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Looking for Common Ground: Marine Living Resource Development in Alaska and Northern Norway in the Context of the Blue Economy

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Abstract: Although the concept of the blue economy was created by the Small Island Developing States, its relevance extends to any coastal region around the globe, making the engagement of both state and corporate actors imperative. At the core of the blue economy framework stands the incorporation of ocean values and services into economic modeling and governance. Sustainable fisheries and aquaculture are thus significant in this endeavor, particularly for Arctic nations, the economies of which are predominantly based on seafood production. Yet, while focus is increasingly placed on sustainability and blue economy models among Arctic states, the need for structured transnational collaboration is not always acknowledged. In that respect, this article aims to articulate a comparative study of the status quo, challenges, and opportunities of fisheries and aquaculture in Alaska and northern Norway and seeks to explore potentials for cross-sectoral synergies between the two regions in the context of the blue economy.

Keywords: Alaska; Arctic; northern Norway; blue economy; fisheries; aquaculture; mariculture; SDG 14

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1. Introduction

Over the past two decades, the blue economy has slowly but steadily emerged as a concept that captures the goals of sustaining economic development opportunities while maintaining ocean ecosystem health. The growing pressures on ocean systems and the recognition of their central importance for human and non-human well-being have heightened policy attention around the world, as well as the development of local, national, and international policies, roadmaps, and benchmarks for sustainable ocean governance [1]. The 2012 UN Conference on Sustainable Development (Rio+20) and its explicit focus on ocean-related challenges is considered the catalyst for a broader use of the blue economy as a relatively new term in the global environmental and ocean governance arena [2]. Echoing principles originally identified in discussions around green growth/economy, the concept of the blue economy is connected to the UN's sustainable development goals (SDGs), which emerged shortly after Rio+20 in direct response to economic growth being described as 'brown': highly industrial, with high energy demands, often destructive and unsustainable, and based on inequitable employment [3]. While the blue economy is mainly discussed in relation to SDGs #14, #15, #16, and #17 [4], it is inextricably linked to SDG #14 (life below water), which aims to protect and sustainably use oceans, seas, and marine resources by conserving and restoring marine and coastal systems and developing capacity in marine science and technology transfer. Yet, identifying

the scope and boundaries of the blue economy in line with the UN's SDGs has previously proven to be a vague and challenging task [4]. As outlined by Spalding [5], more baseline data on SDG #14 is needed to measure ecological functions, as well as trade in goods and services and how they each change over time (p. 4).

Today, the ocean is viewed by some as equivalent to a land-based resource system, to be managed, allocated, and developed as property and governed through market mechanisms. This interest becomes relevant when the international community confronts multiple and overlapping uses for ocean and marine environments, as opposed to separate uses, such as fishing, aquaculture, or mining [6]. As such, the term "blue economy" emphasizes the multifaceted economic and societal importance of the ocean (and, in some countries, certain inland waters), along with five key components: ecosystem resilience, economic sustainability, community engagement, institutional integration, and technical capacity [1,7]. It constitutes an evolution of ideas about sustainable economies used to denote an expansion of economic wealth derived from the oceans and coasts while maintaining or even improving the natural systems upon which economic systems depend. It shares the idea that economic activities/growth are not antithetical to ecological conservation but are rather complementary or even reinforcing [8].

Although increasingly conceptualized in the multidimensional terms of sustainable growth and conservation and accordingly invoked by governments, international organizations, and relevant stakeholders to tackle both ocean-related opportunities and challenges, the concept, as well as the implementation steps to achieve an ecologic–economic balance of sustainable maritime exploitation, remain vague and disputed [1]. The lack of clarity dates back to Rio+20 and how the blue economy was perceived, discussed, and eventually defined in different ways that all prioritized particular problems, solutions, and stakeholders. Today, it remains unclear whether the blue economy is to be singularly understood as the domain of a particular set of actors or as a short-hand reference to particular sets of governance mechanisms or ideologies [2]. Additionally, research has failed to theorize key geographical concepts such as space, place, scale, and power relations as pertains to the development of a blue economy; all of these concepts have the potential to lead to uneven development and regional differentiation [9]. This also relates to a persisting lack of analysis on distinct geographical areas of blue economic potential, such as the Arctic region [10].

Over the past two decades, retreating sea ice, changing distributions of natural marine resources, and demands for those resources have combined to create a perfect storm for increased economic interests in the Arctic region. With rapid changes underway across the circumpolar north, questions are being asked both about the sustainability and profitability of northern economic ventures and about conditions for local and regional development [11]. Today's Arctic political agenda is not only occupied by questions on how to sustainably manage regional resource exploitation and extraction but, increasingly, also on how to best govern emerging disputes between the various industries involved [12]. In a contemporary Arctic context, the blue economy encompasses a large variety of sectors driving Arctic economies, including oil and gas extraction, fishing, aquaculture, shipping, marine technology, tourism, offshore wind energy, mining, and marine biotechnology. The Arctic Ocean and its surrounding waters hold the potential to become a key region in contributing to these developments. Three factors are currently transforming the Arctic with astonishing speed: climate change, technological advances, and the forces of (global) economic development. Although these factors individually and/or in combination are set to change the Arctic in the years and decades to come, change will affect the region and its inhabitants at different rates [13]. This holds particularly true for Arctic fisheries and aquaculture as their (economic) role is distinct and different for the Arctic Ocean coastal states (Canada, Denmark, in relation to Greenland, Norway, Russia, and the United States).

Against this background, this article focuses on developing empirically viable ways to understand the complexity of socio-ecological interactions in fisheries and aqua-/mariculture in the context of the blue economy among two leading Arctic regions: Alaska and northern Norway. Notwithstanding their geographical distance, both regions are widely characterized by their crucial dependence on marine living resources, novel technologies and harvest methods, significant public participation, societal inclusion in fisheries and aqua-/mariculture management, and organizational and regulatory changes toward the development of effective and sustainable markets around the globe. This article aims to address why fisheries and aqua-/mariculture are important for the development of the blue economy in both Alaska and northern Norway and seeks to enable synergies for further development and cross-sectoral collaboration between these two regions. While SDG #14 already covers, among other features, economic pressures pertinent to maritime industries, the blue economy complements this goal, draws synergies, and provides a guiding ethos for policymakers. By providing a nuanced understanding of what the blue economy implies for Alaska and northern Norway, our article directly feeds into global discussions on SDGs, addressing SDG #14's objective to sustainably use marine resources, and thus bridging existing conceptual gaps between the blue economy and SDGs.

The article is structured into five parts: (1) an introductory segment on the concept of the blue economy and its value for the sustainable management of fisheries and aqua-/mariculture within Alaska and northern Norway; (2) a short section on the materials used and methods employed for the needs of this article; (3) a literature review on the status quo of the two sectors in both regions, highlighting their economic, societal, and environmental aspects, as well as existing challenges; (4) a discussion focusing on how best practices and existing opportunities in Alaska and northern Norway could provide a potential for cross-border collaboration and synergies in fisheries and aqua-/mariculture management between the two regions; (5) finally, a critical synopsis of the main results and concluding reflections on possible future trajectories.

For the purpose of this article, we distinguish between aqua- and mariculture, referring to the latter when discussing developments in Alaska and to the former when reviewing the status quo in northern Norway. The word "aquaculture" is generally used to describe the art, science, and business of producing aquatic plants and animals, and it is often also confusingly referred to as "mariculture" [14] (p. 161). However, globally, it is difficult to distinguish between coastal aquaculture production and mariculture, with the latter often referred to as a specialized branch of aquaculture.

2. Materials, Methods, and Definition of Scope

The precise nature of the blue economy depends on both the narrators of the blue economy development story and their related interests, as well as the economic sector and geographical location under analysis. Given this inherent conceptual ambiguity, a widely adopted list of criteria of what the blue economy is has not yet been determined [15]. Thus, moving toward a veritable blue economy, the key question concerns the matter of comparative measurement and related analysis: How can the blue economy be distinguished from other types of economic activity? How will it be known whether the blue economy is moving toward or away from a balance of ecosystems and economic uses [16]? As such, the blue economy is an attempt

"to create a unified, global definition of economic industries and activities that relate to the ocean in order to generate comprehensive and progressive economic health without violating the other goals of sustainable development. It not only takes into consideration the economic benefit to an industry, but also the potential ecosystem service effects" [5] (p. 5).

The realization that a blue economy potential is highly relevant for the sustainable future of Alaska and northern Norway extends beyond academic discussions and has been echoed by both U.S. and Norwegian authorities. A recent NOAA Blue Economy Strategic Plan aspired towards the potential of a blue economy for the United States, laying

out a roadmap for new ways to advance the state's blue economy at a federal level [17]. The report, *inter alia*, highlights the need for advancing ecosystem-based fisheries management, combating illegal, unreported, and unregulated (IUU) fishing, and fostering the development of sustainable aqua-/mariculture operations in the U.S., yet with only minimal references to Alaska and the particular socio-ecological conditions that characterize the state [17]. At state level, engagement with blue economy visions in Alaska is still absent from official policy documents and, at the time of writing, remains limited to university campaigns, such as the Alaska Blue Economy Center, established by the University of Alaska, Fairbanks. Alaska Blue Economy Center: https://uaf.edu/cfos/research/alaska-blue-economy-ctr/index.php, (accessed on 1 January 2022).

Highly dependent on ocean-based industries, Norway has incorporated the further development of the blue economy sectors as a key point in its 2019 Ocean Strategy, with a particular focus on also promoting sustainable blue development in the Norwegian Arctic [18]. The strategy acknowledges the pivotal role of the blue economy throughout Norwegian history, while also recognizing the cooperation and exchange of knowledge between research institutions, businesses, and public sector as a crucial prerequisite for Norway's establishment as an ocean economy [18] (p. 6). Further, appointed by the Norwegian Government, the Center for the Ocean and the Arctic was founded in 2018 with a national mandate to compile, analyze, and communicate knowledge about the blue economy and the effects that regional and global processes have on it. Centre for the Ocean and the Arctic: https://www.havarktis.no, (accessed on 1 January 2021). Thus far, the Center has published a number of studies on the sustainable blue economy in the Norwegian Arctic as well as on the co-existence of the ocean-related economic activities on a national level [19,20].

As the blue economy manifests many different and often conflicting meanings, it is necessary to delineate, step by step and case by case, every potential pillar to eventually unravel the mystery of what the blue economy is and could be. Particular ambiguity concerns the implications of the term's vagueness on matters of ocean governance [21], relating to questions of the geographic (e.g., how does the concept interact with land-based management systems) or the sectoral scale of the concept (e.g., which industries are considered blue, which ones are not, and how marine interactions between various stakeholders are governed) [22] (p. 599). Similarly, the concept's legitimacy is debated on three levels: individual projects or activities, entire sector or use, and the overall conceptual level [23] (p. 102).

For the purposes of this article, we have distilled three main blue economy indicators from a United Nations Environment Program report on the blue economy: (a) economic growth in marine and coastal areas, (b) improvement of human well-being, local engagement, and social equity, and (c) reduction in environmental risks [24]. Most commonly, blue economy approaches are generally focusing on technological and financial aspects of economic growth and business planning, yet lacking a holistic approach grounded in social–ecological indicators along with economic ones [25]. As suggested by Cisneros-Montemayor et al., there is a need for an integrated approach to the blue economy by assessing social inclusion and equitable outcomes, community engagement and Indigenous participation, environmental impacts, and ecosystem needs, in addition to economic factors [25]. To address these domains, the article sheds light on the economic status quo of fisheries and aqua-/mariculture in Alaska and northern Norway, as well as of these sectors' societal and environmental impacts. Subsequently, the article addresses major challenges that the regions need to overcome to further develop their blue economies. Drawing on the status quo, challenges, and opportunities in both regions, our discussion will attempt to bridge existing gaps and facilitate potential cross-sectoral and cross-border collaboration.

These themes form the point of departure for this analysis. By providing an overview of some key conditions with the potential to enable fisheries and aqua-/mariculture in

Alaska and northern Norway and analyzing related consequences for intra-Arctic cooperation, the article intends to add another missing puzzle piece to existing global blue economy discussions. An overview and analysis of this kind is a precondition for identifying areas for improvements. Albeit acknowledging that the blue economy consists of 'many more economies', the interface of fisheries and aqua-/mariculture management with a variety of other sectors (e.g., infrastructure development, navigation, mining, and energy) extends beyond the purpose of this article. Consequently, the article will develop a case study on the status quo of the blue economy in Alaska and northern Norway, solely in the context of fisheries and aqua-/mariculture.

The initial first step in such an undertaking is to give a comprehensive overview of fisheries and aqua-/mariculture in Alaska and northern Norway. In that regard, a main research question was formulated: *Q1. What is the current economic, societal, and environmental status of fisheries and aqua-/mariculture in the two regions?* To address this question, a literature search was conducted (Section 3), tracing information from digital databases, such as Science Direct, Google Scholar, Research Gate, and others, and using a snowball and citation search method [26]. In addition, through guidance from existing governance and research authorities in both regions, official government and industry reports were also considered. Finally, further information and sources were provided by relevant regional partners of the AlaskaNor project: the Center for the Blue Economy (Monterey, CA, USA), the Institute of the North (Anchorage, Alaska), Ytterstad Fiskeriselskap (Lødingen, Norway), the Arctic Economic Council (Tromsø, Norway), the Alaska Ocean Cluster (Anchorage, Alaska), and the Juneau Economic Development Council (Juneau, Alaska). AlaskaNor: www.alaskanor.com (accessed on 1 January 2022). By synthesizing the results of Section 3, Section 4 attempts to highlight potentials for the exchange of methods, information, and best practices that could contribute to a conceptualization of a pan-Arctic blue economy framework and pave the road for future trajectories. In turn, this study could contribute to the ongoing endeavor of increasing the conceptual clarity of the blue economy, both per se and against the background of SDG #14.

The economic reports, estimates, forecasts, and recommendations contained in this article mostly refer to data available as of early 2020. However, the published data were primarily collected prior to the global COVID-19 pandemic. Due to the global impact of the pandemic, some estimates and forecasts, particularly in the context of economic growth and societal inclusion, may no longer represent the most likely scenarios, and timelines may have to be adjusted to reflect new economic realities.

3. Results

This section describes the current status of fisheries and aqua-/mariculture in Alaska and northern Norway, aiming to address the main research question. Although international law of the sea plays a vital part in providing the mechanisms and procedures for (Arctic) states to manage marine resources more broadly, the predominant mode of governance for Arctic economies underlies unilateral management schemes enforced by each of the five Arctic coastal states [12]. In this context, marine living resource management varies between the two regions under analysis and depends on the formal structures that govern and regulate seafood harvesting and processing. Through a literature review, this section explores how fisheries and aqua-/mariculture are organized in both regions, discussing their economic, societal, and environmental impact, as well as the main challenges that each sector faces. A brief historical retrospection of each region's past precedes the following discussion.

3.1. Development of the Seafood Industry in Alaska

When the United States purchased Alaska from Russia in 1867 for $7.2 million dollars, some thought that the US had acquired useless land [27]. However, this "Seward's Folly", as it was initially characterized in reference to Secretary of State William Seward, soon proved to be a valuable purchase. With over 3 million lakes, 3000 rivers, and 34,000

miles of coastline bordering three different seas (Arctic Ocean, Pacific Ocean, and Bering Sea), Alaska has been one of the world's most biologically productive regions, producing a wide range of seafood products [28]. Being rich in all five species of Pacific salmon, four species of crab, many kinds of groundfish, shrimp, herring, sablefish, pollock, Pacific halibut, and others, Alaska has gradually emerged as a leading stakeholder in seafood markets across the globe.

However, the rapid development of Alaskan fisheries did not start before the mid-20th century, given that Alaska initially held limited interest for the United States due to its great size, remoteness, and challenging climate, which initially discouraged capital investments for development [29]. Only after the Second World War and Alaska's recognition as the 49th State of the US in 1959 did the region witness an accelerating growth of population and related developments in the fisheries sector, which soon became the state's most profitable industry, surpassing the previously dominant mining sector. A milestone in this development was the devolution of the Alaskan fisheries management to the State of Alaska in 1960 [29]. Since then, the state has assumed responsibility for fisheries management from the federal government, incorporating into commercial fishing the principle of sustained yield, an idea reaffirmed in Alaska's Constitution (Article 8, Section 4). Of great importance for the management of Alaskan fisheries was also the enactment of the 1976 Magnusson Stevens Act, establishing a 200-nautical-mile (nm) exclusive economic zone off the coast of the United States. As provided by the Act, the federal government exercises authority up to 200 nm, while the State of Alaska establishes its own jurisdiction (and can enjoy the royalties of resource development) up to 3 nm [30]. These regulatory amendments provided a fertile ground for a decentralized and community-inclusive fisheries regime, which was gradually consolidated and became one of the world's most sustainable governance schemes.

Today, Alaska produces more than half of the fish caught in waters off the coast of the United States, having an average wholesale value of $4.5 billion a year [31] that originates from commercial fisheries off Alaska in two major areas: the Bering Sea and Aleutian Islands, and the Gulf of Alaska [10]. In 2018, the seafood industry contributed more than $172 million in taxes and fees to the state, municipalities, and a wide spectrum of state and federal agencies, providing numerous opportunities for the state's population [28]. Annual seafood harvest in Alaska consistently accounts for about 60% of total US seafood harvests, while more than 9000 vessels are home-ported in Alaska, delivering fish to over 120 shoreside processing plants [28].

3.1.1. Economic Significance of Alaskan Fisheries

The seafood industry of Alaska generates an average of $5.6 billion per year for the state's economy, derived from a large variety of products [32]. Among all species in the Alaskan seafood industry, salmon has the greatest economic impact (jobs, income, and total value), thanks to the abundance of wild salmon in Alaska's waters and the recent development of hatcheries and the sustainable management of salmon stocks. The increasing development of salmon fisheries started in the early 1970s, when the first modern hatchery program was initiated. Alaska's salmon hatchery program was designed to supplement and not replace sustainable natural production of wild salmon stocks and is still flourishing [33]. With finfish farming practices considered illegal, Alaska's hatcheries have only focused on supplementing wild stock production by incubating fertilized eggs and releasing progeny as juveniles (i.e., fry or smolt). Since 1974, the hatchery program has been expanding, authorizing private, non-profit corporations to operate salmon hatcheries [34]. Consequently, in the 1980s, Alaskan salmon already dominated markets both in the US and abroad, and Alaska accounted for nearly half of the global salmon supply. The hatchery program was intensified in the 1990s and remained the world's leading salmon industry until 1996, when salmon farming started to rapidly expand around the globe and surpassed wild salmon for the first time [35]. The Alaskan fishing industry responded to the competition by further improving fish quality, implementing intensive

marketing efforts to differentiate Alaskan salmon from farmed salmon, and moving part of the processing sector to China. As observed by the Alaska Department of Fish and Game, by 2004, these efforts paid off through increasing demand and prices [35]. Still, Alaska's 29 hatcheries today account for just 12–15% of the global supply of salmon, and the state needs to find sustainable solutions to regain its role in the world's major salmon markets [35].

The second most profitable fishery for the state and the largest single-species fishery, by volume, is Alaskan pollock. Pollock is the most abundant wild whitefish species on the planet and, together with the remaining groundfish fisheries, makes up more than 80% of Alaska's total catch accounts [36]. Pollock fisheries accounted for 44% of global supply in 2015, while in 2018, pollock was the second most caught species in the world after Anchoveta and above skipjack tuna catches, that stood in third place [37]. In addition to pollock, Alaska's groundfish fisheries include five more major species-complexes: Pacific cod, sablefish, Atka mackerel, the flatfish complex, and the rockfish complex. By volume, the fisheries for Pacific cod succeed pollock, with a retained catch of 298,000 metric tons in 2017 [36]. Halibut, black cod, and crab fisheries are also significant fisheries that, in 2015, contributed 19% of total labor income and economic output [38]. Pacific halibut, however, is not a federally managed species like the rest of the groundfish, and it is subject to specific management under the Pacific Halibut Treaty between Canada and the United States [39]. Alaskan king and snow crab successfully reached 29% of global supply for 2015, lacking, though, in comparison to foreign competitive industries, such as Canada and Russia.

Groundfish are processed into several different product forms for wholesale markets, such as filets and headed and gutted [36]. As a result of pacific cod (and pollock) headed and gutted processing, Alaska produces approximately 1 billion pounds of fish heads per year, part of which is used in meal/oil production [40] (p. 8). Indeed, the exact volume of heads discharged every year is unknown but is estimated to correspond to a substantial amount of raw material. Heads, along with the internal organs being removed after headed and gutted processing, are usually discharged or used as raw material for fish meal or oil production, thanks to their significant value in omega-3 fatty acids [40] (pp. 2, 14, and 66). Altogether, Alaskan processors produce approximately 70,000 metric tons of fishmeal and 90,000 metric tons of fish oil, mainly burned as a diesel fuel substitute [40] (p. 1). While most meal and oil are currently produced by large fishing ports, specialists estimate that there is much more meal/oil that could be collectively produced from smaller ports if such facilities were developed [40] (p. 1). However, developing such plants could be a complicated and economically unviable process, with industry experts arguing that meal/oil production has currently nearly reached its maximum feasible limit in Alaska [40] (p. 1).

3.1.2. Economic Value of Alaskan Mariculture

Although fish farming in Alaska is prohibited by law, many species have been produced and sold from Alaskan mariculture operators over the last three decades. Since 1990, mariculture production has included several species, the most important being Pacific oyster, geoduck, blue mussel, green sea urchin, littleneck clam, and pink scallop [41]. Today, mariculture in Alaskan waters primarily revolves around oyster farming. As of 2020, the shellfish and aquatic plant farming industry in Alaska comprises 58 aquatic farms, 8 nurseries, and 4 hatcheries for a total of 70 permitted operations—42 in southeast Alaska, 22 in Prince William Sound and Kachemak Bay (south central), and 6 around Kodiak [42]. The overall sales of shellfish and aquatic plants for all permitted operations reached $1.2 million in 2016 [43] (p. 68). Approximately 29 (32%) of the aquatic farm operations sold over 1.32 million Pacific oysters, 42,695 pounds of Pacific geoduck, and 4975 pounds of blue mussels, with a total farm gate value of $1.23 million [43] (p. 68), constituting, in addition to fisheries, a promising source of income.

3.1.3. Societal Impact of the Seafood Industry in Alaska

The second indicator we envisioned evaluating in accordance with the blue economy's aspirations is the contribution of Alaskan fisheries to the state's social wellbeing. In 2018, it was recorded that the Alaskan seafood industry was the single largest private-sector employer in the state (about 30% of the state's total private sector jobs), ensuring jobs and income for approximately 58,700 people (37,700 full-time equivalent jobs and $2.1 billion in labor income), and creating an additional 10,000 secondary jobs [32] (p. 4 and 10). About 25,000 of the workers are employed as processor workers (7400 Alaskans and 17,450 non-residents) [28]. Against this backdrop, the seafood industry has been of great value for remote and rural areas of the state, where employment opportunities are limited. The commerce associated with harvesting and processing thus contributes both to local utility and commodity usage (fuel, electricity, potable water, etc.), as well as maritime transportation and infrastructure for the purpose of moving supplies in and finished product out [44] (p. 5). Indeed, the fact that the workforce predominantly comprises non-residents has led to challenges both for the workers and the industry itself. The remoteness and extreme weather conditions in the region may interfere with the workers' performance, while also increasing the risk for work accidents, illnesses, and challenges to mental health and well-being [45]. Conversely, much more favorable are the working conditions for local operations that have traditionally been nurtured under extreme conditions.

Characteristically, a great number of fishing operations in Alaska remain family-based, and some of them are still grounded in traditional knowledge and artisanal techniques [46]. Local participation in commercial and subsistence fishing is important for the maintenance of economic and social viability in Alaskan communities, ensuring food security. Participation in any fishery of the state provides, next to food security, a means that involves local collaboration and maintains strong relationships with families, communities, and the surrounding landscape [47]. To achieve this goal, the Western Alaska Community Development Quota (CDQ) Program was introduced to provide eligible villages with the opportunity to participate and invest in fisheries. In Alaska fisheries, the privatization of access to resources has traditionally been a common institutional solution that includes various initiatives, such as the Individual Transferable Quota (ITQ) program in federal fisheries and the Limited Entry Program in state managed fisheries, established in 1974 [48]. Since the 1990s, the CDQ program has allocated approximately 10% of all Bering Sea and Aleutian Islands quotas for groundfish, halibut, and crab fisheries to CDQ groups. These groups may use royalties from such fisheries to advance regional economic development through investments, and promote the local communities' economic and social well-being [48]. To date, CDQ has largely contributed to the sustainable economic development and poverty alleviation in rural areas and has provided economic and social benefits for residents. As of 2020, there are 65 communities associated with the CDQ program, 80% of which comprise Alaskan Natives [49].

The participation of Alaskan Indigenous communities extends also to hatcheries, with the prominent example of the Tamgas Creek Hatchery, a hatchery exclusively held by local Indigenous populations. Although these examples ensure, to a certain degree, the inclusion of Indigenous communities in marine living resource management, such developments are rather localized and lack consistency across the state as well as considered integration of traditional knowledge in accordance with international instruments providing for Indigenous rights [50]. This is not surprising, given that the U.S. has not yet implemented the non-binding United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), nor has yet ratified the Indigenous and Tribal Peoples Convention, 1989 (No. 169). A need for additional representation in Alaska fisheries and mariculture workforce is also pertinent to women fish workers. Recent qualitative studies demonstrate that opportunities for women's inclusion in the sector have recently increased, yet statistics reveal that men continue to dominate the industry, in parallel to the way the sector is organized around the world, with women's engagement remaining highly relevant only to family-based operations [51].

3.1.4. Environmental Impact of the Seafood Industry in Alaska

Environmental sustainability and ecosystem protection goals are also high on the agenda of Alaskan fisheries and mariculture management and thus play a key role in their governance and regulation. In that regard, the NOAA Alaska Fisheries Science Center (AFSC) (NOAA Alaska Fisheries Science Center: https://www.fisheries.noaa.gov/about/alaska-fisheries-science-center, accessed on 1 January 2021) has been monitoring the health and sustainability of fish, marine mammals, and their habitats across nearly 1.5 million square miles of water surrounding Alaska, as well as implementing regulations adopted by the North Pacific Fishery Management Council, (North Pacific Fisheries Management Council: https://www.npfmc.org/, accessed on 2 February 2022) the major body in charge of developing management techniques, policies, and regulations related to federal fisheries outside 3 nm. The AFSC has also developed the Economic and Social Sciences Research Program, which fosters economic and sociocultural information in order to assist the National Marine Fisheries Service in meeting its stewardship responsibilities. Significant research progress has also been made by the North Pacific Research Board, (North Pacific Research Board: https://www.nprb.org/, 1 January 2021), which was created in 1997 to recommend marine research activities to the US Secretary of Commerce. The Board's agenda includes, among other tasks, science planning, ecosystem information needs, coordination and cooperation between research programs, enhanced information availability, and public involvement in fisheries in the North Pacific, Bering Sea, and Arctic Ocean.

Of great importance in this development is the contribution of educational institutions to research and public engagement. The AFSC annually participates in many academic events across the state. The University of Alaska Fairbanks College of Fisheries and Ocean Sciences offers undergraduate and graduate programs in fisheries science, while the University of Alaska Southeast is focusing on training fisheries technicians. A joint BS program in fisheries and ocean sciences is also available, while programs such as marine biology, salmon enhancement, fisheries technology, and others can be accessed at different campuses across the state.

The state's goal for sustainable fishing extends beyond academic research and is well grounded in the combination of tough regulation, strict enforcement, close monitoring, and innovative technologies. The AFSC, the Alaska Regional Office, academia, and the commercial fishing industry have long been working with the NOAA's Fisheries Information System Program to develop innovative technologies for the effective and cost-efficient management and monitoring of US commercial fisheries. Of great importance was the 2018 introduction of electronic monitoring for catch estimation. The AFSC, along with the state's universities and commercial fishermen, have been working together to develop additional innovative monitoring tools able to identify and measure fish from digital images. By transitioning the former paper-based fish ticket system to an electronic reporting form, fisheries agencies have managed to improve the accuracy and timeliness of commercial landings data for several species in the United States [52]. Innovative technologies toward sustainability are also supported by private fishing corporations. Alaskan companies strive to develop technology methods to reduce energy costs, meet strict environmental legislation, and create value from waste. For instance, aiming to minimize its eco-footprint, private corporations such as Westward Seafoods, by separating the fish oil from the stick water, managed to clean the water and obtain valuable fish oil to use for omega-3 supplements as well as an alternative to diesel. (Westward Seafoods: https://www.westwardseafoods.com/, accessed on 1 February 2022).

3.2. Development of the Seafood Industry in Northern Norway

Comprising the two northernmost counties in Norway—Nordland and Troms and Finnmark (Troms and Finnmark merged as a single county on 1 January 2020)—northern Norway accounts for a substantial part of the whole Norwegian fisheries and aquaculture

sector. Due to its access to high-yielding coastal and offshore sea areas in the Norwegian and Barents Sea, more than five times larger than the land area, and the relatively warm impact of the Gulf Stream, northern Norway's seafood industry is traditionally the most important factor for the development of the region's (blue) economy. Those conditions, in combination with sound management and environmental consideration, determine northern Norway's advantage in the development of its seafood industries.

For centuries, much of the harvesting of the most abundant fisheries of the region was carried out by communities settled further south or inland that had relocated in accordance with the seasonality of the fisheries, along with the Coastal Sámi communities, who have been operating fisheries in the fjord areas of the North since time immemorial on the basis of customary subsistence use [53]. With the development of trade relations between different communities based on the respective resources, however, access to the sea gradually provided them with stable income and livelihood and facilitated the establishment of the culturally distinctive fishing villages and the permanent settlement along the coast [54] (pp. 80–89).

Currently constituting one-third of Norway's land area, and home to just under 10% of its population [55], northern Norway accounts for a crucial and significant part of the national fisheries and aquaculture sector, contributing to the increased welfare of its inhabitants. In addition, both sectors combined have been responsible for a far greater part of the value creation in Nordland and Troms and Finnmark, compared to the national average [56]. It has been also acknowledged that the large fish stocks in these waters are currently being harvested within stable biological limits and managed in accordance with sustainable development objectives [57] (p. 51).

The cornerstone of the North Norwegian fisheries sector has undoubtedly been Barents Sea cod, the largest stock of Northeast Atlantic cod, referred to by the locals as *skrei*, or wandering cod [58]. Migrating from the northeast part of the Barents Sea along the northern Norwegian coast down to Lofoten every winter, this distinct fish stock was a prerequisite for the largest and longest maintained fishery in Norway, the *Lofotfisket*, which has shaped the culture and economy of the local communities since the 10th century and yearly provides thousands of fishermen with seasonal occupation [54] (p. 98). Preserved by drying, cod was turned into a lasting and invaluable export product, stockfish [59] (p. 89), the target commodity of an export continuing into the present.

Other traditionally important species benefiting the communities of northern Norway include pelagic fish species such as mackerel, Norwegian Spring-spawning herring, and capelin, all found in the coastal waters of the region, as well as the rest of the whitefish species, such as coastal cod, saithe, and haddock. In addition, some small district communities have typically benefited from geographically confined fisheries, such as the shrimp fisheries in northern Troms and, in more recent times, the red king crab fisheries in eastern Finnmark. Native to the North Pacific, red king crab was brought experimentally to the Barents Sea by Soviet scientists during the 1960s and has been spreading along the northern Norwegian coast gradually, with observations as far south as Lofoten in Nordland county [60] (p. 11). It is currently classified as an invasive species of high risk and has been causing concern among fishermen with regard to environmental repercussions in the local ecosystem, specifically to the potential damage to the cod fish stocks [61] (p. 24).

With the rapid development of sea-based aquaculture in the rest of Norway, fish farming was regarded as unfeasible in the north due to the colder climate and lower sea temperatures [62] (p. 12). However, northern Norway has proven to hold an advantage exactly due to the climatic conditions, especially in recent decades, as this prevents the development of parasites and diseases among farmed fish [63] (p. 49). The region currently stands for around 50% of the salmon produced on a national level, which has also been characterized by continuously increasing value. Keeping in mind the increasing global demand for sustainably produced seafood, prognoses have shown that northern Norway holds the potential to keep growing its aquaculture industry while offering employment opportunities in the related value chain.

3.2.1. Economic Significance of Northern Norwegian Fisheries

With the development of greater capacity and effectiveness, and an increased focus on sustainable fisheries, the fisheries sector in northern Norway has transformed rapidly since the 1980s as a result of the decreased number of vessels, technical and regulatory changes, and the increasing value of the final products [64] (p. 28). During 2019, 890,000 tons of wild capture fish [65] were landed in the northernmost counties, with an estimated value 13.3 billion NOK ($1.5 billion), accounting for almost 38% of the landed amount on a national basis and, importantly, representing more than 54% of the value of the national total [65]. In addition, while the total volume of wild caught fish on a national basis has experienced an overall decrease of 25% during the last two decades, it has remained relatively stable in the north. Furthermore, the fisheries sector has had a crucial impact for value creation in related industries in the region, such as fish reception and processing facilities. Studies have shown that the additional value created from fisheries in northern Norway was 5.9 billion NOK ($686 million) during 2016, or corresponding to 42% of the national total [62] (p. 8).

The immediate access to the waters of the Barents Sea and the associated whitefish stocks (cod, saithe, and haddock) have shaped northern Norwegian society, while the *skrei* has undoubtedly been the single most decisive factor for economic growth and welfare, traditionally and today, being the largest stock of cod fish in the Atlantic Ocean. During 2019, almost two-thirds of the total amount of wild caught fish in the region constituted cod and related whitefish species (582,000 tons), representing 73% of the total cod landed in Norway [65] and further highlighting its crucial importance for the economic and social well-being of the region. A gradual and continuous increase in catch value has been seen during the last decade, despite considerable fluctuations and a recent decrease in the catch volume of cod fish. During 2019, the total landed value of cod and related whitefish species in northern Norway amounted to 9.9 billion NOK ($1.1 billion), or 76% of the value on a national basis [65].

The pelagic species constitute a substantial part of the total volume of wild fish caught in the region, and although subject to significant stock fluctuations caused by overfishing or natural variations in stock size, they have contributed accordingly to economic growth [64] (p. 11). After a significant decrease in the volume of pelagic fish catches in the period from 2010 to 2013, the quantity has been growing again since 2016 [64] (p. 15). During 2019, 441,699 tons of pelagic species were landed, which together accounted for almost 19% of the total fish caught in the region [65]. In terms of value, this represented almost 30% of the value of pelagic species landed on a national level.

An important part of the wild caught marine living resources in northern Norway consists of crustaceans and mollusks, with the invasive red king crab having great economic significance for the local communities in Finnmark. It has been developed as a target species for regional fisheries because of its ever-increasing value as food. Due to its ecological risk status, it is governed by a two-fold management scheme [60], with the objective of minimizing its spread and negative impact while keeping its productivity for a sustained and profitable fishery within a quota-regulated zone. Currently an important target species for coastal fisheries in Finnmark, it has provided both fishermen and landing stations within the quota-regulated zone with seasonal diversification and additional income, not least as a means to compensate for potential impacts on traditional fisheries [60] (p. 138). Monitoring studies have shown that the spreading of red king crab has indeed been limited in accordance with management objectives, while creating significant economic value to the local communities [66]. During 2020, the total catch of red king crab amounted to 2081 tons, with a total value of 391 million NOK ($44 million) and with most of the catch exported to Southeast Asia, Japan, and the European Union [67].

3.2.2. Economic Value of Northern Norway's Aquaculture Sector

Salmon and rainbow trout have undoubtedly been the characteristic products of Norwegian aquaculture, and the exponential development of the sector in recent decades has determined economic growth in many Norwegian regions while supplying more than 50% of the salmon globally [68]. Although commencing later than the rest of the country, the northern Norwegian aquaculture sector already accounts for over 40% of the national production [69] (p. 14). Current prognoses for the development of the seafood industry project highest potential for growth in the aquaculture sector driven by global demand, while the current management regime in Norway grants the greatest production increase for the northernmost regions [19] (p. 86).

During the last two decades, the production of all species of farmed fish has been expanding exponentially and has increased from around 150,000 tons in 2001 to more than 600,000 tons in recent years [70]. During 2020, the two newly formed counties—Nordland and Troms and Finnmark—together produced 595,178 tons of salmon and rainbow trout [69] (p. 14), with Nordland being the leading producer on a national level until recently (and currently second), with more than 20% of the total volume, followed by Troms and Finnmark with almost the same amount of production. Most important, while just over one-third of the seafood in northern Norway is produced in the aquaculture sector, it generates a significantly greater value per kilogram of production compared to the fisheries sector, as the growing demand and successful marketing [63] have been drivers for rapid price increases [71]. Growing from 2.7 billion NOK ($308 million) in 2001 [70], the landed value of the production in the two counties was almost 28 billion NOK ($3.2 billion) during 2020 [69] (p. 14).

In addition to the first-hand sale of farmed fish, the aquaculture sector in northern Norway contributes to the further development of the related value chain. It is estimated that the region's share of the national value creation from aquaculture has grown from around 28% and 1.1 billion NOK ($125 million) during 2008 up to a share of 42% and 13.2 billion NOK ($1.5 billion) during 2016 [62] (pp. 12–14). It has also been estimated that aquaculture stands for a considerably greater share of the total value creation (between 5.8% and 6.6%) in the region, compared to the sector's share on a national level (under 1%) [56].

3.2.3. Societal Impact of the Seafood Industry in Northern Norway

Both sectors of the seafood industry have contributed significantly to the social welfare of the region in the form of employment and have further created effects in the related value chain. In addition to around 8000 people directly involved in aquaculture and fisheries, it is estimated that 2200 people are occupied in the logistics and service sector. The overall value creation from both sectors together was estimated to be 15 billion NOK ($1.7 billion) in 2019 [72] (Vedlegg 7, p. 3). For some of the district municipalities with small populations, the seafood industry as a whole has been undoubtedly the biggest employer, providing more than 50% of the working opportunities [72] (p. 32).

The Register of Norwegian Fishermen [73] tracks the number of people directly engaged in seawater fisheries or hunting, including the entire crews of fishing vessels, and lists their occupations either as primary or secondary activities. After a significantly decreasing number of registered fishing vessels and occupational fishermen from the 1980s onward, the fishing fleet has been characterized as having greater capacity with regard to motor power and efficiency of catch, paired with the simultaneous increase in value of the final products. The numbers have been stable since the beginning of the last decade, and for 2020, the number of people listed in the register with a main occupation as fisherman in northern Norway was 4272, while another 770 people were registered with secondary occupations in the sector. However, research suggests that these numbers may be under-reported [63] (p. 52), as the statistics are calculated annually during the third quarter, while the occupation in the fisheries sector is highest between January and April in relation to the cod fishing

season. It has been calculated that the overall number of people occupied in the sector might have been as high as 7000 during 2015 [63] (p. 53). More importantly, occupational fishermen registered in northern Norway during 2020 accounted for around 50% of fishermen nationally, further emphasizing the sector's invaluable social significance and the region's contribution to the national economy. In addition, the registered vessels in the two counties numbered 3251 and accounted for 55% of the national total [73].

The fisheries sector has traditionally played a significant role in the local distribution of employment, with the municipalities closest to the marine resources naturally accounting for greater numbers of workers employed in the fisheries sector and offering the most employment opportunities. In some of the island communities historically important for the cod fisheries, such as Træna, Røst, Værøy, and Moskenes in Nordland county, more than 40% of the workforce has been employed in the sector [57] (p. 53). The Norwegian Marine Resources Act, relating to the management of wild, living marine resources, establishes the stable and predictable settlement and employment in coastal communities as one of its main principles and goals, together with the sustainable management and exploitation of marine living resources, in an economically profitable way, as a means to achieve that.

Although Norwegian society has widely been recognized as a role model in terms of gender equality, the fisheries sector, similar to the Alaskan case described above, stands out as male-dominated, a result of traditional work distribution, gender-blind policies preventing women from seeking careers as fishers [74], and significantly lower salaries for women in this occupation [75] (p. 21). With less than 5% of those employed as fishermen as a primary or secondary occupation being women in 2020, northern Norway still accounts for over twice as much female representation in fisheries compared to the national average [73]. Traditionally, women have been occupied with the equally important, land-based side of the fisheries—as part of the preparation of the boats and fishing equipment, the post-harvest processing of the catch, or other administrative tasks. In recent decades, with the increasing focus on gender equality, governmental action plans [76] and strategies [75] have been produced in order to improve attitudes toward female fishermen within the sector, as well as to remove any structural and social barriers for women to enter the workforce. The gender-segregated labor market within ocean-based industries has also been addressed in Norway's 2019 Ocean Strategy, which commits to improving the gender equality in entrepreneurship and businesses [18].

With regards to health and safety in the fisheries sector, it has long been acknowledged that this type of work exposes fishermen to higher risk for work-related injuries or fatalities because of the exposed nature of coastal and offshore fishing [77]. However, most fishermen employed in one of the northernmost counties express that they are satisfied with the occupation, not only in terms of income but also with regards to non-monetary values such as independence, companionship, and work fulfillment [77].

Fish farming has also been responsible for improving social welfare and value creation in the north, with exponentially increasing employment opportunities [69] (p. 11). During 2020, 3252 people were employed within hatcheries, smolt production, and farming, representing over 35% of the 9093 people employed in this industry nationally [69] (p. 12). Importantly, aquaculture provides occupations for more than 10% of the workforce in some of the municipalities on a district level, with 0.3% as the national average.

While Norway has played an important role in the development of UNDRIP and has so far acknowledged different cultural, procedural, and land rights for the Sámi people, Sámi participation in marine living resource management has been minimal, with small-scale fisheries gradually depleting, and Sámi fishermen nowadays facing an array of challenges [78]. Serious controversies have arisen due to the development of aquaculture projects within traditional fishing grounds used by the Coastal Sámi and other small-scale fishermen [79], as well as concerns related to pollution and ecological threats. In a recent speech, the Sámi Parliament of Norway appeared particularly concerned about the main dangers that aquafarming has posed to traditional Sámi activities and questioned the existing standards for the development of aquaculture, mentioning major challenges such

as salmon lice, fish farm escapes, and the risk of salmon diseases infecting wild salmon populations that are of paramount importance for Sámi small-scale fishermen [78].

3.2.4. Environmental Impact of the Seafood Industry in Northern Norway

As a sustainable and profitable blue economy is completely contingent on a healthy and productive ecosystem, the development of both wild capture fisheries and aquaculture, with its use of marine spaces, is inseparable from fundamentally sound environmental considerations. This is also highlighted in the management of the seafood industry in Norway as a whole, and it applies equally to northern Norway, where there are some of the largest commercial fish stocks and numerous aquaculture localities.

The sustainable harvesting of living marine resources and the application of the precautionary approach in fisheries are fundamental principles of management in the fisheries sector in Norway, with the preservation of the ecosystems' productivity and economic development in mind. Most of the fish stocks that fall under the Norwegian fisheries' jurisdiction are shared and are governed through quota and access regulations based on the best available scientific advice. Importantly, while most commercially exploited fish stocks are currently fully utilized or overutilized globally [80], it has been recognized that the economically significant fish stocks in Norwegian waters are successfully managed within safe and sustainable limits [57] (p. 51). In addition, IUU fishing of northeast Atlantic cod in the Barents Sea has been completely eradicated [81]. In this area, Norway cooperates with neighboring countries in the management process via regional fisheries management bodies such as the Joint Norwegian–Russian Fisheries Commission and the North-East Atlantic Fisheries Commission. The Norwegian Institute of Marine Research and the Norwegian Directorate of Fisheries are the national institutions cooperating with the International Council for Exploration of the Sea for the assessment of stock sizes and quota advice, which are then proposed and implemented on a national level.

Further, the exploitation and management of the red king crab in the Barents Sea raise important questions regarding the preservation of the native ecosystem and the traditional seafood industries based on it, balanced against the potentially economically significant advantages that the harvesting of an invasive or alien species can create for a small coastal community [60] (p. 7). Its governance plan may serve as an example of a management approach taking into account both factors, which together create serious opportunities for further development of the blue economy [60].

With regard to aquaculture, one of the key factors contributing to the Norwegian salmon's increasing value and its lasting establishment on international markets is the focus on food safety in the production process, not least achieved in cooperation with businesses and research institutions working for increased fish welfare and quality [63] (p. 50). Strict regulations on the use of medication, vaccine development, and monitoring have been crucial factors in the development of the sector [63] (pp. 54–55).

In addition, particular importance is placed on the environmental impact of aquaculture, such as the negative pressure on wild salmon populations, the spread of salmon lice, and discharges, balanced against the significant economic and employment growth the sector provides, especially in small and sparsely populated regions. Enacted in 2020, the Norwegian government's "traffic light system" management strategy for predictable and sustainable growth in the aquaculture sector divides the Norwegian coast into 13 production regions, each of which is assessed based on environmental indicators before production increases are granted [82]. The current factor in consideration is the impact of salmon lice on the wild salmon and trout population. According to this system, northern Norway is divided into seven production regions (regions 7–13); currently, five of these regions have received the green light for an increase in production of up to 6% [82].

As part of the growing consciousness surrounding food waste and utilization of rest raw materials from harvest industries, and the stronger implementation of the circular economy, Norway has also been developing its marine ingredients industry in collabora-

tion with the seafood industry. Importantly, more than 90% of the resulting surplus biomass in aquaculture has been utilized and processed into fish oil for human consumption or fish flour for use in animal feed [83] (p. 25).

3.3. Challenges in Fisheries and Aquaculture

3.3.1. Challenges in the Further Development of the Seafood Industry in Alaska

With Alaskan fisheries and mariculture generally operating under an arguably sustainable apparatus, it is difficult to look for new ground for further development. However, the blue economy conceptualizes oceans as spaces of constant development and aims at overcoming any potential challenge in that regard. Surrounding a remote and vast area characterized by a harsh climate, Alaskan fisheries and mariculture are confronted with remaining challenges, which the state needs to overcome to achieve its blue economy aspirations.

While there is a constant push by the US administration to improve marine resource management and economic development in Alaska, the lack of stable funding remains an issue in the region. Funding and investments are also restricted in mariculture, which has more recently emerged. Furthermore, capacity limitations, lower production and investment priority for specialty products and low-value species, and production and market development costs are among the main challenges that characterize the sector [40] (p. 3). Given that Alaska's fisheries include a variety of harvested species, several species fisheries remain underdeveloped in the region, such as the arrow tooth flounder, the spiny dogfish, the skate, and the Alaskan herring, the exploitation of which is more costly and less profitable [40] (p. 2).

In addition to financial questions, environmental challenges may often arise. While the impacts of hatchery salmon production on native salmon populations are minimal compared to the challenges posed to wild salmon by salmon farming in other countries, hatcheries may also pose challenges to aquatic ecosystems. By design, hatcheries' operations may threaten the healthy spread of genetic diversity by increasing the chance for adult salmon to stray and return to different locations than their origin, which, in turn, may affect the genetic pool of natural runs and can lead to genetic swamping, changing the gene pool of the natural population [84]. For salmon populations, climatic changes may also pose risks when mature salmon return, as has been demonstrated through the case of "the Blob," an abnormally warm body of water that has been circulating the coast of outheast Alaska. Warm water bodies tend to be less nutrient-rich and have less dissolved O2, which plays a role in decreasing the salmon returns [85].

Ecological risks connected to mariculture production mainly exist with regard to harmful algal blooms (HABs) and their associated toxins [86]. The most significant challenge introduced by HABs in Alaska is paralytic shellfish poisoning, which is caused when humans consume "shellfish that have bioaccumulated a suite of toxins collectively known as paralytic shellfish toxins" [87] (p. 531). Paralytic shellfish toxins (called saxitoxins) accumulate in the flesh and viscera of shellfish fed on toxic algae and may cause consumers a variety of symptoms and even death. Although paralytic shellfish treatment is expensive, Alaska has successfully developed different methods for monitoring HABs, including the Citizen Science Program, which tracks toxins found in harvestable shellfish. The state currently regulates, monitors, and tests commercial shellfish development; however, systematic testing may not always be available for coastal areas where recreational, traditional, and even subsistence shellfish harvesting takes place. Given the lack of an algae bloom early warning system, the toxic blooms may cause commercial shellfish fisheries to lose revenues if they do not harvest before the bloom strikes and the fishery closes [86]. In response to these issues, the National Centers for Coastal Ocean Science research project has initiated a process of monitoring the shellfish industry in collaboration with state authorities and the NOAA's weather service and provided the shellfish industry, as well as community leaders, with funding, training, and communication with HAB experts [86].

Despite these developments, mariculture remains less developed compared to other sectors. Although mariculture operations are rapidly increasing, both industry and policymakers may often be criticized for not understanding the potential economic impact that a fully developed mariculture industry could bring to the state. In general, the sector is confronted with challenges associated with the cost of transportation of test samples, and product shipping, barriers to entry, long processes for permissions, and increasing costs that discourage new operations from emerging. Looking at successful mariculture cases across the world and drawing on characteristics from the successful Alaskan salmon and king crab industries may be a means for overcoming existing challenges and mobilizing respective stakeholders and agencies [88]. In this context, the Alaska Mariculture Task Force has identified several areas for making mariculture more viable and sustainable, arguing that, in just 20 years, Alaska's mariculture industry could grow by $100 million through workforce development, improved state policies and regulations, education, and market development. The Task Force has further highlighted the need for increasing Alaska Native participation and inclusion of traditional knowledge in mariculture development, which remains minimal [43].

3.3.2. Challenges in the Further Development of the Seafood Industry in Northern Norway

The most pressing issues for the further development of the seafood industry in northern Norway are closely aligned with global and national challenges posed by climate change, although they might not be experienced simultaneously or to the same degree. Changing sea water temperature, migrating fish stocks, ocean acidification, and melting ice in the Arctic, as well as the cumulative effect of these factors, will have an impact on the industry and the blue economy as a whole. In addition, with the development of the circular economy and the growing conscience surrounding the complete utilization of any resource, the sector stands to fully accommodate the generated rest raw materials and, in collaboration with research institutions and businesses, further develop value chains for its application and commercial realization.

With regard to the Barents Sea, there has been a continuous trend of melting sea-ice and increasing water temperatures, though no acidification has been detected yet [89] (p. 6 and 19). Indeed, the state of the commercially exploited fish stocks in northern Norway has been defined as stable, not least due to sound scientific-based management, and their exploitation is estimated to have reached the maximum sustainable level [89] (p. 70). The current and updated management plan for the Barents Sea suggests no increase in the harvest volume of any of these fish stocks, with the exception of snow crab [89] (p. 70), but rather suggests improvements in terms of optimal fish size and reduction in by-catch. However, in order to maintain the current state of fisheries in the region, the sector is and will be fully contingent on a healthy ecosystem, while further economic growth will depend on the increasing value of the final products, as has been predicted [90] (p. 19).

Harvesting on lower trophic levels of the marine ecosystems for the development of nutritional or pharmaceutical products might create challenges for traditional and established fisheries, as further knowledge about its impact on the ecosystem is required before a commercial exploitation commences, with potential impacts on predator species and by-catch of juvenile fish [91] (p. 15). Such is the case with the harvesting of copepods, a plankton species and one of the largest resources in the northeast Atlantic in terms of biomass [91] (p. 4). It is currently harvested mainly on an exploratory basis in northern Norway with the aim to increase knowledge about the stock and its feasibility as a target species for fisheries, with only a few companies licensed for its commercial harvest.

However, it has been predicted that the seafood industry globally, including northern Norway, will mark its greatest growth within the aquaculture sector, given that existing pressure on wild fish stocks prevents increases in catch volumes, while global demand for sustainable food sources is increasing [90,92]. Not least, aquaculture does not put further pressure on terrestrial areas and is estimated to account for significantly lower greenhouse

gas emissions compared to land-based farming [93]. In order to grow further, however, the sector needs to accommodate even stricter regulations for food safety and environmental protection by, for example, potentially adding multiple factors determining permission to increase production via the traffic light system [94]. Escapes from salmon and rainbow trout farms are considered to potentially be the greatest environmental risk [62] (p. 16) created by the aquaculture sector in Norway, causing genetic contamination in wild fish populations and the spread of parasites. It has been estimated that 6.9 million fish escaped from farms between 2001 and 2018. However, the number might be even greater, as relevant institutions have pointed out that a certain degree of underreporting is to be expected.

With regard to temperature, favorable farming conditions have been moving northwards, given that it already has been estimated that the sea water temperature along the coast has increased by an average of 1° since the 1980s and is expected to continue to increase [90] (p. 30). However, the aggravating state of the climate and the impacts on the marine environment are effective at different rates, and the region has already experienced challenges potentially linked to climate change, with warming sea water impacting aquaculture in terms of fish feed intake and growth and providing fewer days with optimal temperature.

In addition, in the spring of 2019, the aquaculture sector in northern Norway experienced a massive algal bloom, leading to the death of more than 9 million salmon in farms, causing further economic losses and impacts in the related value chain while exposing the sector's inadequate preparedness and need for improved monitoring [95] (p. 3). The estimated losses amounted to around 2% of the national production and more than 6% of the total production in the two regions, estimated at between 2.3 and 2.8 billion NOK ($ 225-275 million) in lost profit, including the impacts on employment in slaughterhouses, production, and logistics. Attempts were made to process the resulting biomass for use as a raw material for the marine ingredients industry, but because of its volume, the process was too slow, further highlighting the need for proper contingency planning.

Other important challenges for significant growth in the aquaculture sector include the relatively strained reputation of farmed products [63] (p. 48), not least because of the use of medication and its potential interaction with traditional fisheries through discharges and environmental impacts, as well as spatial planning dimensions. Enclosing and moving the production further away from the coastal areas, or offshore aquaculture [96] (p. 6), has the potential to resolve most of the main challenges for the sector. Expected to offer optimal farming conditions through mobility, limiting the impact of parasites, and creating less spatial competition with other uses of the sea, the concept is already taking shape, and trial licenses for developing such installations have been issued by the Norwegian government [97]. In northern Norway, aquaculture companies have commenced operating on different conceptual designs for offshore farming, with Nordlaks operating the two "*Havfarm*" concepts—both moored and mobile installations—and Norway Royal Salmon employing the concept of Arctic offshore farming.

4. Discussion: Drawing Synergies

As promising starting points for future comprehensive and multidisciplinary research on the subject, the results of this study contribute to determining the crucial dimensions of fisheries and aqua-/mariculture in Alaska and northern Norway, paving the way for cross-regional dialogue in further pursuing the blue economy. Our interdisciplinary research overview has revealed how existing research within the different disciplines offers data, research foci, and insights about the status quo of fisheries and aqua-/mariculture among two leading Arctic regions. From our descriptive synopsis, an overview of several thematic areas emerges, wherein both regions would benefit from an exchange of information, best practices, and technological improvements.

In the era of climate change, ongoing changing ocean conditions should be conceptualized as a common background for fisheries in Alaska and northern Norway. Alaska has already experienced marine heatwaves that exacerbate climate change impacts for

fisheries in the northeast Pacific, while discussions about the risk for sea water temperature reaching above the optimal level for the fish welfare in northern Norway are also undergoing. For both regions, it would be imperative to understand how species will be affected by the impacts of climate change, including diminishing Arctic sea-ice, ocean acidification, and higher sea surface temperatures. In that regard, there is a common need to increase the quantity and quality of information available to fisheries managers in order to set annual harvest levels and improve decision-making processes.

Sustainability in seafood industries extends beyond coping with the rapidly changing Arctic climatic conditions. Novel technologies, harvest methods, and regulatory changes are tools that have been successfully used in Alaska and northern Norway. A constructive exchange of such practices may offer the potential to further enhance these regions' blue economy aspirations. At a governance level, Alaskan fisheries management is strongly grounded in close cooperation between federal and state authorities, while in Norway, fisheries management remains highly centralized. Indeed, the US is a federal state, while Norway is not; however, decision-making can successfully be delegated to the regional level in non-federal states also. To date, northern Norway's fisheries are inextricably linked with economic and cultural welfare in the northern and western parts of the country, but less in the more heavily populated eastern parts. Decentralizing decision-making power and promoting, to a certain extent, the regionalization of Norwegian fisheries management may help further engagement with local needs in the future.

New ground can also be broken at a sectoral level. As demonstrated above, both Alaska and northern Norway are global players in the salmon industry, with salmon being an extremely profitable source of income and employment for both regions. Although salmon farming is carried out in fundamentally different manners in these two areas, there is great potential for them to learn from each other's practices, with Alaska's successful development of hatcheries and sustainable management of salmon stocks in accordance with socio-ecological needs and northern Norway's highly profitable aquaculture. With half of Norway's aquaculture companies operating in northern Norway, the region can offer practical experience, innovative technologies, and technical solutions for the development of industries in Arctic conditions, as well as successful marketing strategies for maintaining stable and profitable markets. Improvements in seafood processing, packing, and distribution should be actively shared between the states, while Norway's modern naval architectural designs and operating processes could exemplify design methods relevant to Alaska's fleet.

When assessing the societal impact of seafood industries, in general, both regions have well-maintained management models and practices in order to promote local socio-economic growth. Although significant challenges remain concerning the lack of a systematized inclusion of local and Indigenous stakeholders, as well as women in the working force, certain aspects of the existing models in place could be worth exchanging. For example, Alaska's community-based fisheries, such as the native Tamgas Creek Hatchery, and management schemes, such as the CDQ, which have managed to support several local communities, could inspire similar approaches in northern Norway. On the other hand, the established management regime of the red king crab in Finnmark could serve as an example for the maintenance of small-scale fisheries for the benefit of local (and Indigenous) communities while preventing ecological impacts on the native ecosystem. Furthermore, with a significant portion of Alaskan and (northern) Norway seafood production being processed abroad, increasing domestic processing centers could contribute to the creation of new jobs in both regions, increase local engagement, and sustainably revitalize small Arctic and subarctic settlements currently impacted by outmigration. Yet, to achieve a holistic approach to marine living resource management with equitable outcomes for the regions' entire population, there is a shared need for both regions to ensure further participation of Indigenous communities in the existing governance forms and endorse a strengthening of regulations on small-scale and Indigenous fishermen, as provided by international law instruments.

Cross-border collaboration and partnerships could also involve additional exchanges of research and innovation. As demonstrated above, Alaska has developed different methods for successfully monitoring the HABs with which its mariculture industry is confronted. Norway has already felt the consequences of HABs through the salmon industry and could therefore distill insights about better monitoring HABs by looking at the best practices enforced in Alaska (e.g., the Alaskan Citizens Science Program that, among its other mandates, tracks shellfish toxins). Research partnerships have also contributed significantly to academic and scientific progress related to fisheries and should dominate both states' scientific agendas for the near future. Further collaboration between academic institutions focusing on fisheries and aqua-/mariculture research, such as the University of Fairbanks, the Arctic University of Norway (UiT) in Tromsø, or the High North Research Centre for Climate and the Environment (Fram Center), should be fostered, stimulating new interdisciplinary fields, increasing opportunities for meaningful impacts on policy making, and finding solutions to challenges that the two regions share.

5. Conclusions: Future Trajectories

An increasing amount of published literature has been devoted to promoting interdisciplinary research in the context of both Alaskan and northern Norway fisheries and aqua-/mariculture. However, comprehensive studies, comparative assessment, and knowledge exchange concerning the blue economy's potential in Alaska and northern Norway is still lacking academic engagement. In this article, we sought to initiate a conceptual mapping of the current economic, societal, and environmental status of fisheries and aqua-/mariculture in both regions in the context of the blue economy. Our effort has overcome a first stumbling block in the trans-border engagement of Arctic seafood industries and the conceptualization of the controversial and ambivalent definition and interpretation of the term "blue economy" for Alaska and northern Norway's fisheries and aqua-/mariculture, making this knowledge available for relevant stakeholders and decision-makers. However, insights into the research overview and its critical synopsis reveal that further research is needed on the subject of fisheries and aqua-/mariculture. This relates in particular to how key stakeholders in both regions perceive each SDG, especially SDG #14, how they identify the scale and scope of the blue economy, and how such a multi-faceted term meets the expectations of different stakeholders in different settings of different regions [4]. While the SDGs initiated the need for a sustainable transformation of the world's ocean-depended economies, the blue economy concept can be instrumental in further facilitating this transition [25].

Our synopsis provides an assessment of how fisheries and aqua-/mariculture have been highlighting the need to develop a deeper engagement with the concept of the blue economy. With the latter remaining an underdefined concept, we deemed it useful to focus on the assessment of three main domains: economic value, societal impact, and environmental sustenance. In Alaska and northern Norway, these three aspects are arguably operating in an outstanding way with regard to both seafood harvesting and processing, having managed to consolidate both regions steadily among the world's most sustainable and profitable seafood industries. Despite their existing competitive interests in global seafood markets, Alaska and northern Norway will continue to be commonly characterized by strong dependency on the ocean and its living resources. Therefore, interfacing fisheries and aqua-/mariculture research through this article facilitates future collaboration in many sectors: policy development, exchange of technologies, improving services, infrastructure and governance, community engagement and Indigenous participation, environmental sustenance, and market best practices. Against this background, both regions would benefit from a toehold in exchange of information, best practices, and technological improvements. However, there are still many watersheds left on the path to a meaningful answer to the call for the blue economy. Conceptualizing a blue economic development for Arctic nations could pave the way for understanding the complex dynamics of the

Arctic economies in light of ongoing changes and also lead to a pan-Arctic conceptualization of a blue economy framework.

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