Deliverable 2.3

Blue Bio Value Chain & Social Enterprises Cases

Funded by the European Union under the Grant Agreement ID 101060703. Views and options expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Grant Agreement number	101060703
Project title	BlueBioClusters–Supporting European coastal regions in their transition to a sustainable blue bioeconomy
Deliverable title	Blue Bio Value Chain & Social Enterprises Cases
Deliverable number	2.3
Deliverable version	Version 2
Contractual date of delivery	02.02.2024
Actual date of delivery	02.02.2024
Document status	Final
Document version	2.0
Online access	Yes
Diffusion	Public
Nature of deliverable	Report
Work Package	2
Partner responsible	1 - SUBMARINER
Contributing Partners	ALL
Author(s)	Silvia Tosatto
Editor	Alberto Terenzi
Project Officer	Javier Martin-Membiela
Abstract	This deliverable highlights nine companies within blue bioeconomy value chains operating in regions targeted by the BlueBioClusters project. Selected by regional partners, these case studies aim to inspire and inform regional stakeholders. Through desk research and interviews, the studies explore each company's regional context, utilisation of value chains, and the enabling conditions, ultimately assessing their impact on the blue bioeconomy.
Keywords	Bluebioclusters, blue bioeconomy, blue value chains, SMEs, start-ups

HISTORY OF CHANGES		
Version	**Publication date**	**Changes**
1.0	02.02.2024	Final version

2.0	02.12.2024	Version edited based on feedback contained in the Interim Project Review Report

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Acronyms

BBC	BlueBioClusters
CoP	Community of Practice
ERA-NET	European Research Area Network
IOC	Iceland Ocean Cluster
MSP	Marine Spatial Plan
RAS	Recirculation Aquaculture System
SAMS	Scottish Association for Marine Science
SDGs	United Nations Sustainable Development Goals
SMEs	Small and Medium Enterprises

Executive Summary

This deliverable presents and analyses nine companies operating in blue bioeconomy value chains and contributing to developing their region and communities. These case studies are intended to inspire regional stakeholders and help them better understand and engage with blue value chains. These companies, located in the nine regions targeted by the BlueBioClusters (BBC) project, were selected by BBC's regional partners as representatives of innovative applications in the blue economy: C Food Norway, Nordic Seafarm, Colruyt Group, SEAentia, OCEANIUM, Eylíf, Vetik, and PhospoTech. The case studies are based on desk research and interviews conducted with representatives of the companies. Each case study introduces the regional context in which the companies operate, their use of one or multiple value chains, and regional enabling conditions.

The findings reflect a recurring theme: smaller companies prioritise operational stability over broader social sustainability initiatives due to limited resources and early-stage development. Despite these constraints, they hold significant potential to benefit coastal communities and integrate social sustainability principles as they grow. Moreover, shared challenges across regions, such as market underdevelopment and skills shortages, are identified, and the need for targeted support mechanisms is emphasised. By fostering transregional collaborations, knowledge exchange, and access to funding, policymakers can empower startups and SMEs in the Blue Bio Value Chain sector to balance operational priorities with broader sustainability goals.

Introduction

Confronted with climate change and environmental degradation, coastal communities in Europe face significant challenges, as their economic activities are threatened by habitat loss, biodiversity decline, and increased flooding and erosion. In this context, the blue bioeconomy offers a critical solution. It shows that integrated and circular value chains can provide new opportunities and transform remote and rural areas into sustainable, economically vibrant communities. In this pursuit, the blue economy offers a chance to utilise blue bioresources to their full potential. In light of this, examining successful cases of enterprises seeking to leverage blue value chains and innovation to create new, high-value products and services can be of inspiration.

This deliverable showcases a collection of pioneering companies from BBC regions Norway, Sweden, Belgium, Portugal, Scotland, Iceland, Estonia, and France. These entities, including C Food Norway, Nordic Seafarm, Colruyt Group, SEAentia, OCEANIUM, Eylíf, Vetik, and PhosphoTech are companies at the forefront of valorising local blue bioresources like fish, macroalgae, bivalves, crustaceans, and microalgae. Through their endeavours, they exemplify how innovative practices and technologies, ranging from sustainable utilisation of fish by-products to advancing large-scale seaweed farming and beyond, can drive regional growth and contribute to creating more sustainable and responsible uses of blue bioresources.

The innovations spotlighted within these case studies are as diverse as the regions from which they originate. C Food Norway is a pioneer in the sustainable use of marine by-products, while Nordic Seafarm and Colruyt Group are revolutionising seaweed farming and commercial sea farming in Sweden and Belgium, respectively. Further afield, SEAentia's and Noras LT's recirculating aquaculture systems transform fish production in Portugal and Lithuania. Finally, further down in their value chains, OCEANIUM and Vetik explore innovative processing technologies for seaweed through biorefinery models in Scotland and Estonia. At the same time, Eylíf and PhosphoTech capitalise on sustainable health supplements, building onto other innovative enterprises that extract high-value ingredients from multiple blue bioresources.

The impact of these companies transcends the boundaries of their regions, influencing not only their regional economies by creating jobs and fostering growth but also the environment and society by promoting sustainable practices and addressing pressing challenges. For instance, OCEANIUM's technological advancements have the potential to catalyse job creation throughout the seaweed value chain, SEAentia's endeavours in Peniche (PT) have the potential to bolster regional development, and initiatives like Eylíf's leverage marine resources for health products embodying the synergy between innovation and sustainability. Moreover, these case studies demonstrate the pivotal role of regional collaboration and innovation clusters and the importance of continued investment in research and innovation to advance the further valorisation of local value chains. The outcomes of this deliverable, given their

significance for inspiring other blue bioeconomy players, will be featured on the project's website and social media to ensure high visibility.

Methodology

This section outlines the methodology employed in analysing and selecting case studies for this deliverable.

Selection of Case Studies

As a first step, The BBC Consortium consulted the comprehensive overview compiled in deliverable D5.1, a detailed database of start-ups and small and medium enterprises (SMEs) active in the blue biotechnology sector within the BBC regions, making it the ideal foundation for selecting case study candidates. To support project partners in identifying suitable companies, a set of criteria was established as follows:

- **Promising.** The company should have a well-established standing in the value chain or the potential to develop one.
- **Innovative**. The company should use innovative technologies.
- **Positive Impact.** The company should positively impact the region in economic, social and environmental terms. For example, the business model should integrate multiple SDGs, create employment, and contribute to reducing eutrophication.
- **Diverse.** The company should provide an overview of the application of different biomasses and their potential for the blue bioeconomy to ensure diversity.

These criteria also required a diverse representation of companies working with different biomasses. Partners were instructed to propose three to six companies that meet these criteria, aiming to guarantee a varied and comprehensive selection while accommodating potential non-responses or declinations from the companies.

Engagement and Data Collection

Upon receiving all partners' suggestions, a first shortlist of companies was compiled. These companies were then approached to assess their interest in participating in the analysis. After companies accepted to participate, they were asked to schedule a 45-minute interview and provide answers to a list of questions by email before the interview, aimed at collecting critical figures on business impact performance and gaining insights into each company's operations. This allowed for a more targeted and efficient discussion during the interview and enabled a deeper exploration of specific areas of interest. The methodology for these interviews and the email questions are detailed in the Annex of this deliverable.

Analysis

The final analysis integrated insights from the interviews and additional desk research. Each case study opens with a brief description of the company, followed by an examination of the regional context in which they operate. The analysis then delves into how the company works within its value chains, detailing the biomass it produces or processes and the activities it conducts in-house versus those outsourced to partners. Furthermore, it explores the regional enabling conditions and challenges. Finally, each case study reflects on the company's regional impact, focusing on socio-economic and environmental effects and their contributions to the advancement of research and innovation within their value chains.

C Food Norway

C Food Norway, one of NCE Blue Legasea's regional partners, is a world-leading enterprise that commercialises by-products from whitefish to promote a more sustainable seafood consumption that utilises all parts of the catch. The company has established close collaborations with regional producers and international partners in Europe and Asia. C Food Norway purchases raw materials from Norwegian fishing fleets and aquaculture providers and uses regional facilities like slaughterhouses, canning factories, fillet, and dried fish industries to process their products. Their international partners facilitate further processing and product sales inside and outside Europe.

Regional Context

C Food Norway is based in Ålesund, a town on the West coast of Norway, in the Møre og Romsdal County and considered the heart of Norway's fishing industry. The region is characterised by an active marine industry with several companies occupied within sectors such as fishing, aquaculture, raw materials processing and marine ingredients and engage with international partners working on both traditional and novel seafood products. Activities in the field have also been supported by the work of BlueBioClusters' project partner NCE Blue Legasea, a collaboration and innovation network dedicated to promoting new sustainable and commercially viable uses of seafood and seafood waste products.[1]

[1] Møre and Romsdal County Council, *Cooperation for Growth - Research and Innovation Strategy for Møre og Romsdal 2021-2024,* Retrieved from https://www.hustadvika.vgs.no/content/download/21901/233963?version=1, Accessed January 10, 2024

Value Chain

Figure 1 outlines C Food Norway's current value chains and new ventures that it plans to develop in the future. In 2023, raw materials purchased from local suppliers included 1000 tonnes of cod, redfish, and ling heads, 2000 tonnes of backbones from cod, saith (also known as coley or pollock), ling, and brosme (cusk), and 300 tonnes of meat from backbones, neck, and skin.

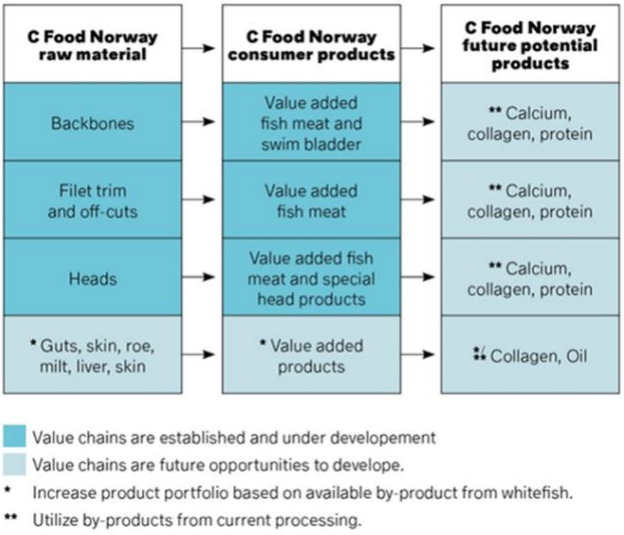

Figure 1. C Food Norway Value Chains[2]

As mentioned above, these raw materials are then processed by locally leased companies. At this stage, raw cod bones are processed to produce dried swim bladders, industrial migas[3] and loin meat; heads are transformed into products like butterfly head, cheek, head loin, tongue, migas/fish meat, and gills, while filet trim and off-cuts are used to produce wet salted fish meat, dry salted fish meat, and de-salted fish meat.

The final products are then delivered to partners in the EU and East Asia, who are responsible for distribution and sale.[4] C Food Norway emphasises the importance of working with regional partners, especially in the case of more complex markets like China, Vietnam, and South Korea, which require specialised strategies for processing and marketing their products.

C Food Norway's work has also been recognised through various awards and nominations in recent years. The company received a nomination for two years in a row for the "Sustainability Award" by the Industrial Design Conference (IDC), Norway's most prominent industrial design conference, in 2021 and 2022.[5] Additionally, in 2022,

[2] C-Food Norway, *Our business,* https://c-food.no/our-business/#business. Accessed 21 January 2024.
[3] In Norway, the term "migas" is used to smaller pieces or flakes of fish meat that are obtained during the filleting or processing of fish.
[4] See https://c-food.no/. Accessed 21 January 2024.
[5] C-Food Norway, *C Food Norway has been nominated for the IDC.Awards Sustainability Award,* https://c-food.no/icd-awards-2022/. Accessed 21 January 2024.

C Food Norway's Chief Executive Officer, Claus Opshaug, was nominated for Entrepreneur of The Year by Ernst & Young in their world's most extensive growth creator programme[6]. The company also won the highly competitive Nyskaperprisen (The Innovation Prize) for making swim bladders a saleable, attractive human food. The Innovation Prize is awarded to honour those who develop sustainable businesses.[7]

Regional and Local Enabling Conditions

The idea of creating a business around valorising unused whitefish by-products was driven by the awareness of unutilised raw materials and the market potential of products such as dried swim bladders, especially in Asian markets. The connection and interaction with business partners in Asia allowed C Food Norway to develop the idea and its value chain. While suppliers initially struggled to see the financial value in by-products, company founders did not face challenges in purchasing the raw materials. However, attitudes towards the business model have evolved significantly in recent years. Sustainability and economic considerations have led more and more local suppliers to work with C Food Norway, overcome challenges derived from new fishing quotas imposed by Norwegian authorities, and access financing programmes to purchase, for instance, new fishing vessels.

Impact on Regional Development

Despite being a small company with only seven employees, C Food Norway significantly impacts the regional ecosystem, including suppliers and distributors. Just recently, C Food Norway announced a new collaboration with Ode, the world's largest cod farming company, also located in Ålesund, to support the establishment of new value chain productions from raw materials like fish skin and liver. This development is not only likely to bring C Food Norway closer to its goal of utilising 100% of catch but also to support the R&D of technological equipment that can facilitate the processing and conservation of all by-products.[8]

[6] C-Food Norway, *Claus Opshaug has been nominated for Entrepreneur Of The Year,* https://c-food.no/claus-opshaug-has-been-nominated-for-entrepreneur-of-the-year/. Accessed 21 January 2024.

[7] C-Food Norway, *Nyskaperprisen 2021,* https://c-food.no/nyskaperprisen-2021/. Accessed 21 January 2024.

[8] C-Food Norway, *Ode and C Food Norway collaborate to utilize the entire cod,* https://c-food.no/collaboration-with-ode/. Accessed 20 January 2024.

Social Impact

C Food Norway supports the local fishing industry by fostering sustainable practices and economic resilience in the Ålesund region. The company's innovative use of marine by-products creates new market and revenue opportunities for local fishermen, helping them adapt to stricter fishing quotas and shifting market demands.

Nordic Seafarm

Nordic Seafarm is a Swedish company born out of an interdisciplinary research project involving five universities with an ambition to discover the environmental impact of large-scale seaweed farms[9]. On a farm located off the West Coast of Sweden, the company cultivates and harvests various seaweed species and works on developing new products and services to find innovative ways of scaling seaweed production. Through cooperation and partnerships, Nordic Seafarm is also dedicated to exploring new seaweed applications and promoting multi-use marine practices.

Regional Context

Nordic Seafarm's primary facility is in Otterön Farm, located off the west coast of Sweden, outside the village of Fjällbacka, while the company offices are in Gothenburg.[10] The choice of the facility location was linked to the unique conditions of Västra Götaland coastal waters, characterised by high salinity, rich in marine species, and predominantly in moderate to good ecological status. This environment is conducive to seaweed growth, providing a natural, nutrient-rich habitat for these cultivations. However, environmental pressures such as over-fishing, leisure boating, and pollution, including marine litter and microplastics, still challenge this marine ecosystem.[11]

[9] Seafarm, *Makroalger – ett steg på vägen mot ett biobaserat samhälle,* http://www.seafarm.se/web/page.aspx?sid=10831. Accessed 31 January 2024.

[10] Nordic Seafarm, *About,* https://nordicseafarm.com/about/. Accessed 31 January 2024.

[11] Interreg Baltic Sea Region Programme funded project Land-Sea-Act, *Case study Gothenburg Region, Sweden - Draft for a Regional Maritime Strategy for the Gothenburg Region (Orust and Uddevalla),* https://maritime-spatial-planning.ec.europa.eu/sites/default/files/lsa_case_study_sweden.pdf. Accessed 31 January 2024.

Value Chain

In their 30-hectare farm, Nordic Seafarm cultivates and harvests on a large scale around 100 tonnes of Sugar Kelp and Sea Lettuce (Ulva) but has also been testing Dulse cultivations, hoping to scale up this production in the future, with the first test happening in the summer of 2024. The company has recently decided to focus solely on scaling seaweed production, while in the past, its ambition was to work on processing, too. In recent years, the company decided to strategically specialise in the earlier stages of the value chain, as it seeks to focus on enhancing and scaling its production capacity while expanding its seaweed varieties and improving the efficiency of its farming operations.

This choice was driven by the challenges posed by processing the harvested seaweed. This is a common pain point for many businesses that work in the seaweed value chain, as the demand for this raw material, especially in Europe, has been inconsistent. While their first harvest caught the attention of many Swedish Michelin star restaurants, and their seaweed has been served at the Nobel Banquet for two consecutive years, overall demand for seaweed as a food source has been slower than anticipated.[12]

To overcome this challenge, Nordic Seafarm has established a joint venture with OceanCollective to develop new plant-based food from the sea, focusing on new food concepts and leveraging seaweed and other marine ingredients. The venture, Ocean Next, plans to develop these concepts both in-house under its own brand and through partnerships with global players.[13] This partnership offers Nordic Seafarm the chance to increase consumer demand for seaweed and explore a new collaborative approach that could serve as a model for further scaling the value chain.

Regional and Local Enabling Conditions

As previously mentioned, the favourable water conditions that characterise the west coast of Sweden, with cold temperatures and nutrient-rich conditions, are particularly favourable for growing high-quality seaweed on a large scale compared to other European countries, providing a critical advantage for Nordic Seafarm's success.

Since its inception in 2016, Nordic Seafarm has partnered with several Michelin restaurants and innovative food producers who have been drawn to the company's locally sourced, high-quality seaweed-based ingredients.[14] This has also attracted

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[12] Nordic Seafarm, *Nordic SeaFarm's Seaweed At the Nobel Prize Dinner,* https://nordicseafarm.com/news-article/nordic-seafarms-seaweed-at-the-nobel-prize-dinner/. Accessed 31 January 2024.

[13] OceanCollective, *Blue Food / Ocean Next - The next wave of blue food,* https://www.oceancollective.se/business-areas/ocean-next/. Accessed 31 January 2024.

[14] Nordic Seafarm, *Raising 20 MSEK to drive blue revolution,* https://nordicseafarm.com/news-article/raising-20-msek-to-drive-blue-revolution/. Accessed 31 January 2024, and JCE Group, *JCE invests in Nordic SeaFarm,* https://jce.se/en/news/jce-investerar-i-nordic-seafarm/. Accessed 31 January 2024.

various investors to the company. In 2020, Nordic Seafarm launched a program solely dedicated to restaurants, providing them with exclusive access to seaweed. The program has since been expanded to support anyone interested in growing seaweed. Participants receive a buoy in the Fjällbacka and can visit the farm in the spring. This initiative has ensured a constant crop demand and promoted the use of algae in different food applications.

Figure 2. Example of a "MySeaFarm" branded buoy for Swedish restaurant "VRÅ" [15]

Impact on Regional Development

With 14 employees, a 2023 turnover of approximately €600,000, and its growing visibility in the Swedish food sector, Nordic Seafarm is shaping up to significantly influence the regional development of Västra Götaland's coastal community, as well as the development of Europe's seaweed sector. Its positive environmental impact on the coastal waters, which instilled the idea of its inception in 2016, is Nordic Seafarm's primary drive. Their farm plays a pivotal role in combating eutrophication: the company actively removes excess nutrients like nitrogen and phosphorus from the sea through their harvest.

In addition, the company is dedicated to working in the food sector because it believes that seaweed represents a promising source of protein with unique nutritional and regenerative qualities that can contribute to healthier diets. They have been awarded the 2023 Impact Maker Award, a prize for innovative start-ups working in the food sector for their commitment to supply food that is both environmentally friendly and beneficial for human health.[16] Moreover, their continued involvement with the Nobel Banquet is a recognition of Nordic SeaFarm's successful efforts in promoting sustainable food production.

[15] Nordic Seafarm, *MySeaFarm,* https://nordicseafarm.com/my-seafarm/. Accessed 31 January 2024

[16] Nordic Seafarm, *Winner: Impact Maker Award,* https://nordicseafarm.com/news-article/winner-impact-maker-award/. Accessed 31 January 2024.

Furthermore, Nordic Seafarm has held ongoing discussions with OX2, one of Europe's leading developers of renewable energy sources, to investigate opportunities for large-scale cultivation of seaweed at the planned Galatea-Galene offshore wind farm in the Swedish economic zone off the coast of Falkenberg and Varberg, two cities in the Halland county located south of Gothenburg. The wind farm's potential to power 1.2 million households underscores the scale of this synergy, representing a great example of innovative marine multi-use.[17]

In this scenario, Nordic Seafarm's operations can substantially increase employment opportunities beyond their current site and contribute to economic growth along Sweden's west coast. By partnering with the fishing industry and offshore wind power providers, the seaweed industry can help maintain or increase employment. This shift would entail a transfer of skills that could revive local economies and create new opportunities for those previously employed in traditional fishing. Therefore, Nordic Seafarm has the potential to play a crucial role in supporting the transition of coastal regions and communities towards a sustainable blue economy.

Social Impact

Through its buoy programme, Nordic Seafarm engages local communities and food enthusiasts by offering hands-on experiences in seaweed farming. This initiative not only fosters greater awareness and ocean literacy but also supports the development of sustainable aquaculture, which has the potential to tackle pressing employment challenges faced by coastal communities. These efforts play a significant role in job creation and promoting environmental stewardship along Sweden's West Coast.

[17] Nordic Seafarm, *OX2 x Nordic SeaFarm,* https://nordicseafarm.com/news-article/ox2-x-nordic-seafarm/. Accessed 31 January 2024.

Colruyt Group

Colruyt Group is a prominent Belgian retail group that works in several sectors, including food distribution, food services, and green energy production. In all its activities, the Colruyt Group is dedicated to sustainable entrepreneurship. They have committed to over 150 sustainable initiatives encompassing various impact areas, including reducing their environmental footprint.[18] As part of this, in collaboration with DEME, they have established the very first commercial sea farm in the Belgian North Sea, *Zeeboerderij Westdiep*, off the coast of Nieuwpoort and Koksijde.[19]

Regional Context

The Colruyt Sea farm is located off the coast of Nieuwpoort and Koksijde in the Belgian North Sea. It is a relatively compact region currently serving multiple purposes, encompassing offshore renewable energy production, shipping, ports, sand extraction, nature conservation, fisheries, tourism, and other activities.[20] Due to its limited coast size, the Belgian Marine Spatial Plan (MSP) underscores the significance of adopting a multi-use approach as the primary standard for concurrent activities within the same area.

To promote multi-use practices, authorities will, in the future, assess concessions for new renewable energy applications by considering proposed multi-use activities such as aquaculture, restoration projects, or passive fisheries as evaluation criteria.

[18] Colruyt Group, *Our Sustainable Initiatives,* https://www.colruytgroup.com/en/sustainable-entrepreneurship/initiatives. Accessed 29 January 2024.

[19] Colruyt Group, *Belgian mussels from our own sea farm,* https://www.colruytgroup.com/en/sustainable-entrepreneurship/initiatives/sea-farm. Accessed 29 January 2024.

[20] European Commission, European MSP Platform, *MSP Country Information Profile – Belgium,* https://maritime-spatial-planning.ec.europa.eu/media/document/12774. Accessed 29 January 2024.

Consequently, new bioeconomy applications can be expected in the coming years, mainly by implementing extractive aquaculture within offshore wind farms.[21]

Value Chain

Around ten years ago, the Colruyt group decided to invest in aquaculture research in the North Sea. With the implementation of the MSP in 2020, which opened the North Sea to commercial activities, the Group obtained permits for cultivating mussels, seaweed and, later, oysters. At the beginning of 2022, the Group launched the construction of the first sea farm in the Belgian North Sea in the Westdiep region, one of the five zones for commercial and industrial activities provided in the MSP (2020-2026) for the Belgian North Sea.

Colruyt's group venture into mussel farming involves a comprehensive value chain that starts from the cultivation of mussels in the North Sea using the longline or suspended rope culture method. This technique, already established in New Zealand, allows mussel lines to move along with the sometimes powerful currents; they serve as shelter for fish and other marine life, increasing biodiversity in and around the cultivation area, and when harvesting, the seabed is not damaged. This method was designed to respond to the challenging conditions posed by the currents in the North Sea.[22]

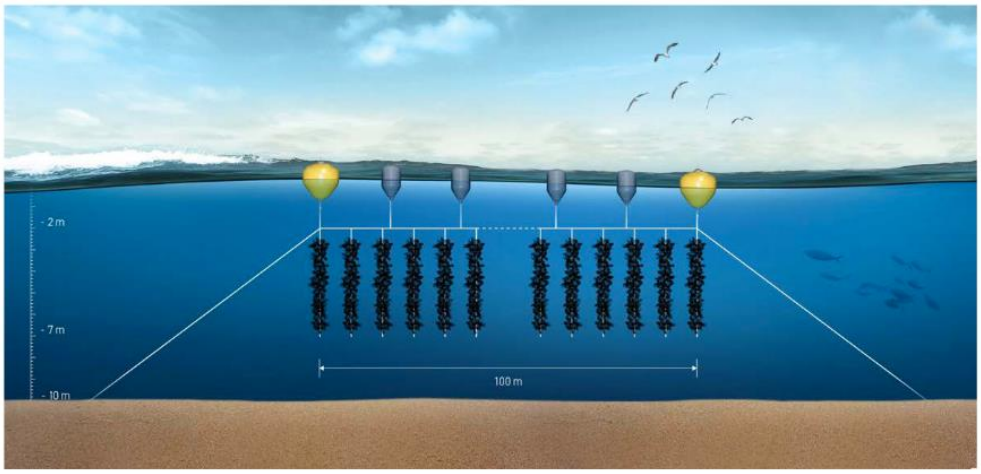

Figure 3. Example of longline mussel cultivation: simulation of one mussel line with 12 mussel ropes [23]

Cultivation occurs at Westdiep Sea Farm, approximately 5 kilometres off the Belgian coast. In 2023, only a third of the available space, one square kilometre, had been cultivated, with 31 lines successfully installed. However, the Group has since

[21] European Commission, European MSP Platform, *MSP Country Information Profile – Belgium,* https://maritime-spatial-planning.ec.europa.eu/media/document/12774. Accessed 29 January 2024.
[22] Colruyt Group, *Colruyt Group harvests first Belgian mussels from its commercial sea farm,* Press Release, https://press.colruytgroup.com/colruyt-group-harvests-first-belgian-mussels-from-its-commercial-sea-farm#. Accessed 29 January 2024.
[23] Colruyt Group, *Construction of the sea farm,* Factsheet, https://cdn.uc.assets.prezly.com/8211fb1d-469b-4104-8bdf-5aec15f2ec65/-/inline/no/factsheetbelgische-mosselenenbouw-zeeboerderij.pdf. Accessed 29 January 2024.

established new mussel lines to increase their net production to 50 tonnes annually, purchased a boat to support their operations, and expanded their team to five full-time employees. The aim is to install 150 lines to cover the whole area.

The first harvest, presented in June 2023, consisted of 10-15 tonnes of mussels and was sold in four markets managed by Cru, a fine food and drink market chain part of the Colruyt group.[24] While the choice of starting with mussel production was driven by their ease of cultivation and strong demand compared to oysters and seaweed, the Group plans to expand production to these species in the future.

Regional and Local Enabling Conditions

The Belgian North Sea is ideal for cultivating mussels due to its nutrient-rich waters, suitable temperatures, and excellent water quality. Although mussel seed naturally exists in these waters, it was never previously farmed. Initiatives to farm mussels in this region face specific challenges, including the presence of strong waves and storms and robust currents that can reach up to three knots in strength, as well as tidal currents that shift four times a day. However, some of these adverse conditions have desirable effects on mussel cultivation. For example, strong currents ensure higher quantities of plankton, which helps bivalves grow faster and results in richer flavour mussels and better quality.

The Group's research and development efforts allowed the team to take advantage of these critical enabling conditions. In fact, adopting the longline method will enable mussels to grow twice or three times faster than in bottom culture, contributes to cleaner shells and less sand and provides a final product with more meat. These enabling conditions, combined with the region's evolving regulatory framework, particularly the MSP, create a conducive environment for pioneering aquaculture projects like those initiated by Colruyt Group.

Nevertheless, the Colruyt group's initiative has faced significant opposition from local groups. Since October 2020, the city of Nieuwpoort has opposed establishing the sea farm, expressing concerns about its potential impact on the movement of fishing vessels and recreational boats. The city, along with local fishermen and three sailing clubs, approached the Council of State to challenge the environmental permit granted to Colruyt by the North Sea Ministry.[25] Nevertheless, the Council of State, Belgium's highest court, denied the petitions of these groups against the project.[26]

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[24] Colruyt Group, *Importance of aquaculture in Belgium,* Factsheet, https://cdn.uc.assets.prezly.com/08db7e80-f41e-4071-a5ba-9f2293fcc74a/-/inline/no/factsheetbelgische-mosselenenbelang-aquacultuur-belgie.pdf. Accessed 29 January 2024.

[25] The Brussels Times, *Belgium receives first-ever mussels harvest from controversial North Sea farm,* https://www.brusselstimes.com/612959/belgium-receives-first-ever-mussels-harvest-from-controversial-north-sea-farm. Accessed 29 January 2024.

[26] The Brussels Times, *Bid to block Colruyt's commercial sea farm project fails,* https://www.brusselstimes.com/belgium/612289/bid-to-block-colruyts-commercial-sea-farm-project-fails. Accessed 29 January 2024.

Impact on Regional Development

The Colruyt group's establishment of the Westdiep Sea farm will propel aquaculture development in Belgium and offer multiple opportunities for the region's economy and social development.

Colruyt Group's involvement in numerous research projects, such as AquaValue, SeaConomy, and North Sea Aquaculture, provided them with valuable practical experience. This experience has demonstrated the feasibility of aquaculture in the region. Moreover, the Group also collaborated with universities and private companies on projects like Edulis and Value@Sea and European innovation projects like United to expand the knowledge base further and demonstrate the viability of ocean multi-use practices.[27] Hence, the Colruyt Group's continued investment in aquaculture research and innovation demonstrates their long-term commitment to developing the sector in Belgium and their dedication to pursuing ocean multi-use solutions across Europe.

The environmental benefits of Colruyt's mussel farming are also critical. The farm uses extractive aquaculture, effectively removing excess nutrients from the water and contributing to the health of marine ecosystems. Moreover, the sea farm also serves as a shelter and nursery for fish and other marine life, increasing populations and biodiversity there.[28] The Group is also aware that aquaculture innovation can contribute to meeting the rising demand for balanced and sustainable protein sources.[29] Mussels have a low carbon footprint (about 0.6 kg CO2 per kg of mussel meat), making them a highly sustainable source of animal protein (17.2 g protein/100 g), low in calories, fat, and rich in vitamin B12 and omega 3.[30]

The farm is planning to expand its production by including oysters and seaweed in the future. This expansion will create new job opportunities and pave the way for a new regional industry – contributing to the local job market. The Colruyt Group's research and technological advancement investment helps lower other players' entry barriers. By absorbing significant initial costs in research and development, the Group effectively streamlines the path for smaller entities to enter the market with reduced

[27] Colruyt Group, *Importance of aquaculture in Belgium,* Factsheet, https://cdn.uc.assets.prezly.com/2eed167a-dc2b-4783-b901-c10a18c7f342/-/inline/no/factsheetbelgische-mosseleneninnovatief-onderzoek.pdf. Accessed 29 January 2024.

[28] Colruyt Group, *Innovative research on aquaculture,* Factsheet, https://cdn.uc.assets.prezly.com/8521783d-1f7b-46a1-98f5-41cd1e19e304/-/inline/no/factsheetbelgische-mosselenenduurzaam-voedzaam.pdf. Accessed 29 January 2024.

[29] Colruyt Group, *Importance of aquaculture in Belgium,* Factsheet, https://cdn.uc.assets.prezly.com/08db7e80-f41e-4071-a5ba-9f2293fcc74a/-/inline/no/factsheetbelgische-mosselenenbelang-aquacultuur-belgie.pdf. Accessed 29 January 2024.

[30] Colruyt Group, *Mussels: sustainable and nutritious,* Factsheet, https://cdn.uc.assets.prezly.com/8521783d-1f7b-46a1-98f5-41cd1e19e304/-/inline/no/factsheetbelgische-mosselenenduurzaam-voedzaam.pdf. Accessed 29 January 2024.

financial and technological burdens. This will catalyse the growth of the aquaculture sector as a whole.

Social Impact

The Belgian family-owned retail corporation integrates sustainable entrepreneurship into its core operations, emphasising respect for people and the planet to achieve long-term positive impacts. For instance, through the Colruyt Group Foundation, the company manages projects aimed at educating and training vulnerable young people, both in Belgium and internationally. [31] In 2024, the foundation added eight new projects, including the Mussels Farm one here discussed focusing on regenerative agriculture. Others included facilitating access to nutritionally balanced food, supporting livelihood security and community development. Additionally, Colruyt Group collaborates with suppliers and partners to promote sustainable practices across the supply chain, ensuring that social and environmental considerations are integrated into business operations.[32]

[31] Colruyt Group, *Colruyt Group Foundation makes a meaningful difference,* https://www.colruytgroup.com/en/about-us/who-are-we/our-business-strategy/colruyt-group-foundation. Accessed 29 November 2024.

[32] Colruyt Group, *Sustainable entrepreneurship,* https://www.colruytgroup.com/en/sustainable-entrepreneurship/our-engagements-and-partnerships. Accessed 29 November 2024.

SEAentia

SEAentia is a start-up based in Portugal, founded by four academics in September 2017. Their main objective is to produce high-quality, sustainable, healthy seafood for the human population. SEAentia aims to become a leader in producing Meagre (*Argyrosomus regius*), known as Corvina in Portugal, from hatchery to commercial size, using a Recirculating Aquaculture System (RAS). Their long-term goal is to establish themselves as a global reference in the aquaculture industry by exploring new commercially relevant fish species with good consumer acceptance and setting up new farms worldwide. The pilot system currently serves as a research and development centre where numerous ongoing projects are being conducted in partnership with well-known national and international collaborators.

Regional Context

Portugal has a strong connection with the ocean and the seafood industry. The coastal regions of Portugal are important centres for fishing, as they provide easy access to high-quality marine water and are close to fish industry stakeholders. Peniche, a fishing community one hour north of Lisbon, is significantly involved in Portugal's blue bioeconomy. This area is well-known for its abundant marine resources and long-standing fishing traditions, which make it an ideal location for innovative aquaculture projects like SEAentia.

Peniche's strategic location provides access to rich marine biodiversity and proximity to significant research and development centres, which positions it well for pioneering efforts in sustainable fish farming. The presence of forward-thinking companies like SEAentia in Peniche contributes to the area's reputation as a hub for blue bioeconomic development, emphasising environmentally sustainable and economically viable marine activities.

Value Chain

As mentioned, SEAentia has important plans to establish a large-scale production of Meagre (Corvina) in RAS. RAS is an expensive land-based technology that offers significant advantages for sustainable fish farming. This technology allows SEAentia to use marine water directly from the ocean, which is treated to remove contaminants, microplastics, and heavy metals, ensuring optimal water conditions for fish health. Despite its artificial nature, the system maintains the highest water quality to promote the best animal welfare. The technology ensures optimal feed utilisation, reduces waste production, and eliminates the need for chemicals to maintain water quality.[33]

Based on scientific research, SEAentia has developed a RAS approach to enhance fish performance that contributes to developing adequate growth models and feeds. Not only does this production method ensure biosecurity through physical and biological filters, but it also favours environmental protection by minimising waste, avoiding antibiotics, and ensuring optimal animal welfare. The RAS system also provides an enriched environment for the fish, including objects for interaction and controlled lighting conditions to suit the species' natural preferences.

The company also seeks to mitigate stress factors, such as light intensity and photoperiod, ensuring the fish are not subjected to uncomfortable conditions they cannot escape, unlike in open ocean cages. Understanding the biology of Meagre is critical to this process, allowing SEAentia to fine-tune the system for optimal fish welfare. The company regularly monitors bioindicators of stress to ensure the fish are thriving.

SEAentia's choice of Meagre was strategic, as it is an emergent saltwater species in fish farming, known for its large size and rapid growth under optimal conditions, and highly appreciated by consumers due to its superior taste and versatility in cooking. Additionally, Meagre has a high content of omega-3 fatty acids despite its low-fat content, making it nutritionally beneficial.[34]

As pioneers in applying RAS technology to Meagre, SEAentia navigates uncharted territory. Because of the high cost of the technology and novelty of the project, the founders had to start from a pilot-scale RAS pilot project dedicated to collecting valuable data on the species' response and performance in such systems. This had to be done to test the technological limits of the system and was a crucial ground block to ensure the success of future operations. Currently, the pilot system is used as an R&D facility where several ongoing projects are being conducted in collaboration with renowned national and international partners.

Furthermore, SEAentia collaborates with Clean Valley CIC to harness the nutrient-rich wastewater from SEAentia's fish farming operations to cultivate microalgae and oysters, effectively transforming waste into valuable biomass. This innovative

[33] SEAentia, *Why RAS?,* https://www.seaentia.pt/why-ras/. Accessed 29 January 2024.
[34] SEAentia, *Why Meagre?,* https://www.seaentia.pt/why-meagre/. Accessed 29 January 2024.

approach valorises every stage of their production process and contributes to developing sustainable aquaculture technologies.[35] The initiative showcases how SEAentia's operations can attract and enable other companies to engage in eco-friendly projects, reinforcing a circular philosophy in the aquaculture industry. This symbiotic relationship highlights SEAentia's role in fostering an ecosystem of sustainable practices, where waste is minimised, and by-products are efficiently utilised for additional production, reflecting a shift towards more sustainable and integrated aquaculture systems.

SEAentia's founders have been awarded various prestigious awards for their forward-thinking approach, bolstering their credibility and attracting investors' attention. In 2020, they were honoured with the PwC Blue Revelation Diploma for Entrepreneurship, recognising their contributions to the blue economy. Additionally, SEAentia won the BlueBioValue, a start-up acceleration programme, in 2018, further affirming their innovative efforts in aquaculture. Their project was also selected by the European Commission for the Blue Invest program as a success case in Europe.[36]

Regional and Local Enabling Conditions

Peniche's high-quality marine water makes it an ideal setting for SEAentia's RAS operations and production. The region's minimal riverine pollution and lack of major estuaries ensure that the ocean water is clean and unpolluted, a critical factor in the region's reputation for producing some of the best seafood in the world.

Furthermore, the local administration in Peniche has significantly supported SEAentia's efforts in the region, providing a supportive environment for growth. Recognising the economic potential of the blue economy, the municipality actively facilitates the establishment of new businesses in the area. This administrative support is also complemented by access to a network of stakeholders supporting blue economy initiatives. Peniche's status as Portugal's primary seafood hub also offers SEAentia invaluable industry connections. The region's well-established fish industry, encompassing everything from catches and processing to distribution, presents SEAentia with crucial channels for collaboration, marketing, and distribution of its products. Moreover, being located in an economically disadvantaged region, SEAentia can access higher funding rates for European projects, a strategic advantage that supports the development of the area's aquaculture sector.

Lastly, SEAentia's proximity to educational institutions like the School of Tourism and Maritime Technology of the Polytechnic Institute of Leiria in Peniche enriches its operations with academic collaborations. Partnerships with educational institutions are essential for a start-up in a highly specialised field like aquaculture. They provide

[35] Entrevestor, *Clean Valley Extends European Trial*, https://entrevestor.com/home/entry/huge-point-of-validation-clean-valley-extends-european-trial. Accessed 29 January 2024.

[36] European Commission, Oceans and Fisheries, *SEAentia-Food: Growing with BlueInvest,* https://oceans-and-fisheries.ec.europa.eu/news/seaentia-food-growing-blueinvest-2022-08-25_en. Accessed 29 January 2024.

access to research, skilled labour, and resources. SEAentia values the ability to seek quick assistance from researchers on issues like disease analysis in fish, which is invaluable. The academic community also benefits from these relationships as practical experiences are provided for students to enrich their learning.

Impact on Regional Development

SEAentia is expanding its operations in Peniche, which is anticipated to impact regional development significantly. While the direct job creation may be moderate, with an estimated 30 to 50 positions, the broader economic effects are expected to be substantial. This is due to the company's use of advanced automation and technology, which will enable them to become the first to commercially produce Meagre through RAS. This pioneering status is expected to draw industry professionals, researchers, and educational institutions to the region, seeking to learn from SEAentia's innovative practices.

The production of SEAentia will not only bring direct benefits to the local economy but also stimulate growth in related sectors, such as fish processing and distribution. As the company does not plan to include processing as part of its operations, local processing companies that currently do not process Meagre will expand their operations and workforce in response to SEAentia's expanded production. This will lead to a significant increase in indirect job creation, providing a substantial boost to the local job market. Additionally, this phenomenon might offer the opportunity to absorb a workforce segment, such as local fishermen, within the aquaculture industry, particularly in processing tasks like fish filleting. This transition will not only provide new employment avenues for the traditional fishing community but also integrate them into a more sustainable and technologically advanced sector, thereby contributing to the socio-economic evolution of Peniche. SEAentia's success in Peniche can significantly raise the municipality's profile, attracting attention and investment to the area. This can lead to further development and growth opportunities in the aquaculture sector and across the broader local economy.

All of the above is bound to have a positive ripple effect on Peniche's regional development. The impact will likely involve not only the creation of direct and indirect job opportunities but also the creation of new local businesses and the attraction of global investors and aquaculture specialists. SEAentia's unwavering focus on sustainability and innovative practices will position Peniche as a critical player in the aquaculture industry.

Social Impact

While SEAentia is still in the early stages of its operations and is focused on scaling its innovative aquaculture model, the company shows great potential to make significant contributions to social sustainability. In particular, SEAentia's efforts to integrate traditional fishing communities into aquaculture present opportunities for upskilling and reintegrating fishermen into the blue economy, creating pathways for economic resilience in coastal Portugal. Additionally, its partnerships with educational institutions provide practical training opportunities for students, enriching local skill development and ensuring a pipeline of talent for the blue bioeconomy that can further contribute to the development of a rich regional sustainable economy.

OCEANIUM

OCEANIUM is a Scottish-based company established in 2018 that uses sustainably sourced seaweed to create natural and innovative products. Their mission is to kelp the world, as they aim to integrate seaweed into our daily lives to benefit our health and the planet. With decades of experience in marine science, they can extract the maximum value from the seaweed using innovative refinery technology. This allows them to produce high-demand products, such as high-purity bioactives for nutrition and cosmeceuticals, plant-based food ingredients, and innovative materials.[37] The company is involved in several EU-funded projects that support the development of a sustainable seaweed industry in Europe.

Regional Context

OCEANIUM is located in Dunbeg, a small town on the west coast of Scotland, within the Argyll and Bute Council. The company shares its R&D centres with the Scottish Association for Marine Science (SAMS), one of Europe's leading marine science research organisations and Scotland's largest and oldest independent marine science organisation, which has specialist expertise in the Scottish blue economy, including aquaculture, marine biotechnology, marine renewable energy, oil and gas, industrial impacts and social-ecological systems.[38]

The region is characterised by a diverse range of sectors, including aquaculture, fisheries, seafood processing, marine energy and renewables, marine biotechnology, and marine environmental services, which play a critical role in both Scotland's economy and in the livelihood of many local communities. A strong focus on leveraging the region's natural marine resources, such as seaweed, for sustainable

[37] OCEANIUM, *Our Story,* https://oceanium.world/our-story/. Accessed 29 January 2024.

[38] Scottish Association for Marine Science, *Research to enable a sustainable blue economy,* https://www.sams.ac.uk/science/blue-economy/. Accessed 29 January 2024.

development in fields like marine biotechnology and bioprocessing has grown in significance in recent years.[39] Moreover, many marine biotechnology networks have come into play. In particular, with the growing role that the seaweed sector is coming to play, the Scottish Seaweed Industrial Association[40] has become a critical network striving to connect industry actors to support the growth and innovation of the seaweed Blue economy sector in Scotland.

Value Chain

OCEANIUM operates in the macroalgae value chain and has specialised in the processing of sugar kelp (*Saccharina latissima*). However, they have also tested other species, such as winged kelp (*Alaria esculenta)* and sea lettuce (*Ulva lactuca*). In 2023, OCEANIUM reached a significant milestone, successfully processing 79 tonnes of seaweed in a new facility while preparing to scale up its operations to process a target of 5000 tonnes of seaweed in 2025. They operate in the middle of the value chain, working alongside farmers and downstream partners, such as B2B businesses, to develop the industry further.

They have established good relationships with around one hundred seaweed farmers, and their suppliers are mainly located in Norway, France, the Faroe Islands, Portugal, and Scotland. They are also currently working on establishing relations with suppliers located in North America and Alaska and on the East Coast in Maine. The company is committed to supporting sustainable practices and prioritises cultivating seaweed, notably to support the emerging seaweed farming industry in the Western hemisphere. This decision is based on scientific evidence that seaweed farming can help diversify aquaculture, meet demand, and provide environmental, social, and economic benefits when responsibly scaled.[41]

As part of its operations, OCEANIUM uses biorefinery technology to convert farmed seaweed into different products that are sold in large-volume markets. Their product portfolio predominantly includes bioactive nutraceuticals and cosmeceuticals that offer a range of health and personal care benefits, but they have also developed a sustainable and fully biodegradable water-based ink and are developing other innovative seaweed-based materials. Currently, OCEANIUM has two products available in the United States: OCEAN ACTIVES® Fucoidan, which is a high-purity marine bioactive ingredient that has nutritional and cosmeceutical applications due to its fucose-rich sulphated polysaccharide content,[42] and OCEAN HEALTH® Fiber, a sustainable dietary fibre derived from seaweed. Its Ocean Health Fiber product has

[39] Highlands & Islands Enterprise, *The Blue Economy in the Highlands and Islands - Towards a regional delivery plan,* Executive Summary, https://www.hie.co.uk/media/13380/the-blue-economy-in-the-highlands-and-islands-executive-summary.pdf. Accessed 29 January 2024.

[40] See https://www.ssia.scot/about. Accessed 29 January 2024.

[41] OCEANIUM, *Our Impact,* https://oceanium.world/our-impact/. Accessed 29 January 2024.

[42] Cosmetic&Toiletires, *Oceanium Develops Ocean Actives Fucoidan, Marine Skin Care Bioactive*, https://www.cosmeticsandtoiletries.com/cosmetic-ingredients/actives/news/22861259/oceanium-develops-ocean-actives-fucoidan-marine-skin-care-bioactive. Accessed 30 January 2024.

gained regulatory approval in the United Kingdom and the European Union, and it is gaining popularity among global food companies that want to include sustainable ingredients in their products.[43]

OCEANIUM works closely with its customers and user companies to develop and strengthen the seaweed value chain. They recognise the importance of market demand for the seaweed industry's success and growth, which motivates the company to actively collaborate with businesses interested in incorporating seaweed into their products. This, in turn, ensures a robust demand and a substantial market for seaweed growers to sell their produce.

Besides product development, OCEANIUM is also involved in fostering the seaweed industry through various EU and local projects. The company has joined the SeaMark Project Consortium, which has been awarded a €9 million Horizon Europe grant and sets out to upscale seaweed production and market applications across Europe. The project specifically looks at how to cater to the increasing demand for seaweed-based products and attract investments from multiple sectors by also analysing the entire value chain. Moreover, the company has recently applied for funding for another Scottish project that aims to accelerate the growth of the Scottish seaweed value chain. If funded, this project will not only boost the Scottish industry but could also catalyse the entire UK seaweed sector. OCEANIUM's commitment to these partnerships and initiatives demonstrates its dedication to the sustainable growth and development of the seaweed value chain as a whole.

Regional and Local Enabling Conditions

OCEANIUM's co-founder, Dr. Charlie Bavington, has been involved in the Scottish Seaweed Industry Association and has connected the company closely to critical stakeholders in the region since its foundation. Insights into the challenges and potential of seaweed farming in Scotland, combined with regulatory hurdles in wild harvest, have shaped OCEANIUM's operational and strategic decisions. Their close association with SAMS offers invaluable support, particularly in areas like seaweed disease and genetics research. However, bureaucratic challenges in obtaining seaweed farming licenses have impacted the pace of industry development in Scotland, prompting the company to rely on more established European suppliers while supporting Scottish farmers wherever possible.

Impact on Regional Development

The potential impact of OCEANIUM 's growth on regional development is multifaceted. While the company currently employs 20 individuals, with 18 in full-time positions, its

[43] Aquaculture Magazine, *The Scottish company Oceanium secures USD 2.6 million to scale and commercialize following investment round led by* Builders Vision, https://aquaculturemag.com/2023/10/27/the-scottish-company-oceanium-secures-usd-2-6-million-to-scale-and-commercialize-following-investment-round-led-by-builders-vision/. Accessed 30 January 2024.

success has significant potential to spur job creation in adjacent sectors of the seaweed value chain, especially in logistics and primary processing. A scaled-up European seaweed industry could create up to 115,000 new jobs by 2030, including alternative jobs at all skill levels in coastal communities. In this context, OCEANIUM's achievements and committed participation in EU and national projects can significantly contribute to expanding economic and employment opportunities in Scotland and beyond.

In its work and operations, OCEANIUM also sets out to measure its impact against six of the United Nations Sustainable Development Goals (SDGs). Amongst their targets stands SDG 5, Gender Equality, as the company is dedicated to promoting equality in women's employment in their industry. In recognition of their efforts and potential for shaping the future, co-founder and CEO Karen Scofield Seal was awarded the prestigious Veuve Clicquot Bold Future Award in 2023, designed to recognise women who have brought a new and innovative offering to the market.[44]

OCEANIUM's alignment with the SDGs underscores its commitment to local and global sustainability and its ambition to make a meaningful impact. Moving forward, OCEANIUM's pioneering work in sustainable seaweed processing and utilisation is set to catalyse broader industry advancements, aligning with global environmental objectives and driving on a new model for responsible and innovative marine resource use on a worldwide scale.

Social Impact

OCEANIUM is deeply committed to promoting gender equality in the blue bioeconomy, exemplified by its proactive approach to empowering women in marine biotechnology. The company cultivates a supportive work environment where women assume leadership roles, significantly contributing to innovation and sustainability in the seaweed sector. This commitment has earned recognition, including the prestigious Veuve Clicquot Bold Future Award, which honours women for their role in bringing groundbreaking solutions to market. Beyond gender equality, OCEANIUM also works on strengthening Scotland's coastal communities by collaborating with local seaweed farmers and driving economic opportunities through sustainable practices.

[44] OCEANIUM, *Karen Scofield Seal, OCEANIUM Co-founder and CEO selected as winner for prestigious Veuve Clicquot, Bold Future Award 2023,* https://oceanium.world/news/karen-scofield-seal-oceanium-co-founder-and-ceo-selected-as-winner-for-prestigious-veuve-clicquot-bold-future-award-2023/. Accessed 29 January 2024.

Eylíf

Eylíf, founded in 2018, is dedicated to facilitating access to sustainably produced, high-quality biomasses from Iceland to enhance consumer health and wellness. The company's name, combining "*Ey*" (island) and "*líf*" (life) to signify "forever," underscores its commitment to using sustainable Icelandic resources. Eylíf's philosophy, "The first wealth is your health," encourages informed choices for health preservation, reflecting the founder's passion for well-being through responsible consumption. The company has been a part of the Iceland Ocean Cluster since 2019 and has played a significant role in creating opportunities for many producers of various blue value chains by-products.

Regional Context

Iceland has a proactive approach towards the blue bioeconomy and capitalises on its historical dependence on the sea. Fish and fish products account for around 40% of Iceland's exports. Direct employment in the fishing industry is estimated to be about 8,000 by Statistics Iceland. However, if all fishing-related activities are considered, the number of employees will likely exceed 30,000, approximately 17% of the total workforce in a country with fewer than 350,000 people.[45] There is a growing trend of fishing-related activities that involve blue bioeconomy ventures, which aim to maximise the value of fish waste and by-products from the fishery.

Although the government of Iceland has not yet developed a formal blue bioeconomy strategy, several projects, start-ups, and initiatives are underway in Iceland. Such initiatives, like the Iceland Ocean Cluster (IOC), aim to find innovative ways to use existing resources more effectively and transform marine bio waste into new

[45] European Commission, Maritime Forum, *Iceland and the blue bioeconomy: making the most from fish,* https://maritime-forum.ec.europa.eu/contents/iceland-and-blue-bioeconomy-making-most-fish_en. Accessed 31 January 2024.

commodities. The IOC, in particular, strives to achieve 100% fish utilisation, which in Iceland currently stands at 80% (compared to an average rate of just over 50% in Europe and North America).[46] Iceland's government has recognised that innovation is essential to its ocean-based economy and is actively involved in research and innovation projects such as the Blue Bioeconomy Cofund. Moreover, it has been a driving force in establishing a Nordic Bioeconomy Programme under the intergovernmental Nordic Council of Ministers, which provides funding for bioeconomy projects.

Value Chain

Eylíf operates with raw materials from various blue biomasses and is active in valorising multiple value chains. They use Astaxanthin, an ingredient derived from spray-dried microalgae known to support skin, heart, and brain health.[47] They source calcified seaweed from Ískalk, a company located in a fjord in the northwest of Iceland, which extracts and processes this ingredient, a rich source of calcium-rich minerals that is highly bioactive and can be used as a dietary supplement.[48] They also use GeoSilica, a natural and vegan-certified quality product that extracts minerals from the geothermal areas of Iceland using a revolutionary production method.[49] They source Chitosan (Liposan Ultra), an enzyme extracted that supports the digestive system as a whole, from Primex, an Icelandic marine biotechnology company located in the northern part of Iceland.[50] Finally, Eylíf uses Collagen, which is highly bioavailable and comes from fish skin. Icelandic Collagen from Grindavík, in the north of Iceland, contains peptides and amino acids that the body uses as building blocks to maintain healthy, smooth, and hydrated skin. Eylíf's product's Collagen comes from the processing of wild-caught, sustainably harvested cod living in the North Atlantic Ocean around Iceland.[51] The company also uses hand-picked Icelandic herbs.

Leveraging her extensive experience as a pharmacy technician with a BSc in Business Administration and roughly 30 years in consumer health products, founder Ólöf Rún Tryggvadóttir developed high-quality food supplements using sustainably and locally produced ingredients. Their product portfolio includes Active JOINTS, Stronger BONES, Smoother SKIN&HAIR, Happier GUTS, and Stronger LIVER. All these products are manufactured in Grenivík by Pharmarctica, a contract

[46] Íslenski Sjávarklasinn (Iceland Ocean Cluster), *100% fish,* https://sjavarklasinn.is/en/100-fish/. Accessed 1 February 2024.

[47] Eylíf, Innihaldsefnin í Eylíf heilsuvörum, *Smáþörungar (Astaxanthin)*, https://www.eylif.is/innihaldsefni/smathorungar-astaxanthin/. Accessed 1 February 2024.

[48] Eylíf, Innihaldsefnin í Eylíf heilsuvörum, *Kalkþörungarnir*, https://www.eylif.is/innihaldsefni/kalkthorungar/. Accessed 1 February 2024.

[49] Eylíf, Innihaldsefnin í Eylíf heilsuvörum, *GeoSilica*, https://www.eylif.is/innihaldsefni/https-www-eylif-is-innihaldsefni-geosilica/. Accessed 1 February 2024.

[50] Eylíf, Innihaldsefnin í Eylíf heilsuvörum, *Kítósan*, https://www.eylif.is/innihaldsefni/kitosan-hrein-islensk-hraefni/. Accessed 1 February 2024.

[51] Eylíf, Innihaldsefnin í Eylíf heilsuvörum, *Kollagen*, https://www.eylif.is/innihaldsefni/kollagen/. Accessed 1 February 2024.

manufacturer specialising in producing cosmetics, dietary supplements, liquid soaps, and others.

Figure 4. Eylíf products

Eylíf has achieved significant success in Iceland and is now preparing for international expansion. The brand has been listed in two prominent supermarket chains in Iceland, Nettó and Krónan, facilitating sales. Eylíf's sales have doubled within the first two years of operations, maintaining profitability from the outset, with over 100,000 units sold in Iceland alone. In early 2022, the IOC recognised Eylíf as one of the 12 most prominent companies to monitor.[52] Eylíf's has registered its brands in 30 countries, including China, the UK, the USA and some European countries. The company has recently been listed on Amazon US, where sales should start in 2024, complementing its existing Amazon UK presence. The company revamped its website in 2023, featuring subscription options as well as a German version, to enhance its digital footprint. Additionally, the founder's participation in a German documentary about Iceland has increased the brand's reach and recognition, and she is now actively searching for a distributor in Germany. To strengthen its business strategy further, Eylíf has formed an Advisory Board with four business experts, focusing on international sales readiness.

Regional and Local Enabling Conditions

Eylíf's strategic connection with the IOC has been crucial for its development and networking within Iceland's blue bioeconomy. The owner's involvement since 2019 has facilitated valuable partnerships, highlighting the importance of being immersed in an innovative and collaborative environment. Additionally, the well-established blue

[52] Eylíf, *Eylíf is one of the twelve start-ups that were selected as the "Most exciting project for 2022",* https://www.eylif.is/en/eylif-is-one-of-the-twelve-start-ups-that-were-selected-as-the-most-exciting-project-for-2022/. Accessed 1 February 2024.

bioeconomy in Iceland has provided Eylíf with an ideal setting for finding production partners and leveraging the country's rich marine resources for product development. This ecosystem has been crucial for start-ups like Eylíf, offering networking opportunities and access to a community committed to sustainable use of marine resources.

Impact on Regional Development

Eylíf's impact on regional development in Iceland reflects a lean operational model, with only two primary staff handling the core business activities, supplemented by outsourcing key projects such as production, product development, distribution, and marketing. This outsourcing strategy to businesses like Pharmarctica for GMP-standard production exemplifies a cost-effective approach while fostering collaborations within the Icelandic blue economy. Recognition by the Ocean Cluster and the Icelandic Seafood Cluster highlights Eylíf's contribution to innovation, collaboration, and the utilisation of Icelandic natural resources, promoting the circular economy and enhancing the value chain of unique Icelandic raw materials. The IOC also testified to this achievement in March 2023, where Ólöf Rún Tryggvadóttir was awarded a special recognition for contributing to collaboration and innovation in the blue economy by utilising diverse Icelandic raw materials in her products and creating opportunities for other producers to work with Iceland's natural resources. The founder continuously shares her experience and knowledge with other pioneers in the industry, serving as an excellent example of collaboration and cooperation in the sector.

Social Impact

As a small company with a lean operational model, Eylíf has prioritized building a solid foundation for its business. However, its approach of outsourcing key activities, such as production and product development, provides significant opportunities to foster local employment and skill development. This collaborative strategy engages various service providers in Iceland's blue bioeconomy, indirectly supporting regional economies and sustainable practices. Through partnerships with local producers, Eylíf promotes sustainable harvesting practices while creating opportunities for innovation within Iceland's blue value chains. As the company grows, its potential to contribute more actively to social sustainability, such as through workforce development or educational initiatives, remains promising.

Noras LT

Noras LT is a Lithuanian company specialising in innovative aquaculture and RAS. The company, located in Letūkai, a village in the Klaipėda District Municipality, grows Arctic Charr, a cold-water salmonid fish.[53] The business was created in cooperation with Noras Watertech, a partner of Noras LT located in Norway that had developed aquaculture water treatment technologies. The company operates a closed aquaculture system, recycling 99% of the water and demonstrating advanced water treatment technologies. They continue cooperating with scientific institutions, contributing to ongoing research and experimental development in aquaculture.

Regional Context

Lithuania's aquaculture sector is undergoing significant transformation and growth, partly driven by an ambitious national strategic plan set to run until 2030.[54] This plan aims to nearly double production volume and significantly increase the sector's value. The focus is on various aspects such as sustainability, fish health and welfare, and added value. Key components of the strategy include promoting environmentally friendly practices and boosting organic aquaculture production, aligning with broader EU initiatives such as the Green Deal and Farm to Fork strategy. The plan also emphasises modernising the sector through technological innovation and efficiency measures and explicitly calls for the increased use of RAS and promoting renewable energy sources.[55] Currently, Lithuania's aquaculture production is primarily comprised

[53] Noras LT, *About Us,* Story, https://noraszuvys.lt/en/about-us/story/. Accessed 25 January 2024.

[54] European Commission, EU Aquaculture Assistance Mechanism, *Plan for the Development of the Aquaculture sector in Lithuania for the years 2021-2030,* https://aquaculture.ec.europa.eu/system/files/2023-03/AAM_MNSP_LITHUANIA_0.pdf. Accessed 25 January 2024.

[55] Eurofish, *Lithuanian aquaculture – a strategic plan with ambitious targets,* https://eurofish.dk/lithuanian-aquaculture-a-strategic-plan-with-ambitious-targets/. Accessed 25 January 2024.

of pond aquaculture, dominated by common carp. However, there is a rising trend in producing high-value species like African catfish and a shift to RAS.

Innovation is at the heart of Lithuania's aquaculture strategy, with efforts to integrate biotechnology, optimise dietary processes, and develop local markets. The focus is also on improving farm management and increasing access to knowledge and innovation through cross-border cooperation and partnerships with scientific bodies. There is a strong emphasis on research and development in aquaculture, with collaborations involving local universities and international partners. Projects like TETRAS and others focus on advancing recirculating aquaculture systems and other sustainable practices.

Value Chain

Noras LT has developed a RAS farm to grow Arctic Charr. Currently, the company is producing around 100 tonnes of fish and is seeking to reach the 250 tonnes mark in 2024. The decision to focus on Arctic Charr, a cold-water fish of the salmon family that usually lives in cold and extremely clean waters, was started by the uniqueness of the fish, which, at the time, was unexplored in the Lithuanian aquaculture sector.[56] Moreover, the flesh of this fish is characterised by a firm consistency, contains less fat than other salmonid species, does not suffer crowded conditions, and hence still grows well in high densities.[57] Therefore, Arctic charr had a higher value on the market compared to alternatives suitable for aquaculture.

As of 2021, the company had four separate systems: an incubator hatchery, a juvenile system, and two fish grow-out systems. They grow the artic char from egg to commercial size but import the eggs for cost-effectiveness reasons. Noras' clients include supermarkets, local restaurants, and private customers with smaller orders. They sell portion sizes (around 400 grams) and large-size fish (from 1 to 4 kg). [58] Their biggest customers are outside Lithuania, including wholesalers that purchase larger quantities than LT retail chains. Because of logistics' vital role in ensuring that the high quality of the product is not compromised, Noras LT uses its own transportation logistics for 80% of its services.

Additionally, the company has tested an aquaponics system, a technology and a process in which fish and plants are raised together in a joint project with Klaipėda University. Noras LT was responsible for monitoring the experiment, which would guarantee the production of two food sources, fish and vegetables, in one space-saving location.[59] Additionally, the company supplies a farmer in the area with sludge

[56] Circular aquaculture in the South Baltic region, JSC Noras LT/Klaipeda District Lithuania, https://www.youtube.com/watch?v=356lvR1Av54. Accessed 25 January 2024.
[57] Noras LT, *About Us,* Story, https://noraszuvys.lt/en/about-us/story/. Accessed 25 January 2024.
[58] Noras LT, *Home,* https://www.norasgroup.no/. Accessed 25 January 2024.
[59] Klaipeda University, *Experiment of KU Researchers: Shall We be Growing Vegetables in Lithuania with the Help of Fish?,* https://www.ku.lt/en/news/experiment-of-ku-researchers-shall-we-be-growing-vegetables-in-lithuania-with-the-help-of-fish. Accessed 25 January 2024.

used to fertilise the fields. This sludge is a typical by-product of systems like RAS, where waste products accumulate at the bottom of tanks or pods as sludge. This sludge typically contains organic matter, including fish excrement, uneaten feed, and other organic materials, and is rich in nutrients like nitrogen and phosphorus, essential for plant growth. Therefore, it can be an effective and sustainable fertiliser for agricultural purposes.

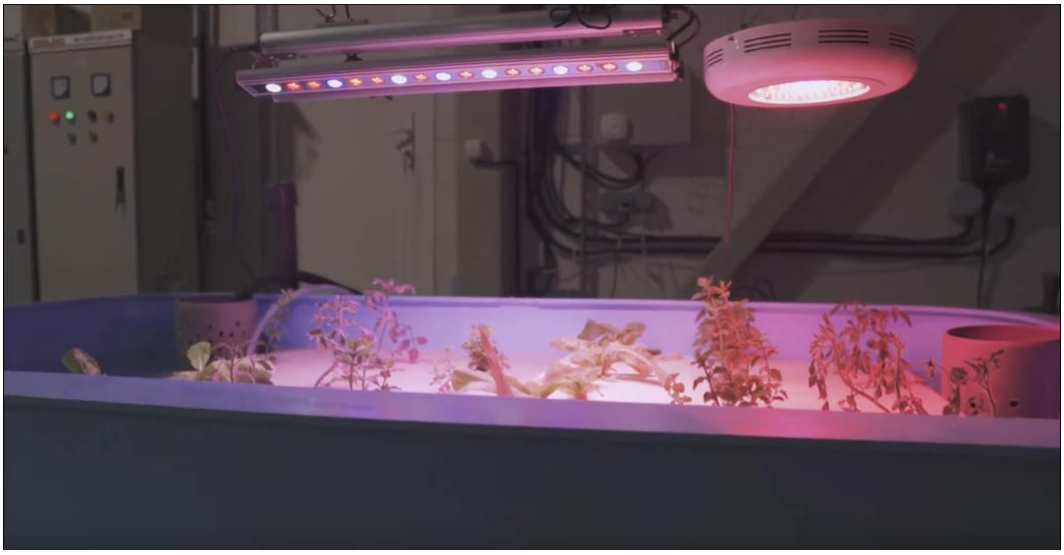

Figure 5. Noras LT experimental aquaponics system [60]

Regional and Local Enabling Conditions

Noras LT employs 12 people, all residents from the Klaipėda region. Their collaboration with Klaipėda University has helped them recruit new personnel, as they offer regular internships during the summer for students. Through this collaboration, they have gained two employees, who were offered a permanent position at the end of their internship.

The company, however, has also encountered several challenges to their operations. In the Klaipėda region, a significant issue for aquaculture, particularly RAS, is managing the high iron content in the water, a common characteristic along the coastal areas. Noras LT, using water from boreholes, had to address this by installing iron filters to ensure the water's suitability for fish cultivation.

In terms of operations, the quest for affordable and accessible local processors has also been harrowing. The company initially sought external processing services but encountered challenges, notably with product prioritisation and quality control. This led to dissatisfaction with the final product quality, as the company strives to produce high-quality fillets. This product requires specific processing expertise different from that for salmon or trout. The company also has ambitions to expand into value-added products like smoked, salted fish and ready-to-grill steaks. Still, it faces reluctance

[60] Circular aquaculture in the South Baltic region, *JSC Noras LT/Klaipeda District Lithuania,* https://www.youtube.com/watch?v=356lvR1Av54. Accessed 26 January 2024.

from processors to cater to these specific requirements. They observed that many local processors focus primarily on cutting costs, often compromising quality. While they have found processors that satisfy their standards, plans to expand their operations to include this critical production stage are in place.

Lastly, the company has encountered significant challenges in creating a local market for its products in Lithuania and has hence prioritised international markets. At present, Lithuanian consumers are not willing to pay a premium for environmentally friendly products, and retail chains often do not highlight local Lithuanian products, differentiating them from imported goods. Despite the lack of local demand and difficulty in finding processors who prioritise quality over price, Noras LT is still committed to proving the worth of their products. They believe that with time and education, consumers will begin to appreciate and prefer locally grown, high-quality fish. The company is open to prioritising the Lithuanian market if local demand for high-value local products were to increase, acknowledging the benefits of shorter supply chains and the importance of reducing transport carbon footprint. Private customers are welcome to visit the farm and purchase even small product units directly from the premises.

Impact on Regional Development

The company is determined to create highly qualified jobs, as skilled specialists are needed to advance and scale their operations and generate higher added value. The company's involvement in research and educational projects also promotes technological advancement and sustainable practices. They offer internships to students and cooperate with the University on several projects that support the creation of unique blue-tech skills in high demand in the aquaculture sector. They were featured in a virtual study visit as part of the AquaVIP project, where Klaipeda University was a partner. The project aims to boost the aquaculture labour market within the South Baltic area by engaging students and companies along the aquaculture value chain through cross-border training and networking.[61] Through their virtual study visit, the company showcased their innovative farm and contributed to upskilling future employees in the blue economy sector.

Additionally, Noras LT is planning to expand its operations to include processing and employ local labour with experience in the field to control the quality of their product from start to finish. The company recognises a potential to employ locals in their processing, as the region has many experienced workers in fish processing who might otherwise have to emigrate. Therefore, their move into processing could not only enhance their product quality but also contribute positively to local employment and stability in the region.

In terms of environmental contributions, using aquaculture waste as fertiliser is an example of a circular economy approach, where waste from one process becomes a

[61] AquaVIP, *Home,* https://aquavip.edu.pl/. Accessed 26 January 2024.

resource for another. This approach addresses waste management in aquaculture and contributes to environmental sustainability by reducing the need for synthetic fertilisers, which can have various environmental impacts. By collaborating with local farmers and providing them with natural fertiliser, the company is managing its waste responsibly and supporting the local economy.

Social Impact

As a company in the early stages of scaling its operations, Noras LT has primarily focused on optimising its aquaculture production systems. Nonetheless, it has already made meaningful strides in social sustainability, with significant potential to expand these efforts as it grows. The company employs 12 Klaipėda region residents, creating valuable job opportunities and contributing to the local economy. Moreover, its collaboration with Klaipėda University, particularly through providing internships and recruitment opportunities for students, plays a role in fostering innovation and developing a specialised regional workforce in aquaculture. The value of this partnership should not be underestimated, as it contributes to building a specialised regional workforce in aquaculture. Moreover, Noras LT engages with local farmers by repurposing aquaculture sludge as fertilizer, promoting circular economy practices and strengthening ties with the agricultural community. These efforts also highlight the company's dedication to integrating aquaculture operations with the broader regional economy.

Vetik

Vetik is an Estonian-based start-up founded in 2017. The company focuses on discovering innovative ways to valorise a local wild red seaweed called *Furcellaria lumbricalis*. It grows in the sea between the two biggest islands of Estonia - Saaremaa and Hiiumaa, in the West Estonian Archipelago. The company aims to develop algae-based products to utilise local red seaweed's full potential, e.g., a new bio-stimulant and a red colourant for row crops. While the company is only beginning, it has high ambitions of establishing a new value chain in Saaremaa Island to create new job opportunities and valorise critical biomass.

Regional Context

Estonia's marine strategy and regulatory framework are evolving to support emerging marine industries, with a focus on eco-friendly and economically sustainable practices, as outlined in a recent study of shellfish and algae farming business plan issued by the Estonian Climate Ministry. The regional context of Estonia, particularly in relation to the blue bioeconomy and commercial activities in the macroalgae value chain, is marked by growing interests and investments in seaweed, as well as shellfish farming. Estonia's coastal areas, notably the West Estonian Archipelago, offer a conducive environment particularly for seaweed farming, given the presence of several native seaweed species like Baltic Sea red seaweed (*Furcellaria lumbricalis*). The sector is gaining traction due to its multiple food, biotechnology, and environmental applications. Moreover, the potential of aquaculture as nitrogen and phosphorus removers from seawater is particularly relevant for Estonia due to the high levels of eutrophication that characterise the Baltic Sea.[62]

[62] Riigi Tugiteenuste Keskus, Kliimaministeerium, *Karbi- ja vetikakasvatuse äriplaani uuring tegevuse majandusliku otstarbekuse väljaselgitamiseks*, https://kliimaministeerium.ee/en/media/11815/download, Accessed 31 January 2023.

Value Chain

Vetik's operates in the Baltic Red Seaweed value chain. This local seaweed has been harvested in Estonia since the 1960s, and the harvesting process has not appeared to harm the raw stock. This algae's estimated wild stock resource is 150,000 tonnes, and the company's shareholders have successfully obtained a license to harvest approximately 2,000 tonnes per year. Initially, this red seaweed was used to produce furcellaran, a polysaccharide gelling agent used predominantly in the food industry as a vegetarian- and vegan-friendly alternative to gelatin and in the pharmaceutical and biotechnology fields. While the *Furcellaria lumbricalis* seaweed is also found in Denmark, Poland, Latvia, and Canada, only the Estonian company Est-Agar produced furcellaran from this red seaweed.[63] However, as demand for this product has fallen in recent years due to market shifts, the price of this seaweed has lowered significantly, making it less economically viable to harvest and use as done in the past.

Vetik embarked on a fascinating challenge by focussing on *Furcellaria lumbricalis*, which is not commonly used commercially. This leads to a lack of established market knowledge and applications for this particular seaweed. Unlike widely used seaweeds with known properties like carrageenan, *Furcellaria*'s distinct properties limit its interchangeability in the market. This poses a risk to potential customers who will lack alternatives if Vetik's production faces issues. The company is now at a crucial juncture, needing investment for scaled production but facing uncertainties about market acceptance and consistent quality. This situation creates a dilemma, requiring a calculated risk to invest in machinery without guaranteed buyers.

For this reason, the company has sought to establish itself as the mid-section of the value chain to link seaweed harvesting with the production of new high-value compounds by establishing a biorefinery. Vetik is focused on understanding the unique properties of this seaweed and identifying market niches where it can offer superior performance. Hence, through research, Vetik is exploring new uses of this seaweed for products that can make its harvest and cultivation more commercially viable, namely the extraction of a red colourant pigment to be used in both food and cosmetic applications and the development of a bio-stimulant.

While Vetik's development of processing techniques and product samples is crucial, they confront a challenging situation: investment in machinery for scaled-up production hinges on confirmed customer interest, but securing customers requires demonstrating large-scale production capability and consistent quality, a leap of faith for both Vetik and potential buyers. Their approach to solving this challenge is leveraging funding opportunities such as TACO Algae, a BlueBioCofund project, and other grants supporting further research for product applications. The former, an ERA-NET project, is a collaborative research initiative funded under the European

[63] Invest in Estonia, *Estonia's unique red algae finds its way into sweets and pharmaceuticals,* https://investinestonia.com/estonias-unique-red-algae-finds-its-way-into-sweets-and-pharmaceuticals/. Accessed 31 January 2023.

Research Area Network (ERA-NET), which amounted to €100,000.[64] ERA-NET projects aim to coordinate research activities and policies across national and regional European research programmes.

At this stage, Vetik's involvement in the value chain involves not only processing seaweed but also finding the right partners for further stages of product development. They aim to process seaweed efficiently, discover new high-value product applications, and seek collaborations with industrial partners to co-create high-value products from their processed biorefinery side streams. However, finding suitable partners is challenging due to Vetik's small size and the high-risk investment that is involved in product development. For example, their collaboration with a Finnish company on bio-stimulants has been ongoing for three years without reaching a sales stage, illustrating the lengthy process of building trust and forging partnerships.

Additionally, the company recognises the need to transition from wild-harvested seaweed to cultivation, a more sustainable approach necessary for scaling up their operations to ensure sustainable resource management and consistent supply for their biorefinery processes. However, as seaweed cultivation involves additional licensing and higher costs compared to harvesting, this step cannot be taken at the current stage. Nevertheless, Vetik sees the current situation as a starting point for growth. With their access to wild seaweed, they can begin operations and, over time, transition to a more sustainable cultivation model. This approach might attract more interest and investment as they provide proof of concept for their business model.

Regional and Local Enabling Conditions

Vetik's operations in the Muratsi village on Saaremaa Island benefit from its unique geographical setting. Besides providing access to substantial quantities of *Furcellaria lumbricalis*, Saaremaa's lower salary scales compared to mainland Estonia, its higher quality of life, as well as fewer alternative employment opportunities make it an attractive location for Vetik's business operations.

Moreover, Vetik's presence in Saaremaa also involves participation in a local Community of Practice (CoP), a collaborative group focusing on bio-systems and their governance. These CoPs are regional co-creation labs that bring together stakeholders from various sectors, including research, industry, policymaking, and the local community. They work together to increase awareness, provide feedback on business concepts, and support social innovation in bio-systems.

Lastly, Vetik benefits from being the only significant seaweed-focused entity in Estonia. This exclusivity has led to increased visibility in EU projects, enhancing opportunities for collaboration and funding. The company's active involvement in projects like the AlgaeProBANOS, a project seeking to accelerate the development of

[64] Vetik, *Funding,* https://vetik.eu/#looking. Accessed 31 January 2024.

sustainable and innovative algae-based products in the Baltic and North Sea, has been instrumental in its efforts to establish a value chain for this particular biomass.

Impact on Regional Development

Vetik's work in seaweed cultivation and processing has the potential to significantly impact the environment, economy, and society in its region. From an environmental standpoint, cultivating seaweed in the Baltic Sea can help absorb excess nutrients and address eutrophication issues. The company's products, such as bio-stimulants, aim to reduce the use of harmful fertilisers and pesticides in agriculture, while pigments extracted from seaweed offer healthy and eco-friendly alternatives to synthetic colourants.

Vetik's operational strategy is intensely based on a localised approach. The cultivation and processing of seaweed near their base ensures streamlined operations, reducing transportation and logistical costs, and preserves active ingredients. As these critical value chain activities are to be carried out on the island, Vetik's operations can stimulate job creation in seaweed farming, logistics, and processing sectors, fostering local economic growth, introducing new skills and knowledge, diversifying the local economy, and offering a blueprint for regional development that balances commercial success with ecological sensitivity.

Social Impact

As a nascent enterprise, Vetik is primarily focused on establishing its operations and exploring innovative applications for local seaweed resources. Vetik's initiatives hold significant promise for the region. Their operations not only have the potential to provide employment in seaweed farming, logistics, and processing but to also diversifies the local economy and impart valuable skills to the community. As Vetik continues to grow, its potential to enhance the social and economic resilience of Saaremaa remains substantial.

PhosphoTech

PhosphoTech is a company located in Nantes (France) that produces nutraceutical products from blue biomasses, mainly from fish by-products, but also from molluscs, crustaceans, micro and macroalgae. PhosphoTech's philosophy is grounded in the belief that the entire biomass can be utilised to develop nutraceuticals that improve human health and animal nutrition, making the company a pioneer in the sector. Abundant blue biomass supply thanks to regional historic fishing activities, as well as close partnerships with innovation clusters like Pôle Mer Bretagne Atlantique and research institutes such as IFREMER and Atlanpole Biotherapies, in addition to in-house R&D, allow for the production of innovative nutraceuticals. Thanks to the rising demand in the global market for these products, PhosphoTech aims to grow in the next few years.

Regional Context

PhosphoTech is located 50 kilometres away from the Atlantic coast in Nantes. The city and its surroundings are historically and culturally part of Brittany, a region with 2730 kilometres of coastline, more than any other French territory.[65] Easy access to the Atlantic Ocean, paired with its rich maritime biodiversity, made Brittany, over time, an important aquaculture and fishing region.

[65] European Parlament, Committee on Civil Liberties, Justice and Home Affairs , DRAFT MISSION REPORT, https://www.europarl.europa.eu/doceo/document/PECH-CR-746868_EN.pdf. Accessed 27 June 2024.

To ensure sustainable blue economy development, Brittany has developed in recent decades into a European leader in marine research, serving as a role model for bringing academia and industry together in driving innovation within the maritime sector.[66] One influential actor supporting the maritime ecosystem in this region is the Pôle Mer Bretagne Atlantique Innovation Cluster, which provides networking, funding, and market access.

Value Chain

About 20 years ago, when PhosphoTech's founder Gwenaël Baudimant was working for IFREMER (the French National Institute for Ocean Science and Technology), he came to the conviction that marine resources could be used to develop high-value extracts and products contributing to the health and nutrition of humans and animals. Today, PhosphoTech works with various blue biomasses, mainly fish by-products, including fish skin, bones and livers. In addition to fish, the company also utilises bioresources from molluscs, crustaceans, and micro- and macroalgae.

Fish by-products are sourced primarily from local fish markets and fish processing companies in the Loire-Atlantique-Bretagne area.[67] Bivalve biomass, such as mussel meat, is currently imported from New Zealand. However, an ongoing project with Pôle Mer Bretagne Atlantique aims to find Brittany-based providers of this biomass.

Extracting and processing biomass is the next step in PhosphoTech's value chain. This stage involves extracting target molecules using innovative technologies that require less energy, leading to increased production and higher purity levels, resulting from 20 years of interplay between in-house R&D and international research teams.[68] Once molecules are extracted, nutraceuticals serving different needs are manufactured in a single location at Saint-Herblain near Nantes.[69]

PhosphoTech offers a broad product catalogue of nutraceuticals, including five product categories: marine powder, marine & vegetable oil powders, marine oils, marine & vegetable soft gel capsules, and innovative & bioactive marine ingredients. PhosphoTech's most exceptional products are innovative & bioactive marine ingredients specifically targeting the health industry with sustainable nutraceuticals. "LeciBrain", "ChondroFLX", "SulfoBiolin", "CollaSea", "ElaSkin",

[66] BIENVENÜE, Maritime economy for blue growth**,** https://msca-bienvenue.bretagne.bzh/strategic-innovation-areas/maritime-economy-for-blue-growth/. Accessed 27 June 2024.
[67] Nantes Saint-Nazaire Développement, BIORESSOURCES MARINES : PHOSPHOTECH DONNE UNE SECONDE VIE AUX DÉCHETS DE POISSONS. https://actus.nantes saintnazaire.fr/article/bioressources-marines-phosphotech-donne-seconde-vie-dechets-poissons. Accessed 27 June 2024.
[68] Phosphotech, NATURAL INGREDIENTS SUPPLIER, https://www.phosphotech.com/natural-ingredients-supplier/. Accessed 25 July 2024.
[69] Phosphotech, Supplier-of-marine-ingredients, https://www.phosphotech.com/supplier-of-marine-ingredients/. Accessed 25 July 2024.

"BlueMussel", "OysterCal", and "CalciSepia" are nutraceutical products made by PhosphoTech. Whereas "LeciBrain", composed of a lipid extract rich in phospholipids (60%) and highly esterified DHA (Omega 3), is said to improve cognitive health, "ChondroFLX", derived from marine micronutrients such as minerals and proteins, is said to be beneficial for joint health.[70] PhosphoTech's innovative ingredients are the result of close partnerships with research teams from institutes such as the University of Brest and Atlanpole Biotherapies. New research, currently carried out internally and through scientific partnerships, has the potential to support advancements in certain cancer and diabetes treatments.[71]

Figure 6. PhosphoTech's nutraceutical product "ChondroFLX [72]

Distribution of products takes place through a vast network of partners. Most products are distributed B2B to clients in bulk packages, such as powders in 10-25 kilogramme packages and soft gel capsules in boxes of 5,000-12,000 pieces. Since PhosphoTech's soft gel capsules are finished goods, B2B clients directly rebrand and resell them in their shops. As an exception, the innovative & bioactive marine ingredients and brands, such as "ChondroFLX", "LeciBrain", "SulfoBiolin", "CollaSea", "ElaSkin", "BlueMussel", "OysterCal", and "CalciSepia" are marketed directly B2C by PhosphoTech via e-commerce marketplaces.

The demand for nutraceutical products is large, mirroring PhosphoTech's production numbers. Currently, over 200 million capsules and 80 tonnes of oil are produced for the global market per year.[73] A large portion of PhosphoTech's clients are from Asia,

[70] Phosphotech, INNOVATIVE AND BIOACTIVE MARINE INGREDIENTS, https://www.phosphotech.com/supplier-of-marine-ingredients/products/our-specialities/. Accessed 4 July 2024.
[71] Ouest-France, Ronan Sévette, directeur général de Phosphotech, https://lemarin.ouest-france.fr/sciences-environnement/ronan-sevette-directeur-general-de-phosphotech-ef391d94-848d-11ee-9b65-2282e6d4bdd9. Accessed 4 July 2024.
[72] Phosphotech, INNOVATIVE AND BIOACTIVE MARINE INGREDIENTS, https://www.phosphotech.com/supplier-of-marine-ingredients/products/our-specialities/. Accessed 4 July 2024.
[73] Ouest-France, Saint-Herblain. Phosphotech, l'économie bleue comme boussole, https://www.ouest-france.fr/pays-de-la-loire/saint-herblain-44800/saint-herblain-phosphotech-l-economie-bleue-comme-boussole-309fd276-89b5-11ec-acfe-cf8b6b6910d6. Accessed 27 June 2024.

the United States, and Scandinavia, which are at the forefront of the blue economy.[74] To strengthen the European market share, in 2023, a new partnership with Mabitec, an exclusive distributor for the German-speaking market, was initiated.[75]

Regional and Local Enabling Conditions

PhosphoTech benefits from a large maritime innovation ecosystem in Brittany encompassing the Pôle Mer Bretagne Atlantique, Atlanpole Biotherapies, and the University of Brest. By working closely with these actors, PhosphoTech ensures knowledge transfer, which is crucial for innovative product development.

Next to the regional innovation ecosystem, historic fishing activities in Western France, paired with the under-exploitation of fish by-products, represent a critical enabling condition for PhosphoTech's business model. They ensure a high number of suppliers and an abundant volume of blue biomass. However, this supply is also at risk, as climate change impacts like rising water temperatures negatively affect the health and development of local marine species.

Further down the value chain, processing blue biomass requires suitable production machinery and equipment. PhosphoTech leverages production machinery and equipment from the agricultural sector in Brittany by repurposing these machines for marine applications. For example, agriculture equipment used for processing plant oils is adapted to process marine oils. Using equipment from the regional agriculture industry offers several advantages, including cost savings, efficiency, and sustainability. All regional enabling factors mentioned allow short and cost-effective value chains essential for sustainable growth.

Impact on Regional Development

PhosphoTech's underlying circular business model has a positive impact on the environment. Namely, by valorising previously unused fish by-products, waste is reduced. Further, having a regional supplier network ensures short transport routes, hence allowing for reduced CO_2 emissions.

Focusing on the social dimension and its impact on local communities, PhosphoTech minimises the economic losses of oyster producers by repurposing oysters contaminated by the norovirus into valuable products. In this way, PhosphoTech

[74] Ouest-France, Saint-Herblain. Phosphotech, l'économie bleue comme boussole, https://www.ouest-france.fr/pays-de-la-loire/saint-herblain-44800/saint-herblain-phosphotech-l-economie-bleue-comme-boussole-309fd276-89b5-11ec-acfe-cf8b6b6910d6. Accessed 27 June 2024.

[75] Phosphotech, MABITEC, EXCLUSIVE DISTRIBUTOR IN GERMANY, https://www.phosphotech.com/2023-mabitec-exclusive-distributor-in-germany/. Accessed 4 July 2024.

ensures a steady income for affected producers. Further, PhosphoTech is responding to the need to develop bio-health clusters in Nantes and the surrounding region, particularly by raising awareness amongst actors in the value chain about the potential for valorisation in the fishing and aquaculture sector. Ideally, new value chains can be unlocked once this new paradigm of full valorisation of blue biomass is fully adopted by regional historic industries such as fishery, oyster, and mussel farms. Already today, PhosphoTech works in close partnership with other companies along the value chain, creating opportunities for other businesses and driving employment in the sector. PhosphoTech's active partnerships and stakeholder engagement impact the local economy, as do the firm's growth plans. In fact, an expansion of production facilities is foreseen in the next two or three years. While the company currently employs ten people, establishing new production facilities will create new jobs and stimulate the local labour market.

Social Impact

PhosphoTech, while primarily focused on the valorisation of fish by-products for the nutraceutical and cosmetic industries, has made meaningful contributions to social sustainability in the Brittany region of France. The company supports local producers by repurposing norovirus-contaminated oysters into valuable products, ensuring a steady income for those affected and reducing waste. As the company looks to expand its production facilities in the coming years, it plans to create new jobs and stimulate the local labour market, building on its existing workforce of ten employees.

Conclusion

The blue bioeconomy, as a novel and rapidly evolving sector, poses unique challenges for startups and SMEs. Many of the companies profiled in this deliverable are in the early stages of their operations and are focusing their (limited) resources on establishing sustainable business models that can support their ambitions. This foundational work often takes priority over the emphasis on broader social sustainability initiatives, as these companies must first establish financial viability and operational stability in markets that are still shaping up.

For instance, startups like Vetik, Eylif, Noras LT, and SEAentia primarily concentrate on either refining their production processes or securing market acceptance for innovative products. Their size and stage of development limit their capacity to invest in social sustainability projects, even though their operations hold the potential to benefit the coastal communities they are integrated within in the future. Elements of social sustainability in the blue bioeconomy, particularly in sustainable seafood, such as fair labour practices, equitable resource distribution, and ensuring the involvement of fishing communities in decision-making processes related to fisheries management, are all elements that our case studies are well aware of and can integrate into their operations as they mature. While these efforts may not yet be fully realised, the foundation these companies build provides a clear pathway for incorporating these principles into their business models, ultimately driving positive social and economic impacts in their regions.

While the case studies reflect the unique contexts and challenges of individual companies, they also reveal important commonalities and differences at the basin scale and across the EU. For instance, a shared challenge for companies in the blue bioeconomy is the struggle to establish viable business models in an emerging sector with underdeveloped markets. This is particularly evident among startups operating in peripheral or less economically developed regions, such as Saaremaa in Estonia or coastal areas in Portugal, where local economic conditions and infrastructure often constrain growth. However, these regions also present opportunities for fostering local economic resilience by integrating traditional coastal communities into modern blue bioeconomy practices.

At the EU scale, the commitment to sustainable practices is a recurring theme, with most companies striving to align their operations with circular economy principles and environmental objectives. Differences emerge, however, in the extent to which companies can invest in broader social sustainability initiatives. Larger enterprises, such as Colruyt Group, benefit from economies of scale and access to resources that enable them to implement robust social and environmental projects. In contrast, smaller companies often rely on partnerships, such as collaborations with universities or participation in EU-funded projects, to offset resource limitations and build capacity for social and environmental innovation.

For decision-makers and actors at various levels, these insights highlight the need for targeted support mechanisms that reflect the diverse contexts in which blue bioeconomy actors operate and their skills and capacities. At the basin scale, strategies could focus on fostering transregional collaborations, enabling cross-basin knowledge sharing of best practices and addressing shared challenges, such as skills shortages or market development. At the EU level, policy frameworks should aim to create an enabling environment that facilitates access to funding, promotes knowledge exchange, and enables the integration of social sustainability practices alongside environmental goals within the quickly developing blue bioeconomy sector. By enabling knowledge transfers across basins and by addressing regional commonalities and differences, the blue bioeconomy can better leverage its potential to contribute to sustainable and inclusive economies in coastal communities across Europe.

Deliverable 2.3

Blue Bio Value Chain & Social Enterprises Cases

Interview Questions and Consent Form

In the framework of the EU-funded BlueBioClusters, which supports innovative bluebio value chains in nine selected European Regions, **we are currently interviewing companies,** recommended by our regional partners, **who represent a regional excellence in the blue bioeconomy.** The goal is to showcase innovative, successful applications of blue bio value chains and promote them through case studies, which will be disseminated on the project's website and social media.

We would like to interview your company for ca. 45 minutes to gather key information to tell your story and follow-up with targeted data requests so that we can present your case in a well-crafted case study.

Below you will find the interview questions we would like to ask and specific information we would like to request you in advance via email to enrich our discussions during the interviews.

Please feel free to contact us at sto@submariner-network.eu for any additional information.

The interview structure includes three key components:

1. **Description of Value Chain:**
   - The company will provide insights into its involvement in a specific value chain, offering a comprehensive understanding of the processes entailed.
2. **Regional and Local Enabling Conditions:**
   - We will explore regional and local factors that contributed to the establishment of the company, exploring the conditions that facilitated (or hindered) its growth.
3. **Business Impact on Regional Development:**
   - We will conclude by focusing on the business's broader impact, analysing its contributions to regional economic, social, and environmental development.

To complement our qualitative insights**, we kindly request businesses to respond to the following questions via email:**

- **Biomass Harvesting:**
  - What type(s) of biomass does your company harvest and/or process, and in what quantities?
- **Employment in the Region:**
  - How many employees does your company currently employ in the region?
- **Financial Metrics and KPIs:**
  - Are there any financial metrics or key performance indicators (KPIs) related to your business that you would like to share to illustrate your company's performance?
- **Awards and Recognitions:**
  - Have you received any noteworthy European, national or regional awards, such as Entrepreneur of the Year? If so, please do share them with us as we would like to feature these in your case study description.

Your responses to these questions will help us get more contextual data to conduct the interviews, offering a more comprehensive view of your company's operations and impact that will be reflected in the final case study analysis.

Interview Questions

Description of Value Chain

- Tell us about your business and its role in the valorisation of value chains in the [specific industry or sector] …

Regional and Local Enabling Conditions

- Tell us about what made you decide to start the venture/business in your specific region?

Impact on Regional Development

- How does your business address some of the economic, social and environmental challenges that affect your region/subregion?

  ! If you are a start-up: **What economic performance factors** can you achieve in the region (e.g., jobs, wages, revenues, productivity, attractiveness)?

Informed Consent

The recording of the interview will not be published. Your consent does not authorise the full publication of your responses but only their coding for the development of the case study.

Practicalities

The foreseen interviews will be conducted between December 2023 and January 2024 by a Submariner Network employee and possibly a representative from the respective regional cluster involved in the BlueBioClusters project. The interviews will take place online on MS Teams and last approximately 45min. To ensure a sound analysis of the interviews and a correct interpretation of the answers, the conversation will be recorded to allow transcription and coding. **Therefore, the interviewee is asked to sign a consent form before the interview takes place.**

GDPR and personal data collected in the project

We will not collect direct personal information about you in this project –however we will collect it indirectly. First, we will have recordings of your consent to participate and tape recordings of the interview itself for quality purposes. We will delete the latter when the interview is transcribed. Your consent will be deleted at the end of the project period (August 2025).
We will only use your information for the purposes described in this letter. All information from the study will be treated with confidentiality. Personal data will be processed in accordance with the requirements of data protection legislation (GDPR).

Written consent

I have received and understood information about the BlueBioClusters project, and I have been given the opportunity to ask questions. I consent to:

- ☐ Participate in the interview and answer the questions.
- ☐ That my personal data (recordings of interview) are stored after the session until transcribed or by the end of the project period at the latest.

I consent to all my personal data to be treated until the conclusion of the BlueBioClusters project.

(Signed by participant, date and place)