled labour force within the port ecosystem.

- **Financial Capital:** The level of financial services and support available within the port ecosystem, including access to funding capital, and other financial instruments.
- **Networks:** Crossovers that happen because people know each other, or can refer to other people who have specific know-how (Jensen & Hein, 2023). This can be social networks on a senior level, but also on a junior level, such as Young Ship International, Port Association Rotterdam (including “Jong Havenvereniging” for young people) and Marine Club Rotterdam.

## 4 Case Studies Analysis

### 4.1 Rotterdam port ecosystem

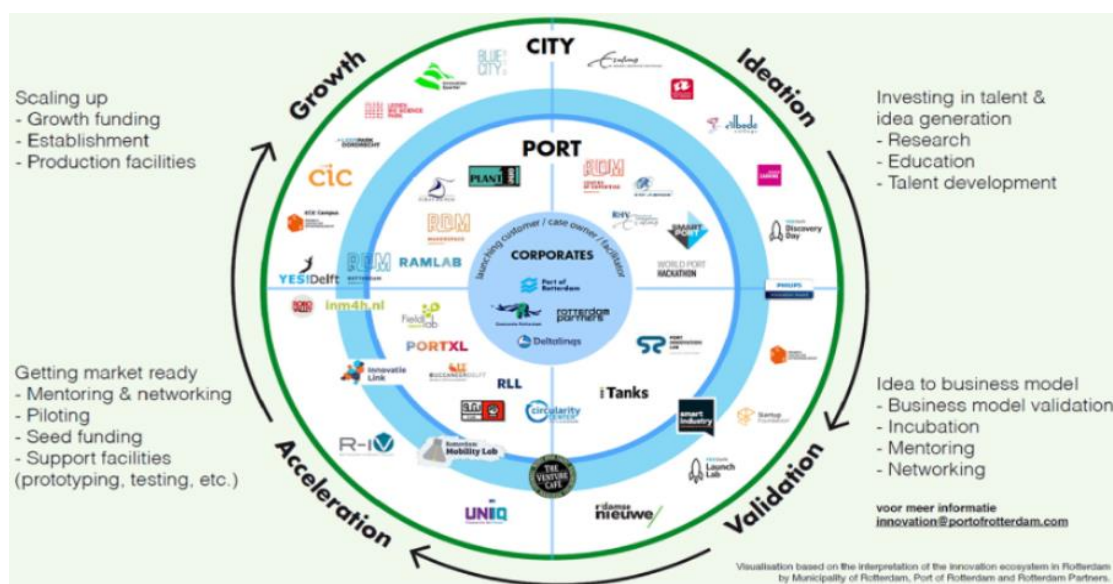
#### 4.1 .1 Profile and policy objectives

Being the largest port in Europe, Port of Rotterdam connects Europe with the rest of the world thanks to its extensive network of shipping routes. The port's principal objective is to strengthen its competitiveness as a world-class industrial complex and logistics center (IAPH, 2021). The Port of Rotterdam Authority is in charge of preserving the secure and efficient processing of shipping as well as managing, operating, and developing the port and industrial region. The port serves as a major hub for the maritime and aquatic industries, and it is home to a number of ecosystems and start-up businesses that support sustainable lifestyles and work to tackle and prevent ocean pollution. Some of these initiatives include the use of renewable energy sources, the promotion of energy efficiency, and investments in circular economy solutions. The port's efforts to promote sustainable development and the blue economy are driven by the need to balance economic growth with environmental protection. One of the port's ambitious environmental policy objectives and targets is to reduce its greenhouse gas emissions by 55% by 2030 and become carbon-neutral by 2050, attracting future resilient cargo flows and operations (Reinders, 2022). Legislation and regulations about ballast water convention, hazardous substances, sailing speed and ship waste are currently applied in the port of Rotterdam in order to contribute to safer and more sustainable services for shipping (IAPH, 2021). Similarly, port has implemented a range of measures to promote circularity, including the establishment of a circular economy hub, which serves as a platform for the exchange of waste and by-products between companies in the port area. Finally, the port is committed and embraces the SDGs in order to achieve sustainable growth and make a major contribution to the Dutch prosperity.

#### 4.1.2 Innovation, Blue Entrepreneurship and Networks

The quality of Rotterdam's port innovation ecosystem is a decisive factor in the digital and energy transitions and in the efforts to widen the portfolio by implementing advanced technologies such as autonomous shipping, blockchain, and artificial intelligence to enforce the blue economy and eliminate problems such as plastic waste, GHG emissions and optimizing resource use (IRENA, 2022). According to the Cambridge Innovation Center (CIC) the three main ingredients for a good innovation ecosystem in Rotterdam are money, ideas and talent. The ambition to be an international leader requires an innovation ecosystem in which all the components are world-class (Port of Rotterdam, 2021). Those components include a training infrastructure, encouragement of entrepreneurship, targeted recruitment of talent, research, test facilities, support for start-ups, availability of venture capital, regulations that encourage innovation, suitable meeting and working places for innovative entrepreneurs, and high-quality demand for innovative products and services (Port of Rotterdam, 2021). In Rotterdam, several public and private investments have been made to realize an innovation ecosystem that is necessary for start-ups to succeed. This infrastructure consists of incubators, accelerators, shared office spaces, test facilities and networking events. The below figure covers several insights of local start-ups, policy makers, academics and the port authority to sketch a complete overview of the settlement climate for start-ups.

**Figure 3.** Port-city innovation ecosystem of Rotterdam



Source: Municipality of Rotterdam, Port of Rotterdam (2017)

To elaborate a little further on Rotterdam's port-city innovation ecosystem of the figure above:

**Ideation:** In this first phase, the port invests in talent development and idea generation through research centers, educational institutions, and knowledge platforms. Some notable examples are the collaboration with Erasmus University Rotterdam, Erasmus Centre for Urban, Port and Transport Economics, TU Delft, etc. These institutions focus on scientific education, research, the transfer of knowledge to society, and the promotion of a sense of social responsibility (Port of Rotterdam, 2022). Another example is the platform Philips Innovation Award which gives the opportunity to students to participate and turn their ideas into successful start-ups (Port of Rotterdam, 2022). Furthermore, at the RDM Centre of Expertise (RDMCoE) students, teachers, and researchers are working together with entrepreneurs on technical innovations for the port and the city through different projects.

**Validation:** In this stage, the concept or idea turns into a business model, through incubation, mentoring, and networking. The Erasmus Centre for Entrepreneurship (ECE) is the leading center for entrepreneurship in Europe and encourages entrepreneurship as an important driving factor for innovation. Then, we have RDM Next which helps companies through workshops and advice with the next steps they can take and guides them in the latest technical innovations in IoT, Machine Learning, 3D printing, and robotics.

**Acceleration:** In this phase, start-ups are getting ready for the market through piloting, mentorship, access to a network of industry experts, funding, and support on their facilities for testing, prototyping, etc. The first example is PortXL; an innovation hub in Rotterdam that supports start-ups in the port ecosystem to accelerate, develop and implement their innovative solutions and technologies for the maritime industrial sector (Witte, 2017). Many of the startups in the PortXL program focus on sustainability and can contribute to preventing marine pollution and delivering environmental benefits, focusing on the blue economy. Additionally, Venture Café organizes weekly meetings where entrepreneurs, and innovators from a wide range of communities in Rotterdam's metropolitan area meet, connect, and exchange ideas. Lastly, UNIIQ helps entrepreneurs in South Holland to bring their unique innovation to the market faster through financing, knowledge transfer, and the use of their network (Port of Rotterdam, 2022).

**Growth:** In this last stage, port is helping to scale up start-ups through growth funding, ensure their establishment and initiate the production of facilities or laboratories they need. BlueCity is where start-ups bring new waves and innovative corporations can catch the tide and develop concrete action perspectives, whether it concerns increasing impact and awareness, living with

zero waste, or developing a future-proof material and consequently contributing to a circular economy within this ecosystem. Similarly, The Cambridge Innovation Center is an ecosystem where entrepreneurs can develop new products, and offers flexible workspaces, private spaces, and co-working workplaces. Plant One Rotterdam realizes and operates locations where companies and research institutes can test and produce their innovative ideas regarding sustainable technology on a commercial scale (Port of Rotterdam, 2022).

Significant achievements regarding the blue economy enforcement could be considered the “unicorn” star example of Ocean Cleanup whose mission is to develop advanced technologies to rid the oceans of plastics (Giezen, & Wiegman, 2020). Another example is the Dutch start-up AquaSmart XL which has developed a system to collect and recycle discarded fishing nets, which are a major source of plastic pollution in the ocean. The company collects the nets from fishing ports and recycles them into new products, such as carpet tiles, bags, and mats (Nickel, 2020). These examples demonstrate how innovation, entrepreneurship, and networking interactions can play a crucial role in preventing marine plastic litter and promoting the blue economy in the Port of Rotterdam. However, overall port of Rotterdam cannot be considered as a leader of the blue economy since their strategic plans, policy objectives and investments in innovation mostly focus on energy transition and decarbonization of the port.

#### 4.1.3 Resources and Financial Capital

Rotterdam’s port infrastructure is continually evolving to keep pace with the changing demands of the global shipping industry, consisting of docks, terminals, warehouses, transportation networks but also campuses, simulator centers, test facilities, field and living labs (Gacel et al, 2021). Besides that, the port has established a training center to educate port workers and engineers on topics such as waste management, recycling, and environmental stewardship (European Commission, 2018). One of the future planned projects includes the installation of shore power to connect ships with electricity.

Port has access to a number of funding sources, including loans, public grants, and private investments. Private investors lend money to the port through loans or investments, including banks, insurance firms, and pension funds. Similarly to this, the Dutch government and organizations like the European Regional Development Fund (ERDF), the Ministry of Economic Affairs, and Climate Policy have played a crucial role in financing the development of the Port of Rotterdam. For instance, the port received a loan from the European Investment Bank in 2020 for the amount of €330 million to assist infrastructure development initiatives



(EIB, 2019). Port has built a number of funding instruments to promote sustainability objectives and the shift to a circular economy in the interim (Schoenmaker et al, 2020). To finance sustainable development initiatives, a €500 million green bond was specifically issued in 2020 (Port of Rotterdam, 2020).

## 4.2 Oslo port ecosystem

### 4.2.1 Profile and policy objectives

Port of Oslo is a vital part of the city's economy and serves as an important gateway for international trade and transportation. The development of this port ecosystem has been an ongoing process over many years, with a focus on creating a sustainable and efficient port city that supports economic growth while minimizing environmental impact. The growth of maritime transportation in the port-city of Oslo has an influence on the marine environment that Norwegian government recognizes and therefore, puts sustainable ocean economy and ocean health as a high priority in its policies (Ministry of Foreign Affairs, 2021). Reducing marine litter and plastics in the oceans and aquaculture remediation have been the central challenges the government and port authorities have lifted in the international arena while close cooperation and a high level of trust between businesses, the R&D sector, workers, and governments have been also crucial in the historical development of Oslo's blue economy (Port of Oslo, 2020). The city has committed to becoming carbon neutral by 2030 and has set a goal of reducing plastic waste by 50% until 2025 (Ministry of Foreign Affairs, 2021). The city also has a number of programs in place to promote sustainable use of the oceans, such as encouraging the use of electric boats and supporting research into new technologies for reducing ocean plastic pollution. Additionally, the city has implemented a number of measures to reduce the use of single-use plastics, such as banning plastic bags and implementing a deposit system for plastic bottles (Norwegian Ministry of Climate and Environment, 2022).

### 4.2.2 Innovation, Blue Entrepreneurship and Networks

The Oslo Port ecosystem has been a hub for innovation and entrepreneurship in the maritime industry. For example, the port has developed new technologies for the offshore energy industry, such as floating wind turbines and subsea power cables (THEMA Consulting Group, 2020). One of the key aspects of Oslo's innovative approach is its focus on sustainable transport solutions. Therefore, the port has invested in electric and hybrid ferries, as well as shore power facilities for ships, reducing emissions and promoting clean energy use (Port of Oslo, 2023). Similarly, the company ECO Subsea has developed an innovative solution for cleaning the hulls of

ships without using chemicals. The solution has proven to be effective and eco-friendly, minimizing the risk of marine pollution (Siem Offshore, 2022). In addition, the port has supported the development of new companies in the blue economy through its incubator programs which provide funding and support for start-ups in the sector.

Another important aspect is the port's collaboration with various stakeholders. For example, the Port of Oslo has partnered with the startup company REV Ocean to establish the world's largest marine research vessel (Kongsberg, 2020). The vessel will be equipped with cutting-edge technology, including sensors that detect and track plastic pollution in the seas. The research vessel aims to promote scientific research that will lead to the development of new strategies for reducing plastic pollution in the seas. Port authorities have also established partnerships with research institutions, industry players, governmental agencies, and NGOs to develop innovative solutions to reduce marine plastic pollution. For example, they have worked with the Norwegian University of Science and Technology (NTNU), University of Oslo, and a start-up called Blueye Robotics to develop an underwater drone-based system to monitor plastic waste in the port area (P. Smith, 2018). These drones can provide valuable data to scientists and policymakers to understand the extent of the problem and develop strategies to tackle it. Oslo's port city ecosystem also has a wide range of networks that facilitates the exchange of knowledge, talent, expertise, and resources among stakeholders. For instance, The Ocean Opportunity Lab (TOOL) is a community platform model that allows the automated matchmaking of global innovators in the ocean industries (TOOL, 2021). This platform provides access to the same global networks and resources and brings together entrepreneurs and established actors who wish to explore ocean opportunities and contribute to the SDGs<sup>17</sup>. Overall, port has taken some important steps and initiatives towards the blue economy but the lack of the physical space within the port makes it difficult to attract a lot of consortium and new entrepreneurs that may desire to do business and invest in blue economy projects there.

#### 4.2.3 Resources and Financial Capital

The Oslo port ecosystem has a range of resources available to support the blue economy, including infrastructure and facilities. The city of Oslo has invested in infrastructure that supports sustainable transportation and waste management. For example, shore power facilities have been installed that allow ships to turn off their engines at the port while reducing emissions and air pollution (Port of Oslo, 2023). Additionally, the port region has implemented innovative waste management systems, promoting circular economy principles through the establishment of a waste reception facility, where all waste from ships is collected, sorted, and recycled. This

initiative has helped reduce the amount of waste that ends up in the ocean contributing to a cleaner and healthier environment. Similarly, port has invested in equipment such as floating trash collectors and cleaning boats, which help to remove plastic waste from the water but also underwater cameras have been implemented to monitor the amount of plastic waste in the water and identify areas that require cleaning. These initiatives have been proven to be quite successful.

The Oslo port ecosystem has access to several funding sources to support initiatives related to the blue economy. One of the main sources is the Norwegian government, which provides financial support for research and development projects related to the blue economy (Norwegian Ministry of Foreign Affairs, 2016). For example, the government's Green Shipping Program provides funding for projects that reduce emissions from ships and increase energy efficiency (Norwegian Ministry of Climate and Environment, 2019). MARFO is another fund that the state grants to the port of around 3 or 4 million EUR dedicated to initiatives on plastic (Norwegian Centre against Marine Litter, 2022). Port also has access to EU funding, which is available for projects related to sustainable development and environmental protection. Specifically, the EU funded approximately USD 1.1 million to the port in 2020 for a project called "Marine Clean-up Technology," which aims to develop innovative solutions for cleaning up marine plastic waste (The Mayor EU, 2020). Private investment is also an important source of funding, In fact, port of Oslo receives around 30 million per year from a cluster of private sector retailers called Retailers Environmental Fund and all that money is allocated to prevent marine plastic (Miljøfond, 2020).

### 4.3 San Diego port ecosystem

#### 4.3.1 Profile and policy objectives

San Diego in California is a bustling port city with a thriving maritime industry. The port authority in San Diego is a public agency based on partnerships that oversee the development and management of the San Diego Bay and the surrounding waterfront. Port has set ambitious policy objectives and is committed to promoting sustainable practices and economic development, with a particular focus on blue economy initiatives as it champions the safekeeping and environmental care of diverse ecosystems. The Port of San Diego's Blue Economy Strategy focuses on six core industries: commercial and recreational fishing, maritime technology, aquaculture, blue tourism, offshore renewable energy, and coastal infrastructure. Additionally, the port oversees the preservation of land, air, and water through GHGs reduction (zero emissions by 2035), water conservation, plastic waste management and responsible business practices (Port of San Diego,

2021). Every year, environmental goals are defined and measured to evolve environmental initiatives, ensuring San Diego Bay remains a vibrant resource and contributes to a remarkable way of life for visitors and residents for generations to come (Port of San Diego, 2022). In addition to that, port had some discussions with the state about setting mandatory regulations about the wise use of plastic and particular ways of preventing ocean plastics. It is also worth mentioning that the port has been recertified and ranked in the top ten percent of North American ports in the Green Marine program for the maritime industry with an average score of 4.3 out of 5 across all categories (Port of San Diego, 2022).

#### 4.3.2 Innovation, Entrepreneurship and Networks

In terms of innovation and entrepreneurship, the Port of San Diego has achieved significant progress in developing and deploying new technologies and business models. Port of San Diego is classified as the cutting edge in terms of technology solutions as each company of the incubator is innovating and creating a first-of-its-kind technology. First and foremost, the port has created the Blue Economy Incubator program (BEI), including partner Zephyr Marine; a company that focuses on marine debris removal in San Diego Bay. The aim of the program is to support startups and entrepreneurs in the blue economy sector, providing access to resources such as office space, mentorship, and funding opportunities. The BEI program seems to be very successful, as 9 startups have already benefited from being able to launch their projects. Another innovative initiative of the port is the partnership with local startups to test new aquaculture technologies, such as floating seaweed farms and land-based recirculating aquaculture systems while also has deployed a network of environmental sensors to monitor water quality and support sustainable fishing practices. At the same time, port authorities have launched several pilot projects to test renewable energy technologies, such as a microgrid system that combines solar power and battery storage at the Tenth Avenue Marine Terminal (Port of San Diego, 2022).

The Port of San Diego has also mobilized a robust network of partners to support its blue economy objectives. Several partnerships are established with regional stakeholders, such as universities, research institutions, and industry associations, to leverage their expertise and resources. For example, the Port has partnered with the Scripps Institution of Oceanography to develop and test innovative technologies for the blue economy, including autonomous underwater vehicles (AUVs) and marine sensors. Additionally, port supports a lot of research with universities and is quite interested in microplastics issues related to the food chain and how it is affecting human health.

### 4.3.3 Resources and Financial capital

The Port of San Diego has allocated a significant amount of money to aiding in the Blue Economy Strategy's execution. A budget of \$87.4 million was approved by the Port in 2021, with a sizable part set aside to fund blue economy initiatives (Port of San Diego, 2020). The National Oceanic and Atmospheric Administration (NOAA), the California Energy Commission, and the California Department of Transportation (Caltrans) are just a few of the private and public organizations with which the Port has partnered and received extra funding (Port of San Diego, 2019). Port uses public funding to support start-ups and invested in total 1.6 million in pilot projects with durations ranging from 1 to 5 years, depending on the needs of the companies. In terms of resources, the Port of San Diego has invested in developing critical infrastructure and facilities to support the blue economy. For instance, a "shore power" program has been implemented, which allows ships to plug into onshore electrical grids while docked, reducing emissions. The development of programs "Green Port" and Climate Action Plan includes initiatives such as stormwater pollution prevention program, dredging management plan, and habitat restoration projects which aim at reducing GHGs emissions and addressing local vulnerabilities to climate change (CTSD Annual Report, 2022). Last but not least, the port has also taken care of establishing training programs where they educate port employees on waste management practices but also about the importance of making sure that there is no access to litter in the oceans.

## 4.4 Barcelona's port city ecosystem

### 4.4.1 Profile and policy objectives

Port of Barcelona is the primary commercial port in Catalonia and one of the most important ports in the Mediterranean. Port plays a crucial role in promoting trade and commerce between Europe, Africa, and Asia by providing employment opportunities for the locals of the port-city region. Recent years have seen a significant shift in policy priorities, with an emphasis on advancing sustainable economic growth and maximizing the potential of the "blue economy" in the context of Barcelona's port environment. The port has been pursuing a variety of goals in this respect, such as developing and updating its infrastructure, encouraging the creation of new technologies, business models, and building alliances and partnerships with stakeholders in government, business, and academia. Moreover, the port has invested in new facilities and equipment, such as a new rail terminal and a fleet of electric vehicles, as well as in initiatives aimed at reducing emissions and improving the efficiency of operations (Port of Barcelona, 2022a). The port has also developed a range of incentives to encourage the use of cleaner fuels

and technologies by shipping companies, including discounts on port fees for vessels with low emissions and a Green Shipping Fund to support the retrofitting of ships with environmentally-friendly technologies (Port of Barcelona, 2020).

#### 4.4.2 Innovation, Entrepreneurship and Networks

In addition to its efforts to promote sustainable transport and logistics, the port has also been working to foster innovation and entrepreneurship in the blue economy. One key initiative in this regard is the Port Challenge, an annual competition that invites startups and entrepreneurs to develop new solutions to address challenges facing the maritime industry (Port of Barcelona, n.d.). The port has also established partnerships with academic institutions and research organizations to support the development of new technologies and business models, such as the Maritime Innovation Hub, a joint initiative with the Barcelona City Council and other partners to promote innovation in the maritime sector and support the development of digital solutions for port operations and logistics (Port of Barcelona, 2022b). Another innovative action is the use of drones in order to provide more accurate and efficient surveillance, improving the port's ability to prevent and respond to pollution incidents. The company AeroTools UAV provides drone services to the port, helping to monitor maritime traffic and detect potential pollution incidents. At the meantime, incubator programs Blue-Up and this year port introduced CreaBlue are present and financed by the Port Authority in order to provide support for the creation and growth of the blue economy while Blue Bio Value program, an accelerator program for start-ups in the blue bioeconomy sector provides support and resources to early-stage companies working on sustainable solutions in areas such as biotechnology, aquaculture, and renewable energy. Finally, the port has been actively mobilizing networks and partnerships to support its objectives in the blue economy. This includes partnerships with other ports and industry associations to share best practices and collaborate on initiatives, as well as collaborations with startups and other stakeholders to develop innovative solutions to industry challenges (Port of Barcelona, 2022c).

#### 4.4.3 Resources and Financial Capital

To support these initiatives, port has secured significant funding from a variety of sources, including the European Union's Horizon 2020 program and the European Investment Bank. For example, the port was awarded €4 million from Horizon 2020 to develop a pilot project for the electrification of its container terminal, and a further €6.5 million from the European Investment Bank to support the expansion of its rail infrastructure (Port of Barcelona, 2019; Port of Barcelona, 2020). Private sector companies, such as banks and investment firms, provide

funding and support in the port ecosystem. For instance, CaixaBank has invested in projects related to the blue economy and sustainability, such as renewable energy, circular economy initiatives, and green bonds. The Barcelona Port Authority also issued a green bond in 2018 to finance sustainable projects. In terms of resources and infrastructure, the port has a well-equipped infrastructure with a range of facilities and services to support the needs of businesses operating in the blue economy. These include specialized terminals for handling containers, bulk cargo, and vehicles, as well as facilities for cruise ships, ferries, and other passenger vessels. More specifically, a pneumatic system for the transport of solid waste is implemented to minimize the manual handling of waste and reduce the risk of littering. Port also has invested heavily in modern equipment and specific machinery for the proper handling of hazardous waste, which has contributed to reducing the risk of spills or accidents, and thereby mitigating the impact of marine plastic pollution. In the meantime, the existence of efficient road and rail connections within the port ecosystem reduces the need for transport by road, which can contribute to air pollution and plastic littering. The availability of a skilled labor force is also a critical aspect of the port ecosystem. The port of Barcelona has a highly trained and experienced labor force that understands the importance of protecting the marine environment and contributes to the blue economy enforcement.

The above-mentioned case studies explained the ways and described the initiatives taken in which the chosen port cities strive to develop into flourishing innovation ecosystems in stimulating the blue economy. Each port authority showed to have distinct characteristics and its own unique approach in how to orchestrate the ecosystems and unlocking shared value for businesses, communities, and port citizens. The table below depicts a general overview of the four port ecosystems and assesses the ports based on the following yardsticks or elements: traction in innovation and entrepreneurship, resources available, access to financial capital, the mobilization of networks and programs to facilitate blue economy development and the policy objectives that are set.

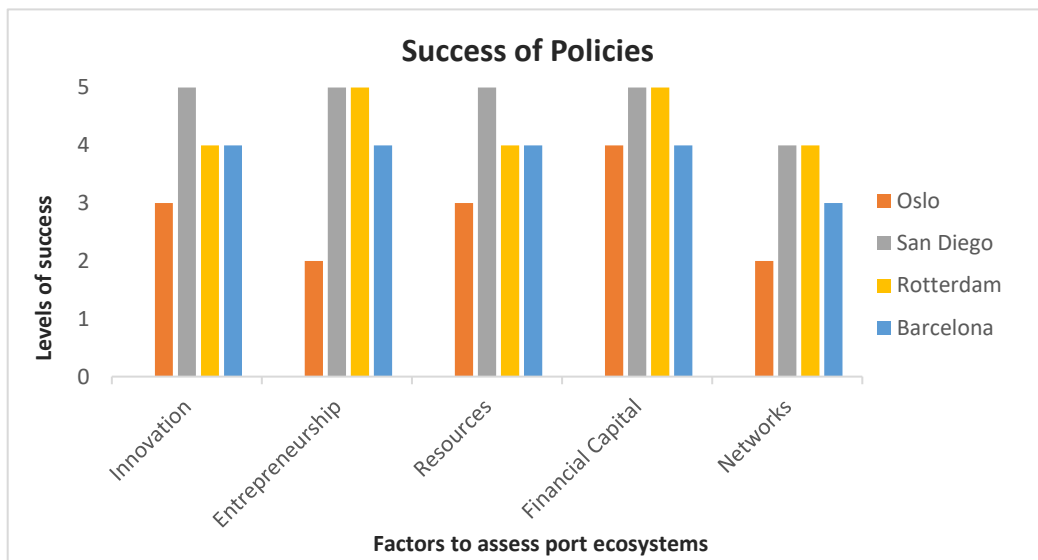
**Table 1.** Overview of the main findings from case studies (Primary Empirical Data)

TRACTION	Port of Rotterdam	Port of Oslo	Port of Barcelona	Port of San Diego
Innovation & Entrepreneurship	<ul style="list-style-type: none"> <li>- Strategic location</li> <li>- High competition</li> <li>- Many stakeholders</li> <li>- High possibilities to connect port with innovations and digital technologies (digitalisation, AI, blockchain, IoT etc.</li> <li>- Cluster of companies &amp; partnerships</li> <li>- Integration of triple helix concept</li> </ul>	<ul style="list-style-type: none"> <li>- Many but small scale initiatives (Cleanup days) and volunteering (divers) to collect ocean plastics</li> <li>- Electric boats, autonomous drones, smart underwater plastic collector bins</li> <li>- Smaller home market</li> <li>- Pressure for start-ups to work, a lot of competition because of the lack of space, small in size port</li> <li>- Lack of consortiums</li> </ul>	<ul style="list-style-type: none"> <li>- Recent actionability on sustainability and blue economy</li> <li>- Difficulty in attracting talent</li> <li>- Many start-ups, enterprises</li> <li>- First steps of triple helix integration (research centers and institutions, innovation labs, companies)</li> </ul>	<ul style="list-style-type: none"> <li>- Many stakeholders and many start-ups</li> <li>- Proactive governments and port authorities</li> <li>- Strategic location</li> <li>- Strong interactions between business, port authority - university - research (triple helix concept)</li> </ul>
Resources Available	<ul style="list-style-type: none"> <li>- Focus on training programs for waste management practices</li> <li>- Experienced labor force</li> <li>- Resilient infrastructure (campuses, simulator centers, test facilities, field and living labs)</li> <li>- Expansion of port space to maximize capacity</li> <li>- Shore power installation to connect ships with electricity</li> <li>- XYCLE (plastic recycling plant)</li> </ul>	<ul style="list-style-type: none"> <li>- Scarce space capacity prevents investments in facilities and deteriorate the smooth operations in the port area</li> <li>- Shore power installation to deliver electricity to the ships</li> <li>- Waste facilities and necessary equipment, resilient infrastructure</li> <li>- Societal programs</li> <li>- Close proximity between port and city (coexistence not functions always)</li> </ul>	<ul style="list-style-type: none"> <li>- Skilled workforce</li> <li>- Strong focus on training programs for waste management practices</li> <li>- Machinery for hazardous waste</li> <li>- Electrification of docks</li> <li>- Insert digitalisation and innovative technologies</li> </ul>	<ul style="list-style-type: none"> <li>- Electrification of the terminals</li> <li>- skills on agenda for port workers</li> <li>- Resilient infrastructure, modern facilities</li> <li>- in the cutting edge in terms of technology solutions</li> </ul>
Access to Financial capital and Instruments	<ul style="list-style-type: none"> <li>- Best practices of private funding (angel investors)</li> <li>- Banks: EIB, ABN AMRO, Rabobank, ING</li> <li>- Venture Capital, Green Bonds</li> <li>- Rotterdam Port Fund, Mainport Innovation Fund</li> <li>- High financial support from the City of Rotterdam and Ministry of Environment &amp; Infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>- Funding is present</li> <li>- Cluster of Private Sector Retailers: The Norwegian Retailers Environmental Fund</li> <li>- State fund : MARFO</li> <li>- WWF</li> <li>- Ministry of Climate and Environment</li> <li>- City of Oslo</li> </ul>	<ul style="list-style-type: none"> <li>- Banks: CAIXA, EIB</li> <li>- EU finances the collaboration of the port in some projects</li> <li>- Green Bonds</li> <li>- VC from private investors</li> <li>- City Hall</li> </ul>	<ul style="list-style-type: none"> <li>- Enough funding available dedicated to blue economy initiatives</li> <li>- Access to VC is high</li> <li>- Plastic Solutions Fund</li> <li>- Green Bonds</li> <li>- Port Authority</li> </ul>
Mobilization of networks and programs	<ul style="list-style-type: none"> <li>- Platform Zero</li> <li>- Port XL (accelerator)</li> <li>- CIRCULAR DELTA (triple helix network)</li> <li>- Young Ship Rotterdam, Port Association Rotterdam, Venture Café</li> <li>- Local ties with knowledge institutions</li> <li>- Maritime related conferences, events and workshops in Rotterdam Ahoy</li> </ul>	<ul style="list-style-type: none"> <li>- TOOL network connects many entrepreneurs with investors</li> <li>- Norwegian Centre against Marine Litter</li> <li>- The Norwegian Fishermen's Association</li> <li>- Knowledge sharing</li> </ul>	<ul style="list-style-type: none"> <li>- Many events and conferences organised regarding the circular and blue economy</li> <li>- Launch of campaigns</li> <li>- Blue Bio Value</li> <li>- Blue Growth Community</li> <li>- BlueUP, CleaBlue (incubators)</li> </ul>	<ul style="list-style-type: none"> <li>- Blue Economy Incubator Program (Pilot project)</li> <li>- Sustainable Ocean Alliance</li> <li>- Green Port Program</li> <li>- Students and broader communities get education how to manage plastic waste and participate in clean-ups organized by NGOs</li> </ul>
Port authority objectives in policy docs	<ul style="list-style-type: none"> <li>- Focus on profitability and productivity</li> <li>- Embraces all SDGs but more emphasis is on the energy transition , reduction of CO2 emissions, electrification of vessels.</li> <li>- Marine plastic waste initiatives at a early stage, niche market for attracting investors and for the port</li> <li>- Ocean plastics not considered as the most serious environmental issue port is facing</li> <li>- Attention to ballast water treatment and cleaning disposal of from ships</li> <li>- Dutch state lagging behind to actualise mandatory regulations about marine litter</li> </ul>	<ul style="list-style-type: none"> <li>- Circularity policies and ambitious environmental targets in line with SDGs</li> <li>- Reduce 50% plastic waste by 2025</li> <li>- Reduce carbon emissions to 85%</li> <li>- The issue of the increasing accumulating rates of marine plastic a high priority for the port</li> <li>- Not plastic free yet, but in the right direction</li> </ul>	<ul style="list-style-type: none"> <li>- Commitment to SDGs</li> <li>- Focus on decarbonisation and energy transition</li> <li>- Marine plastic prevention not a priority</li> <li>- PAs not taking leadership and the responsibility to clean waters</li> <li>- Conflicting interests sometimes regarding port policy objectives</li> </ul>	<ul style="list-style-type: none"> <li>- Net zero CO2 emissions by 2035</li> <li>- Accelerate energy transition</li> <li>- Main priority the blue economy</li> <li>- Port objectives in line with policy frameworks</li> <li>- Embraces all SDGs</li> <li>- Discussion with the state for setting mandatory regulations about ocean plastic prevention</li> </ul>
"UNICORN" STAR EXAMPLE	The Ocean Cleanup	-	-	-



Based on the information collected through the case studies, we created below diagram to better comprehend how each port ecosystem function and in which sectors/elements the policies applied are more effective. Therefore, the figure below quantifies the levels of success of policies for each factor used during the case studies analysis (innovation, entrepreneurship, resources, financial capital, and networks) in order to assess the four port ecosystems. The highest level of success to policies corresponds to a score of 5 and the lowest relates to a score of 1. From the case studies analysis, we explicitly noticed that in each of the five elements port of San Diego scored higher, meaning that the policy objectives and strategic plans are in line with the blue economy targets and all elements for success are present while Port of Oslo had the lowest rating in all factors. Port of Rotterdam and Barcelona in terms of innovation, digital technologies, and entrepreneurship while showed a high performance, the purpose of these investments is not to minimize ocean plastic pollution or to a broader extent enforce the blue economy. On the contrary, the focus is on the energy transition and digitalization of the port. Therefore, the policy objectives and strategic plans of these two ports are not in line with the blue economy targets and consequently, not very successful in order for these ports to be considered as blue economy leaders.

**Figure 2.** Overview of the success of policies between factors per port ecosystem



## 5 Interviews

In this research in order to analyse and validate the above-mentioned elements of the port ecosystems, it was important to gather qualitative-textual data. Therefore, in depth semi-

structured interviews were conducted to provide insights into the strengths and weaknesses of each ecosystem, as well as identify opportunities for improvement and growth. In order to avoid biased results, 8 semi-structured interviews were carried out between March and April, 2023. Participants were chosen strategically from three main categories of actors: 6 of them were representatives of Port Authorities in the port regions of Rotterdam, Oslo, San Diego, and Barcelona, one participant was the founder of the incubator programs Platform Zero and Port XL, which support start-ups in developing or applying radical innovations in blue economy, and the last actor involved was the founding Director of the NGO Clear Rivers that stimulates the blue economy and more specifically the prevention of marine plastic pollution. The interviews with the participants were held through online meetings, phone calls, and mail exchanges. Face-to-face communication and discussion was not possible since some of the interviewees were not residents of the Netherlands or even Europe. Concerning these main groups, as mentioned above, the interviews were carried out following a guide. However, since the participants belonged to different categories, they received slightly different questions in order to obtain a deeper understanding of the issue and impacts from three different angles: stakeholders, start-ups, and the port authorities of each port. Nevertheless, we noticed that the results obtained from the interviews considering actors of the same category matched, which is already indicating a saturation point of the research. The interviews were carried out for three major reasons: testing and validating whether the research, analysis, and results of port ecosystems obtained from the case studies previously discussed could be considered realistic, understanding the reasons behind the lack of regulations and concern regarding the topic and suggesting possible measures that could be applied to limit marine litter caused by shipping activities and port operations and its effects in the ecosystem. In that way, we would be able to obtain more meaningful results and a clearer and more holistic overview of the participants' role, their performance, and the dynamics of these interactions to address the issue. Since not all the interviews were possible to be recorded, a summary of the interviews, the participants' key messages, and their main insights will follow at the ending part of this project.

There are several methods for analysing interview transcripts. The most appropriate method based on our research question, the type of data collected, and the theoretical framework of our study was the narrative analysis. This type of analysis is useful for exploring how people construct and communicate their experiences and can provide insight into how individuals understand and make sense of their lives (Graneheim & Lundman, 2004). The reason why I used narrative analysis is to highlight important aspects of interview respondents' experiences,

knowledge, and expertise that can attribute to the validity of results regarding our research topic. Since the data collected derive from interview transcripts and are classified as textual data, I followed a specific procedure on how to refer to the quotes of the interviewees. Therefore, I used an Excel document where I gathered all my data. In particular, the key messages or quotes in the interview transcripts can be firstly transferred in our thesis document and then referred to or cited through the code texting instead of using the interviewee's name. To elaborate a bit further, the left digit in between the brackets will refer to the number of the interview stated in the Excel sheet and the second digit will correspond to the number of the quote in the interview transcript.

## 5.1 Main Findings from Interviews

### 5.1.1 Port of Rotterdam

Based on the findings, in Rotterdam, several public and private investments have been made to realize an innovation ecosystem which is necessary for promoting and stimulating the blue economy. The port innovation ecosystem has been enriched with various field and living labs, simulator centers, test facilities, educational campuses and start-up incubator centers. Possibilities to connect the port sector with digital innovations and technologies turned out to be large and local ties with knowledge institutes and research centres were vitally important to facilitate this process. However, the focus of these investments is centered on innovations related to the energy transition, decarbonisation, electrification of vessels and acidification of waters and leaving out the contribution to all the SDGs such as blue economy [1,2]. This can be justified by the interview that Rotterdam Port Authority considers ocean plastics as one of the smallest problems in the oceans and not a serious concern that directly affects the port operations. At this moment, the market for entrepreneurs to invest in preventing marine plastic pollution and notably at the port of Rotterdam is very niche, meaning that there is no potential for clients nor a good business to invest money in [1,4].

According to the interviews, it proved that the port offers the best practices of private funding. Nevertheless, plastic waste start-ups are mainly driven and supported by NGOs or by the state, which is not sufficient to make them grow fast and scale up [1,5]. Such start-ups struggle to create a business model. The start-up Ocean Cleanup is the exception to the rule and surprisingly is performing and doing great so far, but without having a business model in the long term it will be difficult to keep attracting funding [1,6]. Based on the interviewees' views, ports are at a very early stage and just learning to work with start-ups compared to companies

such as Coca Cola, Facebook or Unilever that are accustomed to working with start-ups on a daily basis [1,3]. Meanwhile, numerous start-ups or NGOs attempted to work at the port by approaching port authorities and submitting ideas, but there was no response and the proposals were turned down [7,47].

In terms of policy frameworks and regulations, there is some more attention on ballast water treatment, and cleaning the disposal of from the ships [1,9]. Ports are typically designated to just comply with the minimum requirements and without undertaking further responsibilities and actions to promote the healthiness of oceans and develop cleaner ports. Similarly, the reasons why the Dutch government is still lagging behind to actualize mandatory policies regarding marine litter were: budgetary reasons, the lack of exposure, not enough media attention, and not sufficient knowledge about it and the risks it provokes for the future [7,37]. Therefore, it is of crucial importance for the local and national organizations but also port authorities to put the marine plastic pollution issue on their agenda [7,38].

### 5.1.2 Port of Oslo

For the Port and City of Oslo, I found that blue economy and more especially marine plastics prevention is a priority. Port follows the Action Plan of Municipality and based on the findings, has invested in 3 electric boats with the aim to collect the marine debris, sort it out and lastly deliver it to the right facilities [3,15]. Initiatives that have been taken include: small-scale entrepreneurs like Clean Sea Solutions using autonomous drones to clean the water, NGOs that organize events such as Clean Up Action Days, and human divers deployed to pick up plastic waste voluntarily, but these of course are not considered as the optimal solutions [3,16]. Port in cooperation with the company Spilltech developed environmental technologies such as underwater automated marine debris collector bins with lenses that detect waste that go down to the river and pick up the underwater garbage [4,19]. In terms of efficiency, they did not prove to be as efficient as expected and are quite costly to use them regularly [4,19]. Overall, due to the fact that the port is not big in size makes it difficult to invite lots of consortia [4,20]. In Norway the market is also small and less mature; there is not a dedicated place for start-ups to work, so therefore, it's not a good business for entrepreneurs to attract and innovators to invest in [4,20]. One challenge we detected that the port of Oslo faces with regards to blue economy initiatives is the location of the port, being in the middle of the city brings easy access for people to Oslo Fjord [3,46]. Usually, this coexistence works well but sometimes can create conflicts and dangerous situations between the sea trade and the commuting people who want

to be free in the oceans where ships are coming in [3,46]. According to the Port Authority representative, it is not allowed to fish in the Fjord area due to the problem of nitrification, all the emissions and waste coming from other regions make the Ph balance of water not at the right levels. However, buffer zones and artificial reefs are established to improve marine biology and enhance the nature restoration around the port. Another challenge that's worth mentioning is the lack of space in the port creates a lot of pressure in terms of who out of the 1.5 million people will get access to this area.

With regards to funding, port authority receives 30 million per year from the private sector called the Retailers Environmental Fund and all that money is invested to prevent marine plastics [3,18]. MARFO is another fund of 3 or 4 million that the state grants to the port dedicated to initiatives on plastic. Port has invested a lot in having a resilient infrastructure with quite modern facilities [3,18].

There are no challenges in the policy frameworks as port policies are in line with the municipality SDGs targets (Zero CO<sub>2</sub> Emissions, Climate Strategy Plan, reduction of the use of plastics etc.) and all policy agencies are proactive, and supportive while there is a good communication and cooperation to move forward and push customers in the same direction. Respondents also emphasized the lack of regulation in plastic packaging or generally the use of plastics produced and pointed out that this issue needs to be supervised. Regulations on marine plastics exist but when the volume of plastics is too large that it is inevitable to not reach the oceans [4,22]. To summarize, the city's political ambitions are in line with the port authority's objectives for the blue economy, and the necessary funding and infrastructure are in place [4,21]. The problem lies in the lack of consortiums and companies of the private sector due to the constrained physical space in the port that makes it difficult to attract people and accommodate them to start a business there [4,20].

### 5.1.3 Port of San Diego

For the port of San Diego blue economy marks one of the main priorities and has been quite active by enforcing it since 2015 [2,10]. Indeed, as a catalyst for the blue innovation port every year makes sure that there is funding available to promote the blue economy targets such as environmental remediation, improving water quality, marine debris removal and sustainable aquaculture [2,12]. Notably for 2022, according to the results \$1.6 million spent in funding to support the pilot projects. In order to support innovation and entrepreneurship, port created the

Blue Economy Incubator (BEI) program which provided pilot project facilitation to help start-ups demonstrate their technology in the port environment, including partner Zephyr Marine a company that focuses on marine debris removal in San Diego Bay. Based on the main findings, the BEI program proved very successful as 9 start-ups have already benefited from being able to launch their projects, providing them with funding, permitting, and finding locations to establish their activities [2,11]. An important insight was that before the port approves a proposal from a start-up, the port authority first evaluates the TRLs (method to estimate the maturity of technologies during the acquisition phase of a program) because otherwise, it would be difficult for ports to engage with very early stage companies that are not mature enough and just have the innovative ideas [2,13]. The big challenge for start-ups discussed during the interviews was the fierce competition and the limited physical space they face within the port.

Port of San Diego is classified as cutting-edge in terms of technology solutions as each company of the incubator is innovating and creating a first-of-its-kind technology [6,28]. Other companies within the port are using these technologies not just to collect marine plastic but also to reuse it and recycle it into more sustainable building materials [5,24]. In the next couple of years, the interviewee supports that shore power will be expanding for vessels to plug in and port of San Diego will be the first one to have an electric crane in North America. Additionally, the port supports a lot of research with universities and is quite interested in microplastic issues with the food chain affecting human health [5,23]. Equally important for the port are the partnerships with a dozen of NGOs that focus on clean-ups, where group of school or university students and broader communities meet together and get environmental education on how to manage plastic waste and keep San Diego Bay as clean as possible [6,30]. The interviewee provided a negative response about the police framework challenges, stating that port's structure enables to apply policies perfectly and the fact that port is uniquely positioned plays a leadership role in advancing blue economy opportunities through the different roles port is serving, as landlord, operator, regulator and more importantly, environmental steward [2,14]. Emphasizing on our topic of interest, respondents' views showed that marine debris removal equipment seems to be quite expensive and that generally there is a limited budget for it and nobody takes the responsibility to take care of it. Hence, it's difficult to find the right revenue schemes that makes it attractive for the ports to invest in [2,14]. Furthermore, during the conversations, it was argued that more enforcement in regulations regarding ocean plastics is needed specifically, when it comes to how much plastic should be produced and the urgent use of recyclable materials, because when plastics reach the ocean it becomes more difficult to resolve

this issue. Consequently, being proactive in setting up mandatory regulations would definitely help mitigate the issue. The participants concluded that the overall port ecosystem of San Diego is robust and all the elements are present to support new industry development, innovation, and technology adoption. Taking into consideration all above-mentioned statements, I can conclude that the elements for success in fostering the blue economy are present, as the port of San Diego will keep on supporting start-ups for years and include the blue economy as a part of their future plans.

#### 5.1.4 Port of Barcelona

The port of Barcelona is aware of the potential problems caused by marine plastic pollution. Currently, it is not one of the main priorities. Indeed, based on findings, the parties' attention at the moment is focused on the reduction of GHGs emissions and the energy transition to accelerate [8,39]. An interesting insight from the interview was a survey conducted internally and filled in by the port community aiming to identify what are the most crucial environmental issues concerning the port. The results showed indeed that marine plastics matter was below average in the rankings. Notably, following the Energy Transition Plan port prioritized and spent an incredible amount of money, approximately 110 million EUR investing in projects about the electrification of wharves [8,39]. In terms of innovation and entrepreneurship in the port, incubator programs Blue-Up and this year port introduced CreaBlue are present in order to provide support for the creation and growth of the blue economy [8,40]. Funding for such innovative ideas, pre-commercial and commercial projects are mainly provided by Port Authority, and City Hall while the participation in several projects occasionally is financed by the EU Community [8,42].

Other small-scale innovative initiatives regarding ocean plastics are: companies that collect marine litter and convert it to raw materials for 3D printing, another turns marine litter into swimsuits while the other uses materials from outdated rescue boats to manufacture bags and back sacks. A big challenge discussed was the fact that hardware startups in sectors such as manufacturing, marine litter collection, and recycling are more difficult to scale up and develop within the port compared to soft start-ups [8,41].

Regarding the port policy objectives, interviewee asserted that sometimes it happens that conflicting interests may arise between economic growth, competitiveness, and environmental sustainability that port authorities struggle with where to focus on [8,44]. Similarly, it was argued that port of Barcelona complies with the minimum EU regulations and requirements, which it is

obliged to, and does not take further responsibilities by itself to resolve the environmental issues [8,45]. However, after the Strategic Plan Report of 2021, port authority has started to change mentality and has taken steps forward including social, economic and environmental sustainability in their agenda, emphasizing more on the blue economy issues.

## 6 Conclusions

Marine plastic pollution has become a pervasive environmental issue and is also one of the biggest threats to the health of the oceans and the blue economy. The impact it has on the blue economy cannot be overstated as it can harm fish populations, reduce the quality of seafood, and damage coastal tourism, among other economic activities. In addition, the cost of cleaning up plastic waste can be substantial and can impact port operations and supply chains. Therefore, the need to address and face the challenge of ocean plastic waste is urgent and requires immediate action, as plastic pollution crisis in the oceans continues to worsen. Port authorities worldwide should take the blue economy more seriously because it offers a pathway for sustainable economic growth while also preserving the health and integrity of the oceans and coastal ecosystems. To further elaborate, blue economy establishment is important as it encompasses a range of economic activities such as fisheries, aquaculture, tourism, renewable energy, and marine biotechnology. By investing in and promoting these activities, ports will benefit by creating jobs, supporting local economies, and contributing to the development of sustainable and resilient coastal communities.

### 6.1 Summary

In order to identify and determine to what extent at the moment port ecosystems contribute or not to the blue economy we chose the aspects of innovation, entrepreneurship, resources, networks, funding and policy objectives. These components were selected because they are key drivers and enablers of the blue economy. To be more specific, innovation is critical for the development of new technologies and practices that can promote sustainable economic growth while preserving the health and integrity of the oceans and coastal ecosystems. Entrepreneurship is crucial for the establishment of new firms and economic opportunities that can contribute to the blue economy while resources such as natural resources, human capital, and infrastructure are essential for supporting economic activities in the blue economy. Similarly, networks can facilitate knowledge exchange, collaboration, and the sharing of best practices, which can support innovation, entrepreneurship, and the development of sustainable economic activities. Lastly, funding is important for supporting the development and scaling



of sustainable economic activities in the blue economy, while policy objectives can provide guidance and support for the development of a sustainable and inclusive blue economy. Through the use of case studies and the interviews carried out, this research demonstrated that marine plastic pollution is a topic that is not thoroughly researched while the severity of the problem and its implications are still unknown for the general public community. From both case studies and interviews evidence gained that the chosen port ecosystems of Rotterdam, Oslo, San Diego and Barcelona strive to develop into flourishing innovation ecosystems in stimulating the blue economy and consequently, marine plastic prevention. However, the results showed that these prominent ports have distinct characteristics in terms of their management, policies, and initiatives for the blue entrepreneurship. As such, I anticipated that each port authority would have a different approach to enforcing regulations, imposing policies, outsourcing services, and facilitating trade. The answers on how port ecosystems perform, and how active are in fulfilling the blue economy goals were considerably different when I tried to answer our research question: "To what extent are the elements of the port ecosystems for success present for the blue economy."

To accomplish this, I conducted a critical assessment of port ecosystems on the basis of the case studies and also on the basis of interviews. By doing so, I made the validation through interviews more explicit. The critical assessment of the table below can be summarised and therefore provide an answer to our leading research question and sub-question that derives.

**Table 3.** Critical Assessment of the port ecosystems

Ports	Innovation	Blue Entrepreneurship	Resources	Financial Capital	Policy Objectives for marine plastics
Rotterdam	+++	0	++	+++	—
Oslo	++	0	+	++	++
San Diego	+++	+++	+++	+++	+++
Barcelona	+++	0	++	++	—

**Rotterdam:**

The table above and the data acquired for the thesis process support our observation that the Rotterdam Port Authority has made creating a strong innovation ecosystem a priority. Port provided the best practices of funding, but the investments made with those funds are concentrated on innovations connected to the energy transition, decarbonization, and electrification of ships, leaving out their contribution to other SDGs, such as the blue economy. I gave the port of Rotterdam a neutral rating in relation to blue entrepreneurship because there

were not many measures taken to advance the sector through initiatives. The data showed that no evidence was found on programs that actively support cleaner waters, therefore the situation is the same or even worse with marine plastic prevention initiatives. Numerous start-ups or NGOs attempted to work at the port by approaching port authorities and submitting ideas, but there was no response and the proposals were turned down. Port authorities do not see a potential for clients in this market. Due to the fact that the market for preventing ocean plastics is very niche and still unknown to most people, there are just a few entrepreneurs who are drawn to or desire to invest money in such businesses. The Port Authorities are aware of the risks and implications of plastics entering the oceans, but they are not willing or required to take more responsibilities to create cleaner waters. According to our findings about laws and regulations on blue economy, more attention has been placed on ballast water treatment and the cleaning of ships but the port still follows the regulations and complies with the minimum requirements. After analysing the Rotterdam port ecosystem, it is clear that all the necessary components for success exist, however, the emphasis is on investing in other environmental issues (energy transition, CO<sub>2</sub> reduction etc) rather than developing a sustainable blue economy. Therefore, the assessment indicates that the port of Rotterdam is not the best ideal illustration of how to develop and grow the blue economy initiatives.

### **San Diego:**

On the other hand, Port of San Diego is the perfect example to promote sustainable practices. For the port based on the interviews, all the environmental issues had the same importance and value. As such, port of San Diego takes a holistic and balanced approach on how to deal with these problems and embraces all the SDGs by managing the resources, ensuring that the water quality is clean and eliminating the carbon footprint with investments in electrification. Port showed that supports innovation and blue entrepreneurship through various initiatives while also ensuring that every year there is available funding to promote the blue economy targets. In the question of how port deals with policy frameworks, the representative of the port authority during the interview commented that port's organizational structure enables to apply them perfectly and the fact that is uniquely positioned to play a leadership role in advancing blue economy opportunities through the different roles port is serving, as landlord, operator, regulator and more importantly, environmental steward. Therefore, I can conclude that all the elements for success are present to make the port of San Diego a robust port ecosystem that will keep on supporting start-ups and include blue economy as a part of its future plans.

**Oslo:**

Port of Oslo was rated as average in its efforts of creating a sustainable blue economy and promoting a circular economy. More specifically, innovation and entrepreneurship are considered weak elements for the port because of the challenges that lie in the relatively smaller and less diverse home market. Based on the information gathered, only small-scale innovative initiatives are in place because there is a lack of the private sector and consortiums. Due to the fact that port is small in size, is unable to accommodate many entrepreneurs and support start-ups that desire to engage in such initiatives that can foster the blue economy. However, the necessary infrastructure, funding (public and private), and political ambitions are present to support the blue economy goals and also prevent marine plastic pollution. By investing in projects to expand the port and increase the space capacity, port would increase its competitive advantage and could set itself as a good example to follow.

**Barcelona:**

The case of Port of Barcelona is comparable to that of Rotterdam's case. Results revealed that the port has made investments in a number of initiatives designed to promote innovation and entrepreneurship. However, because the parties' attention at the moment is mainly focused on topics such as the energy transition, the renewable energy sources and the reduction of GHGs emissions, almost all of the funding has been allocated and invested in these areas. A small proportion of the budget is allocated for the blue economy enforcement and marine plastic prevention. Although the port is aware of the potential problems caused by marine plastic pollution currently, it is not one of the main priorities. When it comes to policies, port currently complies with the minimum EU regulations and requirements that is obliged to and does not take any further responsibilities on its own to resolve the environmental issues. However, with the implementation of its Strategic Plan issued in 2021, the port authority established more ambitious sustainable plans and has started to strike the balance between economic growth and environmental protection. We can draw the conclusion that, despite the fact that port of Barcelona contains these elements to promote and develop a successful and thriving blue economy, the current focus is not on ocean plastics prevention and enforcement of mandatory regulations regarding plastics use. Therefore, considering the results obtained, we can argue that Barcelona has the potential in the long run to develop into a port that actively supports the development of cleaner waters and a sustainable blue economy.

The general conclusion that can be stated here is that Port of San Diego is the ideal example for other ports to follow of how to develop and grow the blue economy opportunities and

initiatives. Similarly, Oslo showed that has the potential to become a hub center for the blue economy in the coming years by broadening its networks and clients in combination with investments in their infrastructure to expand the port and free up space capacity. Port of Barcelona and Port of Rotterdam do not have the blue economy as a strategy, however, they could learn from Port of San Diego and Port of Oslo. As a consequence, these two ports, Barcelona and Rotterdam cannot be considered as leaders of the blue economy establishment as the focus on their strategic plans and their policy objectives is on energy transition and decarbonization of the port. When we compared Rotterdam, Europe's largest port, to the three other port ecosystems, we discovered that the port of Rotterdam is the only one that does not have an explicit blue economy plan. Thus, the argument here urges the port of Rotterdam to incorporate and drastically include the blue economy establishment in its strategic plans, as it can only benefit the port in the long-run and help protect the health of the oceans while also promoting sustainable economic growth.

## 6.2 Recommendations

Based on our findings, the limitations that arise from analysing the international environmental frameworks with regard to addressing marine plastic pollution are defined by a lack of responsibility for pollution and fragmented approaches with a lack of compliance, liability and enforcement. Therefore, from a governance perspective, we recommend that stricter and mandatory regulations should be implemented on the production and disposal of plastic products. This could include bans on single-use plastics while at the same time promoting the development and use of alternative materials and products that have a lower environmental impact. I would also suggest increasing public awareness about the impacts of marine plastic pollution through education campaigns, workshops, and conferences but also engaging stakeholders in addressing the problem. Such initiatives could stimulate the incentives for companies to use more sustainable materials. In addition, I recommend the development and promotion of innovative technologies and solutions for the collection, reuse, and recycling of plastic waste. For instance, port authorities could implement waste management programs to encourage sustainable practices and reduce the amount of plastic waste generated by the port and its surrounding communities. Furthermore, they can educate stakeholders such as shippers, importers, and exporters on sustainable practices and the importance of reducing plastic waste. This can include providing information on the benefits of using eco-friendly packaging materials, promoting sustainable transportation options, and encouraging the use of reusable containers. Port authorities can also work closely with local communities to develop

sustainable waste management solutions. This can include partnering with local governments and NGOs to develop recycling programs, hosting educational events and workshops, and promoting sustainable behavior. Lastly, by monitoring and reporting on the amount of plastic waste generated by the port and its surrounding communities, port authorities can help identify areas for improvement and inform future sustainability initiatives.

After having analysed and extensively comprehended how port ecosystems function I am able to propose some solutions that need to be taken into consideration. Port authorities of all regions in order to achieve their policy objectives and sustainable targets towards the blue economy, should establish a dedicated incubation center for start-ups in the blue economy sector within the port area. This center should provide resources and support to help and facilitate start-ups to grow and develop, such as access to mentorship, funding, and networking opportunities. In the meantime, we suggest fostering partnerships between established port businesses and start-ups to promote knowledge sharing and collaboration. Encouraging the participation of start-ups in relevant events, competitions and conferences in order to pitch their ideas, showcase their work and network with potential investors and partners is also very critical. Additionally, we would also seriously consider the possibility of start-ups working with academic institutions and research centers to facilitate technology transfer and knowledge exchange between academia and industry. Last but not least, what would be beneficial for start-ups is to provide financial incentives and grants to support the development of innovative blue economy initiatives. This could include seed funding for start-ups, as well as grants for research and development in the blue economy sector and more specifically the marine plastic prevention. By focusing on these specific actions, it becomes obvious that port authorities in cooperation with national governments, environmental agencies and key stakeholders have the potential to curb the rates of marine plastic, recycle and use plastics in a responsible and sustainable manner and foster in that way the blue and circular economy.

### 6.3 Limitations and future research

Conducting research analysing the issue of marine plastic pollution and how port authorities can mitigate the issue by enforcing in blue economy had a number of limitations and difficulties, some of which we have tried to address. First, as we were interested in approaching the topic from a holistic overview, angles and perspectives, the participation of different actors was required. Due to time limits, we conducted only 8 interviews fact which made our sample not completely representative. However, I managed to interview people from different

categories of the business sector and consequently get a better understanding and a holistic view of our topic of interest. Another challenge faced while organizing and carrying out the interviews was avoiding biased results. The actors considered, consciously or unconsciously, answered the questions based on their interests. As we previously mentioned, this biased result was limited by interviewing actors belonging to different categories: Port Authorities representatives, start-ups, NGOs and key stakeholders. Another limitation of the interviewing process is that even though semi-structured interviews were carried out, the actors of the different categories were asked slightly different questions. This is to further understand the different views of the various actors on common topics and at the same time obtain a deeper understanding on topics strictly related to their specific businesses.

The four case studies of Port of Rotterdam, Oslo, San Diego and Barcelona provided a comparison and comprehensive analysis and significant insights of the port ecosystems in their efforts to foster the blue economy which can serve as a valuable resource for further research in the field of sustainable development in the maritime industry. Indeed, Blue Economy is an emerging policy and port authorities should be encouraged to colour their strategies, in a similar fashion as they did in the last decade with green port strategies. Port authorities all over the world should embrace all SDGs and more specifically, SDG 14 “life under water” and recognise their essential role in sustainable blue growth. Furthermore, our sample was comprised of a subset of blue entrepreneurs focused mainly on marine plastics. Future research could expand this to account for other marine-focused sustainable ventures, for example, those working on ocean renewable energy, fishing and aquaculture, and maritime transport.

There is growing political support and investment in the blue economy, and many innovations are being led by startups and small businesses in this field. Follow-up studies can build upon our work to identify the enabling environment for blue entrepreneurs in general by using a wider variety of case studies analysing other port locations with an intense actionability to blue economy initiatives. Lastly, another topic that would be interesting to examine and still under research is the problem of microplastics coming into the oceans from the port operations of industrial companies that are active in the port. A research analysis on microplastics could be interesting by testing the relation of microplastic with the food chain and how is this affecting the human health.

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## Appendix

### Transcription of Interviews

8 semi-structured interviews were carried out and the participants were chosen from three main categories: 6 of them were representatives of Port Authorities, one participant was founder of an incubator program that support start-ups, and the two other actors work in start-ups that contribute to the blue economy and more specifically to the prevention of marine plastic pollution. By choosing to conduct interviews from these categories and from 3 different angles: stakeholders, start-ups, NGOs and governmental perspective, we were able to get more meaningful results and have a clearer overview of their role, performance and the dynamics of these interactions. It is rational to mention that since the participants belonged to different categories, they received slightly different questions. Since not all the interviews were possible to be recorded, a summary of the interviews, participants' key messages and their main insights will follow below.

#### 1<sup>st</sup> Interview:

#### Stakeholder's category – Accelerator program (Rotterdam)

#### Questions:

- Can you provide me some examples, initiatives, partnerships that your company has undertaken to address the blue economy, and more specifically marine plastic?
- Do you think that there are any challenges in the policy frameworks that are established to fulfil these sustainable targets towards the blue economy?
- What are the potential challenges and shortcomings of the existing innovative blue economy related start-ups?
- Is the limitation of marine plastic a priority for the port authority?
- What do you think about the lack of mandatory regulation regarding marine plastic prevention?

The interviewees of this category include the founder of accelerator programs Platform Zero and Port XL with an experience of five years at the Rotterdam Port Authority as well. Those programs are aimed to accelerate entrepreneurship by building-up and investing in start-ups, help them to grow while also helping corporates to find the appropriate innovative start-ups to provide the funding. According to the interviewee, what is happening now in Rotterdam is that there is a

campus facilitated where start-ups, investors, corporates, governments and researchers meet each other and work on maritime, energy & climate tech-innovation sectors to reduce emissions, accelerate the hydrogen economy and so much more. The participant argued that they only do innovation that are related to the port economical cluster, because that is the potential for clients. Although they are building a company, the general purpose is very big for the community; having the desire to help Rotterdam grow and entrepreneurship grow faster, to create more unicorns and at the same time to accelerate climate-tech. Initiatives regarding marine plastic prevention are at a very early stage. RH Marine, for example, is a company that owns litter-seeking robots to clean the waters. What interviewee noted is that help and support will be provided to this company to find clients and gain recognition both domestically and internationally but so far nothing has been initiated and these are only plans for the future. Blue economy enforcement is essential for the port but ocean plastics which is a component of BE is considered a very niche market to focus on, meaning that the connectivity of the Port of Rotterdam with the marine plastic prevention initiatives is very small. An interesting insight is the problem of microplastics, not the plastics we can see in the floating waters but plastic we cannot see and are coming into the oceans from the port operations of companies that are working in the port. This is a problem where people do not have much knowledge about and a comprehensive research around it should be considered. Many start-ups that have focused on ocean plastics struggle to create a business model and that is a real challenge for them. Having a business model helps start-ups scale up, however, most of them are lacking one. Based on the interviewee's opinion, such start-ups are now mainly driven by NGOs or the state support which is not sufficient to make them grow and scale up. Ocean CleanUp, for instance, is an exception but without a business model in the long term it will be difficult to keep attracting funding. Generally speaking, ports are just learning to work with start-ups. Coca Cola, Facebook or Unilever for example are used to work with start-ups on a daily basis but ports neither do that regularly nor are familiar with working with start-ups. Regarding Rotterdam Port Authority policies on blue economy, regulation and more attention has been made on ballast water treatment and the cleaning of ships but still the port simply follows the regulations and comply with the minimum requirements. There are not many programs that actively stimulate cleaner waters. Hence, there is little regulation and no enforcement, and even if there is regulation, it is not being policed or if it is being policed fines are too low. A last comment from the participant declares the necessity of the enforcement of regulations and the willingness of the port to take more responsibilities and initiatives to stimulate and create cleaner ports.

### **Key messages and insights**



- At this moment, the market for entrepreneurs to invest in marine plastic prevention at the port of Rotterdam is very niche, meaning that there is no potential for clients nor a good business to put money in.
- Ports are just learning to work with start-ups, they are at a very early stage yet.
- The Port Authority has invested a lot in innovation, but the focus of these investments is more on decarbonization, the energy transition acceleration, acidification and noise pollution. As such, port considers marine plastic as one of the smallest problems in the oceans and not a serious concern for now.
- Many start-ups related to marine plastic struggle to create a business model. Ocean CleanUp is an exception and is performing great so far, but without a business model in the long term it will be difficult to keep attracting funding.
- Most plastic waste start-ups are driven and get support by NGOs or state but is not sufficient to make them grow and scale fast.
- It is still under research and not much knowledge about the issue of microplastics that are coming into the oceans from the port operations. Therefore, regulations and policies should be considered about the relation of microplastics with the food chain affecting human health.
- We want ports to take more responsibilities and initiatives to make cleaner ports, and not simply comply with the minimum regulations.
- Regulation and more attention has been made on ballast water treatment and the cleaning of ships. There are not many programs that actively stimulate cleaner waters.

## **2<sup>nd</sup> Interview:**

### **Port Authority Representative ( San Diego)**

#### **Questions:**

- Do you know in terms of innovation and entrepreneurship about projects and partnerships with the aim of enforcing a blue economy and reducing marine plastic pollution? How successful are these initiatives?
- How is the Port Authority leveraging technology to achieve these sustainability goals?
- What are the potential challenges and shortcomings of the existing innovative blue economy related start-ups?
- Is the limitation of ocean plastics a priority for the port authority of San Diego?
- How much funding is available to promote such initiatives?
- Has the port invested in providing facilities, resilient infrastructure for the blue economy and training programs for port workers to manage plastic waste?
- Do you think that there are any challenges in the policy frameworks that are established to fulfil these sustainable targets towards the blue economy?

- What do you think about the lack of mandatory regulation regarding marine plastic prevention?

Currently, the blue economy is one of the main priorities for the Port of San Diego and has been quite active in enforcing it since 2015. In order to support innovation and entrepreneurship, port created the Blue Economy Incubator (BEI) program to evaluate opportunities for the blue-tech and sustainable aquaculture. The program is designed to provide pilot project facilitation to help start-ups demonstrate their technology in the port environment. According to the interviewee, company Zephyr Marine got approved with their proposal to create a project that collects marine debris and then build a database of hotspots around the Bay linked to some variables like tide, wind events in order to see the amount of plastics collected in correlation with the debris management practices at the port. The BEI program seemed to be very successful, as 9 start-ups have already benefited from being able to launch their projects, providing them with funding, permitting, and of course finding location to establish their activities. At the same time, the port is also learning from such programs how to educate workers to manage and limit plastic pollution. The vision is to have a broader impact and setting such a program as an example and inspiration for other ports globally. The funding ranges between 100.000 to 350.000 EUR, so in total the port invested 1.6 million with pilot projects ranging from 1 to 5 years depending on what the company's needs are. Based on the interviewee's opinion, one of the shortcomings of start-ups is the TRLs (Technology Readiness Level) when some companies are not mature enough and ready to work with the port and consequently not demonstrating their working prototype and technology. Hence, it is tough for the port, which is in general a busy organization, to support financially and engage with early stage companies that just have innovative ideas to provide. Second challenge on this issue that participants noted was that marine debris removal is obviously very expensive and there is a limited budget for it so almost nobody takes the responsibility to take care of it. It's difficult to find the right revenue schemes that make it attractive for the ports to do it. Port of San Diego though, is an exception and does it as an environmental steward. In terms of facing challenges with policy frameworks, the interviewee answered negatively, pointing out that port's structure enables to apply them perfectly and the fact that is uniquely positioned play a leadership role in advancing BE opportunities through the different roles port is serving, as landlord, operator, regulator and more importantly, environmental steward. It is argued that more enforcement in regulations regarding ocean plastics is needed specifically, when it comes to how much plastic should be produced and the urgent use of recyclable materials, because when it reaches in the ocean it becomes more difficult to resolve this problem, so being proactive with mandatory regulations would definitely help mitigating this issue.

### **Key messages and insights**

- For the port of San Diego blue economy or entrepreneurship is one of the main priorities and has been quite active in enforcing it.
- The Blue Economy Incubator program of San Diego Bay seems very successful, as 9 start-ups have already benefited from being able to launch their projects, providing them with funding, permitting, and finding locations to establish their activities.
- Marine debris removal is quite expensive and there is a limited budget for it and nobody takes the responsibility to take care of it. Every year port makes sure that there is available funding to promote the blue economy targets such as environmental remediation, improving water quality, marine debris removal and sustainable aquaculture.
- Port of San Diego assesses TRLs and value of debt before approving proposals from start-ups. It is difficult to support financially and engage with early stage companies that just have innovative ideas to provide.
- It's just a matter of putting the right people in place at ports. In the case of San Diego, there are no limitations in policy frameworks, port applied them perfectly and are aligned with the blue economy sustainability targets.
- All the elements for success in fostering the blue economy are present, as the port of San Diego keeps on supporting for years start-ups and include BE as a part of its future plans making it seem kind of unique competitive advantage that port has.

### **3<sup>rd</sup> Interview:**

#### **Port Authority Representatives (Oslo)**

##### **Questions:**

- Can you provide examples about projects and successful initiatives undertaken with the aim of enforcing the blue economy and reducing marine plastic pollution?
- Is the limitation of ocean plastics a priority for the port authority of Oslo?
- What are the potential challenges and shortcomings of the existing innovative blue economy related initiatives?
- How much funding is available to promote such initiatives?
- Has the port invested in providing facilities, resilient infrastructure for the blue economy and training programs for port workers to manage plastic waste?
- Do you think that there are any challenges in the policy frameworks that are established to fulfill these sustainable targets towards the blue economy?
- What do you think about the lack of mandatory regulation regarding marine plastic prevention?

For the Port and City of Oslo blue economy and more especially marine plastics prevention is a priority. Following the Action Plan of Municipality, port invested in 3 boats 1 electric, 1 hybrid

and 1 on biofuels with the aim to collect the marine debris, sort it out and lastly deliver it to the right facilities. According to the interviewee, the port has cooperation with small scale entrepreneurs like Clean Sea Solutions that use autonomous drones to clean the water, NGOs that organize events sort of Clean Up Action Days and human divers deployed to pick up plastic waste voluntarily, but these are not the optimal solutions. Port also prompted some innovative solutions, the cooperation with company Spilltech that develops environmental technologies such as Port Bin and Trash Troll, underwater automated marine debris collector bins with lenses that detect waste that goes down to the river and picks up the underwater garbage. In terms of efficiency, they did not prove to be as efficient as expected and the fact that using them is quite costly also plays a crucial role. Overall, due to the fact that the port is not big in size makes it difficult to invite in lots of consortiums. In Norway the market is also small and less mature, there is not a dedicated place for start-ups to work in, so therefore, it's not a good business for entrepreneurs and innovators to invest in. One challenge that the port of Oslo faces with regards to BE initiatives is the location of the port, being in the middle of the city brings easy access for people to Oslo Fjord. Usually this coexistence works well but sometimes can create conflicts and dangerous situations between the sea trade and the commuting people who want to be free at the oceans where ships are coming in. The representative of the Port Authority also noted that in Fjord is not allowed to fish due to the problem of nitrification, all the emissions and waste coming from other regions makes the Ph balance of water not in the right levels. However, buffer zones and artificial reefs are established to improve marine biology and enhance the nature restoration around the port. With regards to funding, Port receives 30 million per year from the private sector called Retailers Environmental Fund and all that money invested to prevent marine plastic. MARFO is another fund that the state grants to the port 3 or 4 million dedicated to initiatives on plastic. Port has invested a lot in having a resilient infrastructure with quite modern facilities. Additionally, the lack of space in the port creates a lot of pressure in terms of who out of the 1.5 million people will get access to this area. There are no challenges in the policy frameworks as Port policies are in line with the municipality SDGs targets (Zero CO2 Emissions, Climate Strategy Plan, reduction of the use of plastic etc.) and all policy agencies are proactive, supportive and there is a good communication and cooperation to move forward and push customers in the same direction. Participants also emphasized the lack of regulation in plastic packaging or generally the use of plastics produced that need to be supervised. On marine plastics regulations exist but when the volume of plastics is too large that it is inevitable to not reach the oceans.

### **Key messages and insights**

- Port follows the Action Plan of Municipality and has invested in 3 electric boats with the aim to collect the marine debris, sort it out and lastly deliver it to the right facilities.
- Small scale entrepreneurs like Clean Sea Solutions using autonomous drones to clean the water, NGOs organize events sort of Clean Up Action Days and human divers deployed to pick up plastic waste voluntarily, but these are not the optimal solutions.
- Port in cooperation with company Spilltech developed environmental technologies such as underwater automated marine debris collector bins with lenses that detect waste that goes down to the river and picks up the underwater garbage. In terms of efficiency, they did not prove to be as efficient as expected and are also costly to use them regularly.
- In Oslo due to the fact that the port is not big in size makes it difficult to invite in lots of consortiums. Therefore, there is a lack of private sector involvement.
- Port receives funding from private and public sectors called Retailers Environmental Fund and MARFO respectively. All that money invested are dedicated to initiatives on marine plastic.
- There are no challenges in the policy frameworks as port policies are in line with the municipality SDGs targets. All policy agencies are proactive, supportive and there is a good communication and cooperation to move forward and push customers in the same direction.
- On marine plastics regulations exist but when the volume of plastics is too large that it is inevitable to not reach the oceans. Lack of regulation there is in plastic packaging or generally the use of plastics produced.
- The infrastructure of the Port Authority, the political ambitions of the city and funding are in place and present.
- One challenge with regards to blue economy initiatives is the location of the port, being in the middle of the city brings easy access for people to Oslo Fjord. This coexistence sometimes creates conflicts and dangerous situations between the sea trade and the commuting people.

#### **4<sup>th</sup> Interview:**

##### **Port Authority Representatives (San Diego)**

##### **Questions:**

- Can you provide examples about projects and successful initiatives undertaken with the aim of enforcing the blue economy and reducing marine plastic pollution?
- Is the limitation of ocean plastics a priority for the port authority of San Diego?
- How is the Port Authority leveraging technology to achieve these sustainability goals?
- What are the potential challenges and shortcomings of the existing innovative blue economy related initiatives?
- How much funding is available to promote such initiatives?

- Has the port invested in providing facilities, resilient infrastructure for the blue economy and training programs for port workers to manage plastic waste?
- What do you think about the lack of mandatory regulation regarding marine plastic prevention?

Port of San Diego is a public corporation that is based on partnerships. With incubator programs port aims to facilitate and support this entrepreneurial spirit of new companies that are bringing new innovative solutions to solve different problems. According to the interviewees, in 2016 the Aquaculture Blue Technology program was created and at the same year they launched the Blue Economy Incubator including partner Zephyr Marine a company which focuses on marine debris removal in San Diego Bay. Other companies within the port using technologies not just collect marine plastic but also reuse it and recycle it into more sustainable building materials. Additionally, Port supports a lot of research with universities and is quite interested in microplastics issues with the food chain effecting the human health. Equally important are the partnerships with a dozen of NGOs that focus on clean-ups, where group of school or university students and broader communities meet together and get environmental education how to manage plastic waste and keep San Diego Bay as clean as possible. One of the participants asserted that the port takes a holistic and balanced approach on how to deal with the environmental problems; managing the resources, ensuring that the water quality is clean and eliminating the carbon footprint with investments in electrification have the same importance and value for the port. In the next couple of years, shore-power will be expanding for vessels to plug-in and port of San Diego will be the first one to have an electric crane in North America. Port of San Diego is classified in the cutting edge in terms of technology solutions as each company of the incubator is innovating and creating a first of its kind technology such as for example the transition from diesel fuel ships to electric battery pilot ships. In that way, port can function as a catalyst by coming up with initiatives and solutions that are exportable to other ports or locations. A challenge that interviewees see regarding start-ups is the novelty of the incubator program and gaining acceptance and figuring out what is the path forward for permitting these sustainable solutions to become the next generation of the environmental project. However, port workers of the incubator program are constantly improving the process to support more and more companies by approving more proposals and facilitating their pilot projects. The big challenge for these start-ups is that there is a lot of competition and the physical space and land within the port is limited. In terms of funding, port uses public funds to support start-ups and ranging from less than \$100.000 to \$400.000. Pilot projects last from 1 to 5 years. Regarding resources, the port has made significant investments in infrastructure and facilities as well as educating and training employees about the importance of making sure there is no access to litter and that it is picked up. With regards to policy frameworks and lack of mandatory regulations, port tries to move the needle and contribute to this through discussions with the state. San Diego Bay is

trying to do its best to eliminate plastic pollution but the environment does not follow politically or regulatory restrictions. Mexico, which is very close to the border, contaminates the port of San Diego even though the port is performing great in terms of marine waste management. As such, local solutions are not sufficient to tackle the issue, all ports collectively are required to do the maximum possible to contribute to reduce the amount of plastics and use plastics in a more sustainable and responsible manner. The participants concluded that overall port ecosystem of San Diego is robust and all the elements are present to support new industry development, innovation and technology adoption.

### **Key messages and insights**

- With incubator programs port aims to facilitate and support this entrepreneurial spirit of new companies that are bringing new innovative solutions to solve different problems.
- In the next couple of years, shore-power will be expanding for vessels to plug-in and port of San Diego will be the first one to have an electric crane in North America.
- Companies within the port of San Diego are using technologies not just collect marine plastic but also reuse it and recycle it into more sustainable building materials.
- Port supports a lot of research with universities and is quite interested in microplastics issues.
- Partnerships with NGOs that focus on clean-ups, where group of school or university students and broader communities meet together and get environmental education how to manage plastic waste and keep San Diego Bay clean.
- The big challenge for these start-ups is that there is a lot of competition and the physical space and land within the port is limited.
- Port uses public funds to support start-ups and ranges from less than \$100.000 to \$400.000. Pilot projects last from 1 to 5 years.
- San Diego Bay tries its best to move the needle and contribute to proper policy making through discussions with the state but the environment as we know does not follow politically or regulatory restrictions.
- The port has made significant investments in infrastructure and facilities as well as educating and training employees about the importance of making sure there is no access to litter and that it is picked up.
- Local governmental solutions are not sufficient to tackle the issue, all ports together worldwide are required to do the maximum possible to contribute to reduce the amount of plastics and use plastics in a more sustainable and responsible manner.

### **5<sup>th</sup> Interview:**

#### **Plastic waste Start-up (Rotterdam)**

## Questions:

- Can you provide examples about projects and successful initiatives undertaken with the aim of enforcing the blue economy and reducing marine plastic pollution?
- How much funding is available to promote such initiatives?
- What are the potential challenges and shortcomings of the existing NGO blue economy related initiatives?
- Do you think that there are any challenges in the policy frameworks that are established to fulfil these sustainable targets towards the blue economy?
- What do you think about the lack of mandatory regulation regarding marine plastic prevention?
- Are the elements for success present for your organization to contribute to the blue economy and more specifically, the ocean plastics prevention?

According to the interviewee, the existence of many rivers in Europe brought the potential to create this organization and focus on preventing the river plastics from reaching the port of Rotterdam and North Sea. Besides that, the organization arranges clean-ups, gives educational workshops and recycles the retrieved litter into new and durable products. City of Rotterdam and partly the Ministry of Environment and Infrastructure supported in the development, and implementation of the first litter traps for the marine debris removal but also helped in the facilitation of projects regarding the recycling of retrieved plastic into new products. Regarding the funding, only the city of Rotterdam supported financially and provided an annual budget of 25.000 EUR to cover the expenses from the services and at once investment of 80.000 EUR for the installation of litter traps. Successful examples so far are the collection of 2 tonnes of plastic but also create awareness and empower people to take more action. Similarly, putting marine plastic pollution on the agenda for most of the local organizations and authorities is also of a great importance so that more supervision and control is adopted to pollutant fuel companies that contribute in a severe way to the plastic pollution. The founder/interviewee noted that the main challenge for the organization is to find the continuation, it is unsure for how long the collaboration with the city of Rotterdam will last and to keep on being active organization needs to find new innovative projects and partners to provide the budget required to initiate such marine plastic solutions. Port of Rotterdam, unfortunately does not support financially these initiatives and also refused to implement the proposals that the NGO provided. An explanation behind this is that there is no willingness. The port mainly focuses on the energy transition and the reduction of carbon footprint, and therefore, plastic is not a concern while at the same time the budget is limited to support and look for the possibilities and opportunities. With regards to the policy frameworks and mandatory regulations in marine plastic issue, the participant opined that the Dutch government is still lagging behind to actualize such policies



because of budgetary reasons, lack of exposure, not enough media attention and not sufficient knowledge about it and the risks it provokes for the future. Concluding the interview with the notion that the elements for breeding ground for success are not there, without the support of more partners and ambition that these initiatives will foster and grow the blue economy.

### **Key messages and insights**

- One of the innovative initiatives of the organisation is the development, and implementation of the first litter traps for the marine debris removal in Rotterdam.
- Another innovative idea was creating a new floating park with the recovered materials from plastic recycling and contribute in that way to the blue economy.
- Additionally, this NGO arranges clean-ups and gives educational workshops, these perhaps are not innovative contributions but will help create awareness and empower people to take more action regarding debris removal.
- In terms of the funding, only the city of Rotterdam supported financially and provided an annual budget of 25.000 EUR to cover the expenses.
- The main challenge for the organization is to find the continuation, still unsure for how long the collaboration with the city of Rotterdam will last. In order to keep on being active organization needs to find new innovative projects and partners to provide the budget required to initiate such marine plastic solutions.
- It is of a great importance for most of the local organizations and authorities when it comes to policy frameworks to put on their agenda marine plastic pollution issue.
- Dutch government is still lagging behind to actualize such policies because of budgetary reasons, lack of exposure, not enough media attention and not sufficient knowledge about it and the risks it provokes for the future.
- Numerous start-ups or NGOs attempted to work at the port by approaching port authorities and submitting ideas, but there was no response and the proposals were turned down.

### **6<sup>th</sup> Interview:**

#### **Port Authority Representatives (Barcelona)**

#### **Questions:**

- Can you provide examples about projects and successful initiatives undertaken with the aim of enforcing the blue economy and reducing marine plastic pollution?
- How much funding is available to promote such initiatives?
- What are the potential challenges and shortcomings of the existing NGO blue economy related initiatives?

- Do you think that there are any challenges in the policy frameworks that are established to fulfil these sustainable targets towards the blue economy?
- What do you think about the lack of mandatory regulation regarding marine plastic prevention?
- Are the elements for success present for your organization to contribute to the blue economy and more specifically, the ocean plastics prevention?

The port of Barcelona is aware of the potential problems caused by marine plastic pollution. Currently, it is not one of the main priorities. This can be exemplified also by a survey conducted internally within the port community aiming to identify what are the most crucial environmental issues concerning the port and the results showed that marine plastics matter was below average in the rankings. Indeed, according to the interviewee, the parties' attention at the moment is focused on the reduction of GHGs emissions and the energy transition to accelerate. In fact, port follows a 5-year Energy Transition Plan which constitutes the largest part of Port Authority's investments (110m EUR) and the main project is about the electrification of wharves. However, there are some small scale initiatives in terms of innovation and blue entrepreneurship. For instance, the project Metropolis NFS is an initiative where different companies give the opportunity to groups of students to participate and solve some challenges they have set, mainly with environmental focus and through continuous guidance, access to training, support and mentorship to turn their ideas and prototype into successful solutions. At the end of this period, the team with the greatest potential for impact and growth, and the award for the team is to work with the assigned company for three months to try to develop this prototype and solve the challenge. Other innovative initiatives regarding ocean plastics are: a company which collects marine litter and convert it to raw materials for 3D printing, another turns marine litter into swimsuits while the other uses materials from outdated rescue boats to manufacture bags and back sacks. Based on the interviewee, the Agency for innovation Barcelona Activa and the City Hall jointly developed the incubator programs Blue-Up and CreaBlue to provide support for the creation and growth of blue economy. With regards to the financial capital, the Fundació Barcelona Port Innovation provides the funding on concrete pilots of port's common interest. In particular, the program is called Ports40 and funding under competitive request is allocated for innovation ideas, precommercial projects and commercial projects (up to 15.000 EUR, 1 million EUR, 2million EUR respectively). Nevertheless, regarding marine plastics there is a lack of knowledge about the consequences of plastics in the oceans and one of the main shortcomings of start-ups in Barcelona's port refers to the hardware start-ups such as manufacturing, marine litter collection, recycling that are more difficult to scale up than soft start-ups that are based on application technologies and software. There are conflicting interests within the port between economic growth, competitiveness and environmental sustainability. With regards to policies port complies with the bare minimum EU regulations and requirements that is

obliged to and does not take any further responsibilities by itself to resolve the environmental issues. But after the Strategic Plan Report in 2021, port authority is starting now to find the balance, change mentality and start taking steps forward for example, by using buildings as observatories of innovation, connecting port with education, research and knowledge centers, organizing conferences and workshops with the aim of addressing the issues and attracting companies to participate in their sustainability projects.

### **Key messages and insights**

- Even though, port is aware of the potential problems caused by marine plastic pollution, the parties' attention at the moment is at the Energy Transition Plan and the largest part of port's investments are focused on.
- The Agency for Innovation Barcelona Activa and the City Hall jointly developed the incubator programs Blue-Up and CreaBlue to provide support for the creation and growth of blue economy.
- Innovative programs are mainly financed by Port Authority and participation in several projects is funded by EU community.
- Port Authority Agency "Fundación Barcelona Port Innovation" provides the funding and allocates it to pilot programs such as Ports40 for innovation ideas, precommercial projects and commercial projects.
- Hardware start-ups (in sectors of manufacturing, marine litter collection, recycling) are more difficult to scale up than soft start-ups within the port.
- Sometimes conflicting interests occur in port policy objectives between economic growth and environmental sustainability.
- Port complies with the bare minimum EU regulations and requirements that is obliged to and does not take any further responsibilities by itself to resolve the environmental issues.
- After the Strategic Plan Report in 2021, port authority is starting to find the balance, change mentality and takes steps forward including in their agenda the social, economic and environmental (SDGs) goals, emphasizing more on the blue economy issues.

## List of participants interviewed

<b>Interviewee name</b>	<b>Interview ID</b>	<b>Organisation</b>	<b>Job position</b>	<b>Date and time</b>
Mare Straetmans	1	Platform Zero, Port XL	Founder	28/03/23, 14:00-14:50 p.m.
Phil LeBlanc	2	Port of San Diego	Consultant/ Innovation Facilitator	30/03/23, 11:00 – 11:40 a.m. CET
Heidi Neilson	3	Port of Oslo	Head of Planning and Environment	31/03/23, 12:00 – 13:00 p.m.
Hakon Vikoren	4	Agency in Urban and Environment, City and Port of Oslo	Coordinator for plastic and marine pollution	31/03/23, 12:00 – 13:00 p.m.
Jason Giffen	5	Port of San Diego	Vice President, Planning & Development	5 April, 20:30 CET / 12:30 EST
Paula Sylvia	6	Port of San Diego	Program Director – Aquaculture and Blue Technology	5 April, 20:30 CET / 12:30 EST
Ramon Knoester	7	Clear Rivers - Rotterdam	Founding Director	6 April, 12:30 – 13:30 p.m.
Francesco Bonada	8	Port of Barcelona	Head of Organisation, Sustainability and General Services	12 April, 09:00 – 10:00 a.m.