BlueRev

Bio-based revitalisation
of local communities

Analysis of governance models in the pilot regions

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Table of Abbreviations and Acronyms

Abbreviation	Meaning
AGCI	Associazione Generale Delle Cooperative Italiane
CFP	Common Fisheries Policy
CMO	Common Market Organisation
DVFA	Danish Veterinary and Food Administration
DFBG (COSVAP)	District of Fishery and Blue Growth
EMFAF	European Maritime Fisheries and Aquaculture Fund
GOIS	Governance of Innovation Systems
LLM	Large Language Model
OIS	Organisational Innovation Systems
PO	Producer Organisations
R&D	Research & Development
SME	Small and Medium-sized Enterprises
TIS	Technological Innovation System
TURF	Territorial Use Rights in Fisheries
TRL	Technology Readiness Level
UNIPA	University of Palermo

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1 Executive Summary

Coastal communities are grappling with challenges arising from the climate crisis, rural depopulation, and economic pressures. The BlueRev initiative addresses these issues by focusing on empowering coastal communities, reimagining policy frameworks and fostering adaptable governance structures. These initiatives aim to revitalise local economies through engagement with the blue bioeconomy.

To understand the dynamics influencing blue bioeconomy value chains, a comprehensive governance analysis is conducted across three pilot regions, in addition to one overseas territory. The analysis utilises the Governance of Innovation Systems (GOIS) approach, an extension of Technological Innovation Systems (TIS), to examine governance structures facilitating or hindering cooperation, innovation implementation, upscaling and dissemination.

The GOIS analysis is structured around six key functions: Knowledge development and dissemination, resource mobilisation, direction of search, market formation, legitimacy creation, and entrepreneurial experimentation. Data collection involves interviews, workshops, and desk research to evaluate governance effectiveness in these dimensions.

The results contribute to the development of recommendations in Work Package 4 (WP4), focusing on local governance but encompassing private sector and national governance aspects. A custom Large Language Model (LLM) specialising in TIS analysis aids in the initial assessment, with subsequent control and refinement carried out by researchers.

Three pilot regions within the European Union are examined, acknowledging the impact of EU policies on marine and aquaculture resources. Key policies influencing fisheries and aquaculture include the Common Fisheries Policy (CFP), Common Market Organisation (CMO) regulation, European Maritime Fisheries and Aquaculture Fund (EMFAF), Strategic guidelines for EU Aquaculture and the Farm to Fork Strategy.

The governance analysis serves as a foundation for generating recommendations aimed at fostering economic, ecological and social development within blue bioeconomy value chains. By understanding existing governance structures, the BlueRev initiative seeks to pave the way for sustainable and innovative practices in European coastal communities.

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2 Introduction

Coastal communities are facing several challenges, including the escalating climate crisis and depopulation of rural areas, which results in economic pressures. To meet these challenges, certain key focus areas, including the empowerment of coastal communities, the reimagining of policy frameworks and regulations, and the cultivation of adaptable governance structures, need to function to enable the revitalisation of local economies in the blue bioeconomy. These are integral aspects of BlueRev and key aspects in the current governance analysis of the pilot regions.

In order to revitalise sectors tied to the blue bioeconomy, there is a need to understand how knowledge, information and resources are shared locally within the region, and to identify the existing policy frameworks and regulations that set the playing field.

The deliverable outlined in this report aims to map the governance environments for the pilot regions to gain a better understanding of how current structures enable or hinder economic, ecological, and social development of the value-chains in the blue bioeconomy.

2.1 Aim and definition of governance

The aim of this analysis is to map and understand current governance structures for the blue bioeconomy across the pilot regions.

Governance refers to societal steering and can be described as a **process of co-ordination within networks**[1,2]. A core meaning of governance is **steering and co-ordination of interdependent (usually collective) actors** based on institutionalised rule systems[3].

A requirement for governance is thus, in other words, the presence of innovation system functions[4] that enable the management and coordination of networks and independent actors in such a way that an exchange between the public and private sectors can operate effectively.

2.2 Methodological approach

The methodology used to assess the governance structures of the pilot regions is the Governance of Innovation Systems (GOIS) analysis. The analysis is a development of the Technological Innovation Systems (TIS) analysis[4,5], used to assess and describe innovation systems functions that hinder or enable technological developments and implementation has also been used to study social innovations and urban innovation systems[6]. In comparison, the GOIS-analysis is focused on the governance of a system, looking at the organisational system to understand barriers and enablers for cooperation in the implementation, upscaling, and dissemination of innovation, new solutions and new forms of governance. The GOIS analysis is further related to what is known as

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Organisational Innovation Systems (OIS), that looks at organisations' conditions for operating in the innovation system[7], whereas GOIS is used to *assess* the governance of the innovation system. The GOIS analysis structure was developed in the Horizon 2020 project RUGGEDISED[6], and has further been used to analyse governance structures in the Horizon 2020 project MOVE21[8]. In MOVE21 it was used to assess innovative modes of governance in the Swedish government's strategic collaboration program[9] and of the initiative Fossil Free Sweden[10] – both being examples of new forms of public-private cooperation models to aid Sweden's sustainability transition.

The first step of the analysis is to map the structures of the system, including the main technologies, actors, networks and institutions involved. This is to get an overview and understanding of the governance landscape, before examining the interactions between the elements in the system. The second step of the analysis is where the GOIS borrows its structure from the TIS framework, analysing governance conditions based on six of the TIS functions (see Table 1).

Table 1. Innovation System functions

Functions	**Explanation**
Knowledge development and dissemination	Generation and spread of knowledge and expertise within an innovation system. Includes activities such as research and development (R&D), training, and education. The development aspect focuses on creating new technological know-how, while dissemination involves spreading this knowledge among various actors within the system, such as firms, research institutions, and government bodies. Effective dissemination ensures that the knowledge developed is accessible and can be utilised for further innovations.
Direction of search	The process of setting and influencing the trajectory of innovation activities. It involves guiding the focus of research and development efforts towards specific areas, technologies, or problems. This direction can be shaped by various factors, including policy decisions, market demands, societal needs, and scientific and technological advancements. Effectively directing the search can lead to more targeted and efficient innovation efforts.
Legitimacy creation	Building social acceptance and support for new technologies or innovation practices. Legitimacy is crucial for the successful diffusion of technology, as it influences public opinion, government policy, and

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	the willingness of stakeholders to invest in and adopt new technologies. Creating legitimacy often involves engaging with various stakeholders, including the public, policymakers, and industry players, to address concerns and build trust in the innovation.
Resource mobilisation	Acquiring and allocating necessary resources to support the innovation process. Resources can include financial investment, human capital, and infrastructural support. Mobilising resources is crucial for driving R&D efforts, supporting entrepreneurial activities, and building necessary infrastructures to enable innovation. The accessibility of these resources and the efficiency with which they are allocated can significantly influence the pace and direction of technological development.
Market formation	Creating demand and developing markets for new technologies. It includes activities such as setting standards and regulations, providing subsidies or incentives for adopting new technologies, and developing infrastructures that facilitate market growth. Market formation is essential to ensure that technological innovations find a viable commercial application and are adopted broadly.
Entrepreneurial experimentation	Highlights the role of entrepreneurs in the innovation system. It involves the testing, development, and implementation of new ideas, products, or processes. Entrepreneurs are vital in innovation systems as they often initiate the commercialisation of new technologies, take risks to bring novel concepts to the market, and adapt to emerging opportunities and challenges within the innovation landscape.

To identify and evaluate relevant enablers and barriers for governance of by-product valorisation in the fishing industry, the system functions along these six dimensions investigated using desk research and responses from interviews.

The results from this deliverable will further be used as input in WP4, where broad recommendations for the development of governance aspects that will allow for the economic, ecological and social development of by-product valorisation in the blue bioeconomy-based industry will be generated. The recommendations will primarily address local governance though aspects on the private sector and national governance will also be included.

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The initial analysis of the data was conducted with the help of a custom Large Language Model (LLM) built on the ChatGPT framework, specialised in TIS-analyses. After an initial assessment had been done by the LLM, the researchers controlled and deepened the qualitative analysis of the interviews to get to the result.

2.3 Data collection

Data and information collected for this analysis was conducted by consortium members, and it took place in the pilot regions in interviews and workshop settings, following a data collection protocol developed in WP3/Task 3.1 and described in deliverable D3.2. Information was also collected through desktop research.

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3 Case studies of pilot regions

In order to map and understand current governance structures surrounding the blue bioeconomy, selected pilot regions were analysed. The pilot regions analysed in this report are Denmark (Western Jutland) and Greenland, Italy (Trapani in Sicily) and Estonia (Saaremaa).

3.1 Shared governance structures

Three pilot regions are a part of the European Union (EU), while one of the pilot regions is an EU associated overseas territory (OCT, Greenland), and are thereby affected by EU policies. These policies collectively aim to manage and protect marine and aquaculture resources, ensure the sustainability of the fishing industry and secure the economic viability of coastal communities within the EU. Each of these policies carries specific measures, regulations and financial tools designed to achieve the sustainable development of fisheries and aquaculture in the region.

Some of the most important EU policies affecting fisheries and aquaculture include:

Common Fisheries Policy (CFP)

The CFP aims to ensure that fishing and aquaculture are environmentally sustainable and provide a source of healthy food for EU citizens. It seeks to manage fish stocks appropriately, reducing the impact of fisheries on the marine ecosystem. Key elements include setting catch limits (Total Allowable Catches), implementing technical measures to design improved fishing gear and protect habitats, and ensuring that EU member states enforce these rules effectively.

The Common Market Organisation (CMO) regulation is a part of CFP and aims to ensure a level playing field for all fishery and aquaculture products marketed in the EU. Producer organisations (POs) play a central role. As of 2023, there are approximately 200 producer organisations in 18 Member States, managing around 80 percent of the species under quota in the EU. These are made up of fishermen or fish farmers who associate freely to take measures to ensure the best marketing conditions for their products. The main advantage of these organisations is that they allow the producers themselves to adjust their production to market demand. The EU has encouraged their creation since the inception of the Common Fisheries Policy in 1970. Member States can financially support POs, which can withdraw fish from the market during price drops to guarantee fishermen a minimum income. Compensation is provided based on product type, with eligibility tied to legal quality criteria and limited to occasional surpluses. Compensation decreases as the withdrawn quantity increases. Withdrawn products can be repurposed, like selling for feed, to avoid waste. POs enforce rules such as exclusive selling through the organisation to concentrate the market. To prevent non-affiliated operators from disrupting the market, the organisation's rules may be extended to all fishermen in a specific area and period.

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European Maritime Fisheries and Aquaculture Fund (EMFAF)

The EMFAF provides funding to support the CFP and EU's maritime policy. It aims to promote sustainable fishing, improve the livelihood of coastal communities, and support innovation and modernisation in the sector, including the transition to more sustainable aquaculture practices.

Strategic guidelines for a more sustainable and competitive EU Aquaculture

This strategy focuses on promoting competitive and sustainable aquaculture in the EU. It highlights the importance of innovation, economic viability and environmental sustainability. The strategy also addresses challenges such as market organisation, access to space and water, and social acceptance of aquaculture.

Farm to Fork Strategy

As part of the European Green Deal, the Farm to Fork Strategy aims at making food systems fair, healthy, and environmentally friendly. It includes commitments to reduce the environmental and climate footprint of EU food systems and strengthen the resilience of food supply chains. This strategy significantly impacts fisheries and aquaculture by promoting more sustainable practices and reducing the dependency on wild fish stocks.

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3.2 Italy

This pilot case unfolds in Sicily, the southernmost island region of Italy. Sicily, with its rich maritime heritage and diverse coastal resources, is uniquely positioned to capitalise on the blue bioeconomy. The focus of the pilot region is to target value chains related to marine bioactive compounds and ingredients derived from fish processing residuals and algae for industrial applications (e.g., cosmetics, nutraceuticals). The pilot region, managed by UNIPA, with the support of DFBG, boasts a robust network comprising enterprises in fishery, aquaculture, processing industries, academia, local government and producer associations. Extensive mapping and characterisation of fish by-products from key value chains have been accomplished, and extraction protocols for marine bioactive compounds have been established in the region. However, two key challenges persist in realising circular economy processes for marine residual biomass:

Infrastructural limitations and a nascent biotechnology sector: insufficient infrastructures and governance measures/business models hinder the effective collection, storage and sale of marine by-products.

Production-to-end-user gap: a gap exists in connecting production with end-users in sectors such as cosmetics, nutraceuticals, and pharmaceuticals, impeding the circular economy's potential.

Overcoming these key challenges is pivotal for Sicily's marine bioactive compounds and fish processing residuals value chains. Governance addressing infrastructural limitations, enhancing stakeholder collaboration, and aligning with circular economy principles will thus unlock sustainable development, economic growth and environmental responsibility.

3.2.1 Current governance structures

The pilot region in Italy demonstrates multilevel governance structures, with strong local, regional, and national levels of government in addition to the vertical connection to supranational governance on the EU-level. The strong nature of multilevel governance in Sicily is in part due to being one of five autonomous regions in Italy. This means that Sicily has the ability to create its own laws and regulations in certain areas. In addition, Sicily has its own government and parliament representing the island’s interests in a wider national context. On a national level the governance of the fishing industry is under the responsibility of the Ministry of Agriculture, Food and Forestry Policies.

On a local and regional level in the province of Trapani (Western Sicily) there are several organisations involved in the governance of the fishing industry:

- Cooperatives
- Producer’s organisations
- Trade associations

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- Consortium for the management of artisanal fishery
- Production districts (i.e. DFBG)

The overarching responsibility for overseeing fisheries matters in Sicily falls under the **Fisheries Department of Sicily**. This means that the region has some autonomy over fisheries related issues, and the department has as its responsibilities to, among other things: encouraging cooperation, through cooperatives consortia and associations of producers; conservation and the optimal exploitation of the biological resources of the sea; and recovery and use of underutilised and/or discarded resources.

Cooperatives provide administrative support for enterprises in the fishing industry. Memberships to cooperatives can be obtained for a yearly fee, and in return the cooperative provides its members with help related to, for example, licencing and subsidised costs for necessary equipment. There are 44 cooperative consortiums gathered under the General Association of Italian Cooperatives Sicily (Associazione Generale Delle Cooperative Italiane - AGCI Pesca [fishing]). ACGI as an overall initiative was first launched to provide Italian cooperatives across industries, with stable coordination and representation.

Producer organisations as well as **trade associations** are present in the Sicilian fishing industry. Trade associations represent and protect the interests of companies and their employees. The trade associations assist their member in interactions with institutional actors and economic stakeholders on multiple levels. They further provide assistance and consultancy services in areas such as: accounting and administration; payroll and contribution management; management of economic and financial aspects; union representation; handling of bureaucratic practices; occupational health and safety; compliance management (environmental, privacy, etc.); organisation of fairs, training events and travel; contracts; statistical analysis and data collection. In general, matters of interest to a company, self-employed worker or public administration body.

Two main trade associations in Sicily are worth mentioning here. The District of Fishing and Blue Growth – DFBG (or COSVAP in Italian) of Mazara del Vallo has been solving problems in the fishing sector and in supporting companies in the supply chain for years. DFBG was established with the signing of the District Agreement, and is recognised by the Sicilian Region with DA n. 182/12.S of 26 February 2008, which was renewed in 2011, and again in 2013, and lastly with DA n.164/GAB of 20/02/2020. The district aims to research, build and implement useful actions for the entire fish supply chain at local, national and transnational level. This is achieved by acting in synergistic cooperation with neighbouring countries, research institutions, public and private institutions, credit institutions and businesses. The DFBG supports and directs their economic and social growth processes according to the principles of the Blue Economy.

Sicindustria is the largest of the Territorial Associations of the Sicilian Confindustria system. It has seven operational and representative offices in the provinces of Agrigento, Caltanissetta, Enna, Messina, Palermo, Ragusa and Trapani with over 1,000 member companies and around 50,000 employees. It represents and protects associated

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companies in relations with institutions and administrations, with trade union, economic and political organisations. Sicindustria offers a wide range of services to provide support and guarantee competitiveness to companies in all fields of interest: trade union, education, training, safety, environment, quality, tax assistance, corporate finance and many others. Sicindustria offers free services to expand the market, launch new products, enhance technological capabilities, access projects and community funding. It has been a part of the Enterprise Europe Network (EEN) for over ten years. The ENN is the European Commission network that helps SMEs to grow, innovate and internationalise.

Consortium for the management of artisanal fishery is a collective management body for coastal resources. The Italian authority introduced Territorial Use Rights in Fisheries (TURFs) for small-scale fisheries to manage mobile species. Under Regulation 1198/06 of the European Fishery Fund, a local management plan can be designed by a collective managed body, comprising at least 70 percent of registered enterprises in the area. This plan, formulated with a research institute, addresses critical issues and proposes solutions for funding allocation. The plan undergoes evaluation, adoption, and enforcement processes, monitored by research institutes for three years. However, implementing regulations faces challenges, such as the need for restrictive measures impacting fishermen's income. To address this, incentives are crucial. In Sicily, ten consortia established local management plans through a participatory process, involving approximately 80 percent of relevant registered vessels. Sicilian fishermen's traditional knowledge was vital in formulating efficient regulations to reduce fishing and rebuild fish stocks, while ensuring long-term economic sustainability.

The organisations are loosely connected, but independent entities that provide support to the fishing industry in varied ways. Cooperatives can be considered more local organisations, helping with administrative support, while the POs aid in the market formation. The consortium is one step up in the hierarchy, organising actors around the sustainable management of fishing areas, whereas the trade associations represent the interests of actors on a regional and national level.

3.2.2 Knowledge development and dissemination

The journey towards fully realising the potential of the blue bioeconomy in Sicily is challenged by limited awareness about the value of marine by-products, their underutilisation, noticeable gaps in specialised knowledge necessary for research and development, and infrastructural constraints that impede the development and export of niche marine-based products.

In Sicily's marine industry, marine by-products are seen more as waste than valuable resources. This view is common across sectors in the fishing industry, including fishing and processing, suggesting a considerable gap in understanding the economic and environmental potential of by-products. The perspective that ‘paying to dispose fish is

much easier than exploring its potential' according to one interviewee, limits innovation and utilisation of side-streams as a resource. Transforming this perception is vital to unlocking new opportunities, encouraging sustainable practices in the industry and advancing Sicily's blue bioeconomy.

Additionally, the population in Sicily is declining. Young people are increasingly emigrating to other European countries in search of job opportunities. This results in shifting demographics, with a combination of early school leavers and an ageing population leading to a lack of workforce in all sectors, including the small-scale fisheries[11,12]. This contributes to knowledge gaps, and a stunted knowledge development due to a diminishing workforce, that are present in the region, particularly in the application and commercial viability of marine by-products. This indicates a pressing need for promoting advanced vocational training courses (curricula creation) as well as focused research and development to discover and leverage the economic potential of resources. Bridging these knowledge gaps would not only benefit the industry economically but also contribute to more sustainable and environmentally friendly practices, aligning with global trends towards green economies.

Despite the existing governance system, there is a general lack of forums for dialogue and activities related to the utilisation of fish waste. There appears to be a general lack of awareness among industry stakeholders about specific initiatives aimed at promoting and valorising marine by-products. The initiatives that do exist seem to be focused on raising industry awareness and improving the market appeal of products, yet their impact appears to be limited in scope. To fully harness the potential of Sicily's marine by-products, more coordinated and widespread efforts are needed, involving stronger collaboration among industry players, academia, and government bodies.

3.2.3 Direction of search

In exploring the 'Direction of search' within Sicily's burgeoning blue economy, particularly in the marine bioactive compounds sector, it is essential to assess how shared visions and broad strategies are being established.

As mentioned, in section 3.2.2 *Knowledge development and dissemination* above, there seems to be a general lack of awareness in the region regarding ways to promoting and valorising marine by-products. Nonetheless, the presence of initiatives such as the "Blue Sea Land - Expo" suggests that there are ongoing efforts to establish arenas for dialogue and collaboration among industry stakeholders. These platforms are critical for fostering connections, sharing knowledge, and aligning strategies and visions among the various actors involved in marine by-product, including fishermen, processors, researchers, the marine bioactive compound industry, local and national policymakers. The importance of arenas for facilitating industry-wide communication and partnership cannot be overstated, as they contribute significantly to shaping a collective direction for innovation and development. Ensuring that involved stakeholders are on the same page is vital for advancing collaborative and coherent strategies.

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The prevalent uncertainty about how solutions can be scaled and optimised over time still indicates a gap in strategic planning within Sicily's fishing and bioactive compound industries. This gap suggests the need for a more comprehensive approach to strategic development and implementation, ensuring that innovations are not only effectively developed but also appropriately scaled and integrated into the broader industry landscape. Such gap can, for example, be bridged by establishing the dialogues between the production sector and scientific research and between these two components and regional planning.

3.2.4 Legitimacy creation

Legitimacy creation is an essential function in establishing broad societal acceptance and ensuring compliance with existing institutions. Legitimacy creation is critical for fostering a sustainable and innovative blue economy in Sicily.

Many respondents point to a need for more engagement with the broader community for the use of marine by-products. Increasing societal acceptance is crucial for the growth of this industry and can be achieved through public awareness campaigns, educational programs, and transparent communication about the benefits and safety of marine by-product utilisation. In general, local production is highly valued for its quality and the authenticity of the value-chain by the public in Sicily and beyond. This can be used as driver to promote marine by-products and strengthening Sicily's blue value chains.

Responses from industry participants frequently indicate a lack of knowledge about existing policies and regulations that govern the utilisation of marine by-products. This uncertainty suggests a need for better dissemination of regulatory information and more accessible guidance for stakeholders. However, references to specific legislations like D.lgs. 152 / 2006 ITA and REG 1069/2009 EU indicate that there are guidelines in place for the sustainable utilisation of marine by-products governing the sector, albeit the participants' awareness and understanding of by-product utilisation within the industry remain unclear.

Furthermore, there is a gap in risk awareness and understanding of safety and environmental implications concerning marine by-product utilisation among the respondents. This gap highlights the importance of initiatives for enhancing industry knowledge about regulatory compliance, safety standards, and environmental impacts. Such initiatives cannot only influence the willingness of stakeholders to invest in and adopt new technologies and marine compounds, but it can also contribute to foster responsible and sustainable practices that over time can build trust among the public.

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3.2.5 Resource mobilisation

Resource mobilisation is crucial for enabling systemic change in the blue economy and it involves attracting necessary financial, physical, and human resources.

Respondents voice concerns about the sufficiency of financial resources for the industry's development. This uncertainty primarily highlights the need for better financial planning and resource allocation strategies to support the growth and sustainable development of the industry.

Industry stakeholders indicate significant quantities of marine by-products being generated annually, with figures reportedly ranging from 8.000 kg to 31.000 kg per organisation of those interviewed in the Trapani region, mainly during the April to September period. However, a common challenge mentioned is the difficulty in finding storage for these by-products, indicating infrastructural limitations in handling and processing these resources efficiently.

Furthermore, interview results suggest that, currently, the industry does not perceive a significant shortage of the skills necessary for developing sustainable utilisation of marine by-products. This could indicate either a satisfactory level of existing expertise or possibly a lack of recognition of potential skill gaps. However, interviewees bring forward that there are gaps related to language and motivation among young people and young entrepreneurs to engage in the Sicilian blue economy. Only in some cases, Sicilian universities are able to support innovation in the sector by transferring useful skills, but they lack various resources for accelerating the transfer of the knowledge.

3.2.6 Market formation

Market formation, involving the creation of mechanisms for price-setting and market development, is a crucial aspect of fostering a robust blue economy in Sicily.

In Sicily, there is currently a general low experience of utilising marine by-product, including how to collect, where to store and how to sell and manage the products. This lack of experience is coupled with low knowledge of market opportunities. Thus, respondents primarily within fishery and the processing industry indicate scepticism about market potentials or highlight a prevailing pessimism about market opportunities.

While local scholars demonstrate a high level of knowledge about the potential for valorisation of marine by-products, including their Technological Readiness Level (TRL), there remains a need to assess the potential and to inform strategies for market expansion. This includes identifying new applications and target sectors. However, there is a lack of resources in research to engage in accelerators, knowledge and technology transfer, and to support start-ups in Sicily's blue economy. This support is crucial for identifying potential markets, new value chains and market opportunities for products derived from marine by-products.

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Furthermore, there is a general lack of knowledge among the respondents regarding policies related to public procurement, guarantees and subsidies that could influence market formations. Some reference to regulatory mechanisms for discarding by-products at sea, though their effectiveness in relation to market support remains unclear.

3.2.7 Entrepreneurial experimentation

Entrepreneurial experimentation, involving the exploration of new commercial applications through innovative practices, is a key driver for growth in Sicily's marine bioactive compound industry.

The lack of end-users for marine by-products (e.g., in biorefineries or the cosmetics industry) and associated knowledge systems or networks represent obvious barriers to innovation development and entrepreneurial initiatives involving by-products from the fisheries sector.

However, respondents from various actors also cite barriers related to the lack of committed individuals within governmental bodies. For example, they point to the importance of smart specialisation, support for skills and knowledge transfer, research and technology infrastructure, and exchange of good practice information between all actors. Although such activities are important for guiding general efforts in strengthening the area, they also encourage innovation development and entrepreneurial experimentation. Enhancing partnerships among private and public organisations is thus a vital step in encouraging more entrepreneurial experimentation and exploration of cross-industry applications. Supporting initiatives investigating the commercial use of marine by-products, including identification of risks and challenges, can further encourage innovation development and entrepreneurial actions.

3.2.8 Summary and conclusions

Sicily's endeavour to cultivate a flourishing blue economy, cantered around the sustainable exploitation of marine bioactive compounds, demonstrates the region's rich maritime heritage and its dedication to sustainable growth. The governance analysis of Sicily has revealed a complex landscape, presenting both challenges and abundant opportunities.

To fully realise Sicily’s potential in the blue economy, a comprehensive and integrated approach is imperative. This entails stronger collaboration with research and education to bridge knowledge gaps, fostering a supportive regulatory framework, effectively mobilising resources, creating vibrant markets for novel products, and encouraging entrepreneurial experimentation. These facets are not only vital individually, but they are also interdependent, creating a synergistic effect that can drive Sicily towards its blue economy goals.

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Achieving success in this endeavour will require concerted efforts from a diverse range of stakeholders, including local enterprises, government entities, academia, and the wider community. Facilitating platforms for dialogue, fostering unified strategies, and cultivating strong collaborative networks are essential for tangible progress. Furthermore, leveraging Sicily's unique characteristics, such as its extensive coastal resources, longstanding maritime tradition and a production that is high valued for quality and the authenticity, is crucial for carving out its niche in the global blue economy.

In summary, Sicily's strategy for developing its blue economy, particularly through the valorisation of marine bioactive compounds, serves as a paradigm for innovative and sustainable regional development. Addressing the challenges identified in the governance analysis, and capitalising on its marine assets, positions Sicily not only for economic growth but also as a contributor to a sustainable and ecologically responsible future. This journey reflects Sicily's broader commitment to innovation, environmental sustainability, and community involvement, establishing a precedent for similar coastal regions worldwide.

Key takeaways:

- **Underutilisation of marine by-products:** The perception of marine by-products as waste rather than valuable resources limits innovation and sustainable utilisation, highlighting a significant gap in understanding their potential.
- **Knowledge and workforce gaps:** The declining local population and emigration of youth contribute to a lack of skilled workforce and knowledge, underscoring the need for enhanced education and training to support the blue bioeconomy.
- **Need for coordinated efforts:** A concerted effort involving industry stakeholders, academia, and government is essential to overcome infrastructural and knowledge barriers, fostering a sustainable and innovative marine industry in Sicily.

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3.3 Denmark & Greenland

The Nordic pilot regions in this study encompasses both Greenland and West Jutland in Denmark, where the fishing industry and seafood processing play pivotal roles in the local economies. The value chain in focus in this project encompasses the valorisation of side streams from fish processing.

Navigating governance challenges is paramount for the Nordic pilot regions' fisheries and seafood processing industry. A strategic governance approach, incorporating innovative solutions and policy adjustments, is essential for sustainable growth and global competitiveness. Eight main challenges have been identified for the Nordic pilot regions:

Funding and investments: Governance priorities in funding lean toward energy reduction and fishing tools, neglecting investments in crucial competencies and skills.

Sustainability: Logistical challenges in Greenland lead to the disposal of side streams into the sea. Denmark faces expensive wastewater disposal due to high protein content.

Regulation: The governance structure's impact on regulatory processes is pronounced. Greenland's non-EU status prolongs approval for technological solutions.

Competition: In Denmark, competition for skilled labour intensifies, impacting the governance dynamics. Greenland faces cost challenges in exports as all products must be shipped long distances in areas lacking road infrastructure.

Talent and workforce development: Recruiting skilled individuals for seafood processing and side-stream development is a governance challenge in rural areas in both countries.

Geography: Greenland's governance structures face infrastructure and logistics challenges, limiting connectivity between settlements.

Business Plan/sales channels: Governance structures must adapt for the industry to develop sustainable business models for side-stream marketing.

Access to raw materials: Governance impacts Denmark's competitive access to raw materials, exacerbated by reduced quotas and BREXIT.

3.3.1 Current governance structures

Management of fisheries policy is shared under the Common Fisheries Policy of the European Union[13], and much regulation is adopted from EU directives and implemented on a national level in both Denmark and Greenland[14].

In Denmark the Ministry of Food, Agriculture and Fisheries is responsible for administrative and research tasks in the areas of farming, fisheries and food production.

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The administration at state level is managed by the Ministry of Food, Agriculture and Fisheries. The national government is responsible for the overall legislation related to fisheries, and that regulations are in accordance with EU standards. The national government is additionally responsible for:

- Improving value from fish catch and conserving resources;
- Developing optimal fishing methods;
- Aquaculture development;
- Regulation and inspections of the fishing industry;
- Support for research in fisheries;
- Support for the development of fisheries, fish industry, fishery harbours;
- Fishing license arrangements for recreational fisheries.

At the regional and local levels, much of the administrative responsibility has been delegated to the municipalities. Local governments can support the fishing industry, and further devise and implement programmes under the European Maritime Fisheries Fund via the national managing authority.

The governance system surrounding fisheries in Greenland has been described in detail in a recent publication[15], and will be summarised here. The overall management of fisheries in Greenland is decided by the Fisheries Act from 1996[16]. The government of Greenland governs the fisheries through the Ministry of Fisheries, Hunting, and Agriculture, which works with the Department of Fisheries as well as the Greenland Fisheries Licence Control, the latter which issues licenses, record statistics on catches, etc. In the Fisheries Act a Fisheries Council was established[17]. The government of Greenland are required to liaise with the Fisheries Council in matter related to policy and catch quotas. The Fisheries Council has over nine members, with Grønlands Erhverv/Sulisitsisut (Greenland Business Association, GE) and Kalaallit Nunaanni Aalisartut Piniartullu Kattuffiat (the Fishers' and Hunters' Association of Greenland KNAPK), representing the industry and fishers respectively, being voting members. In addition, the Council has a number of non-voting members: Government Ministries, Association of Municipalities, Employee's Union, Employer's Association, the Nature Protection Association, Greenland Institute of Natural Resources and Greenland Fisheries Licence Control. The Greenland Institute of Natural Resources also serves as a scientific advisor in the area, conducting stock surveys and serving as experts in various contexts.

3.3.2 Knowledge development and dissemination

In both Denmark and Greenland there are knowledge gaps related to the utilisation of, and maximising the value from, by-products. By-products are to a large degree discarded either directly in the ocean (Greenland) or through the water used in processing the side stream (Denmark). Reports from Greenland indicate a significant volume of by-products, estimated at 30,000 metric tons from species such as cod, shrimps, and crabs, are

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routinely discarded into the ocean. This practice highlights a substantial underutilisation of potentially valuable resources. In examining existing procedures, it is noted that Atlantic Cod undergoes gutting at sea discarding liver and fish stomach, parts traditionally recognised for their value. Both the liver and stomach present harvesting opportunities for increasing the value of catch at sea. In both regions there is a cost for discarding the by-product.

Despite knowledge gaps in the valorisation of side streams, there are signs of change. Innovative initiatives, like recovery of nutrients such as protein and phosphorus from processing water in Denmark, and creative uses of solid side-streams, showcase a shift towards sustainability practices. Economic factors and a historically cautious approach to product development present challenges, but there is a growing trend towards embracing innovation and risk. For example, solid side-streams like carcasses, meat pieces, fins, and swim bladders present opportunities for further utilisation, which have evolved from being used in mink feed and dog food, to now being sold to companies like the biorefinery Biomega in Denmark.

Additional knowledge development is needed in both the fishing industry and among policy makers. This is most pertinent in relation to new products that are based on side streams being categorised as novel foods. This becomes an important hurdle, as it is not always easy to know what novel foods are, and what they are not. Furthermore, novel foods must be cleared for human consumption by the European Commission's Novel Food regulation, which is providing a regulatory barrier for new products to enter the market.

In terms of initiatives to address these gaps, there is evidence of a growing awareness within the industry in both regions to enhance the value derived from by-products. For example, in Greenland cod liver is currently a product sold to Iceland, indicating an emerging market for by-products that could be expanded with increased knowledge dissemination and technical capability.

3.3.3 Direction of search

In both Denmark's and Greenland's fishing industries, the direction of search is characterised by a need for effective collaboration between regulatory bodies and industry players. Navigating the challenges posed by regulatory requirements and market demands is crucial for the successful development and scaling of by-products. Shared visions among stakeholders, centred around regulatory compliance and market viability, will be key to driving innovation and sustainability in the industry.

A common problem for both regions is that it is difficult to get industry actors to collaborate around the use of side-streams, and work towards a common direction of search. Many businesses worry about sharing business secrets in collaborative projects around side-streams, as the fishing industry is very competitive. There is a lack of culture of sharing and collaborating in the industry in general. This needs to be overcome in

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order to find shared perspectives and visions for the development of value chains, and to propel these products forward both towards customers and consumers, and in meeting with regulation and policy.

In Denmark, formal arenas for dialogue and collaboration, particularly regarding by-products, are influenced by regulatory bodies like the Danish Veterinary and Food Administration (DVFA). The industry perceives a gap in inspectors' expertise in managing side streams, prompting DVFA to encourage companies to engage early with their ingredients team and inspectors during pilot production. This proactive approach can facilitate a smoother approval process and ensures compliance.

Industry collaborations do exist in both Denmark and Greenland. There is, for example, an ongoing collaboration between one of the main organisations on Greenland and a Danish food processing company, which has shown some promise. Ongoing dialogue and adaptive strategies are crucial for long-term success in by-product utilisation. The direction of search must therefore be informed by an iterative learning process, where feedback from initial efforts is used to optimise subsequent strategies.

3.3.4 Legitimacy creation

One of the most significant differences between Denmark and Greenland is their differing EU-membership status, and how this affects their fishing industries. While initially a member of the EU, Greenland left the union in 1985 over concerns of the impact of the Common Fisheries Policy (CFP) on local interests. As a result, Greenland has so called association agreements with the EU, including subsidies supporting the growth of the fishing industry and allowing Greenlandic fish to be sold in European markets. Denmark, on the other hand, is a member of the EU and must abide by the rules set out in the CFP. This includes marketing standards covering freshness, size categories, and detailed labelling requirements such as catch area and fishing gear used. These regulations ensure product quality and safety but also add layers of complexity for businesses, especially in handling and marketing by-products.

Policies and regulations significantly influence the market demand for fish processing by-products in both Denmark and Greenland. In both regions, businesses have to pay a fee to dispose of either the by-product directly in the ocean (Greenland) or the wastewater from the processing of the side-stream (Denmark) to minimise the environmental impact of the fishing industry. The financial implications of disposing of side-streams or the wastewater should act as a deterrence and can work as an impetus for innovation and novel uses of by-products.

Overall, the regulatory frameworks in Denmark and Greenland, as well as EU-level regulation can act as both a driver and a barrier for the market development of fish processing by-products. Businesses are incentivised to innovate and find new uses for these by-products within the constraints of existing regulations. Some of the smaller SMEs and start-ups with less specialised and smaller staff find it generally demanding

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and time-consuming to meet the requirements of the DVFA's inspectors. They demand a more manageable and suggestive approach to the inspections. In Denmark, for example, a company cannot get approval for production for both human consumption and animal consumption at the same location/factory. For instance, Biomega in Hirtshals is not allowed to produce products for both human and animal consumption on the same production site in Denmark, whereas it is not a problem on the company's site in Norway.

Additionally, key customers such as the British grocery retailer Tesco plc are beginning to ask what firms in the fishing industry are doing with their side-streams (from both fish and shrimp). This is driven by increased efforts among supermarkets and others to report and reduce environmental impacts throughout the value chain. This applies to Danish actors as well, but it is more salient in Greenland since some of the main producers there have a larger share of their business in ready-made food products (i.e., meals).

3.3.5 Resource mobilisation

Both Denmark and Greenland face pressure due to limited access to necessary input in the fishing industry. For actors in Greenland, fresh water is a bottleneck as it is a scarce resource that is needed to process the side-streams. Diminishing fish stocks and rising energy costs affects both regions, increasing the overall costs for actors in the industry. However, increasing costs for energy and importing fish (in Denmark) have led more actors to look into the use of side-streams to increase their profits.

While the interest to utilise side-streams seems to be on the rise, Denmark and Greenland have challenges related to the infrastructure of processing side-streams. In Greenland, some of the small settlements where the fish is processed do not have the freezing capacity needed that would allow by-products to be shipped to the market. Companies in Greenland also face challenges related to technological constraints. The lack of equipment to process by-products, such as extracting meat from frames, is a noted limitation. Moreover, the potential for exporting by-products like roe, swim bladders, and cod liver is acknowledged in the interviews but remains largely untapped due to these technical constraints. In Denmark, on the other hand, there is a lack of large-scale facilities for processing side-streams to higher value products. Currently, there is one company that focuses on salmon that may be on the verge of investing in a facility. However, the question is whether this is sufficient for the region as a whole.

A further resource challenge affecting Greenland and Denmark is a shortage of, and competition for, employees in the industry. The shortage is both in the fishing industry, finding people to work on boats and in processing facilities, as well as qualified labour working on maintenance such as electricians. Both regions face competition for workers. The service industry and the construction industry in Greenland are big competitors, and the growing life-science industry is presenting a challenge in Denmark. The shortage hampers the development of the side-streams in Greenland, as the lack of workers prevents businesses from processing both filets and side-streams. Developing the side-

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stream business could end up competing with the main business due to companies having to prioritise the former over the latter given the resource constraints.

Despite the similarities, the origin of the problem is somewhat different in Greenland and Denmark. In Greenland the lack of labour has mainly been attributed to a lack of housing, making it difficult for immigrant workers to find a place to live, serving as a disincentive for travelling to Greenland for work. A former barrier has also been long processes to gain work permits, which the government is trying to change through a fast-track system that would allow workers to gain permits faster. In Denmark, the picture is a little different. Here, the aforementioned lack of a labour force is due to a general competition for skilled workers, such as electricians, from other industries such as construction and the life-sciences industry.

Finally, there is a lack of funding and willingness to invest in the industry to scale-up the use of side-streams in both countries. The challenge is to attract sufficient funding in an industry where both quotas and profits fluctuate over time.

3.3.6 Market formation

There is potential for market development of side-streams in Denmark and Greenland. The market for by-products in Greenland, such as flavour enhancers, is substantial, with primary buyers being the food industry, including seafood processors. These products have the potential to be processed into high-value items, provided there is access to more local employees or transport facilities to processing locations. A factory in Maniitsoq has started to produce dog food from side-streams, receiving side-streams for free from a producer of fillets, showing a potential avenue for scaling-up the use of side-streams. There is a potential market for such products in bigger towns in Greenland, where people with greater purchasing power are willing to pay higher prices for products that contain side-streams from hunted and fished products. However, one issue in market development is that one of the biggest businesses on Greenland has 36 plants, many of which are located in very remote settlements. Logistics are very expensive since there are no roads, which makes it difficult to reach scale when processing side-streams.

Denmark lost one of its biggest markets for by-products from the fishing industry when the mink industry was all but terminated during the Covid19 pandemic. Due to the fear that novel Covid19 mutations could be passed from minks to humans, the entire farmed mink population in Denmark was culled in 2020[18]. Prior to the pandemic, much of the side-streams went to feed for minks, but it is now being exported instead. Today, the company Biomega stands out as a key player, offering a profitable avenue for various by-products. There is further market potential in Asia for heads and belly flaps, while scraped meat bits and pieces from smoked salmon fillets could be sold in the European market.

One of the barriers for market development in Denmark and Greenland is the cost of processing side-streams. Side-streams tend to be cheap material, but if there are too

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many processing steps, i.e., freezing, or too labour-intensive processes, i.e., scraping meat from carcasses, it becomes increasingly difficult for businesses to reach profitability. Assessment of markets for new products from side-streams can also be difficult, as globalisation is increasingly rolled back and more protectionist policies are re-emerging, making it difficult to export side-streams or products.

An additional both barrier and enabler for the market formation around the side-streams is consumer behaviour. Consumers have to accept new products made from side-streams, which can be a challenge as consumer habits tend to be sticky and difficult to shift. In the current market new products have to compete with existing products, and there is a need to nudge costumers into new purchasing behaviours or communicate to consumers why they should change. Products from side-streams further need to reach price parity with existing choices, and not be more expensive as price tend to be strong driver of consumer choice.

3.3.7 Entrepreneurial experimentation

Low levels of innovation pose a challenge in the regions. The low levels of innovation are caused by a few factors: lack of experiences of businesses in developing new solutions, lack of smaller innovative companies pushing the development of the industry. There is further a lack of knowledge of how to utilise side-streams in novel ways, and the know-how of how to valorise the side-streams in practice. Regarding the point of a lack of experience with novel side-streams, some businesses, wants to outsource the processing of these to other companies. Most actors in the industry are mainly focused on increasing yield and pay less attention to utilising existing resources to develop new solutions.

Side-streams are seen as both positive and negative by actors in the industry. Many see side-streams as resources, but do not know how to use it and valorise it to attain a higher value. An issue is that few actors are willing to be first movers and take the associated risk, and instead follow the first mover. Knowing that a competitor could get a higher value for their side-streams would serve as motivation for innovation. This points to a competitive environment where collaboration is difficult, as highlighter under section 3.3.3 *Direction of search.*

Regulation is indicated as one barrier to entrepreneurial experimentation concerning side-streams, particularly in Denmark. Actors point to the fact that some products based on side-streams are classified as novel foods. Given EU and Danish regulations around novel foods, companies do not want to invest time in developing products that may not get approval for human consumption. A solution mentioned is the early involvement of the DVFA in production processes for guidance that could provide clear answers, and in turn spur more innovation. EU regulation also provides a barrier when it comes to the sales of new fish species. Sailray/Sharpnose skate (*Raja lintea*), for example, is not on the list of approved species in 22 European countries, and as such is not possible to

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legally exported to these countries. This could further limit innovation as it restricts what species can be used. The uncertainty of waiting for regulatory consultations, especially those tied to EU decision-making, presents a significant challenge, frustrating the companies that are eager to progress in the market.

Finally, despite market opportunities in products such as plant-based burgers with nutrients from fish side-streams, there is a lack of small and innovative companies in the regions. This could be the result of the costs of entering the market, lack of collaboration with bigger market actors, fluctuating market conditions, and unclear regulation.

The export of liver, heads, and collarbones to Asian markets, as done by the Icelandic fishing industry, suggests potential international demand for Greenland's by-products. However, careful consideration of regulatory environments and market dynamics is necessary for successful market entry.

3.3.8 Summary and conclusions

In Greenland the industry's direction is influenced by a combination of traditional practices, emerging market demands, and regulatory frameworks. The shift towards more sustainable and efficient practices is evident, but the industry needs a more cohesive strategy for by-product valorisation and value-chain development. Collaborative efforts and a shared vision among stakeholders are essential for driving innovation and sustainability. This is similar to the situation in Denmark, where the fishing industry navigates complex challenges, and its innovative spirit, underpinned by a robust regulatory framework, opens up avenues for significant growth and sustainability in the by-product market sector.

Labour shortages and logistical challenges are major constraints for the industry in both Denmark and Greenland. The remote nature of Greenland necessitates innovative solutions for workforce development and material sourcing. Investments in technology and infrastructure, coupled with a focus on human resource development, are key to overcoming these barriers.

Innovative approaches to by-product utilisation are crucial for the industry's growth. Experimentation with new applications and market entry strategies is needed to fully capitalise on the potential of these resources. Overcoming regulatory barriers and adapting to changing market conditions will be vital for success. The sector's environment is conducive to entrepreneurial experimentation, where exploration of new commercial uses for by-products is encouraged. Partnerships and collaborations form the cornerstone of this exploration, facilitating the development of novel market channels and transforming by-products into higher-value commodities.

The potential market for by-products in both regions is significant, with diverse applications in industries like pet food production and health supplements. However, logistical complexities, fluctuating market conditions, the competitive nature of raw

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material supply, and the intricacies of regulatory landscapes pose challenges. The industry must navigate these dynamics carefully, leveraging technological advancements and market insights to expand its reach.

Key takeaways:

- **Underutilisation of marine by-products:** By-products remain underutilised in both Denmark and Greenland due to lack of knowledge on valorisation, lack of market, and prohibitive costs of valorising the by-products.
- **Gap in supply and demand of workforce:** Finding enough workers for the industry is a challenge in both regions, fuelled by competing industries, lack of housing, and depopulation. In both Denmark and Greenland, the industry is relying on immigrant workers to work on boats and in processing plants, but still lack skilled workers such as electricians for the maintenance of facilities.
- **Resource and infrastructure challenges:** Both regions face challenges related to resources and infrastructure. Diminishing fish stocks, lower quotas, and rising energy costs affects both regions, increasing the overall costs for actors in the industry. However, increasing costs for energy and importing fish (in Denmark) have led more actors to look into the use of side-streams to increase their profits.
- **Changing market demands:** The industry is facing increasing pressure from policy and regulation, markets, and consumers to become more sustainable. As such, there should be potential in the valorisation of side-streams to prove the industry's sustainability credentials, and to expand the market with new products.
- **Lack of innovation hampering valorisation:** The industry is to some extent held back by a lack of innovation, which is due to lack of experiences of businesses in developing new solutions, lack of smaller innovative companies pushing the development of the industry, lack of knowledge of how to utilise side-streams in novel ways, and regulatory barriers making it difficult for new entrants into the market.

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3.4 Estonia

Nestled in the Baltic Sea, the Estonian pilot region of Saaremaa holds a distinctive place in the blue economy landscape, boasting a rich maritime history. From fishing and maritime technology to coastal tourism and aquaculture, Saaremaa's potential is vast. However, amidst this maritime wealth, the region grapples with governance challenges – limited public awareness of blue bioeconomy, underutilisation of blue bioresources, a scarcity of skilled labour especially in research and development, neglected infrastructures and limited market access for niche products including export markets.

Red algae have been an important resource in Saaremaa for decades. Processed into furcellaran gelling agent since the 1960s, red algae represent a unique opportunity for the region's blue bioeconomy. While historically prominent in confectionary in Eastern Europe, some enterprises in Saaremaa now aim to diversify red algae utilisation into food, nutraceuticals, and cosmetics. This specific focus adds a layer of complexity to the governance challenges, requiring innovative approaches to fully harness the potential of red algae (also including by-products) valorisation.

As Saaremaa navigates the governance intricacies, the aim is not only to overcome existing challenges but to carve a path towards sustainable growth, unlocking the full potential of red algae valorisation and contributing to the region's standing in the broader blue economy landscape.

Seven key challenges have been identified in the pilot region:

- **Awareness and resource utilisation:** Limited awareness hinders the full utilisation of Saaremaa's blue bioresources, necessitating governance measures to enhance understanding and strategic utilisation.
- **Human resources and skilled labour:** Shortages in skilled labour, particularly for Research and Development (R&D), require governance strategies for skill development and talent retention.
- **Infrastructure limitations:** Addressing infrastructure challenges is crucial for modernising production processes and facilitating circular production in the blue bioeconomy.
- **Market expansion and product diversification:** Unlocking the potential of red algae for food, nutraceuticals and cosmetics demands governance initiatives to explore diverse uses, opportunities for valorisation of by-products, and market opportunities.
- **Bioresource use optimisation:** Continuous research, technical development and improved processing techniques are necessary to discover innovative applications for different types and uses of algae (including by-products).
- **Technological innovation and business model development:** Encouraging energy-efficient and modern technologies and fostering business model innovation necessitate governance support for research, development, and implementation.

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- **Institutional and social cooperation:** Strengthening institutional and social cooperation is pivotal for facilitating blue bioresource utilisation, requiring governance frameworks that encourage collaboration among stakeholders.

3.4.1 Current governance structures

The algae value chain in Saaremaa primarily falls under the governance area of two ministries. The governmental level that are responsible for the bioeconomy area are:

- The Estonian Ministry of Regional Affairs and Agriculture supports the development and ensures the implementation of Estonian fisheries policy, as well as the management of aquaculture and commercial fishing practices. They also oversee market organisation, structural support, and state aid. The Ministry also oversee the Agriculture and Food Board, and the Agricultural Register and Information Board. The Agriculture and Food Board is responsible for issuing commercial fishing permits, keeping the national registry of fishing vessels and catch records; the latter is the grant agency for European Maritime, Fisheries and Aquaculture Fund's measures in Estonia.
- The Estonian Ministry of Climate develops and implements the policies for environmental and climate protection, including the marine environment, the protection of blue bioresources, the reproduction of fish stocks, as well as the protection and restoration of spawning grounds and habitats. The ministry governs the Environmental Board (inspection and surveillance; recreation fishing permits) and Environmental Investment Centre. The latter is a state agency for funding environmental projects in Estonia. The centre has been a significant source of funding for various projects on the macroalgae and other blue bioresource uses.
- The algae value chain is also directly affected by the Ministry of Economic Affairs and Communication (maritime industry, energy and infrastructures), the Ministry of Education and Research (education programs and research), and the Ministry of Finance (maritime spatial planning) in various ways.

The local governmental level is represented by Saaremaa municipality. Municipalities can directly affect enterprises through the construction of planning permissions, but those concern only facilities that are on land, and not at sea. Trawling quotas, planning of sea facilities and the like, are not governed at the local level, but at the national level. However, the local government leads the development of visions and strategies for the area, including primary and secondary education, infrastructure, cultural activities and other activities that might impact the development of the blue bioeconomy in the present and the future.

Local governments do not have the financial means to support enterprises, nor is it within its mandate. Thus, their main support to enterprises is through communication and

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through voicing their concerns to the national government and the relevant ministries, as well as the local land-based spatial and local societal planning, including providing services through the Saaremaa Development Centre, as the local government is represented in the centre's board.

The industrial actors in red algae development in Saaremaa region are the following:

- Est-Agar: the only industrial scale processor in the Saaremaa region producing flaky (for the confectionery industry) and powdered (for the cosmetics industry) from red algae, *Furcellaria lumbricalis*
- Vetik: a start-up working on establishing a business for developing red colourants from *Furcellaria lumbricalis*

Outside the Saaremaa region:

- Kalev: Estonia's largest confectionary producer that uses furecellaran in their marmalade production
- Berrichi: Producer of cosmetics using *Furcellaria lumbricalis*
- Numami: Producer of seaweed-based food products

Research and educational institutions active in the blue bioeconomy in Estonia:

- Estonian Marine Institute of the University of Tartu, the biggest marine research organisation in Estonia
- Estonian University of Life Sciences
- Kuressaare College of the Tallinn University of Technology (located in Saaremaa)
- Tehnopol Science and Business Park

Kuressaare College is the only higher education institution that is located on the island of Saaremaa. It offers education in marine engineering and is in the process of developing a programme for sustainable technologies in the blue bioeconomy. The college is in the process of developing a laboratory for valorisation of marine resources. Such a laboratory could start offering various product developments and other laboratory services, such as services for fish and algae-based products. This would significantly support the local R&D capacity. There is currently no separate producer organisation focusing on macroalgae.

The local non-profit organisations related to the wider blue bioeconomy in Saaremaa include Saarte Kalandus, which is the Local Fisheries' Action Group. Another important institutional actor has been the non-profit Saaremaa Development Centre mentioned earlier, which role is to support local entrepreneurship through training and counselling, as well as through investor support and various other services that are financed mostly by the Ministry of Economic Affairs. Besides offering these support services, participation, and representation of local interests in different initiatives, as well as in national planning activities, Saaremaa Development Centre has been very active in various projects addressing local marine bioresource mapping and uses.

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3.4.2 Knowledge development and dissemination

Saaremaa has an established knowledge base in red algae (e.g., *Furcellaria lumbricalis* and *Coccotylus truncatus*) processing, primarily for the Eastern European confectionery industry. Local commercial actors engage in R&D activities, as well as in national and international projects. Together, they show an active commitment to creating new technological know-how and engage in knowledge exchange beyond the immediate geographical and industrial boundaries.

There are ongoing partnerships between commercial actors and research institutions, highlighting a commitment to explore innovative applications of red algae and its by-products. This includes joint projects with the Estonian Marine Institute and the Estonian University of Life Sciences on applications in nutraceuticals, biostimulants and cosmetics. Currently, the algae-related blue bioeconomy in Estonia is a niche field, with only a few micro-enterprises engaged in the valorisation of algae. Likewise, in universities, only a handful of scientists specialise in algae research.

The awareness, regarding the full scope of the blue bioeconomy and its sustainability practices is relatively limited in the society at large. Nevertheless, the presence of committed actors in the Saaremaa region, like research institutions and commercial actors, comprise important platforms for collaborative learning and knowledge sharing. The development of a regional vision for 2035 also indicates the potential to address current challenges and leveraging future opportunities. Such efforts and signals are important for driving the region's blue bioeconomy forward.

3.4.3 Direction of search

Investigating the conditions in Saaremaa for exploring the blue bioeconomy by particularly focusing on governance and the valorisation of red algae, has identified significant gaps in both collaborative forums and the wide support in the society at large of forward-looking strategic visions. Regular platforms for meaningful dialogue and the cultivation of a mutual understanding regarding the economic potential of marine resources are imperative. Moreover, coherent, long-term strategies for scaling and optimisation of the blue bioeconomy among maritime actors is vital for the sustainable advancement and growth of the industry.

Presently, Saaremaa lacks structured forums specially dedicated to the communication among the municipality, blue bioeconomy businesses and the community. The local government gets most of the information about the blue bioeconomy enterprises' concerns through being represented in relevant boards and participating in the events of Association of Saaremaa Entrepreneurs, Saaremaa Development Centre, Kuressaare College, Saarte Kalandus (Local Fisheries' Action Group). Initiating dedicated forums for dialogue could enhance collaboration and align the objectives of various

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stakeholders. Initiating dedicated forums for dialogue could enhance collaboration and align the objectives of various stakeholders.

Fragmented governance at national level, regulatory gaps, and a lack of comprehensive approach to sectoral governance pose challenges for the development of Saaremaa's blue bioeconomy. The expert interviews demonstrated concern on the lack of holistic vision on blue bioeconomy planning at national level, including the issuing of permits, regulations, speed of the planning processes, infrastructure development, environmental, educational and research funding policies and so on. Still, the importance of shared perspectives, establishing collaborative efforts and long-term strategic planning is emphasised for realising the full potential of the region in the blue bioeconomy.

Furthermore, the data indicates a necessity for local stakeholders and the greater public to revise their perception of the sea as solely a leisure resource and to acknowledge its potential for sustainable economic activities, especially within the blue bioeconomy. This paradigm shift is pivotal for increasing the valorisation of red algae and other marine resources. However, resistance to sea-related developments like wind farms reveals a divergence in opinions on the economic value of marine resources, highlighting the urgent need for a united vision in the wider local community.

Ongoing collaborations between research institutions and commercial actors are crucial, as these partnerships provide access to knowledge, laboratory facilities for development and testing of innovative applications. Such activities are important because science can guide Saaremaa’s exploratory path in the blue bioeconomy, although it is important to highlight that blue bioeconomy topics are rather fragmented between the universities. This fragmentation therefore leads to the current absence of coordinated guidance and clear strategies for temporal scaling and optimisation of solutions, signalling the necessity for a long-term strategic approach to guarantee the sustainable evolution of Saaremaa's blue bioeconomy. Such strategies should concentrate on sustainable practices, market expansion, and infrastructural development. The challenges of fragmented governance and regulatory complexity further stress the importance of a unified governance structure and a holistic approach to sectoral interactions.

Finally, challenges such as the need for pilot production units, scarcity of expertise in this niche field and the complexity of product development make current barriers for the valorisation of red algae and by-products. Yet, these challenges also offer opportunities for innovation and the exploration of untapped areas, such as algae farming and new product lines.

3.4.4 Legitimacy creation

An essential aspect of exploring the potential for valorisation of red algae in various industries is the creation of legitimacy. This involves establishing societal acceptance and ensuring compliance with existing institutions. Currently, the responsibility between

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public and regulatory agencies in the region is fragmented. Aquaculture and fisheries fall under the governance of two ministries, and there are other ministries related to the blue economy and maritime topics to various extent. Each ministry, however, regulates its own field, leading to a lack of a unified or holistic overview of the blue economy and the maritime sector. Consequently, policy responsibilities and governance activities are highly fragmented. Our results also point to a tendency among governmental actors to favour the status quo, indicating a need for developing more flexible governance structures and enhanced administrative capacity in the public sector.

The present policies and regulations addressing the utilisation of marine resources and spatial planning lead to legal and operational uncertainties. Estonian legislation is described by interviewees as complicated and time-consuming, presenting a challenging regulatory environment for entrepreneurial experimentation and new ventures in the bioeconomy sector. Regulations related to obtaining permits and managing quotas for red algae trawling, which further complicate the regulatory landscape.

Some of the interviewees voiced concerns for a growing public resistance to offshore wind farms, potentially signalling a broader challenge in gaining public acceptance for new maritime projects. This could potentially run the risk of extending to marine resource utilisation initiatives, such as building facilities to the sea for macroalgae cultivation, necessitates strategies to build societal acceptance. Strategic communication of streamlined regulatory frameworks and sustainable practices, coupled with community engagement, can thus become crucial activities in addressing potentially emerging challenges associated with public acceptance. Nonetheless, this concern underscores the need for sustainable and ecologically responsible approaches in harnessing marine resources as well as demonstrating direct benefits for local communities. Addressing these risks is essential for gaining broader societal acceptance, especially when considering concerns pertaining to negative environmental impact.

3.4.5 Resource mobilisation

Saaremaa has a longstanding tradition of harvesting and processing red algae, particularly for furcellaran production. The history of commercial actors in this sector dates back to the 1960s, with significant investments made over time in competence development, technology and production facilities. For example, Est-Agar's development of a pilot plant for producing powdered furcellaran in cooperation with a French partner. Another example is Vetik, a start-up engaged in the valorisation of red algae for the development of phycoerythrin for the cosmetic industry, which more recently has invested in research and development. It is clear that the commercial actors involved in the current red algae industry on Saaremaa make substantial investments in human resources, including researchers, technology specialists and production workers.

The current extraction level of red algae is below the environmental permits, which allows for the trawling of 2000 tonnes of red algae annually. Thus, there is room for growth in

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bioresource utilisation. There is also by-product generation coming from waste in the production process, although there is currently a lack of detailed information on the quantity and potential uses of these by-products. Exploring the potential utilisation of these by-products is an important aspect from a sustainable resource use perspective and this could also open new avenues for economic and environmental benefits. The opportunities associated with red algae development is thus emphasised by its potential socio-economic impacts, including job creation, skills development, and contributions to local economies.

Further valorisation of red algae in various industries, such as in agriculture (as organic fertiliser), horticulture (as biostimulant), food (as a texturising additive and source of proteins), and cosmetic and pharmaceutical sectors (as pigment and gelling polysaccharide), will however require effective resource mobilisation. First, there is a need to improve relevant aspects of maritime spatial planning to include macroalgae cultivation, advocating for better recognition, representation, and exploration of co-location opportunities to support this emerging sector's development sustainably. Second, financial, physical, and human resources are essential to enable the broader system changes, such as market expansion and key infrastructure developments needed to expand the blue bioeconomy. However, gaps in the regional innovation support structures, such as the lack of funding for commercialisation and the scaling of innovations, and a research funding gap despite the need for stronger industry-academia partnerships, pose challenges for the development of new technologies and R&D investments for valorisation of red algae. The novelty of the field and its capital-intensive nature also makes investment and developing infrastructure a challenge.

Furthermore, Saaremaa is a region with low population density and is already facing a shortage of skilled labour. Investments in human capital associated with industries such as nutraceuticals and cosmetics can thus be down-prioritised due to the current lack of resources. There are also few R&D actors in the Estonia capable of providing strong expertise and support for technology and product development, in general, indicating a concentration of expertise and potential vulnerability to labour market fluctuations. Lack of pilot production units also indicate a need for more supportive production infrastructures for testing and development. Thus, cross-border grants and participating in international projects, constitute important strategic resource mobilisation activities for the region at present.

3.4.6 Market formation

Supporting the development of markets for products derived from red algae and other blue bioresources is a critical element of Saaremaa's blue bioeconomy strategy. Market formation involves creating mechanisms like price-setting, public procurement, guarantees, and subsidies to foster market growth. In general, the Baltic Sea Region has been identified as having potential for circular bioeconomy development by both the EU and the Nordic Council of Ministers. This includes the production of bioenergy and bio-

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products from new biomass sources like algae, which plays into the larger concept of market formation for new technologies and products. The present red algae processors are exploring different uses for by-products such as replacement for plastic. The potential for growth or expansion in the Saaremaa market for red algae products is, however, not entirely clear. Information regarding the various applications of red algae, their potential markets and buyers, established standards and regulations can thus guide this endeavour.

In general, regulatory frameworks for sustainable harvesting practices, including policies for obtaining permits and managing quotas for red algae trawling, are in place in the Saaremaa and the Baltic Sea Region at large. The major challenges related to market formation for red algae products are connected to the cost effectiveness of the new products, market trends for hydrocolloids and gelling agents and challenges in attracting substantial investment capital, for example for infrastructure development, large scale pilot tests, growing technologies for macroalgae. Thus, financial incentives or subsidies for companies adopting sustainable practices in the blue economy, coupled with the development of new standards and regulations – such as those for sustainable harvesting and processing of red algae or hemp – can stimulate market growth and aid in establishing new market norms.

Supportive policies and financial mechanisms are thus keys to sustainable growth in the red algae industry, leveraging Saaremaa's unique maritime resources and enhancing its position in the blue bioeconomy. Such focus can guide strategic planning, target market formation and, at the same time, foster the diffusion of sustainable practices.

3.4.7 Entrepreneurial experimentation

Saaremaa's blue bioeconomy, particularly the valorisation of red algae, presents opportunities for entrepreneurial experimentation. This involves exploring new commercial applications and innovative entrepreneurship practices.

While there is evidence of initial efforts in market testing and product development, such as organic fertiliser from red algae by-products, existing partnerships or strategies involving other organisations or sectors for new commercial applications of red algae are not yet fully developed. There is still great potential for increased collaboration between industry, academia, and other sectors to explore diversified red algae applications and other blue economy innovation.

Current entrepreneurial efforts to utilise red algae by-products, indicate, however, a proactive approach to leveraging utilisation and exploring new niche markets of red algae and by-products. A broader exploration into novel, innovative commercial applications and potential industries thus remain an area of further development, presenting an opportunity for Saaremaa’s blue economy.

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A mentioned before, there are some significant challenges related to the valorisation of red algae and by-product, such as lack of skilled workers, limited number of experts in the field and a lack of pilot production sites. These could also impede the conditions for entrepreneurial exploration. Addressing these shortages is thus crucial for supporting entrepreneurial activities in the region. Additionally, overcoming regulatory challenges and fragmented governance can also facilitate entrepreneurial experimentation and innovation.

3.4.8 Summary

In Saaremaa's red algae processing industry, the valorisation of by-products remains largely untapped. This is partly due to the limited scale of current operations and a lack of widespread expertise. Moreover, challenges in the broader blue bioeconomy sector, including fragmented governance, regulatory complexities, and insufficient communication among stakeholders, further influence the conditions for valorising red algae. A significant shift in public perception is necessary to recognise the sea's potential for sustainable economic activities. Improved maritime spatial planning is also needed to include macroalgae cultivation, advocating for better recognition, representation, and exploration of co-location opportunities to support this emerging sector's development sustainably. Collaborative efforts between commercial actors, research institutions and policy makers are crucial, yet such work would benefit from a coordinated, long-term strategy for the sustainable development of Saaremaa's blue bioeconomy. Still, there is a need to develop and communicate focused strategies on sustainable practices, market expansion, and infrastructure development.

Creating legitimacy for red algae valorisation involves societal acceptance and regulatory compliance. The Estonian legal framework presents challenges for new ventures due to its complexity related to marine spatial planning, environmental and planning permits. Development of the sector is also hindered by resource mobilisation issues such as skilled labour shortages, funding gaps and the absence of infrastructure for pilot production.

For market formation, supportive policies and financial mechanisms are critical to stimulate sustainable growth in the red algae industry. Entrepreneurial experimentation offers opportunities for innovative commercial applications of red algae and its by-products. Overcoming regulatory and governance challenges is essential to foster entrepreneurial activities and innovation in the blue bioeconomy. Addressing these challenges is thus key for Saaremaa to fully capitalise on its unique maritime resources and enhance its position in the global blue bioeconomy.

Key Takeaways:

- **Innovative potential yet to be fully explored:** Saaremaa has established knowledge and active R&D in red algae processing, but there's significant potential for diversifying its applications beyond traditional uses.

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- **Challenges in governance and strategic planning:** The region lacks structured communication forums dedicated specifically to blue bioresource valorisation and the national governance of blue bioeconomy is fragmented, which complicates the development of a coherent blue bioeconomy strategy.
- **Opportunities for entrepreneurial experimentation:** Despite challenges, there are clear opportunities for innovation in the valorisation of red algae, requiring collaboration, resource mobilisation, and supportive policies to foster market development and new commercial ventures.
- **Need for enhanced collaboration and societal engagement:** Building broader societal acceptance and understanding of the blue bioeconomy's potential, especially for sustainable marine resource utilisation, is crucial. This involves fostering stronger partnerships between industry, academia, and the community to drive innovation and ensure compliance with sustainable practices.

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4 Conclusions

4.1 Summary

Coastal communities are grappling with an array of challenges stemming from the climate crisis, but also from rural depopulation, and economic pressures. The objective of BlueRev is to revitalise local economies through the potential that lies in the valorisation and upscaling of blue bioeconomy resources. This report has investigated how this can be achieved by reimagining policy frameworks, fostering adaptive governance structures and empowering coastal communities to engage in the blue bioeconomy.

We have employed the Governance of Innovation Systems (GOIS) approach, an adaption of the Technological Innovation Systems (TIS) framework, to examine governance structures facilitating or hindering cooperation, innovation implementation, upscaling, and dissemination impacting blue bioeconomy value chains.

The GOIS analysis is structured around six key functions: Knowledge development and dissemination, resource mobilisation, direction of search, market formation, legitimacy creation, and entrepreneurial experimentation. The report is based on desk studies, interviews and workshop results.

Our analysis suggests that knowledge sharing, and collaborative learning, are of utmost importance to enhance the valorisation of side-streams in the blue bioeconomy, as well as identifying common visions and enabling clear regulatory structures. This will help mobilising resources, bring actors together and build trust among partners. Allowing for entrepreneurial discovery processes is also key to foster novel product developments and from there, contribute to strengthen coastal communities throughout Europe.

4.2 Key learnings valuable for other European regions

Based on the results from the pilot regions detailed in this report, we have compiled six key learnings that can be generalised and used by other geographical regions and networks of actors in Europe facing the same challenges in the upscaling of bioeconomy resources.

4.2.1 Emphasise collaborative knowledge development

One of the critical learnings is the importance of collaborative efforts in knowledge development and dissemination. Regions should prioritise establishing strong networks between academia, industry, and government to enhance the flow of information and innovation. This collaborative approach can lead to more effective utilisation of marine by-products and drive sustainable practices.

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4.2.2 Align stakeholders towards a common vision

The significance of a unified strategic vision among diverse stakeholders cannot be overstated. Regions benefit from clear communication channels and structured processes that align various actors' goals and strategies. This alignment is crucial for coherent policy development and effective implementation of innovative technologies and practices.

4.2.3 Navigate regulatory environments for building legitimacy

Understanding and navigating the complex regulatory environment is essential for building legitimacy. Regions should focus on balancing innovation with compliance to foster an environment conducive to sustainable development. Additionally, enhancing societal acceptance through education and public awareness campaigns is vital for the long-term success of new initiatives.

4.2.4 Mobilise resources strategically

Effective resource mobilisation is key to overcoming infrastructural and financial challenges. Regions should explore public-private partnerships and international collaborations to pool resources and expertise. Investing in education and training can mitigate skilled labour shortages, supporting industry growth and innovation.

4.2.5 Innovate in market formation

Market research and strategic marketing initiatives are critical in identifying potential markets and buyers for innovative marine by-products. Regions need to understand and adapt to market dynamics, leveraging policy mechanisms to stimulate market growth and encourage innovation.

4.2.6 Encourage entrepreneurial experimentation

Fostering a culture of entrepreneurial experimentation can drive innovation and commercial exploration in the marine sector. Regions should promote partnerships across industries and explore cross-industry applications of marine by-products to unlock new growth opportunities.

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